WADAA Water Quality Monitoring and Aeration

A History of Progress

In July 2019 WADAA suffered a catastrophic oxygen crash, followed by a major fish kill at one of it's trout fisheries. It occurred following a rapid 'die-back' of algae, somewhere between midnight and 8am.

The events exposed WADAA's complete lack of understanding and preparation for such events and served to illustrate the significant risk at many of the club's venues.

A number of environmental changes mean that this risk is increasing significantly year on year:

- Climate change and increasing levels of sunlight are driving larger algal blooms
- Increased pressure to keep venues weed-free reduces natural oxygenation capacity of waters
- Drive and demand for more and larger fish
- Increasing concentrations of nutrient loading in water, particularly nitrates and phosphates

These combined factors mean more algae, less oxygen and less oxygen producing capacity. This presents an exponential increase in risk and the likelihood of 'an event'.

In the aftermath of the 2019 fish-kill, WADAA took time to consider it's entire approach to the management of it's fisheries, and came to some stark conclusions:

- The club had no knowledge of water quality management
- Tell tales signs had been missed (such as a rapid growth in algal levels) and subsequent clearing of the water

- No sampling or measurement was being carried out
- There were few controls regarding stock quantities
- The club had no emergency response capability
- The club had no understanding of linked events, such as the impact of weed removal on oxygen levels
- The club had no data/measurement profiles for each of it's venues, so could not determine when an abnormality was occurring
- The club had no additional aeration capabilities to counterbalance some of its other activities (such as weed removal)

Additionally, as a professional organisation, with a pride in it's operation and a responsibility for managing fish health, a serious kill is a very damaging event, both emotionally, financially and reputationally. It also places a significant burden of stress on club officials.

The club made some immediate short term changes:

1. Purchased a set of petrol driven air pumps which could be deployed in the event of a crash, to raise oxygen levels in water.

2. Purchased a hand-held Dissolved Oxygen meter and began taking weekly measurements at venues deemed as ‘at-risk’

3. Carried out water sampling using Chemical Analysis kits

These activities immediately raised an awareness, began to build a profile of what was normal and abnormal conditions in venues and set some venue 'baselines'.

In addition to this, the club began to introduce some basic methods to minimise the growth of algae, particularly in it's trout venues:

1. Addition of blue dye
2. Setting of barley straw 'sausages'

It also carefully considered its weed removal activities. This is a difficult one to solve though, as maximum weed growth is always in the height of summer when the risk of weeding is at its greatest. As well as removing the oxygen producing plants, mechanical weeding also liberates silt into the water column, mobilising bacteria which multiply quickly and consume dissolved oxygen at a vast rate (the same bacteria which consume dead algae in a crash-event).

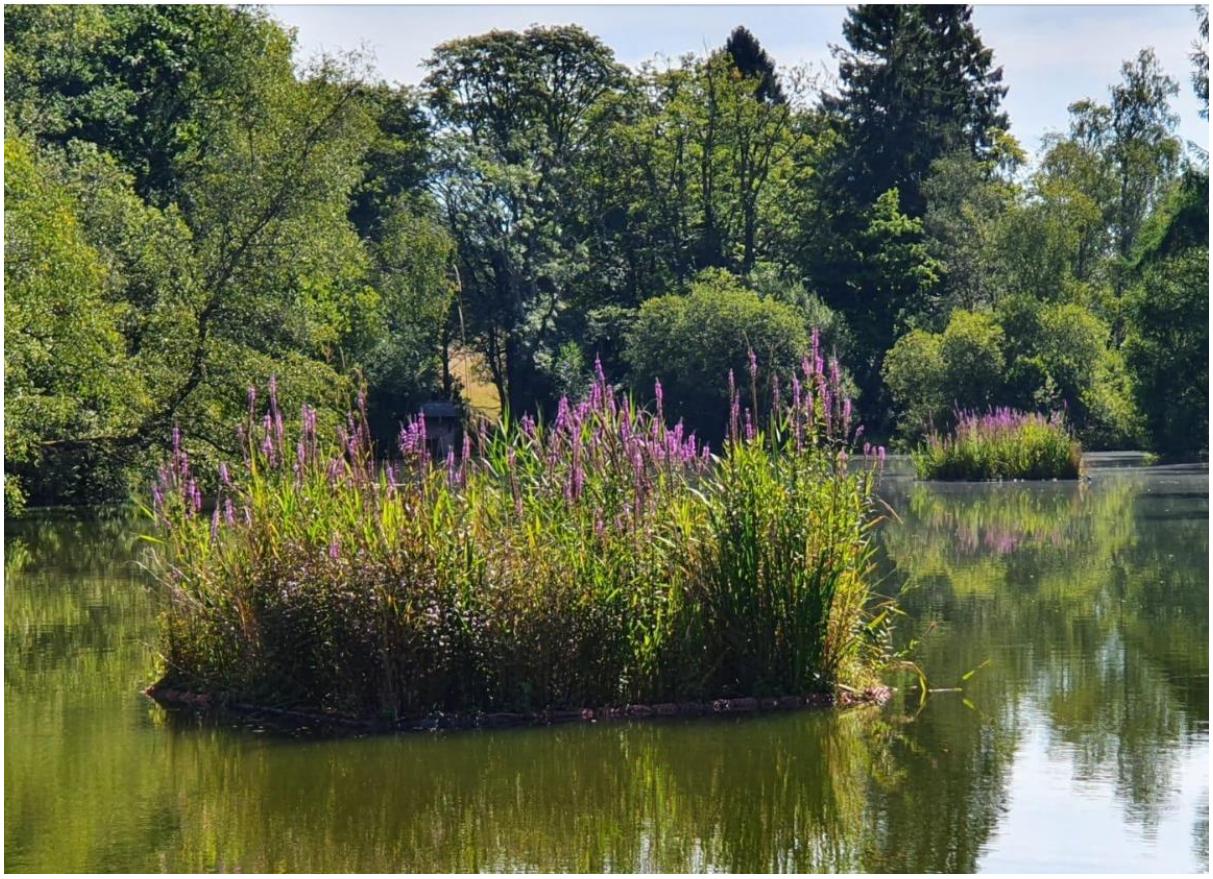
The club continued this approach for 12 months. Water sampling was added to the activities of the bailiff and a specific board (committee) member took responsibility for chemical analysis.

The chemical analysis showed some surprising results:

1. One particular venue was being 'polluted' by on overflowing private water treatment plant – this resulted in an immediate prohibition notice being placed on the plant by the Environment Agency
2. The general level of nutrients in the water across all venues were high

Again, the club took immediate action to try and mitigate these by creating large floating islands; controlled planting to take up the excess nutrients, (as a

side note, these were placed on top of sunken gabion baskets to provide fish refuges.



At this stage, club officials had begun to understand some of the very important management parameters. Lots of information was also shared with club members, raising general awareness and understanding. This is a huge advantage and creates a ‘many eyes on the water’ capability.

As the solutions developed, the club started to witness drawbacks in the approach it was taking. With a portfolio of nearly 20 venues, bailiffing, water sampling and oxygen monitoring manually was very time consuming.

Also, to be most effective, sampling needs to be done in a very consistent manner – same time, same place. And critically for the measurement of dissolved oxygen, at the same depth. This is virtually impossible when using a handheld meter thrown from the bank.

Furthermore and vitally, weekly sampling (though better than nothing), is fairly ineffective if an oxygen crash can happen in a matter of hours. The club needed to work smarter; quicker, more regularly and more accurately.

An approach was developed to target 3 specific areas:

1. How to constantly measure what is happening
2. How to prevent issues from arising
3. How to respond to issues once they manifest

Constant Monitoring

Working with contacts that the club had at Manchester University, the club partnered with a data and measurement company specialising in water sampling and analysis (not in fishing but in domestic water management).

An automatic, 4G monitoring unit and probe were deployed, measuring the critical parameters of water temperature, % dissolved oxygen saturation and dissolved oxygen concentrations, mg/l.

Clam RTU

. . . remote monitoring of the environment

SALAMANDER GROUP

KEY FEATURES

- Low power operation allows remote deployment for extended periods
- Fully waterproof and robust enclosure designed to IP68 standard
- Connects to many types of low power sensors used in the water environmental sector
- Unique in-built relay for activating external devices from sensor reading trigger levels
- Bi-directional 4G cellular communications for remote configuration, data upload and alarming
- Bluetooth mobile app for local set up, control and data collection
- Powerful Clamnet Portal data management and visualisation
- Being used by charitable aid organisations in many parts of the world to help ensure drinking water is safe

CLAMNET

The Clam RTU is part of the Clamnet system of sensors, telemetered data loggers, mobile app and web data portal. The Clam RTU can be used with a wide range of sensors to monitor the water environment. From rainfall, upland and lowland water courses, lakes and reservoirs to drinking water networks, many parameters defining water quality can be measured, stored and uploaded to the cloud based Clamnet data portal.

CLAM RTU

The Clam is a battery powered data logger and telemetry unit which has been designed to operate in fairly challenging conditions for long periods. Through continuous development the device can power a range of our own and third-party sensors, for long periods from the internal batteries. Using RS485 communications a single Clam can collect data from multiple sensors at a single location.

Alarm levels for each parameter can be stored on the Clam which trigger email warnings when these are breached. Uniquely, the Clam has an in-built relay which can be used to activate external devices, such as pumps, valves, aerators.

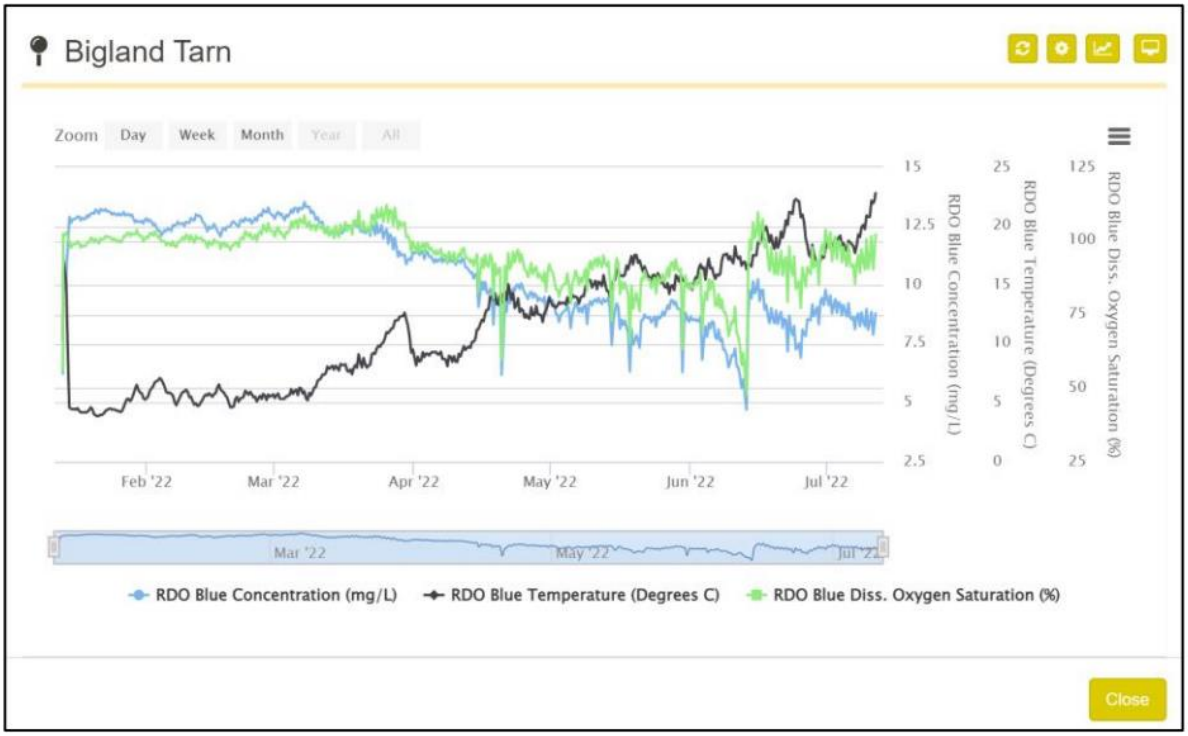
The Clamnet App is now available on Google Playstore and Apple Appstore and has been enhanced for greater control of the Clam via a bluetooth connection.

CLAMNET PORTAL

Data from the Clam is stored and viewed on the very secure Clamnet Portal. With flexible device management and visualisation tools the portal can manage large Clam fleets. Data can also be exported as CSV files or via our API to import into SCADA or other corporate systems.

Contact: info@salamander-group.co.uk

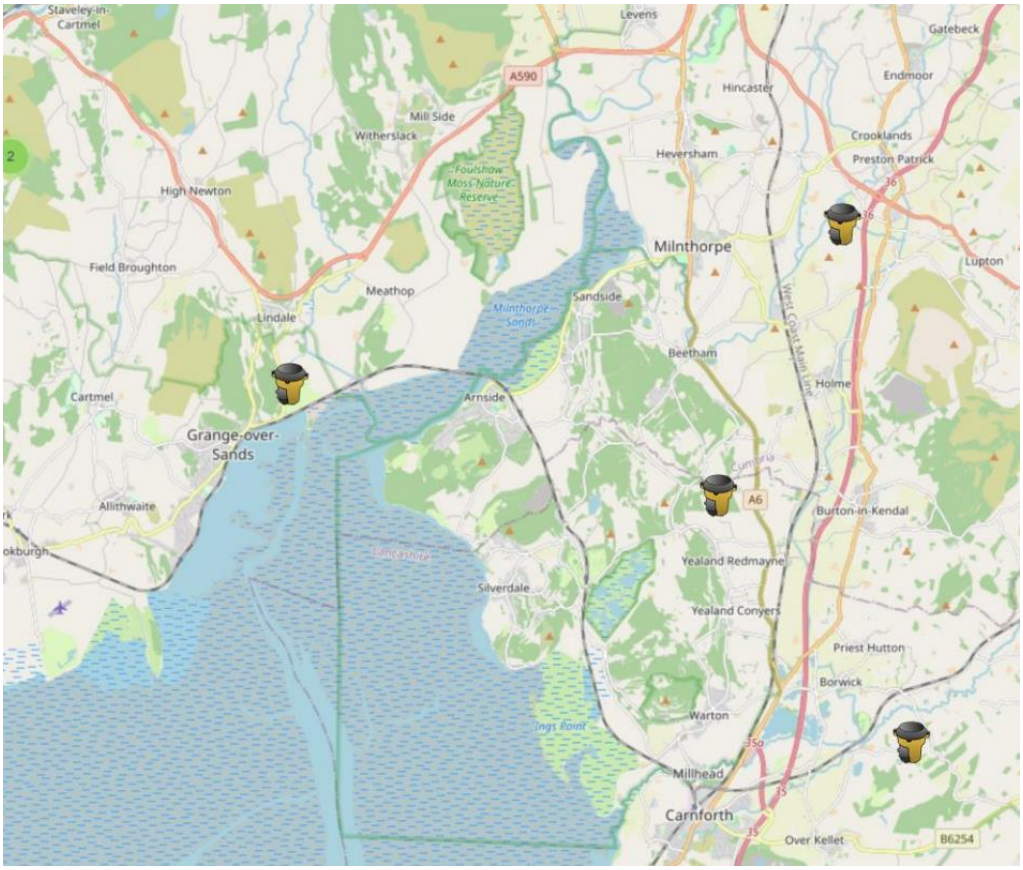
Data is compiled automatically through the company database and WADAA has direct access to the information.



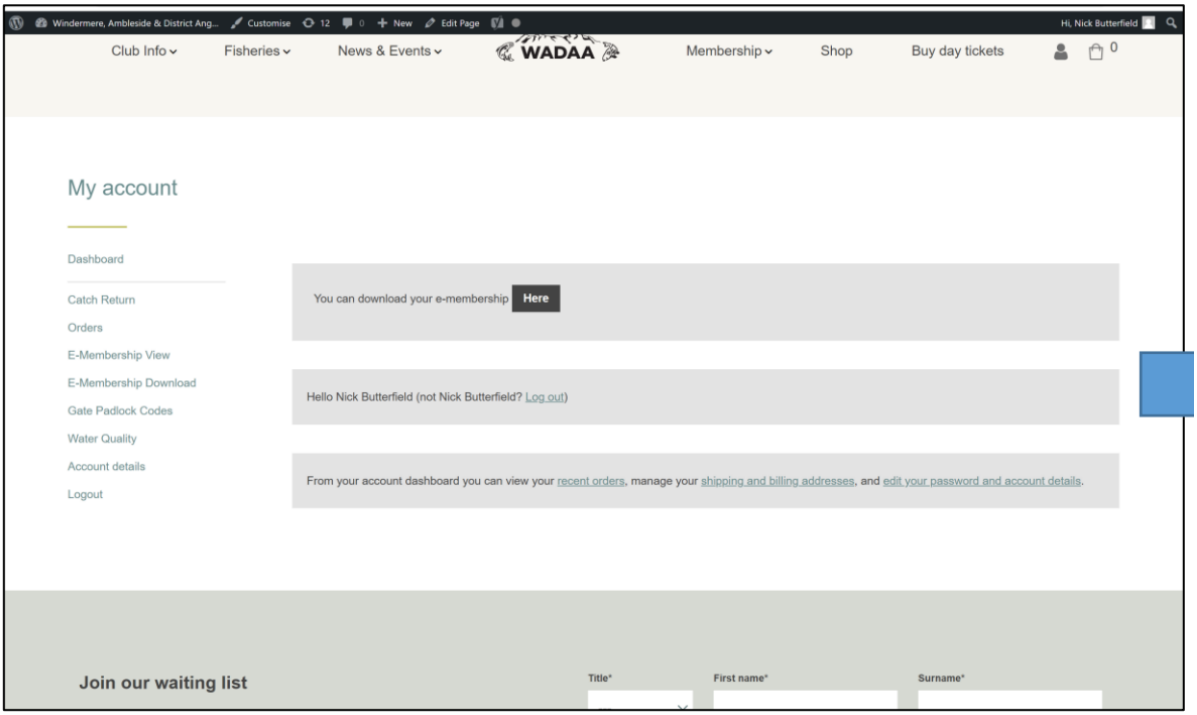
Control parameters are set within the database and warning notifications are automatically issued when readings fall outside set limits.

The monitors are attached to floats and anchored in position in the lake. The probe hangs suspended beneath the float at a determined height.

This has been hugely successful and the club now has all of it’s high-risk venues covered by the capability. The data is accessed through a simple map interface.

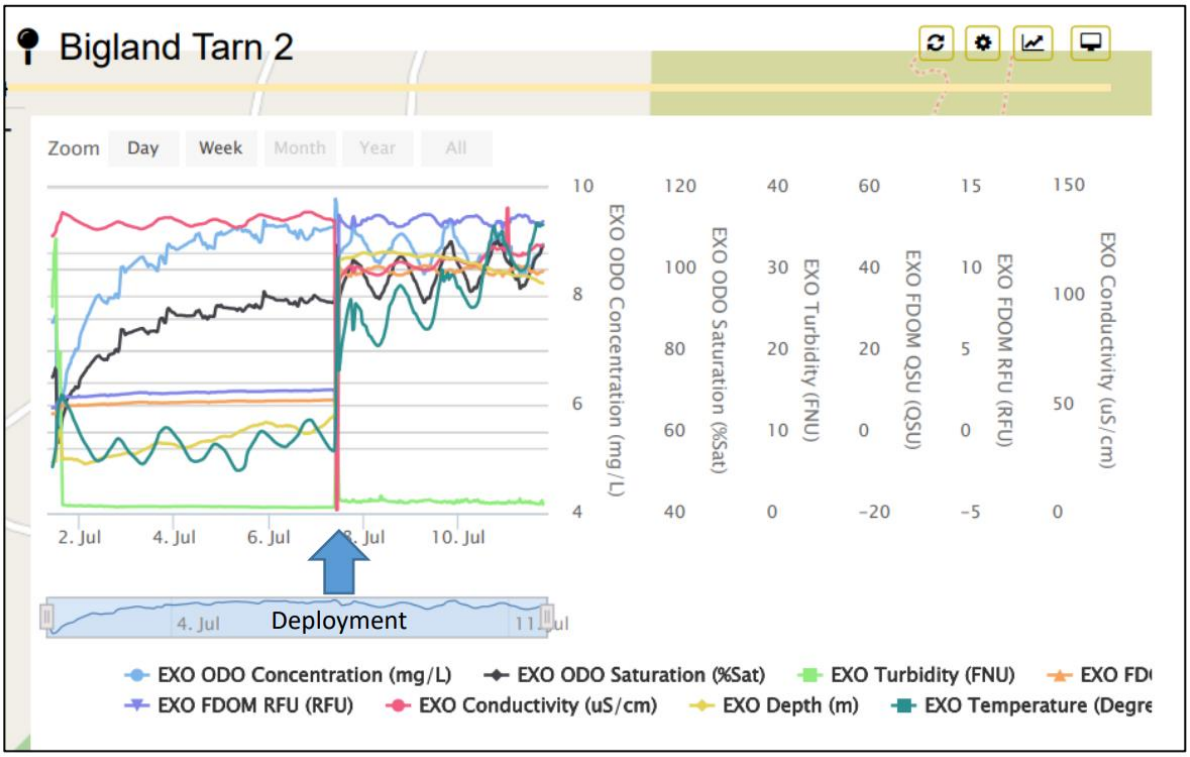


The data is also shared with all club members via their personal account. This not only encourages members to take an interest in the water conditions and gain an insight into the overall management of lakes (and not just chucking loads of fish in!!), but also means that the club has more eyes looking out for problems. When conditions are poor ie high water temperatures on trout venues, members also have the information they need on venue selection.



The system has proven to be almost entirely ‘fit and forget’. The probes need cleaning every 4 months and of course, positioned where they are not likely to be cast over.

On a day-to-day basis, temperature and dissolved oxygen are the key measurements, however, other information is also useful. On a sample basis, the club, again working with Manchester University has used a more sophisticated probe. This allows sampling of the chemical constituents of the water; nitrates, phosphates etc. This probe fits on the same data communication device, but produces a much greater data spread.



This has proven useful in a number of areas:

1. Identifying areas of high concentrations of ‘pollutants’ allowing a focused use of controlled planting and buffer-zone creation
2. Providing the EA with real-time, ‘hard-data’ to help with any enforcement activities.

In deploying this capability, WADAA now has real-time, accurate and comparable data on which to make intervention decisions.

Issue Prevention

Much can be done to improve water quality by sympathetic management of land over which water flows into the venues. Over the last few years, as has previously been mentioned, a significant effort has been made in planting. The club has set planted floating islands on many venues. These have been well-

engineered to prevent them from becoming broken and as a result are now very well-established units. The islands are constructed from framework of sealed drainage pipes, covered in a mesh and subsequently planted with suitable aquatic plants. The use of rush and more ‘woody’ species prevents them from being destroyed by birds. Additionally willow saplings are pushed through the floating frames and into the lake bed below.

As well as floating islands, margins have also been well-planted, with plants of different types extending well into the water.

Where farm field runs down close to the water, buffer strips have been developed. This area is again planted to reduce as many nutrients from in-flowing water as possible.

All inflow areas are thus protected. Additionally, the placement of barley straw ‘sausages’ are also set here.

These ‘soft’ measures have also been supplemented with the addition of mechanical aeration.

Where the venue has mains power availability, there are many options and aeration is a relatively straight forward process.

WADAA has deployed several types of aerator, depending on the specifics of the venue:

1. Depth
2. Size
3. Noise sensitivity
4. Silt loading

A large venturi water circulator has been used on a large (but shallow) lake to create flow.

Paddle wheels to create surface agitation and flow.

A splasher unit to mix water, and create flow.

Though simple and reliable, shifting water is expensive. With steep rises in electricity prices, running mains power aeration is very expensive, with individual units costing £1000's to run annually.

Where mains power is not available, providing forms of mechanical aeration is altogether more difficult. The obvious answer is solar. WADAA had good experience of using very simple solar panel solutions to support a recharge capability for batteries operating electric fences. The club has been able to very simply eliminate battery changes (in entirety) on it's electric fences, both saving a significant labour burden in winter, but also reducing the risk of a power outage.

2 years ago the club set out to take this learning and develop a solar powered aerator. Whilst some commercial products were available 'off-the-shelf' the club felt that these didn't serve it's needs.

Firstly, aeration is of most use during the night, when oxygen levels are at their lowest (the diurnal cycle caused by a lack of aquatic plant photosynthesis during dark hours). Many commercial solutions couldn't provide dark running.

Secondly, the units needs to have both a capacity high enough to provide sufficient aeration and run over a long enough duration. Again, the club felt that commercial options were either not sufficient or very expensive.

Building a series of panels and charging a battery bank is fairly straight forward. A Photovoltaic panel bank of 1000w, charging 8 lead acid batteries, configured to provide 24v and around 450ah capability was constructed.

For over a year the club then attempted to engineer, through many iterations, a suitable paddle aerator.

Though simple to get to run, it proved impossible to get reliability and durability over a period of time. The club tried many, many combinations of motor, 24v dc, 110v ac, 240v ac motors of both brushed and brushless type.

The aim was to achieve a minimum 6 hour run duration covering the period 2am to 8am – the period of highest risk.

A ‘water moving’ aerator consumes about 1000w during runtime. It proved impossible to generate 1000w continuous power, over a 6 hour period, 7 days a

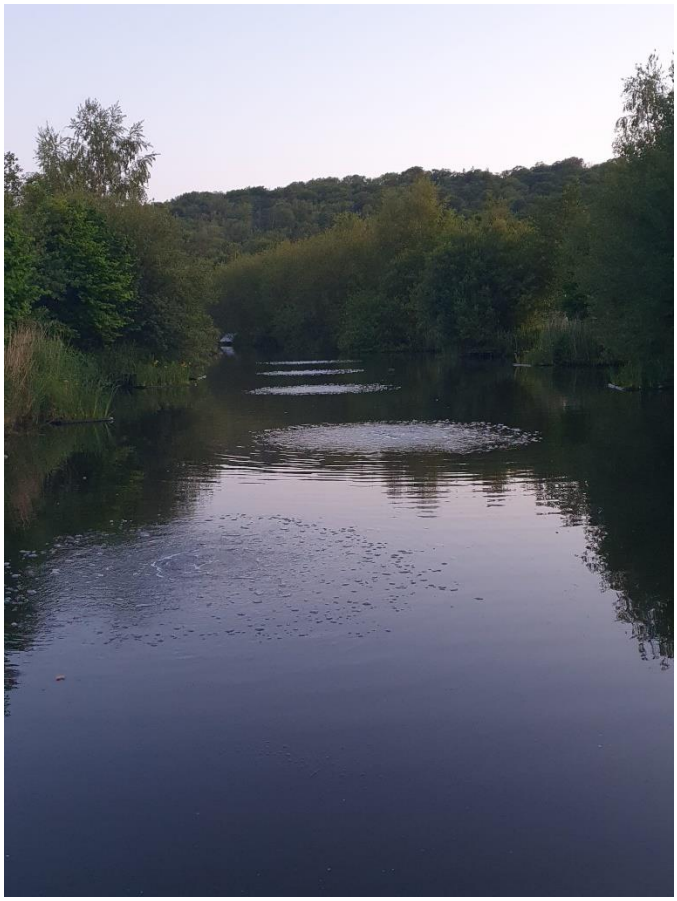
week. The size of both PV panel and battery bank to achieve this were not feasible.

After much effort and failed attempts, the club looked for a different solution. As air is much lighter than water, the amount of energy used to move it is much less. Though aerators that create splash, such as paddlers are the most effective aerators, less efficient diffusers would be a viable alternative over expended run durations.

Working with the very knowledgeable guys at a company called Aquaculture Equipment Ltd, a multi-head diffuser set-up was developed. Air, driven by a pump is fed through a series of pipes and out through a micro-diffuser head.

The club worked with 2 pump sizes delivering 150litres/minute and 250/litres/minute of air and experimented both with a different number of heads and run duration.

Finally, in the late spring of 2023 the club had a feasible, reliable and effective solution, which it was able to deploy quickly onto 3 lakes (1 trout, 2 coarse).



The system, controlled by a timer, is able to run for 20 hours in a 24 hour period. During two short, 2 hour periods, 8am-10am and 1pm-3pm operation is halted to allow for a fully battery recharge.

In sunny conditions, the system can run for the full 24 hour period, though this is unnecessary under standard lake conditions.

It is also important that the solar solution has a back-up that can be used in event of a failure. The pumped air system that has been developed has a very simple, cheap and effective back-up.

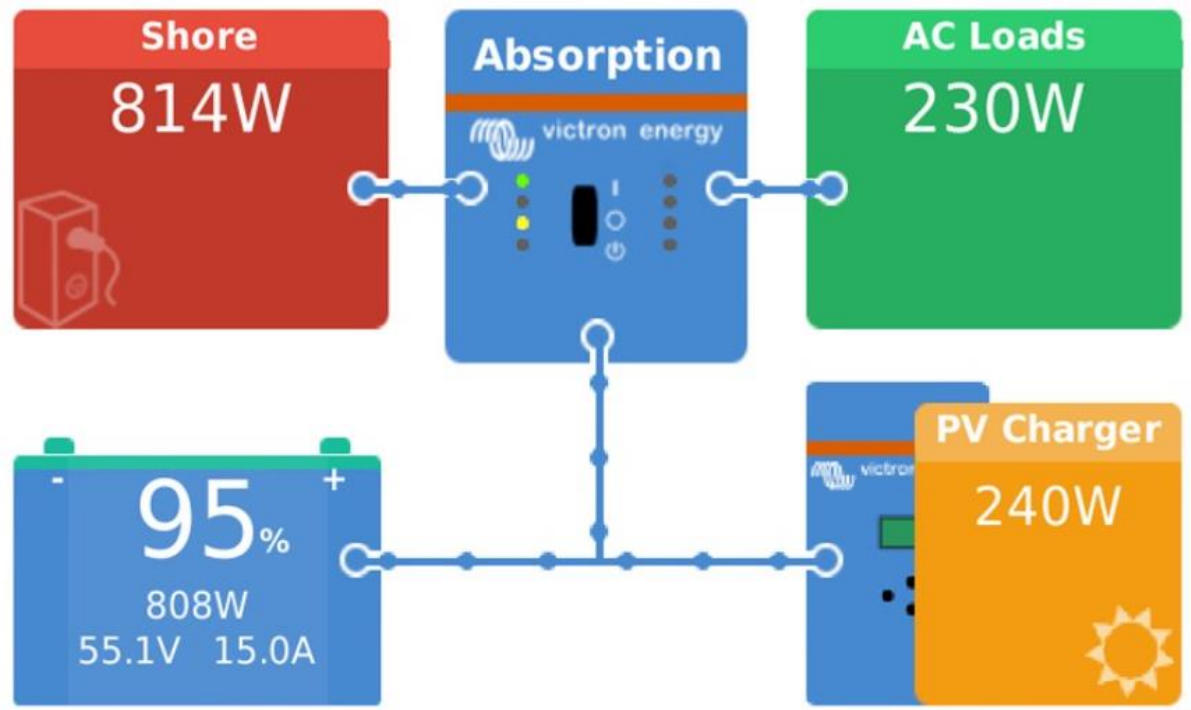
Given the low power consumption of the air pump (115w for the 150 lite/minute version), the system can be powered by a low capacity petrol generator.

Compared to the water pump that the club had previously used for aeration (in emergencies), this offers many benefits.

1. Cheap to buy
2. Light and easy to carry and set-up
3. No cumbersome water pipes – it runs the system through the same pump and pipe network as the standard set-up
4. Very fuel efficient, using only ¼ of the fuel of a water pump

The whole system can be build, start to finish in 2 days.

Given the solution is largely electronic, it can also be monitored remotely – in a similar way to the water quality monitors. Real-time operational data covering run state, battery charge condition, solar charging rate and remaining available operational time can be viewed via an app.



It is a massive advantage not having to visit a venue to see if the solution is running.

Furthermore, the functionality allows the system to be controlled via the app – remote on/off.

WADAA has also developed the ability to link the water quality monitor solution (measuring temperature and dissolved oxygen) to the aerator, thus allowing the system to start automatically if pre-determined parameters are exceeded.

However, to date, the club has not used, nor implemented this.

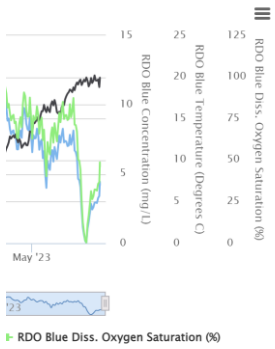
The journey to develop a capable solar aeration solution has been long, arduous and very difficult. It has taken 2 years of constant work to perfect the approach.

Emergency Management

Despite best efforts, emergency situations do arise. They can emerge very quickly and have catastrophic effects. The final piece of the jigsaw that WADAA has developed is being prepared for the worst. This is in terms of seeing the problem as early as possible and being able to respond (with people, knowledge and equipment) immediately.

A real example

Out of the blue, and at a relatively early point in the year (early June), one of the WADAA monitors indicating a rapid crash in oxygen levels at a coarse venue. The speed of this decline was stunning. In the space of 12 hours, oxygen saturation crashed from 87% to 0.2%.



This was catastrophic and the club had to take immediate action. The club immediately deployed air pumps and 5 diffusers heads and created a 'safe-zone' within the lake.

The diffuser head solution was connected to a back-up petrol generator and the system was run immediately. This gave 8 hours continuous run time.

In the evening, the pump and diffuser heads were swapped to run off the solar/battery set-up. This was for 2 reasons:

1. Silent operation
2. 12 hour untouched run duration of the battery bank

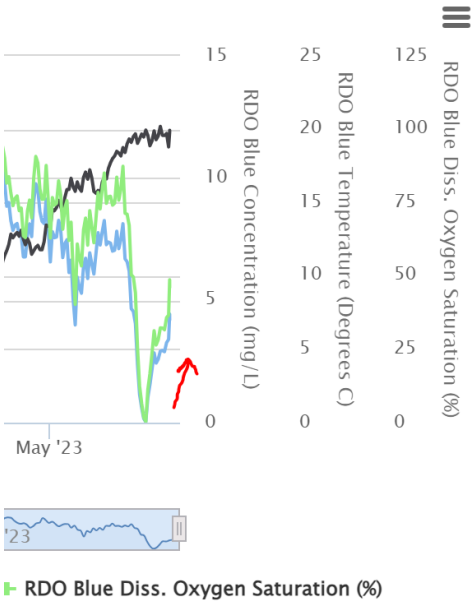
This cycle was repeated over the next 2 days.

Concurrently, the club constructed another solar power station at the other end of the lake.

This took a further 2 days (taking into account sourcing the required materials).

During this time, system 1 ran continuously using the combination of petrol and battery power.

Though oxygen saturation rates remained low, they improved daily.



By day 6 the 2nd solar set-up was fully commissioned and running. The combined 9 diffuser heads were run for a combined 24 hours per day (full coverage between the 2 units). At this point running with the petrol generator was no longer required.

At day 8, the critical danger was averted and the system was returned to night time running only.

This episode proved the value of everything that the club had been working on. Though the lake suffered a few losses (around 5% of overall stock), 95% of the fish were saved – a remarkable figure given the severity of the emergency.

Next steps

1. The lake in question has a history of issues caused by a high biological oxygen demand as a result of thick legacy silt. Removal of this silt will be necessary to address the root cause. Silt removal is difficult and expensive. However, following support from the Environment Agency, the club has been developing a pumping solution. After successful early trials, activity will be undertaken in winter 2023/4 to clean out the silt.

Action cannot be done sooner because of the risk of triggering further crashes.

2. Some of the WADAA venues do not lend themselves to aeration solutions. These are venues with no mains power, of a size above 3 acres and with high stock density. These are now at the top of the club ‘at-risk’ list.
   As permanent aeration solutions are not practical, the club has developed a ‘rapid response’ kit. Prepared and ready to go, the club will hold a pre-assembled series of pipes and diffuser heads, powered by a small capacity petrol generator.
   To maximise effectiveness and minimise the labour burden, the generators will be modified with an expanded fuel tank to allow for an uninterrupted 48 hour running period. The kits will be stored pre-assembled trolleys and ready to be deployed at very short notice.

   Summary

   Managing fisheries is a careful balancing act, often managing away from what would be a natural state:

   - High fish stock levels
   - Low natural weed

- Low cover and shade

In order to help the club manage this risk, a significant level of development and innovation has been deployed.
Though difficult events will occur on our venues, and the risk of this is likely to get greater as a result of climate change, the club will do all it can to avoid, mitigate or react to minimise impacts.

This innovation comes at both a financial cost and requires a lot of effort to both develop and deploy.

These are actions are necessary to maintain our wonderful fisheries in top condition and offer the very best quality fishing, whether that is coarse or trout, that we can.