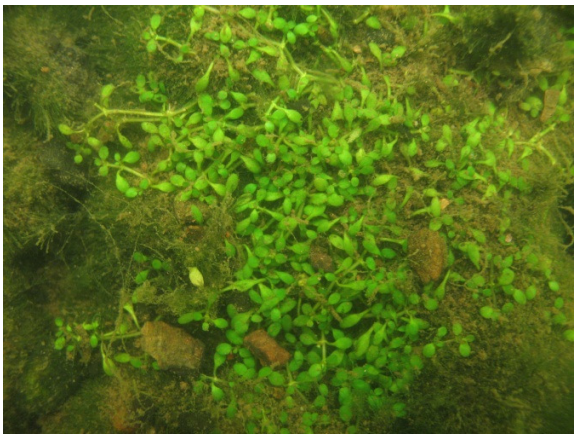
Loe Pool SSSI Macrophyte Survey 2012

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Author:	**Dr Jan Dinsdale**
Survey Dates:	**26/28 June 2012;**
	09/19/21 September 2012
Dive contractor:	**Kennack Diving**
Ecologist:	**Dr Jan Dinsdale**

NATURAL ENGLAND

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David Roberts, Des Glover, Rebecca Morton-Clarke and Milo Lekic (Kennack Diving) who carried out scuba-dive survey work;
Rob Hunt (National Trust) for digital mapping;
Nick Stewart (independent aquatic plant surveyor) for discussion and guidance on survey methodologies and long-term management aims to benefit Loe Pool macrophyte communities.

Executive Summary

This report details macrophyte survey work undertaken by Dr Jan Dinsdale, Independent Ecological Consultant, and Kennack Diving from June to September 2012. The work was carried out on behalf of the National Trust and funded by Natural England's Conservation Enhancement Scheme.

Loe Pool Site of Special Scientific Interest (SSSI) in Southwest Cornwall, is currently eutrophic and in unfavourable condition. The Loe fails to meet Natural England's conservation objectives for the macrophyte community composition and associated habitat conditions; failures include the paucity of aquatic vegetation coverage and the Lake's elevated nutrient status.

The 2012 macrophyte survey work included: A broad qualitative search for macrophyte communities using scuba-diving; and setting up new permanent transects to permit repeated quantitative recording at an appropriate scale.

These surveys established that:

- There are no additional unrecorded macrophyte beds in the lake.
- The long-term boat and grapnel monitoring technique employed since 1999, is an adequate method for recording macrophytes at present.
- The inundation plant community (comprising Shoreweed *Littorella uniflora*, Needle Spike Rush *Eleocharis acicularis* and Six-stamened Waterwort *Elatine hexandra*) has been relatively stable since 1999. This community appears to have extended into deeper water from 0.6m in 1999 to around 1.7m in 2012, though variations in accuracy of the survey methods must be taken into account.
- The majority of the suitably stable benthic substrates within the Lake support aquatic vegetation. The lack of macrophytes round northern shores of the Lake, including the Cober arm and Penrose Inlet, can be attributed to the extremely unstable benthic sediments in these locations.

Recommendations for future macrophyte monitoring include:

- Repeating the long-term boat and grapnel monitoring biannually, with the next survey in 2013.
- Non-destructive quantitative monitoring of the permanent transects. These 4 transects are now in place and the baseline survey has been undertaken. The transects will be surveyed biannually, with the next survey in 2014. This survey will require scuba-dive support in order to survey plant abundance at depths greater than 1.0m.

Based on the findings of the scuba-diving survey, macrophyte translocation experiments are not recommended until the Lake's benthic sediments become more stable.

Successful lake rehabilitation from a eutrophic algal dominated condition relies heavily upon the re-establishment of submerged vegetation. It is critical that the Loe Pool Forum continues to take a collaborative multi-agency approach to addressing external sources of nutrients and sediment to the Lake. Alongside this catchment approach, two in-lake management recommendations are proposed to help 'kick-start' the growth of macrophytes within Loe Pool. These comprise:

- Adopting a water level management regime that provides an extensive seasonal drawdown zone around the margins of the Pool
- Control of Willow *Salix* scrub along southern shores of the lake.

1. Introduction

1.1 Monitoring Sites of Special Scientific Interest

One of the key responsibilities of the statutory nature conservation agencies in the UK is the identification and protection of a series of sites intended to conserve important wildlife and earth sciences features. Under the Environmental Protection Act 1990, Natural England and the Joint Nature Conservation Committee (JNCC) are required to establish common standards in England for the monitoring of nature conservation, thus enabling consistent reporting to UK Government (JNCC, 2005).

Under the JNCC framework the procedure for monitoring is as follows:

- Identify each notified interest feature within the Special Scientific Interest (SSSI).
- For each notified feature set a conservation objective, thus providing a 'formulated standard' for monitoring.
- Assess each feature condition against its conservation objective. If the objective has been achieved, the feature condition will be described as 'favourable'.
- Assess whether management activities will enable the feature to attain or retain 'favourable condition'.
- Report the condition of all notified interests to JNCC within each reporting cycle.

1.2 Loe Pool Site of Special Scientific Interest

Loe Pool is located within the Penrose Estate near Helston, Southwest Cornwall SW649247 (Figure 1; Photo 1). The Loe is the largest natural freshwater lagoon in Cornwall. The SSSI extends over 122 ha, and includes: The lake with an area of 56 ha, a coastal shingle bar and other associated wetland and coastal habitats (including BAP Wet Woodland, Reedbeds and Maritime Cliff and Slopes). The Loe provides a winter refuge for nearly 80 species of wildfowl including high counts of Shoveler *Anas clypeata*, Pochard *Aythya farina* and Tufted Duck *Aythya fuligula*. The coastal shingle bar that separates the Loe from the sea is of importance for geomorphology, flora and fauna; it is the only known British site for the Cornish subspecies of the Sandhill Rustic Moth *Luperina nickerlii leechi*. Other relevant SSSI information is provided in Appendix 1.

The condition of the standing open water habitat at Loe Pool SSSI is currently defined as unfavourable (no change) (Natural England, 2009). The conservation objectives for the open water feature of Loe Pool SSSI, in terms of the macrophyte community composition and associated habitat conditions, are as follows:

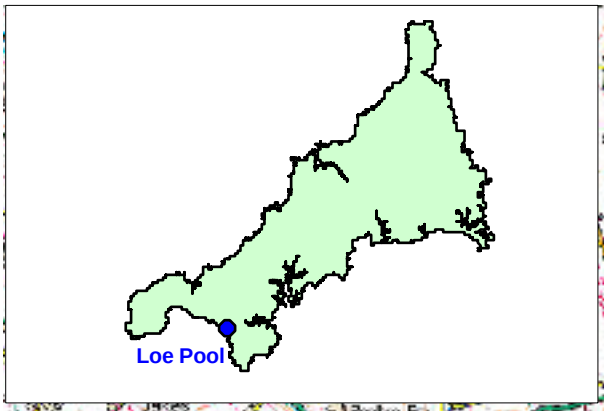
a. There should be no loss of characteristic species recorded from the site. Six out of ten sample spots should include at least one characteristic plant species.
[The full national list of characteristic plant species for a lake of this type comprises 35 species (see Appendix 1). The Loe SSSI citation sheet, however, lists just 3 of

these 35 characteristic species, namely: *Littorella uniflora*, *Elatine hexandra* and *Potamogeton perfoliatus*].

b. At this site, occurrence of non-native species should be no more than 50% frequency.
c. Characteristic zones of vegetation should be present, maximum depth distribution should be maintained and at least the present structure should be maintained.
d. Mean annual total phosphorus concentration less than target for appropriate lake type, namely 20µg P l^{-1} (as total phosphorus).
e. Stable pH/ANC values appropriate to lake type: pH 7.00 (circumneutral between 6.00 and 8.00); adequate dissolved oxygen levels for health of characteristic fauna
f. No excessive growth of cyanobacterial or green algae.
g. There should be a natural hydrological regime.
h. No loss of marginal vegetation and maintain the natural shoreline of the lake with no more than 5% of lakeshore being heavily modified.
i. Maintain natural and characteristic substrate and maintain natural sediment load.

Natural England (2009)

Photo 1: The Loe (National Trust)



Legend

National Trust Ownership

Loe Pool SSSI

National Trust

Property: Penrose

Title: Figure 1: Loe Pool SSSI

Scale: 1:50 000 @ A4

Grid Ref: SW647250

Date: 28/01/2013

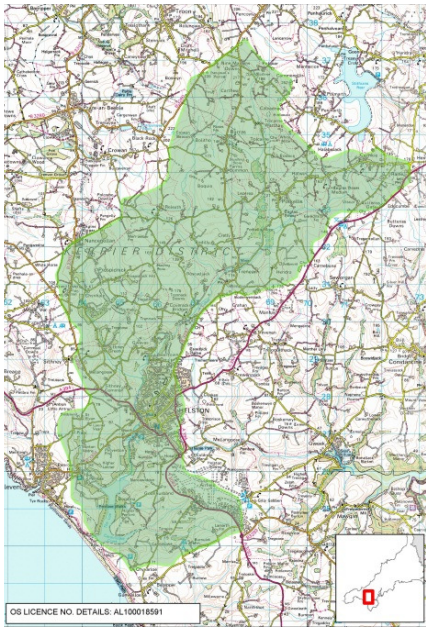
Filename: loe pool SSSI 50K

Heelis
Kemble Drive, Swindon SN2 2NA
Telephone 01793 817400

1.3 Addressing water quality at the catchment scale

Loe Pool has suffered from the effects of elevated nutrient levels, eutrophication, and excess silt deposition over many decades (Wilson and Dinsdale, 1998; Dinsdale 2003; Dinsdale, 2009). The Loe Pool Forum continues to take a collaborative multi-agency approach to addressing external sources of nutrients and sediment to the Lake. The Forum's Catchment Group (which includes representatives from Natural England, the Environment Agency, South West Water, the Rural Payments Agency and Catchment Sensitive Farming) is working to deliver an integrated programme of regulation, advice and capital grant incentives, at the catchment scale, in order to bring about the necessary improvements in water quality for the Lake (Clitherow and Dinsdale, 2012).

The SSSI target condition is for a mean annual total phosphorus concentration less than 20µg P l^{-1} (listed as objective d above). In-lake total phosphorus concentrations have reduced by 75% since 2000 (Dinsdale, 2009; EA unpublished data). This huge improvement in water quality can largely be attributed to the installation of tertiary phosphorus stripping at South West Water's Helston Water Water Treatment Works. With current in-lake phosphorus levels stabilised at around 80µg P l^{-1} (Dinsdale, 2009; EA unpublished data), the Loe Pool Forum continue to working towards further reductions in nutrient inputs from both point and diffuse sources, including:



- RNAS Culdrose Sewage Treatment Works
- Helston Waste Water Treatment Works
- Agricultural and domestic diffuse nutrient sources across the catchment

(Hambrook and Dinsdale, 2012; Clitherow and Dinsdale, 2012).

Figure 2: The Loe Pool Catchment

1.4 Existing records of the Loe macrophyte community and associated habitats

Both boat-based grapnel surveys and shore-based bathyscope surveys of the macrophyte communities within Loe Pool have been undertaken on a regular basis since 1998 (Wilson and Dinsdale, 1998; Stewart, 2000; 2003; 2006; Dinsdale, 2007-2011).

1.4.1 Boat and grapnel survey

The deep-water macrophyte communities within Loe Pool have been monitored using a repeat boat-based grapnel survey along 14 fixed transects across the lake since 1999. This survey has

been undertaken annually since 2006. The locations of the 14 fixed boat transects within the lake are shown in Figure 3.

The main observations over this thirteen-year monitoring period have been:

- The annual algal blooms, which had been a feature of the lake's ecology for many years, ceased in 2006. The last bloom of both of the previously abundant algal species, Water Net *Hydrodictyon reticultum* and the blue-green alga *Microcystis aeruginosa,* occurred in that same year, 2006.
- There has been a single boom-and-bust of the Nuttall's Waterweed *Elodea nuttallii* population. *Elodea nuttallii* was prolific across the lake between 1999 and 2006. At its peak in 2006, the population extended to both the Penrose inlet and the Cober inlet and occurred in 60% of the boat survey sample stations across the lake. The population of this non-native Waterweed crashed in 2007 and has not been observed within the lake or recorded in any of the boat survey's 14 transects since that time.
- Perfoliate Pondweed *Potamogeton perfoliatus,* one of the old inhabitants of Loe Pool, is still present in the Pool. *Potamogeton perfoliatus* was recorded from 2003-2007 (Stewart, 2003; Knight, 2003). Loe Pool is its only Cornish locality and this native pondweed was present here in large quantities in the mid-nineteenth century (Johns, 1848) and was still abundant in 1964 (Turk and Turk, 1976). *Potamogeton perfoliatus* was then not recorded until 1983 (record: RJ Murphy) and subsequently was not seen again until 2003, when a small number of plants were recorded in Carminowe Creek. Stewart (2003) suggested that the reappearance of *Potamogeton perfoliatus* 'must be due to local stabilisation of conditions by the abundant growth of the *Elodea nuttallii*'. Following the decline of *Elodea nuttallii* only small amounts of drift material of *Potamogeton perfoliatus* were recorded during the annual macrophyte surveys of 2006 and 2007, both within Carminowe Creek. The Pondweed has not been recorded more recently, despite a thorough search with the help of Cornwall BSBI plant recorder Ian Bennallick (Dinsdale, 2010).
- The water clarity has improved steadily since 2005 from less than 1.0m to 1.4m.
- Overall, there has been very little measurable change to the macrophyte communities in response to the dramatic improvements seen in the nutrient status in of the lake water in 2003-2004 and the cessation of algal blooms in 2006.

It is clear from this repeat boat and grapnel monitoring that the Loe currently supports a severely impoverished macrophyte community. While the *Elodea nuttallii* population was at its peak, this species was present in more than 6 out of 10 sample stations, but it is non-native species. Since 2007 macrophytes have been recorded in less than 1 out of 10 samples spots; indeed some years the only plant growth recorded by the boat-based grapnel survey has been the planted water lily *Nymphaea sp*..

The boat and grapnel survey is not deemed to be suitable to record the response elicited in the inundation community because:

- This community is very sparsely distributed and not adequately sampled by the 14 boat survey transects.

- The grapnel, constructed of two rakes back-to-back, is too coarse to capture the diminutive plant species which make-up the inundation community.
- The destructive nature of the grapnel sampling method is not appropriate within this rare and fragile plant community.

A summary of the most recent results of the boat and grapnel survey is provided within *Appendix 4*.

1.4.2 Shoreline and inundation community bathyscope survey

The first botanical shoreline survey of Loe Pool was undertaken October 1999 (Stewart, 2000). This study included detailed mapping of both the shoreline and aquatic inundation communities. In 1999, the inundation community comprised Shoreweed *Littorella uniflora*, Needle Spike Rush *Eleocharis acicularis* and Six-stamened Waterwort *Elatine hexandra.* These three species were described as 'frequently occurring together …although in some areas there also seems to be a zonation with *Littorella uniflora* more frequent in the shallows and *Eleocharis acicularis* more frequent in slightly deeper water. *Elatine hexandra* is less widespread than *Eleocharis acicularis* and tends to be occur in small quantity but it is sometimes locally frequent (e.g. on the headland west of Lower Pentire Farm)' (Stewart, 2000).

Stewart (2000) goes on to state 'In normal situations this [inundation] community would occur in water up to about 1.0m deep extending upwards into the draw down zone exposed by falling summer water levels. There is no shortage of shallowly shelving shores in the Loe Pool which ought to be suitable but there are two factors working against this; the dense algal blooms make it very difficult for any submerged aquatic species to survive and in many places results in a covering of soft decaying algal ooze over the firmer substrates that this community prefers. In addition the higher water levels in summer reduce the light penetration further during the main growing season. As a result, in most areas where this community occurs in the Loe Pool it is terrestrial occurring just above the water level. However, in a few places the community does extend into the water up to 60cm depth'.

Elatine hexandra is Nationally Scarce (found in only 16-100 10km grid squares nationally) and the *Eleocharis acicularis* is only known from about 125 10km grid squares. Both species are also rare in Cornwall. This must, therefore, be considered the most important aquatic community in the Loe Pool. This community is not described in the National Vegetation Classification.

This botanical shoreline survey was repeated in 2003; there had been no detailed survey of the Loe Pool inundation community since that time.

1.5 Aims and objectives of the survey

The aim of this study was to refine the long-term strategy for monitoring the macrophyte communities within Loe Pool SSSI in order to best inform the future management of both the Lake and its catchment, and therefore to enable the waterbody, and the wider SSSI, to move towards recovering condition.

The three objectives of the survey work were:

- To continue to build a long-term record of the changes in the macrophyte beds within Loe Pool using existing methods.
- To ensure that these methods are appropriate for sampling deep water species, i.e. that no deep water macrophyte beds are being overlooked by the current survey techniques.
- To extend survey methods in order to gain a better understanding of the changes to the distribution and abundance of the Lake's inundation community with water depth and over time.

National Trust

Property: Penrose

Title: Figure 3a: Loe Pool boat transects survey; commenced 1999

Scale: 1:2500 @ A3

Date: 04/02/2013

Filename: loe 1999 survey A

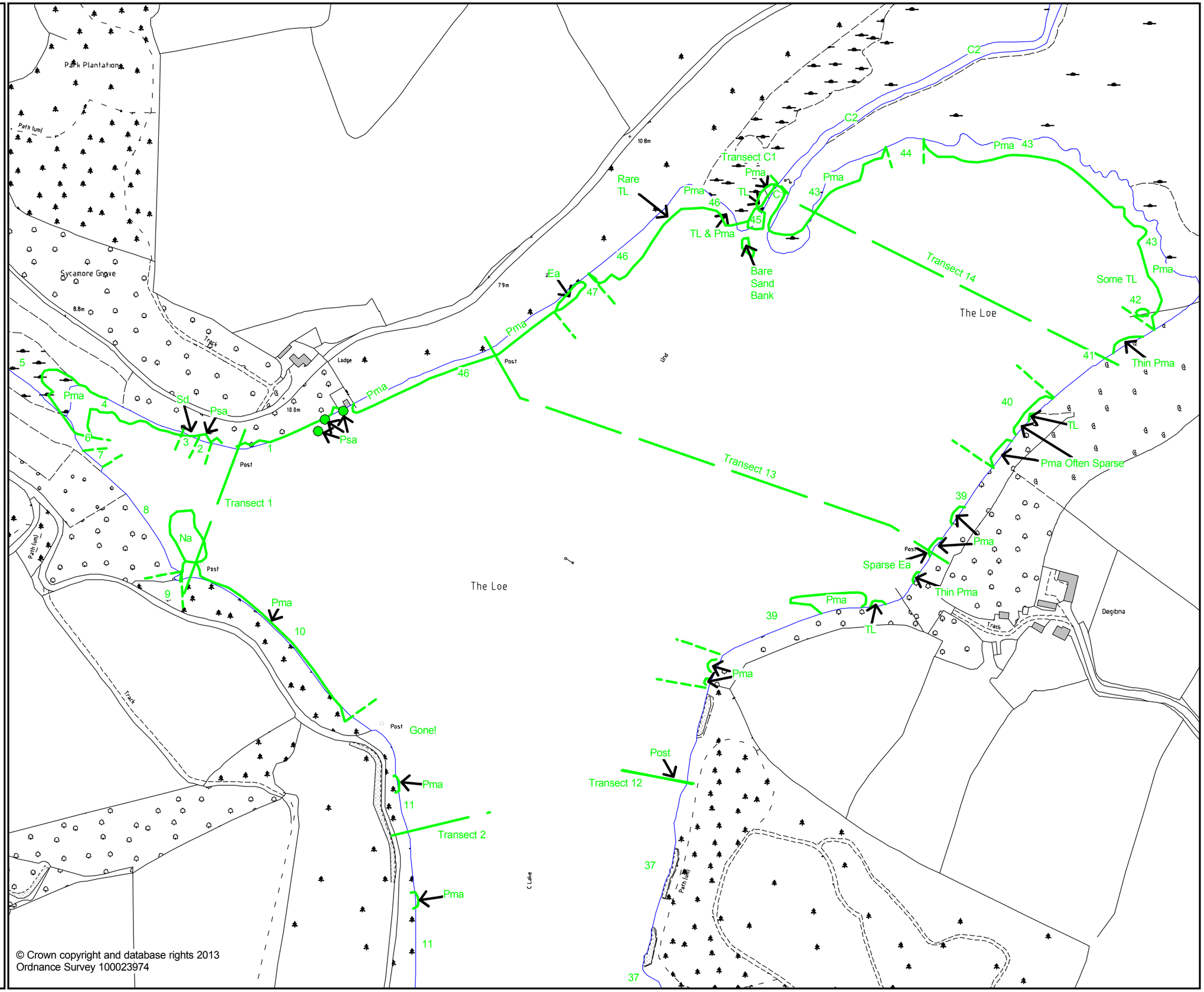
South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

- Boundaries of communities
- Boundaries between shore sections
- Lines of transects

Abbreviations

Eh =	*Elatine hexandra*
Ea =	*Eleocharis acicularis*
Ep =	*Eleocharis palustris*
Lu =	*Littorella uniflora*
Na =	*Nymphaea alba*
Pla =	*Phalaris arundinacea*
Pma =	*Phragmites australis*
Psa =	*Persicaria amphibia*
Sd =	*Solanum dulcamara*
Se =	*Sparganium erectum*
St =	*Schoenoplectus tabernaemontani*
Tl =	*Typha latifolia*



National Trust

Property: Penrose

Title: Figure 3b: Loe Pool boat transects survey; commenced 1999

Scale: 1:2500 @ A3

Date: 04/02/2013

Filename: loe 1999 survey B

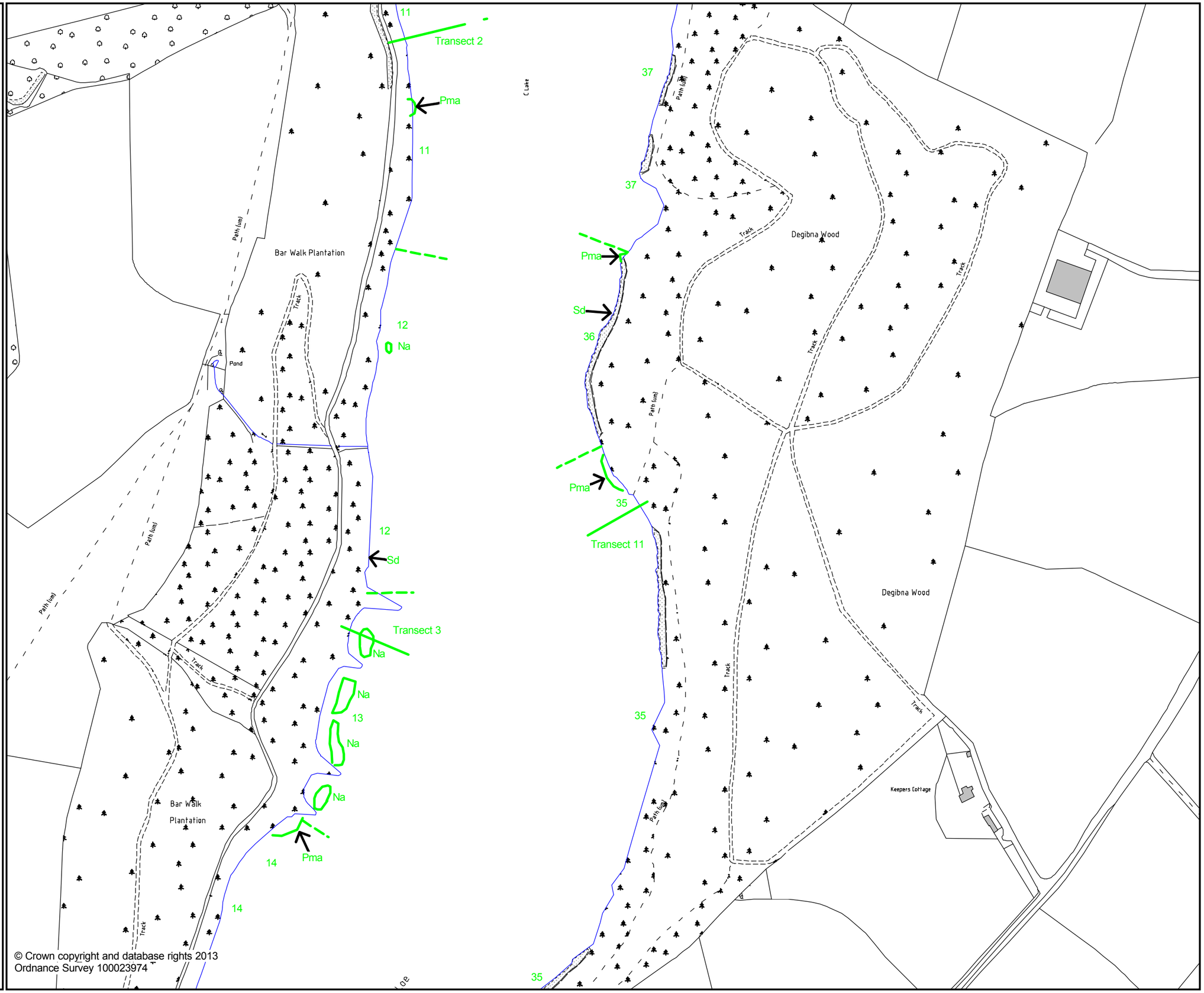
South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

- Boundaries of communities
- Boundaries between shore sections
- Lines of transects

Abbreviations

Eh =	*Elatine hexandra*
Ea =	*Eleocharis acicularis*
Ep =	*Eleocharis palustris*
Lu =	*Littorella uniflora*
Na =	*Nymphaea alba*
Pla =	*Phalaris arundinacea*
Pma =	*Phragmites australis*
Psa =	*Persicaria amphibia*
Sd =	*Solanum dulcamara*
Se =	*Sparganium erectum*
St =	*Schoenoplectus tabernaemontani*
Tl =	*Typha latifolia*



National Trust

Property: Penrose

Title: Figure 3c: Loe Pool boat transects survey; commenced 1999

Scale: 1:2500 @ A3

Date: 04/02/2013

Filename: loe 1999 survey C

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

- Boundaries of communities
- Boundaries between shore sections
- Lines of transects

Abbreviations

Eh =	*Elatine hexandra*
Ea =	*Eleocharis acicularis*
Ep =	*Eleocharis palustris*
Lu =	*Littorella uniflora*
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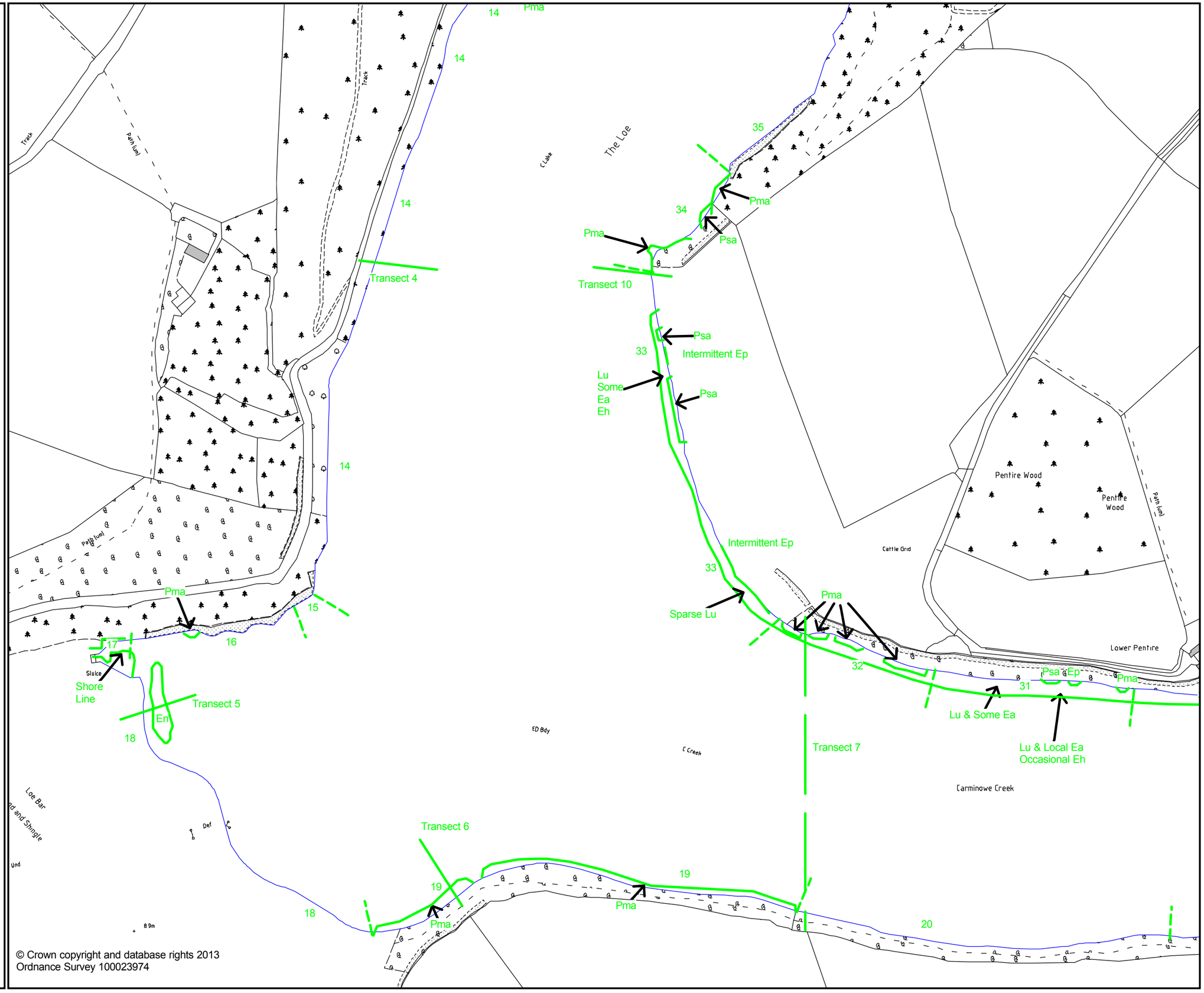
St =	*Schoenoplectus tabernaemontani*
Tl =	*Typha latifolia*



National Trust

Property: Penrose

Title: Figure 3d: Loe Pool boat transects survey; commenced 1999

Scale: 1:2500 @ A3

Date: 04/02/2013

Filename: loe 1999 survey D

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

- Boundaries of communities
- Boundaries between shore sections
- Lines of transects

Abbreviations

Eh =	*Elatine hexandra*
Ea =	*Eleocharis acicularis*
Ep =	*Eleocharis palustris*
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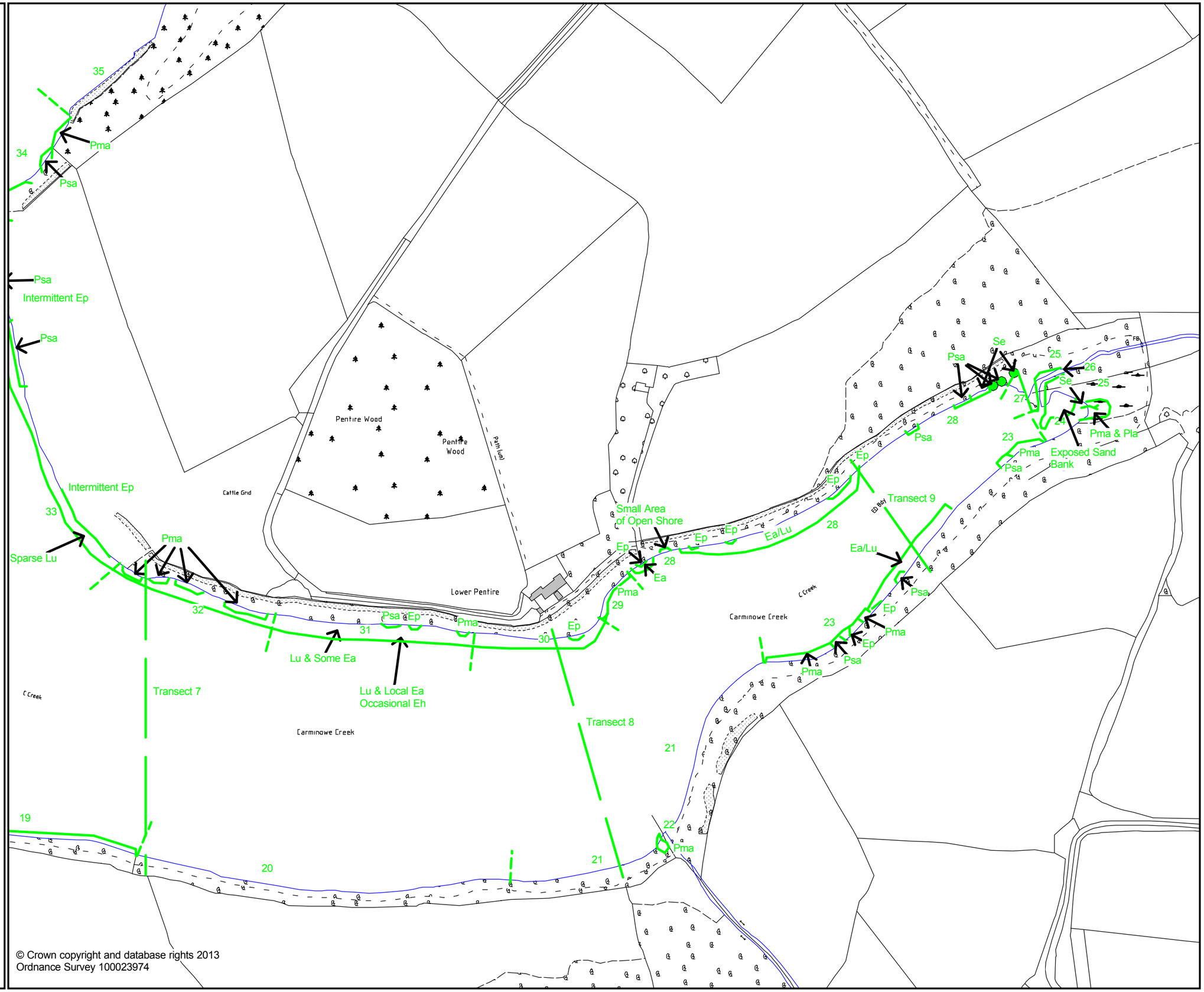


2. Methodology

Three separate survey techniques were adopted to meet the project aim and objectives:

i. Continuation of the long-term 'boat and grapnel' monitoring technique employed since 1999 (Stewart, 2000)
ii. A broad qualitative search of macrophyte communities using scuba-diving
iii. New permanent transects to permit repeated quantitative recording of the macrophyte inundation community at an appropriate scale.

2.1 Boat and grapnel survey

The fourteen fixed-location boat survey transects at Loe Pool were first surveyed in 1999 and repeated in 2003, 2006, 2007, 2008, 2009, 2010, 2011 (Dinsdale, 2011). The location of these 14 transects are shown on Figure 3. This survey is undertaken in September; a date originally selected as all current species of the inundation community are in a vegetative state and also the risk of poor water clarity due to algal blooms is low. Each transect commences at the shore and runs either out into deep water or across the entire lake, creek or inlet. Along the length of each transect, survey points are located at regular 5m intervals from the shore and, once the depth is greater than 2m, at quarterly intervals across the waterbody. At each survey point along the 14 transects, two grapnel trawls are thrown approximately 4m from the boat. The grapnel is constructed of two rake heads, wired together back-to-back. The total catch for each trawl is weighed *in situ* to the nearest 5g. Weights are wet weights with excess water shaken off. The proportion of the catch occupied by each species is assessed visually. These must be considered very approximate, particularly since density varies between species.

2.2 Qualitative survey using scuba-diving

Scuba-diving was proposed as a more accurate, non-destructive and benign method of searching for plant growth which had not been detected during the on-going boat and grapnel surveys. The aims of the scuba-diving survey were as follows:

i. To survey the three main arms of the lake (Carminowe Creek; Penrose Inlet and Cober arm) from the shore out into the deep lake centre.
ii. To provide GPS position mapping of each macrophyte beds identified.
iii. To carry out a thorough search in the vicinity of recently recorded macrophytes in Loe Pool, i.e. the stonewort *Nitella flexilis* (ENSIS, 2003) and *Potamogeton perfoliatus* (Stewart, 2003).
iv. To cover as much of the lake as possible in allotted time.
v. To survey all sections of the lake shore where the inundation community has been recorded since 1998 and undertake qualitative mapping of this community to:
    - enable comparisons to be drawn with previous Loe Pool shoreline surveys (Stewart 2000; 2003).
    - inform the positioning of the new permanent transects (see Section 2.3 below)

vi. To photograph the plants and lake benthic substrates for interpretation and communication purposes.

A team of four qualified scuba-diving staff (David Roberts, Des Glover, Rebecca Morton-Clarke and Milo Lekic) worked on the 3 dive survey days (26 June 2012; 28 June 2012; 9 September 2012) alongside the project ecologist, who remained on the shore. Entry into the lake was from the shore (Photo 2). Divers worked in buddy pairs at all times to comply with The Diving at Works Regulations 1997 (HSE 1997). Pairs were always physically connected via a buddy line due to very turbid conditions and unstable benthic sediments. A Diving Risk Assessment was produced prior to the dive operations in accordance with the Scientific and Archaeological Approved Code of Practice (HSE, 1998) (*Appendix 2*).

When surveying in deep water away from the shore, diving buddy pairs were followed by the GPS operator; a third team member floating on the surface (Photo 3). The GPS recorded positions at 5 second intervals. Water depth was recorded using a Suunto Dive Computer (*Appendix 3*).

Photo 2: Des Glover entering lake from shore to commence dive in Carminowe Creek (Jan Dinsdale)

Photo 3: Kennack Divers undertaking survey within Carminowe Creek with GPS on the surface (Jan Dinsdale)

Photo 4: Underwater image showing very poor visibility , less than 0.5m (Des Glover, Kennack Diving)

Photo 5: Checking GPS data collected by scuba-divers (Tim Walker, University of Exeter)

Visibility was extremely poor on all three survey dates, less than 1.0m (Photo 4). Divers needed to be within 0.5m of the lake floor, in order to carry out a thorough search for macrophytes. Any contact with the unstable benthic sediments that were present across much of the lake rapidly reduced visibility to 0m. The need for accurate and careful movement underwater combined with poor visibility made the scuba-divers progress very slow at times.

Non-consecutive dive dates were chosen to represent different periods of the plant growing season. July and August were avoided due to risk of poor visibility during potential peak algal bloom periods.

The extent of the scuba-diving survey is shown on Figures 4 and 6. The dive team carried out six deep water dive routes covering a total of 1052m; and 2269m of shoreline search at a depth of 1-4m. They spent a total of 10 hours and 40 minutes in the water over the three days.

The shoreline-search method combined bathyscope and scuba techniques. The shoreline was surveyed in 100-200m sections, following Stewart 2000. The diver and ecologist team worked alongside each other, in a smaller group of three, to undertake this element of the survey work:

- The ecologist surveyed 0.0m to 0.75m depth with bathyscope
- Diver One surveyed across the main plant growth zone, recording presence/absence and abundance of each species
- Diver Two mapped the outer limit of the plant communities and recorded water depth at this limit at regular intervals.

2.3 Detailed quantitative survey of permanent transects

A programme of quantitative monitoring along permanent transects was proposed as a more accurate and non-destructive method of searching for plant growth within the inundation communities. This new permanent transect survey aimed to:

i. Provide a long-term monitoring technique suitable for the inundation plant community
ii. Quantitatively record changes in plant abundance with water depth and over time.

The locations of the four transects were selected systematically, based on the qualitative observations of dive survey (Section 3.3). The location of each transect was chosen with an aim to fulfilling the following criteria:

- To sample existing inundation communities and, ideally with representations each of the three inundation species (*Eleocharis acicularis; Elatine hexandra* and *Littorella uniflora*)
- To represent the full geographic range of the community around the Lake margins
- To represent the widest range of shore profiles, i.e. steeply sloping to shallow

Each transect was positioned perpendicular to the shore, in order to sample a linear transition from the shore out into deep water. The four chosen locations for permanent repeat transects were:

- Transect 1: Carminowe Creek north shore (SW65232432-SW652332432)
- Transect 2: Carminowe Creek south shore (SW6520024211-SW6519124220)
- Transect 3: Pentire Point (SW64734824347-SW6475024327)
- Transect 4: Penrose Inlet (SW6460925571-SW6473824339)

The botanical survey of these permanent transects were undertaken over two days, the 19th and 21st September 2012. A September survey date was chosen to coincide with the timing of the boat and grapnel survey, and for the same reasons, see section 2.1. A Garmin GPS was used to record the position of each permanent transect and at this site operated with an accuracy of ±1.0m. The locations of the four transects are shown in Figure 5. For the duration of the survey, a weighted rope was used to indicate the location of the transects. A 0.5m x 0.5m quadrat was positioned along the linear transect, with sampling either side of the rope to record a continuous belt transect of 1.0m in width.

The 0.5m x 0.5m quadrat size was chosen as the most appropriate sampling scale, based on:

- The scale of individual plants to be sampled
- The distribution pattern of inundation plant communities to be sampled
- The benthic area visible through the bathyscope.

The DOMIN scale	
10	= 91-100% cover
9	= 76-90% cover
8	= 51-75% cover
7	= 34-50% cover
6	= 26-33% cover
5	= 11-25% cover
4	= 4-10 % cover
3	<4% many individuals
2	<4% several individuals
1	<4% few individuals

Vegetative cover for individual species in each 0.5m x 0.5m quadrat was recorded quantitatively using the DOMIN scale. Periodic checks and comparisons were carried out between the two surveyors (Dr Jan Dinsdale, Ecologist and Rebecca Morton-Clarke, Assistant) conferring on cover estimates to ensure consistency of recording. The depth of water was measured at 0.5m intervals using a metre rule.

Photo 6: Permanent transect survey equipment: Bathyscope, quadrat and weighted rope
(Jan Dinsdale)

Photo 7: Surveying with bathyscope. Wearing a dry suit 0.5m was very useful when surveying the deep end of the transect
(Jan Dinsdale)

National Trust

Property: Penrose

Title: Figure 4: Loe Pool Dive Routes 2012

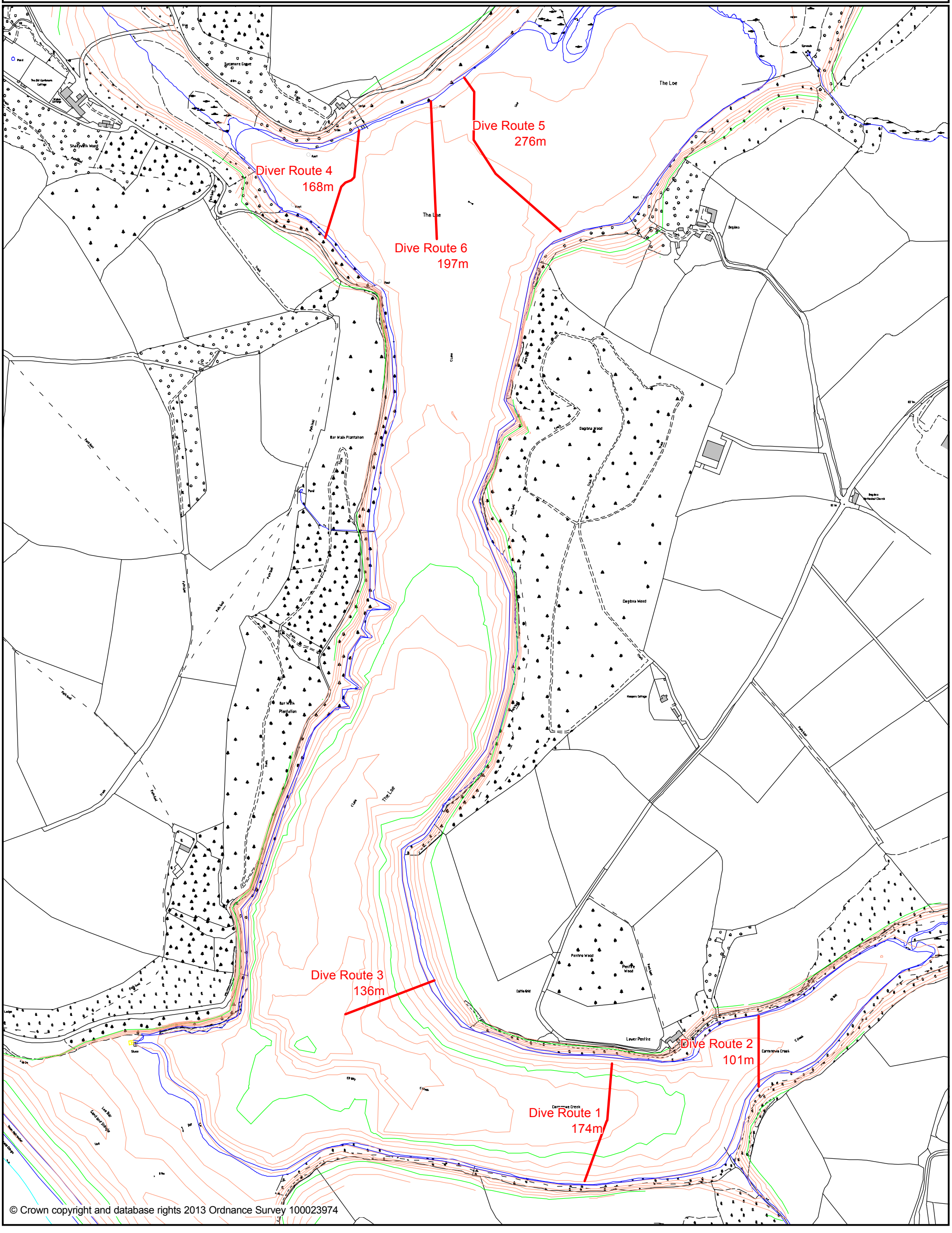
Scale: 1:5000 @ A3

Grid Ref: SW647250

Date: 04/02/2013

Filename: loe pool dive routes

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691



National Trust

Property: Penrose

Title: Figure 5: Loe Pool Permanent Transects 2012

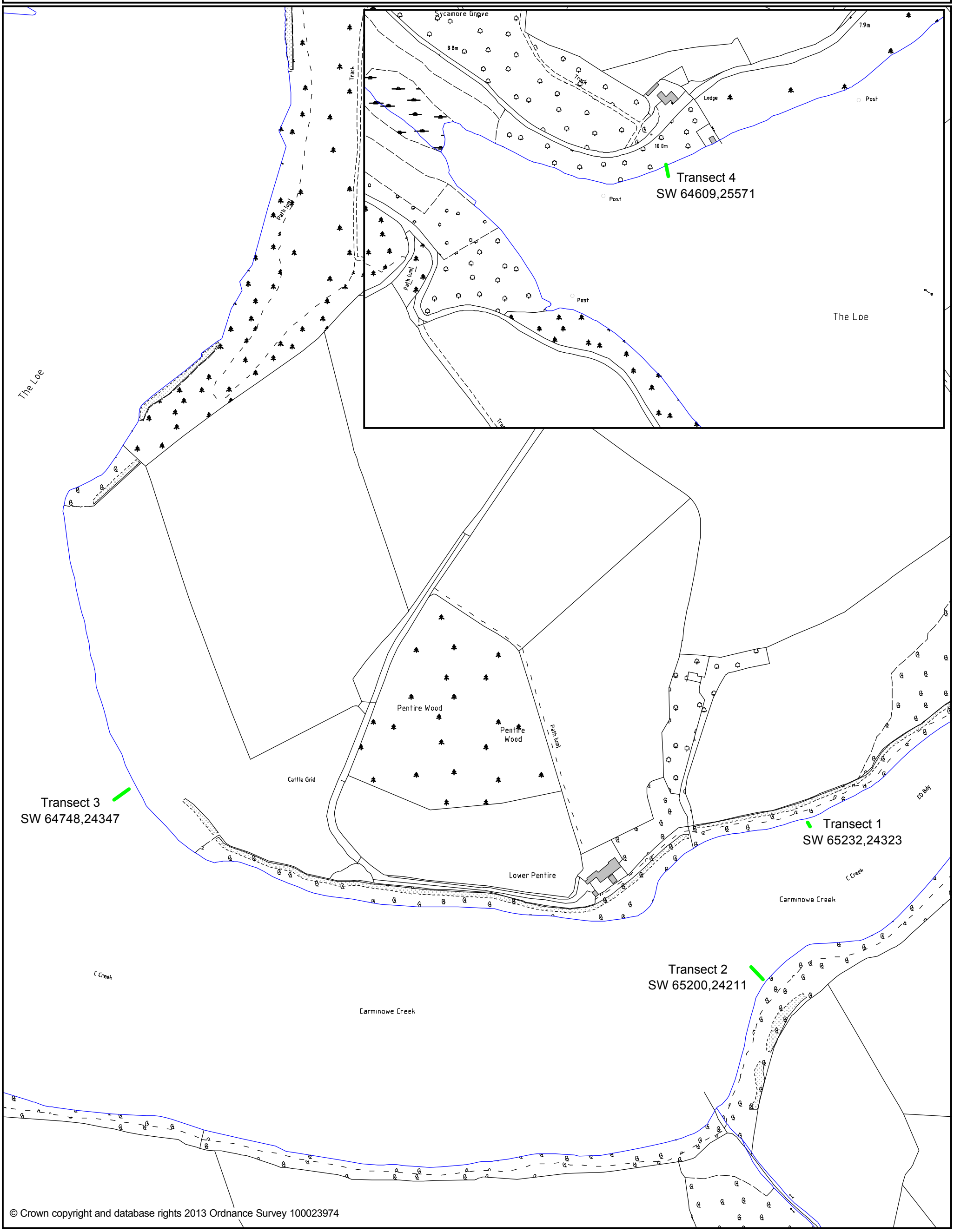
Scale: 1:2500 @ A3

Grid Ref: SW647250

Date: 04/02/2013

Filename: loe pool perm transects

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691



National Trust

Property: Penrose

Title: Figure 6a: Loe Pool Dive & Bathyscope Shoreline Survey Qualitative recording of the inundation community

Scale: 1:2500 @ A3

Grid Ref: SW646255

Date: 04/02/2013

Filename: loe shoreline survey A

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

Common Reed
Phragmites australis

Lu *Littorella uniflora*

Ea *Eleocharis acicularis*

Eh *Elatine hexandra*

Plant abundance
D = Dominant
A = Abundant
F = Frequent
LF = Locally Frequent
O = Occasional
R = Rare

Park Plantation
Path (um)
Sycamore Grove
9.4m
8.8m
Track
Lodge
10.0m
10.8m
7.9m
Post
Section 10
Section 11
Ea R
Eh R
Section 12
Und
The Loe
Track
Path (um)
Track
Post
The Loe
Post
Degibna
Track
Path (um)
(Lake

National Trust

Property: Penrose

Title: Figure 6b: Loe Pool Dive & Bathyscope Shoreline Survey Qualitative recording of the inundation community

Scale: 1:2500 @ A3

Grid Ref: SW650241

Date: 04/02/2013

Filename: loe shoreline survey B

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

Common Reed
Phragmites australis

Lu *Littorella uniflora*

Ea *Eleocharis acicularis*

Eh *Elatine hexandra*

Plant abundance
D = Dominant
A = Abundant
F = Frequent
LF = Locally Frequent
O = Occasional
R = Rare

Section 1
Lu LF/A
Ea O
Eh R/O

Section 2

Section 3
Lu O
Ea O

Section 4
Lu R/LF
Ea R

Section 5

Section 6
Lu F/LA
Ea F/LA
Eh R/O

Section 7
Lu R
Ea R/LA
Eh R

Section 8
Lu O
Ea O
Eh O

Section 9
Lu R
Ea R

Nitella flexilis ENSIS 2003

Sparganum erectum

Potamugetan perfoliatus Stewart 2003

The Loe
Penfire Wood
Penfire Wood
Path (um)
Cattle Grid
Lower Pentire
Carminowe Creek
Carminowe Creek
Nanspean
Nanspean Farm
FB
ED Bdy

3. Results

3.1 Boat and grapnel survey

The boat and grapnel survey was not undertaken during 2012. This survey was last undertaken in 2011 and will be repeated biannually, with the next survey due in September 2013. A summary of the findings of the previous boat and grapnel surveys is provided as Appendix 4.

3.2 Deep water dive survey

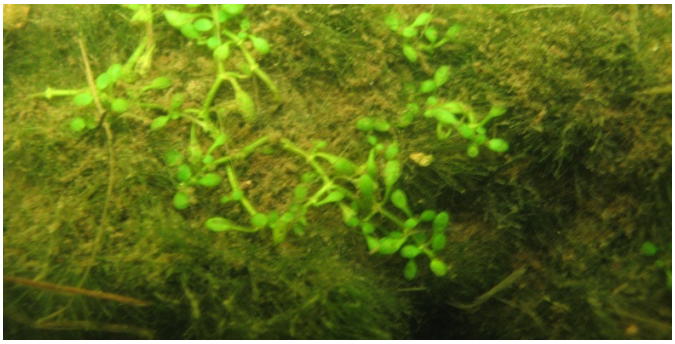
No rooted or floating macrophytes were recorded during the scuba-dive survey beyond the shoreline inundation community survey (Shoreweed *Littorella uniflora*, Needle Spike Rush *Eleocharis acicularis* and Six-stamened Waterwort *Elatine hexandra*).

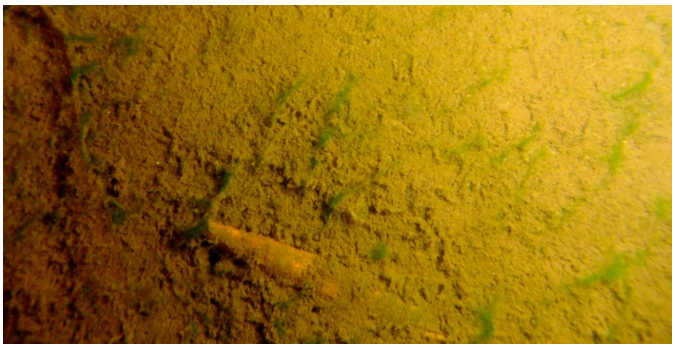
Extensive colonies of the freshwater bryozoan *Plumatella fungosa* were identified across the Lake (Photo 8). This benthic, suspension-feeding invertebrate was present on submerged stems of Common Reed *Phragmites australis*, on tree roots and on submerged deadwood. Colonies were also well-established across the lake floor, attached to pebbles and boulders, both across Carminowe Creek and the Penrose inlet.

Large areas of the stony lake floor also support an encrusting filamentous green algae, *Cladophera aegagropila*; Photo 9 shows the green algae among the inundation plant community.

The deep water dive survey presented an opportunity to explore and record the Lake's benthic sediments. Across all of the areas surveyed, when more than 20-30m from the shore, the lake floor comprises extremely unstable, fluid sediments. These have the consistency of thick soup or soft mousse! The texture of these fine fluid sediments varies a little across the Lake, but out beyond 3.0m depth the sediment is not sufficiently stable to support a person's weight. These sediments are very mobile; light contact from a diver would 'explode' a cloud of particles, reducing visibility in that locality to zero. Photo 10 indicates how these mobile fluid sediments appear to be hostile to higher plant growth.

Photo 8: *Plumatella fungosa* on reed (Des Glover, Kennack Diving)





Photos 9 and 10: Stony substrate supporting green algae and mobile benthic sediments (Des Glover, Kennack Diving)

3.3 Dive and bathyscope shoreline survey 2012 and comparison to Stewart (2000)

The abundance of the three plant species which currently comprise the inundation community at Loe Pool (*Elatine hexandra, Eleocharis acicularis* and *Littorella uniflora*) is mapped on Figure 6. The corresponding descriptions of each surveyed section of the shore, with comparisons drawn to the previous, similar survey of the site, Stewart (2000) are given below. There are notes on the nature of the substrate and the variation in species distribution with water depth. The Lake's water-level at the time of survey would have an impact on this measure of plant abundance compared to water depth. Therefore the water level Above Ordnance Datum (AOD) at the time of survey must be provided. There was in fact only a small difference in the Lake's water level across the survey dates:

- 3.6m AOD in October 1999
- 3.7m AOD in June 2012
- 3.5m AOD during September 2012

(Environment Agency, unpublished data made available to the Loe Pool Forum Dec 2012).

Section 1 (Stewart:33)
2012 description: A shore of stones and gravel backed by 1-2 metre band of *Phalaris arundinacea*. Below this is an open community including *Ranunculus flammula*, *Juncus articulatus*, *Mentha aquatica*, *Eleocharis palustris* and *Persicaria amphibia*.

Underwater the stony substrate extends to a maximum of 35m from the shore to where, at the time of survey, the water was 3m deep. Beyond this the substrate changes quite rapidly to soft

fluid mud. The extent of this stony substrate is greatest to toward the south of this stretch, being only 10m wide to the north. At the northern end there is an area where shelving bedrock replaces the stone shore.

Littorella uniflora is locally frequent to abundant across this entire section to a depth of 0.5m. *Elatine hexandra* is present but mainly within slightly deeper water, 0.5-1.2m, where it is rare/occasional and rather patchy. *Eleocharis acicularis* is also present, rare to locally occasional, mainly towards the north of this stretch in water up to 1.0m deep. There was no evidence of plants growing in water deeper than 1.7m.

***Stewart (2000) described**:* 'Frequent patches of *Littorella uniflora* on this shore above the water and scattered to locally frequent *Littorella uniflora* in a band around 0.4m deep. *Eleocharis acicularis* and *Elatine hexandra* are also present mainly towards the north of this stretch; both are rare to locally occasional'

Change to shoreline and inundation plant communities: Abundance and extent of these species appears to be similar in 1999 and 2012. The inundation community appears to have extended into deeper water, but this recorded change may be due in part to increased accuracy in the dive observation in 2012 compared to the bathyscope survey in 1999.

Section 2 (Stewart:32)
2012 description: This section of shore supports continuous Reed bed, *Phragmites australis*, which extends out into the water to 1.0m depth. There are scattered Willows *Salix* behind the reeds; no inundation community present here.

Stewart (2000) described: 'A rocky and stony shore with patches of *Phragmites australis*. Outside the reed beds, the open rocks and stones are more or less unvegetated. In the stonier parts there are occasional patches of *Littorella uniflora* at the shoreline and sparse *Eleocharis acicularis* and *Littorella uniflora* in the water to a depth of 0.4m. There are scattered willow bushes at the back of the shore but these do not extend to the water's edge.'

Change to shoreline and inundation plant communities: The inundation community here was sparse in 1999, *Phragmites australis* has expanded here, apparently excluding the inundation community.

Section 3 (Stewart:31)
2012 description: This rocky and stony shore supports small patches of *Phragmites australis* within an open shore community including *Ranunculus flammula* and *Persicaria hydropiper*. In the water are occasional, sparse patches of *Littorella uniflora* and *Eleocharis palustris* which extend to a depth of 0.5m.

Stewart (2000) described: similar to Section 2, with willow abundant at the back of the shore, but the shore zone generally open with sparse *Littorella uniflora*, *Ranunculus flammula* and *Persicaria hydropiper*. There are also occasional small patches of *Eleocharis palustris* and *Persicaria amphibia* at the water's edge and very sparse *Eleocharis acicularis* extending to 0.4m depth.

Change to shoreline and inundation plant communities: The abundance and extent of these species appears to be similar in 1999 and 2012, although plants may have extended slightly into deeper water by 2012.

Section 4 (Stewart:30)
2012 description: Stony gravely shore is backed by dense willow scrub. *Littorella uniflora* and *Eleocharis acicularis* are both rare, but with patches where *Littorella* is locally frequent to 0.6m depth.

Stewart (2000) described: 'Scattered *Littorella uniflora* and *Eleocharis palustris* where the substrate is not too stony. Near the headland below Lower Pentire Farm the substrate underwater contains more sand among the stones and *Littorella* becomes quite extensive in depths up to 60cm. *Eleocharis palustris* is also locally frequent and there is occasional *Elatine hexandra*. There are also some open areas above the water here which contain *Littorella uniflora* and *Eleocharis acicularis*.

Change to shoreline and inundation plant communities: The abundance and extent of *Littorella uniflora* and *Eleocharis acicularis* appears to be similar in 1999 and 2012. *Elatine hexandra* was occasional in 1999 but not recorded here in 2012.

Section 5 (Stewart:29)
2012 description: A *Phragmites australis* bed extends into the water to a depth of 1.5m, in front of this the lake floor comprises extremely fluid, unstable mud. No inundation species present.

Stewart (2000) described: '*Phragmites australis* bed ... the substrate on the lake-ward side of the Phragmites is soft mud which seems to be too soft for the *Littorella/Eleocharis acicularis* community.'

Change to shoreline and inundation plant communities: No change apparent to either plant communities or substrates.

Section 6 (Stewart:28)
2012 description: Stony/gravel shore backed by willow with the shoreline dominated by *Phlaris arundinacea* with abundant *Eleocharis palustris* and occasional patches of *Persicaria amphibia*. In the water there are sandy patches at a depth of 0.6-1.0m. *Littorella uniflora and Eleocharis acicularis* are thriving, being frequent to locally abundant in the south-western half of this

stretch, particularly where the substrate is sandier. *Littorella* is most frequently seen to a depth of 0.5m while Eleocharis acicularis prevails in slightly deeper water; to 1.75m depth at the far west of this section, and generally to a depth of 0.7m along the entire south-western half. *Elatine hexandra* is rare; being present only in occasional sparse patches. This inundation community is absent from the north-eastern half of this stretch, where the substrate in the shelving shallows is finer sand and mud. No sign of the evergreen stonewort, *Nitella flexilis,* recorded in this locality in 2003 (ENSIS, 2003).

Stewart (2000) described: Shore backed by scrub and willows leaving just 0-1 m of unshaded shore in the north-east of this section, broadening to 1-3m in the south-western half. This is dominated by the *Phlaris arundinacea* community with occasional patches of *Persicaria amphibian* and *Eleocharis palustris* at the water's edge together with rare patches of *Schoenoplectus tabernaemontani* and *Sparagnum erectum* near the head of the inlet. In the water the substrate is stony/gravely at the shore becoming sandier offshore particularly towards the head of the inlet.... *Littorella uniflora* and *Eleocharis acicularis* are locally frequent in the shallows in the south-western half of this stretch, particularly where the substrate is more sandy, with *Littorella* preferring the shallower water and *Eleocharis acicularis* more frequent in the slightly deeper water up to c 60cm. *Elatine hexandra* is also occasional but rather patchy. These species are however absent in the water from the north-eastern half of this stretch, despite the extensive area of shelving sandy shallows which ought to be suitable. *Littorella* and *Eleocharis acicularis* do however, occur at the shoreline.

Change to shoreline and inundation plant communities:
The abundance and extent of these species appears to be similar in 1999 and 2012. The inundation community appears to have extended into deeper water, but this apparent change may be due in part to increased accuracy in the dive observation in 2012 compared to the bathyscope survey in 1999.

Section 7 (Stewart:23)
2012 description: A *Phragmites australis* bed extends across much of this section into 0.5m water depth. Inundation species are confined to areas which do not support reeds. *Littorella uniflora, Eleocharis acicularis* and *Elatine hexandra* are all rarely present to the north-east of this section. In addition, *Eleocharis acicularis* is locally abundant to the western end of this section on a fairly steeply shelving stone and gravel bank, where this species forms dense patches of turf up to 1.0m in diameter and out to a depth of 2.0m. *Elatine hexandra* is also present here but no *Littorella.*

Stewart (2000) described: 'Mostly *Phlaris arundunacea* dominated shore with some *Mentha aquatica, Persicaria hydropiper, Lotus pedunculatus* on a firm stony or gravely base. Frequent open strip at the water's edge with *Persicaria hydropiper* type community. Occasional patches of *Persicaria amphibia* up to 2m wide ... and rare, small patches of *Eleocharis palustris* and patches of *Phragmites* at the south-western and north-eastern ends. In the south-western part,

Littorella uniflora and *Eleocharis acicularis* are occasional to locally frequent from just above the water to c.80cm depth, the *Littorella* tending to prefer shallower water than the *Eleocharis*. However, these are absent below the water towards the head of the inlet despite the more gradually shelving sandy substrate there'

Change to shoreline and inundation plant communities:
The abundance and extent of these species at the western end of this section appears to have increased and extended into deeper water. While some of this change could be due to increased accuracy in the dive observation in 2012 compared to the bathyscope survey in 1999, it is worthy of note that previous surveys have not observed *Eleocharis acicularis* growing to such depth, 2m.

Section 8 (Stewart:21)
2012 description: The substrate here includes some larger cobbles. *Littorella uniflora, Eleocharis acicularis* and *Elatine hexandra* are all occasional along this stretch of shore, with *Littorella* extending out to 0.7m depth of water; with *Eleocharis acicularis* and *Elatine hexandra* generally present further from the shore, to a depth of 1.7m.

Stewart (2000) described: …. very scattered patches of *Littorella uniflora* up to 50 cm in diameter at the shoreline but not extending into the water. Also rare *Eleocharis acicularis*. Onshore now 40% cover of *Persicaria hydropiper*, *Agrostis stolonifera*, *Sagina procumbens* with *Urtica dioica*, *Potentilla anserina*, *Epilobium obscurum* and weeds.

Change to shoreline and inundation plant communities:
The abundance and extent of these species appears to have increased and extended into deeper water within Section 8.

Section 9 (Stewart:20)
2012 description: Gently shelving stony shore backed by continuous willow scrub. *Littorella uniflora* and *Eleocharis acicularis* present in very small quantities – rare. Despite a thorough search *Potamogeton perfoliatus* was not found in this section or the reed bed to the west. It was last recorded in Loe Pool, in this location in 2003 (Stewart, 2003).

Stewart (2000) described: Inflow seepage with *Phragmites australis* and *Phalaris arundinacea* along it with *Lythrum salicaria*, *Persicaria hydropiper*, *Eupatorium cannabinum* etc. It emerges from this just above the water's edge and there are patches of *Ranunculus hederaceus* and prostrate *Apium nodiflorum* at the edges of the seepage. There are a few plants of *Ranunculus hederaceus* and *Callitriche stagnalis* along the water's edge to the north-east of the seepage.

Change to shoreline and inundation plant communities: The willow at the back of this shore is more established than in previous surveys; the inundation community appears to have

expanded into this area; substrates and water depth are suitable for further population expansion.

Section 10 (Stewart: 2- 10)
2012 description: Gently shelving stony shore shaded by continuous willow scrub. The substrate here appears to be suitable for the inundation community but has not been recorded in this location.

Stewart (2000) described: Inundation community not present.

Change to shoreline and inundation plant communities: No change.

Section 11 (Stewart: 1)
2012 description: An open shore of gently shelving gravel and stones with a 0.5m bank behind, which is eroding. The shore supports *Agrostis stolonifera* with *Lotus pedunculatus*, *Lythrum salicaria* and *Juncus effusus. Eleocharis acicularis* and *Elatine hexandra* are both present, but rare, and only to a depth of 0.5m, which is the full extent of the stony substrate. Beyond this the substrate rapidly changes to mobile silts. Littorella is absent.

Stewart (2000): Did not record the inundation community present in this locality but Stewart (2003) recorded small patches of all 3 species.

Change to shoreline and inundation plant communities: It is likely that this community has expanded in recent years but is limited by the extent of suitable stony substrate.

Section 12 (Stewart: 47)
2012 description: An open stony shore, immediately in front of the bird hide, and within a short gap in the reed fringe. No inundation community present.

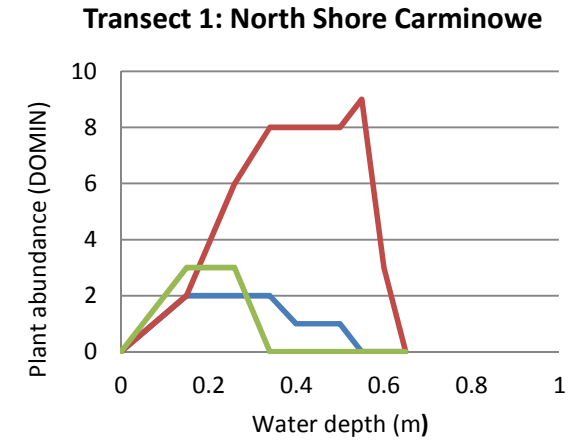
Stewart (2000): The shore is mostly unvegetated or has scattered *Persicaria hydropiper* and *Urtica dioica*. The shallow water is unvegetated but as the substrate becomes more sandy, *Eleocharis acicularis* becomes locally frequent at c.60 cm depth. Further offshore the substrate becomes softer and there are only *Hydrodictyon reticulatum* masses.

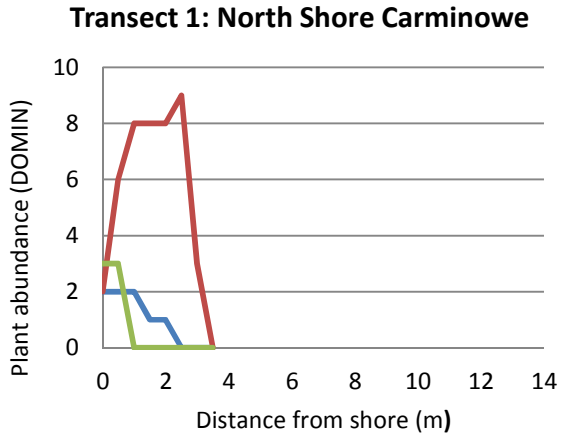
Change to shoreline and inundation plant communities: Stewart (2003) did not refind *Eleocharis acicularis* within this area. Inundation community absent.

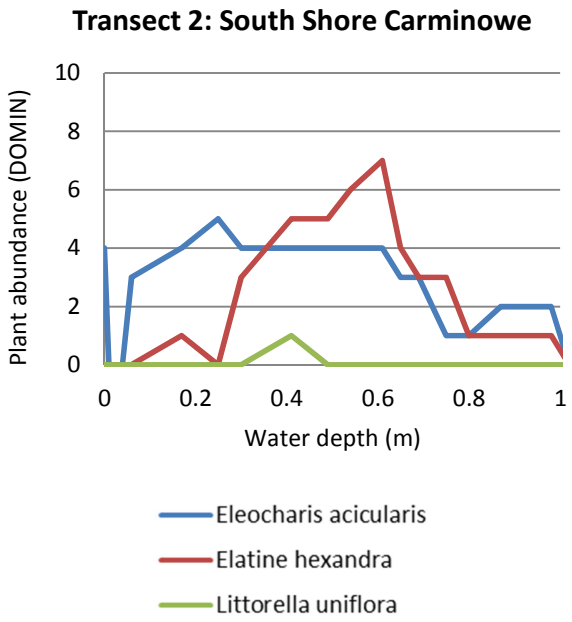
3.4 Detailed permanent transect survey

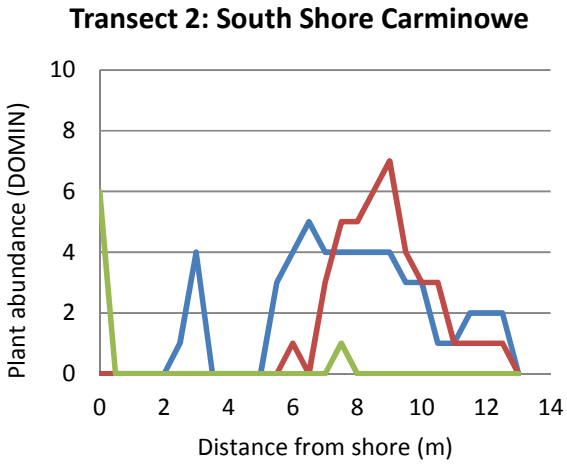
The survey results of the four permanent transects are shown in Figure 7 below.

The locations of the four permanent transects were chosen following the qualitative dive and bathyscope survey outline above, to best fit the criteria outline in Section 2.3. In practice, however, the southern half of the lake, particularly Carminowe Creek, was well represented in the survey while the inundation communities were absent from the Cober arm. One transect was positioned in the Penrose Inlet to represent the northern lake, despite of the weak inundation community present at this location. At this location only two of the three inundation species were present (*Eleocharis acicularis* and *Elatine hexandra*).









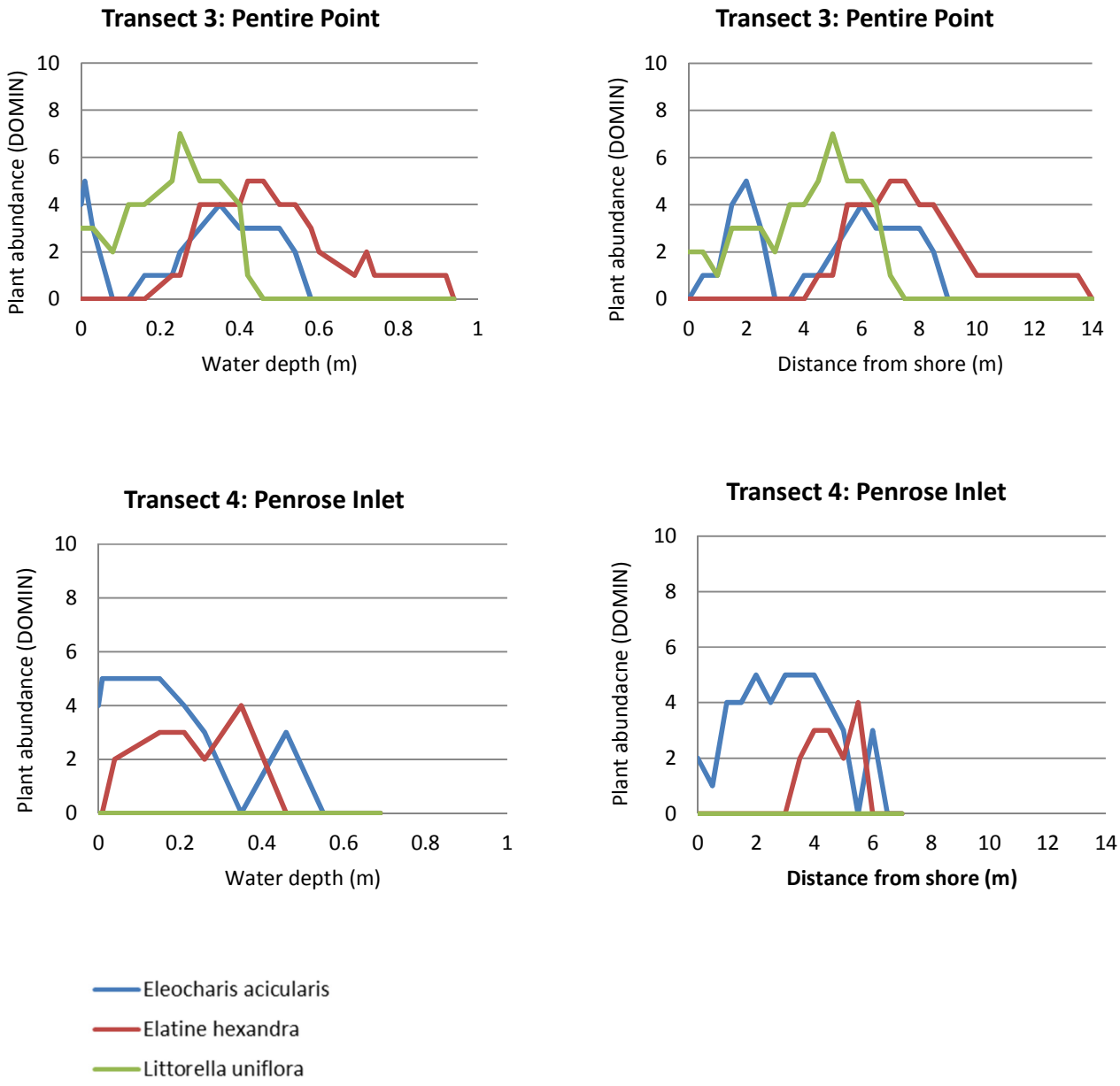


Figure 7: Variation of species abundance within the inundation community with water depth and distance from shore along four transects within Loe Pool SSSI

3.5 Summary of macrophyte community composition in 2012 and changes 1999-2012

In 2012, the extent of established macrophyte beds within Loe Pool remained pitifully low: No rooted macrophytes were recorded beyond a water depth of 2m.

There has been little overall change then in the macrophyte community since 1999, despite dramatic improvements to water quality since 2003-2004 (Dinsdale, 2009), the cessation of decline of algal blooms within the lake in 2006 and corresponding improvements to water clarity (Dinsdale, 2011). Within this period, however, an extensive population of Nuttall's waterweed *Elodea nuttalli* was present within the lake from 1999 until 2007; small amounts of Perfoliate Pondweed *Potamogeton perfoliatus* and the stonewort *Nitella flexilis* were recorded in 2003. These species were not recorded within the lake in 2012 despite a thorough search.

Macrophyte growth is currently limited to the inundation community which comprises three species: *Littorella uniflora*, *Eleocharis acicularis* and *Elatine hexandra.* This community generally occupies the drawdown zone, exposed by falling summer water levels.

Littorella uniflora, *Eleocharis acicularis* and *Elatine hexandra* frequently occur together on sandy and stony substrates but do not extend onto the mobile silts. *Littorella* alone was also recorded in areas of larger cobbles.

In many areas of the shore a community zonation is present, with *Littorella* more frequent in the shallows to a depth of 0.3m and *Elatine hexandra* found in deeper water, 0.5m-0.6m. *Eleocharis acicularis,* Needle Spike Rush, occurs across the full range of both other species.

The *Elatine hexandra* continues to be less widespread than *Eleocharis acicularis*, as observed by Stewart (2000) but is more abundant in the two Carminowe Creek transects.

Large areas of apparently suitable habitat, firm stony substrates, out to water depths of up 1.0m depth at Penrose Inlet, 2.0m around the shore of Carminowe Creek and to 3.0m depth at Pentire Point, are currently unpopulated by macrophytes. On some of these southern shores, shading by willow growing at the back of the shore is limiting macrophyte growth. In some areas of Carminowe Creek the inundation community has been lost to the expansion of reed bed along the shore.

The inundation community appears to have extended into deeper water over the period 1999 to 2012. In 1999, Stewart observed that 'in most areas where this community occurs in the Loe Pool it is terrestrial occurring just above the water level. However, in a few places the community does extend into the water up to 60cm depth'. In 2012, *Eleocharis acicularis* and *Elatine hexandra* were both frequently recorded to depths of 1.7m. Of course the water-level at the time of survey would have an impact on water depth, however, there was only a small difference in the Lake's water level across the survey dates. This recorded change is likely to be due, at least in part, to the increased accuracy in the dive observation in 2012 compared to the bathyscope survey in 1999. It was observed in 2012 that accuracy of plant recording using the bathyscope was limited beyond 0.6m.

4. Publicity

There was considerable media interest in this Loe Pool 2012 macrophyte survey using scuba-diving. An interview with the survey team and National Trust staff at the lake during the survey was shown on local BBC and ITV news:
BBC Spotlight Monday 25 July 2012- Divers survey Loe Pool, Cornwall's largest lake:
http://www.bbc.co.uk/news/uk-england-cornwall-18579540

ITV Westcountry: Friday 29 July 2012 – Cornwall's largest natural freshwater lake surveyed by divers for first time:
http://www.itv.com/news/westcountry/update/2012-06-29/cornwalls-largest-natural-freshwater-lake-surveyed-by-divers-for-first-time/

There was also media coverage in:

- the local newspaper http://www.thisiscornwall.co.uk/Polluted-pool-showing-signs-life/story-16482707-detail/story.html
- the Devon and Cornwall National Trust members' magazine
- the National Trust South West blog http://www.ntsouthwest.co.uk/2012/06/loe-pool-dive-survey/
- the National Trust local property blog http://lizardandpenrose.blogspot.co.uk/2012/06/scuba-divers-explore-depths-of-loe-pool.html

The study also featured in a presentation given at the UK and Ireland Lakes Network annual symposium http://www.ukandirelandlakes.org/uploader/pdf/Loe_SWW_Presentation_v2.pdf

Examples of these articles are included with this report as *Appendix 5.* This was very positive publicity for Natural England and for their work, as part of the Loe Pool Forum, towards delivering favourable condition status for the SSSI, both within the Lake and across the its catchment.

5. Lake and Catchment Management Recommendations

This section outlines recommendations for further survey work and for management both within the SSSI and across the catchment, based on the findings of the survey.

5.1 Further survey recommendations

The boat and grapnel survey method is adequate to record rooted macrophytes in deep water within Loe Pool; no additional records were found during this 2012 scuba-dive survey. It is, therefore, recommended that the boat survey is repeated bi-annually in September and it is considered that there is no need to repeat the full deep-dive survey for the foreseeable future.

Scuba-diving was an accurate method of recording abundance of the inundation community at all water depths.

In view of current water clarity in the Loe, a bathyscope provides a reliable method for surveying this community type up to a maximum depth of 1.0m. Scuba-diving is therefore recommend as part of the permanent transect survey, in order to survey the quadrat location at more than 1.0m water depth on each of the 4 transects. It is recommended that this survey is repeated biannually and also in September; this frequency is selected to be sufficient to measure change while minimising physical disturbance to the vegetation in the location of the permanent transects. This would require 1 day of the dive team biannually in future years.

5.2 Macrophyte translocation trials

Translocation experiments for *Littorella uniflora* and *Potamogeton* spp were outlined as part of this Conservation Enhancement Scheme funded study. The aim of this element of the research programme was to provide further information on the suitability of the shoreline for macrophyte colonisation and establishment and help to elucidate any factors currently limiting plant growth.

Based on the information gathered as part of this scuba-dive survey. It is clear that the physical texture of the benthic sediments continues to be unsuitable for rooted plant growth and therefore the macrophyte translocation trials are not recommended at present.

5.3 Working at the catchment scale

The work of the Loe Pool Forum to reduce both sediment and nutrient inputs from diffuse and point sources across the Lake's catchment is considered to be critical to the successful rehabilitation of Loe Pool. In particular, the work of the Loe Pool Point Sources Group to reduce nutrient inputs from the two water treatment works within the catchment and the work of the

Loe Pool Catchment Group to address agricultural inputs through farm advisory and grant assistance will be invaluable, working to deliver improvements to water quality and benthic sediment structure within the Lake SSSI.

5.4 In-lake management

Delivery of improvements to water quality and sediment inputs towards the SSSI target levels may alone, in time, provide the required conditions for recovery of the macrophyte communities within the SSSI, in order to meet the conservation objectives listed in Section 1.3. Great progress towards these macrophyte conservation objectives has been seen to date with a huge reduction in phosphorus inputs, a decline in algal blooms and corresponding improvement in water clarity. The low occurrence of non-native plant species is also favourable but the extent of established submerged vegetation remains very low.

In terms of the Lake's broader ecology, successful lake rehabilitation from a eutrophic algal dominated condition relies heavily upon the re-establishment of submerged vegetation. The importance of extensive beds of submerged vegetation for water clarity, and the numerous mechanisms by which rooted vegetation exerts positive effects on the lake rehabilitation process, are well documented (Moss, 1990; Jeppesen *et al*., 1990; Meijer, 2000; Jeppesen, 1998; Phillips, 2005). It is therefore worth considering in-lake management techniques which could 'kick-start' the growth of macrophytes within Loe Pool. The options available could include:

- exclusion of wildfowl from discrete areas to improve plant establishment
- disturbance of the shore sediments to stimulate emergence of plants from the seed bed
- physical stabilisation of the benthic sediments.

Each of these options would require in-situ trials before being undertaken as a management measure within the SSSI. They are not recommended for consideration at present, but should perhaps be considered in the long-term, if there continues to be no improvement to the extent of macrophyte growth in Loe Pool. Based on the findings of this 2012 Macrophyte Survey, two management recommendations that should be considered immediately, to improve habitat conditions for the establishment of macrophytes in Loe Pool are given below.

5.4.1 Water level management

One of the key conservation objectives for Loe Pool SSSI states that 'There should be a '**natural'** hydrological regime' (Natural England, 2009) A wholly 'natural' lake hydrology is considered unrealistic:

- Water levels in Loe Pool have been artificially controlled for over 200 years (Wilson and Dinsdale, 1998)
- The current water level regime is controlled using an engineered outlet structure at Loe Bar.
- The town of Helston has a history of high flood risk linked to water levels within the lake.

Perhaps then, rather than a 'natural lake hydrology' it would be more appropriate to set an objective to deliver 'a hydrological regime that best serves both the lake's ecology and flood risk management'.

Historic shoreline flora data strongly indicate the presence of a summer drawdown zone at Loe Pool (Stewart, 2000). An increased summer drawdown zone would improve both the extent and quality of habitat for macrophytes: *Elatine hexandra*, for example, does not flower beneath the water (Stace, 1997); *Littorella uniflora* can tolerate extreme inter-annual fluctuations in water levels and long periods of exposure (Natural England, 2009). Generative reproduction occurs during dry periods, on the emerging sediments or in extremely shallow water (Brouwer *et al*., 2002). Additionally, periodic emergence of the sediment of shallow lakes stimulates germination from the seed bank (Brouwer *et al*., 1999). Most softwater macrophytes produce long-lived seeds and re-establishment from the seed bank often occurs in large amounts (Bellemakers *et al*., 1996). The macro-invertebrate communities would also benefit from an increased area of seasonally inundated shore (Knight, 2003).

Using bathymetric data collected by Mason Survey in 2000, Haycock (2000) calculated that the current normal range of water level (approximately 3.5 to 4.1 mAOD) exposes 7.6 ha of littoral edge. These calculations can be extrapolated to predict that a winter 3.5m AOD and summer 3.05mAOD would increase the littoral shore by up to 3.5 ha, giving a total littoral area of 11.1 ha. This extended drawdown zone would benefit of both the plant and the macro-invertebrate communities and would be consistent with Natural England's Conservation Objectives for the site (Natural England, 2009).

5.4.2 Shoreline scrub and reed management

Willow shading on southern shores Carminowe and Penrose inlet is likely to be limiting the establishment of the macrophyte community in these otherwise suitable areas. Controlling the growth of these willows would help to provide good habitat conditions to promote macrophyte growth in these areas. It is recommended that the willows in these priority areas are cut back and the stumps treated with a Glyphosate-based herbicide. Use of this systemic, low-toxicity compound will reduce regrowth considerably but follow-up cutting will still be required. The use of any herbicide in or close to a waterbody requires written approval from the Environment Agency.

Lower summer water levels will have an impact on shoreline reed communities (Haycock, 2000). This could also have a positive impact on the inundation communities as in some areas around Carminowe Creek these macrophytes have been lost to competition from the expanding reed bed.

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APPENDIX 1

Natural England SSSI citation and excerpt from SSSI condition statement

SSSI Citation

COUNTY: CORNWALL SITE NAME: LOE POOL
DISTRICT: KERRIER
Status: Site of Special Scientific Interest (SSSI) notified under Section 28 of the Wildlife and Countryside Act 1981 (as amended)
Local Planning Authority: KERRIER DISTRICT COUNCIL; CORNWALL COUNTY COUNCIL
National Grid Reference: SW 647250 Area: 128.7 (ha) 318.0 (ac)
Ordnance Survey Sheet 1:50,000: 203 1:10,000: SW 62 SW SE NW NE
Date Notified (Under 1949 Act): 1951 Date of Last Revision: 1973
Date Notified (Under 1981 Act): 1986 Date of Last Revision: –

Other Information:
Cornwall Area of Outstanding Natural Beauty and Cornwall Heritage Coast. Site boundary amended by extension and deletion. Mainly National Trust owned.

Description and Reasons for Notification:
Loe Pool, located south of Helston on the South Cornish coast, is the largest freshwater lagoon in Cornwall covering an area of approximately 50 hectares and with maximum depth of 6 metres. The underlying rock is composed of Devonian shales and siltstones, locally overlain by head deposits. Soils developed over the surrounding area are mainly acidic brown earths. Both the pool and the shingle bar provide scarce habitat not found elsewhere in Cornwall, with rare species of higher plants, bryophytes, and algae, together with many rare and local insect species. The area is also important to wintering birds. The pool supports several locally rare aquatic plant species including Six-stamened Waterwort *Elatine hexandra*, Perfoliate Pondweed *Potamogeton perfoliatus*, Shoreweed *Littorella uniflora,* Horned Pondweed *Zannichellia palustris*, and Amphibious Bistort *Polygonum amphibium*. One noteworthy species of alga, Stonewort Alga *Nitella hyalina*, has also been recorded. The shingle bar supports local plant species including Sea Holly *Eryngium maritimum*, Sea Fern-grass *Catapodium marinum*, Yellow Horned-poppy *Glaucium flavum*, Sea Sandwort *Honkenya peploides*, Sea Mayweed *Tripleurospermum maritimm*, and the very rare Strapwort *Corrigiola litoralis*.

At the northern inflow area is an extensive area of willow carr, mainly Grey Willow *Salix cinerea*, with Common Reed *Phragmites australis* locally dominant within the willow. There is a wide fringe of Reed around the northern border of the lake. An area of relatively undisturbed ancient oakwood, mainly Pedunculate Oak *Quercus robur,* occurs in the west of the site. Areas of maritime grassland occur along the cliff edge with Red Rescue *Festuca rubra* forming an extensive mat. Other species include Thrift *Armeria maritima*, Wild Carrot *Daucus carota*, Wild Thyme, *Thymus drucei*, Spring Squill *Scilla verna*, and Western Clover *Trifolium occidentale.*

Loe Pool is the only known site in Britain for the Cornish subspecies of the Sandhill Rustic Moth *Luperina nickerlii leechi*, which feeds on Sand Couch Grass *Agropyron junceiforme*. Nine species of Odonata, including the Keeled Skimmer *Orthetrum coerulescens* have been recorded here. The nutrient rich status of the pool has encouraged an abundance of benthic invertebrates, and there are also many rare or local species of Coleoptera and Hymenoptera. Loe Pool has the only recent record in Cornwall of the rare woodlouse, *Porcellio dilatatus.*

Loe Pool supports nearly 80 species of wintering birds with up to 1,200 wildfowl. Numbers of Shoveler *Anas clypeata* can reach nationally important levels and regionally important counts of Teal *Anas crecca* are not unusual.
There are also high counts for Pochard *Aythya ferina*, Tufted Duck *Aythya fuligula*, Mallard *Anas platyrhynchos*, Goldeneye *Bucephala clangula*, Cadwall *Anas strepera*, and Coot *Fulica astra*. Several rare birds have been recorded here in winter and on autumn migration. There is a breeding colony of about 20 pairs of Sand Martins *Riparia riperia* a species not well represented in Cornwall.

Loe Bar encloses a lagoon occupying part of a former ria, and forms an integral part of a beach system extending from Porthleven to Gunwalloe. The site is important for coastal geomorphology on two accounts. First, Loe Bar is a classic coastal landform; and second, the beach system is an essential member of a suite of major beaches formed and maintained by predominantly south-west wave regimes. The beach is formed mainly of flint shingles and coarse sand. Current inputs from adjacent cliffs are small, and overall, the beach is in deficit. The Bar is washed-over during periods of high wave energy as demonstrated by a series of washover fans. The annually laminated sediments composed of classic material are unique in Great Britain.

SSSI condition statement excerpt

Box 1. Characteristic species of oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Iseoto-Nanojuncetea.* ** mesotrophic species only		
Characteristic species: *Littorelletea* flora:	**Other characteristic species:**	**Associates:**
Littorella uniflora	*Pilularia globulifera*	*Callitriche hamulata*
Isoetes lacustris	*Elatine hexandra*	*Callitriche brutia*
Isoetes echinospora	*Baldellia ranunculoides*	*Myriophyllum alterniflorum*
Lobelia dortmanna	*Carex rostrata*	*Potamogeton polygonifolius*
Subularia aquatica	*Utricularia* spp.	*Potamogeton berchtoldii*
Sparganium angustifolium	** *Nitella* spp.	*Potamogeton natans*
Luronium natans	***Sparganium natans*	*Nymphaea alba*
Potamogeton rutilis	**Broadleaved *Potamogeton* species:	*Juncus bulbosus*
	P. alpinus	*Eleogiton fluitans*
	P. praelongus	*Equisetum fluviatile*
	P. perfoliatus	*Nuphar lutea*
	P. gramineus	*Menyanthes trifoliata*
	P x nitens (and any other established hybrid of these species)	*Eleocharis acicularis*
	***Najas flexilis*	***Persicaria amphibia*

APPENDIX 2
Risk assessments: scuba-diving

Dive Project Plan + Risk Assessment for Underwater Plant survey with Jan Dinsdale/National Trust at Loe Pool/Carminowe Creek (Lower Pentire)

Date

Type of site/ Dive…Rock/pebble beach shore dive. FRESH WATER!

Type of Diving - Trial Dives €

Guided dives €

Open Water Course Training €

Adv O/w Training €

Rescue Diver Course Training €

Dive master Training €

Other € Details……

……

All Courses to be conducted according to PADI General Standards And Procedures and using the PADI RDP dive table ,general guidelines HSE Diving at Work ACOP'S 1997

ALL DIVERS TO CARRY OUT BUDDY CHECK BEFORE EVERY DIVE

ALL PERSONS TO SIGN THIS SHEET AT THE END OF DIVING ACTIVITIES

Personnel -

Dive Contractor …… Des Glover €……. David Roberts €

Supervisors - Des Glover €…….David Roberts €

DIVERS / SHORE SUPPORT

NAME	QUALIFICATION	ROLE	SIGNED
David Roberts	**MI 609353**	**Instructor/DIVER**	
Des Glover	**MSDT 632321**	**Instructor/DIVER**	
Rebecca-Morton Clark	**Divemaster**	**Divemaster/DIVER/ Shore & surface**	
Jan Dinsdale		**Ecologist/on shore at all times**	
Chris Cattlin	**Divemaster**	**Shore/logistics support**	
Milo Lekic	**Instructor**	**Instructor/Diver**	

Equipment - Full PADI Standard Scuba Equipment Inc SMB, Whistle / Signalling device, Knife/ cutting tool.

EXTRA EQUIPMENT -50 metres of 11mm Rope – Large fishing buoy for GPS attachment, 20metre rescue throw line,

Gas Mix - All Air Unless specified on Diver Log

Safety Equipment - The First Aid Kit and O2 are located in the large orange O2 box on site at all times!! ALL DIVERS ON THIS DIVE are First Aid, Emergency Oxygen and Diver Rescue trained!!

Communication Equipment …… Emergency Phone – Helston Cottage Hospital ORANGE/VODAFONE mobiles checked at site and work ok!

In event of accident …. Call 999 ask for Coastguard. Give details of Accident and location….

Lower Pentire . Grid reference 243652-Carminowe Creek

Nearest Decompression Chamber - Derriford Hospital - Plymouth - Emergency contact Number 01752 209999.

If Coastguard Rescue Delayed - Navy Diving Doctor - 07831 151523 for advice

HAZARDS & ACTIONS

WALKING DOWN SLOPE TO SHORE……Please ensure good footwear etc

BOAT TRAFFIC & POSSIBLE ANGLERS…….. None anticipated SMB AT ALL TIMES

FISHING LINE UNDERWATER……. All divers to carry knife / cutting tool

WATER TEMP' ……..Appropriate exposure to be worn

Wet/dry suit Gloves, Hood etc

HAZARDS SPECIFIC TO TODAY ……None anticipated, no untoward currents , thermoclines are anticipated also no specific threat of hazardous marine life.

Advise all divers of need for VERY close buddy contact at all times due to anticipated poor visibility and to be aware of potential underwater obstructions eg: Tree branches……

Be aware of any water ingestion and observe correct hygiene procedures, alcohol wash available at all times.

Tide

High Water ……N'A……Low Water……N/A…….

Weather Present…….....Forecast…….....

Water conditions

Sea State Present…….. …Expected Future……

Expected Viz…ZERO -…1/2 METRES……Expected Temperature ……19 Degrees C……

<u>This action plan and risk assessment has been agreed by the appointed contractor and supervisor. They have both agreed to their roles as laid down in the diving at work HSE regulations. The action plan and risk assessment have been relayed to all divers by the contractor and all points explained and understood.</u>

Signed …….....DIVING CONTRACTOR

Signed…….....DIVING SUPERVISOR

Risk assessments: transect survey

ACTIVITY:

Transect survey – wading and snorkling in lake

LOCATION:

Loe Pool, Helston

DATE OF ASSESSMENT:

17/09/2012

ASSESSED BY:

Jan Dinsdale

PROJECT NAME:

Loe Pool CES Transect Survey

SURVEYORS:

Janet Dinsdale

Rebecca Morton-Clarke

Key:

RISK RATING - L = Likelihood (Low, Medium, High), S = Severity (Low, Medium, High), R = Risk (Likelihood x Severity)

RISK LEVEL - L = Low; M = Medium; H = High; N/A = Not applicable

LIKELIHOOD

H Certain or near certain to occur

M Reasonably likely to occur

L Very seldom or never occurs

SEVERITY

H Fatality, major injury or illness causing long-term disability

M Injury or illness causing short-term disability

L Other injury or illness

PLOT ASSESSMENT OF SEVERITY v LIKELIHOOD AND HIGHLIGHT VALUE OBTAINED

H/H 100% avoid whenever possible

L/L 0% may be ignored

For all other values, control or minimise risk

KEY:

Hazard (something with potential to cause harm)– this list is not exhaustive, consider and select relevant actions, and add any additional hazards identified

Risk (chance or likelihood of harm being caused

Who is at risk – staff, general public, landowners, people with special needs, other

Risk Level – write down whether Low, Medium or High

Precautions – List the safety measure to be put in place to lower risk level

Risk Level – following precautions what is risk level

Continue with activity? – Is risk level too high to continue?

Further action – consider and list other action to be taken to permit activity to continue

Action by whom – yourself, landowner, group leader, etc

Action done – date and initial

HAZARD **Potential for harm**	**Who is at risk and might be harmed?**	**RISK LEVEL:** **Low** **Medium** **High**	**PRECAUTIONS** **To reduce the risk level**	**RISK LEVEL** **Following precautions**	**Continue with activity or too hazardous?**
Hazards – general	Surveyors	L	1. Ensure mobile phone battery is charged 2. Take first aid kit with up to date contents.	L	
Litter, metal, glass, hypodermic needles, etc	Surveyors	L	1. Wear appropriate footwear on site and be watchful	L	
Slips, trips, falls	Surveyors	L	1. Take care of slippy rocks 2. Wear waders/appropriate footwear 3. Work closely with buddy and be vigilant at all times for fall in water	L	
Deep water	Surveyors	M	1. Do not wader out in chest waders beyond waist deep 2. Buddy to stay on shore close to snorkel surveyor at all times	L	
Entanglement	Surveyors	M	1. Check for ropes and trees along route before surveying 2. Remove hazards of relocate transect to avoid risk	L	
Toxins in water	Surveyors	M	1. Do not ingest water 2. Use alcohol gel before eating	L	

HAZARD Potential for harm	Who is at risk and might be harmed?	RISK LEVEL: Low Medium High	PRECAUTIONS To reduce the risk level	RISK LEVEL Following precautions	Continue with activity or too hazardous?
Deep mobile sediment	Surveyors	M	1. Only wade on rocky substrates not on mobile mud 2. Do not put feet down when snorkling over mud 3. One buddy to remain shore on safe sediment at all times 4. Carry a 30m rope	L	
Weather	Surveyors	L	1. Wear protective clothing and sun block. 2. Cease work if inadequately prepared or extreme weather conditions are encountered.	L	

Signed ……. Date ……

GENERAL SAFETY PROCEDURES

Office-Field Contact Safety Procedure

At least one mobile phone should be carried per field group.

First Aid kit with up to date contents to be taken.

Office staff or buddy should be informed of field destination, approximate working time and mobile phone number.

If expected departure time is outside working hours a buddy must be informed of your expected time of departure from site.

Field workers should report to office (or buddy if outside office hours) upon departure of the field site.

The office or buddy must be informed of changing circumstances.

N.B. A buddy can be a member of staff, a family member, partner or friend, and must be aware of the system.

FORM 2 - RISK ASSESSMENT Site specific record

SITE: Loe Pool Transect survey

DATE: 17 Sept for survey on 19 and 21/09/2012

ASSESSED BY: Jan Dinsdale

EMERGENCY INFORMATION:

In the event of an incident call 999 IMMEDIATELY.

Stay with the injured party and administer first aid.

Mobile signal good

Tell the emergency services where you are.

Location description:

Loe Pool, Helston

Either Carminowe Creek where best vehicle access is from Lower Pentire

Grid Reference: SW652243

Or Penrose Estate, The Stables/boathouse

Grid Reference:SW646256

The nearest casualty department is (please indicate):

Helston Cottage Hospital

APPENDIX 3

Dive computer read-outs

Suunto Dive Manager 3.0.0 08/10/2012

3237. 10/09/2012 11:57:51

Loe Pool

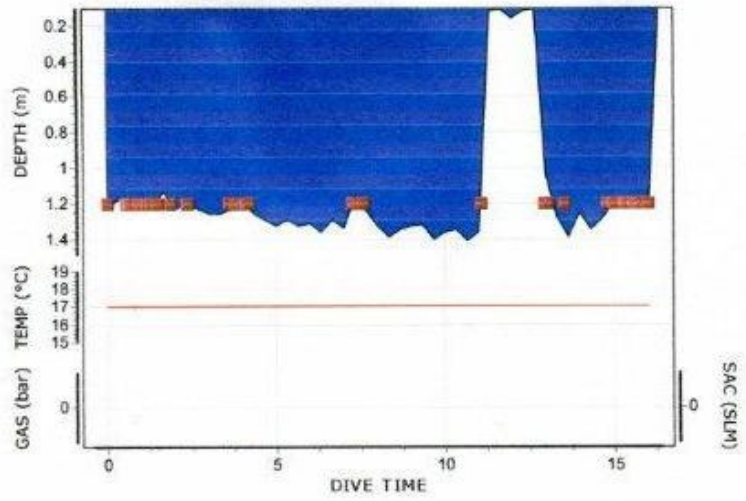
Information from dive computer

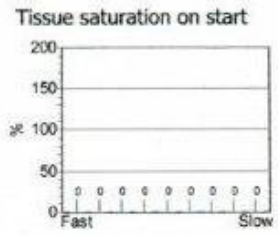
Dive no.	**3237**	DC Dive no.	**1**	Sampling Rate	**20 sec**
Start time	**10/09/2012 11:57:51**	Surface Interval	**44:12:00**	Altitude mode	**A0**
End time	**10/09/2012 12:08:51**	ID no.	**93700906**	Personal settings	**P0**
Dive time	**00:11:00**	Model	**Vyper Air**	Dive type	**Nitrox**
Max depth	**1.5 m**	Personal info	**Suunto Diver**	Alarms Recorded	**48**
Oxygen Percent	**21%**			OLF	

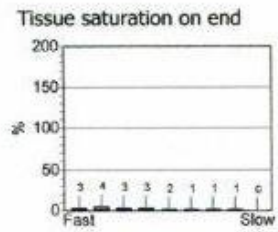
Weather		Temperatures		Buddy	**DES**
Visibility	**1m**	Start of dive	**17 °C**	Boat name	
Weight used	**0 kg**	Max depth	**17 °C**	Dive Master	**REBS**
		End of dive	**17 °C**	Custom 1	
Dive gear				Custom 2	
				Custom 3	
				Custom 4	
				Custom 5	

Cylinders

Cylinder size	Oxygen Percent	Start	End	Average depth	SAC Rate	Gas used Pressure used	Gas used Rate used	Gas used Volume gas used
15 liters	**21%**	**0 bar**	**0 bar**	**1.3 m**	**0 SLM**	**0 bar**	**0 bar/min**	**0 liters**







Notes

Suunto Dive Manager 3.0.0 08/10/2012

3238. 10/09/2012 13:16:12

Loe Pool

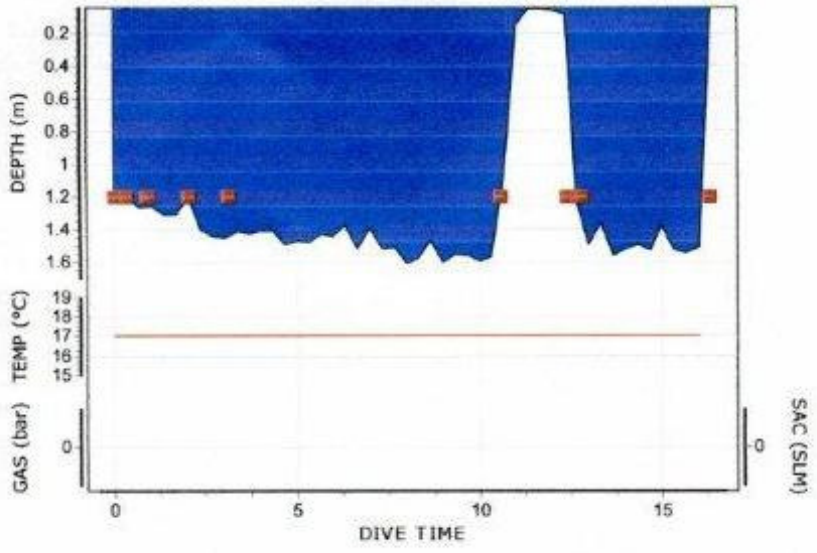
Information from dive computer

Dive no.	**3238**	DC Dive no.	**1**	Sampling Rate	**20 sec**
Start time	**10/09/2012 13:16:12**	Surface Interval	**01:02:00**	Altitude mode	**A0**
End time	**10/09/2012 13:29:12**	ID no.	**93700906**	Personal settings	**P0**
Dive time	**00:13:00**	Model	**Vyper Air**	Dive type	**Nitrox**
Max depth	**1.6 m**	Personal info	**Suunto Diver**	Alarms Recorded	**16**
Oxygen Percent	**21%**			OLF	

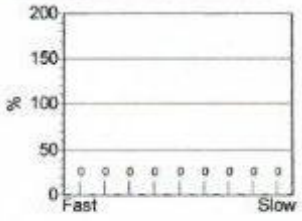
Weather		Temperatures		Buddy	**DES**
Visibility	**less than 1m**	Start of dive	**17 °C**	Boat name	
Weight used	**0 kg**	Max depth	**17 °C**	Dive Master	**REBS**
Dive gear		End of dive	**17 °C**	Custom 1	
				Custom 2	
				Custom 3	
				Custom 4	
				Custom 5	

Cylinders

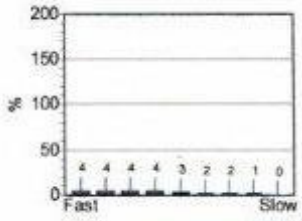
Cylinder size	Oxygen Percent	Start	End	Average depth	SAC Rate	Gas used Pressure used	Gas used Rate used	Gas used Volume gas used
15 liters	**21%**	**0 bar**	**0 bar**	**1.4 m**	**0 SLM**	**0 bar**	**0 bar/min**	**0 liters**



Tissue saturation on start



Tissue saturation on end



Notes

APPENDIX 4

Overview of Boat and Grapnel Survey 2011

Loe Pool Annual Botanical Survey 2011
Brief Summary of Findings

1. Results Summary

- The 2011 Loe Pool annual botanical survey was undertaken on September 21st. The methodology was a repeat of the 14 boat transects first surveyed in 1999. This survey was repeated in 2003 and has been carried out each year since 2006.

- There was no evidence of the two previously abundant algal species, Water Net *Hydrodictyon reticultum* and the blue-green alga *Microcystis aeruginosa* during the 2011 survey. These species have not been recorded within Loe Pool since 2006. Helston's Coronation Lake, which is located less than 2km upstream and is hydrologically connected to the Pool, continues to exhibit blooms of Water Net and blue-green algae each year (2007- 2011). However, there is some indication that the extent of the bloom here is also reducing in magnitude and period.

- Secchi Disc Transparency, a measure of water clarity, is recorded as part of the annual botanical survey. With the absence of algal blooms, water clarity within Loe Pool has been gradually improving across the majority of the lake and in 2011 was ca. 1.35m. The transparency in the Cober arm, to the north of the lake remains poor at 1.24m in 2011. There is a long way to go to reach the Loe Pool forum's target Secchi depth of 3.0m (Wilson and Dinsdale, 1998; Dinsdale, 2009)

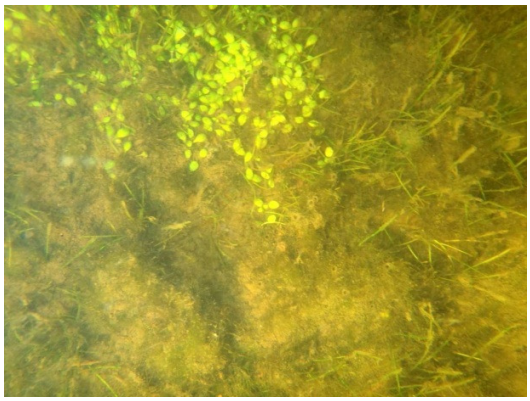
- The general paucity of submerged, rooted aquatic vegetation recorded during the transect survey within Loe Pool continued in 2011, this pattern has been in place since the loss of Nuttall's water weed in 2007:

  - The population of Nuttall's Waterweed, which increased so prolifically between 1999 and 2006, crashed in 2007 and has not been observed within the lake nor recorded in any of the transects since then. At its peak in 2006, the population extended to both the Penrose inlet and the Cober inlet and occurred in 60% of the sample stations across the lake.

  - Perfoliate Pondweed *Potamogeton perfoliatus* is one of the old inhabitants of the Pool; it was present in large quantities in the mid-nineteenth century (Johns, 1848) and was still abundant in 1964 (Turk and Turk, 1976). Perfoliate Pondweed was then not recorded until 1983 (record: RJ Murphy) and subsequently was not seen again until 2003, when a small number of plants were recorded in Carminowe Creek by both Stewart (2003) and Knight (2003). At the time Nick Stewart suggested that the reappearance of Perfoliate Pondweed 'must be due to local stabilisation of conditions by the abundant growth of the Nuttall's Waterweed'. Following the decline of Nuttall's Waterweed only small amounts of drift material of Perfoliate Pondweed were recorded during the annual macrophyte surveys of 2006 and 2007, both within Carminowe Creek. Loe Pool is its only Cornish locality. The Pondweed has not been recorded more recently, despite a thorough search in both May and September 2010 with the help of Cornwall BSBI plant recorder Ian Bennallick.

- The inundation community, which includes the three diminutive plant species Needle Spike Rush *Eleocharis acicularis,* Six-stamened Waterwort *Elatine hexandra* and Shoreweed *Littorella uniflora* has apparently expanded in both 2010 and 2011. It is thought that the increase in cover and extent of this plant community could be in response to the increased drawdown zone seen within the Lake due to relatively low summer rainfall levels in the past two summers. There was a good sward of Needle Spike Rush on the rocky shores of both Carminowe and Penrose Creeks. Both Needle Spike Rush and Shore Weed were observed to a depth of 200-250mm beneath the water in 2010. In 2011 Natural England Freshwater Specialist Genevieve Madgwick observed patches of *Eleocharis acicularis* and *Elatine hexandra* growing deeper into the lake on sandier substrates, to 0.75–1m depth.

- There was no recorded for these inundation species within the survey transects; these observations of an increased extent and vegetative cover in 2010 and 2011 come from an additional visual assessment only.



Carminowe Creek: Inundation community with Needle Spike Rush and six-stamened waterwort. Photo: Gen Madgwick

- There were no non-native invasive aquatic plant species noted in the Pool this year.

- The freshwater bryozoan *Plumatella fungosa* has been recorded in Loe Pool each year since 2009. Relatively large colonies of this benthic, suspension-feeding invertebrate were also present this year, on submerged tree roots and floating deadwood within the central neck of the lake and Carminowe Creek; smaller colonies were also attached to rocks on the lake floor within Carminowe Creek. *Plumatella fungosa* flourishes in warm, eutrophic waters and is among the most tolerant of all freshwater bryozoans to organic pollution. The colonies are capable of prolific growth when not overgrown by algae (Sládeček, 1980).

Plumatella fungosa
Photo: M. Hardy, NT, 2009

2. Discussion

- It is very positive to have a five consecutive years without substantial algal blooms within the Loe.
- Despite dramatic improvements to in-lake phosphorus levels, and generally to water clarity as well, the re-establishment macrophyte beds within Loe Pool remains poor.
- Visual walk-over assessments suggest that there has been some increase in the percentage cover and extent of the inundation communities in Carminowe Creek and Penrose creek during 2010 and 2011. However, the current survey method is not appropriate for recording these discrete plant population changes. Genevieve Madgwick, Natural England Fresh-water Lakes specialist, visited Loe Pool in September 2011 and suggested an additional, more intense, fixed transect survey methodology, in order to monitor changes to the existing macrophyte beds. If possible, this detailed fixed transect survey should commence in 2011 and run alongside the current whole lake boat survey, which remains useful for recording gross plant population changes across the lake.
- Successful lake rehabilitation relies heavily upon re-establishment of submerged vegetation. Results of multi-lake studies have shown that where macrophytes are slow to respond to clear water conditions, lake rehabilitation becomes a longer process and is less likely to be ultimately successful (e.g. Moss, 1990; Jeppesen *et al*., 1990; Meijer, 2000; Jeppesen, 1998; Hosper *et al*., 2005; Phillips, 2005; Broads Authority, 2009). The positive effect of submerged rooted vegetation on lake rehabilitation is the result of a number of mechanisms including:
    - providing refuge for phytoplankton-grazing zooplankton
    - structural complexity promotes piscivorous perch promoting top-down control on algal growth
    - reducing availability of nutrients for phytoplankton reducing wind- and fish- induced resuspension of sediments (Hosper *et al*. 2005)
- Natural England's condition statement for Loe Pool sets specific macrophyte community composition targets which include an overall site total of at least 8 characteristic species with a quantification target of six out of ten sample spots should include at least 1 characteristic species (Natural England, 2010). Loe Pool needs to see a substantive improvement to macrophyte communities in order to move towards these targets.
- It is now also 5 years since the decline of the last population boom within the Loe's macrophyte communities. With continued improvements to water quality and a decline in algal blooms, other environmental factors could be limiting the re-establishment of these plant communities:
    - Year-round relatively static water levels, without an adequate summer drawdown is likely to have had a deleterious effect on the inundation community. Some of the inundation species, including the nationally scarce Six-stamened waterwort, do not flower beneath the water (Stace, 1997). That said, generative reproduction of both Needle Spike Rush and shorweed occurred during the dry summer period of 2011, on the emerging sediments. Further dry years, or adopting an artificial lowering of summer water levels are likely to benefit these inundation communities.
    - Dense growth of willow along the lake shore and overhanging into the water has developed in recent years and this has also reduced the extent of the open shore habitat favoured by these aquatic plant communities.
    - Lack of stimulation of the seedbank may also be a contributing factor. Most softwater macrophytes produce long-lived seeds and re-establishment from the seed bank often occurs in large amounts (Bellemakers *et al*., 1996). Periodic emergence of the sediment of shallow lakes generally stimulates germination from the seed bank (Brouwer *et al*., 1999). Much of the shoreline of Loe Pool, however, has seen significant amounts of sediment laid down and disturbance of the substrate may be required to activate significant germination from the seedbank. A re-introduction of shoreline grazing could provide suitable sediment disturbance.
    - The high metal content of the Lakes' floor substrate is well documented (Coard, 1987). While this has brought water quality benefits in recent years, by locking up historic phosphorus loading within the sediments (Olosundé, 2002), these same metals may inturn inhibit the next stage of lake rehabilitation, the re-establishment of macrophyte beds.
    - Lack of external vegetative and seed sources may also be a contributing factor.

- In order to elucidate which of these factors are contributing to the slow re-establishment of macrophytes in Loe Pool, it is recommended that consideration is given to undertaking some plant translocation trials including:
    - Re-locating *Littorella* from Carminowe to the Cober arm.
    - Introducing Potamogeton species from local populations to the Loe shores.
    - Growing Littorella from the Loe population and from nearby reservoir populations in sediment from both Carminowe Creek, the Cober arm of Loe Pool and a control reservoir sediment.
    - In each case these re-located plants would require careful monitoring of both growth and establishment for a 24 month period.

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APPENDIX 5

Media coverage of this study

1. National Trust Members Magazine Devon and Cornwall Autumn Winter 2012-13

Diving into Loe Pool

© National Trust Images/Joe Cornish

© Jan Dinsdale

If you've ever looked into a pond and seen it bright green with algae, you'll know it's not a very healthy sight.

Loe Pool, Cornwall's largest natural freshwater lake, has suffered from serious algal blooms for the last 40 years. This was caused by nitrate and phosphate nutrients from nearby sewage treatment works and agricultural fertilisers flowing into the lake.

Unfortunately, the algal blooms fed on the excess nutrients and grew rapidly, reducing oxygen for other species and blocking out sunlight from the bottom of the lake.

Thanks to the work of the Loe Pool Forum, the future of the lake, part of the National Trust's Penrose estate, is looking brighter.

The forum (which brings together the National Trust, Natural England, Environment Agency, South West Water and local farmers, colleges and nearby Culdrose Naval Station), has been working since 1995 to improve the lake's water quality, wildlife and connection with the communities around it.

Over the past 15 years, Helston Waste Water Treatment works have worked to reduce phosphates going into the lake, which is a Site of Special Scientific Interest. Our farm tenants have also created new wildlife habitats around the edges of the pool, shifting productive farming away from vulnerable areas. As a result, there has been far less of anything entering the Loe's waters, and the ecological balance is being tipped to favour wildlife.

This year, an underwater survey by Kennack Diving will survey plants and sediments from the depths of the lake. Led by Dr Jan Dinsdale, local ecologist and forum member for over 10 years, this is the first part of a longer study, funded by Natural England's Conservation Enhancement Scheme.

Jan says: 'The work of the divers will give us vital information about the state of the natural vegetation on the bottom of the lake. Over time we'd like to see plenty of plants growing up through the water from the bottom of the lake which would be a vital step in the recovery of the lake's natural balance.'

For more information call 01326 561407 or visit **nationaltrust.org.uk/penrose** or **lizardandpenrose.blogspot.com**

2. West Briton Local Newspaper June 28 and July 5 2012

Pollution in Arthurian lake falling dramatically

Noel **Perry**
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DIVERS are carrying out a survey of water plant life at a National Trust-owned beauty spot recovering from decades of pollution.

The study aims to discover just what's growing in Loe Pool, between Helston and Porthleven.

Because of algae caused by excess nutrients, for many years the pool has been too murky for proper underwater research to be conducted.

The work forms part of a four-year study funded by Natural England.

Apart from its importance as a habitat, Loe Pool is one of several candidates for the lake into which, in the Arthurian legend, Sir Bedivere threw King Arthur's sword Excalibur.

National Trust property manager Alastair Cameron said: "Loe Pool has suffered from summer algal blooms for almost 40 years, caused by excess nutrients flowing into the pool from Helston, RNAS Culdrose and farms and other settlements up the valley."

Improvements to South West Water's sewage treatment works serving Helston had now reduced phosphorus levels in the pool by 75 per cent.

"We haven't seen any algal blooms in recent years," he said. "The clarity of the water is improving and gives us the opportunity to do this survey."

Dr Jan Dinsdale, who has been surveying the water plants from a boat for the past ten years, said: "Over time we'd like to see plenty of plants growing up from the bottom.

"The return of these plants is a vital step in the recovery of the lake's natural balance; they'll help make sure algal blooms are a thing of the past."

David Roberts, from Kennack Diving, carrying out the survey, said: "We'll be mapping the location of any rooted plants and bringing small samples to the surface for Jan to identify, but I'll also be looking out for the native brown trout in the pool, other fish, and with a bit of luck we'll find Excalibur down there."

■ Des Glover: "It was darker than diving in the sea at midnight."

Polluted pool is showing signs of life

DIVERS have been working in difficult conditions surveying the life in Loe Pool, between Helston and Porthleven.

The aim is to discover what is growing in the freshwater lake, now recovering from decades of pollution: but the dive has not been easy.

Natural England and the National Trust are behind the project, assisted by personnel from Kennack Diving, including Des Glover.

Emerging from the lake's centre, the deepest part, he said: "It's so dark down there: darker than diving in the sea at midnight. The lake bottom's like a moonscape, but there's probably more chance of seeing life on the moon."

Fellow team member Rebecca Morton-Clark said: "It was an extremely challenging environment to dive in, so different from the sea.

"In many places the lake 'floor' was so loose and unstable, like bottomless blancmange, and so we couldn't hang around in any one place for too long, but then in shallower water here and there we'd spot tiny specks of green plants between the stones.

"It was just like hunting for treasure."

Jan Dinsdale, who has been surveying the lake from the more secure base of a boat for ten years, said: "This dive survey is the first opportunity we've had to accurately map which areas of the lake still support plant life.

"We found just three species of native aquatic plant rooted on the bottom. "These three grow together to form a short 'turf' in some areas. They all thrive in the stony areas; nothing grows on the mud.

"The plants were very much confined to the shallows, with none growing in a water depth of 1.5 metres or more.

"It's great news that there are plants hanging on under the murky water; if it was clearer more light would get down there and enable these species to extend down into deeper water."

National Trust property manager Alastair Cameron said the pool had been affected by summer algae blooms for 40 years due to excess nutrients from the surrounding land, although the situation had improved greatly in recent years.

■ Some of the Kennack Diving team, including Des Glover and Rebecca Morton-Clark, take a (re)breather before their next dive at Loe Pool, top. Above: Submerging for another exploration.

Loe Pool SSSI Macrophyte Survey 2012 Dr Jan Dinsdale