What does this mean?

Our data indicate that Loweswater has deteriorated in ecological quality over the past 20 years. This is a common problem for water bodies everywhere and is being addressed by the EC Water Framework Directive which is being implemented by the Environment Agency and requires certain ecological standards for water-bodies to be reached by 2015. As the ecological status of Loweswater, based on current ecological boundaries, suggests that the lake is at moderate status for phytoplankton chlorophyll *a* concentration (equates to algal levels) and just in the good category for total phosphorus concentration, there is likely to be a legal requirement to improve the ecological status of Loweswater.

The models suggest that the highest priority management approach, in terms of magnitude of effect and practicality, is to ensure that all of the septic tanks are functioning correctly as this has the largest effect on the crop of phytoplankton produced in the lake. The second priority would be to reduce losses of phosphorus from animal husbandry activities- for example by restricting slurry spreading and by reducing input from slurry tanks. However, the catchment, especially the improved grassland, is a major source of phosphorus. Current attempts to reduce phosphorus inputs by reducing P-application in fertilisers are to be encouraged. The speed of any recovery from this is hard to predict and will depend on delivery pathways in the catchment and the extent of internal recycling of phosphorus within the lake.

An investigation into the potential impacts of farming practices on Loweswater

Summary of a report for the Rural Development Service and the National Trust carried out by the Centre for Ecology & Hydrology (CEH) at Lancaster and Edinburgh

Summary by Lisa Norton and Stephen Maberly –March 2006

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This report is the result of work carried out over a 12 month period (Sept '04- Oct'05) on Loweswater. The work was aimed to provide scientific evidence on how the lake functions and responds to nutrients from the Loweswater catchment (the area from which rainfall goes into Loweswater). It also aimed to provide advice on sound management of the catchment in order to improve lake quality.

This leaflet provides a summary of findings which are contained in a much larger report which has been produced for the Rural Development Service and the National Trust.

The work carried out on the lake included a range of different approaches;

- Monthly lake and stream water sampling,
- Analysis of data collected from previous lake water surveys carried out by CEH and the Environment Agency,
- Comparisons of current data with sediment sample data from previous work carried out for the Environment Agency,
- One off sampling of streams in the catchment
- Sampling of Dub Beck at times of specific farming activities (slurry spreading and fertiliser application),
- Catchment modelling – i.e. using data from the catchment, such as the cover of different vegetation types or the numbers of people/livestock in the catchment, to estimate amounts of nutrients entering the lake,
- Algal modelling – using data collected in the lake to try to understand the occurrence of algal blooms.

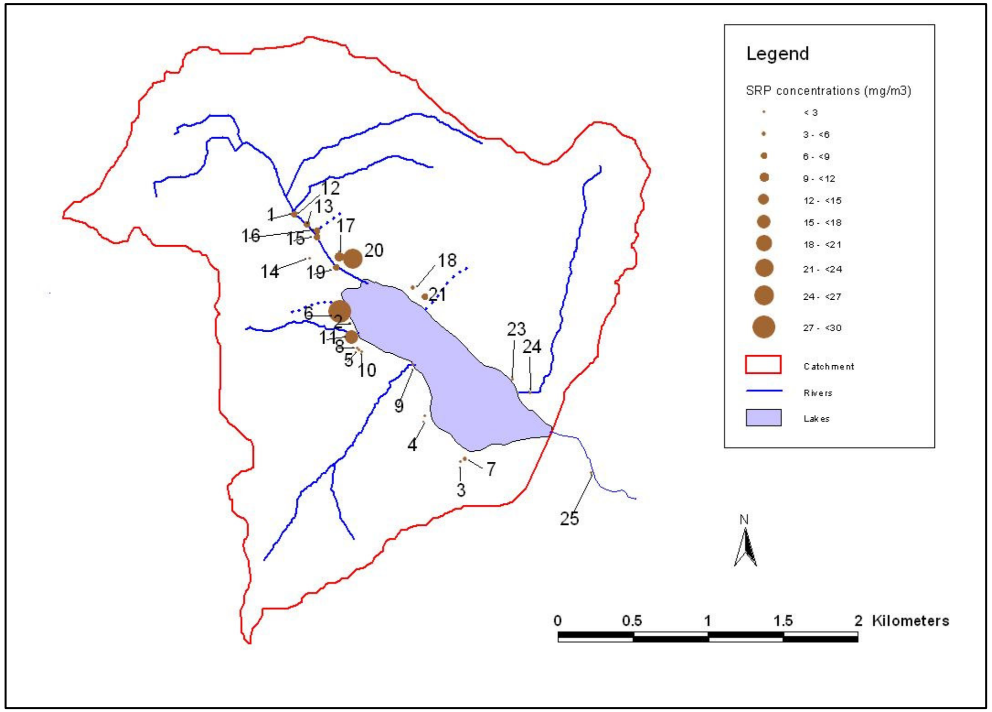


Fig 3 Data from the survey of soluble reactive phosphorus (the form used by algae) concentrations in the Loweswater feeder streams, 5 November 2005. Numbers refer to stream sampling number

Modelling

Catchment models indicate that most of the phosphorus which comes from land in the catchment itself comes from the improved grassland within the catchment which contributes 62% of the total phosphorus load even though it only occupies 35% of the catchment area, presumably at least in part as a result of fertiliser and slurry applications. The importance of one-off storm events in causing increased levels of phosphorus in the catchment was apparent from direct measurements, two of which fortunately coincided with storm events (see Fig 3). Estimated amounts of total phosphorus entering Loweswater under different scenarios are given below

Scenario description	Phosphorus load (kg P y^{-1})
Landcover only	168
Slurry and farmyard manure (FYM)	52
Functioning septic tanks	23
Non-functioning septic tanks	96

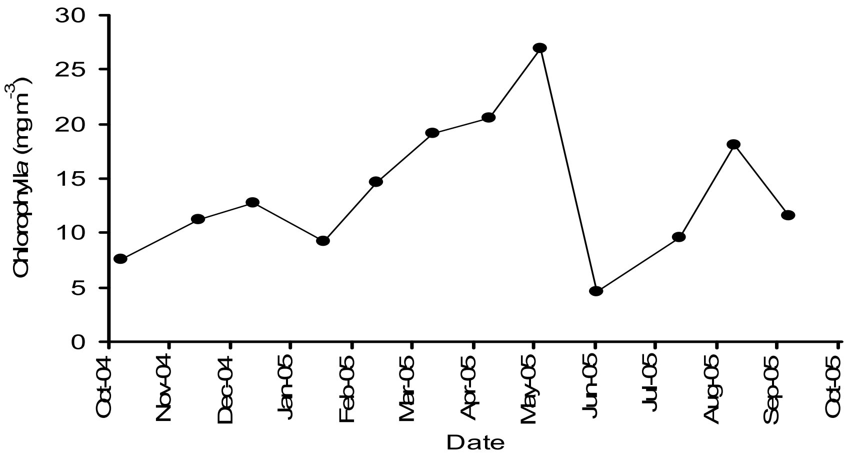
If, in a worst case scenario, all the septic tanks were malfunctioning they would contribute four times as much phosphorus.

Algal modelling confirmed the dominant effect of phosphorus in controlling algae production. Interestingly the models indicated that concentrations of phosphorus recorded in the monthly sampling were inadequate to support the kind of blooms Loweswater experiences emphasising the importance of one-off rainfall events at Loweswater.

Research Findings - algae

In Loweswater, like most lowland lakes, the production of algae is controlled by the availability of phosphorus. Concentrations of other nutrients essential to algal growth (silica and nitrate) were sufficient for algal growth throughout the study period. The spring algal bloom (see Figs 1 and 2) was dominated by cyanobacteria (blue-green algae), mainly *Planktothrix mougeotii*. In many other lakes in the area a different form of algae (diatoms) dominates the spring bloom. The difference between Loweswater and other lakes is probably caused by the fact that water moves less quickly through Loweswater than through other lakes allowing slow-growing cyanobacteria to dominate.

Fig. 1. Seasonal change in algal chlorophyll



The large numbers of algae produced in the lake causes a reduction in oxygen levels at depth. This may allow phosphorus stored in the sediment to be released into the water and become available to the algae. The smaller summer algal bloom (see Fig. 1) is probably largely supported by cycling of nutrients already present in the lake aided by phosphate release from the sediments.

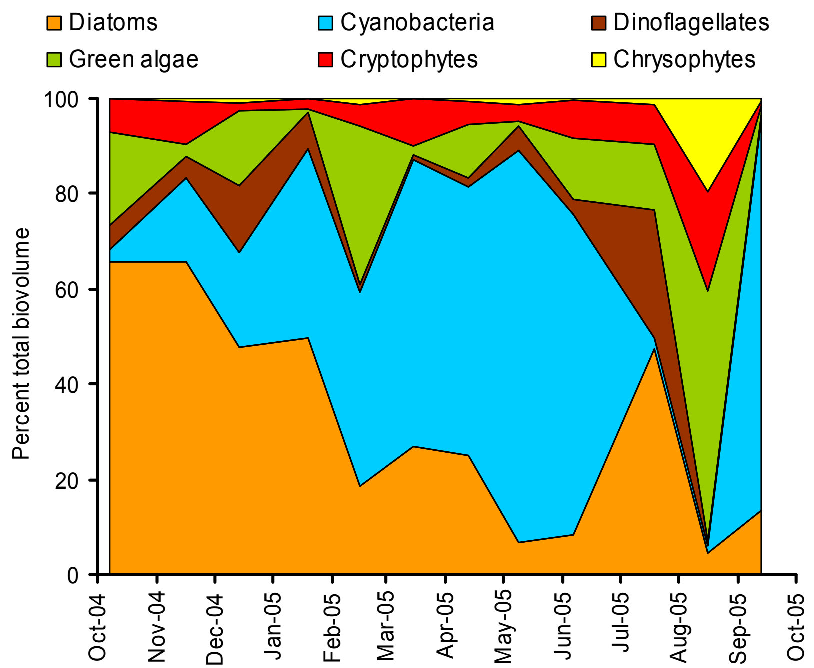


Fig. 2. Seasonal changes in the proportions of different groups of algae.

Historical change

Long-term changes in Loweswater were assessed largely from 'Lakes Tour' samples taken four-times a year in 1984, 1991, 1994, 2000 and 2005 by CEH and its predecessors.

The data provide clear and consistent evidence of increased lake productivity caused by increased supply of phosphorus to the lake both in spring and as an average over the whole year. In response, concentrations of algae in spring and across the year as a whole have also increased and this is likely to be linked to the recorded decline in water transparency. Declining concentrations of nitrate in summer and autumn probably result from greater availability of phosphorus which causes increased demand for nitrate. The long term data reveals that the reduction of oxygen at depth caused by high levels of algal production observed in the monthly sampling over last year is part of a pattern of decreasing oxygen at depth over time.

It is possible to estimate from the properties of lake bed sediments and the size of Loweswater what historical concentrations of total phosphorus in Loweswater were, i.e.10 mg m^{-3}. This compares with a 12-month mean for the sampling period of 14.5 mg m^{-3}. Interestingly, this is slightly lower than the mean in 2000 of 16.5 mg m^{-3} which gives slight hope that the trend towards increasing levels in recent years may now have halted.