OXFINITI

OXFINITI SUPER OXYGENATION SYSTEM DEMONSTRATION STUDY

A report on the trial of the OXFINITI Oxygenation Box at
WICK ST LAWRENCE STW

Table of Contents

EXECUTIVE SUMMARY

1. The OXFINITI* Wastewater Treatment system

The OXFINITI wastewater treatment system is a proven technology for direct injection of oxygen from a generator more efficiently into an activated sludge process. No liquid oxygen or storage is required. This results in significant energy savings and enhanced quality benefits.

Wessex Water STP was selected for the trial. The OXFINITI box was set up at the Wick St Lawrence stw (Wick SL) activated sludge oxidation ditch plant. This serves approximately 20,000 PE using four surface aerators, floating aerator and two paddle aerators.

2. The Site's Oxidation Issues

- The activated sludge process was struggling at times owing to high loads receiving insufficient aeration.
- At peak load times the ditch was under-aerated commonly resulting in high ammonia levels
- Even with additional aerators added to the original configuration the system was incapable of consistently meeting DO targets.
- Inlet flows to the works varied fivefold affecting oxidation.

3. The OXFINITI Solution

The OXFINITI system is housed within a self-contained 20 foot intermodal box. It can be integrated into a SCADA system, or run independently as it was in the Wessex Water trial. It can be operated delivering a base load or controlled to deliver its oxygen in response to changing dissolved oxygen demand in the basin.

Pure oxygen is directly injected from a generator into a side-stream taken from the ditch. The oxygenated stream is then introduced into the effluent, where required, increasing the DO levels very quickly to the desired levels.

PLC control and monitoring ensures consistent DO levels. No hardware is required in the ditch/basin. A key characteristic of the system is that it is capable of cycling on and off in response to changing dissolved oxygen demands in the basin.

At Wick SL stw in normal operation the four controlling surface aerators would cycle on and off to maintain an appropriate DO target in the basin. During the trial the OXFINITI box was set up to supplement the base load which delivered sufficient oxygen to maintain the targeted DO and full treatment. The maximum power of the four surface aerators is 60kW and the OXFINITI box's maximum power at base load in contrast was 40kW.

During the trial the use of the OXFINITI system operating alone resulted in significant energy savings of 21% as compared to normal cycling operation of the works treatment process. Whilst running the OXFINITI system there were noticeable reductions in ammonia levels and sludge settling volumes in the secondary clarifiers indicating an improved health for the plant's aeration process.

** The Company and product name has been changed since the trial from O2NRG to OXFINITI*

4. Features of the OXFINITI Process & Box

- Oxygen is generated within the box at low pressures. There is no costly stored liquid oxygen or use of high pressure systems;
- System delivers higher oxygen transfer rates compared to conventional air systems;
- Portable system enabling fast and easy installation. Set up on a new site in less than 12 hours;
- It has a small footprint and can be easily removed and transported quickly to another site;
- An innovative turbulation device (mixer) enables alpha figures (α) throughout the ditch to be >0.9;
- As the box sits along the side of the basin, H&S risks are greatly reduced;
- Equipment is not within the basin, and hence H&S risks are greatly reduced;
- No disturbance to existing infrastructure;
- Low maintenance costs (routine seals and oil changing) and is carried out easily within the box, unlike conventional systems (e.g. FBD, jet or surface aerators);
- Whole system is more robust and reliable than existing aeration systems;
- The process is mechanical and requires no chemicals;
- No periodic major maintenance (e.g. for diffusers or acid washing diffuser).
- There is no degradation in performance over extended periods of time unlike fine bubble diffusers that require routine acid washing to maintain competitive oxygen transfer rates;

5. Trial Objectives

The OXFINITI system was set up to test its efficiency in introducing oxygen into the wastewater and its effectiveness in providing enhanced treatment. This was compared to the existing aeration system used at the plant.

Dissolved oxygen, ammonia, and sludge volumes were measured.

The plan was to run the four surface aerators for a week, then to disable them and operate the OXFINITI box which would take over control of the oxidation ditch keeping the weighted dissolved oxygen at sufficient levels compared to the existing equipment.

Energy usage, inlet flows, ammonia, nitrates and SV's were monitored on site. The Wessex Water Process team agreed to take samples and provide historic data for analysis. The total works energy was recorded hourly by Wessex Water for the duration of the trial.

6. Findings

The use of the OXFINITI system resulted in significant power savings compared to when it was not used as part of the treatment process. There were also reductions in inlet flows, ammonia, nitrates and sludge volumes. NB. This was a test installation rather than one optimised for a permanent installation which would have resulted in additional savings.

The aims and objectives of the trial were to:

- Measure Energy Consumption;
- Identify Power Requirements;
- Sludge Volumes;
- Effect of OXFINITI oxidation on ditch health.

The trial showed:

1. **Reduced Energy Consumption** of 21% (258 kWh) a day. This excludes additional OPEX savings in reducing sludge treatment & transportation, equipment maintenance and manpower. N.B. The savings were in a test configuration instead of one which had been optimised for a permanent installation.

2. **Power Requirements Lower** - max power OXFINITI at Wick 40kW, surface aerators max. power 60kW. A reduction in power consumption of 33%

3. **Positive Sludge Consolidation** - sludge volumes reduced from 18% to 11%, a 40% reduction. This improves operational costs by reducing sludge handling, transportation and disposal costs. These tangible operational savings have not been calculated in this trial. From a visual perspective the clarifier was actually able to operate within normal parameters when the OXFINITI box was operating instead of being overwhelmed with poor settling sludge

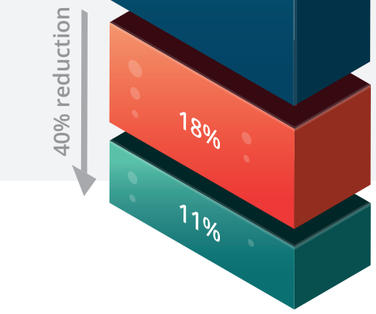
4. **Water Quality & Plant Health** - in and downstream of the oxidation ditch plant there were significant improvements in visual appearance of the secondary clarifiers and micro-organism levels;

5. **Significant Reduction in Ammonia Levels**. The OXFINITI system had the capacity to reduce ammonia levels very quickly compared to the existing surface aeration system. The more readily available molecular dissolved oxygen means that the solids are more effectively digested by the micro-organisms.

Biological oxygen demand (BODATU) samples were taken during the trial by Wessex Water and the results showed that the plant ran in normal operation throughout the duration of the trial.

Other operational observed benefits that were identified during the trial by the operatives and photographic evidence is included in the report. These were as follows: -

- Oxygen production takes place within the OXFINITI box at low pressures. There is no stored liquid oxygen or use of high pressures.
- System delivers higher oxygen transfer rates compared to conventional air systems;
- Efficiency of oxygen transfer does not drop off as is common in other aeration equipment.
- Portable system enabling fast and easy installation. Set up on a new site in less than 12 hours;
- It has a small footprint and can be easily removed and transported quickly to another site;
- The process is mechanical and requires no chemicals.
- Low maintenance costs (routine seals and oil changing) and is carried out easily within the box, unlike conventional systems (e.g. FBD, jet or surface aerators which are difficult to maintain and generally requires untethering, manoeuvring and lifting the equipment out of the ditch;
- There is no need for the routine maintenance of diffusers or acid washing diffuser faces for restoring performance.



- Equipment sits along the side of the oxidation ditch and not within it. Hence H&S risks are greatly reduced;

- There is no hardware required in the ditch/basin and therefore no maintenance in the basin required such as the cleaning/replacement of membranes.

- If a basin has particular localized zones that are septic, the system can easily be directed to directly address those needs. In the case of Wick the existing design was short circuiting the full aeration cycle and the OXFINITI system helped to balance the basin.

7. Conclusions

The trial showed that the use of the OXFINITI system delivered significant cost and operational benefits compared to conventional aeration system:-

1. **Operational energy and carbon savings**. During the short trial the OXFINITI box showed a minimum of 21% energy saving in aeration. This excludes additional OPEX savings in reducing sludge treatment & transportation, equipment maintenance and manpower. For a permanent installation further energy savings can be achieved through optimisation;

2. **Positive Sludge Consolidation** - sludge volumes reduced from 18% to 11%, a 40% reduction. This improves operational costs by reducing sludge handling, transportation and disposal costs;

3. **Power Requirements Lower** - max power OXFINITI at Wick 40kW, surface aerators max. power 60kW;

4. **Water Quality & Plant Health** - in and downstream of the oxidation ditch plant there were significant improvements in visual appearance of the secondary clarifiers and micro-organism levels;

5. **Significant Reduction in Ammonia Levels**. The OXFINITI system had the capacity to reduce ammonia levels very quickly compared to the existing surface aeration system. The more readily available molecular dissolved oxygen means that the solids are more effectively digested by the micro-organisms.

6. **Other observed benefits** (e.g. simple maintenance, reliability, H&S risks reduced, ease of installation and removal). These were confirmed by observation by the operatives and photographs;

7. **Further Optimisation**. The test conditions using a standard design box did not allow a full optimization of the OXFINITI system on a plant that can be achieved with a long-term installation. There are optimization alternatives in a permanent installation that could reduce the existing energy consumption of the OXFINITI system by a further 50%. In this case it could reduce the total energy consumption of the OXFINITI box from 40 kW to 20 kW.

REPORT

8. Introduction

The OXFINITI aerobic digestion box is a proven new technology in the UK. The patented process involves direct injection of oxygen from a generator (no liquid oxygen or storage required) into a stream taken from the basin/ditch in question. The oxygenated stream is then re-introduced into the effluent, where required - increasing the DO levels of the contents very quickly to the desired levels. PLC control and monitoring ensures consistent DO levels. There is no hardware required in the ditch/basin

This offers energy savings and enhanced quality benefits in activated sludge processes as compared to conventional aeration activated sludge systems utilised in wastewater treatment. It employs five different innovations to treat wastewater. It can typically save 30% or greater on energy savings as compared with conventional activated sludge systems.

The company presented the technology to the Isle Utility TAG and a consortium of five water utilities expressed interest in running a trial in the UK at a municipal wastewater treatment works to demonstrate the technology and associated benefits. Wessex Water was selected for the trial at their Wick St Lawrence stw (20,000PE). This report describes the trial and identifies the energy savings and associated benefits realised during the trial.

9. Aims & Objectives

To quantify:

1. Operational savings in terms of energy savings;

2. Health improvements in the oxidation ditch, secondary clarifiers, micro-organism and on sludge;

3. Other observed benefits regarding maintenance, Health & Safety issues etc.

Specifically:

A key focus of the trial was to see if the OXFINITI system could supply similar amounts of oxygen in the ditch to the existing four surface aerators but at a lower cost in terms of energy.

And secondly to show that the process produced a healthier bio system with better water quality and sludge settleability at similar dissolved oxygen levels as determined by chemical analysis and physical measurements.

10 The Innovative Process

The OXFINITI technology incorporates a number of innovations in the 100 year-old conventional activated sludge process. This results in a step change in technology and performance. It directly injects oxygen from a generator (instead of air). This oxygenated stream is then introduced into the effluent, where required, increasing the DO levels very quickly to the desired levels.

PLC control and monitoring ensures consistent DO levels. There is no hardware required in the ditch/basin. There is therefore no maintenance in the basin required – e.g. cleaning/replacement of membranes.

This system employs a complex aerating carburettor that phase blends the oxygen and mixed liquor. Then a violent turbulation (mixing) system and finally discharge nozzles that provide a final shearing to the mixture at the injection point. The aeration bubbles are extremely small giving much better retention and distribution. There is also some evidence that any "conventionally" derived oxygen may be being picked up by the process and retained longer.

In previous trials it saves between 30% – 60% of the energy required for conventional aerators. Also, using oxygen instead of air in this process produces healthier micro-organisms which in turn delivers a more efficient treatment basin and improved water effluent quality.

11. The OXFINITI Trial

11.1 Location

Figure.1 shows the location of the Wick SL stw adjacent to the River Congresbury Yeo in North Somerset where the OXFINITI box was installed. The sewage works is about 5 miles NE of Weston-Super-Mare.

Figure 1. Location Wick St Lawrence - Wessex Water

11.2 Plant Characteristics

The Wick SL stw (~20,000PE) is a conventional stw with inlet screens, primary and secondary processes which includes an oxidation ditch as its activated sludge process. It also has tertiary lagoons. The aeration of the ditch consists of two horizontal brush aerators, a small surface aerator and four jet turbine aerators (*Figures 2 & 3*).

The aeration of the ditch is controlled by targeting a weighted dissolved oxygen value derived by monitoring the dissolved oxygen at two locations within the ditch (DO1 & DO2). This is achieved by only controlling the operation of the four jet turbines aerators. The final effluent is discharged into the River Congresbury Yeo estuary. It also has its own sludge thickener operation.

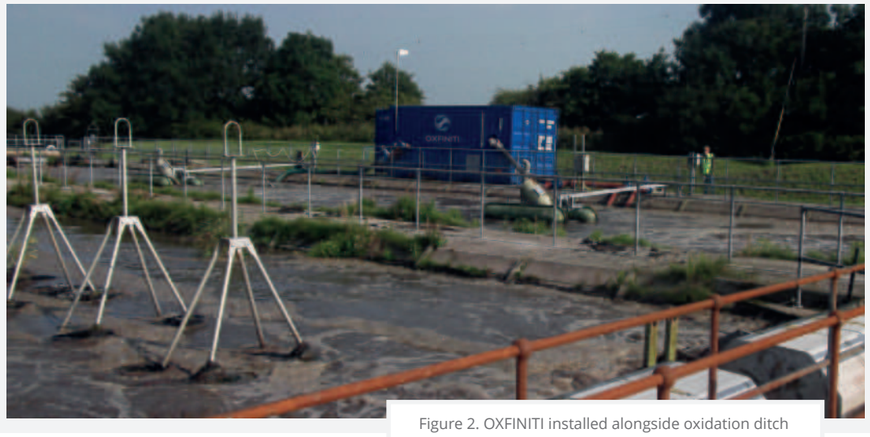


Figure 2. OXFINITI installed alongside oxidation ditch

Figure 2 also shows the blue 20' container and its brown inlet pipe and discharge pipe with the oxygen enriched wastewater exiting the box through a manifold into the oxidation ditch.

11.3 Wick SL Activated Sludge Process

Figure 3 shows the oxidation ditch layout. It shows the inlet pipe, the aeration equipment, the two horizontal shaft aerators, the small surface aerator and the four floating 15kW spiral aerators.

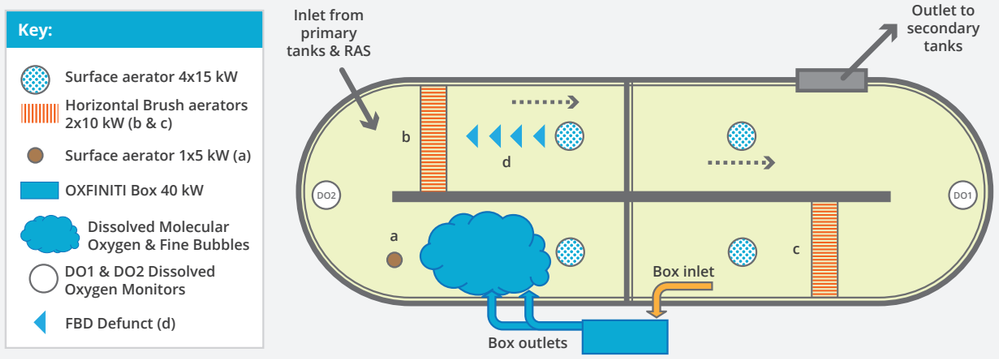


Figure 3. OXFINITI Oxidation Ditch Layout - Wick SL stw

11.4 The Demonstration Trial

Initially, it was envisaged that the output from the OXFINITI box would continually deliver a base load of oxygen to the ditch and the existing four dissolved oxygen controlled surface aerators would correspondingly drop down their aeration delivery, correspondingly be utilised much less and therefore show savings. However, it became clear after months of operation that the oxygen demand of the ditch was so variable that this approach was not viable. The output from the OXFINITI box at low load times was too much and at high loads the ditch required all aeration kit including OXFINITI to meet target dissolved oxygen levels. The trial period of comparison was then started on the 6th February 2015 and was completed by 18th February 2015.

At the beginning of the trial the four surface jet aerators were temporarily disabled and the OXFINITI box took over control of the oxidation ditch keeping the weighted dissolved oxygen at 1.0mg/l. (see *Figure 5*). Energy usage, inlet flow, ammonia, nitrate and SV was monitored on site. The Wessex Water Process team took samples and provided historic data for analysis.

12. Results

12.1 Oxygen Transfer Efficiency

A factor in designing and comparing performance of activated sludge systems is their oxygen transfer efficiency in clean water. The net amount of oxygen utilised in the biodegradation process is important and can be expressed as an efficiency figure. The efficiencies for both the HS Surface Aerators and the OXFINITI box were calculated (Tables 1 & 2) and the comparison shown in (Table 3). This can be expressed in a number of ways (e.g. SOTR standard oxygen standard rate, SOTE standard oxygen transfer efficiency and SAE standard aeration efficiency). High oxygen transfer efficiency is observed in OXFINITI operations as the innovative process of treating the surface tension of the wastewater allows additional oxygen present in the wastewater in the form of air bubbles from other aeration units is taken up and additionally utilised.

Table 1 Existing Surface Aerator System

Carbonaceous	Demand In	Demand out	Reduction	Units
BOD_{ATU} load	143	14	129	mg/l
Flow	6.05	6.05	6.05	Mld
Load	865	85	78 0	kgs of BOD_{ATU} /d
O_2 required per kg of Load	1.2	1.2	1.2	kg of O_2/kg of BOD_{ATU}
Total Demand	1038	102	937	kgs of O_2/d
Ammonium	**Demand In**	**Demand out**	**Reduction**	**Units**
Ammonium load	29	5	24	mg/l
Flow	6.05	6.05	6.05	Mld
Load	175	30	145	kgs of Ammonium/d
O_2 required per kg of Load	4.6	4.6	4.6	kg of O_2/kg of Ammonium
Total Demand	807	139	668	kgs of O_2/d
Total reduction			1604	kgs of O_2/d
Assumed amount supplied by paddles			720	kgs of O_2/d
Net amount supplied by SA HSSA			**884**	**kgs of O_2/d**

Table 2 OXFINITI Box Oxygenation

Carbonaceous	Demand In	Demand out	Reduction	Units
BOD_{ATU} load	143	14	129	mg/l
Flow	6.05	6.05	6.05	Mld
Load	865	85	780	kgs of BOD_{ATU} reduction /d
O_2 required per kg of Load	1.2	1.2	1.2	kg of O_2/kg of BOD_{ATU}
Total Demand	1038	102	937	kgs of O_2 demand
Ammonium	**Demand In**	**Demand out**	**Reduction**	**Units**
Ammonium load	29	3	26	mg/l
Flow	6.05	6.05	6.05	Mld
Load	175	18	157	kgs of Ammonium reduction /d
O_2 required per kg of Load	4.6	4.6	4.6	kg of O_2/kg of Ammonium
Total Demand	807	83	724	kgs of O_2/d
Total reduction			1660	kgs of O_2/d
Assumed amount supplied by paddles			720	kgs of O_2/d
Net amount supplied by OXFINITI box			940	kgs of O_2/d

Table 3 Efficiencies of Oxygen utilised

Comparison	Total kgs of Air/d delivered	Total kgs of O_2/d delivered	Net kgs of O_2/d consumed	Efficiency of O_2 consumed/ delivered
4 x SA	22,080	4,615	884	20%
OXFINITI	N/A	952	940	99%*

** This high oxygen transfer efficiency is observed in OXFINITI operations.*

However, in reality these standard figures need to be corrected in activated sludge systems as they can be significantly reduced in the operating environment.

In order to calculate actual transfer rates three factors, the α (alpha), β (beta) and θ (theta) factors are utilised to determine actual oxygen transfer rates. The dominant factor is the alpha factor which is affected by a number of aspects in the wastewater system, such as type of aerator, flow rates, solids concentration, contaminants, salinity and surfactants. These factors are also greatly influenced due to lack of maintenance, tank geometry air leaks, blockages, biofouling and scaling effects. These are often difficult to assess especially if the aerator itself is submerged (e.g. FBD).

Standard oxygen transfer rates (SOTR), standard transfer efficiencies (SOTE) are often quoted as comparisons whereas actual oxygen rates OTR's and OTE's reflect actual performance. These 'actual' figures are also difficult to determine due to varying experimental methods of determination and therefore direct comparisons can be meaningless.

The generation of oxygen in the OXFINITI box is very different from conventional aeration systems and as a consequent its oxygen transfer rate and efficiency in real wastewater conditions does not drop off as conventional systems do.

The alpha factor for OXFINITI systems is > 0.9 throughout its operation whereas an FBD system may drop to 50% of its SOTR after 6 - 12 months of operation. The alpha factor in an oxidation ditch will vary from 0.3 to 0.8 around the ditch.

In the comparison of the 4 SA units to the OXFINITI box under field conditions we confirm some of these facts. The data appears to indicate that the SA units are putting in 4.6 times more oxygen than the OXFINITI box into the aeration basin. However, the critical matter is the level of consumption by the basin of the oxygen presented. Is the oxygen presented in a form that is highly accessible or easily assimilated by the basin?

In this comparison, only 20% of the oxygen delivered by the SA units into the basin was in a form that was actually assimilated by the basin. In contrast, the OXFINITI box confirmed field test results of 99% efficiency in delivering oxygen in the optimal form for assimilation in the basin. In addition, the trial confirmed that the OXFINITI box was able to achieve this result using 22% less energy than the SA units. In other permanent installations in the US, where the OXFINITI box is optimized for the installation, the energy savings are in the range of 30 to 50%.

The OXFINITI box achieves a "Quantum Leap" in aeration technology and provides a radically new approach to aerating activated sludge. More than 50% of the treated water flow from the OXFINITI box contains molecular oxygen "in solution" in a concentration of up to 100 mg/l or more. Approximately a further 20% of the supersaturated oxygenated water is embedded and entrained with submicron or nano size oxygen bubbles providing for a very efficient transfer of oxygen to the aerobic wastewater treatment process. The rest of the oxygen is delivered in a combination of fine and coarse bubbles.

13. Improved Dissolved Oxygen Levels in Process Waters

13.1 Molecular Oxygen

The OXFINITI system delivers at least 40% of its dissolved oxygen in a 'molecular' form rather than a 'bubble' as in conventional aerators. This molecular oxygen enables a vastly greater and more efficient oxygen take up by the microbes. Also, this form of oxygen stays longer in solution compared to other systems. This adds to the system efficiency of delivering usable oxygen to the wastewater facility.

For example, an open top tank test of the supersaturated oxygenated water degraded from slightly above 500% saturation to slightly below 500% saturation over a period of 4 days with a water temperature of at 30oC.

13.2 Standard Aeration Efficiency and Actual Oxygen Transfer

Oxygen transfer rates (OTR) are typically measured in clean water at standard conditions (SOTR), and then taking the power (P) usage into consideration are expressed as 'Aeration Efficiencies' (AE =SOTR/P). For different conventional aerators (i.e. FBD, SA, Jet, etc.) these AE's at standard conditions (SAE) are compared on a 'like for like' basis and used as the main criteria by process designers in selecting aeration technology.

However, in process conditions these AE's are significantly reduced up to 75% in fine bubble diffusers as compared to the OXFINITI system, due to the presence of high levels (000's mg/l) of suspended solids. The actual AE's are corrected by using alpha factors (α) (e.g. αAE for FBD, MLSS 4000mg/l, α= 0.25). In total contrast the OXFINITI box delivers alpha factors of >0.9 which delivers aeration transfer efficiencies 3 or 4 times higher than conventional FBD aeration.

13.3 Operational Energy

Table 4 Works Energy Usage during Trial Period

DATE	ENERGY USE kWh/d Whole STW	ENERGY USE kWh/d Aeration HSSA or OXFINITI	COMMENTS
1/2/15	2645	1112	SA units only
2/2/15	2882	1349	SA units only
3/2/15	2682	1149	SA units only
4/2/15	2443	910	SA units only
5/2/15	2336	803	SA units only
6/2/15	2695	1162	SA units only
7/2/15	2773	1240	Set up aeration
8/2/15	3107		Optimising OXFINITI Box
9/2/15	3255		Optimising OXFINITI Box
10/2/15	3055		Optimising OXFINITI Box
11/2/15	2785	960	OXFINITI Box on optimised
12/2/15	2554	960	OXFINITI Box only
13/2/15	2806	960	OXFINITI Box only
14/2/15	2671	960	OXFINITI Box only
15/2/15	2517	960	OXFINITI Box only
16/2/15	2898	960	OXFINITI Box only
17/2/15	703		Works Power Failure
18/2/15	2826		Ditch Recovery
19/2/15	3079		Ditch Recovery
20/2/15	2376	960	OXFINITI Box only
21/2/15	2328	960	OXFINITI Box only
22/2/15	2301	960	OXFINITI Box only
23/2/15	2294	960	OXFINITI Box only
24/2/15	2237	960	OXFINITI Box only
25/2/15	2149	960	OXFINITI Box only
26/2/15	2199		Ditch Acclimatisation
27/2/15	2226		Ditch Acclimatisation
28/2/15	2673		Ditch Acclimatisation
1/3/15	2997	1464	SA units only
2/3/15	3084	1551	SA units only
3/3/15	3031	1498	SA units only
4/3/15	2583	1050	SA units only
5/3/15	2450	917	SA units only
6/3/15	2706	1173	SA units only
7/3/15	3201	1668	SA units only

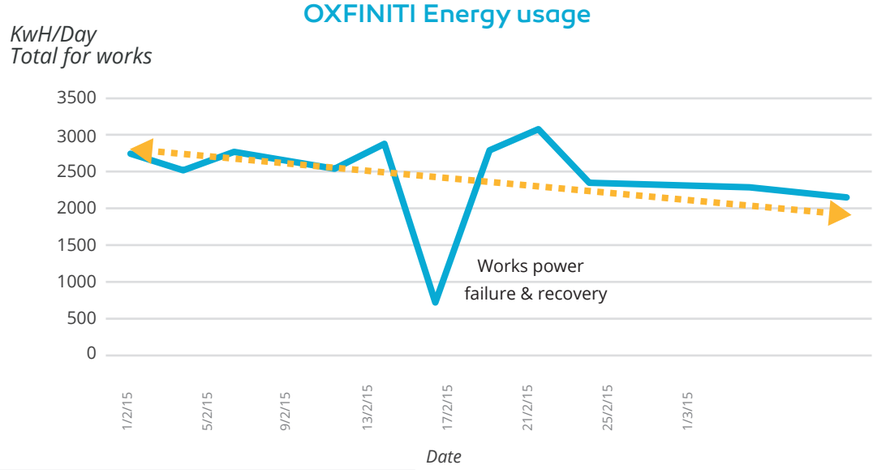


Figure 4. Energy usage during February 2015 trial

13.4 Energy Savings Calculation from Table 4 Results

1. Energy use for whole works kWh/d 1/2/2015 to 7/3/2015

- **a)** SA only running shown in white
- **b)** Change over and optimisation period shown in yellow
- **c)** OXFINITI only running shown in blue

2. From above figures

- **a)** Average energy for works with SA operating is 2751 kWh
- **b)** Average energy for works with OXFINITI box operating is 2493 kWh

3. OXFINITI box uses 40kW x24 = 960kWh Whilst OXFINITI box operating the works base energy usage is 2493 - 960 = 1533kWh

4. SA energy usage is 2751 – 1533 = 1218kWh

- **a)** Aeration for SA 1218 kWh
- **b)** Aeration for Box 960 kWh

5. Hence energy saving is 1218 – 960 = 258 kWh

6. Hence saving is $\frac{258 \times 100}{1218}$ = 21% saving

Over the two weeks of the OXFINITI box trial the energy requirement dropped 21%. It is anticipated that this saving would have increased with:

- **a)** Longer trial period as the micro-organisms adapt to utilising oxygen;
- **b)** if a Dissolved Oxygen control system had been employed;
- **c)** If the system had been optimised for a permanent rather than a test installation.

14. Water Quality/Sludge Quality Benefits

14.1 Dissolved Oxygen

The weighted dissolved oxygen for the ditch was set at 1.0 mg/l for the duration of the trial (see Figure 5). It delivered the dissolved oxygen as required through the trial.

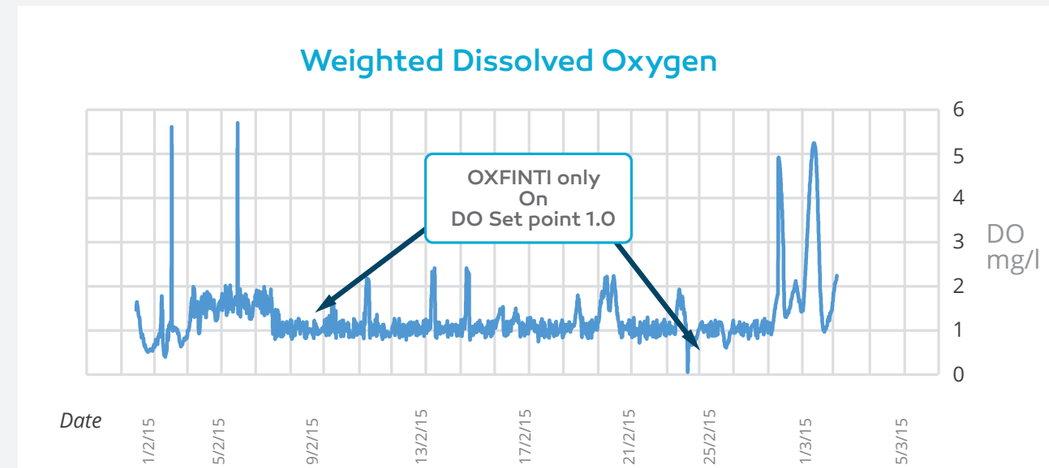


Figure 5. Weighted Dissolved Oxygen in levels of ditch

14.2 Ammonia and BOD

At Wick SL stw higher ammonia arrives at the works when higher flows are entering it. The ammonia levels exiting from the secondary clarifiers averaged at around 2.5 mg/l during the trial. This is a typical performance level for the ditch at the time of year.

During the trial the ammonia level from the secondary clarifiers reached 5.5 mg/l. This is below any alarm level (the permit level entering the river discharge is 25 mg/l). It had been observed prior to the trial that if ammonium levels in the oxidation ditch were high, the Wessex Water operatives increased the oxygen output from the OXFINITI box to 30 mg/l of dissolved oxygen to effectively bring down high ammoniums in the ditch.

Biological oxygen demand (BOD_{ATU}) samples were taken during the trial by Wessex Water scientific staff and these resulted and results were consistent with normal operation of the plant.

14.3 Sludge Settleability & Process Appearance

Wessex Water undertook SV's sludge volumes during the week's trial and the results show SV's dropped from 18% to 11% (see *Figure 6*). This change in sludge volume is seen in the US trials and although not calculated in this case reduces operational costs through reduced handling, sludge transportation and disposal.

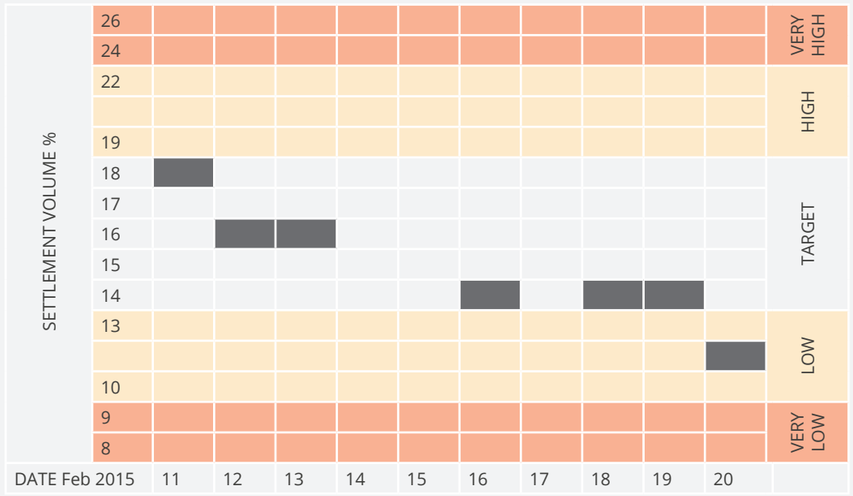


Figure 6. Settlement volumes during trial, showing increased settleability

The appearance of the secondary clarifiers shows a much healthier plant in appearance in the secondary clarifiers as shown in *Figures 7 & 8* below.

Figure 7. Secondary Clarifier Before Trial

Figure 8. Secondary Clarifier After Trial

14.4 Other Observed Benefits

Maintenance of a surface aerator is difficult and generally requires untethering and lifting the equipment out of the ditch. See *Figure 9* below.

Figure 9. Aerator removed for maintenance and repair

The process requires no chemicals. Maintenance costs are low and easy to undertake as all work is inside the box unlike traditional aerators.

The box sits adjacent to the oxidation ditch and no work is needed in the ditch which reduces Health & Safety issues. The oxygen production takes place within the box and therefore there are no liquid oxygen deliveries. Also there are no high pressures as the oxygen generator runs at low pressures.

15 Conclusions

The aims and objectives of the trial were to:

- Measure Energy Consumption;
- Identify Power Requirements;
- Sludge Volumes;
- Effect of OXFINITI oxidation on ditch health.

The trial showed:

1. **Operational energy and carbon savings**. During the short trial the OXFINITI box showed a minimum of 21% energy saving in aeration. This excludes additional OPEX savings in reducing sludge treatment & transportation, equipment maintenance and manpower. For a permanent installation further energy savings can be achieved through optimisation;

2. **Positive Sludge Consolidation** – sludge volumes reduced from 18% to 11%, a 40% reduction. This improves operational costs by reducing sludge handling, transportation and disposal costs;

3. **Power Requirements Lower** – max power OXFINITI at Wick 40kW, surface aerators max. power 60kW;

4. **Water Quality & Plant Health** - in and downstream of the oxidation ditch plant there were significant improvements in visual appearance of the secondary clarifiers and micro-organism levels;

5. **Significant Reduction in Ammonia Levels**. The OXFINITI system had the capacity to reduce ammonia levels very quickly compared to the existing surface aeration system. The more readily available molecular dissolved oxygen means that the solids are more effectively digested by the micro-organisms.

6. **Other observed benefits** (e.g. simple maintenance, reliability, H&S risks reduced, ease of installation and removal). These were confirmed by observation by the operatives and photographs;

7. **Further Optimisation.** The test conditions using a standard design box did not allow a full optimization of the OXFINITI system on a plant that can be achieved with a long-term installation. There are optimization alternatives in a permanent installation that could reduce the existing energy consumption of the OXFINITI system by a further 50%. In this case it could reduce the total energy consumption of the OXFINITI box from 40 kW to 20 kW.

These other operational observed benefits are listed below and were identified during the trial by the Wessex Water operatives and where practical photographic evidence is included in the report.

- Oxygen is generated within the box at low pressures. There is no costly stored liquid oxygen or use of high pressure systems;
- System delivers higher oxygen transfer rates compared to conventional air systems;
- Portable system enabling fast and easy installation. Set up on a new site in less than 12 hours dependent on logisitics;
- It has a small footprint and can be easily removed and transported quickly to another site;
- An innovative turbulation device (mixer) enables alpha figures (α) throughout the ditch to be >0.9;
- As the box sits along the side of the basin, H&S risks are greatly reduced;
- Equipment is not within the basin, and hence H&S risks are greatly reduced;
- No disturbance to existing infrastructure;
- Low maintenance costs (routine seals and oil changing) and is carried out easily within the box, unlike conventional systems (e.g. FBD, jet or surface aerators);
- Whole system is more robust and reliable than existing aeration systems;
- The process is mechanical and requires no chemicals;
- No periodic major maintenance (e.g. for diffusers or acid washing diffuser).
- There is no degradation in performance over extended periods of time unlike fine bubble diffusers that require routine acid washing to maintain competitive oxygen transfer rates;

15.1 Oxygen Transfer

As OXFINITI is an innovative process the generation of oxygen in the box is very different from conventional aeration systems and as a consequent its oxygen transfer rate and efficiency in real wastewater conditions does not drop off as conventional systems do. The alpha factor for OXFINITI systems is > 0.9 throughout its operation whereas an FBD system may drop to 50% of its SOTR after 6 - 12 months of operation. The alpha factor in an oxidation ditch will vary from 0.3 to 0.8 around the ditch.

The aeration bubbles are extremely small giving much better retention and distribution. There is also some evidence that any "conventionally" derived oxygen may be being picked up by the process and retained longer. The result of this is significant reduction in sludge levels. As shown in this trial there was a significant sludge volume reduction from 18 to 11%.

The transfer of oxygen from OXFINITI will also facilitate additional dissolution of oxygen due to the surface tension modification process the wastewater is subjected to. As aeration was also produced by two shaft aerators the efficiency of oxygen transfer was further increased in the basin.

15.2 Other Case Studies

Appendix 2 identifies some capital and revenue savings in four plants in Texas.

16 Acknowledgements

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18 Appendices

18.1 Appendix 1 Wick St Lawrence stw Works Permit

Discharge No. 1 BIOLOGICAL TREATMENT				
Name	**Status**	**Consent**	**Unit**	**Limit**
Ammoniacal Nitrogen	Consent	25	mg/l	95%
Biochemical Oxygen Demand ATU	Consent	40	mg/l	95%
Dry Weather Flow	Consent	4612	m³/d	Absolute
pH Higher Limit	Consent	9		Absolute
pH Lower Limit	Consent	5.5		Absolute
Suspended Solids	Consent	40	mg/l	95%
PE 19,838 in 2011				

18.2 Appendix 2 US Case Studies

OXFINITI's associate company has conducted a number of extensive field tests which have validated its oxygen saturation technology and its substantial energy savings.

a) **Tomball, Texas USA** - A privately owned facility with a capacity of 200,000 gpd Results: Three tests generated between 50% and 70% power consumption reduction.

b) **Decker Hills, Texas USA** – A facility owned and operated by Southwest Water Company with a capacity of 220,000 gpd. The results showed oxygen was increased by over 200% and power consumption was reduced by over 51%.

c) **Sienna Plantation WWTP, Texas USA** – a municipal facility with a plant capacity of 900,000 gpd (300,000 gpd on the side of the plant with which we were engaged). The results showed that oxygen increased by over 2000% and power consumption reduced by over 33% (target for plant wide savings under long term operation is over 45%).

d) **Remington WWTP, Texas USA** (Operated by Severn Trent USA) - Aeration basin testing was performed before and after the OXFINITI was installed and tuned to the plant. After the OXFINITI was installed and tuned, the average DO levels in the aeration basins during August (the hottest month of the year) rose approximately 30% with 2x100 HP and the S-1000 OXFINITI compared to 3x100HP blowers.

	Blower amperage 460V 3P	OXFINITI Box amperage 460V 3P	Net reduction in amperage	Percent aeration amperage reduction	Aeration basin DO average in 85^{0}F water
Pre OXFINITI	288	0	NA	NA	2.84 mg/L
Post OXFINITI	192	43	53	18.4%	3.39 mg/L

In addition, the amperage level for aeration was reduced a total of 53 amps. The amperage demand was reduced from +/-96 amps from a single 100HP blower to 43 amps from the OXFINITI resulting in an overall aeration energy and demand reduction of 18.4%.

18.3 Appendix 3 Oxfiniti System 1000 Technical Specifications

Capacity

- Municipal Loading: 10,000 – 20,000PE;
- Adjustable oxygen generation: 400 – 1,000kg of O2 per day.

Operational Parameters

- Electrical Supply: 3 phase 200 amps;
- Base running load (1000 system) on 24/7 basis: 40 amps.. Power consumption max 40kWh;
- OXFINITI box wastewater Intake: Pipe dia: 15 cm, 60cm below surface;
- OXFINITI box Wastewater Flow through 37- 47 litres/sec;
- O2 produced on demand VSA. Ambient pressure;
- Discharge Lines: 3 x dia. 10cm outlet pipe;
- Discharge Nozzles location: 3x min. 30cm above basin floor;
- Container should be adjacent to the basin. This reduces risks of leaks and reduced pump head;
- Closed loop effluent taken from and returned into basin with no negative impact on plant hydraulics.

Physical Characteristics

- Dimensions: Standard 20ft (6.1m) container; [20ft (6.1m) l x 8ft (2.44m) w x 8ft 6ins. (2.59m) h, for a volume of 1,360ft^{3} (39.0m3)];
- Box weight: 7.5 metric tonnes.

SCADA linked and/or Remote 24/7 Telemetry

- System constantly monitored on and off-site;
- System operational status: On/Off;
- Automatic shutdown on low flow, low O2 flow and equipment failures;
- Error messages are automatically sent to monitoring centre for action.

Site Requirements

- Suitable access for a 20ft container truck with integral crane. Flat dry ground adjacent basin/ditch;
- Required container base 4 concrete corner piers to support the 20ft container (2 tonnes per pier);
- Access to dissolved oxygen control parameters;
- Three phase power grid or generator connection;
- Continuous access required to the box for maintenance and upgrades.

Configurations

- Other configurations can be provided on request with either oxidation or ozonation system;
- Different levels of water flow can be configured subject to slight hardware modifications;
- Boxes can be combined and can be built in parallel or series for scaling to any size application.

Applications

As a green technology the process can be utilised for wastewater treatment, pollution remediation, industrial oxidation or disinfection processes which includes:

- Municipal Wastewater Treatment process;
- Industrial Wastewater Treatment and Oxidation processes;
- River/Lake/Pond Pollution recovery; stagnant water bodies;
- Storm water treatment;
- Aquaculture wastewater treatment. (Requires additional controls);
- Odour issues; septic primary treatment and sewerage systems.

Ozone treatment

For higher oxidation needs the system can be upgraded to ozone treatment. Applications include:

- Drinking water disinfection;
- Drinking water organics removal VOCs & SOCs (e.g. colour/THMs/pesticides);
- Tertiary wastewater post treatment (an alternative to chlorine/ dechlorination). This improves colour issues of the discharge.

OXFINITI

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