

Selwyn District Council Pines WWTP Upgrade Staging Options

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1 Introduction

The Pines Wastewater Treatment Plant (WWTP) currently provides treatment for the townships of Rolleston and West Melton. The plant was commissioned in early 2007 and was designed to cope with a population of up to 6,500 population equivalents (p.e.). In addition to the Pines WWTP, Selwyn District Council (SDC) also operates a second WWTP in Rolleston, known as Helpet, which is located on the outskirts of Rolleston and able to treat flow from the equivalent of 4,000 people. The two plants provide a total treatment capacity equivalent to 11,500 people.

Wastewater from the other towns in East Selwyn, Prebbleton, Lincoln, Springston, and Tai Tapu, is discharged into the Christchurch City Council (CCC) network. The agreement with CCC limits the discharge volume which is currently restricting potential development, in particular in Prebbleton. As ratified by the Urban Development Strategy (UDS), the eastern area of Selwyn District will continue to grow and hence adequate infrastructure is needed to meet this growth expectation. The proposed solution is to expand and upgrade the Pines WWTP to provide sufficient capacity for the expected growth in the east Selwyn area, and divert flows from the above towns (except Tai Tapu) to the Pines for treatment.

2 Purpose

The purpose of this report is to outline the proposed upgrade strategy for the Pines WWTP. The upgrade will be staged to accommodate the population increases projected for the area, as well as to maximise use of the existing facility.

3 Existing WWTP

The Pines WWTP was commissioned in March 2007, and is due in 2010 / 2011 to be expanded to accept more flow from Rolleston and surrounding townships.

The Pines WWTP incorporates screening, biological activated sludge treatment with nitrogen removal, clarification and UV disinfection before irrigation to land. The activated sludge system is a 4-Stage Bardenpho process consisting of sequential anoxic and aerobic zones to achieve advanced nitrification and denitrification. Within the aerobic zones the ammonia in the wastewater is converted to nitrates, which is recycled back through the anoxic zones where the nitrate is stripped to nitrogen gas in the absence of oxygen and released to the atmosphere in a process called denitrification. UV disinfection then provides a reduction in bacterial concentrations.

4 Future Requirements

4.1 Population Projections

The expected population served by the Pines WWTP is shown in Figure 4-1 below. The population has a step increase of around 12,000 p.e. when the flows from the surrounding towns are diverted to the Pines (note population equivalents value includes allowances for industrial wastewater). The current capacity of the Pines and Helpet plants will not be sufficient for these flows. Therefore the Pines will be upgraded prior to the flows being diverted.

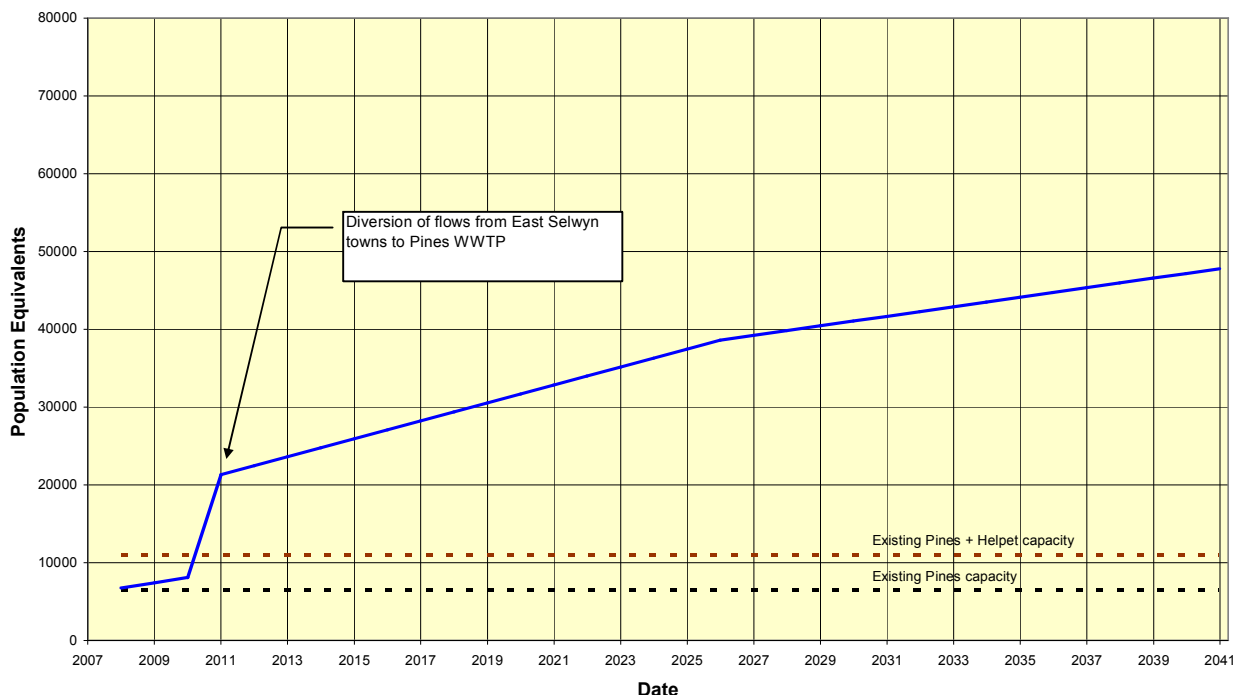


Figure 4-1 : Projected Population Served by Rolleston WWTPs

4.2 Disposal Options

Future disposal will continue to be to land. However, there is potential for reuse of treated wastewater for irrigation on dairy pasture in the surrounding area. Irrigation in the Canterbury plains has had a high profile recently as the demand for water for irrigation has increased, which is arguably the result of more farms trying to increase crop production or convert to dairy. Wastewater is increasingly being recognised as a valuable resource worldwide and water recycling is being utilised in areas where water is scarce. There is clearly demand for water in the area surrounding the Pines WWTP, and the treated wastewater can be considered a valuable resource in that it has the potential to impact production on the surrounding farm land.

Treating the wastewater to the standard required for reuse would have further benefits:

- Further reduce the risk of contaminating groundwater – providing stakeholders additional assurance
- Allow for irrigation of dairy pasture
- Allow irrigation of parks and reserves

The disposal requirements for controlled irrigation to SDC land are expected to remain the same (i.e. similar mass loadings will apply in future). However, if reuse of wastewater is desired then more stringent quality criteria must be adhered to, which will require additional treatment processes, or a change in technology, to be adopted at the Pines WWTP. The requirements for both the current disposal route and for irrigation of dairy pasture are summarised in Sections 4.2.1 and 4.2.2.

4.2.1 Current Disposal Requirements

The treated wastewater from the Pines WWTP is currently disposed of by irrigation to land on dedicated disposal fields owned by SDC. The existing resource consent for discharge to land places the following limits on the treated wastewater quality:

- Biochemical Oxygen Demand (BOD): median of 15 mg/L, and 95th percentile of 60 mg/L
- Suspended Solids (SS): median of 20 mg/L, and 95th percentile of 90 mg/L
- Faecal Coliforms (FC): median of 500 cfu/100ml
- Total Nitrogen (TN): maximum of 150 kg-N/ha/year

The limits were set to reduce the public health risk from treated wastewater draining through the soil and into the ground water. Previous studies have shown that in general the irrigated wastewater will drain through the soil and into the groundwater. The current resource consent conditions for the quality of the treated wastewater would prevent contamination of potable water taken from groundwater supplies.

4.2.2 Fonterra Requirements for Irrigation

While there are opportunities to recycle the treated wastewater from the Pines WWTP, it would require a robust treatment process to ensure the quality standards required by the dairy industry are consistently met.

The dairy industry is concerned about the health implications and public perception of feeding its stock pasture irrigated with human effluent. Until 2005 there was a complete ban on irrigation of treated domestic wastewater to pasture used for dairy feed. In 2005 Fonterra reassessed this position and changed to a strict level of treatment and monitoring if pasture was to be irrigated with treated domestic wastewater. Under these regulations effluent being irrigated to pasture is required to meet the California Code of Regulations, Title 22,

Division 4 for reuse. Under these regulations effluent must meet disinfected secondary-23 recycled water standards for irrigation to pasture used for milk production for human consumption. These standards require the wastewater to have been oxidised and disinfected, so that the median total coliform concentration for the previous 7 days does not exceed 23 MPN (Most Probable Number)/100mL and the maximum for the previous 30 days does not exceed 240 MPN/100mL. Oxidised wastewater is water that has been stabilised, is nonputrescible, and contains dissolved oxygen. Aerobic secondary treatment, such as that at the Pines WWTP, meets the criteria of “oxidised wastewater”.

The sampling requirement in the California Title 22 regulations for disinfected secondary-23 recycled water is at least daily, with samples being tested at an approved laboratory (IANZ accredited in New Zealand). These requirements allow little freedom and involve a heavy financial burden. Fonterra have indicated¹ that if a particular control method could be proved to meet the required effluent standards for three months of daily sampling then sampling could be reduced to once monthly.

For reuse of treated wastewater for irrigation on dairy land (or irrigation of parks and reserves), the Pines WWTP would need to meet the following conditions:

Groundwater Requirements:

- Biochemical Oxygen Demand (BOD): median of 15 mg/L, and 95th percentile of 60 mg/L
- Suspended Solids (SS): median of 20 mg/L, and 95th percentile of 90 mg/L
- Faecal Coliforms (FC): superseded by Fonterra requirements (see below)
- Maximum annual nitrogen loading of 150kg-N/ha/year

Fonterra Requirements:

- Median total coliform concentration of 23 MPN/100ml from last 7 samples
- Maximum total coliform concentration of 240 MPN/100ml for any 1 sample in any 30 day period
- 3 months of daily sampling to prove quality standard, then monthly sampling.

For irrigation of parks and reserves a similar quality standard would be required to the Fonterra standards.

4.3 Treatment Process Options

This section discusses the treatment processes required to meet the more stringent quality standards for irrigation of dairy pasture.

The quality required to prevent contamination of groundwater is already being met by the existing treatment process at Pines. Therefore there is no need to change from the activated sludge BNR (Biological Nutrient Removal) treatment process. However, additional process units, or a change in technology, would be required in order to meet the Fonterra requirements of a total coliform median less than 23 MPN/100ml. With a conventional bioreactor/clarifier system the main objective would be to provide consistently low suspended solids in the wastewater flow into the UV disinfection plant, which would ensure consistent good performance from the UV. Suspended solids affect the applied UV dose in two ways; reduction of UV light transmission and shielding pathogens from the UV light. Both of these reduce the effectiveness of the UV disinfection process. A low level of suspended solids ensures good pathogen kill required to satisfy the required quality standard.

¹ Pers comm. With Charlotte Rutherford, Fonterra Ltd, 23 Sep. 08. Relaying message from Jim Barnett, Fonterra.

There are two main treatment technology options available to ensure compliance with the required standards:

- Conventional bioreactor/clarifier technology with tertiary filters following the clarifier, or
- Membrane bioreactor

The conventional bioreactor/clarifier configuration currently in operation at the Pines WWTP has performed better than expected. However, this level of performance cannot be relied upon, especially as the load to the plant increases with population growth. To ensure reliable performance within the Fonterra quality standards tertiary filters would be required after the clarifier to protect the UV disinfection process. The filter would provide a physical barrier in the form of the filter media. The media used could be sand (or similar), cloth type, or membranes. The UV disinfection system would then be designed based on the worst case filter solids capture at peak flow rate to ensure the required pathogen reduction is achieved at all flows.

Membrane bioreactors (MBR) are increasingly being used to provide high quality treated wastewater where there is either a receiving environment that demands it, or where there is potential for water recycling. The membranes provide the solids separation process (replacing the clarifier). They have the advantages of a smaller footprint and, being a physical barrier with microscopic pore size (typically 0.05 to 0.1µm), also provide complete separation of solids and bacteria (for microfiltration). UV disinfection would be used to kill any viruses present, or ultrafiltration is a possibility which would also remove viruses. Figure 4-2 shows the removal rates from micro and ultra filtration, as well as the typical membrane pore sizes used for wastewater treatment.

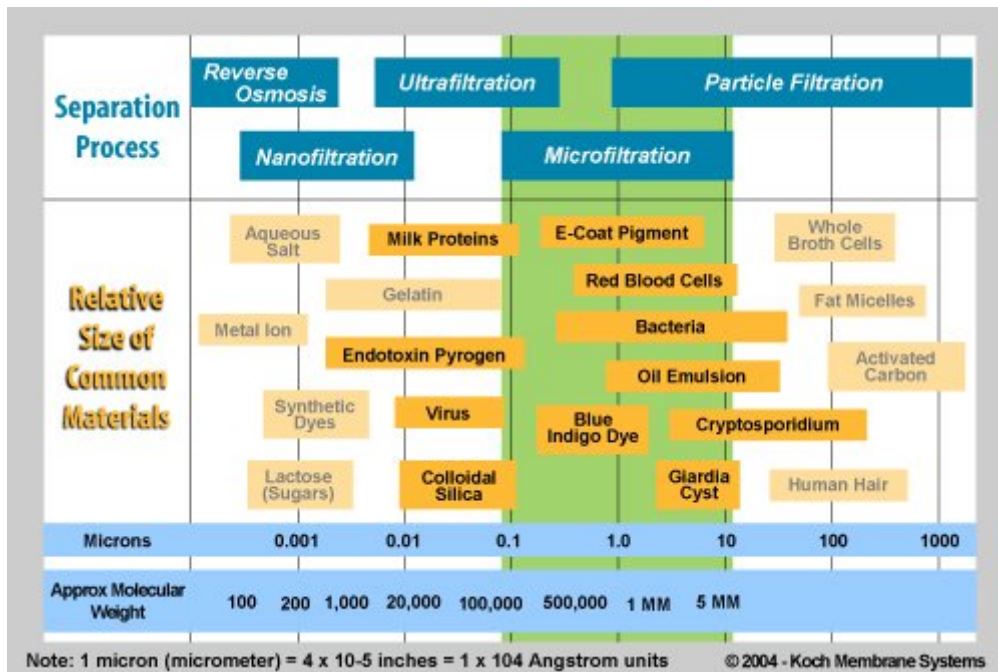


Figure 4-2 : Membrane separation (microfiltration highlighted) from Koch Membrane Systems

While MBRs are not common in New Zealand, there are now a number of plants around the world that have been operating for long periods and the technology has advanced to the point where MBRs are an established wastewater technology. Table 4-1 contains a comparison of the two options for treatment technology.

Table 4-1 : Comparison of Options for Treatment Technology to meet Fonterra Quality Standards

Criteria	Conventional: Bioreactor/Clarifier & tertiary filtration	New Technology: Membrane Bioreactor (MBR)
Required Footprint	Similar to existing Pines stage I, except: <ul style="list-style-type: none"> • Larger module sizes for increased capacity per module • Additional area for tertiary filters to meet reuse quality standards 	Smaller than conventional footprint: <ul style="list-style-type: none"> • Higher operating solids concentration therefore smaller bioreactor • No clarifier required • Easier to construct in modules than with clarifiers
Auxiliary Equipment	Similar to existing Pines I, except: <ul style="list-style-type: none"> • Required tertiary filters to meet reuse standards 	Similar to conventional except: <ul style="list-style-type: none"> • No clarifier or tertiary filter • Second screening stage required • Greater aeration requirement (higher airflow, more diffusers)
Operation	Similar operation and maintenance requirements to existing Pines I operation, but with the addition of tertiary filtration	Increased maintenance requirements for membrane cleaning (in place) and inspection
Operating Cost	Similar to Pines I operating cost rates, but with additional costs for tertiary filtration	Higher operational cost overall: <ul style="list-style-type: none"> • Greater aeration requirement • Larger volume of screenings • Membrane replacement (life 7-10 years) • Membrane cleaning (automatic clean in place)
Capital Cost	Similar to Pines I capital cost rates, but with additional costs for tertiary filtration	Higher overall capital costs: <ul style="list-style-type: none"> • Smaller bioreactor size, no clarifier • Membrane cost, second screening step & more diffusers required • High peak flows would make system uneconomic
Treated Wastewater Quality	Similar to existing Pines I performance: <ul style="list-style-type: none"> • Treated wastewater requires tertiary filtration to meet reuse standards • Required filtration capacity linked to sludge settling characteristics 	High quality: <ul style="list-style-type: none"> • Membranes provide physical barrier • Quality acceptable for reuse of treated wastewater where appropriate
Summary of Advantages & Disadvantages	Advantages: <ul style="list-style-type: none"> • Operators familiar with conventional treatment • Lower capital and operating costs • Filtration provides physical barrier Disadvantages: <ul style="list-style-type: none"> • Tertiary filtration process required to meet reuse standard • Solids separation performance linked to required capacity of tertiary filters 	Advantages: <ul style="list-style-type: none"> • High quality effluent integral to process • Physical barrier provides robust reliable treatment to meet reuse standards • Reduced footprint • Effluent quality not impacted by sludge settling characteristics Disadvantages: <ul style="list-style-type: none"> • Second screening step required to protect membranes –however this also results in less trash/inerts in waste sludge • Higher capital & operating cost • Potential high capital cost, if flow balancing tank required • New process for operators to learn

While the MBR option has higher capital and operating costs, it has the advantage of consistently producing high quality treated wastewater (which is integral to disposal) and independent of sludge settling characteristics. The quality would be consistently below the Fonterra requirements: expected quality is <1 suspended solids, BOD and faecal coliforms (note that a separate test would be required to confirm virus removal). Therefore it is recommended that the MBR upgrade option is investigated further.

5 Upgrade Staging Options

5.1 Bioreactor

The main treatment process to achieve the required effluent standard is provided by the bioreactor. The existing bioreactor has a design capacity of 6,000 p.e., which along with the existing Helpet WWTP provides sufficient treatment capacity until around 2015. However additional capacity is required before wastewater from the other East Selwyn towns (Lincoln, Prebbleton, Springston) are diverted to the Pines WWTP. Diversion of flows is currently programmed for 2010/2011, however this cannot occur until the Pines is upgraded to increase treatment capacity.

The objective of the bioreactor upgrade would be to provide new bioreactor module(s) prior to flows from East Selwyn towns being diverted to Pines, while also allowing time for decommissioning and retrofitting of the existing Pines bioreactor to MBR, before it is also required in operation for treatment capacity.

The recommended upgrade path for the bioreactors is presented in Figure 5-1. The proposed upgrade includes construction of a new 25,000 p.e. MBR module in 2010, which would provide treatment capacity until 2014 without the existing Pines bioreactor or the Helpet WWTP. The existing Pines bioreactor and Helpet WWTP would provide treatment capacity until the new MBR was operating. Once the new MBR is operating the existing Pines bioreactor/clarifier can be decommissioned and converted into a MBR during 2011/12 (expected timeframe for this is approximately 6 months and expected capacity is approximately 16,500 p.e.). Once retrofitting of the existing bioreactor is complete, the total capacity of the two bioreactors would be in the order of 41,500 p.e. which provides sufficient capacity until 2030. A second MBR module would be constructed prior to 2031 to meet population expectations beyond 2040.

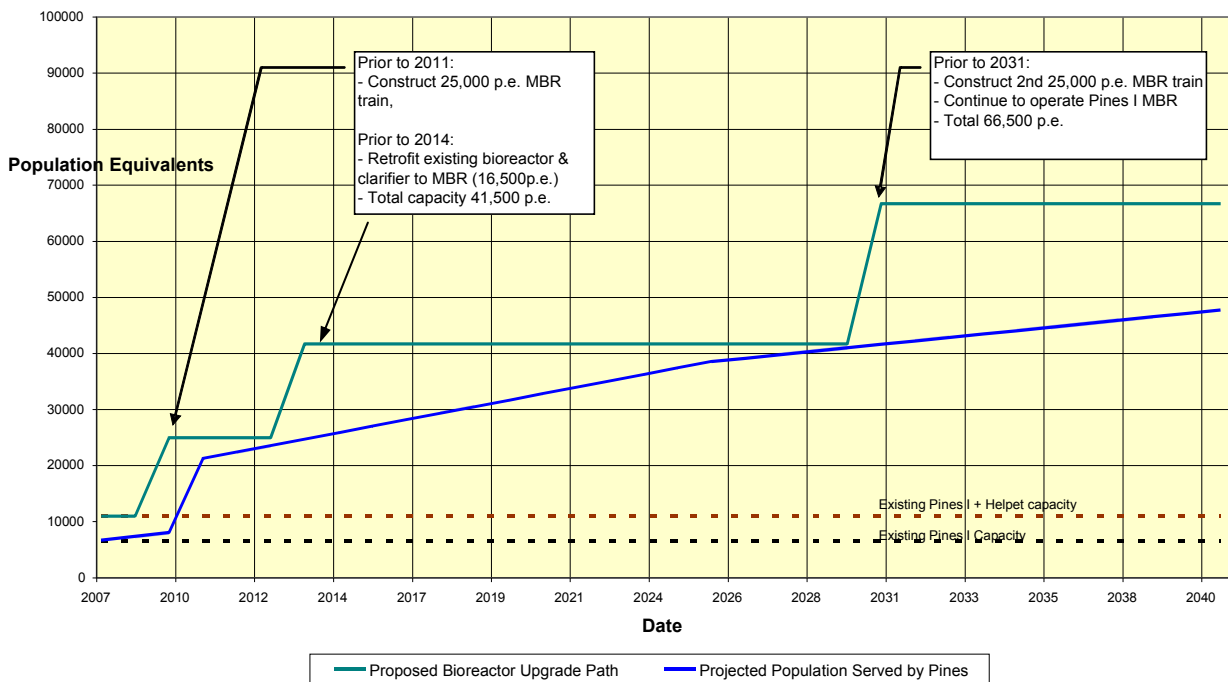


Figure 5-1 : Proposed Bioreactor Upgrade Path

The proposed upgrade path has the advantages of capital savings by utilising the existing bioreactor/clarifier asset, while significantly increasing treatment capacity and not delaying diversion of flows from East Selwyn. It also allows the upgrade construction of a new bioreactor, followed by retrofitting the existing bioreactor to occur over four calendar years 2010 to 2013, assuming construction can start in 2010.

The MBR modules would be a rectangular shape with anoxic/aerobic/anoxic/aerobic zones (similar to the existing bioreactor) and a final membrane compartment, where modular membrane cassettes would be submerged in the mixed liquor. The rectangular shape allows for easy construction of multiple modules in stages. A new flow spitting chamber designed for the ultimate plant layout would be required to split flow to each bioreactor. The effluent from the MBRs would be combined prior to UV treatment.

The ultimate (beyond 2040) bioreactor layout may comprise up to three 25,000 p.e. modules providing a total capacity of 75,000 p.e. This layout might be desired earlier than required by population growth to provide redundancy so that a bioreactor can be taken out of service for scheduled maintenance e.g. diffuser replacement.

5.1.1 Existing Bioreactor/Clarifier

Utilising the existing bioreactor/clarifier for liquid stream treatment as an MBR maximises the use of the existing asset. Conversion to MBR can increase its capacity from 6,000 p.e. to around 16,500 p.e, which is more than double its design capacity. At some point in the future it could be replaced by a third 20,000 p.e. MBR module, but as the existing bioreactor/clarifier structure was constructed in 2006 and its expected lifetime is 50 to 70 years, there should be no need to replace it until around 2055. However, in terms of plant operation identical modules of 25,000 p.e. MBRs may be preferred to continuing to operate the separate round bioreactor/clarifier

structure, and replacement could occur at an earlier date if desired. A decision on the continued use of the structure could be made prior to the upgrade around 2028.

The structure could also be considered for sludge treatment and storage, but its dimensions are not ideal for this use. Therefore liquid stream treatment with conversion to MBR to increase capacity is the preferred use for the structure because it maximises the use of the existing asset.

Conversion to MBR will require the existing clarifier to be converted to use as additional aeration volume with the membranes submerged in a section in the centre. The conversion will also require additional diffusers to be installed and a capacity upgrade for the blowers, mixers and recycle pumps.

5.1.2 Existing Helpet WWTP

The existing Helpet WWTP would no longer be required once the upgrade of the Pines WWTP to 41,500 p.e. capacity was complete. This plant should be decommissioned unless there is a compelling need to keep it operating. The only foreseeable need would be for water recycling in the area surrounding the Helpet plant. If end users of wastewater treated to reuse standard were available near the Helpet plant then it would make sense to consider upgrading this plant to provide recycled water to those users, rather than construct a pipeline from the Pines WWTP to the Helpet area. This would be consistent with the treatment at the point of use approach for water recycling, similar to 'sewer mining' plants in use overseas.

5.2 Inlet Screens

The existing screen has a capacity of 140L/s and 5mm diameter holes. The projected 2028 peak wet weather flows to the Pines will be in the order of 375 L/s.

The inlet screens would need to be upgraded in order to protect the membranes and also to cater for increased flows. A second screening step with smaller aperture size is required to further improve screening capture in order to protect the membranes. Membranes are susceptible to damage from hair and fine grit. Screen aperture sizes are continually being reduced to protect the membranes from damage and prolong their life. The inlet screening capacity will also require upgrading prior to flows being diverted from other East Selwyn towns to the Pines.

The inlet screen upgrade should coincide with construction of the new MBR in 2010. A minimum of two screens should be considered to allow for redundancy and the design should also consider expansion of the screens for future development up to and beyond 2040. While the staging of the inlet screens could be timed to coincide with the bioreactor upgrades, it may be more efficient to upgrade the screens independently given the shorter expected lifetime for mechanical equipment of 15 to 20 years.

5.2.1 Second Screening Step

A second screening step with smaller aperture size is required for MBR plants to further improve screening capture in order to protect the membranes.

The second screening step can be provided after the inlet screens or it can be used to screen the mixed liquor from the bioreactors. The best option for the second screening step should be discussed with the preferred membrane supplier and provided at the same stage as the bioreactor upgrades.

5.3 UV Disinfection

The existing UV disinfection system has a peak hydraulic capacity of 50 L/s, however this is reduced from the peak flow to the WWTP due to flow balancing in the bioreactor. UV channels will require a greater hydraulic and disinfection capacity if flow balancing is not included in future upgrades.

The UV disinfection system will need to be upgraded prior to flows being diverted from East Selwyn. With the use of MBRs the effluent quality entering the UV system will be very good (<1 suspended solids) so that the required UV disinfection power will be reduced compared with conventional effluent quality requirements.

The UV disinfection system may need to be relocated to accommodate higher flows and allow for additional channels to be added in the future as flow to the Pines increases with population growth.

5.4 Irrigation Pump Station

The irrigation pump station has a capacity of 50 L/s. The pumps are fixed speed and start and stop based on wet well level. Overflow to soak holes have been provided for emergencies.

The pump station will need to be upgraded for future flows prior to diversion of flows from East Selwyn to the Pines. The pump station was designed to deliver water to the dedicated irrigation fields owned by SDC. If irrigation of other pasture is required, a second pump station may be required to deliver recycled water to the desired destination because of the differing flow and head requirements. Retaining the existing pump station allows continued use of the existing irrigation fields, which may be required if demand for recycled water is seasonal as expected.

5.5 Centre Pivot Irrigators

The existing 200m radius centre pivot irrigators are each designed to irrigate a maximum of 11mm depth per day. The irrigation system requires upgrade as the population increases. SDC have land set aside for future irrigation needs.

5.6 Sludge Handling

The future sludge disposal strategy is discussed in the report "Pines Long Term Sludge Handling Options" (MWH, 2009). At this stage drying beds is the preferred option, which would require aerobic digestion and biosolids storage facilities at the WWTP.

5.7 Buildings

The new MBR will require building space for switchboards, chemical storage (for cleaning), and blowers. The use of the existing building should be considered in conjunction with the new building requirements. The existing building could be retained as is, but may be better suited to being converted to house switchboards for the site. The new building could include a new operations/control room, lab, shower etc. as well as new blowers and chemical storage required.

Further buildings for sludge handling may also be required depending on the sludge disposal route chosen. At this stage a room for sludge dewatering equipment and storage bins is expected.

6 Recommendations

Master planning for wastewater in the Selwyn district includes diversion of flow from East Selwyn towns to the Pines WWTP. The diversion is currently programmed for 2011 however the Pines must be upgraded prior to this to provide capacity for the increased flows.

In addition, there is potential for reuse of high quality treated wastewater for irrigation on dairy pasture in the area surrounding the Pines WWTP. Stringent quality standards must be met in order to allow treated wastewater to be reused. This will require a change in treatment process at the Pines WWTP. Further investigation into the use of membrane bioreactors is recommended as a robust, reliable treatment solution to meet the required reuse standards.

The upgrade of the Pines WWTP should be staged to provide the required future treatment capacity. The proposed upgrade strategy includes construction of a new MBR module of at least 25,000 p.e. capacity, which would provide sufficient treatment capacity for increased flows after diversion from other East Selwyn towns to the Pines. The 25,000 p.e. upgrade would also allow the existing bioreactor to be taken out of service for retrofit to MBR (providing an increase in capacity from 6,500 to around 16,500 p.e.). This upgrade strategy would provide a total capacity of 41,500 p.e. which is sufficient until around 2028. Further MBR modules could then be constructed to increase capacity prior to 2028.

Other treatment processes will also require upgrade prior to diversion of flows from East Selwyn to the Pines. Upgrades of the inlet screens, UV disinfection, irrigation, sludge handling, and other associated equipment should occur at the same time as the bioreactor upgrade.