Institute of Freshwater Ecology

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Report To: Dynamco
TFS Project No: T04073g1
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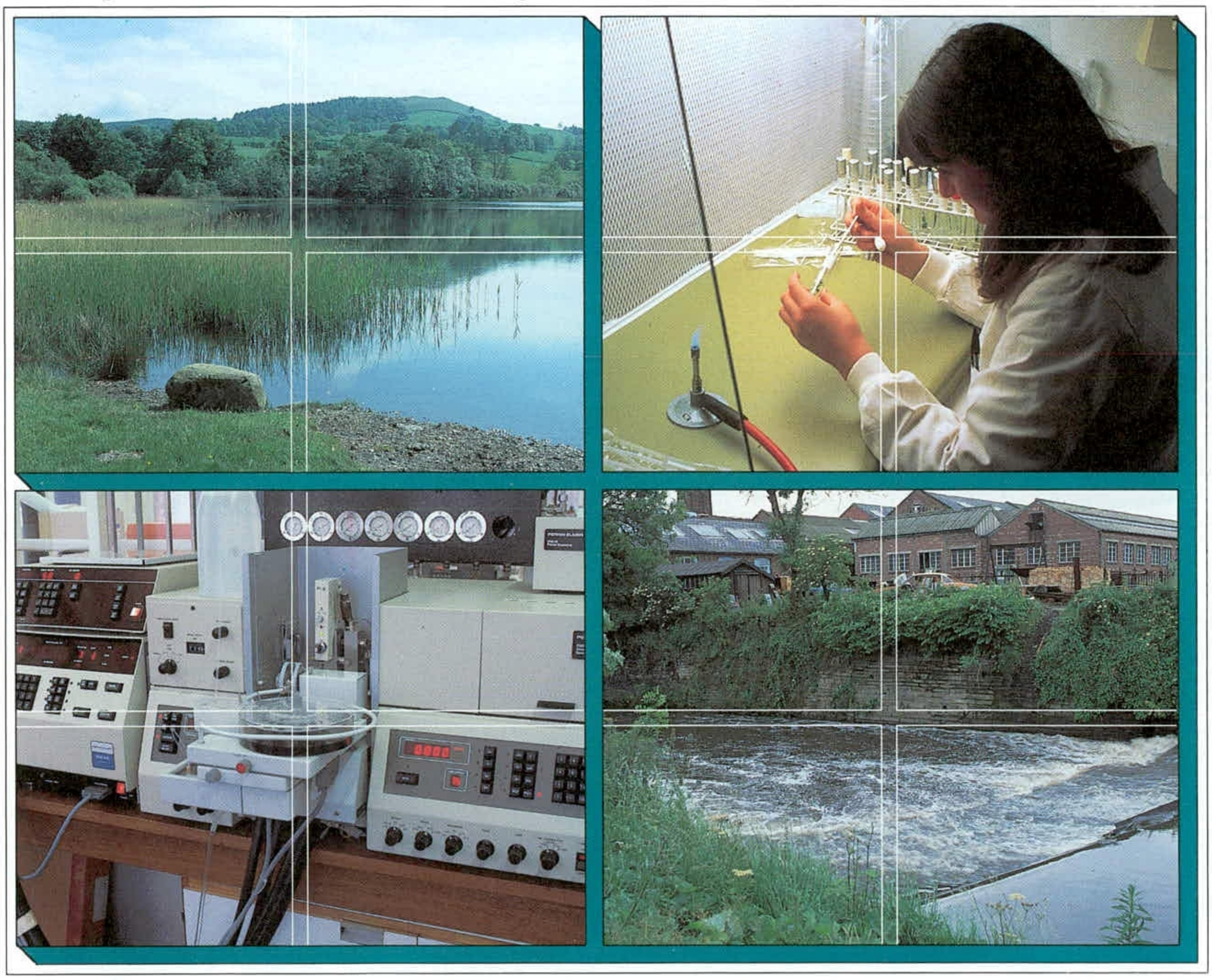

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# BARCOMBE RESERVOIR - AN ASSESSMENT OF MANAGEMENT OPTIONS BASED ON AN FUNDAMENTAL UNDERSTANDING OF ALGAL GROWTH IN RESERVOIRS

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*This report makes its recommendations from a state of the art understanding of the way in which aquatic systems work and is considered to represent the best advice available at the present time. However it should be borne in mind that changes in the physical and chemical properties of water are driven by a complex interaction of biological, chemical and physical processes which are still not entirely predictable and the Institute cannot guarantee that changes will occur exactly as predicted.*

**Barcombe reservoir - an assessment of management options based on an fundamental understanding of algal growth in reservoirs**

Barcombe reservoir develops very high algal crops at certain times of the year making the raw water feed to the works very difficult to treat. South East Water, through their subsidiary, Dynamco, commissioned the Barret-Grubb Partnership (BGP) to assess the situation and propose remedial measures. BGP carried out a monitoring programme and used the chemical data, with some observations on the biological response, to come to a number of conclusions and some tentative proposals for remedial action which they presented in their final report. Given that there is a wish to retain the reservoir in order to maintain the twin benefits of an increased margin of safety in the event of pollution in the river and an addition resource yield, there is a requirement to reduce the algal populations in order to increase the treatability of the water. In this short monograph I will consider the problem from the biological point of view to derive an additional set of possible remedial actions.

Algae are microscopic plants which, like all normal plants, require certain things to grow: nutrients (N, P, K); reasonably warm temperatures; light; and sufficient time to take advantage of the presence of the former properties when they are available. In fresh waters all nutrients are normally in sufficient supply to allow the algae to grow except P. If P is introduced in quantities which are too high then algal growth can develop out of control. BGP confirmed that nutrients were in excess in Barcombe and that P was likely to be the limiting nutrient. Hence they suggested that control should be focused on P limitation. This is normally achieved by adding either aluminium salts, or in the case of Barcombe, iron salts to the inflowing water to cause the formation of insoluble phosphate salts. The present format, where iron salts are added directly to the inflowing water to the reservoir and allowed to react and settle in an unconfined way within the body of the reservoir, has been found by the author to be a very effective method of P removal with efficiencies approaching 90% (Hilton, May, unpublished) for high iron dose rates. Alternative methods used at sewage treatment works where iron or aluminum salts are added to water prior to the final settling tanks have been found to be less efficient with a removal of only about 80% being achieved on average. Since the NRA is unlikely to accept continued dosing of iron salts into the reservoir inflow with unrestricted settlement of the precipitate (due to its possible effect on benthic (bottom living) invertebrates) BGP proposed a small bunded area for settlement to occur prior to overspilling into the main reservoir. This is likely to reduce the effectiveness of treatment so that efficiencies closer to 80% are likely to be the norm. With an average river concentration of 0.6 mg/l it is likely that feed water concentrations will increase from the present (assumed) levels of 0.06 mg/l towards levels approaching 0.12 mg/l. In either case it will be almost impossible to regularly achieve the level of 0.01 mg/l P proposed by BGP as the target value to limit algal growth. (This value is taken from the OECD monograph produced in the seventies and is a reasonable, blind objective for P treatment but, in fact, there is no absolute limiting concentration of P. It depends on the loading to the system. Large volumes of water with a low P content can, in one system, cause as much algal growth as lower volumes of high concentration water in another system. However, although regular achievement of P concentrations of 0.01 mg/l will certainly reduce the algal content of the reservoir, the likely levels of algae have not been predicted.) An added complication, identified by BGP is that the role of the sediments as a source of P in the future is unknown. They do contain a significant store of

P which could potentially be released into the reservoir, artificially raising P levels in the water column for many (possibly tens) of years. Although the present evidence suggests that it is likely to be stable, it is an added uncertainty making P removal a risky option.

Other parameters which are required for plant growth could also be used to control algal growth. Growth is not instantaneous. If the algal cells do not spend sufficient time in the reservoir they will be unable to utilise the nutrients present there to grow. Hence the second of BGP's proposals to reduce the retention time in part of the reservoir. They suggest a retention time of 5 days. The doubling rate of algae seldom exceeds about 2 days so that a 5 day retention time could allow increases in algae up to 2.5 times the input concentration. BGP data show several values for chlorophyll-a around 50 ug/l in the river water. Hence reservoir concentrations approaching 250 ug/l could be achieved in water flowing out of the reservoir on these occasions. These levels are similar to present levels, although they would appear relatively infrequently (1 or 2 times per year). Chlorophyll levels are unlikely to normally exceed about 100 ug/l. A smaller retention time, say two days would be better and still allow some protective dilution in case of a pollution event.

In the remainder of the reservoir the retention time would have to be maintained at a much longer retention time, being used only as emergency supplies. In this case the long retention time area would be filled over the winter. High algal blooms would develop early in the year but they would not be a problem as the water would not be used for supply at this point. By early summer, the algae would have used all the P and algal populations would start to reduce, producing good quality water. However, in order to maintain this quality no new P must be added, i.e. under no circumstances must the long storage section be allowed to have water flowing in and out renewing the P. It must be used in a single shot, or a series of large gulps with refilling and time for algal crops to reduce in between, i.e. if the two chambers are not sealed from each other then both sub-reservoirs must be operated at close to constant level, until the emergency supply is needed. This method of operation assumes that sediment release will be minimal or rapidly reduce to minimal levels. Operation as a free flowing two chamber reservoir with one long and one short retention time compartment would be a cheap alternative as the intervening wall would not need to be water tight, its only function would be to stop significant amounts of mixing between the two. Hence it could be made either of a flexible material such as butyl rubber or from simple, book-end shapes of concrete which were stood in a line across the reservoir with, say, two, shielded openings in it to allow free flow of water. If the operation of the reservoir at constant level is operationally difficult then the two sub-reservoirs would need to be separate, in which case a water tight wall would be required which could withstand the pressure difference between the two reservoirs when one was empty and the other was full. This would be very expensive and significantly reduce the storage volume of the joint reservoir.

Because algae are plants they require quite high light levels to grow. This requirement can be manipulated to develop an alternative control method. Practically, control can be achieved either by reducing the amount of light getting into the water or by reducing the average length of time that algae spend in the reservoir. In the latter case, the available light is reduced by making the reservoir deeper so that the average depth exceeds the photic depth (the depth of light penetration). In this case, in a fully mixed reservoir, the average light climate reduces in proportion to the ratio of the photic zone depth to the mean depth of the reservoir. BGP concluded, reasonably that this would be far too expensive and option. However, it would be possible in a small reservoir like Barcombe, to reduce the light by covering to reservoir. This is not untried, it is, after all, one of the main reasons (although not the only one) for covering service reservoirs. It would be too expensive to make a roof of concrete or equally durable material such as steel sheeting, However, there is no structural requirement, it is necessary simply to reduce the light, and this could be met by floating an opaque covering on, or just above, the water surface (in a similar way to coverings on swimming pools to reduce heat loss). Since it would not be necessary to exclude light completely expensive engineering would not be necessary. A similar technique using geotextiles has already been used successfully in rivers to reduce the growth of large water plants which can increase the risk of flooding if left to grow unchecked (Dawson, 1983). Dawson (1986) reported that trials were carried out in the early eighties in the US to extend the technique to light reduction in lakes. The trials were only partially successful at that time but there have been major advances in materials technology since then and the technique is now worthy of serious consideration since it would remove both the need to dose with iron or to carry out complicated hydraulic balancing of the reservoir. Initial estimates suggest that a floating covering which would last 5-10 years would cost about £50k (including installation).

## Conclusions

1. Three potential control mechanisms are available: a) reduction in P concentrations; b) reduction of the retention time in part of the reservoir; c) reduction in the light climate.

2. Because of the requirements to confine the settling area within the reservoir, or to carry out this process externally, the efficiency of P removal is unlikely to increased above its present levels without the inclusion of much more sophisticated control techniques than presently available.

3. The potential for the sediments to recycle P is an unknown factor.

4. Operating the reservoir in two sections requires either the building of an impermeable wall between the two sections which would be expensive or the operation of the reservoir at constant level except when the emergency supply is required. In the latter case the engineering required is relatively cheap but UNDER NO CIRCUMSTANCES MUST WATER BE SHUNTED IN AND OUT OF THE LONG RETENTION TIME RESERVOIR. Water must be abstracted then time allowed for the algae to exhaust the new supply of P.

5. Control of the light climate by light weight, floating covers has potential as a cost effective control method for a small reservoir like Barcombe.

## Recommendations

1. SEW should explore the engineering feasibility and costs of the three control methods outlined above.

2. Very serious consideration should be given to controlling the light climate.

3. An engineering feasibility study of the three options should be carried out using the data collected by BGP to calibrate a dynamic model of algal growth in Barcombe. The model would then be used to test the likely efficiency of the proposed solutions and the levels of P loading, hydraulic flushing and/ or light reduction which would be required to achieve target algal biomass objectives..

## References


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