Phosphate Removal

using sand filters to control the principle source of eutrophication throughout the Norfolk Broads

by Paul Barter

The Norfolk Broads is a complex wetland habitat covering an area of over 300 km^2 and includes 40 or so lakes, and over 200 km of linking waterways. Although several major rivers flow through the area, the flat nature of the topography and the proximity of the sea and its tides means that flushing through is slow. The network of dykes used to access and drain the land also attenuate the flow, as have the tidal locks and sea water defences over the centuries. This paper looks at the positive impact that phosphate reduction in sewage discharge has had on the ecology of the UK's East Anglian Broads and how the achievements in managing eutrophication, and understanding its complex causes, have implications for other wetlands in the UK and Europe.

The Norfolk Broads - Courtesy of Hydro International

Background

It was not until the 1960s that Victorian theories about the Broads' creation through mass peat cutting in the 13th and 14th centuries were generally accepted. By carving out shallow lakes, and connecting them to the meandering rivers with a system of dykes, the cutters created the basis for today's much-loved landscape and Britain's largest protected wetland.

Long after peat-cutting stopped, small-scale agriculture, fishing and reed harvesting for thatch and horse bedding shaped the ecology of the Broads. This habitat provides a waterbird and insect paradise for which the whole area is much treasured.

Managing the Broads

In common with many European wetland areas, managing the Broads is about achieving an acceptable ecological balance between human impact and reclamation by nature. But in the last 50 years, the accelerating effects of modern agricultural practice and population growth introduced changes which threaten the equilibrium.

An increase in soluble phosphate load from sewage treatment outfalls was first identified as having an impact on the Broads' fragile ecosystem as long ago as the 1970s and was leading to wide-scale eutrophication.

Attempts to remove phosphates continued until, in the late 1990s, a project employing DynaSand® sand filtration technology from Hydro showed a significant impact.

Extended to several treatment works in the area, after ten or so years the project resulted in lowering of the total phosphorus content of the waterways by 90%, compared to the 1970s, and proved hugely successful in eliminating eutrophication when combined with other management practices.

Rapid change

In the 1960s and 70s, it became apparent that the habitat of the Broads was changing drastically and rapidly. Disturbing signs included increasing areas suffering toxic algal blooms, with high BOD and loss of indicator flora species due to eutrophication.

Sedimentation also occurred as a result of algal build-up, with shallowing of major open water and dykes which had the knock-on effect of even slower water movement. Accelerating settlement was accompanied by water heating resulting in less oxygen for sustaining macrophyte, invertebrate and vertebrate diversity.

The principal cause of this increased eutrophication was identified as effluent from domestic sewage, with phosphate being a specific factor. In addition, East Anglia had become a major arable agricultural producer and, since the 1950s, farmers had turned to nitrogen phosphate potassium (NPK) chemical fertilisers to promote intensive cereal growing in the vicinity of the Broads.

Other factors identified included the changes in Broads management practice. As reed cutting declined, reed beds increased in area, encouraging stagnation and siltation and reed management skills also started to decline. Dykes fell into disuse which accelerated the stagnation.

Study for improvement

To try to remedy the situation, a key area for study was Barton Broad, probably the largest open water area at c.70 hectares. As well as turbid water, algal blooms and reduced plant and animal diversity, Barton's decreasing depth made it almost unavailable for the popular leisure activity of boating and sailing, despite the River Ant running through the Broad.

As an identifiable point source of pollution, sewage treatment works were assessed as contributing between 60% and 80% of the phosphate loading into the local rivers, such as the Ant and the Bure. Isolated communities not on main sewerage were also possible sources of more diffuse pollution, as was agriculture.

The drivers for the phosphate removal in the 1990s were the Broads Directive and the Habitat Directive. Now the Broads are part of the National Environment Programme, and are identified for improvement as part of the River Basin Management Plan under the EU Water Framework Directive and for this, Anglian Water is working closely with the Environment Agency.

Phosphate reduction success

To reduce phosphate additions in the discharge to water courses from sewage treatment works, the sewage is treated with iron salts, which are converted to insoluble ferric phosphate. The phosphate is then passed through Hydro DynaSand® vertical sand filters, which are designed to provide final removal of suspended and other solids as a tertiary polishing treatment and provide a convenient point for rapid ferric sulphate treatment. The ferric sulphate solution is injected into the vertical sand filter and rapidly converted to phosphate which is removed with the other solids. The solids are concentrated through a lamella plate clarifier and reintroduced to the primary treatment and sludge settlement stage. It is ultimately removed with the sludge for agriculture.

Hydro installed DynaSand® filters in 1997 initially at Stalham and later at other STWs around the area - Courtesy of Hydto International

Hydro installed the DynaSand® filters in 1997 to achieve rapid, high volume treatment, initially at Anglian Water's Stalham STW which discharges into the River Ant at 60 litres/second (consent maximum 76 l/s), and later at other STWs around the area.

Phosphate is measured as total phosphorus mg/litre. Discharge levels had been in the 5-12 mg/litre range before treatment started at Stalham. Its consent for discharge is a maximum 1 mg/litre, and the plant now achieves an average of 0.4 mg/litre.

Further steps

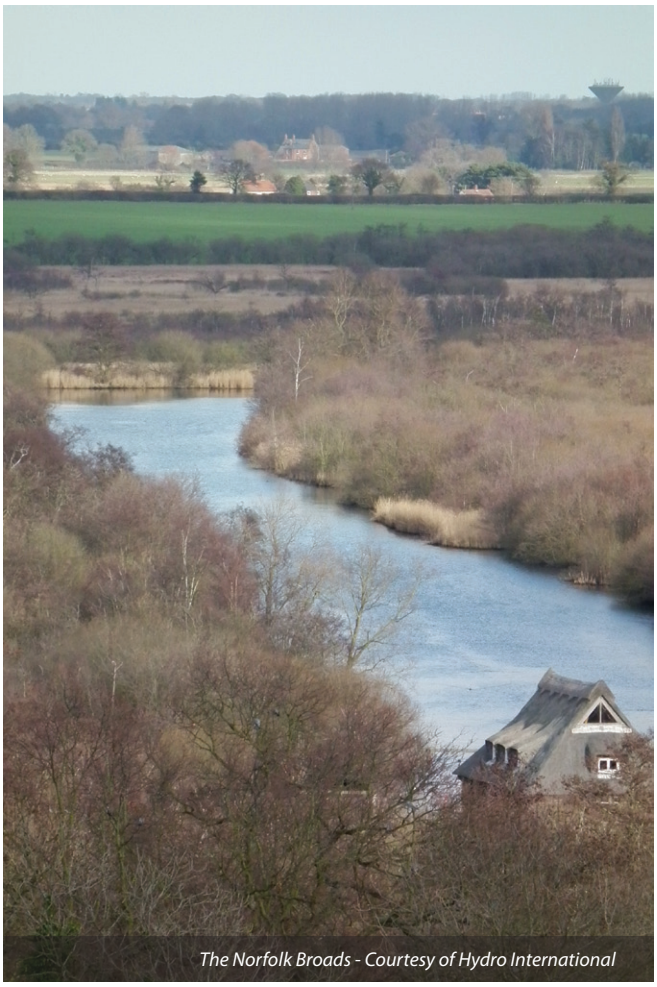
The introduction of phosphate stripping using vertical sand filters has resulted in lowering of the total phosphorus content of the waterways by 90%, compared to the 1970s. In addition, changing farming practices in East Anglia, with a more balanced approach to cereal production than spreading large quantities of costly chemical fertilisers, has helped reduce other sources of diffuse loading.

Despite this, in the 2000s, Barton Broad remained turbid and still bore the signs of extensive eutrophication.

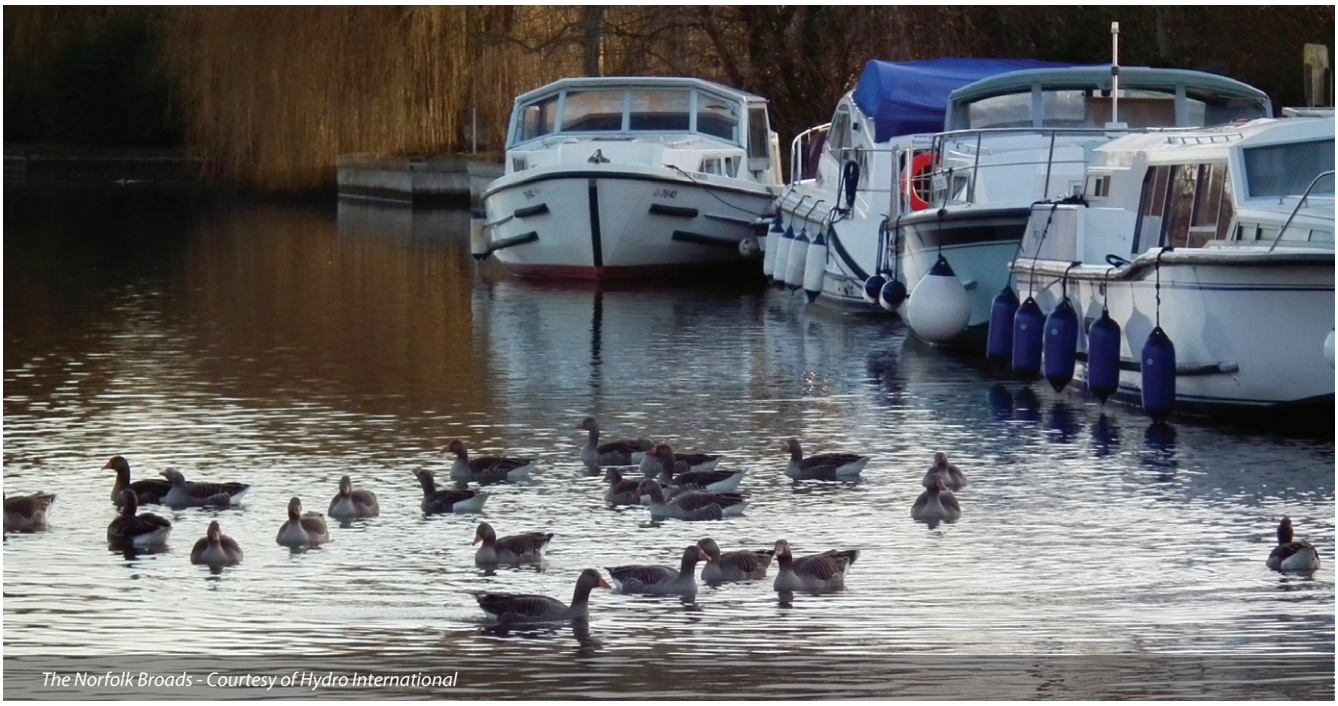
At this time, the complex role of sediment in holding and releasing phosphates was being investigated. From this, it was decided that, although mass suction dredging to remove sediments could cause temporary release of phosphates, where there was sufficient river flow through the broad, such as Barton, released phosphate would be flushed out.

As a result of suction dredging of large areas of Barton Broad, a relatively rapid recovery has occurred in its ecosystem. The recovered sediments were spread on agricultural land well away from the water, and provided enriching mulches for farmers.

Other trials by Anglian Water have included the reintroduction of managed reedbeds, e.g. at Freethorpe, which have been shown to



The Norfolk Broads - Courtesy of Hydro International



The Norfolk Broads - Courtesy of Hydro International

have a role in phosphate removal as well as in ammonia reduction. At Freethorpe, the reeds are unsuitable for thatch, so are burnt on site for potash enrichment of the reed rhizomes, elsewhere, suitable reeds may be harvested for thatch.

Biosphere improvements

RBS surveys on the nearby Sutton Fen Broad have shown some recovery in indicator species like the willow warbler. The diversity at this broad demonstrates what the area could be like including some 14 important rare plant species, for example, the Fen Orchid at Sutton with some 250 plants is about half the UK population. Eighteen birds and animal species and nearly 150 insect species have been recorded there; over 1,500 invertebrate species have been noted in the last 100 years or so.

However, only some of the factors involved in maintaining the status quo are known and understanding what are attributable to biosphere management and what are part of natural fluctuations, reduced eutrophication, or other broader changes is complex.

Conclusion

The DynaSand® vertical sand filter tertiary treatment has proved to be extremely effective in removing a prime source of phosphate. It is been a trouble-free and easy to maintain solution, and the sand filter and ferric sulphate approach enables Anglian Water to control the principle source of eutrophication, and enable other measures to add their effect. There are possibilities of extending the existing phosphate stripping to other treatment plants across the area to increase the benefits.

Management of the Broads over the last 20 or so years has been carefully observed. Observations and conclusions could hold lessons for other wetlands which are affected by human encroachment; the Somerset Levels are one example.

However, at present the complete picture is not yet known and there are still lessons to be learned about the complex influences on fragile ecologies like the Broads.

The Editor & Publishers thank Paul Barter, Principal Process Engineer at Hydro International's Wastewater Division, for preparing the above article for publication.

This article was produced with the kind assistance of Anglian Water and the generous support of Jamie Pizey, Treatment Manager, and Phil Ginn, Anglian Water Service Delivery Scientist for Norfolk.

Wildlife on the Norfolk Broads: (left) Canada Geese (centre) Mute Swan and (right) Moorhen - Courtesy of UK Water Projects