Loe Pool Catchment Management Project

2009 Review

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Photo NT

Prepared on behalf of the Loe Pool Management Forum

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Abbreviations:

AOD	Above Ordnance Datum
CC	Cornwall Council
CORE	Co-Ordinated Review of Evidence
CRoW	Countryside and Rights of Way
CSF	Catchment Sensitive Farming
CSO	Combined Sewer Overflow
EA	Environment Agency
EQS	Environmental Quality Standard
FL	Fork Length
FRM	Flood Risk Management
FWAG	Farming and Wildlife Advisory Group
LPCMP	Loe Pool Catchment Management Project
LPMF	Loe Pool Management Forum
MOD	Ministry of Defence
N	Nitrogen
NAP	Nitrates Action Programme
NE	Natural England
NHM	Natural History Museum
NIWA	National Institute of Water and Atmospheric Research (NZ)
NT	National Trust
NVZ	Nitrate Vulnerable Zone
NZ	New Zealand
P	Phosphorus
PiP	Priority Implementation Plan
PSYM	Predictive System for Multimetrics
RBD	River Basin District
RNAS	Royal Naval Air Station
SDT	Secchi Disc Transparency
Sec	Secretariat LPMF
SMART	Specific, Measureable, Achievable, Relevant, Time-bound
SSSI	Site of Special Scientific Interest
STW	Sewage Treatment Works
SWW	South West Water
TP	Total Phosphorus
TRS	Trophic Ranking Score
UK	United Kingdom
UWWT	Urban Waste Water Treatment (Directive)
WFD	Water Framework Directive
WRA	Water Resources Act
WL	Water Level
WLMP	Water Level Management Plan

The Loe Pool Catchment

Executive Summary

- Loe Pool is the largest natural freshwater lake in Cornwall. Its national significance is reflected in its designation as a Site of Special Scientific Interest (SSSI) and a County Wildlife Site.

- The Lake is in an advanced stage of eutrophication: The standing water unit of the SSSI is currently in "unfavourable declining" condition; both the ecological and chemical status of Loe Pool are classified as 'poor' under the Water Framework Directive (WFD). The Loe Pool catchment suffers from a number of other inter-related and equally complex problems. Historic channelisation and reprofiling of the River Cober in order to reduce flood risk in Helston has also reduced the ecological function of the watercourse and separated the river from its floodplain.

- The Loe Pool Management Forum (LPMF) seeks to address these problems and is clear that a catchment management approach is most appropriate. The Government's Public Service Agreement target for SSSIs is to have 95% in favourable or recovering condition by 2010. Favourable condition on SSSIs is also a Priority 1 measure in the National Trust Regional Nature Conservation Strategy. The WFD requires that waterbodies be in 'good' condition by 2015. Eutrophic standing waters are a priority habitat under the UK Biodiversity Action Plan (UKBAP, 2005).

- The aim is to rehabilitate Loe Pool to a state that is ecologically stable, and one that the local community finds attractive. The lake community will be macrophyte, rather than algae, dominated with a thriving population of trout (*Salmo trutta*). The water will be clear.

- Loe Pool Catchment Management Project (LPCMP) set project end targets and objectives in 1998. These remain largely unaltered in 2009. Under the WFD, Loe Pool is now subject to a comprehensive programme of long-term monitoring. For the first time it has been possible to measure progress against the Project's targets; the results are extremely encouraging.

- There was a four-fold reduction in the average annual total phosphorus concentration of Loe Pool between 1997 and 2004. This coincided with the installation of phosphate removal plant at Helston Sewage Treatment Works (STW) and work to address exports from agriculture.

- The lake rehabilitation programme can be divided into 3 clear steps:
  (1) Reduction of nutrient loading; (2) Biomanipulation; (3) Recovery of water plants
  The LPCMP remains firmly within step 1 of this programme. The focus of management for 2009-2014 needs to remain on reducing nutrient export sources within the Catchment.

- There is new evidence to suggest that RNAS Culdrose STW L Site contributes a significant portion of the overall total phosphorus budget of Loe Pool. The EA are to review the current evidence base and consider if it is sufficient to warrant a modification to the discharge consent. Installation of phosphate removal plant at RNAS Culdrose STW is likely to be a key step in the rehabilitation of Loe Pool.

- An integrated catchment approach to addressing agricultural sources of nutrients, sediments and pesticides is also a priority for the next reporting period (2009-2014). The proposed Rural Catchment Initiative will combine outreach to the farming community with technical evaluation of environmental risks, management options and outcomes, to bring improvements catchment water quality. The successful delivery of this initiative requires Environment Agency support through compliance and NVZ visits and other regulatory enforcement. Changes in land use and farm management can also improve the retention of water in soils, with benefits for flood risk management and the assisted recovery of the lower River Cober.

- The development of a lake nutrient budget is proposed, in order to apportion the lake's total phosphorus load to the various sources of phosphorus within the catchment. This nutrient budget

will provide additional robust evidence of the need to address individual known sources of nutrients to the Pool in order to facilitate lake rehabilitation.

- Rehabilitation of the River Cober requires a two-pronged approach. Good progress has been achieved towards reach-based restoration activities and these should continue alongside a whole river catchment approach, which is recommended to resolve river restoration issues at source as far as possible.

- A strong community base is paramount to the Project's success.

- Adopting a water level regime that provides an extensive seasonal drawdown zone around the margins of Loe Pool is critical for the re-establishment of submerged vegetation, and hence for successful lake rehabilitation.

- Priority monitoring, survey and research requirements not delivered under the current WFD programme are identified. For the LPCMP to make best use of the monitoring data collected under the WFD, all of these site-specific data need to be analysed and presented annually.

- The LPMF is trialling a change to the configuration of its meetings in order to facilitate the catchment management process over the coming years. The Forum has been split into four smaller task groups, each of which will meet 3 or 4 times per annum. The individual management measures recommended within this report have been allocated to the most appropriate task group and incorporated into that group's annual action plan. The whole LPMF intend to meet on an annual basis in order to review progress.

- The LPMF is ideally placed to help deliver the catchment management measures required to under the WFD and should work with the Environment Agency South West River Basin District Management Team to fulfil common goals.

1. Introduction

With an area of 56 ha, Loe Pool is the largest natural freshwater lake in Cornwall. Its national significance is reflected in its designation as a Site of Special Scientific Interest (SSSI) and a County Wildlife Site (CWS).

In the mid 19th century, Loe Pool was described as follows: 'in the summer the whole of the lake, except some of the deepest parts, is filled to the surface with tangled weeds; these are *Potamogeton perfoliatus* and *P. pusilius*, perfolate and small, pondweed (Johns, 1848). The lake is now almost completely devoid of submerged vegetation (Stewart, 2003; Dinsdale, 2008).

Loe Pool is one of a large number of British lakes suffering from the effects of advanced eutrophication. Eutrophication is defined as the input of elevated levels of nutrients, mainly nitrogen (N) and phosphorus (P), to a waterbody or watercourse from its catchment. In the early stages, eutrophication leads to an increase in productivity within existing communities. With continued inputs of nutrients, the ecosystem suffers deterioration in water quality, changes in community structure, reduction in species diversity and a frequent occurrence of summer algal blooms. Lakes and other enclosed inland waters suffer more frequently from eutrophication than rivers owing to the lower turnover of water. Nationally the condition of eutrophic waterbodies continues to decline, although this is slowing (UKBAP, 2005).

As a consequence of the advanced eutrophication, the standing water unit of the SSSI is currently in "unfavourable declining" condition. (NE, 2009). Under the EU Water Framework Directive (WFD) (2000/60/EC), both the ecological and chemical status of Loe Pool are classified as 'poor' (EA, in prep.).

The first management plan for Loe Pool and its catchment with respect, primarily, to water quality, but encompassing related issues, was produced in 1998 (Wilson & Dinsdale, 1998). This Loe Pool Catchment Management Project (LPCMP) Final Report identified Loe Pool to be not only in an advanced stage of eutrophication, but also suffering from a number of other inter-related and equally complex problems. The history of intensive mining activity in the catchment has produced a highly silted river. Channelisation and reprofiling of the River Cober to reduce flood risk in Helston has reduced the ecological function of the watercourse and separated the River from its floodplain (Wilson & Dinsdale, 1998). The River does not fulfil its drainage function sustainably (Haycock & Vivash, 1999) and delivers high levels of nutrients and fine sediments to Loe Pool (EA data).

The LPCMP seeks to address these problems. The Government's Public Service Agreement (PSA) target for SSSIs is to have 95% in favourable or recovering condition by December 2010. Favourable condition on SSSIs is also a Priority 1 measure in the National Trust Regional Nature Conservation Strategy (NT, 2004). The WFD requires that waterbodies be in good condition by 2015 (EC, 2000; 2000/60/E). Eutrophic standing waters, including lakes such as Loe Pool which were formerly mesotrophic (middle-nourished) but are now eutrophic (well-nourished), are a priority habitat under the UK Biodiversity Action Plan (UKBAP, 2005).

The restoration of Loe Pool is not deemed practical or appropriate (Wilson & Dinsdale, 1998). The aim is to rehabilitate Loe Pool to a state that is ecologically stable, and one that the local community finds attractive. The lake community will be macrophyte, rather than algae, dominated with a thriving population of trout (*Salmo trutta*). The water will be clear.

Lake rehabilitation targets and objectives were set in the LPCMP Report 1998, together with the measures necessary to achieve them. The first review of the developments and progress towards these objectives covered the period 1998-2002 and demonstrated significant progress over these four years (Dinsdale, 2003). This 2009 review provides an opportunity to take account of new scientific information and developments in policy and legislation and to prepare for the next stage in the rehabilitation of Loe Pool. The review aims to revisit the original targets and objectives, take stock of the progress made during the period 2003-2008 and to make recommendations for future management.

2. Management Strategy Review

Loe Pool Catchment Management Project targets and objectives remain largely unchanged. The Water Framework Directive (WFD) brings numerous opportunities for the Project.

There was been a four-fold reduction in total phosphorus (TP) levels within Loe Pool during the period 1997-2004. This significant change in nutrient status follows P-removal at Helston Sewage Treatment Works and action to reduce nutrient exports from agriculture within the catchment. With current annual average TP concentrations now 70-80μgl^{-1}, the remaining sources of phosphates in the catchment need to be substantially reduced in order to meet target levels (10-35μgl^{-1}). Carminowe, Chyvarloe and Nansloe Streams continue to input high TP concentrations, with the River Cober now achieving low concentrations but remaining the largest proportional contribution.

Catchment management activities should be directed to enhance the establishment of dense beds of water plants within Loe Pool, in order to improve the speed and likelihood of lake rehabilitation success.

This section sets out the context for the LPCMP 2009 Review. The questions considered are: What are our goals? Where we are now? What next steps do we need to take?

To this end, the section includes: an update of the Loe Pool end targets; an overview of the WFD and the opportunities it presents to the LPCMP; and an inaugural review of the progress made towards water quality (P) targets.

An outline rehabilitation programme is then set out, and the LPCMP's current position identified, in order to provide a focus for catchment management activities in next reporting period 2009-2014.

2.1 Targets and Objectives

Four catchment objectives and eight lake rehabilitation end targets were set in 1998 (Wilson & Dinsdale, 1998; pp. 89-92 and 95). The four objectives remain little altered in 2009, save the introduction of sustainable flood management into objective 2. The eight end targets have been reduced to seven; the target referring to eradication of water net (*Hydrodictyon reticulatum*) has been removed, as this is referred to sufficiently within target 4. The remaining targets have been expanded, in an attempt to make them SMART (Specific, Measureable, Achievable, Realistic, Time-bound); although they are not time-bound as this was not considered to be appropriate at this stage of the lake rehabilitation programme.

Loe Pool Catchment Objectives

1. **Water Quality:** To bring about a change in Loe Pool from an algae-dominated turbid water state to a macrophyte-dominated clear water state, characteristic of mesotrophy.

2. **Water Levels:** To restore hydrological function throughout the river catchment in order to bring sustainable flood management. To instate natural seasonal fluctuations in lake water levels, in order to create conditions for a more diverse shoreline and submerged flora.

3. **Nature Conservation:** To maximise the biodiversity value of Loe Pool and enhance the biodiversity value of its catchment.

4. **Community Involvement and Communication:** To interest and engage individuals and the local community in the management of Loe Pool and its catchment and to raise the profile of the Loe Pool Project, both locally and further afield.

Loe Pool End Targets

1. Clear water, with mean Secchi disc transparency (SDT) of 6m to 3m, and a minimum SDT of 3m to 1.5m.
2. Mean annual total phosphorus concentration of 10 to 35 μg/l.
3. Mean annual chlorophyll *a* concentration of 2.5 to 8 μg/l, and a maximum of 8 to 25 μg/l.
4. Macrophyte, rather that algae, dominated community, composed of a diverse range of species such as *Potamogeton natans, Ranunculus peltatus*, *Elatine hexandra* and charophytes, with characteristic vegetation zonation within increasing depth and a Trophic Ranking Score (TRS) of between 5.5 and 7.
5. Diverse assemblage of benthic macroinvertebrates indicative of mesotrophic waters, with the riffle beetle *Oulimnius troglodytes* abundant and a Predictive System for Multimetrics (PSYM) Index of 3.
6. Diverse open shoreline vegetation communities which include species such as *Littorella uniflora*, *Eleocharis acicularis*, *Ranunculus flammula, Bidens sp., Persicaria hydropiper*. Stands of *Phragmites australis* swamp community (NVC S4a) are extensive but not covering more than 40% of total shore length.
7. Self-sustaining population of trout (*Salmo trutta*).

2.2 The Water Framework Directive (WFD)

The WFD entered into force in 2000 (EC, 2000) and was transposed into national legislation in 2003. The Directive will replace seven existing Directives, mostly those from the 1970s, to bring about the integrated approach to protecting all elements of the water cycle and protecting water quality. It is the most substantial piece of water legislation ever produced by the European Commission and presents enormous opportunities for the LPCMP. The Directive requires that all inland and coastal waters (excluding those that are artificial or heavily modified) must reach at least ‘good’ status by 2015, and defines how this should be achieved through the establishment of environmental objectives and ecological targets for surface waters. The result should be a healthy water environment achieved by taking due account of environmental, economic and social considerations (WFD IC, 2009).

Under the WFD, Loe Pool is one of only four lakes in the South West to be assigned 'surveillance' waterbody status. This is of enormous benefit to the LPCMP as surveillance waterbodies are subject to the most detailed level of data collection, in order to validate the characterisation pressure, assess impact and detect long-term trends (WFD UK TAG, 2009). For the first time, Loe Pool will be subject to a comprehensive programme of long-term monitoring which includes over 30 biological and physico-chemical indicators of environmental quality, with progress measured against specific targets.

The WFD requires that waterbodies are classified within good, moderate, poor and bad ecological status categories; in 2008 22% of lakes in England and Wales were in good condition or better, 51% moderate, 23% poor and 4% bad (EA, in prep.). Loe Pool is currently classified as ecologically and chemically 'poor' (EA, in prep.).

The development of River Basin District (RBD) Management Plans is a key component of the WFD. These set out the actions required within each RBD to achieve set environmental quality objectives (EA, in prep.). This includes so-called gap analysis where, for each waterbody, any discrepancy between its existing status and that required by the Directive is identified. A Programme of Measures will then be put in place to achieve the desired goals (EA, in prep.).

Loe Pool falls within the South West RBD, which covers over 21,000km^2, and includes all of Cornwall and the Isles of Scilly, Devon, Dorset, parts of Somerset, Hampshire and Wiltshire. The South West RBD Management Plan is currently with the Secretary of State for Environment, Food and Rural Affairs and due to be published upon approval in December 2009 (EA, in prep.). Member states then have 3 years to put the prescribed programme of measures into place; ensuring that they are fully operational by 2012 (EC, 2000; Article 11). The RBD Management Plans will be reviewed on a six-yearly cycle, the first review of progress will be in 2013 (WFD IC, 2009).

2.3 Current Water Quality within Loe Pool and its Catchment

Although the 1998 LPCMP set end targets for the ecological and chemical status of Loe Pool, a comprehensive monitoring programme was not put in place and, therefore, it has not been possible to effectively measure progress towards these targets. This has been of constant concern to the Loe Pool Management Forum (LPMF) (e.g. LPMF minuted meeting, 9 September 2005).

From 2007, the WFD will provide an appropriate long-term monitoring programme for Loe Pool. This will include repeat recording of a wide range of biological and physico-chemical variables, with progress measured against site-specific targets (WFD UK TAG, 2009). These data will provide a firm baseline, and enable the LPMF to measure progress towards the LPCMP end goals. Further details of the extent and period of monitoring provision for Loe Pool under the WFD are provided in section 4.

It is now possible to draw some inaugural comparisons between these in-lake WFD data and historic discreet time-period data sets, such as those collected by the Environment Agency

(EA) to meet the Urban Waste Water Treatment (UWWT) Directive in 1995-1997 (Geatches, 1997; Murdoch, 1997; EA data, 1995-7) and National History Museum (NHM) data from the period 1995-1996 (John *et al*, 1998; John *et al,* unpublished). Not all these data sets are comparative, but there is sufficient information to preliminarily evaluate the progress made to reduce TP concentrations towards target levels (Figure 2.1). There are no TP data available for the period pre-1995 or 1998-2003.

Within Figure 2.1, all three of the current mean annual phosphorus (P) concentrations represent direct measurements from EA WFD surveillance data. One of the historic mean annual P concentrations bars is also a direct measurement, from EA UWWT Directive data, but, the remaining two historic levels represent modelled TP loadings. These modelled estimates were calculated by Johnes *et al*. (1994) and Wilson (1995) using export co-efficients. Export co-efficients rely on the assumption that a given land-use will export a reasonably constant nutrient load per unit of land area to receiving waters, and are calculated by multiplying the appropriate export co-efficient value by the area of land in each land-use category within the catchment. For a more detailed explanation see Wilson (2005).

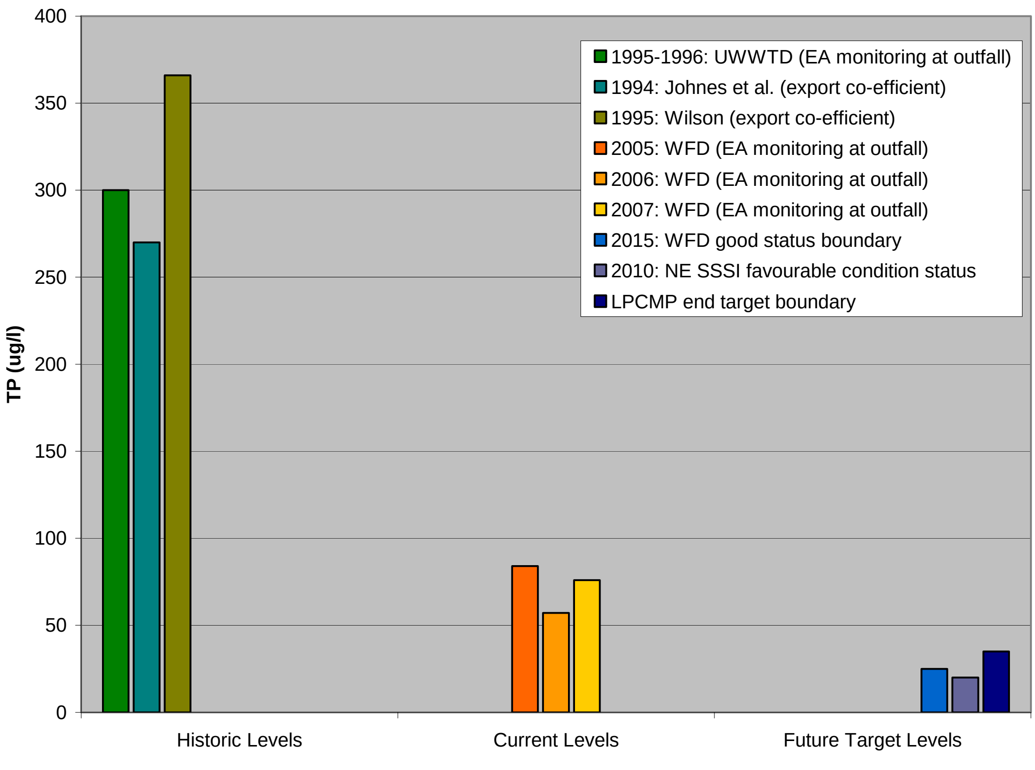


Figure 2.1: Historic, current and target total phosphorus concentrations for Loe Pool

Figure 2.1 shows a four-fold reduction in the average annual TP concentration of Loe Pool between 1997 and 2004. This coincides with the installation of P removal plant at Helston Sewage Treatment Works (STW) in 2003 (section 3.2.1) and work to address exports from agriculture (1999 to date; section 3.1).

These results are extremely encouraging and imply that there is currently little remobilisation of P from the benthic sediments of the Pool. This contrasts to the experience of many lake restoration schemes where P concentrations continue to be high and water quality does not improve upon reduction of influent nutrient loads due to the release of P from the upper layers of the sediment (see Marsden, 1989; Phillips, 2005). Loe Pool has experienced high levels of P inputs over a long period of time, and so the sediment could conceivably become a significant source of P during lake rehabilitation (Wilson & Dinsdale, 1998). From January 1995 to March 2000 the annual external input of P to Loe Pool exceeded the output, with approximately 50% of the external orthophosphate load retained by the sediment (Olosundé, 2002). However, it was predicted that the presence of a high iron content within the sediment, resulting from historic mining activity within the catchment, would retain sediment P stably bound (Olosundé, 2002). These data appear to support that theory (Figure 2.1).

With current annual average TP concentrations in the range 70-80μgl^{-1}, Loe Pool requires further three or four-fold reduction of P inputs from its catchment in order to meet target levels (in the range 10-35μgl^{-1}).

In addition to the WFD programme of monitoring, BREY Utilities (now Kelda Water Services) and the NT have collaborated to undertake a nutrient study of all tributary watercourses flowing into Loe Pool. Nutrient sampling was extended to all six watercourses feeding into Loe Pool; weekly samples were collected for the period May 2007 to July 2008 and then sampling was reduced to fortnightly and later monthly (McCaffrey, 2008; BREY Services, 2009). The findings of this study are very valuable for the LPCMP, and enable a broad comparison of the nutrient contributions from Royal Naval Air Station (RNAS) Culdrose STW, diffuse agricultural inputs to the Cober Catchment and farms in close proximity to the Pool (Figure 2.2; Figure 2.3).

Figure 2.2 shows concentrations of TP exhibit high peaks in Nansloe Stream and moderately high peaks in Chyvarloe Stream. These peak readings do not reliably correlate to high rainfall events (McCaffrey, 2008), but it is presumed that they are related to agricultural activity within these very small rural catchments. TP concentrations within Carminowe Stream are also high, and more consistent, as would be expected when the major source is P exported from the RNAS Culdrose STW (section 3.2.2). Concentrations within the River Cober, Degibna and Penrose Streams were consistently low, save one peak within Degibna during March 2008.

The results of BREY Services tributary survey also illustrated that the majority of phosphorus entering Loe Pool was in the form orthophosphate, readily available for biological uptake (McCaffrey, 2008). In addition, the study identified high nitrate and ammonia concentrations within the tributary streams, particularly Penrose, Stream Chyvarloe Stream and Degibna Stream (McCaffrey, 2008; BREY Services, 2009).

Figure 2.3 shows that the River Cober remains the largest proportional contributor to the Lake TP budget, despite low concentrations. The contributions of TP from Carminowe Stream and Nansloe Stream are excessively high.

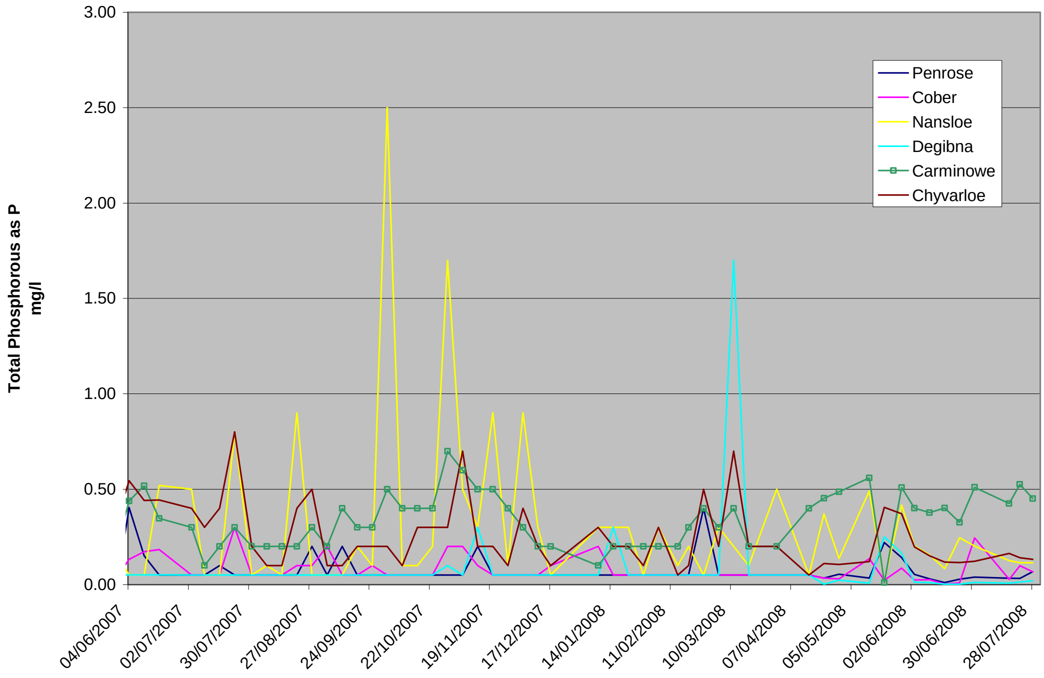


Figure 2.2: Total Phosphorus concentrations of Loe Pool's six tributary watercourses, June 2007-July 2008 (BREY Services)

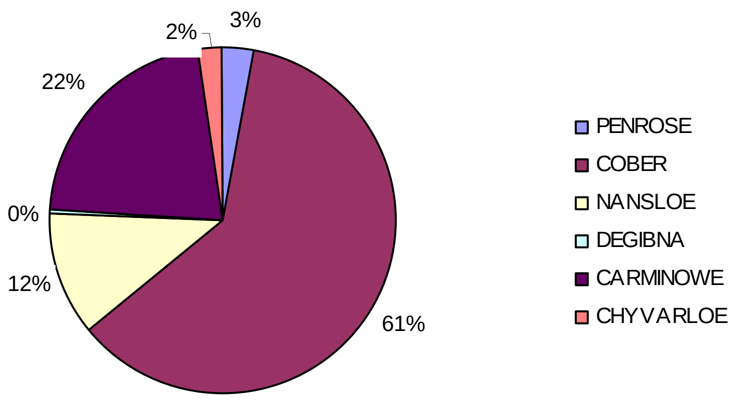


Figure 2.3: Proportional total phosphorus load to Loe Pool contributed from its six tributary watercourses, June 2007-July 2008 (BREY Services)

2.4 The Lake Rehabilitation Process

The scale and complexity of the task of rehabilitating Loe Pool is immense. Deterioration in water quality has not been a natural, gradual phenomenon but has taken place over the last 200 years, a relatively short time when compared with the history of the lake (Wilson & Dinsdale, 1998).

The pollution of Loe Pool has affected all of the aquatic life and restoration will therefore be a long-term process. The LPMF have agreed that it will not be possible to turn back the clock, but believe it is desirable and possible to move forward, to re-establish a cleaner, healthier and more diverse water environment which is self-sustaining and self-supporting, benefiting biodiversity and all who enjoy and appreciate Loe Pool (Wilson and Dinsdale, 1998; Dinsdale, 2003).

An expansive management plan spanning an entire water catchment area was fairly novel at the time of the first LPCMP Report in 1998, but, in the last 10 years landscape-scale thinking has come to dominate the forward agenda for nature conservation (e.g. Alexander, 2007; Saunders, 2008). There is an increasing emphasis on the use of catchment-wide management strategies in response to the WFD, which states that 'The best model for a single system of water management is management by river basin …' (EC, 2000). The LPMF are clear that a catchment management approach is most appropriate.
The management measures prescribed in the previous management plans (Wilson & Dinsdale, 1998; Dinsdale, 2003) prescribe a step-by-step approach to the rehabilitation of Loe Pool. A brief summary of the current knowledge and understanding of the rehabilitation process of eutrophic, temperate, shallow, lowland lakes is provided below for reference.

Step 1: Reduction of nutrient loading

Reduce nutrient inputs from catchment as far as practicable and to at least $50\mu gl^{-1}$ (from Moss *et al.*, 1996; Mehner *et al.,* 2002; Phillips, 2005; Hosper *et al*., 2005).

Step 2: Biomanipulation

Biomanipulation, the manipulation of a lake's food chain, has been heralded as a powerful tool for the management of eutrophic lakes and has even been called 'the lynchpin of shallow lake restoration' (Moss *et al.*, 1996). The theory of biomanipulation is based on a combination of:

- the knowledge of the importance of fish in structuring the zooplankton communities of lakes and the cascading impacts, through grazing, on phytoplankton and nutrient status (e.g. Carpenter *et al*. 1985; Carpenter & Kitchell, 1993);
- the theory that at moderate nutrient concentrations in shallow and eutrophic lakes, two alternative stable states may exist, a turbid-water and a clear-water state (May, 1977; Moss, 1999).

Substantial selective reduction of the fish population, relaxes the predation pressure and so promotes high densities of large-bodied zooplankton, which then consume the algae. The major disturbance of the turbid-water system brought about by the reduction of fish stocks triggers a shift between alternate stable states; away from the algal dominated, turbid-water state with high densities of planktivorous and benthivorous fish and towards the macrophyte dominated clear-water state with low fish stocks. For further explanation of this theory see Wilson & Dinsdale (1998).

Over the past 10 years, the use of biomanipulation as a lake restoration technique has been widely trialled in shallow lakes, both in the UK and in Holland (e.g. Broads Authority, 2009; Hosper *et al*., 2005; Phillips, 2005; Meijer, 2000). Lake restoration and rehabilitation projects employing biomanipulation techniques have frequently recorded rapid initial improvements in water clarity and curtailment of algal blooms, but many then fail to achieve long-term stability of the clear-water state. In such cases, sustained annual fish removal is then required in order to maintain the clear-water state.

In their extensive reviews of lake restoration and rehabilitation projects employing biomanipulation, Mehner *et al.* (2002) and Hosper *et al.* (2005) suggest criteria for selecting lakes in which biomanipulation is likely to bringing about a stable clear-water state. Results from multilake studies suggest stable clear water with Secchi-disc depth >1m can be expected at TP <50μgl^{-1} (Hosper *et al*., 2005). For large lakes such as Loe Pool, both clear and turbid waters are found at TP concentrations of 50-100μgl^{-1}, and it is tentatively concluded that alternate stable states may be expected within this range of TP concentrations (Jeppesen *et al*., 1990, Jeppesen, 1998; Hosper *et al*., 2005).

Step 3: Recovery of water plants

The re-establishment of dense, submerged water plant beds in clear water is critical to the recovery of the whole ecosystem and the future stability of the lake. Results of multilake studies have shown that where macrophyte 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; Jeppesen, 1998; Broads Authority, 2009; Hosper *et al*., 2005; Phillips, 2005; Meijer, 2000).

The positive effect of submerged rooted vegetation on lake water clarity is the result of a number of mechanisms including:

- providing refuge for phytoplankton-grazing zooplankton
- structural complexity promotes piscivorous perch promoting top-down control
- reducing availability of nutrients for phytoplankton
- reducing wind- and fish- induced re-suspension of sediments

(Hosper *et al*., 2005)

The LPCMP remains firmly within step one of this rehabilitation programme. Much work remains to be done to reduce in-lake nutrient levels before moving onto steps two and three. The focus of catchment management for 2009-2014 needs to remain on reducing nutrient export sources within the Loe Pool Catchment. This will require a variety of techniques and investments. RNAS Culdrose STW and farms close to the Lake, particularly within the Nansloe catchment, have been highlighted as potentially important sources. Nutrient exports within the Cober Catchment also require further investigation, with a focus on agricultural sources and Helston's urban drainage. Sufficient monitoring should be undertaken to enable the development of a lake nutrient budget, in order to provide robust evidence of the relative contribution of various phosphorus inputs into the Pool.

Biomanipulation techniques may be required to invoke a switch to a stable macrophyte dominated, clear-water state in the future. This will not be evident until nutrient levels are reduced to <50μgl^{-1}.

Management activities should be directed to enhance the establishment of dense beds of water plants within Loe Pool, in order to improve the speed and likelihood of lake rehabilitation success.

The review process and catchment management delivery should be carried out in the context of climate change projections. Climate change is a potential threat which may over-ride all others: increased storm events have the potential to impact upon water quality; a substantial change in water supply and throughput would alter the character of the lake; rising sea levels may impact upon the geomorphological development of Loe Bar; any rise in temperature may produce wide-ranging effects in-lake including accelerated growth of some algal species and lower dissolved oxygen concentrations.

3. Catchment Management Delivery Review 2003-2009

This section includes a summary of the catchment management progress made during this reporting period, 2003-2009 and, taking into consideration the LPCMP targets and management strategy, sets out recommendations for future management. The management recommendations made here are translated into measures and actions within section 5.

3.1 Reducing the Impacts of Agriculture

There is a clear need to control diffuse and point source agricultural contributions of nutrients and sediment across the Loe Pool catchment in a strategic way. The agricultural advisory work undertaken to date and the work on National Trust (NT) tenant farms provides a sound base to build upon.

There has been considerable change in the agricultural sector over the past 10 years, resulting from reform of the Common Agricultural Policy (CAP). The LPCMP is now served by national policy and support systems to help farmers adapt to the need to control nutrient, sediment and pesticide losses from their land. The NT has identified appropriate next steps on their tenant farms and implementing these should be one of the NT's highest regional countryside conservation priorities.

A whole catchment approach is recommended. This will require an intimate combination of outreach to the farming community and technical evaluation of environmental risks, management options and outcomes in order to help to contribute towards the desired change in catchment water quality and also attempt to bring economic benefits to the farming sector.

The changes required to agricultural management to control nutrient, sediment and pesticide loss can also act to improve catchment retention of water in soils, with benefits for flood risk management. This restoration of natural hydrological function within catchments must be a cornerstone of adaptation to climate change.

Water pollution from agricultural land and the associated infrastructure presents a major catchment management challenge as it commonly involves processes that are relatively small in magnitude and distributed over a large spatial scale (Defra, 2004). Addressing larger point sources of pollution, for example STWs, is generally more readily achievable and cost effective (see sections 3.2 & 3.3) and, as a result, strategic actions to control smaller agricultural point sources (such as slurry stores, silage clamps and farmyards) and diffuse agricultural contributions are in their infancy, despite their recognised importance (Mainstone *et al*., 2008). However, with progress made towards cleaning up gross point discharges at the national level, there is now growing recognition of the need to attempt to tackle agricultural diffuse water pollution if the requirements of the WFD and conservation targets are to be met (EA, 2007a; WFD UK TAG, 2009).

It is true to some extent that concern regarding water pollution from agricultural sources within the Loe Pool Catchment focuses on excessive nutrients, with sediments a secondary issue (CSF, 2008). Points sources associated with agricultural infrastructure are considered to be a priority. However, many of the agriculture-derived nutrients are transported through catchments attached to the fine sediment, therefore these two issues are closely linked (Mainstone *et al*., 2008). In addition, sedimentation of the River Cober is itself an important issue; curbing the export of sediment from agricultural land within the Cober Catchment would reduce the need for the current practice of de-silting the river bed (section 3.4). Agriculture may also contribute to algal proliferation in Loe Pool via the export of pesticides, since these pesticides are toxic to the zooplankton that prey on algae (Irvine *et al*. 1989; MacKenzie, 1998).

Stemming nutrient, sediment and pesticide losses from farms is best addressed via routes of mutual benefit to individual farm business and the local environment (EA, 2008). Soil, nutrient and pesticide losses through runoff cost farmers in England and Wales more than £50 million a year. These losses are also a big problem for the water industry, which spends nearly £200 million a year on treating pollutants from agriculture (EA, 2008).

(i) Farm advice delivered in the Loe Pool Catchment

In the last LPCMP Review, offering soil and water management advice to farmers, with a focus on areas at high risk of surface water run-off, and encouraging entry of land into agri-environment schemes were considered to be the most effective means of reducing the impact of agriculture on the water quality of Loe Pool (Dinsdale, 2003). To this end, the LPCMP management measures for the period 2003-2005 included the continued support of a catchment-based Farming and Wildlife Advisory Group (FWAG) Project Officer (Dinsdale, 2003).

FWAG visited approximately 20 farms within the catchment and entered 5 farms into Countryside Stewardship agreements during the period 1998-2002 (Dinsdale, 2003). A further 11 farm visits and 4 CSS agreements were completed during 2003, before the Project Officer post came to an end in December of that year. These FWAG visits delivered soil and water management advice across 1727ha. In addition, the West Country Rivers Trust wrote 4 integrated river basin resource management plans for farmers and landowners in the Cober Catchment (Cornwall Rivers Project, 2006). These Plans delivered advice on 2km of river, nutrient management and invasive weed control.

The agricultural advisory work undertaken to date provides a sound base to build upon. However, with a total of less than 25% of farms visited, there is scope for further new contacts. For the majority of farms visited by FWAG, this one-to-one environmental advice was the first they had received (A. Keast, FWAG Cober Catchment Officer 2002-2003, pers. comm.); follow-up visits to these farms are advisable and have the potential to yield additional environmental benefits. However, the desired change in nutrient inputs from agricultural sources will not be achieved by the provision of advice and small scale capital grants alone. There is a need for full integration with cross-compliance, NVZ and other regulatory requirements.

Future advisory work should include a focus on reducing contributions from farm point sources, for example slurry pits, silage clamps, farm tracks. There are numerous locations within the catchment where farmyards and slurry storage are located close to watercourses or where farm track and lanes deliver surface run-off, along with the associated sediment and nutrient load, into watercourses (M. Rule, Environmental Consultant, pers. comm.).

Unfortunately it has not been possible to determine the level of impact this first round of agri-environment advice has had upon water quality within the Catchment. The nutrient status of

Loe Pool has certainly improved over the delivery period of the FWAG advisory project (see section 2.3; Figure 2.1) but the provision of monitoring within the catchment has not been sufficiently detailed to apportion any of this change in nutrient status to changing agricultural practices. The routine ‘snap-shot’ surveillance data collected by EA cannot be used to adequately evaluate or observe changes in nutrient and sediment exports from diffuse agriculture: There are not enough sample locations to provide a spatial understanding of nutrient and sediment supplies within the catchment (section 4; Table 4.1; see Grayson *et al.*, 2007); and fortnightly, or less frequent, sampling fails to recorded the significant levels of nutrients and sediment arriving during spate and flood flow conditions (see Davison *et al.*, 2008). Storm events have the potential to transport significant amounts of sediment over a short period of time, for example, it has been documented that within Devon rivers, 90% of the total suspended sediment transport takes place in 10% or less of the time (Webb & Walling, 1982). It has also been identified that diffuse inputs of TP increase with rainfall intensity (Salvia-Castellvi *et al.*, 2005). The accurate estimation of the levels of diffuse water pollution from agriculture is a major challenge (Mainstone *et al.*, 2008). Careful consideration should be given to the provision of water quality surveillance and monitoring in order to inform the delivery of and measure the impact of any further farm advisory work.

(ii) Common Agricultural Policy reform

At a national level, recognition of the need to tackle agricultural inputs comes at a time of considerable change in the agricultural sector, resulting from reform of the Common Agricultural Policy (CAP), the key agricultural support mechanism of the European Union. The decoupling of CAP payments to farmers from production levels has removed the incentive to maximise agricultural production, and moved the incentives regime further towards payments for public goods, in the form of ‘environmental assets’. A considerable programme of cross-compliance has been introduced, linking payments to compliance with relevant legislation and the new terms of Good Agricultural and Environmental Condition (GAEC). The reform package has greatly helped to focus farmers and landowner’s attention on diffuse pollution issues, however, there is a resource need for prioritising compliance visits. Targeting key farms within the catchment for compliance visits is essential (Measure 1.4.6).

Environmentally sustainable soil and water management is included as an objective in the Environmental Stewardship Scheme in England, providing support to all farmers for farm planning and a range of practical management measures. Whilst funds are limited, in relation to the scale of change required, this provides a valuable mechanism for securing the engagement of the farming community.

(iii) Catchment Sensitive Farming

The England Catchment Sensitive Farming (CSF) Delivery Initiative has established catchment officers in priority target areas covering around one-third of England. Within these target areas, advice is given to farmers and contractors focusing on better use of nutrients, soil management and soil and water issues that may pose a risk of diffuse water pollution from agriculture. A Capital Grant Scheme has been offered in 2007, 2008 and again in 2009 providing funding towards items that are intended to reduce water pollution from agriculture. Advisory topics include appropriate management and use of fertilisers, manures and pesticides; promoting good soil structure and rain infiltration to avoid run-off and erosion; protecting watercourses from faecal contamination, sedimentation and pesticides; reducing stocking density; managing stock on farms to avoid compaction and poaching of land; and separating clean and dirty water on farms.

In April 2008, the CSF delivery initiative target areas for the West Cornwall Catchments were extended to include the River Cober Catchment. The target areas already included Marazion Marsh, Lower Fal and Caerhays to coast. (CSF, 2008).

In the Cober catchment, all holdings over 5ha within the catchment (approximately 150) receive the West Cornwall Catchment Newsletter and a small number of farms have received a visit from one of the CSF contracted advisors or the CSF Project Officer (Kate Allingham, West Cornwall Catchments CSF Officer. pers. comm.). It is recognised that staff resource time severely limits the delivery of the CSF, with one CSF Project Officer dividing time between the West Cornwall Catchments target areas and a second target area in North Cornwall (Kate Allingham, West Cornwall Catchments CSF Officer. pers. comm.). Loe Pool is a target river catchment within the West Cornwall Catchment area for 2009/10 and 2010/11 (CSF, 2008). Over the next two years, CSF priorities within the Loe Pool Catchment include engagement with farmers, focussing mainly on nutrient management planning, and improving soil structure (CSF, 2008), and improvements to yard infrastructure through the separation of clean and dirty water (Kate Allingham, West Cornwall Catchments CSF Officer. pers. comm.). Any additional farm advisory work undertaken within the catchment must take account of and complement the CSF delivery initiative.

(iii) Nitrate Vulnerable Zones

The European Nitrates Directive (Directive 91/676/EEC) concerns the protection of waters against eutrophication and pollution caused by nitrates from agricultural sources. The Directive requires that Member States identify all areas of land which drain into polluted waters as Nitrate Vulnerable Zones (NVZs), and establish and implement nitrogen action programmes to reduce water pollution from N compounds in these vulnerable areas. The Directive's definition of polluted waters includes 'natural freshwater lakes which are eutrophic'. A recent review of progress regarding implementation of the EU Nitrates Directive in the UK, indicated that previous domestic regulations had not fully achieved the objectives set out within the EC Directive. As a result, the Nitrate Pollution Prevention Regulations 2008 (SI 2008/2349) was passed to provide a stronger legislative baseline for soil/water/manure management across the UK. These 2008 Regulations extended NVZs in England from 55% of the land area to 70% and brought in the more stringent Nitrates Action Programme (NAP) measures, which came into force in January 2009.

The entire Loe Pool water catchment area falls within a newly-designated NVZ and is therefore subject to the revised NAP measures, which include:

i. Controlling when N is applied to land. There are closed periods over winter for slurry and manufactured fertiliser application. Do not apply when soil waterlogged/frozen or heavy rainfall forecast within 48 hours.
ii. Specifying storage requirements for manure. Sufficient storage must be provided for all slurry produced on holding for a 22-week period (to provide adequate storage during closed period). Manure must be stored in an animal house, on concrete or at a temporary field site.
iii. Controlling how much N can be applied to land. Total N application limits are set for the whole farm and for main crop types; farmers must demonstrate they have calculated N balance of inputs and outputs to inform their fertiliser applications. There is a specified manure production limit of 170kgha^{-1} per year (Defra is currently seeking a derogation to raise this limit to 200-250 kgha^{-1} per year for up to 4 years).

There is a three-year lead in on these NAP measures. Farmers in the Loe Pool Catchment have until January 2010 to create a risk map showing areas of the farm that have a high run-off risk (based on slope, soil type, presence of field drains) and until April 2010 to calculate their slurry storage needs to meet the 22-week storage requirement. Each farm must have sufficient storage in place to meet the 22-week requirement by January 2012.

A large proportion of holdings within the catchment are small dairy farms (about 100 cows), with very limited slurry storage. As a consequence, these farmers currently spread slurry year round, leading to issues with run-off in wet weather and exacerbating this run-off by soil compaction (A. Keast, FWAG Cober Catchment Officer 2002-2003, pers. obs.). As these NAP measures are rolled out, they should provide a strong legislative baseline for soil/water/nutrient management within the Loe Pool Catchment. However, there are numerous potential issues, not least a possible lack of enforcement and the probability of a high intensity of slurry spreading once the closed period has passed. It is important to ensure that farmers receive appropriate advice through the transition period, in order to deliver the significant improvements in water quality required to successfully rehabilitate Loe Pool (Measure 1.4.4) and it is essential that key farms within the catchment are targeted for EA compliance visits (Measure 1.4.6).

(iv) Lowland farms close to the Pool

A number of the farms in close proximity to Loe Pool appear to make a substantial contribution to the Pool's overall P budget (section 2.3; Figure 2.2). Those within the Nansloe and Chyvarloe Catchments are of particular note. It is likely that this is due in part to the immediacy of nutrient delivery, but farm practices are also contributory (see Haycock, 1999).

Much of farmland bordering Loe Pool forms part of the NT's Penrose Estate and all the tenant farms now have Whole Farm Plans, which include Farm Conservation Plans and, where appropriate, Farm Waste Management reports. As these tenancies become available to change, water quality issues are an important part of the process in establishing new farm practices on the land. The majority of the agricultural land immediately adjacent to the Pool is now under Countryside Stewardship Scheme, with a proportion of the arable fields under reversion to grassland, and funding allocated to specific works to reduce diffuse water pollution from runoff each financial year during this reporting period.

Negotiating changes to farm practice aimed at reducing nutrient and sediment exports from these farms is a lengthy and delicate process, due to the significant cost implications involved for both the NT and the tenant (J. Proctor, NT Regional Farm and Countryside Advisor, pers. comm.). NT staff and tenants are continuing to work, in a mutually constructive manner, to enhance and protect the water quality of the Pool. The NT has identified appropriate next steps, with a focus on high risk locations for surface run-off and phosphates associated with sediment particles from farmland and farm buildings. They also intend to develop costed case-studies for improved land management. Implementing these prescribed actions should be one of the NT's highest regional countryside conservation priorities (J. Lister, Regional Nature Conservation Advisor, pers. comm.) (Measure 1.9.1).

Identifying and addressing the water quality impacts of those lowland farms close to the Pool which are not owned by the NT, particularly those in the Nansloe Catchment (section 2.3; Figure 2.2), should be a priority under any agricultural advisory work within the catchment (Measure 1.1; Measure 1.4).

(v) An integrated catchment approach

It is considered that additional work is required across the whole Loe Pool Catchment to further reduce exports of nutrients and sediment from field and farmyard and to draw maximum local benefits from the national policy measures now in place for controlling diffuse agricultural pollution. There has been a significant change in tack to addressing agricultural water pollution in recent years, moving away from recommending measures to buffer semi-natural habitats from the effects of intensive agriculture (for example, see Dinsdale, 2003) towards implementing measures to address issues at source and using a whole catchment approach to rebuild ecosystem integrity and the associated services (White & Richards, 2007; Kenyon *et al*., 2008). The whole catchment approach is now strongly recommended and will require an intimate combination of outreach to the farming community and technical evaluation of environmental risks, management options and outcomes in order to achieve the desired change in catchment water quality (Measure 1.4). Figure 3.1 describes the basic process for conducting an initiative of the type required, involving parallel but closely linked operational strands on farmer networking and advice provision on the one hand, and catchment and environmental appraisal of sources and source areas on the other (from Mainstone *et al*., 2008). The financial aspects also require consideration.

Efforts to tackle agricultural point and diffuse sources of nutrients and sediment need to be based on a catchment appraisal, to identify the distribution and nature of risk (Figure 3.1). Such an evaluation of environmental risk, often termed risk mapping, forms an important part of this approach, and is necessary to focus advice and management activities on high risk locations and situations (Measure 1.4.3). Unfortunately, in reality, documenting the provenance of nutrients and sediment on the ground is far from straightforward (see Collins & Walling, 2004 for a review; and Grayson *et al*., 2007 for a study quantifying the sources, stores and fluxes of fine sediment in the Helford River). This has led to a strong focus on the use of catchment modelling of the diffuse pollution risk within catchments, using parameters such as slope, erodability, saturation propensity, landcover, upslope area (Mainstone *et al*., 2008; Euroharp, 2005; PSYCHIC - Davison *et al*., 2008). These catchment models may be developed sufficiently to become useful risk mapping tool within the Loe Pool Catchment in the near future. Alternatively, it may be possible to create an adequate risk map by applying the basic rules of these models.

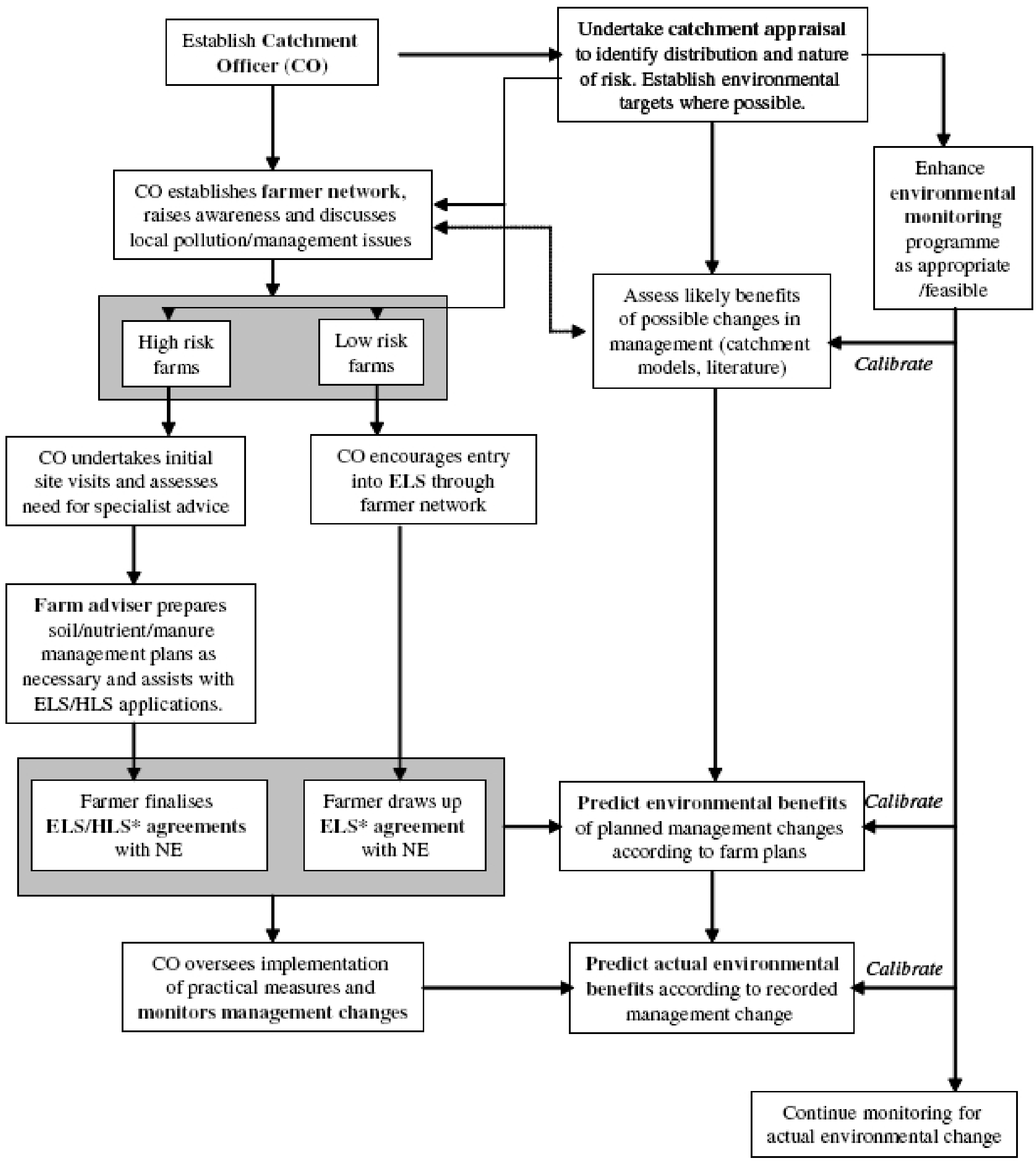
Key conflicts between agricultural production and Loe Pool catchment management include: the use of field parcels for enterprises inappropriate for their inherent soil and water risk; poor management leading to compacted soils where enterprise would otherwise be low risk; and a lack of or poor management of waste infrastructure (J. Proctor, NT Regional Farm and Countryside Advisor, pers. comm.).

It is clear that the provision of monitoring within the catchment has not been sufficiently detailed to apportion change in nutrient status to changing agricultural practices in the past (this section, above) and that a strategic catchment initiative must include an appropriate level of environmental monitoring (Figure 3.1) (Measure 1.4.5). The potential to incorporate surveillance requirements into the core work of the EA should be investigated. Opportunities to carry out specific time period survey(s), similar in approach that undertaken by BREY Utilities (now Kelda Water Services) for Loe Pool (McCaffrey, 2008; BREY Services, 2009), but focussed on the River Cober and its tributaries should also be considered. A water quality study proposed by South West Water (SWW) is expected to provide additional storm event data for the River Cober catchment (section 3.3.2; Measure 1.7.1). These SWW data could be used to estimate the proportional contribution from the rural Cober Catchment to the Pool's annual nutrient budget that arrives during storm events. It would be useful to confirm whether WFD chemical monitoring will provide data on pesticide levels within the Pool (to be delivered as part of Measure 1.4.1). SWW's monitoring of drinking water quality at Trenear may also provide data on levels of pesticide compounds within the River Cober (to be delivered as part of Measure 1.4.1).

Farmers face a formidable assortment of regulations and European directives. The proposed Rural Catchment Initiative should offer on-farm practical advice on simple, low-cost actions that make good sense for both the environment and for farm business. Promoting an integrated approach to farm management, employing the best of traditional methods and advanced technologies, and covering soil protection and careful nutrient management, the project should aim to help farmers to profit from good environmental management.

The changes required to agricultural management to control nutrient, sediment and pesticide loss also act to improve catchment retention of water in soils, with benefits for flood risk management (section 3.4). This restoration of natural hydrological function within catchments must be a cornerstone of adaptation to climate change (Mainstone *et al*., 2008).

The environmental outcomes of the South West RBD Management Plan include an aim to improve rural land management in order to address the main causes of agricultural pollution. The proposed Loe Pool Rural Catchment Initiative will contribute to this outcome and features as a delivery action within the South West RBD Management Plan (EA, in prep.).



* ELS (Entry Level Scheme) and HLS (Higher Level Scheme) are components of the Environmental Stewardship agri-environment scheme. ELS is available to all farmers and includes support for soil and nutrient management planning and other basic pollution mitigation measures, whilst HLS is targeted and includes support for mosre costly changes in land management.

Figure 3.1 Relationship between key activities in a strategic catchment initiative (Mainstone *et al.*, 2008)

3.2 Reducing the Impact of Sewage Effluent

Effluent from sewerage systems is recognised as the primary point source of water pollution in the South West (EA, in prep.).

Phosphorus (P) removal commenced at Helston Sewage Treatment Works (STW) in 2003. The chemical treatment system is performing efficiently, currently surpassing the final effluent targets set under the UWWT Directive. In-lake P concentrations have responded well, reduced from an annual average of around 300μgl^{-1} to around 80μgl^{-1}. This still fails to meet the UWWT Directive standard for total P within Designated Sensitive Areas (50μgl^{-1}), therefore, further improvements may be required.

P contributions from the STW serving RNAS Culdrose L Site are probably substantial. RNAS Culdrose STW discharges into Carminowe Stream, which contributes 22% of Loe Pool's annual TP budget. Average P concentrations in the Stream are 230-460μgl^{-1}, between 3 and 13 times greater than the River Cober's input to the Pool.

P removal at RNAS Culdrose STW is likely to be a key step in the rehabilitation success of Loe Pool. If a more robust evidence base is required this will necessitate additional monitoring. It is recommended that these additional monitoring requirements form part of the proposed nutrient budget for Loe Pool.

3.2.1 Helston STW

In line with the UWWT Directive (Council of the European Communities, 1991) requirements, a P removal plant was installed at Helston Sewerage Treatment Works (STW) and commissioned on 31 March, 2003, with modification to the consent to discharge granted by the EA July 2003 (LPMF minuted meeting, 3 December 2003).

Under the UWWT Directive, SWW is only required to demonstrate a P removal rate of at least 80% or a final effluent concentration of 2mgl^{-1} at the Helston STW. The STW currently surpasses these targets, with a mean reduction of 85% and a mean concentration in the final effluent of 0.96mgl^{-1} [960μgl^{-1}] (SWW data, October 2007 to December 2008).

As part of the UWWT Directive sensitive waters work, the EcOS model was used to simulate the effect of a range of P reductions from Helston STW. This modelling estimated that the UWWT Directive 50μgl^{-1} in-lake standard for total phosphorus (TP) would still be exceeded at P reductions up to 80% whereas 100% P removal from Helston STW would reduce P concentrations in Loe Pool to 30μgl^{-1} (Murdoch, 1997). It was therefore recommended that 90%, and preferably 100% removal, should be the statutory requirement in order to ensure compliance with the standard (Murdoch, 1997).

Implementation of the UWWT Directive at Helston STW has delivered significant improvements to the in-lake P concentration. The observed reduction of P concentration in-lake is very close to the modelled predictions (see Figure 2.1). The current mean P reduction of 85% delivered by SWW is resulting in a mean annual in-lake TP concentration of around 80μgl^{-1} (EA data 2006-2008) and, as predicted by Murdoch (1997), this does not meet UWWT Directive standard for TP within Designated Sensitive Areas (50μgl^{-1}).

Data pertaining to the efficacy of P stripping at Helston STW will be formally reviewed by the EA later this year as part of their Priority Implementation Plan (PiP) under the Co-ordinated Review of Evidence (CORE) process (EA, 2009; Dan Hambrook, EA Environment Planning response to M. Hardy. NT Warden 5 May 2009). The potential requirement for further P removal at Helston STW will be considered as part of this review (Measure 1.3.1).

SWW chose a chemical treatment system in order to comply with the UWWT Directive. Products based upon either iron or aluminium salts are most frequently used to achieve P precipitation from the sewage influent. At a national level, both the EA and, the then, EN were fully aware of the risks involved in using aluminium as the P precipitant, owing to its toxicity, and sought a presumption against its use for all cases affecting SSSIs (EA, 2001; LPMF minuted meeting, 27 March 2002). It was recognised that this concern needed to be translated to the local level, in order that SWW adopt iron as the precipitant at Helston STW (Dinsdale, 2003).

The EAs notice to EN under s281 WCA dated 14 March 2003 (Statutory consultation for modification to consent for unsatisfactory discharge in Helston) stated that SWW were proposing to dose with an iron-based product [ferric sulphate (40% wet weight)] and a second notice dated 28 September 2006 from the EA for a temporary variation to the discharge consent referred to the P-stripping process as 'iron dosing'. However, SWW have also stated that they employ aluminium (product name Clarol WT18) to precipitate P at Helston STW (e-mail from Paul McNie, Principal Scientist SWW to J. Dinsdale, 16 December 2008). NE's position is a presumption against aluminium dosing except in circumstances where there is an ecotoxicological justification (Andrew McDouall, Conservation Officer, NE, Loe Pool Point Sources Task Group Minuted Meeting, 16 September 2009). There is therefore a need to confirm that the product currently used in P stripping at Helston STW is environmentally safe (Measure 1.3.2). New techniques for removing P from waste water may be available in the near future. A gel prepared from the waste products of orange juice production has been shown to be very effective and this treatment allows the P to be re-used, for example in agricultural fertilisers (Biswas *et al*., 2008).

Implementation of the UWWT Directive and upgrading of the works (nitrification) has significantly reduced the biological oxygen demand (BOD)[BOD mean % reduction 96%; mean final BOD 9 (SWW data, October 2007 to December 2008)], ammonium and phosphate levels in the sewage effluent but the issue of high N loads remains. While it is generally accepted that within Loe Pool, as in most European lakes, P is the limiting nutrient (see Salter, 2007), the Pool is estimated to be overloaded with N by between 3 and 12 times (calculated from Peters, 1990). The reduction of N levels in the effluent at Helston STW has been identified as a local issue by the EA and has been the subject of much discussion at the LPMF meetings in the past (Dinsdale, 2003). The LPMF wishes to evaluate the potential use of the eastern willow carr as a denitrification zone; a proposal was outlined to trial the effects of allowing the River Cober to pass through the willow carr close to the mouth of the River Cober (Skinner, 2005; Section 3.4.2). As a first step towards evaluating the efficacy of this scheme, it is recommended that this proposed trial is drawn up in full, implemented and that the local impacts upon the willow carr carefully monitored (as part of Measure 1.8.1).

3.2.2 Culdrose STW

(i) Background history

One of the two STWs serving RNAS Culdrose, which employs several thousand people, discharges into Carminowe Stream. The LPMF, led on this issue by Natural England (NE), have been calling for P removal at RNAS Culdrose STW L Site for more than 10 years (Wilson & Dinsdale, 1998).

RNAS Culdrose L Site sewage treatment plant has had a discharge consent in its current form since 1996 (letter from S. Cundy, Corporate Services Assistant, EA to J. Dinsdale, 27 January 2008). The discharge from RNAS Culdrose L Site serves too few personnel to qualify for monitoring or control under the UWWT Directive. Currently, nutrient limits on the discharge are enforced through consent to discharge under the Water Resources Act (1991). The Water Resources Act (WRA) discharge consent is based on an Environmental Quality Standard (EQS) set for the receiving water and comprises standards for pH (5-9), ammonia (5mgl^{-1}), BOD (20 mgl^{-1}) and suspended solids (40mgl^{-1}), but not standards relating to P.

Following the installation of chemical P removal at Helston STW, the LPMF endorsed the installation of a similar method of enhanced tertiary treatment at RNAS Culdrose STW (Dinsdale, 2003). The use of constructed wetlands and Reed Bed Treatment systems were considered, but rejected, as it was understood that these systems do not reduce P levels sufficiently, especially over time (Wilson & Dinsdale, 1998).

The Ministry of Defence (MOD) first expressed its support for the LPCMP and its willingness to carry out an assessment of the current discharge consent (Rule, 2000), and subsequently signed up to lead action to identify funding for the STW upgrade (LPMF minuted meeting, 15 January 2003). Initially, good progress was made towards this action, and the MOD secured funding to install the appropriate tertiary treatment in the financial year 2003-2004 (Dinsdale, 2003). However, in December 2003, the MOD transferred responsibility for the maintenance and operation of RNAS Culdrose STW to BREY Utilities (now Kelda Water Services) for a 25-year period under Project Aquatrine, a Private Finance Initiative.

BREY Utilities considered that, since the STW currently meets the EA WRA consent to discharge, a re-evaluation of the need for tertiary treatment at the STW was required (LPMF minuted meeting, 13 May 2005). As a result, a Remedy Action Plan was drawn up by Defence Estates Environmental Support Team with the aim of identifying and recording the impact of P outputs from RNAS Culdrose STW on Loe Pool SSSI. The Remedy Action Plan was agreed between RNAS Culdrose, MOD Defence Estates, English Nature (now part of NE), EA and BREY Utilities and included tasks to:

1. Collate and make available all historic MOD and EA phosphate data from STW ouflow at RNAS Culdrose pre-2003.
2. To record nutrient levels, including phosphate, of the STW final effluent and of Carminowe Stream above the outflow, on a weekly basis for one year, February 2006-February 2007.
3. To enable and carry out flow monitoring at STW and within Carminowe Creek (to inform phosphate sampling).
4. To meet to discuss the outcome of this programme of monitoring in order ‘to agree whether RNAS Culdrose STW discharge is significant (either alone or in combination with other phosphate sources) in terms of Loe Pool SSSI condition’ (Howells, 2006).

The EA routine water quality surveillance of Carminowe Stream commenced in 1994, after the discharge ceased to be Crown Exempt, but does not include P analysis. The EA has undertaken orthophosphate sampling of the Stream under the UWWT Directive (Jan 1994 to Oct 1996; fortnightly) and monthly orthophosphate sampling is now included within the WFD Programme of Monitoring (April 2007+).

BREY Utilities commenced the programme of monitoring in 2006, with P sampling taken from 3 locations: the STW final effluent, 1 metre upstream of STW discharge point and 1 metre downstream of STW discharge (LPMF minuted meeting, 21 March 2007). In stream sampling was initially monthly, but was increased to weekly for the period April 2006 to May 2007 after which time in stream P sampling in the vicinity of the STW ceased.

In addition to this monitoring, as proposed within the 2006 Remedy Action Plan, BREY Utilities and the NT have also undertaken a voluntary nutrient survey of all tributary watercourses flowing into Loe Pool. This tributary survey aimed to further inform Task 4 of the Remedy Action Plan, 'to agree whether STW discharge is significant alone or in combination with other P sources'. Nutrient sampling extended to all 6 watercourses feeding into Loe Pool (Cober, Nansloe, Degibna Carminowe, Chyvarloe and Penrose). Water chemistry samples were collected by the NT and analysed by BREY's on a weekly basis from May 2007 to July 2008. Estimated flow data was recorded by the NT from July 2007 to July 2008, to allow nutrient data to be expressed as total daily loads (McCaffrey, 2008; BREY Services, 2009). The results of this survey are summarised in section 2.3 (Figures 2.2 & 2.3) and a summary of monitoring and sampling metadata is provided in section 4; Table 4.1. The results of the Brey Utilities programme of monitoring have been presented to LPMF at regular intervals (LPMF minuted meetings 21 March 2007; 16 September 2009) and the findings are of great value to the LPCMP.

(ii) Water quality impacts: Extent of current knowledge base

It is now clear that the TP contribution from Carminowe Stream is significant, 22% of the overall TP budget of the Pool (Figure 2.3). The discharge from RNAS Culdrose STW may be responsible for a large proportion of the P loading to Carminowe Stream. The final effluent from the STW has a mean annual P concentration of around 4,000μgl^{-1}(BREY Utilities data 2005-09), which is more than 4 times that of Helston STW final effluent 960μgl^{-1}; SWW data 2008). Carminowe Stream continues to carry a mean annual orthophosphate concentration at least ten-times greater than that of the Cober above Helston (< LOD 20μgl^{-1} ; EA 2008 Data) and between 3 and 13 times greater than that below the town of Helston, and its STW (Table 3.1).

While the BREY Services/NT data illustrate that Carminowe Stream contributes a significant portion of the overall TP budget of Loe Pool, the relative contribution from RNAS Culdrose STW to the Total P budget of Loe Pool has yet to be quantified. The P load from Culdrose has not been isolated from that of the remainder of the rural diffuse sources of P within the Carminowe Catchment because flow data for the STW final effluent and 1m upstream of this discharge are still not available. Flow monitoring of the final discharge from the STW is not currently undertaken by Kelda Water Services or the EA.

P concentrations within Carminowe Stream upstream above the RNAS Culdrose STW are similar to those within Nansloe and Chyvarloe Streams (mean ca. 300μgl^{-1}), which are high in comparison to Degibna and Penrose Streams and the River Cober (<100μgl^{-1}) (BREY Utilities data presented at Loe Pool Point Sources Task Group minuted meeting, 16

September, 2009) and may indicate agricultural sources of water pollution within this catchment. The Little Content Stream is a sub-tributary to Carminowe Stream which feeds in downstream of Culdrose STW. An additional water quality sampling location is recommended on this tributary in order to isolate the P load from Culdrose STW from the remainder of the rural Carminowe catchment (Section 4; Appendix 2; Measure 1.1.1).

Year	Source of Data	Carminowe Stream: Mean Annual Orthophosphate concentration (μgl^{-1})	River Cober: Mean Annual Orthophosphate concentration (μgl^{-1})
1994	EA	430	260
1995	EA	570	580
1996 (part)	EA	540	650
2005	EA	420	-
2007 (part)	BREY	230	58
2007 (summer only)	EA	282	76
2008 (part)	BREY	230	80
2008 (summer only)	EA	463	35

Table 3.1: Mean annual orthophosphate concentration within Carminowe Stream and River Cober, at inlets to Loe Pool

The BREY Services/NT data are due to be formally interpreted and reviewed by the EA in 2009/2010 (EA, 2009). The Environment Agency is to consider whether the current evidence base is sufficient to warrant a modification to the discharge consent under the Water Framework Directive to include a P condition (Tracy Reeve, EA Senior Environmental Planning Officer, Loe Pool Point Sources Task Group minuted meeting, 16 September, 2009) (Measure 1.2.1). It is suggested that additional flow monitoring or modelling may be required in order to quantify the relative contribution from Culdrose STW to the Total P budget of Loe Pool (Section 4; Appendix 2; Measure 1.2.2).

The high P concentrations persist in Carminowe Stream, despite a reduction in the number of personnel employed at the air base and the considerable effort by the MOD to reduce their P exports at source, for example through not permitting car washing on-site and taking water from aircraft washing facilities off-site (LPMF minuted meeting, 17 February 2006) and promoting the use of reduced-phosphate detergents on-site (LPMF minuted meeting, 19 September 2007).

The Scientific Committee on Toxicity, Ecotoxicity and the Environment has concluded that although the reduction of P in detergents may contribute to decrease the occurrence of eutrophication in Europe, this is unlikely to be sufficient to solve the problem of eutrophication in Europe (CSTEE, 2003). This is due to the fact that where phosphates are used in detergents this contributes only between 20 and 33% of the TP in sewage, the remainder coming from human wastes and other organic waste (WRc, 2002). As secondary wastewater treatment removes only a small percentage of P from the influent, the majority is released into the river/lake through wastewater effluent.

(iii) Water quality impacts: Ecological considerations
In addition to the significant impact of the STW to the overall chemical nutrient budget of the lake, there is also a secondary localised ecological impact of the STW which is exerting a

very strong influence on the rehabilitation success of Loe Pool. Successful lake rehabilitation, attaining a stable clear-water state, relies heavily upon rapid re-establishment of submerged vegetation (Moss, 1990; Jeppesen *et al*., 1990; Meijer, 2000; Jeppesen, 1998; Phillips, 2005). Unfortunately, there is an extreme paucity of established macrophyte beds within Loe Pool (Stewart, 2000; Dinsdale, 2009). This is generally attributed to historical sediment loads resulting from metalliferous mining within the Cober catchment (Coard, 1987). The Carminowe catchment was not subject to metalliferous mining and Carminowe Creek now retains the only relict rooted-vegetation communities (Stewart 2000; Dinsdale, 2009). The recovery of the macrophyte population is, therefore, most likely to commence there. The pattern of establishment of Nuttall's waterweed supports this supposition (section 3.6). P-stripping at RNAS Culdrose would improve the localised water quality and thus enhance macrophyte habitat quality within the Creek. This is likely to provide a substantial boost to the speed of the rehabilitation process, and increase the likelihood of reaching a macrophyte dominated, clear-water stable state (section 2.4).

(iv) Legislation and agreements

The SSSI duty under the Countryside and Rights of Way (CRoW) Act is the strongest legislative driver currently available to enforce the requirement to address this significant source of P into Loe Pool. Under the CRoW Act 2000, the MOD, as a public body, has the duty 'to take reasonable steps, consistent with the proper exercise of the authority's functions, to further the conservation and enhancement of the flora, fauna or geological or physiographical features by reason of which the site is of special scientific interest' (HM Government, 2000).

Increasingly, the WFD will provide legislative powers as a basis for the integrated management of eutrophic lakes, but there is a more immediate need for action to safeguard those designated as SSSIs (Mainstone *et al*., 2008). It would be advantageous to both the speed and success of the rehabilitation of Loe Pool to see deeper reasoning prevail ahead of these likely enforcements.

In February 2009, the MOD signed a revised declaration of intent with NE 'to improve the stewardship of the natural environment … and to minimise the environmental impact of defence-related activities' (MOD and NE, 2009). The agreement states that the MOD will not intentionally carry out or permit to be carried out any activities likely to significantly damage the special interest of designated sites. This agreement demonstrates a commitment by the MOD and NE to resolving uncertainties and to taking remedial action where damage to SSSIs by MOD activities are shown to occur.

The list of delivery actions within the WFD SW RBD Management Plan includes an action to 'research to investigate the impact of water company assets on the Loe Pool SSSI under the CRoW Act is an action' (EA, in prep.) (Measure 1.11.6).

3.3 Reducing the Impact of Other Point Sources

Nutrient inputs from other point sources will come to the fore as actions to address gross inputs from the two STW and from agriculture within the catchment are put in place. Recent research shows septic tanks have a much more substantial impact on the nutrient status of our rivers and lakes than previously thought. Helston's Coronation Lake is of particular concern for the management of Loe Pool, not solely as a source of nutrients, but also as a potential source of algal propagules. A project proposed by SWW will quantify the impact of Helston's sewer storm overflows on the nutrient status of both the River Cober and Loe Pool.

3.3.1 Coronation Lake

Coronation Lake, a very popular local amenity, is fed by and discharges into the River Cober. It is populated by a large number of wildfowl, that are fed by visitors. The amenity lake probably provides a net source of nutrients within the catchment (Haycock, 2006); this has not been verified, the EA do not undertake routine water quality analysis of Coronation Lake or its discharge.

In addition to its role as a source of nutrients, Coronation Lake also acts as a potential source of algal propagules. There were extensive blooms of the macro-alga water net in the amenity lake in 2007 and 2008, when this species did not bloom in Loe Pool (Dinsdale, pers. obs.). The hydrological connection between the two water bodies is of concern in light of research undertaken in New Zealand (NZ) in which healthy starter colonies of the alga were re-introduced to one study lake, in floating mesh-lined experimental enclosures, following the demise of annual blooms. Vigorous growth rates and large biomass production were observed within the enclosures and this experimentally verified that there was no change in the ability of the lake to support bloom growths (Wells and Clayton, 2001; J. Clayton, NIWA, NZ, pers. comm., 2008.). Vegetative fragments or propagules of water net reintroduced to Loe Pool from Coronation Lake increase the risk of recommencement of algal blooms.

Cornwall Council recognise the need to look at removal of silt, re-engineering lake structure and introducing rooted macrophytes in order to improve water quality within Coronation Lake and are attempting to find funding for this work (Stuart Wallace, Cornwall Council, pers. comm.).

It is recommended that a Water Management Plan is produced for Coronation Lake (Measure 1.7.2). This Plan should address: the requirement for water quality surveillance data; the function of the current abstraction and discharge; the need for operational guidance for leaseholder. In the longer-term, a management plan for the amenity lake is required to assist the owners with planning lake remediation (Measure 1.7.3). The review should include an evaluation of the following options for management: the removal of benthic sediments, alteration of intake to reduce sediment inputs (options to include not abstracting from River Cober during flood events and re-employing springs rather than using river water to top-up lake levels), the alteration to outlet to reduce impacts on Loe Pool. Public consultation will be required (Measure 1.5.1). As a first step towards this, a discussion paper has been produced on behalf of the LPMF and the current leaseholder of Coronation Lake which outlines the technical issues and options for remediation and aims to bring together all relevant organisations and interested parties (Rule, 2009). Charlotte Chadwick, Helston and Lizard

Community Network Manager, is currently pulling together a funding bid which is likely to include provision to undertake some elements of this proposed work.

If the hydrological connection of Coronation Lake is shown to have an impact on the Loe Pool SSSI, it could be argued strongly that rectification is the responsibility of Cornwall Council (CC). Under the CRoW Act 2000, CC, as a public body, has the duty 'to take reasonable steps, consistent with the proper exercise of the authority's functions, to further the conservation and enhancement of the flora, fauna or geological or physiographical features by reason of which the site is of special scientific interest' (HM Government, 2000).

3.3.2 Urban Drainage

The pollutants associated with urban runoff are many and vary widely depending upon the land uses and pollutant sources present in the local area. On average, urban runoff contains four to five times the N and between two and fifty times the P of water flowing from woodland (Harper, 1992). There is relatively little urban area (435ha) within the catchment, most of which is represented by Helston, but added to this is 145km of road (CWT, 1995).

Urban drainage was one of the potential sources of pollution to Loe Pool identified by the LPCMP (Wilson & Dinsdale, 1998). In 2003, the measure to develop a programme on pollution from urban drainage, with a particular focus on Helston, was assigned to implementation phase one (2003-2005) and comprised of four actions, namely: (i) to initiate a community education programme; (ii) to negotiate improved street cleaning and maintenance of drains; (iii) to assess the feasibility of screening physical litter and pollution loading from Helston road runoff and (iv) to investigate the potential for improvements to the combined sewerage systems (Dinsdale, 2003).

Having a representative from the former District Council to sit on the LPMF during the current reporting period (2003-2008) has helped towards delivery of two of these four actions. The District Council liaised with Helston Town Council and, the then, Cornwall County Council Highways Department, of behalf of the LPMF, in order to progress these actions. A new trash screen has been installed at lower Coinagehall Street and improved street cleaning is now in place. All of the leat trash screens are now maintained as part of the daily cleaning programme (LPMF minuted meeting, 18 June 2003). The LPMF aim to investigate further options to prevent street litter from entering the Cober and to progress these with the relevant authorities (Measure 1.5.1)

The relative contribution of Helston's urban drainage to the overall P budget of Loe Pool will be calculated as part of the proposed lake nutrient budget (Section 4; Measure 1.1).

The initiation of a community education programme has received relatively little attention during the current reporting period. However, there have been a number of articles in the local press to raise awareness of the increased accumulation of cigarette butts outside pubs and in the Kennals (roadside open leats) following recent bans on indoor smoking. A publicity campaign on this and other litter issues is proposed (Measure 1.5.1).

A combined sewerage system, accommodating both foul sewage and storm water within the same pipes, currently operates across the majority of Helston (Wilson & Dinsdale, 1998). During times of dry weather the sewage is treated before discharge. Following a storm event, overflow structures limit the volume that is carried to the STW and the excess, potentially a mix of storm water and untreated sewage is discharged into the River Cober. Such combined sewer overflows are usually designed to operate when the current exceeds six times dry weather flow, but there is currently no information available regarding the discharge frequency of untreated sewage into the Cober (P. McNie, Principal Scientist, SWW, pers. comm).

A number of reports of dramatic macro-invertebrate populations crashes both above and below Helston STW and the possible links to Helston's sewerage system storm overflows has been discussed for sometime (e.g. LPMF minuted meetings, 3 December 2003; 9 September 2005; 19 September 2007). As storm intensities increase due to climate change, separation of internal foul drainage of buildings from rainwater carriage and surface flow management are set to become even more critical. This issue is recognised in SWW's 2010-2015 business plan (PR09) and supported by SWWs zero pollution objective for wastewater services (SWW, 2009).

Evaluating the impact of Helston's sewer storm overflows (combined sewer overflows: CSOs) on the nutrient status of both the River Cober and Loe Pool is a priority for the next reporting period (Measure 1.7.1). SWW are due to carry out a project to fulfil this action. The proposed project aims to quantify the total nutrient load from five intermittent discharges (5 CSOs: Monument Road, Helston Market SPS, Grange Road, Guildhall and Helston STW) and express this as a proportion of both the total catchment storm nutrient load and the total catchment annual load (P. McNie, Principal Scientist, SWW, pers. comm). The project will include intensive water quality monitoring during storm events at two locations: the crude influent to the STW and the River Cober inflow to Loe Pool. These data will be used in conjunction with model predictions and EA routine spot-sampling data to estimate the total nutrient load from storm overflows. This study is part of the proposed National Environment Programme (NEP) which is due for approval in December 2009. The project is timetabled for completion by 31 March 2012. If the study shows that SWW CSOs contribute a significant proportion of the total nutrient load to Loe Pool then any improvements will be carried out within AMP6 (2015-2020).

This SWW study will provide useful storm event data for the wider River Cober catchment. The results could be used to quantify the proportion of the total annual River Cober catchment nutrient load, excluding Helston Sewerage System, delivered during storm events. These data will also be useful towards quantifying the rural riverine storm loads to the Pool, e.g. P from agricultural sources and septic tanks (sections 3.1 & 3.3.3).

One in five of the UK's homes and businesses has drains illegally connecting to clean water systems rather than sewers, the most frequent being incorrectly-connected domestic washing machines (EA, 2007a). The EA produce relevant information leaflets and these could be provided to householders as part of a publicity campaign to address this issue (Measure 1.5.1).

3.3.3 Septic Tanks

Following what it terms 'great strides' towards cleaning up gross discharges from STWs and industry nationally, a recent EA report highlights the need to address the impacts of smaller point sources of pollution (EA, 2007a). With a large proportion of the total annual P load to Loe Pool contributed via the River Cober (section 2.3; Figure 2.3; McCaffrey, 2008), all potential sources water pollution within the Cober Catchment require consideration. Rural point sources, such as septic tanks, are often inadequately represented in source apportionment budgets but in many cases need to form a key part of a control strategy (Edwards & Withers, 2007). Field research has show P concentrations emanating from septic tanks can be more than ten times those from arable field drains (cited in Stoate, 2007). However, the volume of flow, and therefore the total contribution to the overall P budget of Loe Pool, is likely to be much less than the contribution from agriculture.

Due to relatively densely populated rural nature of the Loe Pool Catchment, septic tanks may contribute a portion of the P budget. The best method of addressing these private sewerage system failures when they are brought to the Forum's attention by local residents was discussed within the Community Liaison Task Group (minuted meeting 30 September, 2009). Advice on managing septic tanks more effectively is provided in leaflets produced by the EA and specific incidents should be reported to the EA hotline (0800 80 70 60). These leaflets and the hotline number should be provided to relevant householders in the catchment as part of the proposed publicity campaigns (Measure 1.5.1).

3.4 Rehabilitation of the River Cober

Managing flood risk for Helston continues to rely on a traditional engineered scheme. The Environment Agencies proposed changes to the River Cober maintenance regime are likely to bring benefits to the quality of the riverine and riparian habitat within the lower reaches of the River. A number of additional alterations to the river maintenance regime are recommended to further assist a natural recovery of the River's form and function.

There has been a recent shift in national flood policy, away from a framework based on flood protection towards one based on sustainable catchment-scale flood risk management. The main drivers are the EU Water Framework and Flood Directives. At the national level, the EA recognises the need to work with natural processes to successfully manage flood risk.

It is suggested that rehabilitation of the River Cober now requires a two-pronged approach, based around the concept of assisted natural recovery. Good progress has been achieved towards reach-based restoration activities and these should continue alongside a whole river catchment approach, which is recommended to resolve river restoration issues at source as far as possible.

3.4.1 A Catchment-Scale Approach to River Rehabilitation

Infilling of the lower reaches of the Cober was largely associated with the periods of deep mining in the catchment during the late nineteenth and early twentieth centuries. As a consequence, the gradient between Zachary's Bridge and Loe Pool is very shallow.

The lower reaches of the River Cober, from just above St. John's Bridge have been heavily engineered in order to alleviate flooding in the town of Helston. The River was straightened and channelised in 1946 and substantially reprofiled in 1988 (Wilson & Dinsdale, 1998). As a consequence the river system does not function naturally. The River cannot meander across its floodplain through the natural processes of erosion and deposition and it is confined to its channel, save during occasional extreme flood events. The current flood alleviation scheme requires regular de-silting of the River below Helston; since 1988, de-silting has been carried out on three occasions (EA, 2007b).

The engineered approach to flood risk management in Helston continues to meet the original design brief (EA, 2007b). The lower River Cober delivers flood waters rapidly and efficiently through the town and into Loe Pool. However, these rapidly delivered flood waters carry high levels of nutrients and fine sediments into the Pool (EA data 1998-2008; see section 3.1). Within a naturally functioning river system a proportion of these sediments and nutrients would be deposited within the floodplain. The flood alleviation scheme, therefore, has a negative impact on the water quality of the River Cober and exacerbates the eutrophication of Loe Pool (Haycock & Vivash, 1999). The physical disturbance of the de-silting maintenance is also detrimental to riverine and riparian habitats and species (Wilson & Dinsdale, 1998; Haycock & Vivash, 1999; Stewart, 2000). The Helston flood alleviation scheme therefore facilitates the delivery of nutrients and sediment into the Pool and as a consequence hinders progress towards the LPCMP environmental targets and objectives (section 2.1).

The LPCMP Report 1998 recommended the development of a river rehabilitation scheme (Wilson & Dinsdale, 1998). To date river restoration efforts have focussed entirely on the lower reaches of the River below Helston (Wilson & Dinsdale, 1998; Dinsdale, 2003; section 3.4.2 below). Undoubtedly this reach-based focus has occurred because it is in these lower reaches that the catchment-wide land management issues manifest themselves, through high siltation rates and high flood risk, and it is here also that the current flood alleviation scheme is located (Wilson & Dinsdale, 1998).

Environmental improvements have been incorporated into the river maintenance regime for the lower Cober since the last river de-siltation in 1998 (see EA, 2007b). These changes to the maintenance regime have benefitted riverine and riparian habitat quality within this reach of the river (see section 3.4.2 below for a review; Figures 3.2 & 3.3). There are a small number of additional maintenance alterations which would further progress river rehabilitation, within the confines of both the current Helston flood alleviation scheme and the current nutrient and sediment loads carried by the River (see section 3.4.2). In addition, for substantial progress to be made towards river rehabilitation, it is recommended that the LPMF give high priority to developing a whole river catchment-scale approach.

Traditional flood management is dominated by engineered flood alleviation schemes but there has been a big shift in national flood policy in recent years, away from a framework based on flood protection towards one based on sustainable catchment-scale flood risk management (White & Richards, 2007) allied with more sophisticated flood warning. A more holistic approach to managing flood risk is emerging, one which aims to continue to reduce the threat to people and their property while delivering the greatest environmental benefit. The main drivers for sustainable flood management techniques are the EU Water Framework and Flood Directives (EC, 2000; EC, 2007) and the resulting cross-Government programme Making Space for Water (Defra, 2009). The EA states that working with natural processes is now recognised as key to the delivery of successful flood risk management (Corbelli, 2007). The use of natural processes to reduce flood risk has been specifically discussed in the recent EU climate change adaptation green paper (CEC, 2007).

It is the significant developments in catchment management which have led to the wider acceptance of using a catchment approach to address flood risk management. For example, a study carried out within the Nant Pontbren Catchment, mid-Wales, illustrated that land use has a significant effect on surface water run-off, and hence erosion and sediment transfer, during flood events (Caroll *et al*., 2004). A comparison of an area recently planted with young trees and adjacent intensively grazed grasslands showed that changes in soil structure and root depths under woodland increase the soil water storage capacity and dampen run-off. This change occurs very rapidly after stock exclusion and tree planting (approximately 3–4 years); soil infiltration rates in the new woods were up to 60 times higher than in adjacent grazed pastures (Caroll *et al*., 2004; Henshaw, 2007).

Examples of land management measures now recommended as part of sustainable catchment-scale flood risk management include:

- Ensuring good soil structure in every field on the farm
- Avoiding directing runoff towards roads and watercourses
- Under-sowing spring crops
- Removing stock when soils are wet in high-risk fields to avoid compaction and poaching
- Establishing wetlands or runoff ponds
- Using grass strips or woodland belts to intercept water flows (EA, 2008).

Figure 3.2: River Cober below Helston, on National Trust property immediately after de-silting in 1998 (J. Dinsdale)

Figure 3.3: River Cober below Helston, on National Trust property immediately after bank safety works in 2008 (J. Dinsdale)

At present, legislation and the distribution of responsibilities are uncoordinated. There is great potential for agriculture to become part of the solution to flood risk management rather than being part of the problem. However, there are currently few institutional links between flood risk management and agriculture. Sustainable flood management schemes generally rely on the goodwill of landowners, who were under no legal obligation to consider downstream flooding (Kenyon *et al*., 2008). It is expected that future agricultural and water policies will combine in order to meet sustainable flood management goals. The provision of accessible and effective advice and education for farmers (and farm advisors) on flood management is now seen to be crucial (Kenyon *et al*., 2008).

Given the current policy and research situation, a two-pronged approach is recommended to reconcile flood risk management for Helston with the rehabilitation of the River Cober and Loe Pool. The ongoing, reach-based restoration activities should continue (section 3.4.2) and alongside the development of a whole river catchment initiative, based around the concept of assisted natural recovery.

Assisted natural recovery, requires that the recognised river restoration requirements and river habitat degradation problems are resolved at source as far as possible (Mainstone, 2007; Mainstone *et al*, 2008). Changing agricultural practices and land use to increase the absorbency of the entire catchment could serve to both alleviate flooding and reduce sediment and nutrient inputs to Loe Pool, creating a more stable sediment and chemical runoff regime within the catchment. Such an approach could help to alleviate the current symptoms in the lower reach of the River, and so permit deviation from the current engineered flood alleviation scheme in the long-term. These actions would make a significant contribution towards the LPCMP objectives and targets (section 2.1).

Such sustainable catchment-scale flood risk management would require widespread changes in farming practices to reduce flood peaks combined with a whole raft of small site solutions; selective changes in land use, scattered throughout the catchment. Working together, these changes in land management would to slow down the transportation of flood waters and make the whole catchment more water retentive. Many of these solutions could be delivered as part of a wider rural catchment initiative which includes a programme of farm advice (section 3.1)(Measure 1.4). Opportunities for funding could be sought from both agri-environment scheme and water quality and flood management budgets (Measure 1.4.2).

In the longer term, a coherent rural catchment initiative could contribute to wider climate change adaptation objectives, including safeguarding water quality, carbon storage, biodiversity and habitat conservation. Climate change predictions indicate that the need for integrated catchment management, to increase the resilience of catchments, wildlife and people to extremes of weather conditions such as floods, has never been greater (Mainstone *et al*., 2008). In this light, a rural catchment initiative is likely to present a more cost-effective option than the current end-of-pipe solution to flooding in Helston in the longer-term.

3.4.2 The Lower Reach from Helston to Loe Pool

The LPCMP Review 2003 recommended the development of a river floodplain restoration scheme for the lower reaches of the River Cober below Helston. This river restoration scheme included the development of an alternative management strategy for this section of the River Cober (Dinsdale, 2003).

It was expected that opportunities to progress this management measure would present themselves through the full review of the Helston flood alleviation scheme (from Lowertown to the Loe Bar outfall) proposed in 2003 (LPMF minuted meeting 18 June 2003). However, this flood alleviation scheme review was put on hold (LPMF minuted meetings 3 December 2003; 17 February 2006) and has not yet been commissioned (LPMF minuted meeting, 17 September 2008).

Some environmental improvements have been incorporated into the EA's river maintenance regime for the lower Cober since the last major river de-siltation in 1998. A revised river channel maintenance document was released in draft format March 2007 (EA, 2007b). The changes proposed by the EA within this document were generally welcomed by the Forum (LPMF minuted meeting, 18 June 2003) but a final version of the document has yet to be agreed between the EA, NT and NE. NE has not yet been given notice formally of the maintenance regime under section 28H of the Wildlife and Countryside Act. The NT and NE have been working with the EA towards a mutually beneficial end point, meeting regularly to discuss the review of River Cober maintenance and wider issues (LPMF minuted meetings, 18 June 2003; 3 December 2003; 18 September 2006).

A number of changes to the maintenance regime have brought, or are likely to bring in the near future, benefits to the quality of the riverine and riparian habitat within these lower reaches of the River. The last reach of the River (0-665m from Loe Pool; below the last footbridge and boardwalk) has seen substantial in-channel and bankside habitat improvements, created by trees and shrubs extending to the waters edge and reaching over and into the river channel itself. This natural recovery of the lowest reach of the watercourse has been assisted by the reduced frequency of de-silting and cutting of bank-side vegetation in recent years. The EA's (2007b) proposal to reduce the level of de-silting maintenance in the second reach (from 665m to 1150m from Loe Pool; downstream of the two-stage channel and predominantly on NT property and within the SSSI) is also seen as a very positive step forward.

There are a small number of additional alterations to the river maintenance regime which would further assist a natural recovery of the form and function of the lower reaches of the River, whilst operating within the confines of both the current Helston flood alleviation scheme and the current nutrient and sediment loads carried by the River (Measure 1.8.3). The next steps to take which would deliver best benefit to in-channel and bank-side habitat are:

1. **Ensure channel de-silting is kept to a minimum**. Within their draft maintenance plan, the EA propose to maintain de-silting, cutting vegetation and clearance of trees and debris close to Zachary's Bridge (third reach, 1150m to 1650m from Loe Pool; within and directly adjacent to the CC amenity area), but reduce active maintenance on NT land. The river nearer Loe Pool will become relatively undisturbed: within the lower reach (0m to 665m from Loe Pool) river bed levels will be allowed to increase to 0.4m above 1988 design levels; and within the second reach (665m to 1150m from Loe Pool) the river bed levels will be allowed to increase to 0.2m above 1988 design levels (EA, 2007b). These limits will mean that the EA may not have to remove silt for some years over these two lower reaches and the reduced de-silting frequency will assist the restoration of habitat stability and permit habitat recovery.
2. **Allow and encourage the establishment of tree cover on both bank sides within the second reach** (665m to 1150m from Loe Pool). This presents a potential point of conflict with the draft River Cober maintenance plan. Over-hanging tree canopies would enhance the river habitat quality, shade the watercourse and lower water temperature in the summer and tree roots would improve bank stability (Haycock & Vivash, 1999; Skinner, 2005). Flood risk modelling has illustrated that increased 'roughness' of this section of the river (with roughness defined as the growth of long grass or reeds, scattered saplings and vegetation) has no effect on flood risk upstream of the A394 County Bridge (EA, 2007b). However, the EA aim to continue to cut back woody vegetation on the right bank

3. **Retain woody debris in stream where this does not increase flood risk**. The importance of woody debris to the healthy functioning of freshwater ecosystems is becoming increasingly recognised, with benefits including: stabilising river banks and beds by resisting and deflecting flows, adding habitat complexity to the channel, and enhancing the process of change in channelised rivers and their floodplains (Mott, 2005; Sear, 2007). Woody debris has traditionally been seen as a nuisance and woody debris dams are often still referred to as 'blockages', however, research has shown that the flood impacts of both large woody debris (entire trees, large limbs and branches) and coarse woody debris (accumulation of smaller branches, twigs and leaf litter) have often been misunderstood or exaggerated in the past (Mott, 2005; Sear, 2007). Despite the installation of additional litter screens and improved street cleaning in Helston (section 3.3.2), the accumulation of litter (including plastic bags, cans, bottles) in association with the woody debris within this watercourse remains a potential issue (Operations Delivery Technical Support, EA, comment on Draft, 5 May 2009). Awareness of this issue could be raised within the Town as part of the community education programme (Measure 1.5.1).
4. **Allow natural river processes, including bank erosion, to develop unhindered**. As an interim measure, low willow 'fences' have been put in place around the collapsing sections of riverbank (Figure 3.3). These are considered to be an ideal solution, improving public safety by guiding pedestrians around the edge, increasing bank-side tree cover but not restricting natural river processes.
5. **Continue to seek Local Nature Reserve (LNR) designation** (Measure 1.8.5). CC continues to lead on the creation of a LNR, working in partnership with HTC (LPMF minuted meeting, 13 May 2005; LPMF minuted meeting, 9 September 2005). It is recommended that this action continues to be progressed following the formation of the new unitary authority in April 2009.

It is considered that these recommended additional alterations to the river maintenance regime are unlikely to have an impact on flooding in Helston (see EA, 2007b). The EA have investigated the impact of a variety of different factors on flood levels, including channel bed level, growth of vegetation and size of channel. It has been demonstrated that flood levels in Helston, upstream of the A394 County Bridge, are relatively insensitive to change within the River Cober bed and channel where it flows through the willow carr habitat on NT property, but more sensitive to changes closer to Zachary's Bridge. The reason given for this is that a significant proportion of the flood flow is carried, albeit slowly, through the carr (EA, 2007b).

It is recommended that the NT consider adopting their riparian owner's management rights along the lower Cober, and take responsibility for vegetation cutting along the first and second reaches (from 0m to 1150m from Loe Pool). With NT staff based within the Penrose Estate, they may be in a better position to deliver the more sensitive vegetation management required to facilitate the River's assisted natural recovery.

There is a long documented history of the desire to see improved connection between the river channel and the river floodplain (Wilson & Dinsdale, 1998; Haycock & Vivash, 1999; Dinsdale, 2003). Within a natural river system the silt and nutrients carried by a river in flood are deposited within the river's floodplain. Reconnection of the River Cober's floodplain to its channel would allow these natural processes to be restored and this could deliver substantial water quality improvements for Loe Pool. However, such use of the floodplain's ecosystem services must be sustainable in the longer term.

The gross levels of silt and nutrients carried by the River in flood, and the potential impact of directing these into the Loe Valley willow carr have been a concern in the past (Dinsdale, 2003). Proposals to release flood water from River Cober channel into the Loe Valley willow carr were put on hold in 2003 until P-stripping at Helston STW was in place (Dinsdale, 2003). Following the installation of P-stripping plant at the STW, the water quality of the River Cober, and particularly the level of sediment carried, continues to be of some concern. When released into the willow carr, the river water may have an impact on the habitat quality and ecosystem services provided by the carr. The high nutrient status of the river flood waters (see section 3.1) is likely to encourage the growth of ruderal species such as nettle (*Urtica dioica*), broad-leaved dock (*Rumex obtusifolius*) and hemlock water-dropwort (*Oenanthe crocata*). The high silt content may affect flood storage capacity; increasing silt levels across the carr by 0.4m would be likely to have a significant impact on flood risk in Helston (EA, 2007b). However, taking this into consideration, it remains highly desirable from a nature conservation prospective to re-wet the carr (J. Lister, NT Regional Nature Conservation Advisor, pers. comm.).

Skinner (2005) put forward a recent proposal to lower short sections of the riverbank and allow flood flows to pass out into the floodplain, in order to trial the re-establishment of river and floodplain interactions. This proposed location for this trial is very close to the mouth of the River Cober, where the carr is already in close hydrological links to the lake (see Barrett, 2000). In order to inform future management, it is recommended that this proposed trial is drawn up in full and implemented (Measure 1.8.1). The local impacts upon the willow carr, in terms of sediment deposition and vegetation response, should be measured and comparisons drawn to control sites.

The environmental outcomes for the WFD RBD Management Plans include reducing the environmental impact of flood defence schemes and river maintenance regimes. The actions prescribed to deliver this outcome in the South West include increasing habitat morphology and diversity and improving connection between rivers and their floodplains. This project will therefore contribute towards the SW WFD targets (Measure 1.11.6).

3.5 Water Level Management

Adopting a water level regime that provides an extensive seasonal drawdown zone around the margins of the Pool is critical for the re-establishment of submerged vegetation, and hence for successful lake rehabilitation.

Six years of EA water level (WL) data indicate that the current water level management plan (WLMP) is delivering a narrow annual WL range, generally less than 1.5m (3.5m AOD – 5.0m AOD). However, there have been issues regarding the accuracy of this water level recording. A review of the current WLMP is now overdue.

3.5.1 Review of the WLMP

There is continued concern regarding the current lack of intra-annual (seasonal) water level (WL) fluctuations within Loe Pool. A summer drawdown zone is considered to be critical for the successful rehabilitation of the Lake. The extent of established macrophyte beds within Loe Pool remains pitifully low (section 3.6) and successful lake rehabilitation relies heavily upon the re-establishment of submerged vegetation (Moss, 1990; Jeppesen *et al*., 1990; Meijer, 2000; Jeppesen, 1998; Phillips, 2005). An increased drawdown zone would increase the extent and quality of habitat for macrophytes (Figure 3.6). 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 (section 2.4).

The current official WLMP for Loe Pool was proposed in 1998 and comprises a set weir level of 3.8m above ordnance datum (AOD) during the winter months and a lower level, 2.75m AOD, during the summertime (Halcrow, 1998). While this WLMP remains the official plan, it has in fact never been implemented; largely due to concerns that this plan did not encompass sufficient information to make firm management decisions (see Dinsdale, 2003). The National Trust sought a revised WLMP in 2000 and this document recommended the Loe Bar outlet weir level be permanently set to 3.5m AOD (Haycock, 2000). It was estimated that given variations in river flows this would sustain a littoral edge without the need to manage summer and winter levels artificially; a fluctuating mean WL in the order of 3.7-3.8m AOD was predicted. The Haycock (2000) revised WLMP was implemented in October 2001, by fixing metal plates to the outlet weir, raising the outlet level from the previously adopted level of 3.05m AOD to 3.5m AOD (Rule, 2002).

Telemetred recording of WLs within Loe Pool is currently undertaken every 15 minutes from within the NT boat house (SW6460025600). Historically, data were recorded less frequently; however, a daily mean water level data set is almost complete for the period January 1998 to January 2003, with only occasional weeks missing. On 1 January 2003 the telemetry was flooded and destroyed. Replacement telemetry was installed in 2004 but this equipment was not functioning correctly and produced erroneous data for the period 2004 to 2006 (W. Hancock, Hydrometry and Telemetry, EA, pers. comm.). This issue has only recently come to the attention of the Forum and unfortunately there are now no water level data available from the period January 2003 to November 2006. The boathouse telemetry is now functioning (LPMF Lake and Lower Cober Task Group minuted meeting, 18 June 2009).

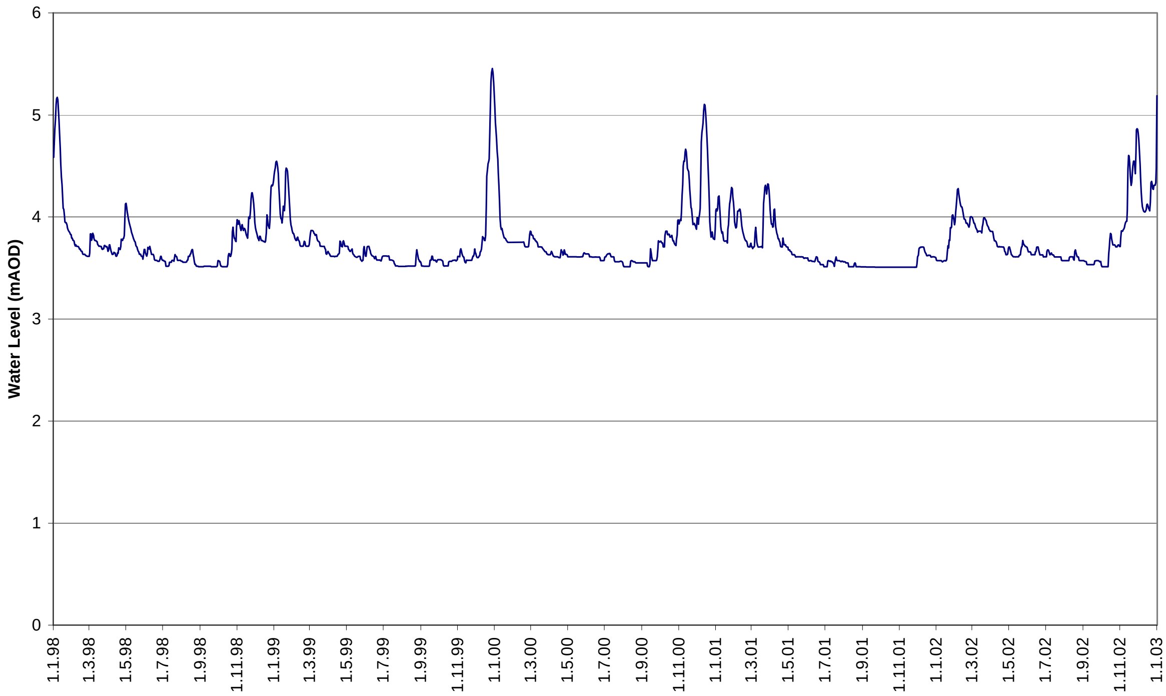


Figure 3.4: Loe Pool average daily water level readings Jan 1998 to Jan 2003 (EA data)

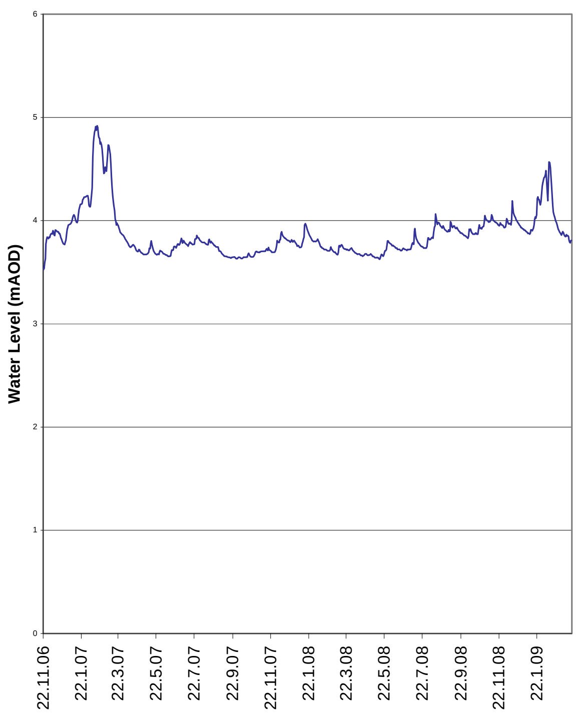


Figure 3.5: Loe Pool average daily water level readings Nov 2006 to Mar 2009 (EA data)

The remaining water level data shown in Figures 3.4 and 3.5 have been verified and calibrated to OD (W. Hancock, Hydrometry and Telemetry, EA, pers. comm.). The main observations from Figures 3.4 and 3.5 are as follows:

- The mean WLs are within the range predicted by the adopted WLMP (Haycock, 2000) (3.7 – 3.8m AOD). The intra-annual (seasonal) water level fluctuations are generally in the range 1.0 to 1.5m; from a base level of 3.5 mAOD up to an annual maximum of 4.5 mAOD, or on occasional years, 5.0 mAOD.
- The recorded water level data exhibit no response to the implementation of the current WLMP in October 2001. This is unexpected and must be erroneous. It is suggested that that the telemetry may have minimum recordable water level (of approximately 3.5m), and that when lake water levels drop below this level recorded levels flat-line. This theory is supported by the fact that the bottom of the telemetry housing is located at 3.438m AOD (W. Hancock, Hydrometry and Telemetry, EA, pers. comm.).
- Due to these unresolved issues with the water level recording, it is not possible to state with confidence the range of seasonal water level fluctuations experienced under either the current WLMP (3.5 mAOD) or the previous water level regime (3.05 mAOD).

Figure 3.6: Drawdown zone in Carminowe Creek during summer 1999, under the previous WL regime (J. Dinsdale)

The 2003 LPCMP Review recommended a WLMP review programme, in order to evaluate the success of the WL management of Loe Pool and to ensure any necessary adjustments are undertaken. The first review of the WLMP was scheduled for 2006, five years after implementation of the current plan (Dinsdale, 2003). This review of the WLMP is over due.

Changes in WL management may affect both lake and floodplain communities; regular long-term monitoring of the littoral, carr and macrophyte communities were recommended to inform any future adjustments to the WLMP (Wilson & Dinsdale, 1998). Two repeat littoral surveys were undertaken (Stewart 2000; 2003). Five repeat surveys of the inundation and macrophyte communities have been undertaken and these plant communities are now surveyed annually (Stewart, 2000; 2003; in prep.; Dinsdale, 2007; 2008). In addition to these floral surveys, the macro-invertebrate fauna of Loe Pool and its feeder watercourses was surveyed in 2003 (Knight, 2003) along with the littoral invertebrates (Alexander, 2003).

Historic shoreline flora data indicate the presence of a summer draw down zone at Loe Pool (N. Stewart, Botanical Consultant, pers. comm.) and both the existing inundation/benthic plant communities and the macro-invertebrate communities would benefit from an increased area of seasonally inundated shore (Stewart, 2003; Alexander, 2003; Knight, 2003; Dinsdale, 2007; 2008). In the absence of significant algal blooms within Loe Pool, the inundation vegetation would benefit from a number of months out of the water during the summer months. Some of the species within the inundation community, including the nationally scarce Six-stamened Waterwort, do not flower beneath the water (Stace, 1997). *L. uniflora* can tolerate extreme inter-annual fluctuations in WL and long periods of exposure (NE, 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).

A review of the current WLMP is therefore recommended, to be undertaken in 2010 (Measure 1.6). It is recommended that the WLMP review should consider options to instate greater intra-annual fluctuations in WL. One option proposed for consideration is to lower the summer water level to 3.05m AOD and retain winter levels at the current 3.5 AOD. The penstocks within the Loe Bar outlet structure were overhauled in 2009 and the penstocks now have the capacity to deliver this two-tier proposal (K. Barnes, Technical Support Team Member, EA, pers. comm.).

Using bathymetric data collected by Mason Survey in March 2000, Haycock (2000) calculated that the current normal range of water level (approximately 3.5 to 4.1 mAOD) will expose 7.6 ha of littoral edge. These calculations can be extrapolated to predict that a winter 3.8m AOD and summer 3.5mAOD would increase the littoral shore by up to 2.95 ha, giving a total littoral area of 11.4 ha. This extended drawdown zone would benefit of both the plant and the macro-invertebrate communities and would be consistent with the Natural England Conservation Objectives for the site (NE, 2009).

In order to inform the WLMP review process, there is a need to ensure continuous and accurate WL recording (Measure 1.6.1). The full range of lake water levels (i.e. including those levels below 3.5m AOD) should be recorded accurately and scrutinised regularly so that any errors occurring cannot persist in longer term. New telemetry recently installed at the Loe Bar outlet may facilitate this recording process.

The proposed two-tier WL management option would have positive implications for water quality; the summer residency time of water in the lake would be reduced, thus reducing the availability of nutrients to the Lake's biota. The proposal would not impinge on the current Helston flood alleviation scheme.

Under this two-tier WL proposal, there may be a need to accept some vegetation succession and drying of the reed and carr communities (see Haycock, 2000). There are opportunities to mitigate this, at least in part, through work to reconnect the River Cober with its floodplain (section 3.4.2) and through the re-introduction of light stock grazing to sections of the lake shore (Measure 1.9.3). Haycock (2000) stated that allowing the weir to operate a 3.05-3.25m AOD invert (i.e. the current concrete shelf of the outflow structure) would avoid saline intrusion under the (then) current sea level rise scenarios or under high surge tides. The risk of saline intrusion would need to be revisited employing current sea level predictions (as part of Measure 1.6).

There have been concerns in the past regarding the accumulation of shingle and the extension of a shingle spit close to the outlet structure. The EA do not currently consider this feature to be affecting flood risk upstream (K. Barnes, Technical Support Team Member, EA, pers.comm.). Shingle and sediment should not be removed from this location without due cause as it assigns increased habitat diversity to the system (Skinner, 2005).

All licensed water abstraction from Loe Pool came to an end in October 2009. The previous abstraction licences for Lower Nansloe Farm (1413m^3day^{-1}), Higher Pentire (796m^3day^{-1}) and Degibna & Lower Pentire (616m^3day^{-1}) were revoked at the holders request. Small unlicensed abstractions may still be in operation; these will be less than 20m^3day^{-1}.

3.5.2 The Geomorphological Evolution of Loe Bar

The maintenance of Loe Bar is considered to be integral to the habitat value of the Bar and Loe Pool as a freshwater system (Wilson & Dinsdale, 1998).

The impact of projected rising sea levels and the gravel extraction operation at Gunwalloe on the stability of the Bar have both been long term concerns (LPMF minuted meetings, 1998-2002). Gravel extraction at Gunwalloe no longer presents a threat; the extraction came to a natural end in 2007, when the operator retired (LPMF minuted meeting, 19 September 2007). Rise in sea level is confidently expected to occur with global warming, although the development of projections of its extent in the 21st century has proved problematic, owing particularly to uncertainties about the rate and scale of ice-cap melting (IPCC, 2007).

In 2002, the EA commissioned Posford Haskoning to undertake a geomorphological study of Loe Bar, in order to describe and predict the likely geomorphological developments of the Bar and the implications for the management of Loe Pool. In 2004, English Nature (now part of NE) commissioned Professor Julian Orford of Queeen's University Belfast to carry out a peer review of Posford Haskoning's 2003 Geomorphological Report.

The two reports show some similarities but also some differences in their predictions for the future of the Bar. Postford Haskoning (2003) conclude that the longshore sediment supply is adequate to maintain the Bar for 80 to 300 years so that, taking projected sea-level rise into consideration, it is unlikely to breach naturally during this period. Analysis of limited historic map data suggests that the seaward side of Loe Bar has remained relatively stable over the last 100 years while, in contrast, the back-barrier zone (landward side) has increased in area at an average rate of 0.9myr^{-1}. (Posford Haskoning, 2003). Orford (2004) agrees that the transport of material is longshore, largely in a south-easterly direction with an occasional reversal of the dominant sediment transfer during easterly storms. However, the assumptions on which the future predictions for the development of the Bar were based are brought into question. Orford (2004) concludes that there is currently insufficient information on the sediment body and the forces upon it to permit any definitive analysis of the historical or future development of Loe Bar.

3.6 Biomanipulation and the Lake's Biotic Structure

Biomanipulation can be a very powerful tool for the management of shallow eutrophic lakes. Reduction of the nutrient load from the catchment is an important prerequisite for biomanipulation success. To invoke a stable clear-water state within Loe Pool, TP concentrations should be reduced to $<50\mu gl^{-1}$. Addressing nutrient inputs to Carminowe Creek is a priority, as relict mesotrophic communities persist and have potential to expand here. Zooplankton and perch gut content surveys are required to inform any future biomanipulation. Water level management should be reviewed in order to improve habitat conditions for macrophytes.

During the development of strategies for rehabilitating lakes affected by eutrophication, emphasis has gradually broadened from solely controlling point sources of P inputs, to more comprehensive and ecosystem-based approaches (Hosper *et al*., 2005).

Biomanipulation, the manipulation of a lake's food chain, has been heralded as a powerful tool for the management of eutrophic lakes (Moss *et al*., 1996). In their extensive reviews of lake restoration and rehabilitation projects employing biomanipulation, Mehner *et al.* (2002) and Hosper *et al.* (2005) suggest criteria for selecting lakes in which biomanipulation is likely to bring about a stable clear-water state.

While Loe Pool is close to the appropriate depth range and profile for biomanipulation success, TP concentrations are currently considered to be too high. Results from multilake studies suggest stable clear water with Secchi-disc depth >1m can be expected at TP $<50\mu gl^{-1}$ (Hosper *et al*., 2005). For large lakes such as Loe Pool, both clear and turbid waters are found at TP concentrations of 50-100μgl^{-1}, and it is tentatively concluded that alternate stable states may be expected within this range of TP concentrations (Jeppesen *et al*., 1990; Hosper *et al*., 2005). Loe Pool average annual TP concentration at the outfall is currently within this range (60-85μgl^{-1}; Figure 2.1), while the average Secchi-disc depth is currently approx 1.4m (Dinsdale, 2008; Dinsdale, 2009). Further work to reduce nutrient inputs is therefore required before turning to biomanipulation techniques.

While continuing to address nutrient inputs during the next reporting period (2009-2014), it is important to gain a better understanding of the structure of the Lake's biotic community. It has been shown consistently that poor biotic structure and functioning in lakes with abundant algae contributes to their resistance to recovery, even after their external P loading has been reduced (see Hosper *et al*., 2005). A better understanding of the biotic structure of Loe Pool is required to inform future management towards attaining a stable, macrophyte dominated, clear-water state.

The WFD Programme of Monitoring is expected to provide much of the ecological data required (Table 4.1). This section provides a brief overview of the results of current monitoring of the main taxonomic groups, with an aim to identifying any additional survey, research or monitoring requirements.

(i) Fish

Anecdotal evidence suggests that historically Loe Pool supported a poor diversity of fish species, but a reasonable sized population of trout (Wilson & Dinsdale, 1998). Eutrophy does not favour trout (Winfield, 2004), but a small population of healthy trout (*Salmo trutta*) does persist and is maintained by natural spawning within the River Cober. Coarse fish are currently present in much larger numbers and perch (*Perca fluviatilis*) predominate, outnumbering trout 4:1 and 16:1 (EA fish survey data, 1998, 1999, 2006; 2007; NT Angling Catch Return Cards, 2003-2008). Rudd (*Scardinius erythrophthalmus*) and roach (*Rutilus rutilus*) are also present.

The NT aims to maintain the wild trout fishery in Loe Pool supported by natural spawning and continues to collect Loe Pool Angling Catch Return Cards, completed by each permit holder fishing the lake during the open season (1 April and 30 September). These data are very useful and anglers should be encouraged to accurately record the information as requested. Analysis of the Catch Return Cards appears to suggest that the trout population continues to dwindle. A total of 19 trout were caught during the period 2003 to 2008, with an average of 9 hours of fishing effort expended per trout caught. Similar angler records from the 1970s show 3 to 5 trout caught per hour, and in the 1990s 4-5 hours fishing effort was required to catch one trout (Wilson & Dinsdale, 1998). The average size of fish caught in 2003-2008 was also smaller than previous. The average Fork Length (FL) of the trout caught during the period 2003-2008 was 21cm; the largest individual caught had a FL of 40cm and weighed 2lb. Although the anglers focus their efforts and techniques on catching trout, a total of 75 perch and 18 rudd were caught during the five year period. This suggests these coarse fish species are both present in large numbers (Figure 3.7). The rudd and perch caught were generally small (average FL 21cm; 25cm respectively) , however, two very large perch FL 43 cm (3lb 10oz) and FL 47cm (3lb 15oz) were caught. The impact of angling on the sustainability of the trout population is not currently considered to be significant; the majority of the fish caught were returned to the lake, with only 3 trout taken over the five year period.

Figure 3.7: Large shoal of coarse fish within lower reach of River Cober, November 2007 (West Briton)

Changes in the fish community structure, as a result of the deterioration of the water quality, are likely to have contributed to the imbalance between zooplankton and phytoplankton, and hence to the magnitude of the algal blooms in the Pool. If biomanipulation is required in order to trigger a switch from the current turbid-water state to clear-water conditions, then manipulation of the fish community to promote to a perch population dominated by large piscivorous individuals by reducing the number of small planktivorous perch would be a likely technique. The relative density of piscivorous to planktivorous fish is of critical importance to lake rehabilitation success (Philips, 2005).

The 2003 management action to implement a programme of fish surveys of Loe Pool to estimate population sizes will be fulfilled by the WFD Monitoring Programme which includes both quantitative (hydroacoustic) and taxonomic surveying (seine netting)(Table 4.1). Two remaining actions from 2003, to design and carry out a survey of perch gut content and to assess the quality of trout spawning beds in the River Cober, were not progressed during the reporting period 2003-2008. The analysis of perch gut content study to elucidate dietary proportions of fish fry, macroinvertebrate and zooplankton species will be required to inform biomanipulation techniques in future years. It is recommended that these two actions are carried forward to 2009-2014 be undertaken as undergraduate or postgraduate projects (Measure 1.10.3).

(ii) Birds

Loe Pool is a significant ornithological site (NE, undated). Numbers of shoveler (*Anas clypeata*) and, more recently, pochard (*Aythya farina*) have reached nationally important numbers (BTO, 2003-2008). Aggregations of non-breeding birds are one of the Features of Interest of the Loe Pool SSSI and therefore the Conservation Objective includes targets for this feature (see NE, 2009). It is generally accepted that over-wintering populations of birds are not particularly sensitive to eutrophication (cited in Mainstone *et al*., 2008); and this appears to be the case for Loe Pool, where population number have not shown any affects (Wilson & Dinsdale, 1998).

The grazing pressure exerted on macrophytes by large population of waterfowl is frequently an issue during the reversal of eutrophication (Hosper *et al*., 2005). The development of extensive macrophyte beds is crucial for maintaining clear water in lakes and previous studies have shown that the short term exclusion of grazing birds from small areas can improve macrophyte establishment and hence lake recovery. A student project to investigate the impact of bird grazing on the establishment and growth of macrophytes could be very informative (Measure 1.10.3).

(iii) Macrophytes

The extent of established macrophyte beds within Loe Pool remains pitifully low (Stewart 2000, 2003, in prep.), and successful lake rehabilitation relies heavily upon rapid re-establishment of submerged vegetation (section 2.4)(Moss, 1990; Jeppesen *et al*., 1990; Meijer, 2000; Jeppesen, 1998; Phillips, 2005).

The SSSI Conservation Objective for Loe Pool includes a list of characteristic species of oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Iseoto-Nanojuncetea (NE, 2009). The Conservation Objective sets specific macrophyte community composition targets for 2010, which comprises at least 3 species of Potamogeton sp characteristic of the community type, 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. Loe Pool needs to see a substantive improvement to macrophyte communities in order to meet these targets. The 2008 macrophyte survey sampled 60 locations along transects across the Pool, only one species of macrophyte was recorded at a single location, and this was the non-native water lily, *Nymphaea alba.*

The priority management activity to deliver improvement to the extent and quality of potential habitat for macrophyte re-establishment is the reduction of nutrient inputs to Carminowe and Chyvarloe Streams. This includes both the point source RNAS Culdrose STW and point and diffuse agricultural water pollution from NT tenant farms (Measures 1.2 and 1.9.1). These streams discharge directly into Carminowe Creek, where relict vegetation communities characteristic of mesotrophic standing waters are currently located. This arm of the Lake has been subject to less historic disturbance than the main Cober arm to the north. Stony stable substrates predominate here, in contrast to the fine silts within the Cober arm which are unstable and less suitable for rooted plant growth. Recovery of the macrophyte population is therefore most likely to commence in Carminowe Creek. The pattern of establishment of Nuttall's waterweed during 1999-2006 supports this supposition.

It is also suggested that additional in-lake management strategies are required to encourage macrophyte re-establishment around the periphery of the Pool. Greater seasonal fluctuations in WLs would help to increase the extent and quality of potential habitat for macrophyte re-establishment and help to control current expansion of reed beds (*Phragmites australis*) (section 3.5.1) (Measure 1.6.2). Further development of shoreline trees and shrubs around Carminowe Creek would be detrimental to macrophyte inundation communities and littoral invertebrates (Stewart, 2003; Alexander, 2003) and should be controlled (Measure 1.9.2).

As sources of nutrient inputs to Loe Pool continue to be abated and the nutrient status of Loe Pool is lowered, the Lake is likely to enter a period of alternating stable states, fluctuating between an algal dominated turbid-water state and a macrophyte dominated clear-water state (Phillips, 2005; Moss *et al.,* 1996). During this time, plant populations, both algae, free-floating and rooted macrophytes are likely to exhibit large population fluctuations, boom-and-bust cycles. This has already been evident in populations of both Nuttall's waterweed and water net (Stewart, 2000, 2003, in prep; Dinsdale, 2007, 2008). Nuttall's waterweed was recorded in Loe Pool for the first time in 1999 (Stewart, 2000). It increased dramatically to 2006 (Stewart, 2003, in prep.) and then the population crashed in 2007 (Dinsdale, 2007, 2008). The species may exhibit a population boom again in the near future and its presence is an accepted part of the current transitional flora of Loe Pool (Dinsdale, 2003). Further information on water net is provided later within this section, under (vi) phytoplankton.

Prevention of the spread of highly invasive non-native species to the Pool is a high priority, since removal once they are established will be very difficult and expensive. This is particularly important during the restoration of the Lake, when improving water quality and transitional community structures are likely to provide openings for their establishment (Measure 1.8.6).

This does not extent to some less invasive non-natives, such as Nuttall's waterweed, but does include parrot's feather (*Myriophyllum aquaticum*), which was found to be present in the lake complex which forms part of CC amenity area (LPMF minuted meeting, 15 January 2003). The mechanical control of this non-native aquatic species in the amenity lakes has been undertaken regularly since 2002, with the use of herbicides limited to follow-up spot treatment. The former district council installed grilles to hydrological links from these amenity lakes and Coronation Lake to the River in order to safeguard Loe Pool from future introductions (LPMF (sub) meeting minutes, 29 November, 2006). The NT considers that this action has been successful to-date, and the species has not been recorded in any abundance (Stewart, 2000, 2003; Dinsdale, 2007, 2008). Infrequent, small amounts of parrot's feather do occur and are removed by NT wardens.

Stithians Reservoir in the adjacent catchment to Loe Pool has been seen to support a large population of *Crassula helmsii*. Cross-catchment transfers of water from Stithians Reservoir are used to supplement drinking water supplies to Helston during times of low flow in the Cober. The potential for introduction of this and other invasive aquatic species from the Reservoir to Loe Pool has been discussed (LPMF minuted meeting, 9 September 2005). This is not considered to be an issue as this water is pre-treated at Stithians and is piped directly to storage tanks at Wendron.

The current programme of annual macrophyte surveys is adequate to record changes in native and non-native plant population and should continue (Measure 1.10.2). This is now supplemented by a broader three-yearly survey undertaken as part of the WFD Monitoring Programme (Table 4.1).

(iv) Macroinvertebrates

Historically, there appears to have been little interest in the aquatic invertebrate fauna of Loe Pool (Wilson & Dinsdale, 1998). From his study of 1899 to 1901, Vallentin (1903) reports a diverse community of Copepoda, Ostracoa and Cladocera but in general terms he did not find 'the littoral fauna to be at all rich in any portion of the lake; indeed it is rather scarce'.

A study by the NHM produced a database on the major groups of macro-invertebrates for the period June 1995 to March 1996 (John *et al.*, 1998). Detailed baseline aquatic macroinvertebrate and littoral invertebrate studies were commissioned by the NT in 2003 and found the Loe Pool invertebrate population worthy of conservation interest and only 'slightly' impacted by the nutrient enrichment (Knight, 2003; Alexander, 2003).

Six Nationally Notable species were recorded in 2003; while most of these species were recorded at a low frequency within the site, the riffle beetle *Oulimnius troglodytes,* was fairly widespread around the pool and abundant at a number of locations along the shore (Alexander, 2003; Knight, 2003). Four species of gastropod were recorded, with *Potamopyrgus antipodarum* relatively abundant (John *et al.,* 1998; Knight, 2003).

Recommencement of livestock grazing along the lake margins is necessary to conserve shoreline invertebrates; stocking levels should be set to deliver light poaching and browsing along some silty shore sections (Alexander, 2003; Davey, 2007) (Measure 1.9.3).

The aquatic macroinvertebrate community is not currently of concern and is likely to respond relatively slowly to water quality improvements (Knight, 2003). The WFD Programme of Monitoring for Loe Pool does not include macroinvertebrate surveys (R. Hillman, Technical Specialist Ecological Appraisal, EA pers. comm.; Table 4.1). Consideration should be given to repeating the 2003 aquatic invertebrates Predictive System for Multimetrics (PSYM) survey in the next planning cycle 2015-2019 (Measure 2.3.1). Analysis of the results of the repeat survey, along with the 2003 data (Knight, 2003) would provide a PSYM Index score in order to measure progress towards one of the Loe Pool End Targets (section 2.1).

(v) Zooplankton

The phytoplankton-zooplankton interface in a eutrophic lake is a critical place, changes in zooplankton community may drastically alter the quality of the water, having implications for the ecological status of the water body. The legacy of metalliferous mining within the Cober Catchment may present specific issues for Loe Pool; toxic effects on zooplankton communities from exposure to a mixture of heavy metal cations have been associated with elevated levels of phytoplankton biomass due to reduced grazing (Jak, 1997). The establishment of a stable clear-water state will be problematic if viable populations of grazing zooplankton are inhibited by heavy metal ingress to the Pool (Pokorný & Květ, 2004; cited in Olosundé, 2002).

Vallentin (1903) reports a diverse zooplankton community during his study from 1899 to 1901. A NHM study by the NHM produced a database on the major groups of zooplankton for the period June 1995 to March 1996. Some zooplankton taxa were recorded in abundance; with peak population numbers of nauplii and calanoids occurring during the optimum growth phase of water net. In a brief undergraduate study, Jackson (2001) considered the zooplankton of Loe Pool to be extremely impoverished, having identified only two small cladoceran (water flea) species. The results of this taxanomic survey cannot be taken to be conclusive but the same student research project also found water taken from Loe Pool restricted the growth and development of *Daphnia pulex* when compared to controls (Jackson, 2001). Daphnia are known to be excluded from many eutrophic lakes (Gliwicz, 2004).

Repeat surveying of the zooplankton community is recommended (spring, summer autumn), to ascertain full annual community composition, which can be very seasonally variable within eutrophic lakes. The survey should record species diversity and estimate population sizes, in order to elucidate the current community structure. Reporting should include likely population limiting factors (metals or other pollutants, predators, food), and the potential for large bodied zooplankton species populations to expand and exert grazing pressure on the dominant species of phytoplankton (Measure 1.10.2).

(vi) Phytoplankton

Control of algal blooms is a critical element of eutrophic lake rehabilitation, both to prevent further P release from the sediments under the reducing conditions found in the presence of algal blooms (Olosundé, 2002) and to enable the stabilisation of a macrophyte dominated clear-water state.

The macroalga water net (*Hydrodictyon reticulatum*) has been present in Loe Pool since 1989, and reached nuisance levels in 1993 (Florey & Hawley, 1994)(Figure 3.8). Unfortunately, a long-term monitoring programme has not been in place and the Loe Pool Forum have to rely on casual observations of the floating surface mats to indicate that water net was prolific over large areas of the lake each year from 1993-2006 (e.g. Geatches, 1997; Knight, 2003; Stewart, 2000, 2003, in prep.; Wilson & Dinsdale, 1998; A. Cameron, NT Property Manager, pers. comm.; S. Bury, NT Warden, pers. comm.).

Water net was not evident within Loe Pool during 2007 or 2008. There were no reported observations of floating surface mats (S. Bury, NT Warden, pers. comm..; A. Cameron, NT Property Manager, pers. comm); the alga was not observed during the macrophyte surveys conducted in early September (Dinsdale, 2007, 2008); and Loe Pool Angling Catch Return Cards for the open season (1 April and 30 September), which request an evaluation of water conditions, showed no record of turbid water 2007 or 2008. In all previous years 2002-2006, algal blooms were noted to be a nuisance and prevented anglers from fishing on numerous occasions.

The Loe Pool population of the macro-algae may have been in decline in recent years. In 1994, 1995 and 1996 healthy surface floating mats of water net appeared towards the end of May and persisted until August (John *et al.*, 1998). In 2003 the first surface mats were reported to have appeared slightly later (NE, 2004), but were evident by late-June (Knight, 2003; A. Cameron, NT Property Manager, pers. obs.). In 2004 and 2005, the blooms appeared later than in previous years but continued to be extensive (LPMF minuted meeting, 9 September 2005).

Figure 3.8: Water Net (*Hydrodictyon reticulatum*) 1998 (J. Dinsdale)

It would be useful to elucidate the reasons behind this apparent decline of water net, not least in order to predict the likelihood of future blooms within the Pool. The most likely causes are considered to be nutrient availability, climatic factors or grazing pressure.

Loe Pool has seen a very significant decline in P concentrations since 1997 (section 2.3; Figure 2.1) but the decline in water net is unlikely to be a direct response to reductions in P loadings. During studies in NZ, no relationship was observed between the health of water net populations and P concentrations (Hall & Cox, 1995; Wells & Clayton, 2001). One lake in NZ where water net bloomed had extremely very low nutrient inputs, with PO_4 less than $3\mu g l^{-1}$.

It is clear that the availability of N is not currently limiting the growth of water net within Loe Pool. Water net has a relatively low requirement for N in comparison to other filamentous algae species (Hawes & Smith, 1993; Hall & Cox, 1995; Hall & Payne, 1997). In contrast to P, N levels in the Pool have remained relatively stable in recent years; Total Inorganic Nitrogen (TIN) levels are consistently around $4{,}000\mu g l^{-1}$ in June each year (EA data: 1997-1998, 2005-2008).

Water temperature does not explain the absence of water net in 2007 and 2008. Small colonies are evident in Loe Pool when water temperatures reach 14°C (John *et al*., 1998); this temperature was attained during May in 2005, 2006 and 2008 and slightly earlier in April 2007 (Figure 3.9).

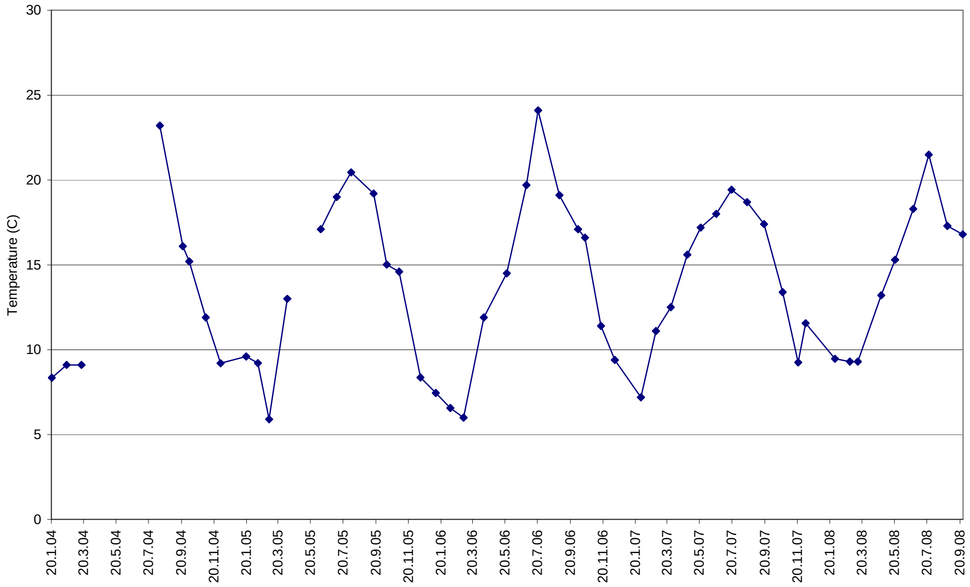


Figure 3.9: Loe Pool monthly water temperature reading at Loe Bar outfall 2004-2008 (EA data)

There is no information available on invertebrate grazing of water net in Loe Pool. There was no direct evidence to indicate that Hydrodictyon mats provide a refuge for macro-invertebrates, but molluscs are particularly common within the mats (John *et al*., 1998). An undergraduate or post graduate research project could provide useful information (Measure 1.10.3).

The environmental factors controlling growth of water net have received much attention and research funding in NZ after the alga became a serious problem in lakes there (e.g. Hawes & Smith, 1993; Hall & Cox, 1995; Wells *et al*., 1994; Wells *et al*., 1999; Wells & Clayton, 2001). Despite this enormous effort, researchers were not able to identify a likely cause which fit the observations (Wells *et al.*, 1999). Annual blooms of water net naturally receded within the study waterbodies after 5-10 years (Wells & Clayton, 2001) and while the species remains present in NZ, and its range is expanding to the south and east (R. Wells, NIWA, NZ, pers. comm., 2008) it no longer reaches the same prominence or nuisance levels (Champion and Clayton, 2000; R. Wells pers. comm., 2008).

The reasons behind the decline of water net in NZ remain unclear (Wells & Clayton, 2001; J. Clayton, NIWA, NZ, pers. comm. 2008.). However, it is of interest to note that following the demise of annual blooms in one NZ study lake, healthy starter colonies were re-introduced into floating mesh-lined experimental enclosures. The same vigorous growth rates and large biomass production were observed within the enclosures and this experimentally verified that there was no change in the ability of the lake to support bloom growths (Wells & Clayton, 2001). Water quality data also supported this conclusion. This has implications for the reintroduction of fresh water net colonies from elsewhere in the catchment (section 3.3.1).

Despite repeated instances of many other populations of aquatic macrophyte declines reported in the literature, the exact reasons behind these declines often remain poorly understood (Chambers *et al.* 1993). For example, some Eurasian watermilfoil (*Myriophyllum spicatum*) populations characteristically decline after 10-15 years of dominance (Carpenter, 1980) while other Eurasian watermilfoil populations, rather than disappearing, have been shown to persist at lower levels of abundance and become integrated into a more diverse plant community (Trebitz *et al.* 1993). Chambers *et al.* (1993) similarly reported that the 'boom bust' growth pattern of Eurasian watermilfoil appeared to be independent of any major changes in trophic status or lake management.

A review of methods of control of water net was undertaken by Wilson & Dinsdale (1998). Mechanical control was considered most appropriate (Dinsdale, 2003), however, this method itself presents major difficulties including: machinery access to the Lake, labour costs, impacts on other biota (particularly zooplankton, macroinvertebrates and fish), disposal of harvested material [water net is very efficient at accumulating heavy metals (Mangi *et al.*, 1978)] and likelihood of frequent repeated harvesting. Mechanical control was of only very limited success in NZ (Wells *et al.,* 1994). No direct management of water net is recommended at present.

The WFD Programme of Monitoring includes two phytoplankton monitoring methodologies, a taxonomic survey and a visual algal bloom assessment. The taxonomic survey will be adequate. The survey period and sampling intensity of the visual algal bloom assessment are insufficient. It is recommended that the three surveys per annum (between July and Oct) undertaken as part of the WFD Programme of Monitoring are supplemented by weekly monitoring May to October, following the same visual assessment methodology (Measure 1.10.2).

3.7 Community Involvement and Communication

> The delivery of catchment-scale management prescriptions requires greater understanding and ownership of the LPCMP objectives and issues affecting the site on the part of those living within the catchment. Work to raise the public profile of the LPCMP should continue. The Project needs a strong community base.

The delivery of catchment-scale management prescriptions to meet the objectives set for Loe Pool requires a substantial level of knowledge and ownership of the objectives and issues among the community of the catchment, and particularly land managers. It is doubtful whether a 'top-down' policy approach alone will yield the desired end targets for Loe Pool. Policy can be a major driver, but science is essential to its validity and local community ownership is essential for its delivery (Pretty & Smith, 2004).

The 2003 LPCMP Review included a measure to promote public awareness and local ownership of the LPCMP (Dinsdale, 2003). A number of activities have been undertaken by the LPMF to progress this measure during the last reporting period. The EA information panels illustrating the LPCMP have been on display at the local library and the NT Chyvarloe Base Camp (LPMF minuted meetings, 18 June 2003). The LPMF produced a leaflet which was distributed locally. The NT has lead on the development of a LPCMP website (LPMF minuted meetings 18 June 2003; 3 January 2003). Members of the LPMF have met with Helston Town Council and Porthleven Town Council (LPMF minuted meetings, 18 June 2003; 3 December 2003; 9 November 2005). Since 2006, the NT has provided guided project days for 300 Helston Community College science students per annum within the Penrose Estate. These project days include water sampling within the River Cober, to illustrate the issues, and a discussion of the links between lifestyles in Helston and their impacts upon the Pool.

The LPMF intends to continue to promote access and quiet enjoyment of Loe Pool, to develop an understanding of the catchment issues affecting the site among the community, and to promote and strengthen links between these two areas. A community task group (section 3.8) will work on a number of key themes including:

- **(i)** **A programme of community action:** Initially focussed on practical action for volunteers, litter and cigarette butts from urban drainage and later to consider septic tanks (section 3.3; Measure 1.5.1) in light of results of lake nutrient budget study
- **(ii)** **A schools programme:** The NT intends to continue to deliver the current education programme to Helston Community College; all schools are to be invited to become involved in the Loe Pool Project and will be offered assistance to develop their education programme (Measure 1.5.2)
- **(iii)** **Publicity:** The opportunity exists for more frequent media releases. Local newspaper reporters have expressed their interest in including regular articles (emails from J. Firth and N. Perry, Helston and Lizard Reporters, West Briton Newspapers to J. Dinsdale) The five-yearly review is to be made widely available, perhaps though the website (Measure 1.5.3).
- **(iv)** **The website:** The website will be maintained and kept up-to-date (Measure 1.5.3).
- **(v)** **Interpretation** The Forum intent to develop an interpretation plan for the Penrose Estate. The process will include community engagement and consultation (Measure 1.5.3).

3.8 The Loe Pool Forum: The Catchment Management Process

It is important that the LPMF maintain their focus and momentum and commitment over the next reporting period. To this end, the Forum has recognised a need to meet more frequently, and for their meetings to be more topic focussed. Forming smaller task groups and breaking-down the recommendations for future management into separate annual action plans for each group could aid the catchment management process.

The LPMF is ideally placed to help deliver the catchment management measures required to under the WFD and should work with the EA South West RBD Management Team to fulfil common goals.

The Loe Pool Management Forum (LPMF) was established in June 1996. Since 1998 the Forum has met bi-annually to discuss the wide range of inter-related and complex issues identified by the LPCMP Final Report. In 2002, the LPMF created a measure ‘to include all stakeholders in the LPMF meetings’ in the hope that best advice regarding the management of Loe Pool would be received, and the experience gained by the LPMF shared, through its implementation (Rule, 2002).

The LPMF currently comprises representatives from the National Trust (NT), the Environment Agency (EA), Natural England (NE), RNAS Culdrose, BREY Services, Cornwall Council (CC), Helston Town Council (HTC), the Catchment Sensitive Farming (CSF) Initiative, Cornwall College and South West Water (SWW). Representatives from other relevant Town and Parish Councils within the catchment should be invited to join the Forum in the near future (Measure 1.11.5).

The LPMF has achieved a great deal since its inception. It is important that the LPMF maintain their focus and momentum over the next reporting period (2009-2014) in order to continue to work to address the many and complex issues relating to the management of the Loe Pool Catchment. Strong collaboration will also be required to develop and deliver the prescribed management measures. To this end, the LPMF is considering a change to the configuration of its meetings. The Forum has recognised a need to meet more frequently and for their meetings to be more topic focussed. Consideration should be given to adopting 3 or 4 task groups within the LPMF, responsible for the delivery of main catchment management measures during the next reporting period. These groups could include, for example:

1. Point Sources Group
2. Community Liaison Group
3. Lake and Lower Cober Group
4. Land Use Group

It is suggested that each task groups could meet perhaps 3 times per year to collaborate and aid delivery of the specific catchment management measures included within that topic area, and then report annually to one wider annual LPMF meeting (Measure 1.11.2). Breaking-down the recommendations for future management (section 5) into annual action plans set for each task group would undoubtedly aid this process (Measure 1.11.2). A brief written summary of the annual progress made by each task group would improve the accuracy and efficiency of the five-year review process (Measure 1.11.4). This process may be best facilitated by the LPMF Secretariat.

Significant progress has been made in limnology, limnetic ecology and particularly catchment management processes since the first LPCMP Report in 1998 and its review in 2003. Developments in water policy, particularly the WFD, also present substantial opportunities to the project. The Loe Pool Catchment Management Plan therefore requires regular updating. It is recommended that the current progress review programme, the production a five-yearly review of the management plan, continues in the future (Measure 1.11.4).

Eutrophication is one of the key challenges facing water quality management in the early part of this century, having major effects on biodiversity as well as a range of human uses of water, including fisheries and recreation (Mainstone *et al*., 2008). The WFD requires that the management response to these problems is integrated across point and diffuse sources of pollution within river basins and individual water bodies. The LPMF is ideally positioned to deliver management measures required by the WFD. It is important that the LPMF members work closely with the South West RBD Management Team to fulfil common goals (Measure 1.11.6).

4. Review of Catchment Surveillance and Monitoring Provision

Under the WFD, Loe Pool is now subject to a comprehensive programme of monitoring which includes over 30 biological and physico-chemical indicators of environmental quality, with progress measured against specific targets.

The Brey Utilities tributary survey continues to provide valuable water quality and flow data.

A nutrient budget is required to provide robust evidence of the relative contributions of the various phosphorus inputs to the Pool. The priority surveillance requirements not delivered under the current WFD/BREY monitoring programme comprise regular flow measurement and phosphate sampling of an additional 6 sites across the Carminowe, Nansloe and Cober catchments along with the Loe Bar outfall.

For the LPCMP to make best use of site-specific data collected under the WFD programme of monitoring, provision must be made to analyse and present these data annually.

Monitoring is an essential and integral component of management planning; there can be no planning without monitoring (Alexander, 2000; 2005; 2007).

The term 'monitoring' needs to be carefully defined as its true meaning is often misrepresented, particularly within the area of water quality. Monitoring is defined as 'surveillance undertaken to ensure that formulated standards are being maintained', where 'formulated standards' are objectives with performance indicators (JNCC, 1998). Hence, the repeated standardised collection of water quality data in order that change can be detected is not strictly monitoring, unless it differentiates between acceptable and unacceptable levels of change (see Alexander, 2007).

To date, Loe Pool has not had a comprehensive monitoring plan. The need for such a plan has been recognised for some time (LPMF sub-group minuted meeting, 14 November 2002) but its delivery has been on-hold, pending adoption of the WFD programme of monitoring. Since the WFD came into force in 2000, it has been apparent that extended surveying and monitoring of waterbodies would be required in the UK in order to meet the requirements of this European Directive (see WFD UK TAG, 2009). While awaiting specification of the WFD programme of monitoring, a monitoring summary table was produced as an interim measure (Rule, 2006). This table also included survey and surveillance information

Under the WFD, Loe Pool has now been assigned 'surveillance' waterbody status. This is of enormous benefit to the LPCMP as surveillance waterbodies are subject to the most detailed level of data collection (WFD UK TAG, 2009). For the first time, Loe Pool will be subject to a comprehensive programme of monitoring which includes over 30 biological and physico-chemical indicators of environmental quality, with progress measured against specific targets. WFD monitoring of surveillance waterbodies runs on a three-year programme, which commenced in 2007 and will therefore continue until the end of 2009. This programme of monitoring is likely to continue unaltered into the second cycle (2010-2012) (R. Hillman, Technical Specialist Ecological Appraisal, EA Bodmin, pers. comm.).

Table 4.1 provides a summary of the current programme of monitoring within the Loe Pool Catchment. The table includes information regarding the location, extent, frequency, timing and period of the monitoring and an evaluation of whether this is sufficient to meet the needs to the LPCMP is provided. Where current monitoring provision is considered to be insufficient, recommendations to rectify this are made. These recommendations are then translated into management actions within section 5 of this report.

Recommendations for research projects, that is hypothesis testing studies such as post- and under-graduate projects, are not included within this section on monitoring, but are included as actions within section 5.

The lack of in-lake physico-chemical sample locations provided under the WFD has concerned the Forum in the past (LPMF sub-group minuted meeting, 29 November 2006). A research study by the National History Museum collected monthly data over a two-year period during 1995-1996 drew comparisons between four sites within Loe Pool (W1: near Loe Bar outlet; W2: within Penrose arm; W3: at head of Cober bay; W4: within Carminowe Creek). These data showed no significant difference in TP or orthophosphate between these sites (John *et al*., unpublished; John *et al*., 1998). The WFD physico-chemical monitoring site close to the Loe Bar outlet should therefore be taken as representative of the Pool as a whole.

The construction of a nutrient budget for Loe Pool would provide robust evidence of the relative contributions of various P inputs to the Pool. A nutrient budget comprises a quantitative assessment of phosphorus moving into, being retained in, and moving out of the Lake. The current programme of monitoring within the catchment does not provide sufficient data to develop a phosphorus budget for the Pool. An ideal nutrient budget would include an estimate of all P sources, that is: all consented point sources, intermittent sources, unconsented and small point sources (e.g. septic tanks), all diffuse sources both indirect and direct (e.g. agriculture). It is recognised that this ideal nutrient budget format is not practical or achievable for the LPCMP at present and therefore a pragmatic approach is proposed. The proposed nutrient budget format will separate and apportion some of the major P contributions within the three catchment that contribute the majority (95%) of the total phosphorus load to Loe Pool. The proposed nutrient budget format is presented within Appendix 2 and the additional monitoring requirements are included in Table 4.1

The priorities identified for additional monitoring and surveillance include:

- Regular flow measurement and phosphate sampling at additional sites within Carminowe Stream, RNAS Culdrose STW final effluent, Nansloe Stream, the lower River Cober and the Loe Bar outlet in order to develop a nutrient budget for the Pool
- Increased period and sampling intensity of the visual algal bloom assessment within Loe Pool; an in-lake zooplankton survey
- More detailed water quality surveillance of the River Cober and its tributaries

(see Table 4.1).

Perhaps the most important gap identified in the monitoring provision of the Loe Pool Catchment is the requirement for analysis and presentation of the site-specific WFD monitoring data in order for these data to be of best use to Forum. The LPMF have recognised for sometime that the raw data received by the NT under a memorandum of understanding with the EA is not sufficient to meet their needs (e.g. LPMF minuted meeting, 21 March 2007). The WFD RBD Management Planning system does not appear to present site specific results (see EA, in prep.). The Forum should therefore request that the EA provide annual presentation and interpretation of these site specific results in order to measure progress against their targets and to inform future catchment management options (Measure 1.10.1).

The provision of monitoring should be reviewed in 2014, or earlier if any elements of the WFD monitoring programme are not continued after 2010 (Measure 1.10.4).

Table 4.1: Current and recent previous programme of monitoring within the Loe Pool Catchment

Location	Lead	Survey	Frequency, timing and period	Meets LPCMP monitoring requirements?
Biological Monitoring: Taxonomic Surveys				
In Lake	**EA** **WFD**	**Phytoplankton** List of species present (qualitative)	3 times per annum Between Jul and Oct 3 year programme 2007-2010	Adequate
		Algal bloom assessment (visual)	3 times per annum Between Jul and Oct 3 year programme 2007-2010	***** Survey period and sampling intensity insufficient. Supplement with weekly monitoring, May onwards. Follow same visual assessment methods (Measure 1.10.2)
SW 64800 24840	**EA** **WFD**	**Phytobenthos** Quantitative algal sampling (including phytoplankton and diatoms)	2 times per annum; 1 spring; 1 autumn 3 year programme 2007-2010	Adequate
-	-	**Zooplankton**	None	***** No provision; Commission baseline survey to assess monitoring needs (Measure 1.10.2)
-	-	**Macroinvertebrates**	None	***** No provision; baseline surveys complete (Alexander, 2003; Knight, 2003); resurvey to be considered in next reporting period 2015-2020 (Measure 2.3.1)
In lake	**EA** **WFD**	**Fish** Quantitative (hydroacoustic)	Once per annum Non-specific time of year 3 year programme 2007-2010	Adequate
		List of species present (qualitative) (seine netting)	Once every 3 years Non-specific time of year 3 year programme 2007-2010	Adequate

Table 4.1: (cont.)

Location	Lead	Survey	Frequency, timing and period	Meets LPCMP monitoring requirements?
Biological Monitoring: Taxonomic Surveys (cont.)				
In lake	**EA** **WFD**	**Macrophytes**	Once every 3 years Between June and September 3 year programme 2007-2010	***** Survey intensity insufficient; Continue with supplementary annual survey (Measure 1.10.2)
SW64800 248400	**EA** **WFD**	**Chironomid Pupal Exuviae Technique** Quantitative sampling of chironomid pupae cases: an indicator of habitat diversity and ecological quality of a water body	Every 3 years 4 times at regular intervals between April and October 3 year programme 2007-2010	Adequate
On lake		**WeBS** Non-breeding water birds	Monthly	Adequate
River Cober	**EA** **WFD**	**Diatoms** Samples taken from 2 sites near suitable substrate	Once every 3 years 3 year programme 2007-2010	Adequate
	EA **WFD**	**Macrophytes** 3 sites surveyed	Once every 3 years 3 year programme 2007-2010	Adequate
	EA **WFD**	**Fish** List of species recorded from 1 site	Once every 3 years 3 year programme 2007-2010	Adequate
Biological Monitoring: Habitat Surveys				
In lake	**EA** **WFD**	**Lake Habitat Survey (LHS)** Survey of shoreline features at a number of plots (Hab-Plots) and a meso-scale survey of entire lake (including shoreline characteristics and pressures, and modifications to the hydrological regime).	Once every 6 years	Adequate

Table 4.1: (cont.)

Location	**Lead**	**Survey**	**Frequency, timing and period**	**Meets LPCMP monitoring requirements?**
Hydromorphological Monitoring				
River Cober Helston Weir SW 65467 27257	**EA** Routine	Flow Water Level (depth)	Every 15 mins Ongoing programme	Adequate to construct proposed nutrient budget
Helston STW: Crude sewage inlet and FE	**SWW** Routine	Flow	Online Continuous (Electronic) every 15mins	Adequate to construct proposed nutrient budget
Loe Pool SW 64600 25600	**EA** Routine	Water Level (depth)	Every 15 mins Ongoing programme	***** Accuracy of recording low levels (<3.5mAOD) questionable. Requires rectification (Measure 1.6.1)
All six tributaries to Loe Pool (Cober, Penrose Chyvarloe, Degibna Carminowe, Nansloe) at point of entry to lake	**BREY Services/ NT** Investigative	Flow	Weekly spot check July 2007 to July 2008 Monthly spot check ongoing	Adequate
Carminowe Stream SW 66243 24296	**EA** WFD	Flow	Monthly spot check	***** Inadequate; require monitoring /modelling of flow upstream of STW discharge point in order to construct proposed nutrient budget (1.1.1)
Culdrose STW: Final effluent (FE)	**EA/BREYS**	Flow	None?	* Provision currently inadequate?; require additional monitoring in order to construct proposed nutrient budget (Measure 1.1.1)

Table 4.1: (cont.)

Location	Lead	Survey	Frequency, timing and period	Meets LPCMP monitoring requirements?
Hydromorphological Monitoring (cont.)				
Loe Pool outfall at Loe Bar SW 64250 24280	**EA** Routine	Water Level (depth)	Every 15 mins? Telemetry installed 2009	***** Need to ensure that this records full range of water levels. Flow monitoring or modelling is also required in order to construct proposed nutrient budget (Measure 1.1.1)
All six tributaries to Loe Pool (Cober, Penrose Chyvarloe, Degibna Carminowe, Nansloe) at point of entry to lake	**BREY Services/ NT** Investigative	Ammonical nitrogen, nitrate, TON, orthophosphate, TP	Weekly single sample May 2007 to July 2008 Monthly single sampling ongoing	Adequate
Loe Pool outfall at Loe Bar SW 64250 24280	**EA** WFD	pH, temp, cond @ 25°C, BOD ATU, COD as O_2, ammonia, N oxidised, nitrate, nitrite, NH_3 un-ion, suspended solids, alky pH 4.5, chloride ion, orthophosphate, DO conc., DO % saturation, SiO_2, Cu, Zn, Fe, chlorophyll, and additional priority chemical substances, including other heavy metals.	Monthly Ongoing programme	Adequate
Carminowe Stream at inflow to Loe Pool	**EA** UWWTD	pH, temp, cond @ 25°C, BOD ATU, COD as O_2, ammonia, N oxidised, nitrate, nitrite, suspended solids, chloride ion, orthophosphate, DO conc., DO % saturation, SiO_2, chlorophyll.	Summer only (May-August)	Adequate (as supplemented by BREY Services recent tributaries survey)

Table 4.1: (cont.)

Location	Lead	Survey	Frequency, timing and period	Meets LPCMP monitoring requirements?
Physico-Chemical Monitoring				
Culdrose STW: Final effluent (FE)	**EA**	pH, BOD ATU, ammonia, suspended solids.	Monthly	* Provision currently inadequate; request EA undertake additional monitoring including P in order to construct proposed nutrient budget (Measure 1.1.1)
Culdrose STW: Final effluent (FE)	**BREY Utilities** Investigative	pH, ammonia, BOD, suspended solids, TP	Weekly since 2005, ongoing	Adequate
Carminowe Stream 1m u/s STW	**BREY Utilities** Investigative	pH, ammonia, BOD, suspended solids, TP	Weekly single sample April 2006 to May 2007	Adequate
Carminowe Stream 1m d/s STW	**BREY Utilities** Investigative	pH, ammonia, BOD, suspended solids, TP	Weekly single sample April 2006 to May 2007	Adequate
River Cober at inflow to Loe Pool	**EA** UWWTD	pH, temp, cond @ 25°C, BOD ATU, COD as O_2, ammonia, N oxidised, nitrate, nitrite, suspended solids, chloride ion, orthophosphate, DO conc., DO % saturation, SiO_2, chlorophyll.	Summer only (May-August)	Adequate (as supplemented by BREY Services recent monitoring)
Helston STW CSO	**SWW**	Operating period: event date and duration (start and stop)	Each operating event	Inadequate; study of proportional nutrient load contribution from Helston CSOs to total lake nutrient budget proposed by SWW under PR09.

Table 4.1: (cont.)

Location	Lead	Survey	Frequency, timing and period	Meets LPCMP monitoring requirements?
Physico-Chemical Monitoring (cont.)				
Helston STW: Final effluent (FE)	**SWW** UWWTD	SWW to confirm	Monthly (24hr time proportional composite samples)	Adequate
Helston STW: Final effluent (FE)	**SWW**	SWW to confirm	Online Continuous (Electronic)	Adequate
Helston STW: Crude sewage inlet	**SWW** UWWTD	SWW to confirm	Monthly (24hr time proportional composite samples)	Adequate
Helston STW: Crude sewage inlet	**SWW**	SWW to confirm	Online Continuous (Electronic)	Adequate
Helston STW: Crude sewage inlet and FE	**EA**	Phosphorus, pH, BOD ATU, COD as O_2, ammonia, suspended solids, chloride ion.	Monthly	Adequate
River Cober u/s Helston STW	**EA** UWWTD	Phosphorus, pH, BOD ATU, COD as O_2, ammonia, suspended solids, chloride ion.	Summer only (May-August)	Adequate
River Cober d/s Helston STW SW 6521726784	**EA**	pH, temp, cond @ 25°C, BOD ATU, COD as O_2, ammonia, N oxidised, nitrate, nitrite, NH_3 un-ion, suspended solids, alky pH 4.5, chloride ion, orthophosphate, DO conc., DO % saturation, SiO_2, Cu, Zn, Fe, chlorophyll.	Monthly	Adequate

Table 4.1: (cont.)

Location	Lead	Survey	Frequency, timing and period	Meets LPCMP monitoring requirements?
Physico-Chemical Monitoring (cont.)				
River Cober at Lowertown Bridge SW 65800 29130	**EA**	pH, temp, cond @ 25°C, BOD ATU, ammonia, TON, nitrate, nitrite, suspended solids, orthophosphate, DO conc., DO % saturation.	Monthly	Adequate
In lake SW 64632 24397	**EA WFD**	Temperature profile	Once per annum (August) 3 year programme 2007-2010	Adequate
In lake SW 64632 24397	**EA WFD**	Dissolved oxygen profile (DO)	Once per annum (August) 3 year programme 2007-2010	Adequate
River Cober below Helston	**EA FRM**	Silt deposition and river bed levels	Once every 5-10 years	Adequate

5. Recommendations for Future Management

Many of the Management Measures assigned to the first phases of implementation in 1998 (i.e. phase one (2003-2005) and phase two (2006-2010)) were completed within the designated timeframe. A summary of the progress during the period 2003-2009 against those Management Measures prescribed in 2003 is provided in Appendix 1.

This section sets out the Management Measures for the period 2009 to 2019. These comprise on-going measures from the LPCMP 2003 Review and new measures adopted since 2003; measures completed since 2003 are not included here.

The Management Measures are divided into two progressive phases. The Measures assigned to Phase 1 (2009-2014) continue to focus on controlling nutrient and sediment exports across the catchment. In the longer term (Phase 2; 2015-2019), the effects of abating sources of water pollution should emerge, and the need to employ an in-lake biomanipulation management strategy will be evaluated. Each Management Measure is divided into sub-actions and a lead organisation assigned to each sub-action, in a similar format to the 2003 LPCMP Review.

In order to facilitate the catchment management process, it is intended that the Phase 1 (2009-2014) Management Measures and sub-actions are divided between 4 topic or task areas. The proposed four LPMF task groups will then further divide the Management Measures allocated to their group to produce annual work programmes (Section 3.8).

Management Measures and Phases of Implementation 2009-2019

Phase 1 (2009-2014)

	Measure	Task Group	Sub-actions
1.1	Develop and agree a nutrient budget for the Pool	Land Use	1. Identify additional water chemistry monitoring requirements (EA PiP action) 2. Monitor P concentration and/or flow at all required locations for 12 months (EA PiP action) 3. Produce a nutrient budget for the Loe Pool catchment
1.2	Continue to review both the requirement for and potential benefits of tertiary treatment at RNAS Culdrose STW	Point Sources	1. EA to review of Brey Services data set and other existing data and consider whether the current evidence base is sufficient to warrant a modification to the discharge consent from RNAS Culdrose STW (EA PiP action) 2. Undertake additional monitoring as required (see 1.1.1 above) 3. Agree whether RNAS Culdrose STW discharge has significant impact on SSSI and act on results of these findings
1.3	Review tertiary treatment at Helston STW	Point Sources	1. EA to review current P levels and identify any requirement for further P removal at Helston STW in order to meet UWWT Directive standards ($50\mu gl^{-1}$) (EA PiP action) 2. Confirm that product used in P stripping at Helston STW is environmentally safe
1.4	Facilitate a Rural Catchment Initiative	Land Use	1. Develop project proposal 2. Secure funding 3. Carry out catchment appraisal 4. Commence farm advisory programme 5. Commence programme of water quality monitoring 6. Target key farms within the catchment for compliance visits
1.5	Strengthen the LPCMP's community base	Community liaison	1. Develop a programme of community action across the catchment and publicity campaigns: to include practical volunteer days, work to raise awareness of impacts of issues such as litter entering via urban drainage, septic tanks etc. 2. Continue to develop and extend local schools programme 3. Continue to raise the public profile of the Loe Pool Project, both locally and further afield, e.g. regular press releases, website, presentations, developing a Penrose interpretation plan
1.6	Review the 2000 WLMP	Lake and Lower Cober	1. Ensure that the WL recording is both continuous and accurate 2. Consider options to instate greater intra-annual fluctuations in lake WLs, in order to improve conditions for macrophyte establishment and littoral biodiversity 3. Adopt revised WLMP
1.7	Evaluate and address the impacts of non-STW point sources	Point Sources	1. SWW to quantify contribution of storm sewer overflows to nutrient budget of Loe Pool as part of National Environment Programme (NEP) (also a EA PiP action) 2. Produce a water management plan to identify impacts of Coronation Lake 3. Review management to reduce identified impacts of Coronation Lake

Phase 1 (2009-2014) (cont.)

	Measure	Task Group	Sub-actions
1.8	Maximise biodiversity value and ecological function of lower reaches of River Cober and its floodplain within limits of current flood alleviation scheme	Lake and Lower Cober	1. Carry out trial re-connection of river channel to its floodplain 2. Continue to monitor riverbed silt levels along the lower Cober 3. Review and agree the River channel and bank maintenance schedule for this length of the River, with the over-arching ethos of working with natural processes wherever possible 4. Develop a strategy to manage sustainable public access within this part of the catchment 5. Seek Local Nature Reserve designation for this part of the catchment 6. Continue control programmes for non-native species e.g. parrot's feather, Japanese knotweed and Himalayan balsam 7. Carry out RAM 4 assessment of River Cober to determine effects of flows and abstraction on ecology (EA PiP action)
1.9	Carry out site management work to benefit lake rehabilitation process	Lake and Lower Cober	1. NT to continue to address nutrient and sediment exports from farms in close proximity to Pool and develop costed case-studies for improved land management 2. Control development of shoreline trees and shrubs along some silty shores 3. Reinstate light grazing along some silty shores 4. Assess feasibility of wetland creation at head of Carminowe Creek
1.10	Monitor, survey and research to inform in-lake management strategy	Lake and Lower Cober	1. Present and interpret site specific data collected under WFD monitoring programme annually 2. Undertake extended weekly algal bloom assessments, a zooplankton survey and annual macrophyte surveys 3. Facilitate student projects to investigate in-lake biotic structure 4. Review WFD monitoring provision at the end of the first cycle
1.11	Support function of LPMF	Whole Forum supported by Secretariat	1. Forum to divide into 3 or 4 task groups 2. Each task group to produce annual action plan at start of year and present summary of progress to whole Forum at year end 3. Produce brief annual progress summary and circulate widely 4. Prepare five-yearly review of management and monitoring plan and circulate widely 5. Include all stakeholders in LPMF meetings 6. Engage with WFD South West RBM Team

Phase 2 (2015-2019)

	Measure	Lead	Sub-actions
2.1	Reduce impact of non-STW point sources	Point Sources	1. Act on results of storm overflow assessment
2.2	Complete the Rural Catchment Initiative	Land Use	1. Complete farm advisory programme 2. Complete programme of water quality monitoring
2.3	Monitor, survey and research to inform in-lake management strategy	Lake and Lower Cober	1. Repeat 2003 aquatic invertebrates PSYM survey 2. Implement biomanipulation strategy if appropriate 3. Ensure an appropriate monitoring programme is in place to measure success of biomanipulation strategies
2.4	Support function of LPMF	Whole Forum	1. Prepare five-yearly review of management and monitoring plan and circulate widely

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Appendix 1:

2003 Management Measures Phases of Implementation (from Dinsdale, 2003)

Phase One (2003-2005)

	Measure	Lead	Sub-actions	Progress
1.1	Early compliance with UWWT Directive	SWW	1. Improvements to works to be operational March 2003, construction from April 2002	Completed. Plant commissioned 31 March 2003
1.2	Negotiate installation of tertiary treatment at Culdrose	MoD EN	1. Identify funding 2. Assist with potential options	Ongoing. A priority for 2009
1.3	Develop River Floodplain Scheme	EA	1. Review Helston Flood Alleviation Scheme	Currently on-hold
		EA	2. All sub-actions listed here to be considered within any new flood alleviation scheme for Helston	As above
		NT	3. Extend hydraulic model (Halcrow, 1999) to scenarios proposed by Haycock & Vivash (1999)	Not progressed. Not considered a priority at present
		NT	4. Develop alternative management strategy for the lower section of the River Cober	Draft maintenance review produced March 2007, further work needed in 2009 to finalise this document
		EA	5. Commission redesign of the River Cober from Zachary's Bridge to the NT boardwalk	Proposal drawn up to trial reconnection of river channel to floodplain in 2005. Trial needs implementing. Consider full redesign 2015+, following proposed whole catchment FRM work to be undertaken as part of a rural catchment initiative
		EA	6. Negotiate redesign Zachary's Bridge and the footbridges within the KDC amenity area	Not progressed
		EA	7. Investigate lowering berm through KDC amenity area	Not progressed
		EA	8. Redesign or preferably remove hydrological links between the River Cober and Coronation Lake / the amenity ponds	Outlet from amenity ponds redesigned 2006. Need to evaluate potential impacts of Coronation Lake on SSSI and adapt management of amenity lake as required
		EA	9. Continue monitoring silt deposition and river bed levels in the Lower Cober	Completed to date
		EA	10. Undertake a botanical survey of the River prior to any desilting	Completed to date

Phase One (2003-2005) (cont.)

	Measure	Lead	Sub-actions	Progress
1.3	Develop River Floodplain Scheme (cont.)	EA	11. Assess feasibility of constructing a silt trap	Not progressed. Not longer considered a priority, instead focus on addressing sediment at source through rural catchment initiative
		EA	12. All parties to have an input to any floodplain redevelopment proposals	Completed to date
		EA	13. Consult local community re: new proposals for flood management	Not yet required
1.4	Encourage farmers to enter land into CSS	SWW FWAG	1. Continue to support FWAG Project Officer 2. Ensure farm advice and CSS is targeted to maximise reductions of nutrients and soil entering water courses	FWAG officer in post until December 2003. 25% of farms in catchment had 1 visit each. Further advisory work a priority for 2009-2014
1.5	Implement and review WLMP	EA	1. Provide water level data to NT on a regular basis	Completed to date. Anomalies in data suggest equipment error which requires rectification
		NT	2. Log lake water level readings monthly	No longer required as EA WFD monitor WLs every 15mins
		NT	3. Undertake 5 yearly monitoring of littoral flora and annual monitoring of benthic plant communities	Completed to date
		NT	4. Monitor willow carr water table each month for 1 year	Completed
		EA	5. Review 2000 WLMP in 2006	Not progressed. A priority for 2009
1.6	Maintain wild brown Trout fishery	EA	1. Implement a programme of acoustic surveys of Loe Pool to estimate perch and trout population sizes and assess seasonal movements of trout	Completed under WFD programme of monitoring
		EA EA	2. Design and carry out survey of perch gut content 3. Assess quality of trout spawning beds in River Cober	Both not progressed. To be undertaken 2009-2014 as part of lake's biotic structure research
1.7	Control Water Net blooms	EA	1. Investigate the control of water net by mechanical removal and possibly the use of barley straw	Completed. Neither method of control considered reliable or appropriate. No longer a priority as water net population currently in decline
		NT	2. Act on results of this investigation	

Phase One (2003-2005) (cont.)

	Measure	Lead	Sub-actions	Progress
1.8	Determine sources of sediment to the Cober	TC TC	1. Research catchment sediment pathways 2. Feed findings into Floodplain Scheme (measure 1.3)	Not progressed. Will be progressed as part of proposed rural catchment initiative
1.9	Manage public access within Lower Cober valley	NT NT KDC	1. Redesign the western bank side path upstream of the boardwalk to restrict surface erosion 2. Elevate boardwalk 3. Review potential for LNRs	All ongoing as part of reach-based river restoration work
1.10	Develop control programmes for invasive non-native species	KDC NT NT NT/ EA	1. Develop project to reduce parrot's feather in amenity area and prevent it's spread to Loe Pool 2. Initiate an annual assessment of Nuttall's waterweed in Loe Pool 3. Initiate control programme for Himalayan balsam 4. Follow current advice of the knotweed forum when undertaking management/maintenance	Completed and maintained successfully Completed to date Ongoing Ongoing
1.11	Develop a programme on pollution from Helston street drainage	KDC KDC KDC SWW	1. Initiate a community education programme 2. Negotiate improved street cleaning and maintenance of drains 3. Assess feasibility of screening physical litter and pollution loading from Helston road runoff 4. Investigate merging CSOs with road drainage under AMP4 process	Received some publicity. A priority for 2009-2014 Good progress made Improved trash screening installed 2003 Ongoing. Project to assess proportional CSO load proposed for 2010-2015
1.12	Include all stakeholders in LPMF meetings	EA EA EA	1. Invite KDC representative 2. Invite HTC representative 3. Invite HMTI representative	Completed to date but requires updating from April 2009 for new unitary Cornwall Council Requires action No longer required

Phase One (2003-2005) (cont.)

	Measure	Lead	Sub-actions	Progress
1.13	Prepare annual reports on progress of management and monitoring plans and circulate widely	EA		Not carried out 2003-2005. Recommend annual summary document is produced 2009+.
1.14	Promote public awareness and local ownership of the LPCMP	LPMF	1. All parties to provide appropriate news stories to the media on a regular basis	Needs further emphasis 2009-2014
		TC	2. Encourage school groups to run regular 'Loe Pool' columns in local papers	Needs further emphasis 2009-2014
		NT	3. Put up information boards about the project on site	Not complete. Requires progress 2009-2014
		NT	4. Produce a leaflet and distribute locally	Completed
		NT	5. Create a web-site, or identify a host site, and initiate a 6 monthly review procedure	Completed. Requires review 2009
		NT	6. Re-launch the LPCMP in 2003	Not carried out
		NT	7. Review need for a liaison officer to develop community involvement in 2003-2004	Needs re-review 2009-2014
		Corn Coll	8. Research potential for a LPMF hosted symposium	Measure deferred
1.15	Initiate a catchment monitoring plan	EA	1. Produce a monitoring plan	Completed in part in 2006 and expanded/updated within this document
		EA	2. Complete baseline monitoring before March 2004	Some surveys undertaken 2003-2006, WFD provides extensive programme of monitoring 2007-2010. Few additional survey requirements identified as part of this document
		EA	3. Set appropriate targets to measure the success of eutrophication management	Completed as part of this review document

Phase Two (2006 to 2010)

	Measure	Lead	Sub-actions	Progress
2.1	Ascertain the optimal biomanipulation strategy	EA EA EA	1. Using biological monitoring data, define potential biomanipulation measures 2. Carry out a literature review of the mesocosm experiments undertaken on these potential measures 3. Employ on-site mesocosm experiments if appropriate	Options broadly defined as part of this document. On site mesocosm experiments unlikely to be required as multi-lake studies now provide comprehensive data. Additional biological surveys required to inform biomanipulation strategy to be a priority for 2009-2014
2.2	Continue to develop River Floodplain Scheme and act on findings	EA		Ongoing and further progress proposed through rural catchment initiative
2.3	Review WLMP	EA		Not progressed. A priority for 2009
2.4	Prepare annual reports on progress of management and monitoring plans and circulate widely	EA		Not carried out 2006-2008. Recommend annual summary document is produced.
2.5	Prepare five-yearly review of management and monitoring plans and circulate widely	LPMF		Completed to date

Phase Three (2011 to 2015)

	Measure	Lead	Sub-actions	Progress
3.1	Implement biomanipulation strategy as appropriate	EA		Not yet appropriate
3.2	Monitor implementation of biomanipulation strategies	EA		Not yet required
3.3	Assess nutrient contributions from minor sources as necessary	EA	1. Evaluate nutrient inputs from Coronation Lake	To be progressed 2009-2014
		EA	2. Evaluate nutrient losses from septic tanks	Very difficult to evaluate. Provide advice to households on managing septic tanks effectively
		EA	3. Investigate levels of nutrient losses from fish farms	Not currently a priority
		EA	4. Consider further nutrient modelling to inform action on minor sources	To be considered as part of rural catchment initiative
		EA	5. Take appropriate action to reduce nutrient contributions from these minor sources as necessary	Not yet appropriate
3.4	Consider the feasibility of introducing Strapwort	EN		Not yet appropriate
3.5	Prepare annual reports on progress of management and monitoring plans and circulate widely	EA		
3.6	Prepare five-yearly review of management and monitoring plans and circulate widely	LPMF		

Appendix 2:

LOE POOL NUTRIENT BUDGET
Proposed Format

A nutrient budget comprises a quantitative assessment of phosphorus moving into, being retained in, and moving out of the Lake. The current programme of routine monitoring within the catchment does not provide sufficient data to develop a phosphorus budget for the Pool.

A pragmatic approach is proposed at this stage, in order to separate and apportion some of the major P contributions within the three catchments that contribute the majority (95%) of the total phosphorus load to Loe Pool (BREY Utilities, 2008; Figure 2.3 within main report), that is:

Within the Cober catchment, contribution from:

- Helston STW
- Helston urban drainage
- Sithney Stream
- The upper Cober catchment (upstream of Burras)
- The remainder of the rural Cober catchment

Within Carminowe catchment, contributions from:

- RNAS Culdrose STW
- The upper Carminowe catchment
- Little Content stream and its tributaries

Within Nansloe catchment, contributions from:

- NT farm(s)
- the remainder of the stream's rural catchment

Further separation and apportionment of P sources within the Penrose, Chyvarloe and Degibna catchments are not considered a priority as these catchments in combination represent 5% of the total phosphorus load to Loe Pool.

It is suggested that the development of a nutrient budget of this proposed format would require the additional phosphorus sampling at 6 sites and flow calculations for 8 additional sites. Details of those sites are shown in table below. An initial monitoring period of 12 months is recommended for all locations.

The EA have added monthly sampling for phosphorus at these additional 6 sampling stations for the period November 2009 to April 2010, at which time they will review these data (e-mail from A. Gilbert, EA Reporting and Analysis to J. Dinsdale, Ecological Consultant, 4 November 2009).

Table: Summary of the existing and proposed phosphorus sampling and flow calculations undertaken within the Loe Pool catchment to inform the proposed lake nutrient budget

Location	Flow	Phosphorus
Cober catchment		
Upper River Cober at Burras Bridge SW6783234895	**required**	Monthly Nov 2009 – Apr 2010 EA Special Investigation
River Cober u/s Helston at Lowertown Bridge SW658291	**required**	Monthly EA routine
Sithney Stream u/s Cober confluence SW6509628613	**required**	Monthly Nov 2009 – Apr 2010 EA Special Investigation
River Cober at Helston weir SW6546727257	15 mins EA routine	Monthly Nov 2009 – Apr 2010 EA Special Investigation
Helston STW FE	15 mins SWW routine	Online continuous SWW routine Monthly EA & SWW routine
River Cober at inflow to Pool	Weekly spot Brey 2007-8	Weekly Brey 2007-8
Carminowe catchment		
RNAS Culdrose STW FE EA Site ID: 82010258	**required**	Fortnightly Brey 2005 to date
Upper Carminowe Stream u/s STW discharge SW6657124261	**required**	Weekly Brey 2006-8 Monthly Nov 2009 – Apr 2010 EA Special Investigation
Little Content Stream u/s of Carminowe Stream confluence SW6573424524	**required**	Monthly Nov 2009 – Apr 2010 EA Special Investigation
Carminowe Stream at inflow to Pool EA Site ID: 82010208	Weekly spot Brey 2007-8	Weekly Brey 2007-8 Monthly EA under UWWTD
Nansloe catchment		
Upper Nansloe Stream u/s NT property boundary SWW6574726356	**required**	Monthly Nov 2009 – Apr 2010 EA Special Investigation
Nansloe Stream at inflow to Pool	Weekly spot Brey 2007-8	Weekly Brey 2007-8
Smaller streams		
Penrose Stream at inflow to Pool	Weekly spot Brey 2007-8	Weekly Brey 2007-8
Chyvarloe Stream at inflow to Pool	Weekly spot Brey 2007-8	Weekly Brey 2007-8
Degibna Stream at inflow to Pool	Weekly spot Brey 2007-8	Weekly Brey 2007-8
Lake outfall to sea		
Loe Pool outfall at Loe Bar SW642242	**required** (from depth: 15mins records EA)	Monthly EA WFD

Appendix 3:

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