South East Water

Fishermans Bend Sewer Mining Plant
Public Version of Concept Design Report, 2016

Issued June 2020

Executive summary

The Fishermans Bend Urban Renewal Area is the largest inner city high density redevelopment in Australia, and one of the largest urban renewal projects in the world.

In 2015 South East Water (SEW) and GHD undertook a strategic review of servicing options for the Fishermans Bend area (*Fishermans Bend Integrated Water Management – Public Version of Options Evaluation*, September 2015). This study examined the water infrastructure required to service the area using a conventional approach and a range of innovative alternatives, including stormwater harvesting and sewer mining at both development and lot scale.

The strategy outlined a number of recommendations, including that a third pipe system be adopted and that the recycled water is sourced from a sewer mining plant located within the area.

In addition to servicing the Fishermans Bend precinct there is also an opportunity to expand the capacity of the proposed sewer mining plant to service existing and future growth areas.

To service the Fishermans Bend precinct the treatment plant would need to produce up to 18.5 ML/d, while a capacity of 36 ML/d is required to provide recycled water to other growth areas.

A number of options for sewage extraction were considered as part of this investigation to identify a preferred location and source. The Melbourne main Sewer and Hobson Bay Main (HBM) Sewer were considered and a number of options for sewage extraction were discussed with South East Water and Melbourne Water. This work identified that the preferred location for sourcing raw sewage would be from a new access chamber that Melbourne Water is proposing to construct on the HBM. This option does not present additional risks associated with flow diversions and accessing aging infrastructure for Melbourne Water, and is expected to provide the lowest capital cost option.

The extraction system would comprise a dedicated wet well with submersible pumps located adjacent to the new manhole. The system would transfer sewage from the Hobson Bay main to the treatment plant via a 2,500 m rising main.

A key focus of this investigation was developing a treatment train option that would produce recycled water that is fit for purpose and that minimises plant footprint due to the significant cost of land in the Fishermans Bend precinct. An assessment of potential treatment processes was undertaken and the preferred treatment process is based around a membrane bioreactor with microscreening upstream to reduce organic loads on the biological treatment process and therefore substantially reduce the overall footprint of the treatment plant. Further work was also undertaken to assess options for constructing the treatment plant on multiple levels. As such, the treatment plant comprises a mezzanine level for mechanical equipment and control rooms.

Abbreviations

ADWF	Average dry weather flow
BOD	Biological oxygen demand
CIP	Clean in place
CWW	City West Water
HBM	Hobsons Bay Main
MBR	Membrane bioreactor
MF	Microfiltration
MMS	Melbourne Main Sewer
MWC	Melbourne Water Corporation
P&ID	Process and Instrumentation Diagram
RAS	Return activated sludge
SCADA	Supervisory Control And Data Acquisition
SEW	South East Water
SMP	Sewer mining plant
UF	Ultrafiltration
UV	Ultraviolet
UVT	Ultraviolet transmissivity
WAS	Waste activated sludge

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1. Introduction

1.1 Outline

This report outlines the concept design of the proposed Fishermans Bend Sewer Mining Plant and sewage extraction system including:

- Design basis establishment and key assumptions
- Options review for sewage extraction system
- Concept design of sewer mining plant and extraction system infrastructure
- Architectural design of the sewer mining treatment plant
- Concept design drawings including plant layout.

1.2 Purpose of this report

The primary objectives of this report are to:

- Outline a concept design for the Fishermans Bend sewer mining plant including the wastewater extraction and transfer system, treatment process and recycled water storage and pump station
- Define the potential footprint requirements based on the proposed concept to assist South East Water with procuring a suitable parcel of land in the Fishermans Bend area.

1.3 Assumptions

The key assumptions adopted for this report are outlined below:

- Treatment plant capacity is based on recycled water demands provided by South East Water (18.5 ML/d for supply to Fishermans Bend only and 36 ML/d for potential supply to surrounding growth areas).
- The extraction system is based on ***extracting*** sewage from the Hobson Bay Main (HBM) Sewer, and that the extraction system would be constructed
- The concept design of the treatment plant is based on ***treating*** sewage from the Melbourne Main Sewer (MMS) and quality data available for the period 2013 – 2015 as this provides a more conservative design that allows for a potential increase in the strength of raw sewage
- There will be sufficient sewage volumes available to feed the plant under ultimate flow conditions so that increasing plant throughput capacity or providing raw sewage storage to manage any shortfall in volume is not required.

1.4 Scope and limitations

The scope of this report includes:

- Design basis establishment:
  - Analysis of Melbourne Main Sewer wastewater quality characteristics and how this influences the treatment plant design
  - Assessment of Melbourne Main Sewer wastewater flow profiles and availability for the sewer mining plant
  - Review of recycled water quality requirements based on known and potential reuse applications
  - Definition of wastewater demands and treatment plant staging.
- Concept design of the wastewater extraction system including:
  - Assessment of options of accessing the wastewater from the Melbourne Main Sewer and the Hobsons Bay Main Sewer, including wastewater extraction and transfer systems and alignments
  - Development of a concept design of the preferred extraction and transfer system.
- Concept design of the treatment plant including:
  - Identification of a suitable treatment train to achieve recycled water quality targets
  - Assessment of opportunities for reducing treatment footprint through process unit selection, building layout and infrastructure configuration
  - Description of the treatment process and conceptual sizing of treatment equipment and ancillary infrastructure including recycled water storage and pump station
  - Process flow diagram, preliminary P&IDs, treatment plant conceptual layout and elevations
  - Review of international examples of decentralised treatment plants and how they have been integrated into the urban environment
  - 3D rendering of the facility to illustrate integration with the future Fishermans Bend precinct.

This report has been prepared by GHD for South East Water and *may only be used and relied on by South East Water for the purpose agreed between GHD and the South East Water as set out in Section 1.2 of this report.*

GHD otherwise disclaims responsibility to any person other than South East Water arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

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The Cost Estimate has been prepared for the purpose of further assessing the feasibility of the proposed Fishermans Bend precinct servicing strategy and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

2. Background

The Fishermans Bend Urban Renewal Area is the largest inner city high density redevelopment in Australia, and one of the largest urban renewal projects in the world. Over the next 40 years the 455 ha area is expected to become home to 80,000 residents and generate more than 60,000 jobs (*Strategic Framework Plan,* MPA 2013).

In 2015 South East Water (SEW) and GHD undertook a strategic review of servicing options for the Fishermans Bend area (*Fishermans Bend Integrated Water Management – Public Version of Options Evaluation*, September 2015). This study examined the water infrastructure required to service the area using a conventional approach and a range of innovative alternatives, including stormwater harvesting and sewer mining at both development and lot scale.

A summary of the key conclusions from this report are outlined below:

- Rain harvesting does not provide a significant or reliable supply
- Sewer mining is a practical possibility in the area due to the proximity to large sewers with low salinity wastewater
- Construction of conventional retarding basins for flood management is not favoured due to the low amount of open space, high land values and the potential for contaminated soil and groundwater to impact costs
- Interconnected tanks throughout the catchment could be integrated into the network but would increase the complexity.

The strategy outlined a number of recommendations, including that a third pipe system be adopted and that the recycled water is sourced from a sewer mining plant located within the area.

This report follows on from this work and outlines the concept design of a new sewer mining plant that would draw wastewater from the Melbourne Main Sewer (MMS) or Hobsons Bay Main (HBM) Sewer and produce Class A recycled water for reticulation throughout the new Fishermans Bend development.

3. Design Basis Establishment

3.1 Overview

The information contained in this section of the report expands on previous work completed and presented in the GHD report "*Fishermans Bend Integrated Water Management – Public Version Options Evaluation*, September 2015", and is based on extracting sewage from the MMS or HBM and two plant capacities defined by SEW:

1. Option 1: 18.5 ML/d recycled water production to service the Fishermans Bend precinct
2. Option 2: 36 ML/d recycled water production to service the Fishermans Bend precinct and some surrounding growth areas.

3.2 Treatment Plant Levels of Service and Capacity

3.2.1 Treatment Plant Yield and Recycled Water Demand

The treatment plant yield and recycled water demand for the two options are presented in Table 1 and are based on information provided by SEW and previous work undertaken by GHD and SEW as part of the integrated water management options evaluation project.

Table 1 Fishermans Bend Treatment Plant and Recycled Water Demand

Parameter	Option 1	Option 2	Comments*
Treatment Plant			
Treatment plant yield (ML/d)	18.5	36.0	• Based on capacity defined by SEW to satisfy 90% peak day demand
Class A storage (ML)	20.6	40.0	• Based on providing one (1 No.) day of peak day demand
Recycled Water Demand			
Recycled water demand: (ML/d) (m^3/hr) (m water)	 20.6 1,430 60	 40.0 2,780 60	• Based on delivering peak day demand (PDD) and peak hour demand (PHD) • PHD:PDD = 1.67 • Customer supply pressure = 40 m water[1]

** Fishermans Bend Integrated Water Management – Public Version of Options Evaluation, September 2015*

3.2.2 Treatment Plant Staging

The proposed staging for the treatment plant is outlined in the table below. At this point the timing for each stage has been decoupled from time given the uncertainty associated with population growth.

Further consideration of treatment and storage infrastructure staging is presented in Section 7, and includes opportunities for staging equipment installation with the objective of maximising flexibility to manage the uncertainty associated with population growth and recycled water demand e.g. installation of significant civil infrastructure initially followed by staged mechanical installation such as screens, membrane modules etc. It is noted that while plant construction would be staged, the three stages would operate as a single system with the ability to isolate stages as required.

[1] *Base Modelling and Mapping* (Fishermans Bend Urban Renewal Area), GHD 2014

Table 2 Fishermans bend Treatment Plant Yield and Staging

Design Element	Design Basis	Comments
Option 1 Yield Stage 1 Stage 2 Stage 3 Total	 6.2 ML/d 6.2 ML/d 6.2 ML/d 18.6 ML/d	• Three trains including recycled water storage with equal capacity to maximise potential for common standby/spare equipment • Maximises redundant capacity when one process unit/train out of operation • Flexibility to better understand timing of ultimate demand
Option 2 Yield Stage 1 Stage 2 Stage 3 Total	 12 ML/d 12 ML/d 12 ML/d 36 ML/d	• Three trains each with equal capacity as above

3.3 Recycled Water Supply

3.3.1 Water Quality Requirements

The sewer mining plant will supply Class A recycled water throughout the Fishermans Bend precinct via a dedicated third pipe scheme. Guidance for these schemes is outlined in the document, EPA Publication 1015 (October 2005), Dual Pipe Water Recycled Schemes – Health and Environmental Risk Management (“guideline”), and a summary of relevant information is presented in the following sections.

Managing Human Health Risks

Chemical Health Risks

The guideline advises that a site specific assessment is required for chemicals that may enter the sewerage system where trade waste inputs are a significant proportion of influent.

The MMS catchment primarily comprises residential and commercial discharges. CWW data shows that of the 1,173 existing trade waste customers, the majority are restaurants, take-away outlets, supermarkets/food courts and hotels motels, with 180 office blocks with cooling towers. It is expected that the type of trade waste customer is unlikely to change in future, and hence the wastewater composition, particularly given the proposed redevelopment of the Fishermans Bend precinct.

We also understand that the HBM comprises a similar catchment and is not considered to present any additional risks when compared with the MMS.

Therefore, for the concept design specific consideration of treatment processes to address specific chemical health risks has not been included, but it is recommended that further consideration of this risk is undertaken as part of subsequent stages of the project. This may include additional sampling and analysis, and a site specific assessment.

Biological Health Risks

The EPA guideline includes a Quantitative Microbial Risk Assessment (QMRA) that was developed to determine microbial criteria for adequate safety. The QMRA was undertaken on the basis of recycling sewage for defined uses in a dual pipe scheme.

The criteria established through the QMRA are provided in Table 3 and the defined uses are provided in Table 4 .

Table 3 Outcome of EPA QMRA of Sewage Recycling in Dial Pipe Schemes

Group	Criterion
Bacteria(1)	< 10 E. coli/100 mL
Viruses(2)	7-log reduction(3) from raw sewage to recycled water
Protozoa(2)	6-log reduction(4) from raw sewage to recycled water

<u>Table Notes:</u>

1. Median – to be demonstrated during treatment plant validation.

2. As a default, the most resistant (or worst-case) virus or protozoan should be used at each treatment step for calculating log reductions. However, suppliers have the option of undertaking the more complex approach of assessing treatment processes based on the removals provided across the system for key pathogenic organisms (rotavirus, adenovirus, Hepatitis A virus, Cryptosporidium oocysts, Giardia cysts).

3. Median removal, with a lower (critical) limit of 6-log reduction.

4. Median, with a lower (critical) limit of 5-log reduction.

Table 4 Class A Water Uses Applicable to the EPA QMRA of Sewage Recycling in Dual Pipe Schemes

Acceptable uses for Class A recycled water of the quality specified
Uses included in the risk assessment: • Irrigation of public open spaces, such as parks and sports fields, where public access is unrestricted and any irrigation method is used (it is acknowledged that this will comprise a minor component of reuse applications) • Domestic garden watering, including vegetable gardens • Toilet flushing • Washing machine use
Uses not specifically included in the risk assessment, but likely to result in very low ingestion of recycled water: • General outdoor uses such as car washing, dust suppression, construction and washdown • Filling water features and ponds that are not used for swimming • Use in cooling towers.
Firefighting and fire protection systems, including hydrants and sprinkler systems*
Other uses, considered on a case-by-case basis, where there is sufficient information provided to support their safety

** SEW does not intend to provide recycled water for sprinkler systems, but removing this reuse application does not reduce the level of treatment required*

Known and potential reuse applications identified by SEW for this scheme are outlined below:

- **Known Reuse Applications:** Laundry, toilet flushing, outdoor irrigation and firefighting (excluding building indoor sprinkler systems)
- **Potential Reuse Applications:** Evaporative cooling[2], treatment plant asset washdown and service water.

Based on the “known” and “potential” reuse applications outlined above, and the applicable uses presented in Table 4, the microbial criteria outlined in Table 3 have been adopted for this project.

[2] Evaporative cooling has been included as a potential reuse application, although it is noted that recent work around recycled water quality and potential impacts (scaling etc.) undertaken by water corporations indicates that this will not be identified as a suitable reuse application in future.

Managing Environmental and Aesthetic Risks

Potential environmental risks relating to the use of recycled water outlined in the guideline include:

- Excess build-up of nutrients in soil and migration to surface water and groundwater which can cause:
  - Toxicity to some plants
  - Loss of soil productivity
  - Toxicity to aquatic life
  - Nuisance growth of aquatic plants, algal blooms and associated water quality problems.
- Excess soluble salts which can result in:
  - Impacts on plant growth
  - Toxicity due to specific ions (such as chloride, sodium and boron)
  - Foliar damage from sodium and/or chloride ions
  - Impact to groundwater and surface water quality through salt migration
  - Impact on soil structure due to the application of excessive sodium in irrigation water. This can make the soil more dispersible and erodible, leading to the hydraulic conductivity of the soil being restricted. This may also lead to waterlogging or build-up of salinity.

Potential aesthetic risks relating to the use of recycled water in the new Fishermans Bend redevelopment include:

- Staining of clothing etc. in laundries as a result of iron and manganese
- Staining of outdoor irrigation areas due to elevated copper concentrations
- Reduced performance of laundry soaps and detergents associated with elevated hardness
- Visual identification of recycled water in toilet bowls
- Odour from outdoor irrigation.

Based on the potential environmental and aesthetic risks outlined above the recycled water quality targets for key parameters for the Fishermans Bend sewer mining plant are outlined in Table 5. These were discussed and agreed with SEW during the concept development workshop.

Table 5 Fisherman's Bend Treatment Plant Key Recycled Water Quality Targets (Median)

Parameter	Units	SEW Potable Supply*	ADWG Guideline	Target (Median)	Comments
Nutrients					
Ammonia	mg/L	0.003	0.5	< 1.0	Minimises chlorine demand at final disinfection stage of treatment process
Nitrate	mg/L	0.18	50	NA	Recycled water is not expected to be used for significant outdoor irrigation. No target proposed, but considered as part of process design
Total phosphorus	mg/L	0.01	Not set	NA	Recycled water is not expected to be used for significant outdoor irrigation. No target proposed
Aesthetics					
Copper	mg/L	0.015	2.0	< 2.0	Target based on reducing risk of "staining" infrastructure
Manganese	mg/L	0.004	0.5	< 0.05	USEPA recommendation based on laundry staining effects
Hardness	mg/L	20	200	< 200	Typically represents good quality water i.e. suitable for soap/detergents
Iron	mg/L	0.07	0.3	< 0.3	USEPA recommendation based on laundry staining effects
Total dissolved solids	mg/L	54	< 600	600	Target based on limited outdoor irrigation, ADWG aesthetic guideline for "good quality" drinking water and CWW land capability assessment
Colour	HU	7	15	< 15	Target based on reducing risk associated visual detection of water in toilets and being achievable through chemical dosing
pH	-	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5	Reduce risk of corrosion and scale
Total suspended solids	mg/L	< 2	Not set	< 2.0	Impacts disinfection and service water spray nozzles
Turbidity	NTU	1.4	< 5	< 5	Target based on reducing risk associated visual detection of water in toilets

** Based on South East Water Annual Drinking Water Quality Report 2014-15 average values, including values for the "South Melbourne" location where possible*

3.4 Raw Sewage Supply (MMS or HBM)

The location of sewage extraction is dependent on various factors, including water quality, access, raw sewage availability etc., so there is a need to understand how these aspects vary for each source. This section considers sewage availability (volumes) and water quality, and an assessment of infrastructure requirements and constructability risk profiles for each source is presented in Section 4.

3.4.1 Sewer Flow Profiles

The hydraulic demand exerted on the MMS or HBM and the requirement for balancing demands with the diurnal flow profile will vary depending on the required yield and the recovery of the sewer mining plant and will be investigated during the concept design phase.

However, historic sewage flow data provided by Melbourne Water for the MMS is presented in Table 6 for reference.

Table 6 Historic MMS and HBM Daily Flows (ML/d)

Parameter	MMS	HBM
10th %ile	22.8	151.7
Median	28.7	185.1
90th %ile	32.8	201.5

In addition to the historic data included above, sewer network model forecasts for the MMS and HBM were also provided by Melbourne Water and are presented in Table 7.

These forecasts were based on the following future growth assumptions:

- Groundwater infiltration unchanged.
- Non-residential flows unchanged.
- Residential population increases from 46,500 people to 275,000 people based on Victoria in the Future 2014. Assuming 150 L/p/day this represents an increase of approximately 34 ML/day.

As a result of these assumptions, the shape of the diurnal profile is predicted to change due to residential flows becoming dominant.

Table 7 Flow Forecasts for MMS and HBM (ML/d)

Scenario	MMS		HBM	
	Weekday	Weekend	Weekday	Weekend
2031	49	45	231	224
2051	66	62	296	291

3.4.2 Raw Sewage Requirements and Plant Capacity

The treatment plant needs to be sized to produce the daily recycled water volumes defined in section 3.2. However, this does not define the capacity or throughput of the treatment plant infrastructure.

Sewer mining typically involves extraction of a small fraction of the flow from dry weather flows. In those cases, the treatment plant capacity generally matches daily recycled water production requirements, as there is a continuous flow available and no constraint on extraction.

The HBM and MMS current (2015) and future (2031 and 2051) flow projections provided by Melbourne Water (outlined above) have been used to estimate the effective yield of the treatment plant factoring in sewage flow limitations.

Figure 1 and Figure 2 provide examples of the operation of the treatment plant and yield from the HBM and MMS respectively based on 2051 forecast flow values and the treatment demand for Stages 1 – 3 for the 18.5 ML/d plant.

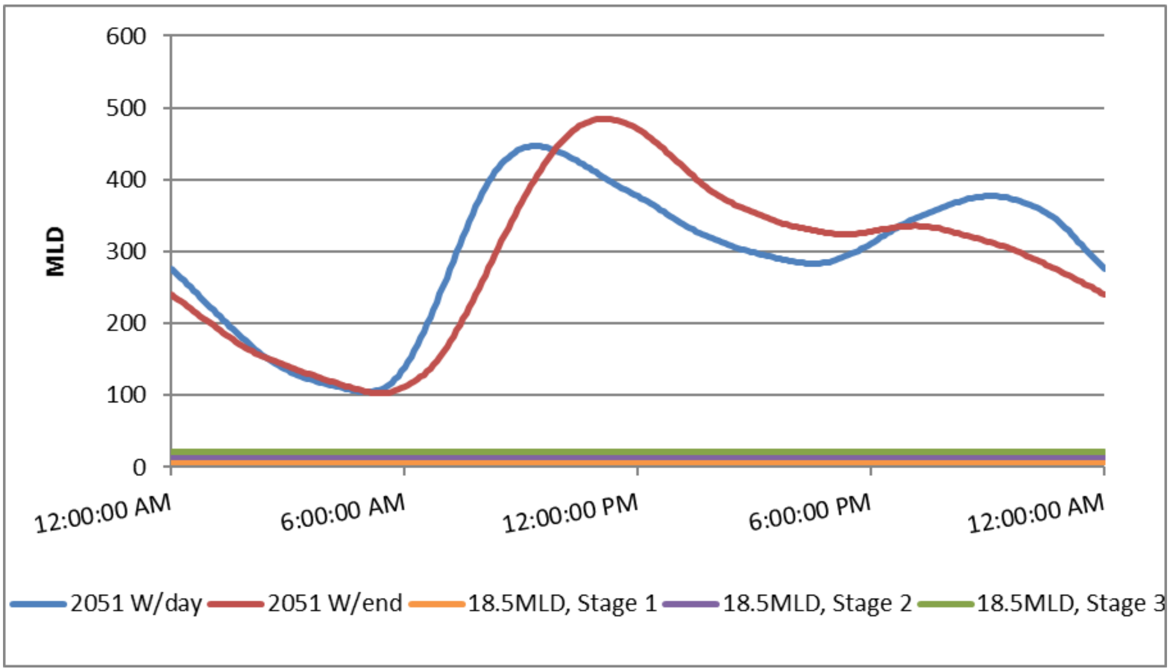


Figure 1 HBM Forecast Flows (2051) and Nominal Extraction Rates

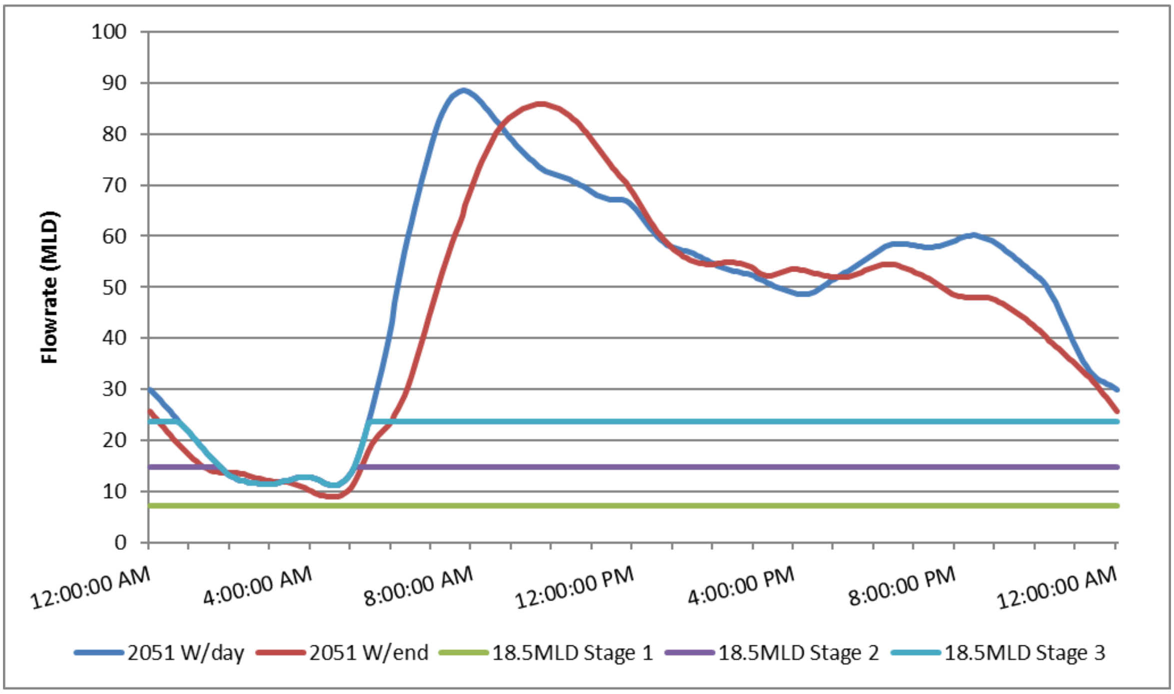


Figure 2 MMS Forecast Flows (2051) and Nominal Extraction Rates

Figure 1 indicates that that there would be sufficient sewage flows in the HBM to satisfy the Stage 3 demands for the 18.5 ML/d and 36 ML/d plants. However, Figure 2 indicates that there is expected to be sufficient flow in the MMS to satisfy the demand for Stage 1 and Stage 2 (18.5 ML/d), but the yield would be 98% for Stage 3 due to the limited flow availability in the early hours of the morning. This is further pronounced for the 36 ML/d plant.

It is noted that this profile is an “average” and there will be some buffering through the recycled water storages but we expect that there would be days where the yield would decrease. It is also likely that it will be impractical to extract 100% of the flow but this was assumed in this instance to demonstrate the potential impact of sewage availability limitations.

This constraint of yield is not expected to apply to the HBM, but is relevant to understanding reasonable staging approaches for the MMS. If the desire is to maximise recycled water production, then the extraction/sewer mining plant needs to be larger, and/or some storage included in the treatment train. If the desire is to minimise cost and footprint, then a staging approach that matches sewage flows would be adopted which will maximise utilisation of treatment plant assets.

To demonstrate this further and show how the potential shortfall in sewage volumes in the MMS could be managed, three potential options were considered:

1. Increase the capacity of the extraction system and treatment plant so that it operates at a higher throughput when sewage volumes are available (increases plant footprint and cost)
2. Increase extraction system capacity and provide raw sewage (post pre-treatment) storage to buffer raw sewage flows and plant throughput remains unchanged (marginal increase in plant footprint and cost but increased odour risk)
3. Match extraction rates and plant throughput to sewage flows (i.e. appropriate staging) and supplement the recycled water demand with potable water if required.

A summary of the potential impact of these options on extraction system capacity when considering 2051 forecast sewage flows, plant capacity, raw sewage storage volume and footprint is presented in Table 8.

Table 8 Options for Managing Recycled Water Demands (MMS)*

Plant	Stage	Recycled Water Demand	Sewage Demand	Option 1 Throughput & Footprint ↑	Option 2 Storage & Footprint ↑	Option 3
18.5 ML/d	1	6.2 ML/d	7.3 ML/d	7.3 ML/d 0%	0 ML 0 m^2	No change to plant capacity or footprint
	2	12.4 ML/d	14.5 ML/d	14.5 ML/d 0%	0 ML 0 m^2	
	3	18.5 ML/d	21.8 ML/d	22.6 ML/d ~2%	2.0 ML ~350 m^2	
36.0 ML/d	1	12.0 ML/d	14.1 ML/d	15.1 ML/d ~1%	0.3 ML ~50 m^2	
	2	24.0 M ML/d	28.2 ML/d	30.4 ML/d ~5%	2.8 ML ~500 m^2	
	3	36.0 ML/d	42.4 ML/d	48.9 ML/d ~8%	6.2 ML ~1,100 m^2	

Based on a treatment plant recovery of 85% and 2051 MMS flows

Based on the information above and the additional cost and treatment plant footprint associated with increasing plant throughput or providing a raw sewage storage, it is recommended that the timing of treatment plants stages match MMS sewage production, and that potable water supplementation is allowed for.

The potential risks and options for managing a potential shortfall in sewage availability within the MMS was reviewed with SEW during the concept development workshop. During this workshop SEW noted that there will be an opportunity to redirect sewage flows from the new Fishermans Bend precinct to the MMS, which would increase sewage volumes and further reduce the likelihood of shortfall in sewage availability. However, this risk will require further consideration and management beyond this concept design stage.

3.4.3 Water Quality

Water quality data for the MMS and HBM was provided by Melbourne Water.

Based on the data, the concentration of COD and TKN in HBM sewage is approximately 30% less when compared with the MMS. This would result in significant benefits for the treatment plant, including reduced reactor volumes, reduced aeration demand, reduced sludge production etc. It is recognised that the TDS concentration is marginally higher than the MMS values, but is still within the required median of 600 mg/L adopted for this project.

However, given that the location of the offtake system has not been fully confirmed, and to allow for potential changes in sewage quality in future, it was agreed with SEW the MMS sewage quality data would be adopted as the basis for sizing the treatment plant to provide a more conservative estimate for footprint.

The data provided has been adopted as the basis for determining the treatment processes required to satisfy the recycled water quality requirements outlined above and for sizing treatment plant infrastructure.

4. Extraction System Options Review

4.1 Overview

This section of the report presents a review of Extraction System Options. The review includes an assessment of the following:

- Extraction offtake locations,
- Pipeline alignments to transfer the raw sewage to the treatment plant,
- Extraction System options.

This review concluded that the preferred option for extraction and transfer would be via a new manhole on the HBM as part of proposed works being undertaken by MWC. This location will reduce the capital cost associated with these works and does not present additional risks to MWC given the proposed new access chamber.

4.2 Extraction offtake locations

As stated in 3, the raw sewage quality for the MMS and HBM is expected to be acceptable as a feedstock to the treatment plant, but there is a risk that there may be insufficient sewage in the MMS to cater for the ultimate demands, particularly for the 36 ML/d facility.

In addition to raw sewage characteristics and hydraulic availability, the selection of the offtake location is also dependent on the feasibility of accessing sewage from either the MMS or the HBM and the infrastructure requirements associated with transferring the raw sewage to the treatment plant.

Four feasible sewage offtake manhole locations have been identified for the accessing of raw sewage in the MMS or HBM. These four locations were identified based on a preliminary review of potential offtake locations with respect to accessibility and the continued operability of the mains (i.e. the feasibility of constructing a new manhole or modifying an existing manhole and diverting raw sewage flows around the construction zone) and are outlined below:

1. Option A: MMS located east of the Fishermans Bend precinct
2. Option B: MMS located south east of the Fishermans Bend precinct
3. Option C: HBM located south east of the Fishermans Bend precinct
4. Option D: HBM located south of the Fishermans Bend precinct

An overview of each location, including the proposed pipeline alignment between the offtake location and treatment plant is presented in the following sections.

4.3 Offtake options

4.3.1 Option A

This option would involve utilising a relatively new manhole on the MMS, located east of the Fishermans Bend precinct. The sewer invert for this location is 13.15 m.

The alignment of the transfer pipeline would run generally north west to the proposed SMP site.

The basis of for this option includes:

- Transfer pipeline offtake connection works
- Expected transfer pipeline geology (approximately 3.5 m depth below ground level) is quaternary Port Melbourne Sand (Qrp)

- Avoiding construction immediately adjacent to residential properties
- The use of open cut trenching methods for this alignment would be highly disruptive due to the high density of commercial buildings and the alignment being on a major road with numerous intersections. Subsequently, the use of trenchless/tunnelling excavation methods for this alignment is likely to avoid this issue.

4.3.2 Option B

This option would involve utilising a relatively new manhole on the MMS located south east of the Fishermans Bend precinct. The manhole is located at a site that is smaller when compared with Option A and may lead to additional constrains during construction.

The alignment of the transfer pipeline would run generally north to the proposed SMP site. The basis of for this option includes:

- Transfer pipeline offtake connection works
- Expected transfer pipeline geology (approximately 3.5 m depth below ground level) is quaternary Port Melbourne Sand (Qrp).

4.3.3 Option C

Option C involves extracting sewage from the HBM via a manhole located south east of the Fishermans Bend precinct. The condition of this manhole is uncertain and may need to be upgraded or relined to facilitate sewage extraction. Furthermore, there is limited access to this manhole, which would further constrain construction activities.

The alignment of the transfer pipeline would run generally north to the proposed SMP site.

The basis of for this option includes:

- Transfer pipeline offtake connection works.

4.3.4 Option D

Option D involves extracting sewage from the HBM via a manhole located south of the Fishermans Bend precinct. As stated for Option C, the condition of this manhole is also uncertain and may need to be upgraded or relined to facilitate sewage extraction. However, there is likely to be sufficient area for construction.

The basis of for this option includes:

- Transfer pipeline offtake connection works
- Expected transfer pipeline geology (approximately 3.5 m depth below ground level) is fill
- Optimisation of open cut trenching.

4.3.5 Offtake Options Assessment

An assessment of the four offtake locations and the respective alignments was undertaken so that a preferred option for the MMS and HBM could be identified. This assessment was discussed with SEW and it was concluded that the preferred options worthy of further consideration and discussion with MWC were Option A and Option D.

These two options were primarily selected as they are expected to provide sufficient access for construction and would reduce the level of disruption to residents within the immediate vicinity of the offtake site.

Further discussion about these options is presented in Section 4.5.

4.4 Extraction System Options

4.4.1 Design criteria

Three options for the extraction and transfer of raw sewage from the MMS and HBM to the proposed sewer mining plant have been identified and developed based on a number of design criteria. A summary of the design criteria adopted for the extraction system design is presented in Table 9.

Table 9 Extraction System Design Criteria

Discipline	Design Criteria
Constructability	Assess the ability to construct extraction options.
	Assets to be planned to optimise construction.
	Identifying significant construction issues e.g. Installation of extraction arrangement, site conditions, existing infrastructure.
Operation and Maintenance	The design to accommodate maintenance requirements for access to components of the extraction system e.g. sewer, pumps, valves.
	Operate reliably and automatically.
	Safe working condition for operation and maintenance personnel.
Design Standard Requirements	Designs for civil, structural, mechanical, electrical and ventilation components of the project are required to be in accordance with the latest WSAA codes and industry codes of practice.
Capability for Staging	Ability to facilitate staging, increases in the extraction demand.
Cost	Minimise total life cycle costs.
	Initial capital cost
	Operating and maintenance costs
	Life expectancy and replacement costs
Minimum Design Life	Civil works design life = 100 years.
	Where existing assets are incorporated into the design, these must be upgraded as necessary to meet the design life requirements stated above.
	Existing HBM manholes to be relined if chosen as offtake location for transfer pipeline. Design life = 50 years.
Suitability of Extraction	Capability to extract wastewater from existing sewer at rates demanded by the sewer mining plant.
	Efficiently deliver wastewater from the offtake to the proposed sewer mining plant.
Contingency	Development of contingency for failure of the extraction system, to avoid total failure and overflows.

4.4.2 Extraction Option 1 – Offline Pump Station

This option comprises of a new pump wet well and valve chamber adjacent to an existing sewer access chamber, with a diversion from the existing chamber to form an offline pump station.

A diversion pipe from the existing access chamber at the sewer invert level will provide the conventional gravity inlet arrangement for a sewer pump station and serve as the interface between the existing sewer and the pump wet well. Penstocks upstream and downstream of the diversion pipe are proposed to achieve double isolation for operation or maintenance purposes.

4.4.3 Extraction Option 2 - Online Pump Station

This option comprises a new access chamber over the existing sewer to create an online pump station with integrated containment - containment weir.

An opening on one side of the sewer and a containment weir was proposed to facilitate extraction of wastewater from the existing sewer. Benching in the base of the chamber is proposed to direct wastewater from the outfall of the weir through cross connection diversion pipework under the sewer to a wet well within the access chamber, which would accommodate pumps to transfer flow to the sewer mining plant. Penstocks upstream and downstream of the diversion pipes are proposed to achieve double isolation for operation or maintenance purposes.

4.4.4 Extraction Option 3 – In Sewer Interceptor

Option 3 comprises 'special' sewerage pumps installed within three existing consecutive access chambers on the existing sewer. The pumps would be mounted to the wall of the chamber and fitted with a long floating arm extending downstream of the access chamber approximately 8-15 metres.

The pumps for this option would have operating capability for normal operation and submersible operation (surcharge event). Surface vacuum priming pumps are also required (located adjacent to the existing access chamber cover) to transfer wastewater to the sewer mining plant.

4.4.5 Extraction System Evaluation

The three options were evaluated against the design criteria to better understand the risks and opportunities associated with each option and to assist with selecting a preferred option with SEW and MWC.

This assessment is summarised in Table 10 .

4.5 Stakeholder (MWC) Workshops

A number of stakeholder engagement workshops were undertaken with SEW and various representatives from MWC, including planning, asset management and operations. The purpose of these workshops was to inform MWC (as the asset owner) of the scope of the proposed project and to obtain input on the potential offtake location and extraction system options.

4.5.1 Offtake Location Selection

With respect to the offtake location options, two key risks were identified:

- To undertake the works in Option A there is a need to divert flows around the manhole during construction (e.g. flume). While this is possible the risk of failure of the bypass system was identified as being significant due to the catchment area serviced by the MMS
- The structural integrity of the HBM is uncertain due to the age of the asset and therefore is a significant risk associated with undertaking works on this asset in Option D. Furthermore, there are also risks associated with diverting the substantial flows around the manhole during construction.

During these workshops MWC advised that an opportunity exists to combine the extraction system with a new access chamber that is proposed to be constructed by MWC at the manhole for Option D as part of the Hobsons Bay Main Sewer Contingency Plan.

The Hobson's Bay Main Sewer Contingency Plan (GHD, 2016) outlines options investigated to manage HBM sewer flows in the event of failure at the river crossing. From discussions with MWC it is likely that part of the contingency plan would involve construction of a new access chamber / pump well at HBM manhole (Option D). This would enable installation of two SERPS II pumps and a penstock to isolate the HBM so that any discharge to the Yarra River can be controlled.

It was agreed by SEW and MWC that integrating the extraction system within the new manhole is the preferred solution for the following reasons:

- It is expected to provide significant cost savings to SEW
- It does not present additional risks to MWC given the proposed new access chamber.

4.5.2 Extraction System

Additional concept design work was completed to develop Option 1 and Option 2 to demonstrate how these extraction systems could be integrated with the proposed new access chamber.

Table 10 Extraction System Evaluation Summary

	Option 1	Option 2	Option 3
Key Advantages	• Standard arrangement for a sewer pumping station • Suitable for extraction from MMS and HBM • Applicable for offtake of Option D • Applicable for offtake of Option A	• Innovative approach • Extraction of the most uncontaminated flow from the 'clean water' zone • Potential later stage treatment cost savings due to reduced contaminant handling • Suitable for extraction from HBM • Applicable for offtake of Option D • Reduced footprint required for construction	• Innovative approach • Extraction of the most uncontaminated flow from the 'clean water' zone • Low initial capital cost • Utilisation of existing HBM access chamber – no excavation • Reduced footprint requirements for access during construction • Potential cost advantages due to staging of installation • Suitable for extraction from HBM • Applicable for offtake of Option D
Key Disadvantages	• High initial capital cost • Limited capability for staging of infrastructure • Flow control risk • Smaller site area at Morris Reserve would make transfer pipeline construction more difficult at Option B • Smaller site area at Howe Parade traffic island would make construction more difficult for Option C	• High initial capital cost • Limited capability for staging of infrastructure • Not suitable for offtake on MMS • Construction risks including support of the existing HBM and sealing the base of the chamber	• Series pumping incurs higher cost • Not suitable for offtake on MMS • Limited capability for standby or emergency pumps due to restriction of diameter of existing access chamber to accommodate additional pumps. • Non-standard design • Risks associated with the operational pumping arrangement – series pumping. • Risks associated with the floating arm arrangement – the floating arm is required to float in the 'clean water' zone free from floating and settling materials, may provide difficulty to control. • Non-standard pumps in the access chamber with a requirement for normal and submersible operation. • In the ultimate stage maintenance of 3 sets of pumps in consecutive access chambers and surface pumps.

Option 1

Extraction system Option 1 would comprise of a new access chamber on the HBM with diversion pipework to direct wastewater from the HBM to the new pump well. Provision would be made within the new chamber to satisfy the requirements of the Hobson's Bay Main Sewer Contingency Plan consisting of sufficient area to accommodate two SERPS II pumps and installation of a penstock in the new access chamber. This option is presented in Figure 3.

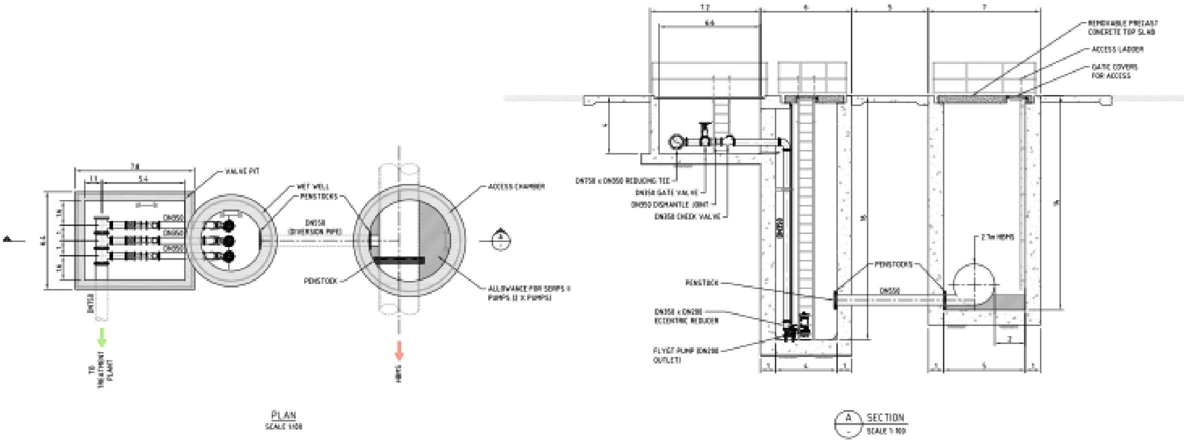


Figure 3 Extraction System Option 1 Preliminary Arrangement

Option 2

Extraction system Option 2 would include a new access chamber on the HBM with an opening in the existing sewer to extract wastewater, and a containment weir and diversion pipes under the sewer to direct wastewater to the pump well for transfer to the proposed sewer mining plant. Provision to accommodate two SERPS II pumps and installation of a penstock downstream of the new access chamber to satisfy the requirements of the contingency plan would also be included. A preliminary arrangement for this options is shown in Figure 4.

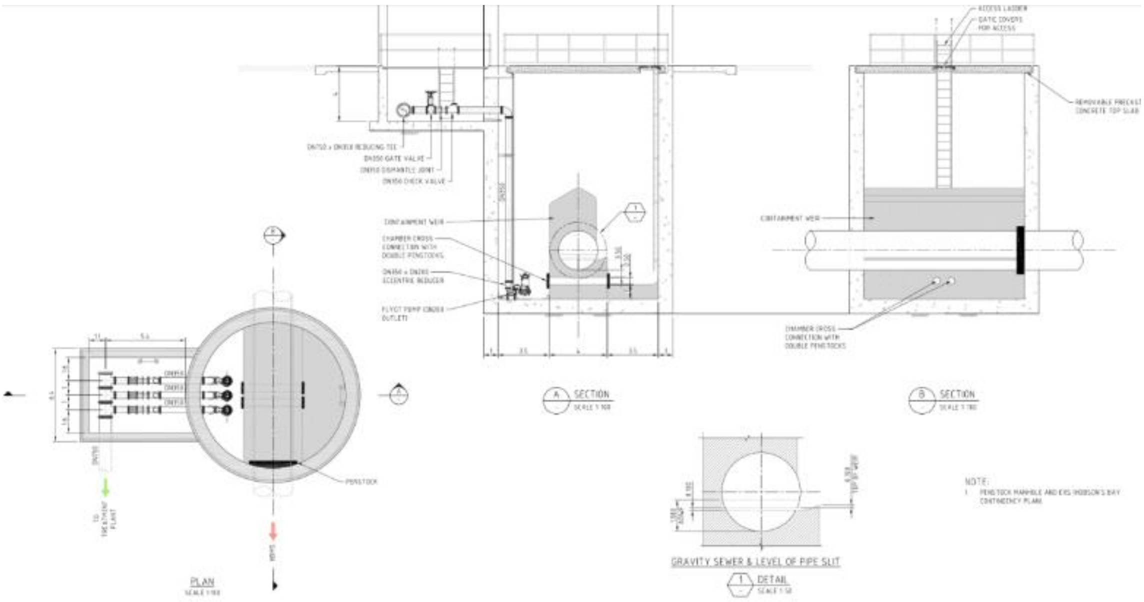


Figure 4 Extraction System Option 2 Preliminary Arrangement

Option 3

Option 3 is expected to provide a number of benefits including reduced capital cost, greater flexibility for staging, potential to target specific zones within the sewage water column, reduced footprint etc. However, the risks associated with having this asset within the sewer are currently unacceptable for MWC, in particular the risk that the suction lines would be dislodged and impact downstream pumps or that they would increase ragging and solids accumulation in this zone, and that this process has not been proven elsewhere. Although, it was agreed between SEW and MWC that this option was worthy of trialling to better understand these risks and enable it to be considered at latter stages of the project.

Preferred Option

The two preliminary concepts for integrating the extraction system into the new access chamber project was considered with SEW and MWC and it was determined that it would be feasible to combine the assets and construction of the new access chamber could make provisions to satisfy the objective of both projects.

It was agreed that Option 1 – Offline Pump Station combined with the new access chamber for the contingency plan at HBM manhole (Option D) was the most feasible option. This option was preferred primarily because it provides delineation between the two assets, avoiding potential issues associated with structural failures, maintenance, access approvals etc. This option also reflects typical pump station arrangement, and therefore is considered to be technically more robust, reducing further potential risks associated with the operation of the pump station.

4.5.3 Preferred Offtake and Extraction System Arrangement

The preferred approach for extracting sewage and transferring it to the proposed sewer mining plant comprises:

- Provisions within the proposed new HBM manhole (Option D) to enable sewage transfer across to a new pump wet well
- Construction of a new pump wet well adjacent to the proposed new HBM manhole (Option D) with submersible raw sewage transfer pumps
- Transfer pipeline between the new pump wet well and the sewer mining plant.

This option is considered to provide the lowest risk option for MWC and lowest cost when compared with constructing a dedicated extraction system in an alternate location on the HBM or MMS.

Therefore, this offtake location may also provide significant cost savings associated with the extraction and transfer system if this location is selected.

5. Treatment Train Concept Development

5.1 Treatment Train Process Selection

The treatment train process selection is determined by the need to minimise footprint and the need to produce Class A recycled water with a requirement for a proven Class A treatment train.

5.1.1 Class A Process Treatment Train

The Class A treatment train is defined by the requirement to achieve Class A recycled water in accordance with the EPA Publication 1015 (October 2005), Dual Pipe Water Recycled Schemes – Health and Environmental Risk Management as outlined in GHD's design criteria technical memorandum.

The most widely adopted treatment train for achieving the required pathogen log reduction requirements comprises:

- Microfiltration/ultrafiltration (MF/UF) 4 log reduction for protozoa and viruses
- UV 2 log reduction for protozoa
- Chlorine 3 log reduction for viruses

This tertiary treatment train has been approved in Victoria for a number of Class A recycled water plants and is proposed for the Fishermans Bend sewer mining plant. This ensures that at the time of writing this report an approved and realistic treatment process for achieving Class A recycled water is adopted as the basis for the concept design.

It is recognised that Victoria (unlike other states) does not currently (at the time of writing) allow for log reduction values (LRV) to be attributed to the MBR process. However, this may be permissible in the future given work being completed by the Australian Water Recycling Centre of Excellence and as part of the NatVal project by Water Research Australia, which involves development of national protocols for treatment process validation. The Victorian Department of Health advised that LRVs for MBRs are expected to be permissible in future and the LRVs attributed to the process will occur via a two stage process:

1. Default Values: LRVs attributed to MBRs based on maintaining operation within a specific envelope e.g. MLSS, sludge age, effluent quality etc. The LRVs would be based on data for various existing MBR systems and recent research completed to assess MBR pathogen reduction. Preliminary LRVs are:
   - Protozoa 2 log
   - Virus 1.5 log
   - Bacteria 4 log
2. Additional LRV credits: These will be assigned on a case-by-case basis following verification testing etc.to confirm pathogen reduction.

Based on this advice there may be potential to eliminate the need for UV disinfection or reduce chlorine demands in future, however it appears unlikely that the new protocol will eliminate the need for a membrane system downstream of the MBR, which would have the greatest benefit for the Fishermans Bend treatment plant in terms of footprint reduction.

Therefore, as stated above, an approved treatment process has been selected for the purpose of this investigation, but reliance on the MBR for LRVs should be considered in the future to assess whether treatment process requirement could be reduced.

5.1.2 Selection of Biological Treatment Process

The objectives of the biological treatment process for the Fishermans Bend treatment plant is to remove the organics from the wastewater and provide a suitable feed to the downstream Class A treatment train. To provide stable performance, it is recommended that the biological process also provides full nitrification. As a total nitrogen requirement for the plant is not proposed, therefore there is no need for the plant to fully denitrify the oxidised nitrogen, although this was considered during the concept design to determine if there are benefits associated with regaining alkalinity for the process and reducing the aeration demand.

The membrane bioreactor (MBR) process has been adopted as the biological treatment process for the Fishermans Bend sewer mining plant. This treatment process was proposed as part of the options evaluation study completed by GHD in 2015 and is widely accepted in Australia and internationally as the most suitable process for treatment plants that have significant space constraints (refer Appendix A – International experience technical memorandum).

To verify the appropriateness of the MBR process to provide biological treatment of the raw sewage, a high-level qualitative comparison of this process, along with three other processes was undertaken. This comparison is summarised in Table 11, and a comparison of process footprint for the Stage 1 (18.5 ML/D) bioreactors is presented in Figure 5. Note that a range (low and high) has been included as the footprint of each system would vary depending on operating parameters e.g. loading rates, sludge age etc.

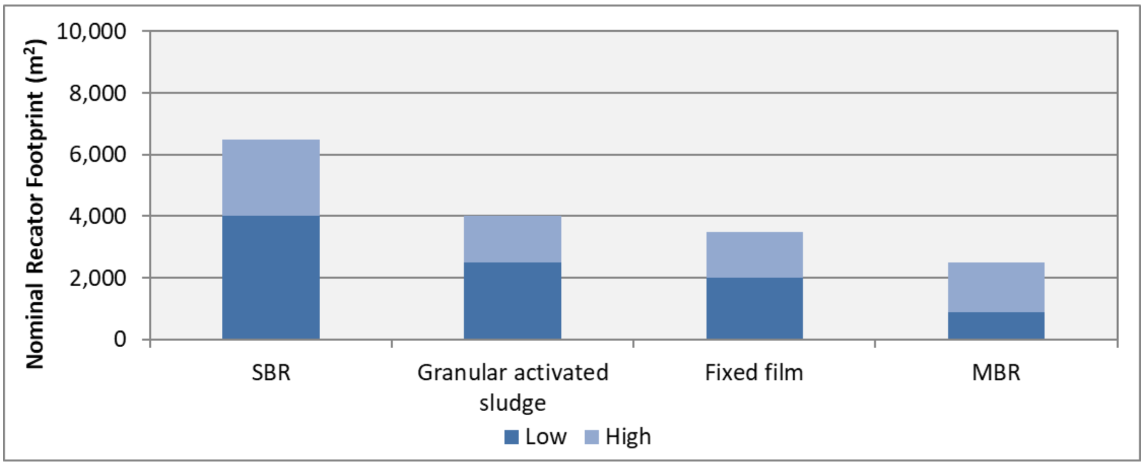


Figure 5 Biological Reactor Footprint Ranges (Stage 1, 18.5 ML/d)

It is recognised that the MBR process infrastructure may have a marginally higher capital cost due to the additional mechanical infrastructure associated with this process, but based on an indicative land value the MBR is expected to provide cost savings when compared to the other processes, and would not require additional mechanical equipment (e.g. disc filters) to provide a suitable feed to the downstream membrane system.

In addition, it is also noted that this technology is well-proven throughout Australia, eliminates the need for a pre-treatment process for the downstream MF/UF membranes and may be assigned a LRV in the future. As such, the MBR process is considered the most appropriate biological treatment technology for the Fishermans Bend sewer mining treatment plant.

Table 11 Biological Treatment Process High level Qualitative Comparison

Comparison Parameters	Sequencing batch reactor (SBR)	Fixed film	Granular activated sludge	Membrane bioreactor (MBR)
Description	• Intermittent biological process that does not require downstream clarification	• Continuous fixed film process that utilises plants to assist with increasing the biodiversity of the biomass • May require clarification step to achieve suitable feed to membrane pre-treatment process e.g. disc filters	• Intermittent biological granular sludge process that does not require downstream clarification	• Continuous biological process that operates at high MLSS concentrations and relies on physical separation (i.e. membranes) of solids
Provides suitable feedstock for MF/UF system	? • Requires additional membrane pre-treatment e.g. disc filters	? • Requires additional membrane pre-treatment e.g. disc filters	? • Requires additional membrane pre-treatment e.g. disc filters	✓ • No requirement for membrane pre-treatment • High quality feed enables MF/UF to operate at high flux rates
Indicative bioreactor footprint (excl. ancillaries) (for Stage 1, 18.5 ML/d)	✓	✓✓	✓✓	✓✓✓
Process complexity, operability and maintainability	• Process reliant on good settleability and decanter reliability • Can be more complex due to automation of sequencing e.g. (feeding, aeration, decanting etc.) • Fewer mechanical components compared with MBR	• Fixed film process more robust that suspended growth	• Enhanced settleability due to granular floc • Fewer mechanical components compared with MBR • Long start-up time of 2-6 months, or seed sludge required	• Not reliant on settleability for secondary effluent production • More mechanical equipment than conventional biological processes • Good inlet screening essential to prevent membrane fouling
Process maturity	✓ • Commercially available and well proven	? • Process becoming more common internationally and is being trialled within Australia	? • Process becoming more common internationally and is being trialled within Australia	✓ • Commercially available and well proven, particularly for site constrained plants
Experience in Australia (full scale)	✓	✗	✗	✓
Comparative capex	✓ • Expected to be more expensive due to tank size	✓✓ • Increased capex due to additional mechanical infrastructure for fixed film media	✓✓	✓✓ • Increased process equipment capex due to membrane process but membrane supply costs have been decreasing over the past 5-10 years • Does not require downstream membrane pre-treatment process
Comparative opex	✓✓	✓✓	✓✓	✓ • Increased opex due to membrane process (membrane replacement, energy and chemicals)

As part of the option selection process GHD engaged with its national and international specialists to determine if there were emerging or leading edge technologies that would assist with reducing the footprint of the biological process. A potential option identified for consideration in future is the membrane aerated bioreactor (MABR). This is a new process that has been developed by technology specialists and is claimed to provide a smaller footprint and improved energy efficiency when compared to conventional biological processes.

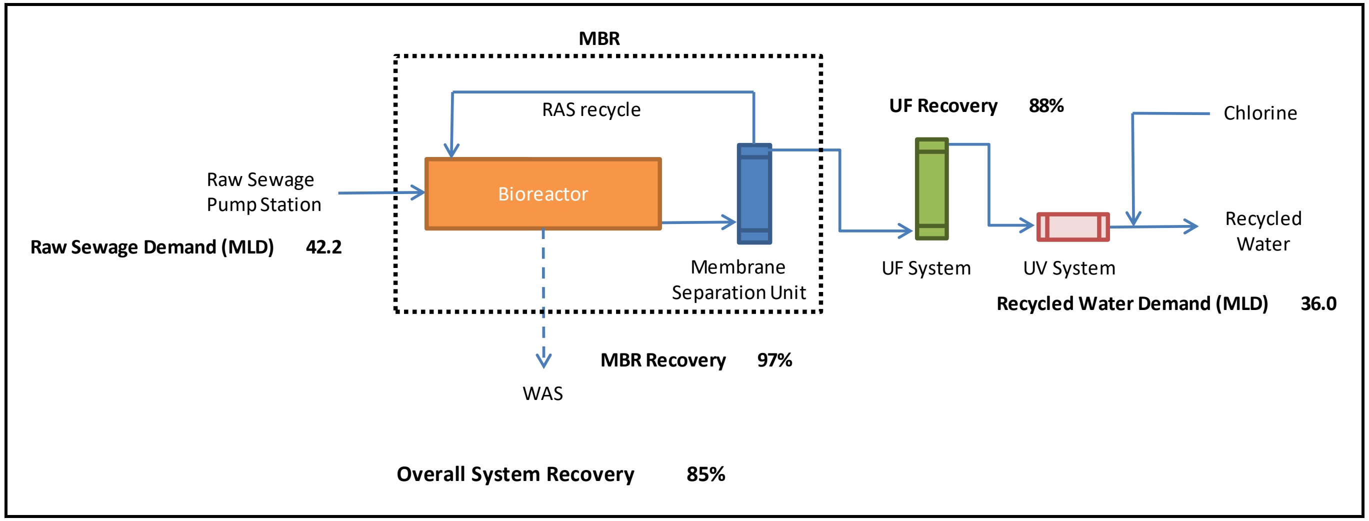
While the MABR is considered to provide an alternative to other biological processes in the future, at present the reactors are limited to a depth of 3.5 m, which would not make this process competitive with the MBR with respect to footprint. However, this process should be revisited in future and its applicability reassessed.

5.1.3 Colour and Salinity Risk Management

The treatment process outlined above is expected to satisfy the water quality requirements outlined in Section 3, but it is noted that additional treatment processes may be required to manage the risk associated with elevated true colour and salinity in the recycled water.

Based on discussions with other water utilities about recycled water that originates from similar catchments to that of MMS, the most feasible approach for colour reduction that would minimise footprint is to adopt chemical dosing (e.g. PAC23). To minimise the impact on the MBR this could be applied upstream of the MF/UF system. The impost on land costs for the treatment plant for this process is considered negligible as it would primarily be limited to a chemical storage and dosing system, and is considered to be a suitable risk management approach for reducing colour in the recycled water.

Alternatively, partial reverse osmosis (RO) or potentially nanofiltration (NF) treatment of the MF/UF permeate is expected to assist with managing the risk of elevated colour in the recycled water, but also manages issues associated with salinity if the TDS concentration of the MMS are not considered to be fit for purpose. While the inclusion of this additional treatment process would assist with managing the risks associated with elevated colour and salinity, it would have a significant impact on plant footprint and cost due to the reduction in overall plant recovery and upstream unit capacities. The impact on overall systems recovery is shown in Figure 6. The footprint of the treatment plant would increase by about 20% due to the inclusion of an additional treatment process (RO membrane skid) and increased treatment capacity requirements of the biological treatment process by 17%.



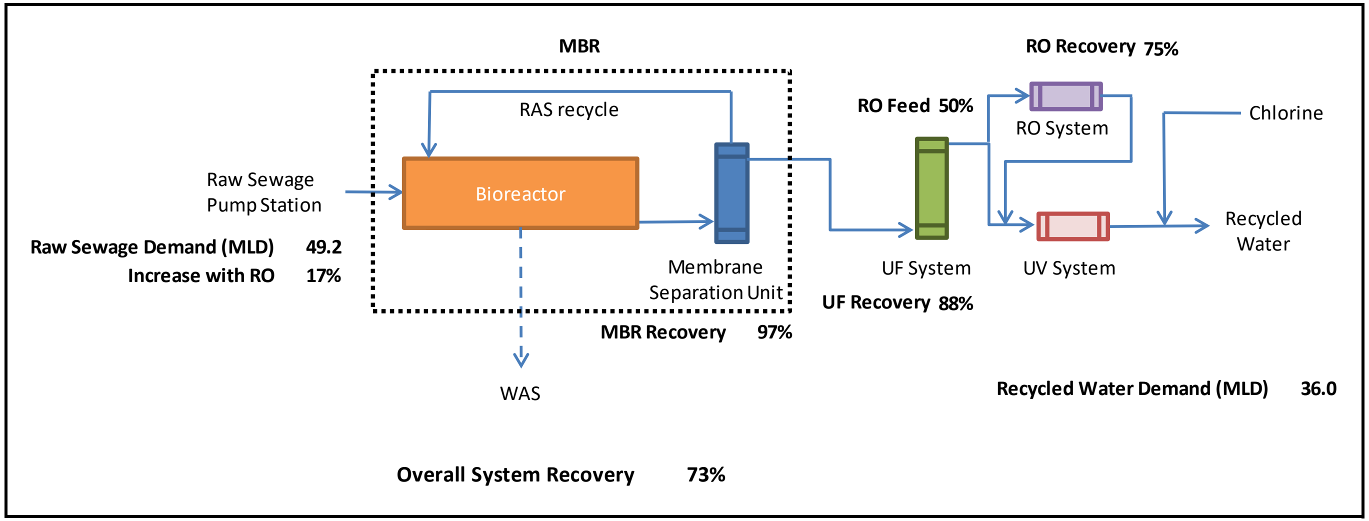


Figure 6 Impact of including RO to provide TDS and colour reduction

Therefore, unless there are significant drivers to reduce the TDS concentrations of the recycled water below the levels of sewage in the MMS, inclusion of partial RO treatment of the MF/UF permeate is not recommended. Instead, the TDS of the MMS sewage should be “actively” monitored over time, and where possible controlled to better understand and limit changes and the potential need for a RO process in future.

The approach to managing colour and salinity was discussed with SEW during the concept development workshop and it was agreed that chemical dosing was a suitable option for managing recycled water colour and has been adopted for the concept design.

Based on the recycled water TDS median limit, it was also agreed that salinity removal through a specific treatment process (RO) would not be required but that active management of sewage TDS was required in future.

While these approaches have been adopted for the purposes of the concept design, it was also acknowledged during the workshop that sewage quality be preserved going forward, and it was agreed that the Melbourne Sewage Quality Management Group (which includes SEW) would provide a suitable mechanism for managing the risk of sewage quality changes in future.

5.1.4 Opportunities for Reducing Treatment Plant Footprint

Treatment Train Considerations

The overall footprint of the treatment plant primarily comprises process equipment and access areas. It is estimated that of the total footprint, the process equipment may only occupy around 40-50%. An indicative breakdown of the contribution of key process units is shown in Figure 7.

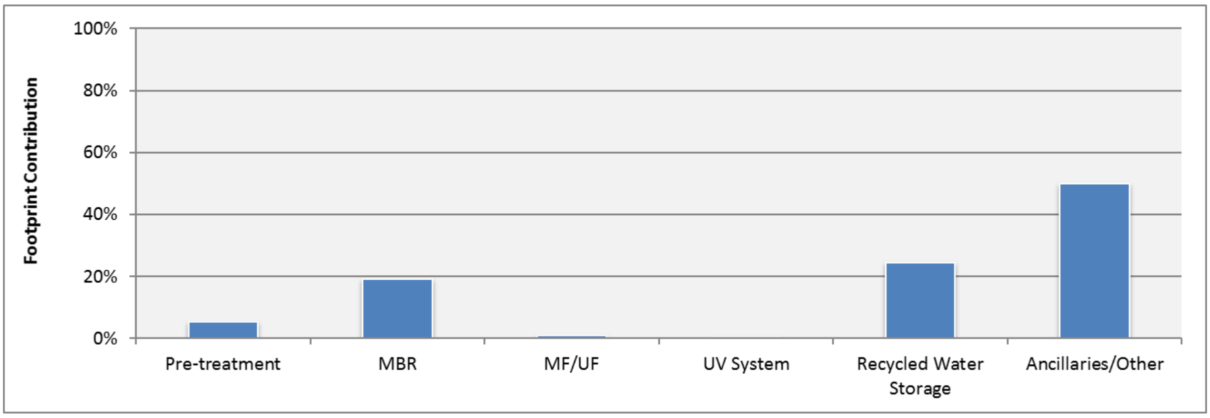


Figure 7 Indicative contribution of unit processes

This figure shows that the greatest opportunity for reducing the overall footprint of the plant is to reduce the footprints associated with the MBR process and recycled water storage. However, given the contribution of overall plant footprint that the process infrastructure occupies, there is also a need to focus on the configuration/arrangement of infrastructure within the facility (refer section 7.5.3).

To consider opportunities for reducing plant footprint, GHD used an adapted version of the “Hierarchy of Hazard Control” methodology which is shown in Figure 8.

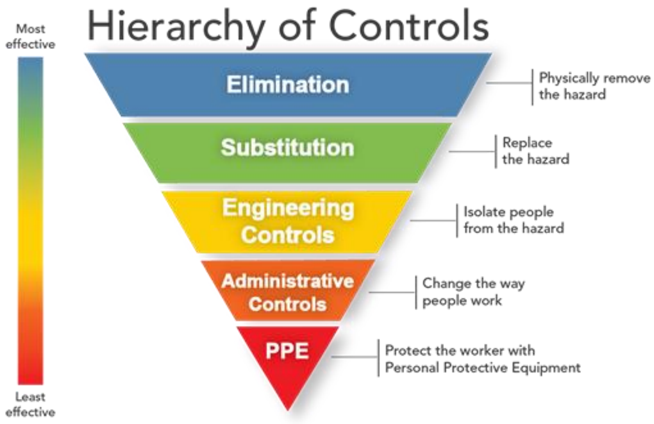


Figure 8 Hierarchy of Controls

The Hierarchy of Hazard Control is a system used in industry to eliminate or minimise exposure to hazards by focusing on the following controls (listed in order of decreasing effectiveness):

- Elimination
- Substitution
- Engineering
- Administration
- Personal protective equipment.

This approach enabled a systematic approach to be taken to identify the key parameters that influence equipment footprint and then options for reducing this through either elimination, substitution or engineering.

To facilitate this process, the following treatment process nodes were assessed:

- Pre-treatment (screenings and grit removal)
- Equalisation tank
- MBR
- UF break tank
- UF system
- UV disinfection system
- Chlorine disinfection
- Recycled water storage and transfer system
- Waste holding and transfer system.

The key outputs identified through this assessment are included below and were considered (and largely all adopted) as part of the concept design phase:

- Elevating the pre-treatment system to enable gravity discharge into the downstream biological process
- Provide additional capacity in the downstream biological process to buffer feed flows and eliminate the need for a raw sewage (screened) equalisation tank
- Physical removal of organic load upstream of the biological process to achieve an overall reduction in the footprint of this process

- Utilise submersible pumps within the MBR reactors where possible to eliminate footprint associated with dry mounted pump stations
- Utilise UF feed pumps for backwashing, reducing the need for a second pump set
- UF systems that operate at high flux rates and therefore reduce footprint, as well as opportunities for stacking membrane skids/installing them on a platform above other infrastructure or stacking containerised systems
- Opportunities for installing UV reactors on a platform above other infrastructure
- Identify opportunities for reducing the recycled water storage volume at the treatment facility site by adopting a decentralised recycled water storage network across the new precinct (not considered further in this report)
- Minimise installation of equipment in building where possible to reduce ventilation requirements
- Maximise the return of suitable waste streams to biological process and gravity discharge of waste streams to sewer where possible to minimise waste holding tank footprint.
- Maximise the return of waste streams to biological process and gravity discharge of waste streams to sewer where possible to minimise waste holding tank footprint, and provide inline maceration or macerating pumps to enable waste screenings and/or biosolids to be discharged directly to sewer
- Minimisation of access areas/roads etc. where practicable and without impacting plant operability and maintainability.

Based on the findings above and the information presented in Figure 7, the most significant opportunity for reducing the footprint of unit processes (i.e. excluding consideration of stacking equipment, multiple platforms etc.) is the removal of organic load upstream of the biological process.

One such process that is expected to provide relatively significant benefits for plant footprint is the installation of microscreening upstream of the MBR. A high rate lamella clarification process was also considered, but did not provide reductions in process footprint that made it worthy of further consideration.

The microscreens are a relatively simple process and require minimal footprint. They can reportedly achieve between 10-30% COD removal and 40-60% TSS removal. Given the proposed recycled water quality, upstream COD removal is not expected to present a risk for the biological process as the requirement for readily biodegradable carbon for complete denitrification is eliminated. The reduction in COD load would also lead to reduced aeration demand and the corresponding reduced energy demand and aeration system size benefits.

The microscreening unit produces a solids stream that is comparable to primary sludge that would be discharged to sewer with other process waste streams. Therefore, in addition to the benefit of a reduced footprint for the MBR system, the waste solids stream produced by the microscreens would also be a suitable feedstock for a co-digestion/waste to energy facility should this be considered viable in future.

Furthermore, due to the compact and enclosed nature of the process, there would also be an opportunity to install the microscreens above the inlet zones of the MBRs, further reducing the overall footprint of the biological process. An indication of the reduction in process unit footprint due to the optimised process is presented in Figure 9. This suggests that this process configuration has the potential to reduce the *overall* plant footprint by approximately 15%, which would provide a considerable cost saving associated with land acquisition.

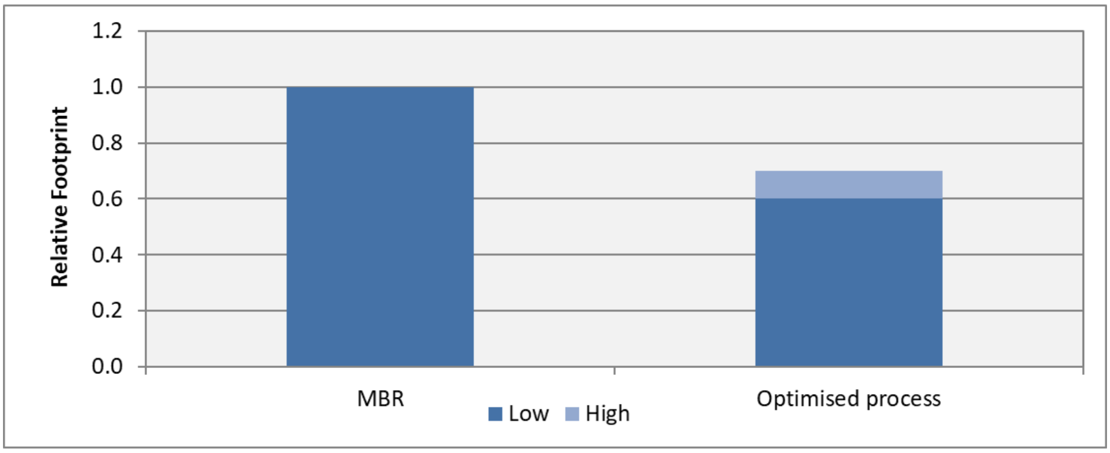


Figure 9 Optimised MBR process footprint (Stage 1, 18.5 ML/D plant)

It is recommended that the installation of these innovative microscreens upstream of the MBR process is adopted as the basis for the concept design. This is considered to be consisted with SEW's requirement to provide a leading edge treatment facility and provides a number of benefits in terms of reduced process footprint, cost and generation of by-products that may be suitable for a future co-digestion/waste-to-energy facility.

It is recommended that some preliminary sieve analysis is undertaken to better understand COD and TSS removal efficiencies. Depending on the success of these trials and the progression of this project, there is also an opportunity to undertake pilot trials using these microscreens.

Structural Considerations of Stacked Infrastructure

Wastewater treatment plants with stacked infrastructure are common, with significant examples including stacking of biological reactors at the Liverpool Wastewater Treatment Works in the UK, and the Ringsend Wastewater Treatment Plant, which treats most of the wastewater generated from the greater Dublin area.

Therefore, a preliminary assessment of the structural requirement and cost associated with stacking infrastructure e.g. suspended platforms, additional foundation requirements etc. was undertaken to assess whether this was worthy of consideration for the Fishermans Bend treatment plant.

The assessment considered three general approaches:

1. All infrastructure on one level
2. Each stage/train on a separate level i.e. including MBR and mechanical equipment
3. MBR tanks on ground floor and mechanical infrastructure (membrane skids, pumps, UV reactors etc.) installed on steel platforms.

The assessment was based on an indicative footprint for the Stage 1 (18.5 ML/d) treatment train and included indicative costs for:

- Foundations (which varied depending on the estimated loads for each option and process infrastructure i.e. water retaining structures or mechanical equipment)
- Steel/concrete structures supporting infrastructure on elevated levels/platforms for:
  - Water retaining structures e.g. stacked biological processes
  - Mechanical equipment e.g. pumps, membrane skids, UV reactors etc.

The conclusions from this work are presented in Figure 10, which indicates the relative structural cost range (low and high) increases associated with stacking infrastructure.

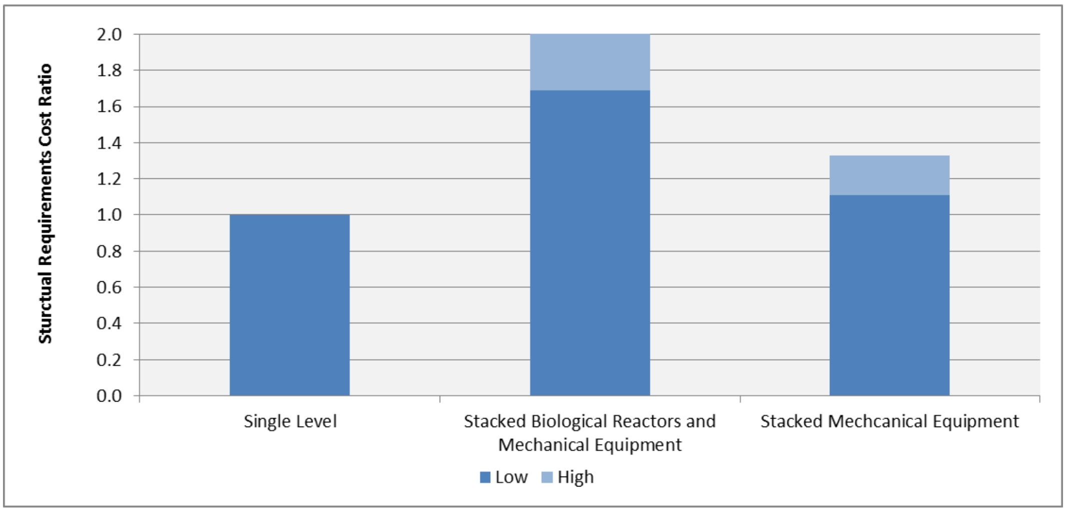


Figure 10 Relative Structural Costs for Multi-level Treatment Plants

The data suggests that for structural work alone (i.e. excludes additional costs associated with the added complexity of stacking process equipment, piping etc.), the construction cost for stacking biological reactors is expected to be around 70 - 100% more than for a conventional plant on a single level.

However, the structural cost for stacking mechanical equipment using steel frames and suspended platforms is not significantly more than a single level facility. Although the installation of mechanical equipment on multiple levels will not provide a reduction in footprint that is comparable with stacked reactors, it is still considered significant.

This was discussed with SEW during the concept development workshop and it was agreed that the plant should be designed based on a compact single storey arrangement as this provides increased flexibility for alternate designs in future and is a more conservative approach that reduces the risk associated with acquiring insufficient land. Further consideration of this is included in section 7.5.3.

6. Concept Design – Extraction System

6.1 Extraction System Concept Design

The following sections outline the concept design details for the Fishermans Bend extraction systems to service the 18.5 ML/d and 36 ML/d SMPs.

The concept design was developed using typical design assumptions, relevant experience from similar sewage pumping systems, information relating to the Fishermans Bend site and HBM, and the preliminary investigations outlined in Section 4.

The purpose of the concept design is to provide a practical arrangement to facilitate the process of wastewater extraction from the HBM and transfer to the SMP, including infrastructure sizing and an indication of potential staging opportunities.

The Fishermans Bend extraction system concept design comprises of the following:

- New access chamber at the extraction manhole on the Hobsons Bay Main Sewer
- Diversion pipework at the offtake location
- Extraction pump wet well
- Extraction pump valve chamber
- Transfer pipeline.

A summary of the individual components of the extraction system is presented in the following sections.

6.1.1 Access Chamber - Offtake from Hobsons Bay Main

Functional Requirement

- Provide access to raw sewage in the HBM.

Description

The new access chamber at HBM, will be situated on the existing HBM and provide the offtake location for the extraction system. Benching in the chamber is proposed to direct flows to the extraction wet well to satisfy the SMP sewage demand and enable sewage to continue to flow through the HBM when there is no demand. The required raw sewage demands for the SMP are defined below.

Table 12 Raw Sewage Demand (L/s)

	18.5 ML/d Capacity	36 ML/d Capacity
Stage 1	78	152
Stage 2	156	304
Stage 3	234	456

** Assumes 22 hr/d operation*

The new access chamber would need to be modified to provide the dual functionality i.e. for the contingency plan project and to enable sewage extraction. The chamber would accommodate:

- Two (2 No.) SERPS II pumps that are required as part of the *Hobsons Bay Main Sewer Contingency Plan*
- Existing 2.7 metre diameter HBM sewer
- Diversion pipe and benching.

Based on these requirements it is anticipated that the diameter of the access chamber would be approximately 7 m, which would meet the minimum requirements for the SERPS II pumps (2.14 m).

6.1.2 Diversion Pipework at HBM Offtake

Functional Requirement

- Provide transfer of sewage from the new access chamber to the extraction system pump wet well.

Description

The diversion pipe would allow for extraction of wastewater from the HBM at the required extraction rates. Penstocks are proposed upstream of the diversion pipe at the extraction manhole and downstream of the diversion pipe at the extraction wet well to provide double isolation for maintenance of the wet well.

To facilitate extraction of raw sewage actuated penstocks would open and close accordingly to provide the inflow to the pump wet well. This would ensure the pump well does not flood and that there is sufficient water depth for the pumps to operate.

The sizing of the diversion pipe is shown in Table 13 and is based on Stage 3 raw sewage demand for the two SMP capacities.

Table 13 Diversion Pipe Requirements

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Nominal Diameter	mm	450	600

6.1.3 Extraction Pump Wet Well

The extraction pump wet well would maintain a similar arrangement to a standard wet well for a wastewater pump station. The diversion pipe from the HBM access chamber would act like the inlet sewer to the pump station, and would comprise typical features including the submersible pumps, communications, alarms and control, equipment and devices.

Sizing of the wet well, pumps and discharge pipework was based on the Stage 3 raw sewage demand and achieving a velocity within a target range 1 to 3 m/s (WSA04). The details of the extraction pump wet well are summarised in Table 14.

Table 14 Extraction Pump Wet Well Details

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Diameter	m	6	6
Pumps	No.	2 Duty, 1 Standby	2 Duty, 1 Standby
Pump duty point (Stage 3)	m head	30	31
Pump power demand	kW	45	75
Discharge Pipework (nominal diameter)	mm	250	375
Velocity:	m/s		
Stage 1		0.6	0.6
Stage 2		1.3	1.1
Stage 3		1.9	1.7
Approximate depth	m	16	18

6.1.4 Valve Chamber

Functional Requirement

- Accommodate valves and provide safe access for operation and maintenance.

Description

The valve chamber will comprise a standard arrangement sized to accommodate valves and other appurtenances with allowance for installation and maintenance, including non-return valve, isolation valve and dismantling joint. The major components are outlined in Table 15 and have been sized based on the Stage 3 raw sewage demand for the two capacity options.

Table 15 Valve Chamber Details

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Nominal diameter	mm	250	375
Reducing Tee	-	DN450 x DN250	DN600 x DN375
Size	m	5.2 x 5.6	5.8 x 6.4

6.1.5 Transfer Pipeline

Functional Requirement

- Transfer raw sewage from the extraction location to the SMP.

Description

The transfer pipeline commences from the valve chamber downstream of the extraction pump station and delivers wastewater from the HBM to the SMP. The proposed alignment of the transfer pipeline would run from the extraction manhole generally north-west to the proposed sewer mining plant site. Trenchless installation is anticipated at two road crossings.

Details of the raw sewage transfer pipeline are summarised in Table 16.

Table 16 Transfer Pipeline Details

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Nominal Diameter	mm	450	600
Length	m	2500	2500
Velocity:	m/s		
Stage 1		0.4	0.5
Stage 2		0.8	0.9
Stage 3		1.3	1.4

Sizing of the transfer pipeline is based on achieving a target velocity of 1.5 m/s (WSA04) for Stage 3 raw sewage demand. Consequently, the velocity in the transfer pipeline for Stage 1 for both SMP capacities is considerably low. It is recommended that further consideration of this is undertaken during the next phase of the project taking into account the friction losses in the pipeline, total head requirements for the pumps and potential to size the transfer pipeline to achieve minimum velocity requirements. Intermittent pumping should also be considered.

6.2 Constructability and Staging

As described in Section 3, the capacity of the sewer mining plant is proposed to be delivered in three equal stages for the 18.5 ML/d option and 36 ML/d option. Taking the proposed staging into account the relatively significant construction requirements for the extraction system based on the raw sewage demands, it is proposed that the civil infrastructure associated with the extraction system and transfer pipeline is sized and constructed for the ultimate demand.

The proposed pumping arrangement of three pumps (2 No duty/1 No standby) is based on the ultimate demand for each SMP capacity. However, there is an opportunity to stage mechanical and electrical equipment to match raw sewage demand, although this would be limited to reducing the installed number of pumps to two i.e. 1 No duty/1 No standby.

Further opportunities for pump staging and arrangements should be considered during subsequent stages of the extraction system design and when forecast sewage demands and the timing of treatment plant staging is better understood.

6.3 Co-location of Extraction System and Inlet Works

There may be an opportunity to locate the inlet works for the treatment plant at the extraction system location. A high level review of key advantages and disadvantages of this opportunity are outlined below. It is recommended that this be considered further with MWC as part of future stages of the extraction system design to assess land availability and other potential risks.

For the purposes of this review it was assumed that the inlet works would comprise screening, grit removal and odour control, and would be contained within a dedicated building with power supply, controls and other ancillary works.

Key Advantages	Key Disadvantages
• Reduce footprint requirements at treatment plant location • Reduce odour risks for treatment plant (reduced foul air treatment requirement) • Direct transfer of screenings and grit back to HBM	• Requires second foul air treatment and discharge system, including chemical storages • Requires procurement of additional land for inlet works and foul air treatment facility • Requires dedicated building, MCC, access controls, ancillaries etc. • May require double pumping i.e. may not be practical to gravity feed treatment plant from inlet works

7. Concept Design – Treatment Plant

7.1 Treatment Train Concept Design

The following sections outlined the concept design details for the Fishermans Bend SMP treatment train for the 18.5 ML/d. It also contains the design summary details for the 36 ML/d facility.

The concept design was developed using typical process design assumptions, relevant experience from similar plants, information provided by technology suppliers and the preliminary investigations outlined in previous section.

The treatment train for the Fishermans Bend SMP concept comprises:

- Pre-treatment (screenings and grit removal)
- MBR pre-treatment (microscreens)
- MBR
- UF break tank
- UF system
- UV disinfection system
- Chlorine disinfection
- Recycled water storage and transfer system
- Waste holding and transfer system
- Odour Control.

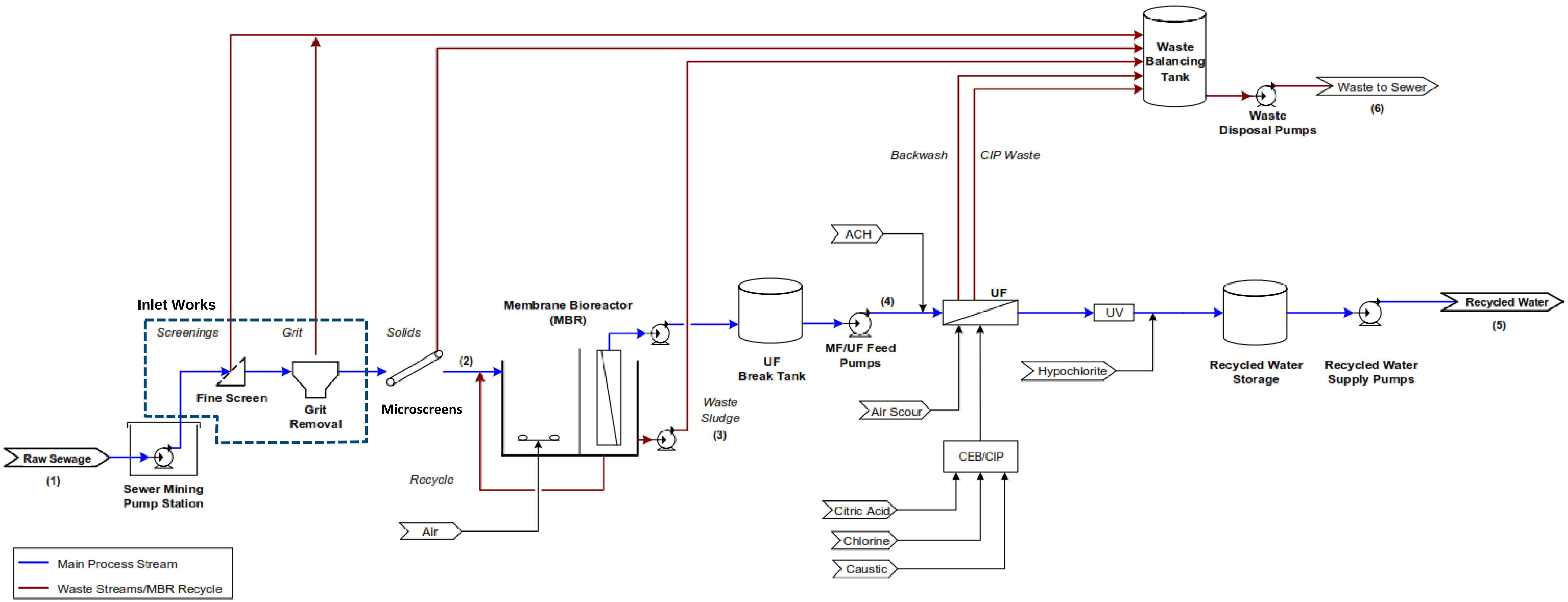
A summary of the individual process units and equipment is presented in the following sections. This includes hydraulic loading rates for each process unit.

The purpose of the concept design is primarily to assist with developing a realistic treatment plant footprint and cost estimate. Therefore, specific equipment items have been referred to herein to better estimate footprint, power consumption and cost estimation. Unit selection was based on the availability of information from suppliers and is not based on an assessment and identification of preferred equipment by GHD. Process units and equipment would be considered further during the functional design.

7.1.1 Concept Design Reliability Assumptions

The following key assumptions relating to infrastructure and equipment reliability were made when developing the concept design:

- "n + 1" was adopted for critical mechanical equipment to provide sufficient redundant capacity during plant operation
- An operating factor of 22 hr/day was assumed to allow for equipment downtime for maintenance.



Major Stream Flows and Loads (18.5 ML/d)							
Parameter	Unit	Raw Sewage (1)	MBR Inlet (2)	Waste Sludge (3)	UF Feed (4)	Recycled Water (5)	Waste to Sewer (6)
Stream No.		1	2	3	4	5	6
Flow rate	ML/d	21.2	21.0	0.4	20.6	18.5	2.7
Flow rate	ML/y	7700	7700	150	7500	6800	1000
TSS	tonne DS/d	6.8	3.4	3.3	Negligible	Negligible	6.7

Major Stream Flows and Loads (36 ML/d)							
Parameter	Unit	Raw Sewage (1)	MBR Inlet (2)	Waste Sludge (3)	UF Feed (4)	Recycled Water (5)	Waste to Sewer (6)
Stream No.		1	2	3	4	5	6
Flow rate	ML/d	40.0	39.6	0.8	38.8	34.9	5.1
Flow rate	ML/y	14600	14400	300	14200	12700	1900
TSS	tonne DS/d	12.8	6.4	6.2	Negligible	Negligible	13.3

Figure 11 Fishermans Bend SMP Process Flow Diagram and Hydraulic Balance

7.1.2 Inlet Works

Functional Requirement

- Remove screenings, grit and residual particulate oil and grease from the raw sewage to protect downstream equipment
- Enable diversion of flows to the individual treatment trains.

Description

Raw sewage entering the facility would pass through the fine screens and grit removal process prior to entering the flow splitting system. Flows would then be diverted to the three treatment trains.

For the purposes of the concept design, it was assumed that the inlet works would be located within the treatment plant building given that this provides a more conservative approach to sizing the plant footprint. However, as noted in section 6.3, there is an opportunity to locate the inlet works at the sewage extraction point.

Conventional treatment plants include equipment to dewater screened materials. In this application, no dewatering is proposed, as pre-treatment waste products would be fluidised returned to sewer in a wet and pumpable state via the waste management system.

Table 17 Process Unit Information – Fine Screens

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Feed flowrate	ML/d	21.2	41.2
No. units	No.	3 (2 Duty/1 Standby)	6 (1 Duty/1 Standby per stage)
Process recovery	%	100	100
Process Footprint	m^2	~ 1 (per screen)	~ 1 (per screen)
Staging		• All civil works completed during stage 1 • 2 No screens installed in stage 1 • Final screen installed in stage 3	• Works completed independently for each stage • 2 screens per stage

Table 18 Process Unit Information – Grit Removal

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Feed flowrate	ML/d	21.2	41.2
No. units	No.	1 (1 Duty)	3 (3 x 1 Duty)
Flow per grit trap	L/s	270	173
Process Footprint	m^2	~ 8 (per grit trap)	~ 7 (per grit trap)
Staging		• All works to be completed during stage 1	• Works completed independently for each stage • 1 grit trap per stage

Table 19 Process Unit Information – Flow Split

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Feed flowrate	ML/d	21.2	41.2
Process Footprint	m^2	~ 3.5 (per unit)	~ 3.5 (per unit)
Staging		• All works to completed during stage 1	• Works completed independently for each stage

7.1.3 MBR Pre-treatment (Microscreens)

Functional Requirement

- Remove raw sewage particulate COD and reduce the organic load on the downstream MBR.

Description

MBR pre-treatment comprises microscreens operating in parallel. The microscreens would provide primary treatment by removing solids and BOD via a filter mesh on an inclined conveyor. This would reduce the load on the MBRs and hence the footprint of downstream processes. The waste stream from the microscreens would be returned to the sewer via the waste management system (without thickening).

Table 20 Process Unit Information - Microscreens

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Feed flowrate	ML/d m^3/h	21.2 365	41.2 1,852
No. units	No.	4 (3 Duty/1 Standby)	9 (2 Duty/1 Standby per stage)
BOD removal	%	20	20
TSS removal	%	50	50
Process Footprint	m^2	~9 (per microscreen)	~ 9 (per microscreen)
Staging		• 2 No filters in stage 1 • Additional microscreens in stage 2 and 3	• Works completed independently for each stage • 3 microscreens per stage

7.1.4 MBR and Ancillary Infrastructure

Functional Requirement

- To remove suspended solids and nutrients and provide a suitable feed to the UF system

Description

The MBR system comprises the MBRs, blowers, WAS and permeate pumps. Each MBR combines an aerated bioreactor with a submerged MF membrane module. Mixed liquor would be pumped into the membrane tanks and be returned to the MBR inlet via gravity. Intermittent aeration is proposed to reduce infrastructure requirement and provide partial denitrification.

Table 21 Process Unit Information – MBR

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Feed flowrate	ML/d m^3/h	21.0 955	40.8 1,852
No. units	No.	3 (3 Duty)	6 (6 Duty)
No. membrane modules	No.	5 per MBR (4 Duty/1 Standby)	5 per MBR (4 Duty/1 Standby)
Process recovery	%	98	98
Process Footprint	m^2	~ 695 (per reactor)	690 (per reactor)

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Staging		• All civil works completed during stage 1 • Membrane modules completed for each stage • n+1 pumps and blowers to be installed in stage 1 • Additional equipment installed for subsequent stages	• Works completed independently for each stage • 2 units per stage

7.1.5 UF System and Ancillary Infrastructure

Functional Requirement

- Provide disinfection through filtration and achieve 4 log reduction for protozoa
- Provide suitable permeate turbidity for UV disinfection.

Description

The UF system will consist of racks of UF modules. Effluent from the MBRs will be stored in a UF break tank then pumped to the UF modules. UF membranes would be cleaned through backwashing, air scouring and CIP systems. UF reject and waste from backwashing and the CIP system would be returned to the sewer via the waste management system.

Table 22 Process Unit Information – UF System

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Feed flowrate	ML/d m^3/h	20.6 935	40 1,817
UF Racks	No.	3 (3 Duty)	6 (6 Duty)
Process recovery	%	90	90
Process Footprint	m^2	50 (per rack)	50 (per rack)
Staging		• 1 UF rack per stage • n+1 pumps to be installed in stage 1 • Additional equipment installed for subsequent stages	• Works completed independently for each stage • 2 racks per and 3 pumps per stage

7.1.6 UV System

Functional Requirement

- Provide disinfection of UF permeate and achieve 2 log reduction for protozoa

Description

UF permeate will pass through an inline UV reactor to provide disinfection.

Table 23 Process Unit Information – UV System

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Feed flowrate	ML/d m^3/h	18.5 840	36.0 1,636
Units	No.	3 (3 Duty)	6 (6 Duty)
Design UVT	%	55	55
Process Footprint	m^2	4 (per UV unit)	4 (per UV unit)
Staging		• 2 UV units installed in stage 1 • 3 UV units installed in stage 3	• Works completed independently for each stage • 2 UV units per stage

7.1.7 Chlorine Disinfection

Functional Requirement

- Provide secondary disinfection and achieve 3 log reduction for virus

Description

Sodium hypochlorite will be dosed into the UF permeate to provide secondary disinfection.

Table 24 Process Unit Information – Chlorine Disinfection

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Target free chlorine residual	mg/L	1.0	1.0
Staging		• All works in Stage 1	• Works completed independently for each stage

7.1.8 Recycled Water Storage and Transfer

Functional Requirement

- Store recycled water to manage peak instantaneous recycled water demand

Description

The recycled water storage and transfer system comprises a recycled water storage tank and duty standby transfer pumps. The recycled water storage tanks have been sized to provide the required contact time in addition to recycled water storage requirements.

Table 25 Process unit information - recycled water storage

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Recycled water feed	ML/d	18.5	36
Recycled water storage	ML	21.1	41.2
Process Footprint	m^2	1200 (per tank)	1200 (per tank)
Staging		• 1 tank in stage 1 • Additional tank for stage 2	• 2 tanks in stage 1. • Additional tanks in stages 2 and 3

Table 26 Process unit information - Recycled water transfer

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Peak flow rate	m^3/h L/s	1430 395	2783 773
Pumps	No.	5 (4 Duty/1 Standby)	10 (8 Duty/2 Standby)
Process Footprint	m^2	130 (total system)	260 (total system)
Staging		• All civil works in stage 1 • 2 pumps installed in stage 1 • Additional equipment installed for subsequent stages	• 1 building and 4 pumps installed in stage 1 • 2 buildings and 7 pumps installed in stage 2 • 10 pumps installed in stage 3

7.1.9 Chemical Dosing and Storage

Functional Requirement

- Coagulant: Colour removal upstream of the UF system
- Acid: UF and MBR cleaning
- Caustic: UF cleaning
- Hypochlorite: UF and MBR cleaning, recycled water disinfection

Description

Coagulant would be dosed upstream of the UF system for colour removal. Acid and caustic would both be dosed to the CIP systems to provide cleaning for UF and MBR membranes. Hypochlorite will be dosed to CIP systems and used for CEB for UF and MBR membranes, and downstream of the UV for disinfection.

Table 27 Process unit Information - Chemical dosing and storage

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Storage volume			
Coagulant	kL	10	18.2
Acid	kL	1.2	2.3
Caustic	kL	0.2	0.3
Hypochlorite	kL	22	42
Process Footprint	m^2	100 (storage area)	90 (storage area per stage)
Staging		• All works in Stage 1	• Works completed independently for each stage

7.1.10 Waste Management

Functional Requirement

- To return the waste streams separated from the raw sewage and from the process back to sewer.

Description

The waste management system comprises gravity pipework for the collection of the waste streams and a wet well pump station equipped with duty standby submersible pumps. The waste stream flows, which include screenings, grit, sludge and reject water would be collected in the Waste Balancing Tank and pumped back to sewer.

Table 28 Process Unit Information – Waste management

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Total waste streams	ML/d	2.7	5.3
Process Footprint	m^2	5 (per wet well system)	5 (per wet well system)
Staging		• All works in Stage 1	• Works completed independently for each stage

7.1.11 Odour Control

Functional Requirement

- To manage odour risks for the sewer mining plant through extraction, treatment and venting.

Description

The odour control system comprises extraction fans, chemical scrubbers, activated carbon filters and vent stack.

Table 29 Process Unit Information – Odour Control

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Foul air flow rate	Am^3/h	56,000	102,500
Chemical scrubber	No.	4	9
Activated carbon filters	No.	4	9
Process Footprint	m^2	280 (total system)	210 (per system for each stage)
Staging		• 2 No fans in stage 1 • Additional fan in stage 2 • 2 No chemical and carbon scrubbers in stage 1 • 1 No of each additional scrubber in stage 2 & 3 • 1 No vent stack	• Works completed independently for each stage • 3 fans, 3 chemical scrubbers, 3 carbon filters per stage

7.2 Power Supply, Electrical and Control Systems

7.2.1 Power Supply and Control System

The estimated maximum power demand and installed capacity for the two plant capacities are outlined below.

Table 30 Power Demand

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Maximum Duty Demand	MW	2.6	5.3
Installed Demand	MW	3.5	7.9

Based on the estimates outlined above it is proposed that a HV supply is for the plant is adopted, with transformers located within the facility. It may be possible to supply the plant with LV power initially but it is recommended that the power supply installed for Stage 1 is suitable for ultimate demand.

The facility includes allowances for:

- HV switchroom
- LV switchroom
- Master control centres (MCCs) and local switchboards around the plant
- Control system:
  - Local operator SCADA workstation
  - PLC system.

7.2.2 General Electrical Infrastructure

The following general electrical infrastructure is also required:

Lighting

- Interior and exterior lighting
- Road entrance lighting
- Emergency lighting
- Exist signs/lighting

Security system

- Monitoring, security and alarm system

Fire detection and alarm system

- Smoke detectors appropriately distributed throughout the facility (internal and external)
- Audible/visual fire alarm warnings.

Note this excludes connection infrastructure between the treatment plant and electricity grid.

7.3 Geotechnical Consideration

As part of the concept design a preliminary review of geotechnical conditions was undertaken to assist with the design of piling and building foundations. Based on this review and estimated bearing capacities of the infrastructure the following was adopted for the design and cost estimate:

- Pre-cast piles (350 x 350) at 5 m spacings
- 600 mm concrete slab.

7.4 Treatment Plant Building

7.4.1 Access

Road access to and within the site will need to be confirmed following identification of a suitable parcel and how this relates to the broader road network.

The concept proposed includes access to the site from a single point from the roadway. Within the site a ring road has been allowed for to enable the delivery of chemicals and other consumables by truck without the need for reversing.

For the purposes of the concept design it was assumed that the roadway would be contained within the final façade treatment adopted for the facility, but this could be considered further during subsequent design stages.

7.4.2 Access (Operations and Maintenance)

Within the main building access for major equipment handling would be provided by a drive through loading bay between the reactors and UF skids, with a separate loading bay for the odour control system.

The following lifting gear would service major items of equipment:

- Travelling bridge gantry crane above the odour control systems for the loading of odour control system media and equipment.
- Individual travelling bridge gantry cranes above each reactor (under side of building roof) for the removal of reactor odour covers, diffuser grids, membrane modules etc. Each crane would traverse the drive through loading bay. The cranes above reactor 1 and 2 would extend to above the inlet works mezzanine for removal of the screens and filters.
- Fork lift access to the ground floor Mechanical Equipment Gallery for removal of blowers and permeate pumps.
- Travelling bridge gantry crane above the UF membrane skids. The mezzanine level height is based on enabling the full removal of a skid over an installed skid. Removal of full skids is typically only required at the end of skid life (say 15 years). It may be possible to lower the total building height and remove this gantry crane if it was accepted that all skids are to be removed and replaced in same operation.
- Monorail for UF Feed Pump removal to the drive through loading bay.
- Monorail for UV removal to the drive through loading bay.
- Travelling bridge gantry crane for recycled water pump removal.

Personnel access to the mezzanine level is provided by an elevator and staircase. Access to the top of the reactors is provided by stairs from the ground level.

7.5 Treatment Plant Layout and Constructability

7.5.1 Treatment Plant Footprint

The proposed footprints for the 18.5 ML/d and 36 ML/d are presented below.

Table 31 Treatment Facility Footprint

Parameter	Unit	18.5 ML/d Capacity	36 ML/d Capacity
Footprint	ha	1.3	2.7

7.5.2 Constructability and Staging

As outlined in section 3.2.2, the capacity of the plant would be delivered in three equal stages.

For the 18.5 ML/d option the following approach was adopted:

- Infrastructure delivered in 3 No trains with some integration e.g. single inlet works, sharing reactor walls and standby pumpsets and blowers.
- Major civil works completed in stage 1 including buildings, reactor concrete, inlet works and major piping. Due to the nature of the facility it is not considered practical to stage construction of the MBR reactor tanks
- Major electrical works completed in stage 1.
- Mechanical and control works completed in stage 1 to include standby equipment. Additional mechanical and control works built for capacity each stage thereafter.

For the 36 ML/d option the following approach was adopted.

  - Infrastructure delivered in entirely 3 independent trains
  - Civil, mechanical and electrical works completed only as required by the stage

It is noted that the approach adopted for the 36 ML/d option is different to that adopted for the 18.5 L/d option and the justification for this is outlined below.

Three approaches were initially considered for the 36 ML/d option as follows:

1. Construct a large building with all major civil works for Stage 3 requirements (i.e. all MBR tanks) and then stage installation of mechanical equipment (same approach as for the 18.5 ML/d plant)[3]
2. Construct a large building with three MBR reactors and stage the installation of mechanical equipment, then replicate this approach to achieve Stage 3 capacity requirements i.e. duplicate the 18.5 ML/d system
3. System delivered in three individual trains. Each stage would comprise a dedicated building to avoid significant upfront capital cost associated with constructing a building and major civil works to accommodate the ultimate 36 ML/d plant infrastructure

Due to the capacity of the stages for the 36 ML/d facility it is proposed that this system is delivered as three individual trains (Option 3 above). This option also has the lowest whole of life cost due to this deferral of capital, but more importantly, provides a greater level of flexibility to manage the uncertainty around population growth and recycled water demand.

The different approaches selected for the two plant capacities both achieve the staging objective, but deliver different outcomes with regards to cost and footprint:

- Cost:
  - The approach adopted for the 18.5 ML/d option is likely to achieve a lower total cost provided that all stages are delivered and the timing of stages is say no more than 10 years apart. If all stages are not delivered (e.g. demand is not realised) the investment will be effectively lost. If the spacing of stages is further apart the project whole of life cost could be less optimal than building independent trains as per the 36 ML/d option.

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[3] It is noted that due to the size of the concrete MBR reactors, it is not feasible to stage the installation of these units within a building due to the construction requirements associated with this process

- Footprint:
  - The footprint of the 18.5 ML/d option is less per ML of capacity than the 36 ML/d option. This is due to the sharing of assets (e.g. tank walls etc. as outlined above) and that there is no need to allow space to enable heavy construction adjacent to the operating plant.

A significant opportunity for further reducing upfront capital investment and initial footprint requirements that was identified included utilising the Stage 2 and Stage 3 MBR reactors for recycled water storages i.e. delaying the need for the external tanks. This could be considered further as part of a functional design, but it is possible that the 2 No reactor tanks used for recycled water storage would need to be separated via an air gap (i.e. not connected to the duty Stage 1 MBR reactor via a shared wall) from the Stage 1 MBR to minimise the risk of recycled water contamination.

7.5.3 Treatment Plant Layout and Footprint Reduction

The layout of the two treatment plants aimed to balance opportunities for footprint reduction without being overly aggressive. An overly aggressive layout could result in the procurement of a site that is too small for delivery of the project in practice or substantially escalate the cost of the plant.

The plant layouts adopted are predominantly single level and above ground (as agreed with SEW during the concept development workshop). Above ground layouts were adopted to avoid the high groundwater levels in the area and the potentially contaminated soils that would require remediation of disposal if disturbed. Single level layouts were adopted as these are expected to be more cost effective.

In addition to the items outlined in section 5.1.4, the following opportunities for footprint reduction were also adopted:

- Shared walls between reactors
- Space below MBR membrane modules utilised as a mechanical service gallery
- Recycle and wasting pumpsets avoiding by raising the membrane modules to allow for gravity discharge
- Travelling bridge gantry cranes adopted to avoid the need to cater for mobile crane vehicles
- Mezzanine floor above UF skids for inlet works, MCC/switchroom and control room.
- Relift pumps downstream of inlet works avoided by locating the inlet works on the mezzanine level
- Shared vehicle access for the mechanical equipment gallery and UF/UV equipment area.

7.6 Consideration of HBM for SMP Extraction

As stated in section 3, the concept design is based on treating sewage extracted from the MMS given that this provides the most conservative approach based on sewage characteristics, allowing for potential changes in sewage concentrations in future or selection of a MMS offtake location (although this is considered unlikely).

However, given that the preferred options for sewage extraction involves sourcing sewage from the HBM, a high level review of the potential impacts associated with using this sewage as the treatment plant feed has been undertaken and is summarised below.

- The concentration of COD and TKN in HBM sewage is approximately 30% less when compared with the MMS. This would result in the following benefits:
  - A significant reduction in MBR reactor volume and ancillary equipment requirements (e.g. blowers), both of which would lead to a reduction in the plant footprint
  - A relatively significant reduction in aeration power demand and operating cost
  - Reductions in MBR air demand and open water area would also lead to a reduction in odour control equipment capacity requirements and chemical consumption.
- If the treatment facility is located in close proximity to the HBM (currently not possible for the MMS extraction source option) there may be an opportunity to avoid the need for a waste stream collection and pump station system. All waste streams could be discharged via gravity directly to the HBM.
- These and other potential benefits should be considered further following selection of the treatment plant site and further assessment of HBM sewage quality data.

8. Architectural Design

8.1 Approach and Assumptions

To assist with developing suitable options for the aesthetic treatment of the treatment facility, an initial inspection and review of existing infrastructure in the proposed vicinity of the plant was undertaken. This highlighted that the current industrial environment is different to the proposed redevelopment proposed in the Fishermans Bend Strategic Framework Plan. The proposed treatment facility will likely be constructed in a location that will evolve into an increasingly urban setting.

The Strategic Framework Plan outlines the long term plan to redevelop the area into The Fishermans Bend Urban Renewal Area (FBURA). This includes rezoning of the surrounding areas, i.e. Lorimer, Wirraway and Sandridge to 12 – 16 storey mixed used (residential / commercial) buildings.

8.2 Option Development

8.2.1 Considerations

The critical factors for the design of the facility include the following:

- Specific site of development and advantages and disadvantages of having a visible and integrated location
- Vehicular and pedestrian access
- Adjacencies with road and neighbouring buildings
- Co-location with other functions
- Treatment of façade

8.2.2 Stakeholder Input

GHD facilitated a workshop with a range of external stakeholders.

The purpose of the workshop was to present preliminary concepts for integrating the proposed sewer mining treatment facility into the new Fishermans Bend precinct so that external stakeholders had an opportunity to contribute ideas and offer suggestions.

Some of the key themes and messages that were received through this process are outlined below:

- The facility roof space should maximise the value this area can provide for the community
- Maximise the integration of green space/green walls and consider the potential for tying this in with the proposed Fishermans Bend “green spine”
- Solar panels were considered to be beneficial but could be used on other facilities with much smaller roof area, and were not considered to maximise the value of the space
- Car parks were not considered to provide value to the community
- There is expected to be a lack of green space and sporting areas in the new precinct so including these facilities within the roof area would be of significant benefit to the community

Based on this feedback, the preferred options for further development were:

1. Active Roof – Integrating sports areas and green space into the roof space of the facility
2. Urban Edge – Combining the facility with a low level high-rise and green space, fully integrating the plant into an urban environment.

The preferred concepts are included in Figure 12 and Figure 13.

Figure 12 Preferred Concept – Active Roof

Figure 13 Preferred Concept – Urban Edge

8.3 Preferred Concepts

The two preferred concepts stated above were developed further to provide greater context around how the facility would be integrated with the urban environment, both visually and from a public access point of view. The stakeholders upheld that the plant should be co-located with other functions, and hence held in locations with public visibility. Also, there was acknowledgement that the sewer mining was a fore front of technology for sustainability and should not be tucked away in a corner of the industrial zone.

9. Project Risks and Safety in Design

9.1 Preliminary Risk Identification

The purpose of this section is to collate and summarise key risks of the project. Key risks identified include:

- Demand forecasts
  - Demand for recycled water is forecast based on inherently uncertain population growth and estimates of recycled water usage per head. Variation in the forecast could alter the proposed timing and size of the plant.
- Sewage availability
  - Similar to demand, sewer flow forecasts are based on inherently uncertain population growth and estimates of indoor water usage per head. Variation in the forecasts could alter the proposed timing and size of the plant.
- Sewage quality
  - Sewerage quality is assumed to be consistent with sampling carried out to date. It is possible that the sewage quality will differ in the future and be more difficult to treat. Increasing sewage salinity is likely to have the largest impact on this project and mitigation measures have been identified and outlined in this report
- Land
  - Land cost and availability have the potential to alter the feasibility of this project. The treatment plants require substantial parcels of land. The cost and availability of suitable parcels in the proposed area is currently unknown.
  - The area required to accommodate the extraction system at the offtake is large and the extent of impact caused to residential roads and private properties can influence feasibility of the location.
- Flooding
  - Land in the area is subject to flooding. Climate change implications are likely to increase the issues associated with flooding. The concept presented assumes that regional flooding will be dealt with outside of this project.
- Contaminated land
  - Land in the area in known to be contaminated. Contaminated land can be hazardous when disturbed and costly to remediate.
- Odour
  - Treatment plants are a source of odour. Management of odour, by capture and treatment prior to discharge to atmosphere, is likely to be heavily scrutinised by community and regulatory bodies in the granting of approvals.
- Condition of Existing Assets
  - The feasibility of the offtake location takes into consideration the condition of the existing sewer. Existing aged infrastructure may present difficulty to maintain as deep excavation adjacent to the sewer may undermine the structural integrity.
- Ground Conditions
  - Unknown geotechnical / ground conditions are likely to impact the construction method.

9.2 Safety in Design

The project involved development of a concept for a sewer mining plant and extraction system. The concepts outlined generally meet current industry practices for safety. Further development of the project will require consideration of a range of risks including those set out below. Given the concept nature of this work, the following list is not comprehensive.

Risks for consideration:

1. Management of explosive and other gases associated with confined spaces (e.g. below odour covers)
2. Management of traffic on a constrained site in construction, commissioning, operation and maintenance
3. Confined space entry for sewer and pump station construction and subsequent operation and maintenance
4. Pathogen and other contaminants in sewage in construction, commissioning, operation and maintenance
5. Working over and around open water in construction, commissioning, operation and maintenance
6. General electrical, mechanical and chemical risks in construction, operation and maintenance
7. Deep excavation for construction of the pump station
8. Working around live services and implementing isolation / bypass procedures
9. Protection of existing services and utilities.
10. General construction risks.

Appendices

Appendix A – International Experience

Memorandum

05 April 2016

To			
Copy to			
From		Tel	+61 3 8687 8260
Subject	International Practices – Wastewater Treatment Plants in the Urban Environment	Job no.	31\33795\03

GHD utilised international resources to obtain information on large WWTPs in urban settings to ascertain the 'international best practice' for these plants, both in terms of treatment processes and treatment plant configurations. This information is collated in Table 1 of this technical memorandum and was summarised into two key themes:

- Integration of WWTPs with the surrounding urban environment
- Approaches for or space minimisation.

Some images of the treatment plants outlined herein are also included in this memorandum.

Key Themes for Integration with the Urban Environment

The most common method of integration with the urban environment for plants in large cities is the location of some (if not all) treatment processes underground. The land above the majority of these plants has subsequently been used for housing and the creation of public spaces such as parks. Some specific information is included below:

- The Dokhaven WWTP in Rotterdam was built in a small harbour that had lost economical value, with apartments and a park subsequently constructed above the underground plant.
- At the Jingxi WWTP in China, the visual impact of the vent stack was eliminated by designing it as a clock tower.
- The North River WWTP in New York, while not located underground, is located on an 11.3 ha platform over the Hudson River and underneath the Riverbank State, giving the plant the largest green roof in New York City.
- The Liverpool WWTW in the United Kingdom is located built within a redundant dock in a world heritage site buffer zone. The Liverpool WWTW is not located underground but was built as a two storey SBR plant with covers over the reactors to reduce environmental and visual impacts.

In urban settings, odour minimisation is a key element of these plants. Odour complaints from residents of West Harlem forced a $55 M (USD) odour control upgrade to be completed in 1993, seven years after the plant was commissioned. Strategies to minimise odour include the isolation of odorous processes underground, complete covering of treatment processes with adequate air extraction, scrubbing of foul air prior to discharge, and foul air discharge in areas least likely to cause issues (such as industrial locations). Noise and vibration concerns have also been considered at the Dokhaven WWTP by placing all engines and pumps on rubber blocks.

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In addition to integration with the urban environment, several of the surveyed plants produce water and energy for the local community. Examples include:

- The Dubai WWTP MBR effluent is used for irrigation, and the plant also includes an 81 ML/d RO plant to treat MBR effluent for local cooling
- The Kakola WWTP in Finland employs heat recovery from treated wastewater to produce either 40 MW of local heating, or 26 MW of local cooling. This has been estimated to reduce greenhouse gas emissions by approximately 80,000 t $CO2_e$/y
- The Henriksdal WWTP in Stockholm produces gas from biosolids to fuel local public transport.

Key Themes for Space Minimisation

Space minimisation has been achieved at the surveyed plants through several key principles, namely:

- Underground plant structures & facilities
- Optimising plant layout, particularly through modularisation and stacking of process units over several stories.
- Adoption of space saving technology, particularly Membrane Bioreactors (MBRs)

MBRs have been favoured at the world's two largest underground WWTPs, Busan Suyeong WWTP in Korea and Jingxi WWTP in China, each with a capacity of approximately 100 ML/d. The use of MBRs eliminates the need for a secondary clarifier and tertiary treatment. MBRs have also been installed at the Henriksdal WWTP in Sweden and the Dubai Palm Jumeirah WWTP in Dubai (21.7 ML/d). MBRs have the additional benefit of being able to provide good nitrogen and phosphorous removal.

The Dokhaven WWTP in The Netherlands, limited by aeration capacity, used the SHARON process to reduce the ammonia load of the effluent by 50%.

Both the Liverpool WWTW (United Kingdom) and the Ringsend WWTW (Ireland) are SBR plants built over two storeys to minimise plant footprint. The Liverpool WWTW was stacked to fit the plant into the limited footprint available at Wellington Dock. The Ringsend WWTW's 24 SBRs the largest in the world.

A serpentine monorail was installed at the Dubai Palm Jumeirah WWTP to cover the entire work space due to limited headspace.

Mark Trickey
Senior Process Engineer

Attachment No. 1 International Treatment Plant Summary

Attachment No. 2 Images of Treatment Plants in the Urban Environment

Attachment No. 1 International Treatment Plant Summary

Table 1 Examples of Wastewater Treatment Plants in the Urban Environment

Plant	Location	Capacity and Footprint	First Operated	Treatment Processes	Notes	References
Dokhaven WWTP	Rotterdam, Netherlands	19 ML/h (470,000 EP) 4 Ha	1987	• SHARON/Anamox	• Limited by aeration capacity, the use of SHARON reduced the ammonia load of the effluent by 50%. • Two stories below ground • All engines and pumps in the plant are placed on rubber blocks for noise and vibration control • All process units are covered (except the final settling tanks). Foul air (80,000 m^3/h) is washed in three-step chemical scrubbers and. Ejected through a 50 m chimney stack with 160,000 m^3/h of clean air from the plant, at a location in an industrial area, at a distance of 600 m from the Dokhaven plant • Hydrogen peroxide injection in the sewer pipelines between the pumping stations in the town and the plant to reduce H_2S levels in the influent. • Built in a harbour which had lost its economic value • A park and apartments were built above the completed plant	[1], [2]
North River WWTP	New York, USA	470 ML/d (ADWF) 1287 ML/d (PWWF) 11.3 Ha	1986	• Screening • Primary sedimentation • Biological treatment • Secondary clarification • Disinfection • Anaerobic digestion • Odour control - Sodium hypochlorite and sodium hydroxide scrubbing - AC filters - Ventilation stacks	• 11.3 ha on platform over the Hudson River • The plant has the largest green roof in New York City, located beneath the Riverbank State Park, a popular recreational facility with three swimming pools, an amphitheater, an athletic center, a skating rink, a restaurant and sports fields • After continual odour complaints from local residents, a $55 M odour control upgrade was completed in 1993 • There is no dewatering on site; wet sludge transported from site via boat	[3], [4]

[1] H. Meijer, Rotterdam-Dokhaven Sewage Treatment Plant; A Large Sewage Treatment Plant In The Midst Of A Developing Residential Quarter, Wat. Sci. Tech. 20, No. 4/5, pp. 267-274, 1988.

[2] R. van Kempen, C.C.R. ten Have, S.C.F. Meijer, J.W. Mulder, J.O.J. Duin, C.A. Uijterlinde, M.C.M. van Loosdrecht, *SHARON process evaluated for improved wastewater treatment plant nitrogen effluent quality,* Water Science and Technology, 52 (4), pp. 55-62

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Plant	Location	Capacity and Footprint	First Operated	Treatment Processes	Notes	References
Liverpool WWTW	Liverpool, United Kingdom	800,000 EP 356 ML/d	2015	• Screening • Primary sedimentation • Biological treatment (SBRs)	• The plant is built within a redundant dock (Wellington Dock) in a world heritage site buffer zone. • The plant has 16 no. SBR basins built over two storeys, with 8 no. on a lower deck and 8 no. on an upper deck. It is the first multi storey SBR plant and largest in the UK. Stacking was done to fit the plant into the limited footprint available at Wellington Dock and to reduce the environmental impact on the surrounding area and the adjacent world heritage site. • Covers are fitted to the upper level for aesthetics and to minimse the wind effects on the basins. • A 3D model was created for construction and operational purpose. It has been used for operator training, HAZOP analysis, clash detection and construction sequencing and planning. Integration with tablets allowed for augmented reality and real-time O&M manuals and maintenance management.	[5]

Ringsend WWTW	Dublin, Ireland	1,700,000 EP
		4.65 m^3/s (ADWF)
		22.6 m^3/s (PWWF)
			2003	• Screening and grit removal
				• Lamellae PSTs
				• Biological treatment (SBRs)
				• UV disinfection
				• Anaerobic digestion with Cambi sludge hydrolysis
					• The plant's 24 SBRS are the largest in the world and housed in a two storey structure.
					• The treatment plant includes a cogeneration plant which generates over 50% of the annual energy needs of the plant
					• The plant produces 25,000 tonnes of Biofert annually
					• A planned expansion would see the plant's capacity increased to 2.4 million EP by:
					  ◦ Expansion of treatment capacity with a new Aerobic Granular Sludge (AGS) system
					  ◦ Installation of AGS technology into the existing SBRs
					  ◦ Expansion of sludge processing facilities
					  ◦ New phosphorous recovery process
					  ◦ Additional odour control facilities
						[6]

[3] http://www.nyc.gov/html/dep/html/harbor_water/northri.shtml

[4] http://www.umich.edu/~snre492/ny.html

[5] Jeff Constantine & Nicola Henderson, *Liverpool WwTW: installation of CASS SBR plant for the secondary treatment process that will keep the River Mersey clean*, http://www.waterprojectsonline.com/publication_date/2015.htm

[6] http://www.caw.ie/ringsend_wwtw.html

Plant	Location	Capacity and Footprint	First Operated	Treatment Processes	Notes	References
Kakola WWTP	Turku, Finland	280,000 EP	2009		- Located underground - Treats waste from 10 towns/cities and built to provide better denitrification for these towns. The result was and estimated 35% reduction in nutrient load to the Baltic Sea - Heat recovery from treated wastewater. Provides local heating (40 MW) and cooling (26 MW) and reduces GHG emissions by approximately 80,000 t/y. - Project cost of EUR 125 M	[7,8]
Viikinmäki WWTP	Helsinki, Finland	280 ML/d (ADWF) 750,000 EP	1994		- Located less than 10 km from centre of Helsinki - Built underground with houses and parks constructed above - Project cost of EUR 180 M	[9]
Stanley WWTP	Hong Kong	27,000 EP	1995	- Secondary treatment - Disinfection	- Constructed in three 120 m long caverns - Ventilation shaft is 400 m from a residential area - Located close to a prison, a school and houses	[10,11]
Henriksdal WWTP	Stockholm, Sweden				- One of the world's largest underground treatment plants - 90% underground, last 10% to be moved inside to reduce traffic and odour - Produces gas from biosolids to fuel public transport in Stockholm - About to undergo a major upgrade with the world's largest MBR. The LEAPmbr from GE will house ZeeWeed 500 membranes, and is designed to meet the stringent nitrogen and phosphorous removal requirements.	[12,13]

[7] http://www.vacon.com/Default.aspx?Id=474925

[8] Mirva Levomäki, Needs of WWT Sector Finald – M. Levomaki Turku Wastewater Treatment Plant

[9] http://www.hel.fi/wps/wcm/

[10] http://www.ststwincaverns.hk/page.php?l=eg_hk&p=4&lang=en

[11] http://civcal.media.hku.hk/sewage/stanley

[12] http://www.dailycommercialnews.com/article/id24160/water

[13] http://www.filtsep.com/view/41604/major-wastewater-plant-to-be-upgraded-by-ge/

Plant	Location	Capacity and Footprint	First Operated	Treatment Processes	Notes	References

Busan Suyeong WWTP	Busan, South Korea	100 ML/d	2012	- Pre-treatment
				- Biological treatment (ZeeWeed MBR)
				- Membrane filtration
					- World's largest underground MBR plant
					- Treats combined stormwater and sewage for river discharge
					- Located in an underground bunker with a residential park above
					- Space constraints limited options
					- ZeeWeed MBR: 120 membrane cassettes immersed in 12 membrane trains. Eliminates the need for secondary clarifier and tertiary treatment
					- Plant meets quality limits of:
					  - 7 mg/L BOD
					  - 40 mg/L COD
					  - 20 mg/L TSS
					  - 20 mg/L TN
					  - 2 mg/L TP
					- Major concern for the plant was the water quality at local beaches
					- The following weighting were given during an MCA for process selection:
					  - Performance: 21%
					  - Applicability: 19%
					  - Reliability: 17%
					  - Environmental Impact: 16%
					  - O&M: 14%
					  - Constructability: 13%
					- Project cost of $120 M AUD
						[14], [15]

[14] http://www.thembrsite.com/installations/busan-suyeong-sewage-treatment-plant/

[15] Jongsok Choi, Kyunghwan Kim, Jeongho Seo, E.Eric Adams, *New concept for completely underground MBR plant in urban area – Suyeong, world's largest underground MBR plant in Busan,*

Plant	Location	Capacity and Footprint	First Operated	Treatment Processes	Notes	References
Jingxi WWTP	Jingxi Gunangzhou, China	100 ML/d 1.8 ha	2010	• Screening • Aerated grit chamber • Biological treatment (MBR) • UV disinfection	• Processes sewage for river discharge • Located in a two storey underground bunker • Space saving design achieved through three key principles: - Underground plant structures/facilities - Modularised and optimised layout - Adoption of MBR technology • Two stories of underground treatment processes, with offices at ground level. • Vent stack is designed as a clock tower • Park built above the plant • MBR eliminates the need for clarifier and polishing filters • Small biological tanks due to high MLSS concentration • Double stack hollow fibre membrane skids to increase packing density and optimise membrane tank height • Energy consumption = 0.3 to 0.35 kWh/m3 wastewater. This is low due to: - Low air-water ratio due to double layer membrane skid and dual air scouring strategy - Dissolved oxygen control strategy - High energy efficiency equipment • Project cost of $60 M AUD	[16]
Dubai Palm Jumeirah WWTP	Dubai, U.A.E	18 ML/d (Average daily flow) 21.7 ML/d (Peak design flow)		• Screening • Biological treatment (MBR – Norit AirLift) • Sludge handling • Disinfection (sodium hypochlorite) • MBR effluent used for irrigation • 81 ML/d RO plant to treat effluent from the MBR for district cooling	• Located on prime land and was therefore constructed below ground to reduce footprint and visual impact • Serpentine monorail installed to cover the entire work space due to limited headspace	
Bondi STP	Sydney, Australia	130 ML/d	1936	• Grit removal • Screening • Primary sedimentation • Sludge digestion	• Located 40 m underground • Screening and sedimentation occurs underground, sludge digestion above ground	[17]

[16] Hailin Ge, Lily Lien, A case study of the 100,000 m^3/day MBR in Jingxi, Guangzhou, PRC

[17] http://www.heritage.nsw.gov.au/07_subnav_01_2.cfm?itemid=4573707

Attachment No. 2 Images of Treatment Plants in the Urban Environment

Figure 1 Dokhaven WWTP, Rotterdam (Netherlands)

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Figure 2 North River WWTP, New York (USA)

Figure 3 Kakola WWTP, Turku (Finland)

Figure 4 Viikinmäki, Helsinki (Finland)

Figure 5 Stanley WWTP, Stanley (Hong Kong)

Figure 6 Dubai Palm Jumeirah WWTP, Dubai (UAE)

Figure 7 Liverpool WWPT (Multistorey), Liverpool (UK)

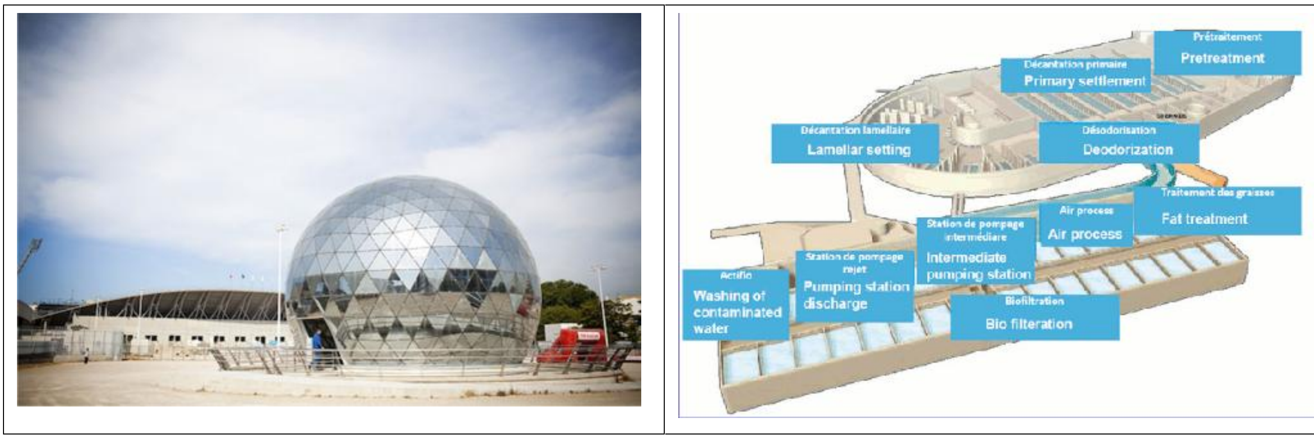
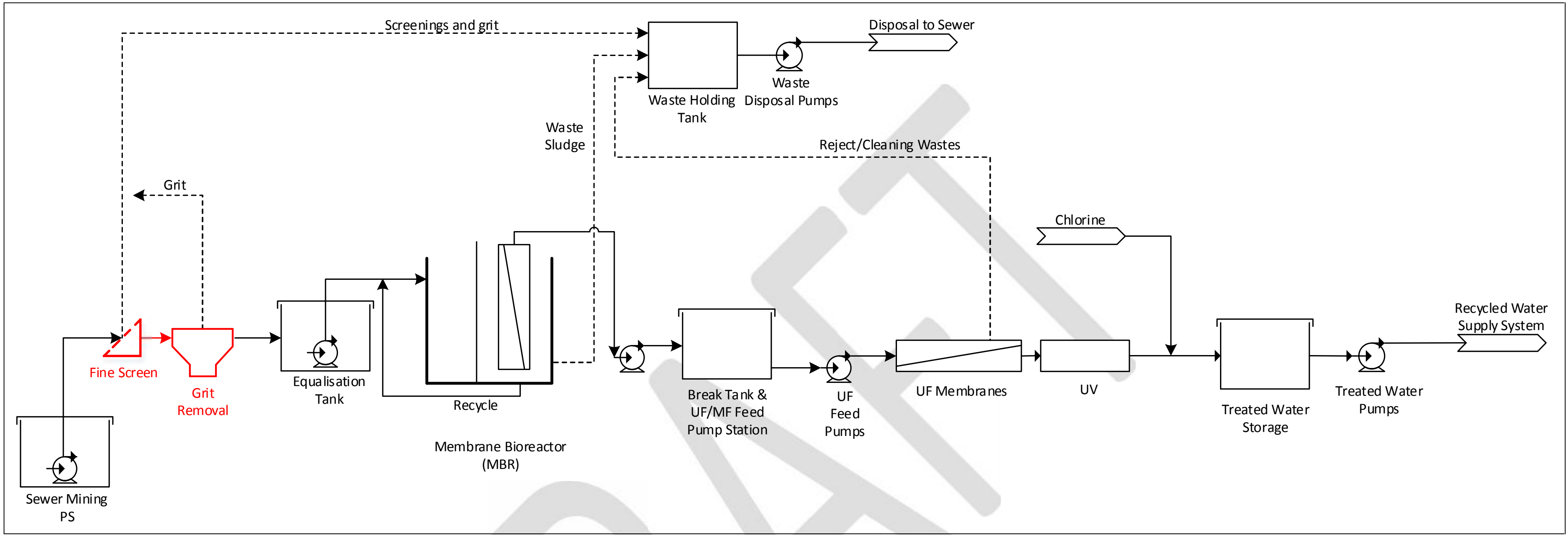


Figure 8 Marseille WWTP, Marseille(France)

Appendix B – Footprint Reduction Process Sheets

Fishermans Bend Sewer Mining Plant
Screenings and Grit Removal Process Assessment



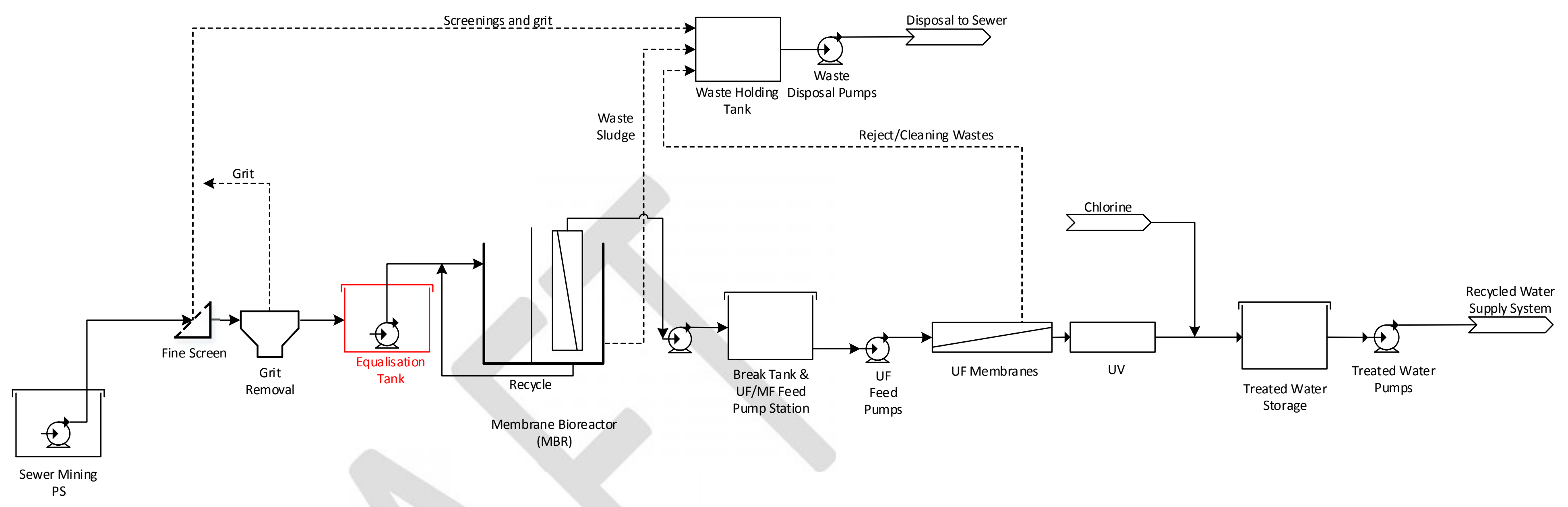
Screenings and Grit Removal – Protection of downstream mechanical equipment

What dictates footprint?	Hydraulic load	Solids Concentration	Process Equipment
Elimination	• NA	• Screenings removal at extraction pump station	• NA
Substitution/Reduction	• Maximise treatment process recovery	• First flush diversion in sewer to reduce peak solids load design requirement	• Consider alternative equipment that minimises footprint
Engineering	• NA	• NA	• Installation of process equipment above downstream processes with gravity discharge

Discussion Notes:

- Key consideration is to minimise transfer of screenings from sewer through design of extraction system

Fishermans Bend Sewer Mining Plant
Equalisation Tank

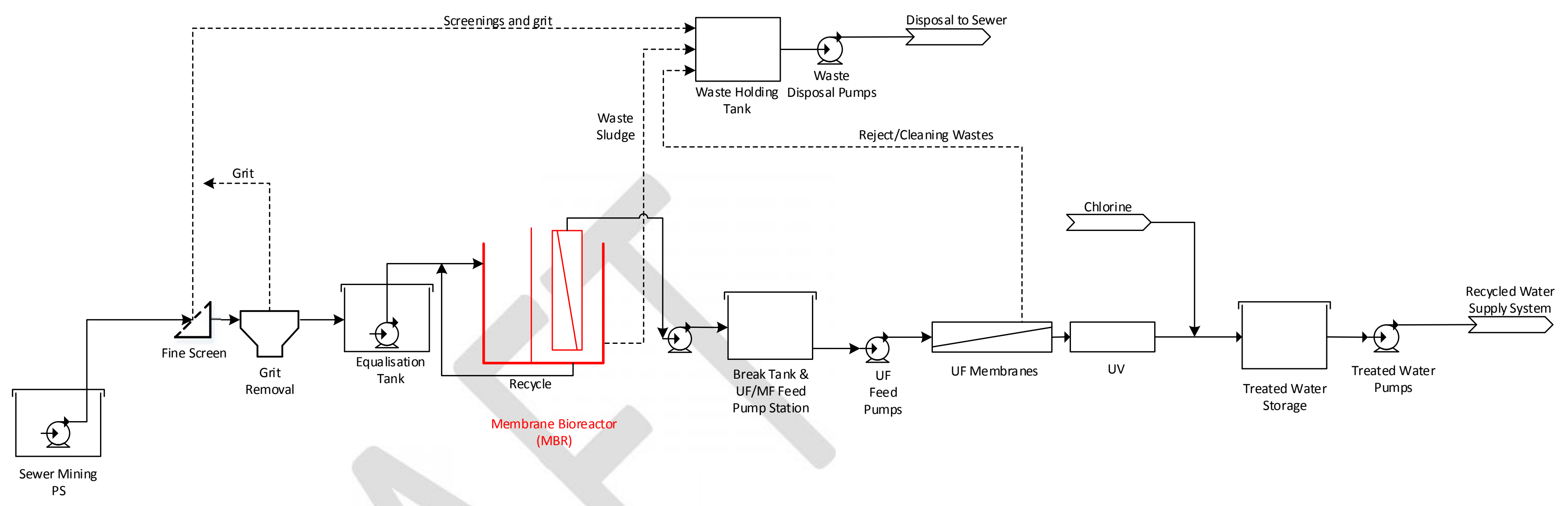


Equalisation Tank: Buffer flowrates between pre-treatment system and biological process (MBR)

What dictates footprint?	Buffering Capacity	Tank Diameter
Elimination	• Elevate screenings and grit removal process to enable discharge directly from pre-treatment process into MBR • Allow for buffering capacity in MBR • Match recycled water production to sewage availability • Integrate re-lift pumps in screened sewage channel	• NA
Substitution/Reduction	• Allow for buffering capacity in MBR	• Minimise tank diameter
Engineering	• NA	• Integrate tank into plant to utilise “dead space”

Discussion Notes:

Fishermans Bend Sewer Mining Plant
Membrane Bioreactor (MBR)



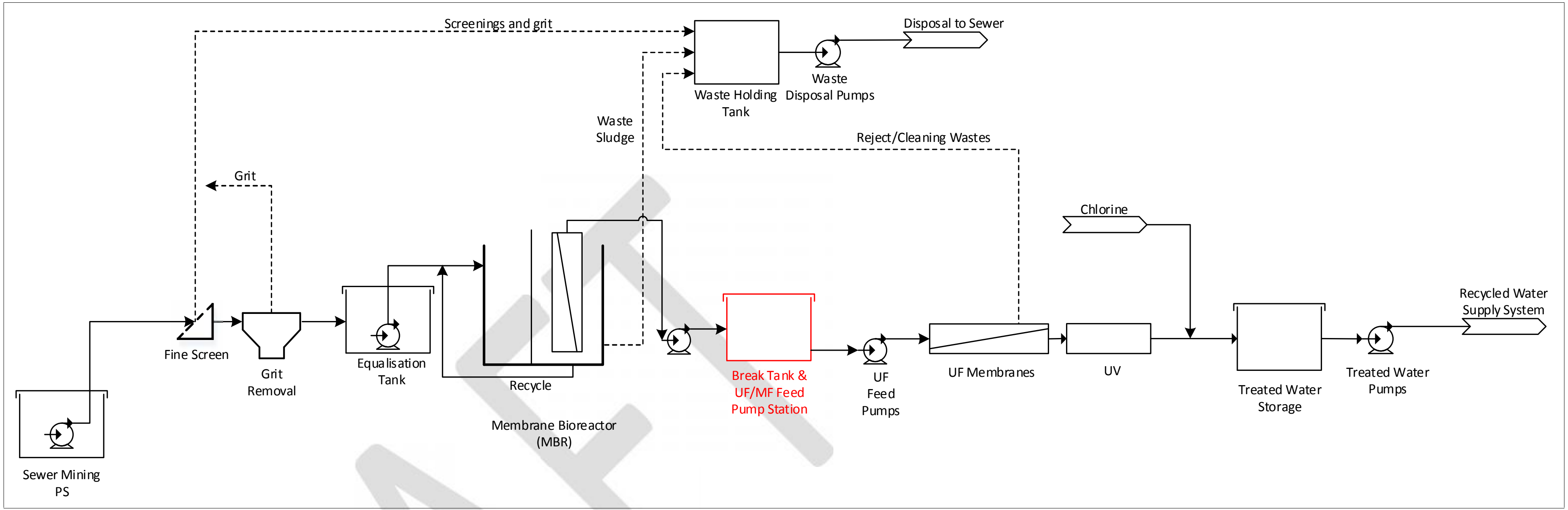
MBR: Biological treatment of sewage, organics and ammonia removal, provide suitable feed for downstream MF/UF process

What dictates footprint?	Hydraulic Load	Organic Load	Tank Configuration
Elimination	• NA	• NA	• NA
Substitution/Reduction	• Maximise recovery in downstream processes	• Installation of upstream solids removal process to reduce organic and solids load on bioreactor	• Maximise tank depth (6 – 8 m) • Equipment selection – access for maintenance
Engineering	• Increase tank depth to provide balancing of peak instantaneous flows	• Locate upstream solids removal process above bioreactor inlet zones	• Enable other equipment to be located above bioreactor tanks or below membrane tank

Discussion Notes:

- Will need to retain access to part of the bioreactor to enable aeration diffusers to be removed
- Allow space above membrane tank for membrane removal

Fishermans Bend Sewer Mining Plant
MF/UF Feed tank



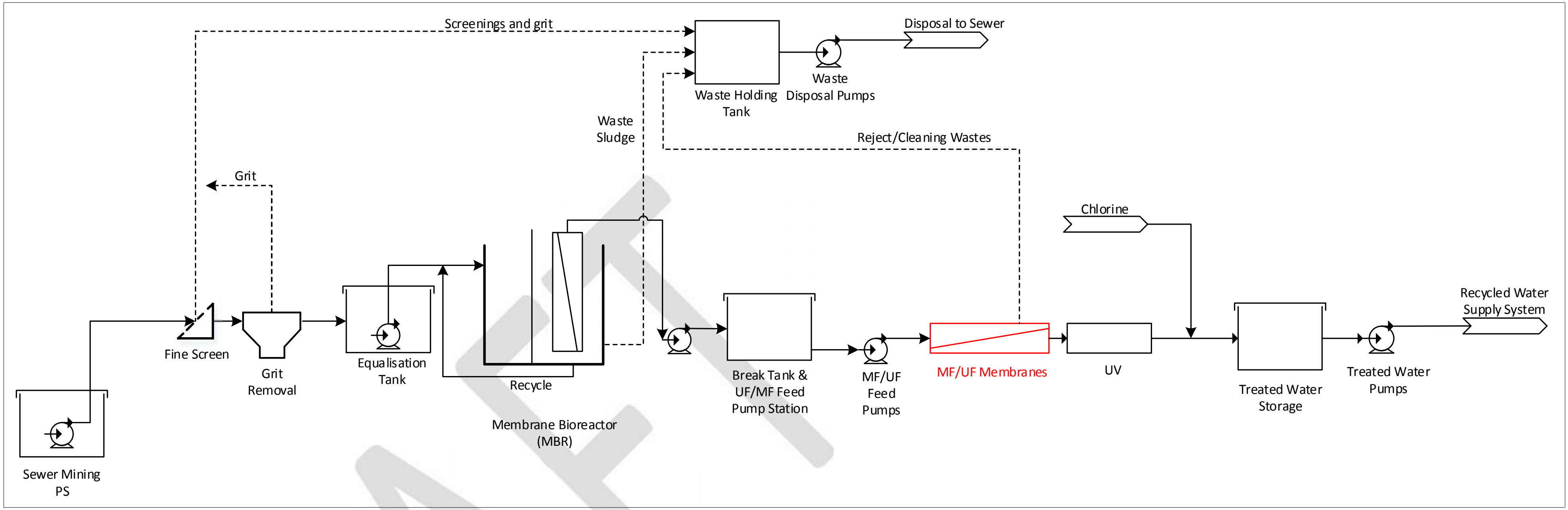
MF/UF Feed Tank: Provide storage to enable relatively constant flow to membrane system

What dictates footprint?	Buffering Capacity	Tank Configuration
Elimination	• NA	• NA
Substitution/Reduction	• Increase MF/UF capacity so feed pumps can ramp up and down to match MBR discharge	• Minimise tank diameter
Engineering	• NA	• Integrate tank into plant to utilise "dead space"

Discussion Notes:

- NA

Fishermans Bend Sewer Mining Plant
MF/UF System



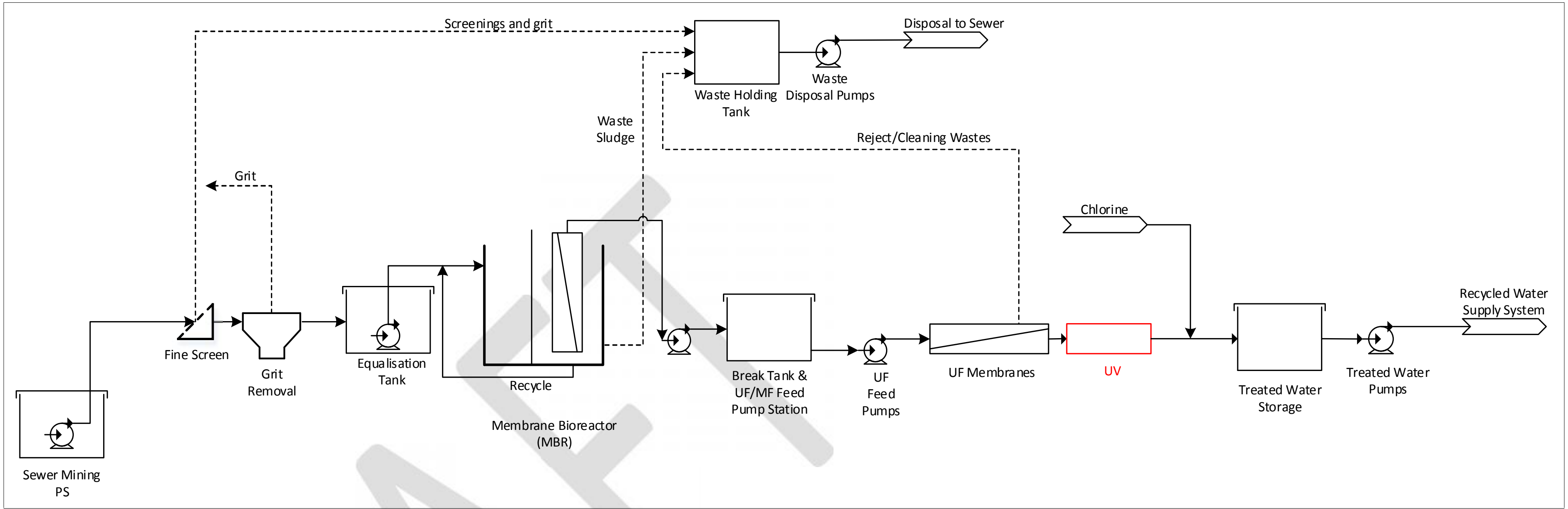
MF/UF System: Provide disinfection and suitable feed for UV disinfection system

What dictates footprint?	Flux rate	Recovery	Configuration
Elimination	• NA	• NA	• NA
Substitution/Reduction	• Consider membranes with high flux rates e.g. ceramic membranes	• Select membrane systems with high recovery rates to minimise membrane surface area requirements • Recycle MF/UF backwash to MBR	• Consider containerised systems rather than individual membrane skids
Engineering	• NA	•	• Stacking of membrane systems – containers or skids on elevated platforms

Discussion Notes:

- GHD discussed the option of ceramic membranes with suppliers of ceramic and non-ceramic membranes, who noted while they do operate at higher flux rates (thereby requiring less membrane area), due to the amount of work that has been invested in non-ceramic membrane for recycled water the footprints of these systems are comparable and recommended that they were not worthy of further consideration for recycled water

Fishermans Bend Sewer Mining Plant
UV System



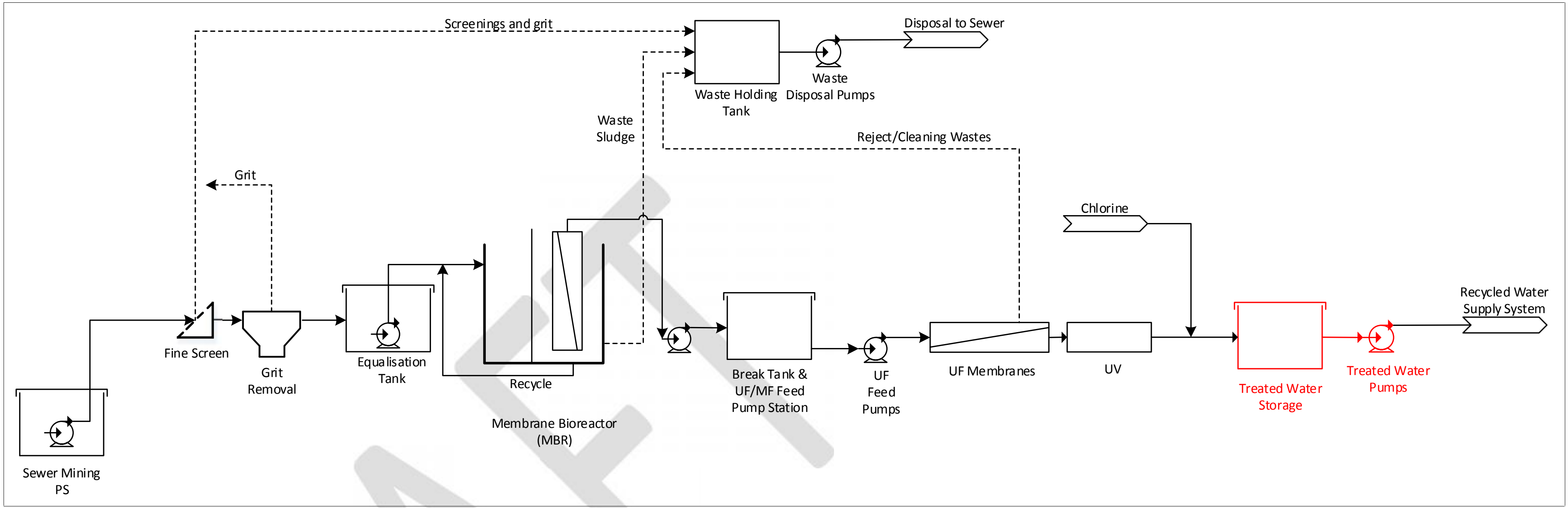
UV System: Provide disinfection

What dictates footprint?	Hydraulic load	Upstream Water Quality	Configuration
Elimination	• NA	• NA	• Channel vs inline reactors
Substitution/Reduction	• NA	• NA	• Consider impacts of No. of units vs footprint
Engineering	• NA	• NA	• Stacking UV reactors on elevated platforms

Discussion Notes:

- NA

Fishermans Bend Sewer Mining Plant
Treatment Water Storage and Transfer System



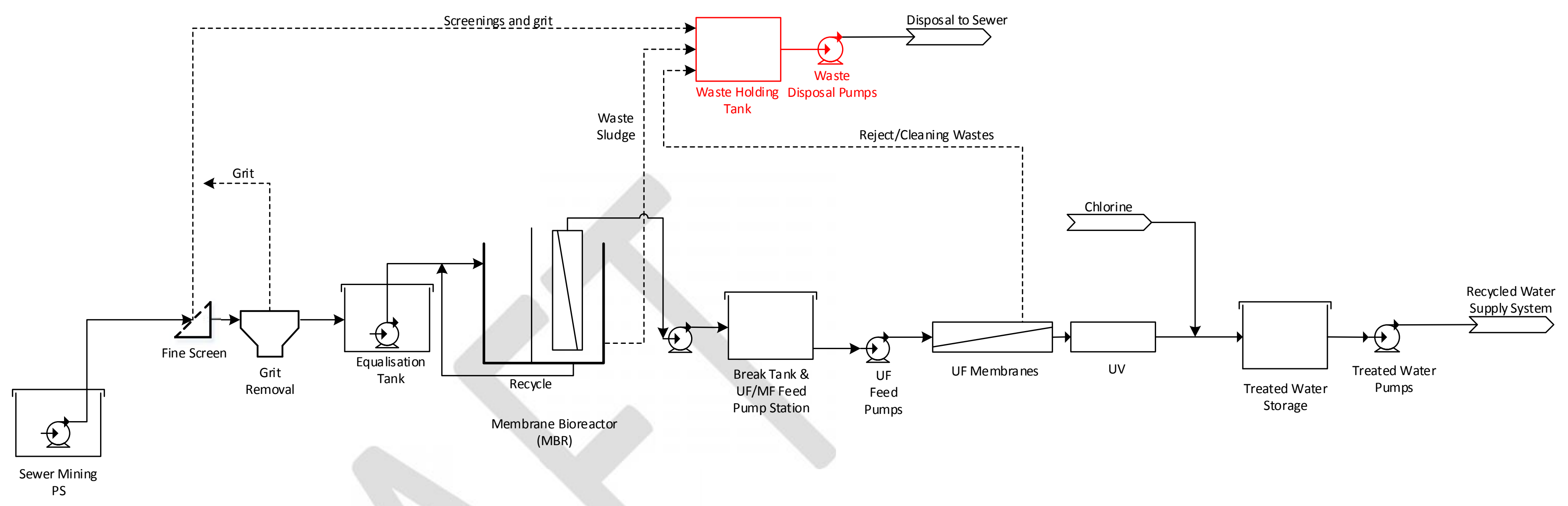
Treated Water Storage and Transfer System: Balance recycled water production and demand

What dictates footprint?	Detention Time	Configuration
Elimination	• NA	• Construct future MBR tank and use as treated water storage until Stage 2 required
Substitution/Reduction	• Optimise chlorine contact time and baffling reactor (MCG plant experience)	• Investigate smaller storage at treatment plant and decentralised storages throughout the precinct
Engineering	• NA	• Increase height to reduce footprint

Discussion Notes:

- Key opportunities are to utilise one or two MBR tanks for recycled water during stage 1 and consider reduced storage at the treatment plant and decentralised storages throughout the area.

Fishermans Bend Sewer Mining Plant
Waste Holding and Transfer System



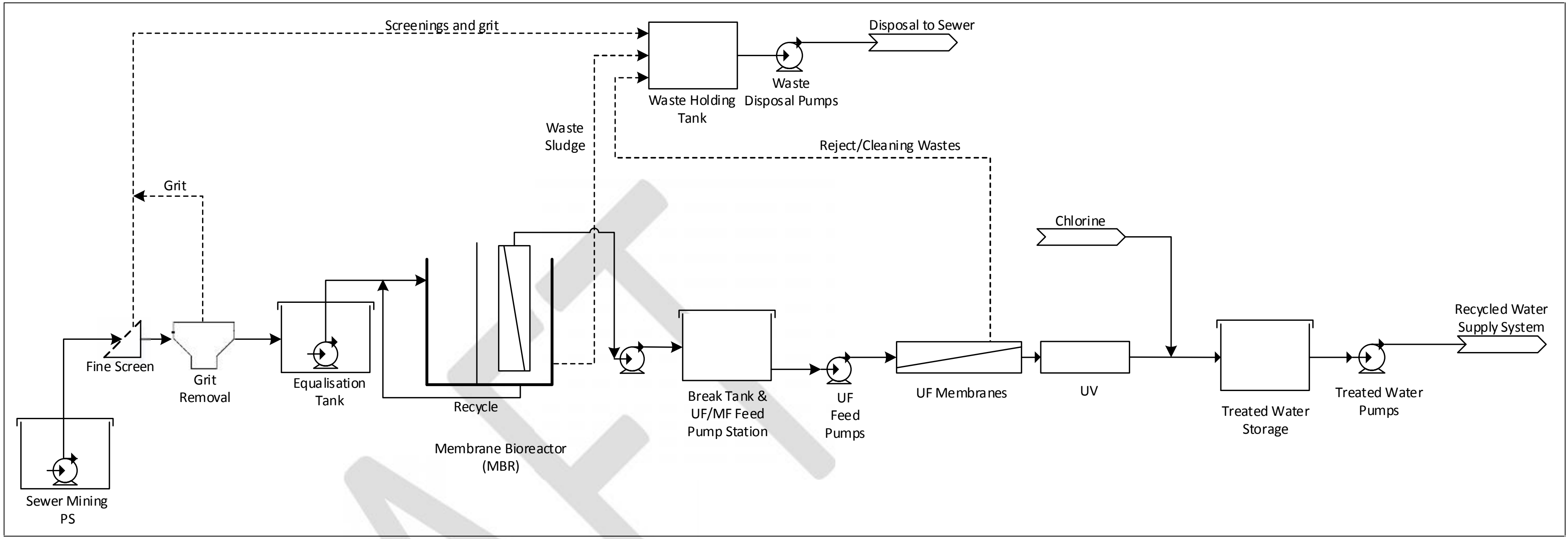
Waste Holding and Transfer System: Balance waste production and discharge to sewer

What dictates footprint?	Hydraulic load	Detention Time
Elimination	• NA	• Screenings and biosolids returned directly to sewer via macerating pumps (MCG plant experience)
Substitution/Reduction	• Maximise return of waste streams to MBR where possible	• NA
Engineering	• NA	• NA

Discussion Notes:

- Eliminating the waste holding system is possible but due to the large volumes and distance between the plant and the sewer a pump station well has been included. If the plant was located close to the HBM then there may be an opportunity to eliminate the need for this system

Fishermans Bend Sewer Mining Plant
Odour Control



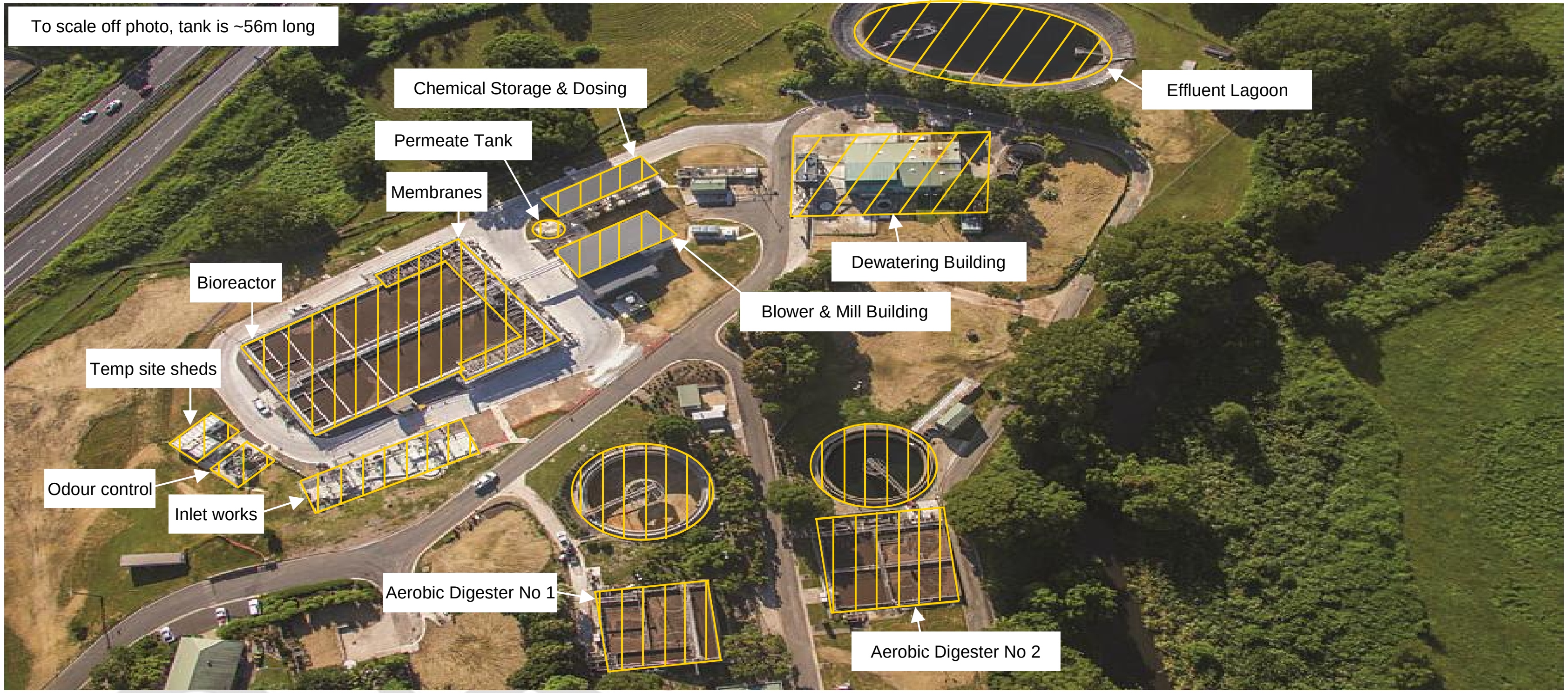
Odour Control: Manage odour control risk

What dictates footprint?	Building Volume	Open Tank Area	Odour Control Treatment Infrastructure
Elimination	• Install all process equipment outside and manage foul air through covers over process equipment	• NA	• Foul air diverted through MBR
Substitution/Reduction	• Contain odorous processes (e.g. pre-treatment) in building – all other processes located externally with foul air removal covers where required	• NA	• Chemical scrubbing over biological scrubbing to reduce footprint
Engineering	• NA	• NA	• NA

Discussion Notes:

- NA

Fishermans Bend Sewer Mining Plant
General



General: Provide access and ancillary services

What dictates footprint?	Roads/Access/Carparks	Administration Buildings/Laboratory
Elimination	• NA	• NA
Substitution/Reduction	• Minimise access routes through plant and rely on overhead gantry systems for maintenance access	• Consider located this infrastructure on a second level above process infrastructure
Engineering	• NA	• NA

Discussion Notes:

- Plant 3D modelling was used by Downer for the MCG plant to identify potential clashes, construction sequencing and opportunities for reducing footprint when dealing with site constraints. GHD also used this approach for the Warrnambool WRP blower augmentation due to site constraints and the need to retain blower capacity during construction, and it was also used for the Liverpool WWTP design (refer international experience)

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https://projectsportal.ghd.com/sites/pp17_01/updatetofishermansbe/ProjectDocs/12531442-REP-SMP-Concept Design.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	M. Trickey	R. van Oorschot		R. van Oorschot		02/08/2016
1	R. Argento	M. Trickey		M. Trickey		26/06/2020

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