RETROFITTING SMALL WATER SYSTEM TO MEET NEW REGULATIONS

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ABSTRACT

Central Highlands Water, in accordance with the *Safe Drinking Water Act 2003* has embarked on a ten year regional community water quality improvement program. Lexton (located in NW Victoria) is one such community water system selected to address the water quality issues, including colour, disinfection by-products, specifically trihalomethanes (THM's), and salinity. A pilot trial was conducted to evaluate the capability of MIEX® Technology followed by microfiltration (MF) & reverse osmosis (RO) to address disinfection by-product (DBP) and salinity issues. MIEX® Technology was used for the reduction of true colour, dissolved organic carbon (DOC) & THM management. Microfiltration & RO was used for removal of turbidity and inorganic salts (i.e. TDS) respectively.

The pilot trials have shown that raw water treated using this combined process will satisfy the relevant guidelines and regulations for True Colour, THMs and TDS and will also achieve the desired "step change" improvement in treated water quality. The preferred option for upgrade of Lexton WTP is use of MIEX® Technology as pre-treatment, followed by MF, then RO membrane filtration (i.e. RO - 50% of total plant flow).

1.0 INTRODUCTION

Lexton (located in NW Victoria) is one of many regional communities that experience water quality issues such as high colour, disinfection by-products (DBPs) and salinity. The colour and disinfection by-products are due to the dissolved organic carbon (DOC) present in the source water, while salinity is due to the inorganic salt content present in the raw water.

Water is currently supplied to the township of Lexton from the Lexton Reservoir via the Lexton Water Treatment Plant (WTP). Water is collected from open sheep and cattle grazing country into an open reservoir. Lexton has 126 water connections serving a population of about 250 people. The township has an annual consumption of about 40ML, but maximum daily consumption can be as high as 300kL/d.

Central Highlands Water selected the Lexton water system to trial and evaluate the MIEX® Technology for the reduction of True Colour, Dissolved Organic Carbon (DOC) and Trihalomethanes (THMs) and a subsequent Micro Filtration (MF) / Reverse Osmosis (RO) system for the removal of turbidity, protozoa and dissolved inorganic salts.

1.1 Current Water Treatment at Lexton WTP

The water treatment system currently located at the Lexton WTP consists of a microfiltration (MF) unit, followed by chloramination. The MF unit consists of 8 x M10V, PVDF membrane modules. The membranes are cleaned periodically using chemical cleaning (CIP) consisting of either hypochlorite and/or citric acid.

2.0 WATER TREATMENT OBJECTIVES

Central Highlands Water is committed to a ten year plan for the improvement of regional community water systems in accordance with the Australian Drinking Water Guidelines - ADWG (NHMRC, 2004) and the Safe Drinking Water Regulations - SDWR (Vic., 2005).

The specific objectives for the pilot plant trials conducted at Lexton WTP were to achieve a "step change" improvement in treated water quality for the following parameters;

- True Colour < 15 HU - ADWG
- Trihalomethanes (THMs) < 0.25 mg/L – ADWG, SDWR
- Total Dissolved Solids (TDS) < 500 mg/L - ADWG

The MIEX® Technology was selected as it is very effective for DOC removal. The DOC present in source water treated at Lexton WTP is responsible for both the high true colour and high THM formation potential. RO membrane technology was trialled to reduce the elevated TDS level (approx. 1000 mg/L) of the current treated water.

An additional objective was to determine whether the combined ion exchange & membrane filtration processes allowed a move from chloramination to straight chlorine gas for disinfection, which CHW prefer on the basis of simplicity, reliability and disinfection performance. The elevated DOC levels present in current MF treated water prevents the use of chlorination. However, using MIEX® Technology to improve DOC removal, will allow conversion from chloramine disinfection to straight chlorine gas disinfection, and still meet THM level targets.

2.1 Proposed Treatment Train: MIEX® + MF + RO

The following is a process schematic indicating the proposed treatment train for Lexton WTP.

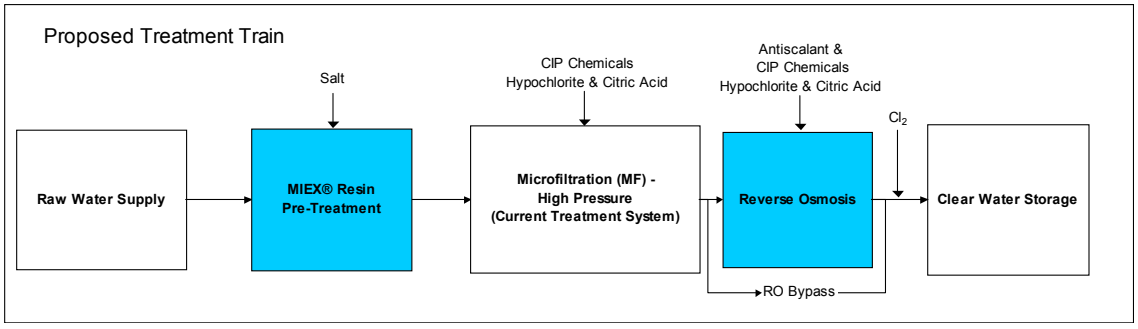

Figure 1: ***Process schematic – Proposed Treatment System at Lexton WTP – MIEX® + MF + RO.***

3.0 RESULTS AND DISCUSSION

3.1 Performance of Treatment Systems – Treated Water Quality

Figure 2 below shows the dramatic reduction in true colour (92% removal) by using

MIEX® Pre-treatment. Furthermore, it is clear that MF treatment does not remove any true colour from either raw or MIEX® Treated waters.

Treatment with RO technology removes the remaining true colour (i.e. 100% removal).

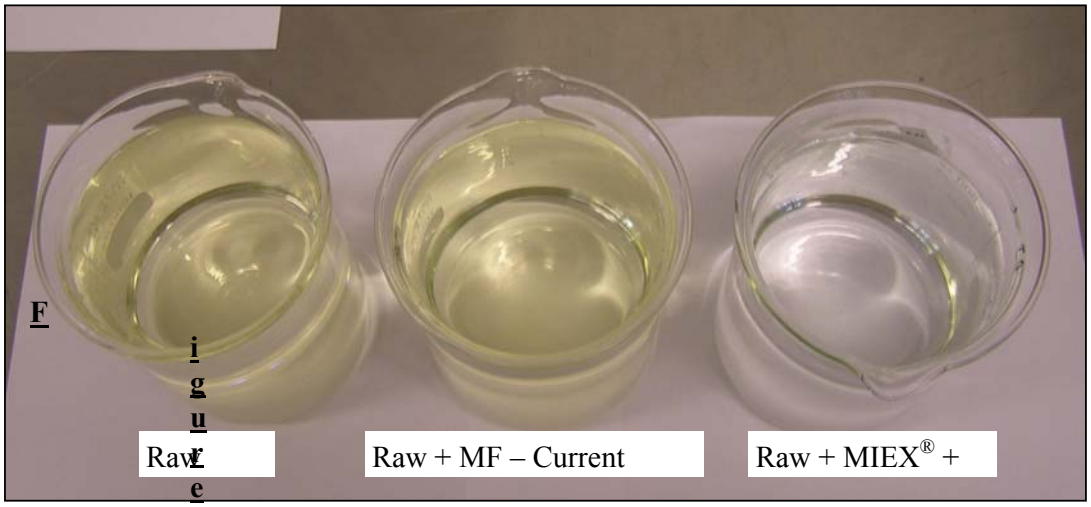

Figure 2: ***Performance of MIEX® + MF + RO Treatment System at Lexton WTP - From Left, Lexton Raw Water, MF Treated Water - Existing Plant & MIEX® + MF Treated Water***

Application of the MIEX® Technology alone satisfies the Australian Drinking Water Guideline with respect to true colour (i.e. < 15 HU units).

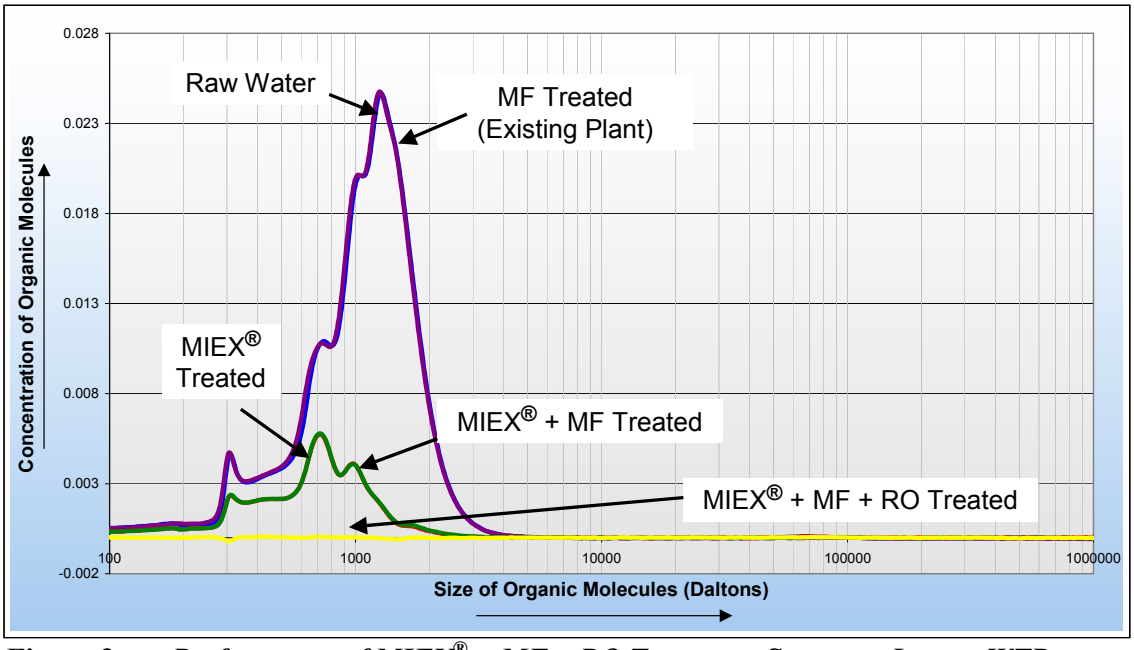

Figure 3: ***Performance of MIEX® + MF + RO Treatment System at Lexton WTP – HPSEC Results.***

Figure 3 shows the size of organic molecules being removed by the MIEX® + MF + RO treatment system. The results suggest the following;

- The raw water treated at Lexton WTP consists of small organic molecules (i.e.

<10,000 Daltons).

- Microfiltration of raw water does not remove the small organic molecules (i.e. colour).
- Treatment using MIEX® Technology effectively removes the small organic molecules.
- Treatment of raw water using the MIEX® Process followed MF and RO filtration removes all small organic molecules.

3.2 Other Disinfection By Products (DBPs)

Use of MIEX® Pre-treatment will allow conversion of the current disinfection process (i.e. chloramination) to chlorination.

Conversion from chloramination to chlorination disinfection will remove the nitrogen source from the treated water and reduce the likelihood of increasing nitrosamines. One specific nitrosamine, N-nitrososodimethylamine (NDMA) is carcinogenic[1] at very low concentrations (i.e. 100-10,000 fold more carcinogenic than THMs). WHO and USEPA have revised allowable limits in drinking water due to the health risks associated with nitrosamines in drinking water.

Therefore, conversion from chloramination to chlorination will prevent this becoming an issue at Lexton WTP.

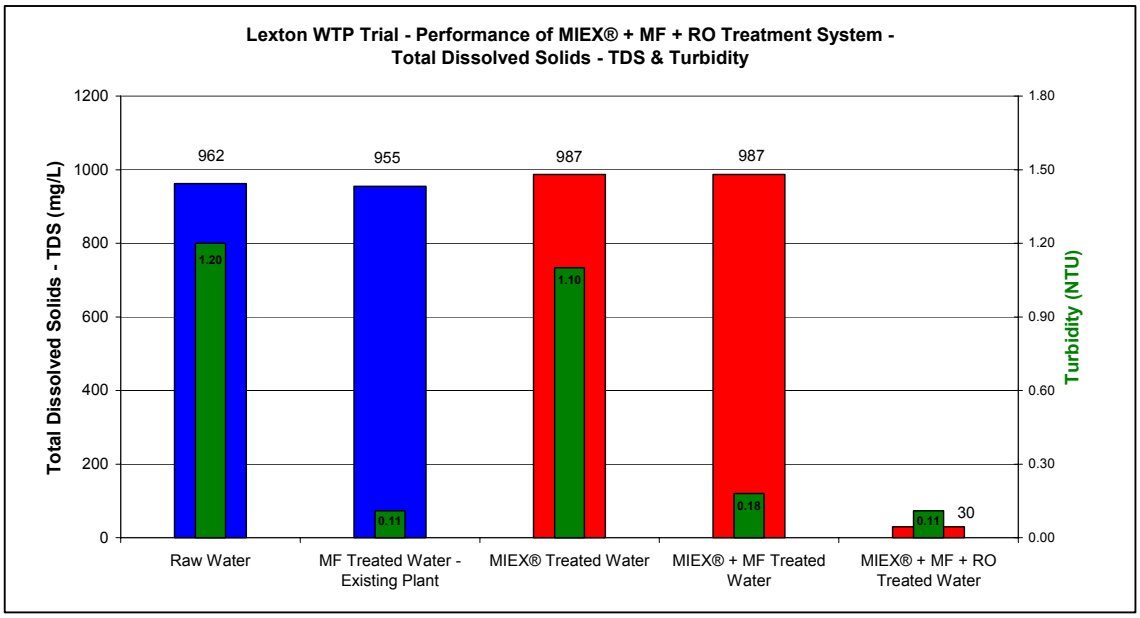

Figure 4: ***Performance of MIEX® + MF + RO Treatment System at Lexton WTP – TDS and Turbidity Results.***

Figure 4 shows the following;

- Microfiltration effectively removes turbidity to below 0.2 NTU.
- Microfiltration does not remove TDS.
- MIEX® pre treatment resulted in a small increase in TDS levels (i.e. due to small increase in chloride). The small increase in chloride is due to the exchange of DOC from raw water onto the MIEX® Resin, where chloride ions are released from the active sites of MIEX® Resin into the treated water.

- Polishing of MIEX® + MF treated water using RO technology effectively removes the majority of TDS and turbidity.

3.3 Performance of Treatment Systems – Process/Operational Improvements

The benefits of MIEX® Pre-treatment prior to both the MF and RO membranes are greater than improved treated water quality. Introduction of MIEX® pre-treatment step is expected to improve performance of both MF and RO membrane process units.

It is expected that using MIEX® Technology as a pre-treatment will;

- Reduce the rate of TMP increase, due to a reduction in fouling associated with the small organic molecules.
- Reduce the frequency of membrane CIP cleaning.
- Reduce the frequency of membrane backwash cycles. Hence, increase recovery of water from the membrane process.
- Improve production capacity through the membrane, as a result of reducing backwash frequency (i.e. higher percentage of plant operation spent in "filtration" mode compared to "backwash" mode).

3.4 Practical Application of Treatment Systems at the Lexton WTP

Examining the various combinations of water treatment processes available for the Lexton WTP, the projected treated water quality can be summarised in Table 1;

Table 1: ***Water Treatment Process Options for the Lexton WTP System.***

Water Treatment Process - Options	True Colour (HU)	Total THMs (mg/L)	TDS (mg/L)	Turbidity (NTU)
Guideline Value (Guideline/Regulation)	<15 HU ADWG	<0.25 mg/L ADWG/SDWR	<500 mg/L ADWG	<0.2 NTU
Raw Water	24 HU	0.503 mg/L	962 mg/L	1.2 NTU
MF Treated Water - Chlorination	24 HU	0.479 mg/L	955 mg/L	0.11 NTU
MF Treated Water - Existing Plant - Chloramination	24 HU	0.310* mg/L	955 mg/L	0.11 NTU
MIEX® + MF Treated Water	2 HU	0.212 mg/L	987 mg/L	0.18 NTU
MF + 50% RO Treated Water	12 HU	0.241 mg/L	493 mg/L	0.11 NTU
MIEX® + MF + 50% RO Treated Water	**2 HU**	**0.100 mg/L**	**500 mg/L**	**0.15 NTU**
MIEX® + MF + 63% RO Treated Water	**1 HU**	**0.078 mg/L**	**384 mg/L**	**0.14 NTU**

Table 1 indicates that only two technology combinations can meet the water treatment objectives as specified in the relevant guidelines and regulations. These are;

- MF + 50% RO Treated Water, and
- MIEX® + MF + 50% RO Treated Water.

Further analysis indicates that only "MIEX® + MF+ 50% RO" treatment can achieve the required "step change" improvement in treated water quality. "MF + 50% RO" treatment only marginally satisfies the THM regulations and does not achieve the desired "step change" in terms of THMs. If Central Highlands Water were required to meet the USEPA DBP limit (i.e. THMs <0.080 mg/L), the "MIEX® + MF+ **63%** RO" treatment will meet this objective.

Therefore, the preferred option for upgrading the Lexton WTP is using MIEX® Technology as a pre-treatment step followed by MF (i.e. existing) followed by RO membrane filtration (i.e. 50% of the total plant flow, followed by blending).
This process selection is an effective treatment solution for many small water treatment systems integrating both DBP precursor removal and salt removal in accordance with the relevant guidelines and regulations.

Table 2: ***Waste Production and Energy Consumption of Preferred Option for Lexton WTP.***

	Treatment Process Units			Lexton Upgrade - Proposed Plant
	MIEX® Pre-treatment	Micro-filtration (95% Recovery)	Reverse Osmosis - (50% Blend - 75% Recovery)	MIEX® + Microfiltration + Reverse Osmosis (50% Blend)
Treated Water Production (kL/d)	368.5 kL/d	350 kL/d	150 kL/d	300 kL/d
Waste Volume (kL/d)	0.5 kL/d (0.07%)	18.5 kL/d (17.4%)	50 kL/d (82.5%)	69 kL/d
Average Power Consumption - Operation	0.03 kWhr/m^3 (0.09%)	0.20 kWhr/m^3 (5.8%)	3.20 kWhr/m^3 (93.3%)	1.88 kWhr/m^3
Operating Pressure	Ambient	3 Bar	12 Bar	
Cleaning Chemicals	Salt	Hypochlorite & Citric Acid	Acid & Alkali Based Cleaning Solutions	MIEX® - Salt, MF - HOCl & Citric Acid, RO - Acid & Alkali Cleaning Solutions

Table 2 shows that MIEX® Technology will produce minimal waste and use minimal energy in comparison to both the MF and in particular, the RO membrane processes.

4.0 CONCLUSION

The pilot plant trials successfully demonstrated the combination of MIEX® pre-treatment followed by MF and RO membrane filtration can achieve the desired "step change" improvement in treated water quality. The combined process will satisfy the relevant guidelines and regulations for the parameters of True Colour, THMs and TDS.

The preferred option for upgrading the Lexton water treatment system is the application of MIEX® pre-treatment step, followed by MF and then RO membrane filtration (50% of total plant flow).

Application of MIEX® pre-treatment will simplify disinfection at the Lexton WTP by allowing conversion to chlorine gas disinfection, reduce risks associated with other emerging DBPs whilst maintaining THMs levels well below limits specified in relevant guidelines and regulations.

5.0 ACKNOWLEDGEMENTS

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6.0 REFERENCE

11th Report on Carcinogens, U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, Pursuant to Section 301(b) (4) of the Public Health Service Act as Amended by Section 262, PL 95-622.