VIROTEC
Global Solutions

A COMMERCIAL APPLICATION OF
VIROSEWAGE™ TECHNOLOGY

CASE STUDY
BRISBANE WATER
FAIRFIELD WASTEWATER
TREATMENT PLANT

"Significant reductions in BOD and SS are noticed. The Technology's ability to reduce nutrient concentrations demonstrates excellent reductions of phosphorus...The increase in the primary sludge thickness has the potential to decrease sludge haulage and sludge disposal costs."

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PROBLEM

Brisbane Water's (BW) objective was to assess whether ViroSewage™ Technology could reduce total nitrogen and total phosphorus concentrations in sewage, improve solids management and reduce operating costs for the Fairfield Waste Water Treatment Plant (WWTP).

At the same time, Virotec set its own objective to demonstrate that the technology had the capability of treating sewage to secondary standards, viz, reduce BOD and SS concentrations, in addition to nutrient removal and solids management.

Fairfield Wastewater Treatment Plant

VIROTEC TOTAL SOLUTION

The ViroSewage™ Technology total solution included design, engineering, installation, testing and commissioning of a process plant that would apply the reagents, monitoring and evaluation of analytical results, and instituting corrective actions as appropriate.

BACKGROUND

The Fairfield WWTP is owned and operated by Brisbane Water, a business unit of Brisbane City Council. The WWTP is in the densely populated Brisbane metropolitan suburb of Fairfield in Southeast Queensland, Australia. The effluent from the WWTP is discharged into the nearby Brisbane River after being treated to secondary standard water quality.

The current strategy adopted by BW in upgrading its sewage treatment plants is to build large biological nutrient removal (BNR) treatment plants to meet its treated effluent discharge license conditions. Given the location of this WWTP and the lack of additional Council owned land beyond it's perimeter, Brisbane Water has not been able to extend it's WWTP design philosophy to this site. The Fairfield plant generally meets its EPA license conditions for treated effluent discharge to the river, but BW intends to investigate suitable methods to achieve a) effluent re-use and/or b) nutrient removal.

As part of its commitment to keep abreast of new technology developments, BW decided to trial Virotec's ViroSewage™ Technology to assess its capability for removing nutrients. The trial was conducted at the Fairfield WWTP in 2004 and 2005.

The Fairfield WWTP is an activated sludge treatment plant processing up to 2.7 ML per day (dry weather flow). In its current configuration, the plant is designed for biochemical oxygen demand (BOD) and suspended solids (SS) removal but not nutrient removal. The WWTP process layout is shown in Figure 2 (see overleaf on pg. 3). The detention time in the aeration tank is two hours and 45 minutes, which is at the low end for activated sludge systems. The primary sedimentation tanks and final settling tanks have detention times of two and five hours respectively. Table 1 records influent raw sewage characteristics for 2004.

TABLE 1 – FAIRFIELD WWTP INFLUENT WATER QUALITY MONITORING DATA

Date	BOD (mg/L)	SS (mg/L)	pH	NH3 - N (mg/L)	TKN (mg/L)	TP (mg/L)
Average 2004	204	356	7.5	35	59	18.6

The WWTP generally performs well, and within the EPA discharge license limits, as demonstrated by the results presented below in Table 2 obtained in 2003- 04.

TABLE 2 – FAIRFIELD WWTP EFFLUENT WATER QUALITY MONITORING DATA

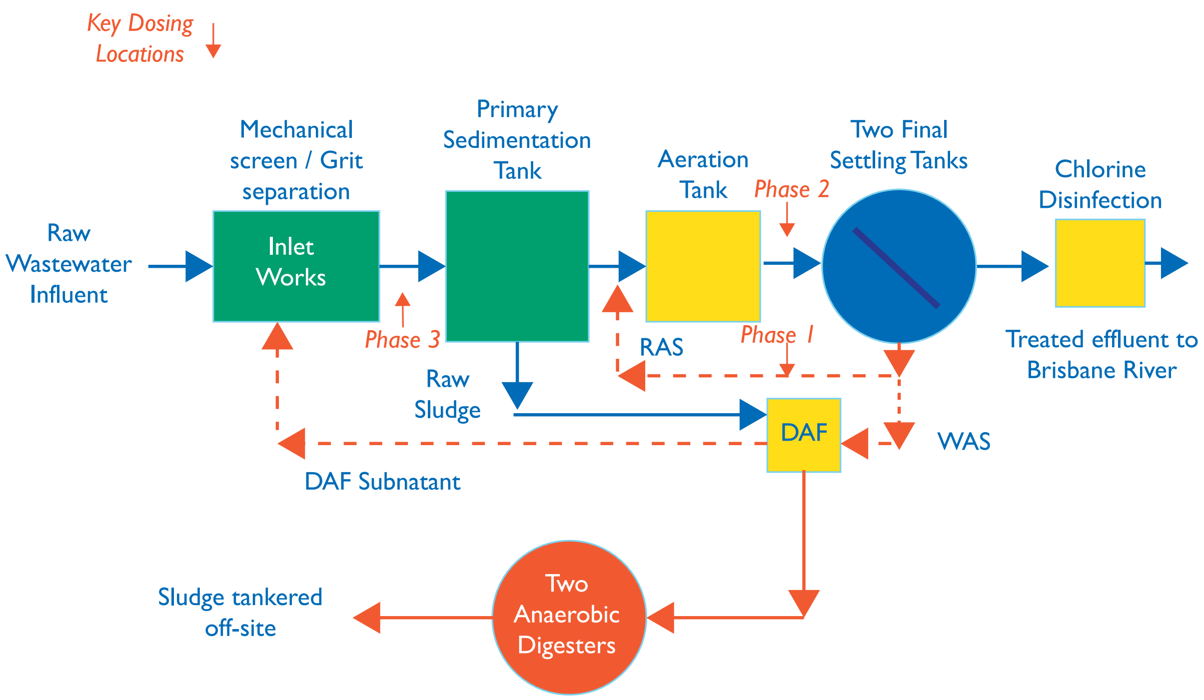
Date	BOD (mg/L)	SS (mg/L)	pH	NH3 - N (mg/L)	TKN (mg/L)	TP (mg/L)
Average 2003-04	3.1	9.9	7.8	24.8	29.4	6.3

VIROTEC TREATMENT METHODOLOGY

The ViroSewage™ Technology consists of the supply of ViroSewage™ reagents and a mixing and dosing plant that introduces the reagents into the sewage liquid stream.

A sampling programme was agreed with BW, which included analyzing a range of parameters covering both influent and effluent. These parameters were: BOD, SS, volatile suspended solids (VSS), pH, TKN (Total Kjeldahl Nitrogen), ammonia, nitrite, nitrate, total nitrogen (TN), and total phosphorus (TP). BW took all samples and analysed them at their laboratories.

FAIRFIELD WWTP PROCESS FLOW



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The treatment dosing locations for these trials were at three different points of the process flow:

> Phase 1 – Dosing ViroSewage™ Reagent #1 into the Returned Activated Sludge (RAS) channel leading into the aeration tank and ViroSewage™ Reagent #2 into the flow leading into the secondary clarifiers or final settling tanks.
> Phase 2 – Dosing both ViroSewage™ Reagents #1 and #2 into the flow leading into the secondary clarifiers.
> Phase 3 – Dosing both ViroSewage™ Reagents #1 and #2 into the flow leading into the primary sedimentation tank.

The ViroSewage™ Technology dosing plant at Fairfield Waste Water Treatment Plant.

RESULTS AND DISCUSSION
PHASE 1

The Phase 1 application commenced in April, 2004 and Table 3 presents the average results for the four weeks of treatment.

TABLE 3 – PHASE 1 – VIROSEWAGE™ TECHNOLOGY TREATED EFFLUENT WATER QUALITY MONITORING DATA

	BOD (mg/L)	SS (mg/L)	pH	NH3 - N (mg/L)	TKN (mg/L)	TP (mg/L)
Average	≤2.5	6.6	No data	29*	35.8*	1.3

These results can be compared to the averages for treated effluent without ViroSewage™ treatment shown in Table 4.

TABLE 4 – PHASE 1 – TREATED EFFLUENT WITHOUT VIROSEWAGE™ TECHNOLOGY

	BOD (mg/L)	SS (mg/L)	pH	NH3 - N (mg/L)	TKN (mg/L)	TP (mg/L)
Average 2003-04	3.1	9.9	7.8	24.8*	29.4*	6.3

* Note: The nitrogen species results are higher than the average 2003 -4 figures because they were from samples taken over a four-week period. The explanation on removal rates is given in the section titled "Nutrient Removal" overleaf.

> BOD & SS

ViroSewage™ Technology has improved BOD removal by as much as 19 percent. It is noted that the BW analyses for BOD does not report results better than 2.5 mg/L because of limitations in instruments used. In other words, the result would have likely been even better if the samples had been analysed utilizing a lower range instrument.

The improvement in SS reduction is even more significant at 33 percent, and demonstrates that the ViroSewage™ reagents are binding suspended solids and settling them more effectively than standard treatment.

ViroSewage™ reagents consist of a cocktail of very fine grained minerals which can have a positive or negative surface charge depending on the pH conditions they are exposed to. The very fine grain size of the mineral particles gives them a high surface area to volume ratio and a high surface charge to mass ratio. These properties make the reagents extremely surface active, giving them the ability to attract and hold charged particles or polar molecules. The reagents enhance precipitation, co-precipitation, coagulation and improve flocculation, resulting in denser agglomerates which settle rapidly. Both suspended solids and organic matter are removed in this way in the liquid stream.

Dosing of ViroSewage™ Technology reagents at Fairfield Waste Water Treatment Plant.

> Nutrient Removal

The technology removed some 79 percent of phosphorus. The combination of both reagents reacting with the phosphorus has brought about this reduction. Thorough mixing of the reagents with the sewage stream is important, and sufficient reaction time should be provided. The solids are subject to flocculation followed by sedimentation.

It appears that the chemical removal of nitrogen species was not proven. However, this WWTP has a sludge age of only two to three days and even though the technology did increase the sludge age in the aeration tank to five to six days, it was inadequate for nitrification to occur. Under normal, favourable operating conditions, carbon oxidation would be followed by a low-rate nitrification. A sufficiently high sludge age must be maintained to allow slow-growth nitrifiers to reproduce in the aeration tank. They must also be prevented from being wasted out of the system. The WWTP's operation did not reflect this during the trial.

There was no reaction between the ammonium radical and the reagents to oxidize ammonium to nitrogen gas.

In the Mixed Liquor Suspended Solids (MLSS), higher life forms (nitrifiers) were starting to appear during the trial but not in great numbers. BW decided not to keep the trial operating as the MLSS had risen to 4,800 mg/L, exceeding its normal operating MLSS of 1,600 mg/L. The high MLSS resulted in some carry-over of solids from the secondary clarifier. The high MLSS was partly due to the poor performance of the Dissolved Air Flotation (DAF) in removing solids effectively.

ViroSewage™ Technology had a dramatic impact on the visual clarity and turbidity of the final treated effluent. The effluent was clear and visibility in the final effluent channel, increased by as much 150 cms. It was also noted that the secondary clarifier rake arms were visible for the first time in the history of the plant, according to the BW operator.

Dosing of ViroSewage™ reagents at Fairfield Waste Water Treatment Plant.

PHASE 2

The Phase 2 trial was conducted in September 2004 and the following results were recorded.

TABLE 5 – PHASE 2 – VIROSEWAGE™ TECHNOLOGY TREATED EFFLUENT

Date	BOD (mg/L)	SS (mg/L)	pH	NH3 - N (mg/L)	TKN (mg/L)	TP (mg/L)
Average	≤2.5	6.6	NA	NA	40.29	1.14

The comments for Phase 1 of the trial apply to Phase 2. The dosing of the reagents in the well mixed inlet chambers feeding the final settling tanks did not change the treatment outcomes. This can be attributed to the slurry reagent being well contacted with the MLSS that is being returned to the aeration tank via the RAS.

PHASE 3

The Phase 3 trial was carried out over a four-week period in February 2005. The dosing location was just before the primary sedimentation tank. Samples were taken from the following sections of the WWTP: Primary Influent, Primary Effluent, Aeration Tank, RAS, Final Effluent, Digester Sludge. Table 6 presents the data for Phase 3 and untreated averages for 2004.

TABLE 6 – PHASE 3 – PRIMARY INFLUENT (RAW SEWAGE) WATER

Date	BOD (mg/L)	SS (mg/L)	pH	NH3 - N (mg/L)	TKN (mg/L)	TP (mg/L)
Average for Trial	170	298	7.6	31	47	7.2
Average for 2004	204	365	7.5	35	59	18.6

> Primary Influent

The primary influent is the raw influent sewage (post-screening and grit removal) entering the Primary Sedimentation Tank (PST). The primary influent into the plant during the trial period was of a lesser strength than the average influent waste water for 2004. However, given that the samples were taken over a short, specific period in time towards the end of the summer vacation period, it is noted that the nutrient and organic loadings were lower.

TABLE 7 – PHASE 3 – VIROSEWAGE™ TECHNOLOGY TREATED PRIMARY EFFLUENT WATER QUALITY MONITORING DATA COMPARED TO 2004

Date	BOD (mg/L)	SS (mg/L)	pH	NH3 - N (mg/L)	TKN (mg/L)	TP (mg/L)
Average for Trial	63	75	7.4	32	39	7.2
Average for 2004	129	125	NA	NA	50	NA

> Primary Effluent

Primary effluent is the effluent leaving the PST after ViroSewage™ Technology treatment. The levels of SS, BOD and TKN were significantly lower during the trial period versus the average 2004 results. These reductions were due to the ViroSewage™ Technology reagents binding nutrients into the primary sludge sent to the digester. The primary sludge increased from 2.5 percent to 4.5 percent solids thereby decreasing the load on the aeration tanks. A benefit of thicker sludge is reduced sludge volume, potentially reducing the number of sludge haulage tankers required on a weekly basis to remove it from the WWTP.

> Aeration Tanks

During the trial period, the Mixed Liquor Suspended Solids (MLSS) concentration decreased from an average 2004 figure of 2,150mg/L to 1,500 mg/L, whilst the volatile fraction of the MLSS remained at 72.3 percent. The reduction in MLSS can be partly attributed to the reduction in BOD and SS loads into the Aeration Tank, 40 percent and 33 percent reductions respectively during the trial period.

The steady decline in MLSS at Fairfield WWTP, which commenced towards the end of 2004, can also be attributed to the improved operation of the DAF unit (BW had introduced a new polymer which was compatible to ViroSewage™ reagent), leading to improved solids removal, and a lower solids load into the aeration tank.

TABLE 8: PHASE 3: MLSS IN AERATION TANKS

Date	MLSS (mg/L)	Volatile SS (mg/L)	VSS/SS Ratio
Average for Trial	1,500	930	72.3
Average for 2004	2,150	1,600	72.3

The steady decline in MLSS is an interesting development, and when steady-state conditions are achieved, it is reasonable to assume that as carbon oxidation oxygen demand is met, subsequent nitrifier growth and multiplication will proceed, resulting in nitrification. This scenario would eventually lead to ammonium NH_4^+ conversion to nitrite NO_2 - and finally to nitrate, NO_3- .

It was also noted that during the trial, the lower MLSS in the aeration tank led to a lower aerator speed. The aerators run on variable speed motors, and the maximum daily average variable speed output decreased from 75 percent of its maximum speed (for the month before trial) to 60 percent during the trial period resulting in reduced power consumption.

> Return Activated Sludge (RAS)

The RAS suspended solids concentration decreased throughout the trial period as the MLSS declined. The RAS rate was maintained at normal levels throughout the trial. The RAS results are summarised in Table 9:

The decrease in RAS suspended solids is due to the decrease in organic load on the aeration tank, and the improvement in DAF operation during the trial.

TABLE 9: RETURN ACTIVATED SLUDGE

Date	RAS SS (mg/L)	Volatile SS (mg/L)
Average for Trial	2,540	1,990
Average for 2004	4,325	NA

> Final Effluent

The final effluent from the Fairfield WWTP during the trial had lower levels of BOD, SS, and TP compared to the Average 2003-04 Final Effluent results; there was no significant change in TKN.

This is shown in the table below:

TABLE 10 – PHASE 3 – TREATED FINAL EFFLUENT WATER QUALITY

Date	BOD (mg/L)	SS (mg/L)	TKN (mg/L)	TP (mg/L)
Average for Trial	2.5	5.9	29	1.9
Average for 2003-04	3.1	9.9	29.4	6.3

The decrease in BOD, SS and TP is most likely due to the reduction in the nutrient load to the aeration tank. This can be directly attributed to removal of BOD, SS and phosphorus in the primary sludge supplied to the digesters, and to an improvement in solids management (improved DAF operation) at Fairfield WWTP during the trial period.

The flow-on impact of ViroSewage™ Technology demonstrates that an overloaded WWTP can operate properly and meet its performance targets.

> Primary Sedimentation Tank Sludge Blanket and DAF Settleability

The primary sedimentation tank sludge blanket ranged between 0.7 m and 1.6 m during the trial. The addition of the ViroSewage™ Technology reagents to the PST influent increased the thickness and volume of sludge pumped to the digester. A contributing factor was the low level of solids returned from the DAF unit during the trial. During the month leading up to the trial, numerous changes were made to the DAF operation, leading to a reduction in the amount of solids returned to the primary tank. These solids contribute to the primary tank blanket height.

> Mixed Liquor Settleability

Mixed Liquor Settleability increased from an average of 30 percent in January to an average of 35 percent during the trial period. The significant removal of BOD and SS from the PST during the trial did not impact on the settleability of the mixed liquor in the aeration tank. This may indicate that the volume of reagent added to the PST was either inadequate or just appropriate, with ViroSewage™ reagents contributing to the higher settleability results in the PST. The aeration tanks during the trial period were a slight red colour, suggesting that some slurry was present with the Mixed Liquor, perhaps carried over during peak flows or wet weather flows.

> Final Settling Tank Sludge Blanket Levels

The final settling tank sludge blanket levels increased during the trial period for Final Settling Tanks 1 and 2 from 0.7m and 1.3m, up to 0.8m and 2.0m respectively during the trial. The Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) rates during the trial period were within normal ranges. The flow split between Final Settling Tanks 1 and 2 was unchanged during the trial.

Possible reasons for higher blanket levels may be due to the carry over of ViroSewage™ reagents from the aeration tanks, and reduced flow through the RAS valves due to valve blockages. The properties of the ViroSewage™ reagents are enabling larger agglomerates to be formed which assist faster settling of solids.

The ViroSewage™ Technology dosing plant adjacent to the Aerator Tank.

CONCLUSIONS

The application of ViroSewage™ Technology at Fairfield WWTP demonstrated that the technology is suitable to treat sewage to secondary treatment standards. Significant reductions in BOD and SS were noticed. The technology's ability to reduce nutrient concentrations demonstrates excellent reductions of phosphorus but not of nitrogen. In this particular WWTP, process configuration and constraints in maintaining MLSS and sludge age have not provided the right environment for the chemical reactions for TN reduction to occur.

The Phase 3 trial points to the possibility of nitrifier colony multiplication as the substrate for carbon oxidation reduces. Consequently, there is a distinct possibility of nitrification occurring with longer treatment conditions.

The reduction in BOD and SS loads on the aeration tanks could lead to savings in energy usage. This is directly associated with greenhouse gas abatement. The increase in the primary sludge thickness has the potential to decrease sludge haulage and sludge disposal costs.

The ViroSewage™ Technology dosing plant adjacent to the Aerator Tank.

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