Warrnambool Screening Strategy

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Glossary

Activated sludge	A type of secondary treatment, an aerobic biological process to remove dissolved nutrients.
Effluent	Treated flow leaving the plant.
IDEA	**I**ntermittent **D**ecant **E**xtended **A**eration process, part of the activated sludge process used at Warrnambool STP.
Influent	Untreated flow entering the plant.
MBR	Membrane Bioreactor – A combination of a microfiltration with a biological treatment process.
Media filtration	Sand (or similar material) filtration for tertiary treatment.
Microplastic	Plastics smaller than 5 mm, includes fibres, beads, plastic pellets and plastic fragments.
NPC	Net Present Cost – A calculation of the costs over a period of time.
Primary treatment	Screening, grit removal and/or gravity separation of solids from the influent.
Secondary treatment	A process following primary treatment to remove dissolved and suspended organic compounds.
Septage	Incoming wastewater from a third party – e.g. waste from septic tanks delivered via a tanker.
STP	Sewage Treatment Plant.
Tertiary treatment	An additional treatment process following secondary treatment, often to treat water to a standard where it can be reused - Watering golf courses, wash down facilities etc.

Background and key issues

Background

The illegal dumping of nurdles through the Warrnambool Sewage Treatment Plant (STP) and their subsequent spill into the ocean in November 2017 highlighted the global problem of plastic pollution on beaches.

With Wannon Water's impending upgrade to the Warrnambool STP, it is timely to investigate the plant's screening requirements and investigate best practice technology that provides a safe, reliable and permanent solution to maximise screening performance and environmental protection.

Wannon Water commissioned engineering consultants GHD to prepare a screening strategy for the Warrnambool STP. It is envisaged that, in the future, this strategy will help inform improvements for Wannon Water's other STPs. Nonetheless, the focus of this work is the Warrnambool STP.

This document was developed to provide context to the issue and analysis of possible strategies that Wannon Water may choose to put in place to minimise risk to the environment.

Problem identification

Solid pollutants in domestic and industrial wastewater include large items such baby wipes and rags, and smaller objects (both visible and non-visible) including cotton buds, straws, microbeads from cosmetic products, fibres from clothing, and nurdles.

Many of these pollutants cannot be removed from wastewater by chemical or biological means, and without appropriate physical separation (including screening), they will end up being discharged as either effluent or biosolids. Indeed, various studies have found increased concentrations of microplastics in surface water downstream of wastewater treatment plants, as well as evidence of microplastics in biosolids.

The environmental impact of microplastics and other small particular matter in marine environments is a growing area of research. Key areas of concern include plastics entering the food chain, the effect of ingested and entanglement on wildlife and impact on habitat.

There is increasing global awareness of the risks of microplastic discharge from STPs and how this may effect the environment. The concept of "best practice" in terms of STP performance and licence conditions can vary over time. What was historically regarded as best practice changes in response to the changing state of science and community expectations.

Key issues

- What is Wannon Water’s role at different parts of the plastic lifecycle?
- How will microplastics/inerts that enter the plant be managed/disposed of?
- Are there any implications for future upgrades/other sites?

Simplified process flow diagram showing the potential pathways for microplastics to enter and leave the Warrnambool STP

Waste management hierarchy

Possible strategies relating to plastics entering the sewer

Elimination/ Avoidance
- Ban on plastics
- Voluntary avoidance, use of alternatives

Reduction, reuse and recycling
- Education and awareness
- Recycling process

Engineering Solutions
- Screening / filtration

Management
- Protocols, audits of customers
- Outfall and beach monitoring

Disposal
- Recovery from the plant and sent to landfill
- Beach clean-up and sent to landfill

Scope and use of this strategy

As indicated in the hierarchy on the previous slide, ideally the focus should be on elimination and reduction.

Wannon Water is either directly or indirectly acting across all areas of the hierarchy. For example, the *Be Smart Choose Tap* program directly promotes avoidance of single use plastic water bottles and the *Be Clever, Never Ever* campaign to influence what customers flush down toilets.

The scope of this report considers controls that Wannon Water can implement as part of the Warrnambool STP upgrade i.e. engineering controls.

The strategy has been an internal working document, reviewed and used over the last 10 months by the Wannon Water Board, senior management, capital works team (and consultants), operations team, and the Environment Protection Authority (EPA). It has led to Wannon Water committing to industry-leading effluent screening standards for the Warrnambool STP.

This screening strategy will remain as a living document and continue to be updated as new information, developments and technology emerge to help inform best practice at Wannon Water STPs in the future.

It has led to Wannon Water committing to industry-leading effluent screening standards for the Warrnambool STP.

Typical plastic pollutants and sewage treatment technologies

Plastic pollutants

Nurdles

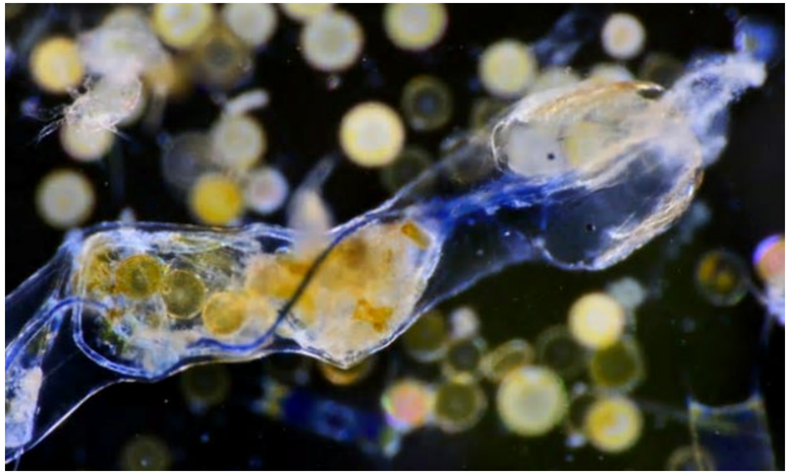
Cotton buds

Micro plastics

Plastic straws

Micro beads

Micro fibres



Plastic capture by sewage screening technologies

The table below shows the range of wastewater treatment plant screening technologies based on their aperture.

Screening class	Aperture	Technology	Rags	Straws	Ear buds	Microplastics	Nurdles
Coarse screens	≥ 6 mm	Bar screen	✓	✗	✗	✗	✗
Fine screens	0.5 mm - 6 mm	Bar screen	✓	✓ / ✗	✓ / ✗	✓ / ✗	✓ / ✗
		Band screen	✓	✓	✓	✓ / ✗	✓ / ✗
		Drum screen	✓	✓	✓	✓ / ✗	✓ / ✗
Ultrafine screens	< 0.5 mm	Drum screen Disc/cloth filters Microfilters	N/A*	N/A*	N/A*	✓	✓
Filtration	N/A	Media filters Membranes/MBR	N/A*	N/A*	N/A*	✓	✓
			Visible to the naked eye			**Not always visible**	**Visible to the naked eye**

* pre-screening would remove these larger items

Microplastic capture across a range of STP technologies

A recent study[1] that examined microplastics (<5 mm) in several wastewater treatment plants in the USA found that:

- The majority of microplastic removal occurs in primary treatment (influent screening and gravity separation). A smaller fraction of microplastics is removed through secondary treatment (activated sludge processes), resulting in around 90% of microplastics being removed by secondary treatment plants. (The IDEA tanks in the Warrnambool STP combine activated sludge and gravity separation processes. It is estimated the capture rate at the Warrnambool STP is approximately 84%)
- Tertiary treatment was seen to be effective to various degrees in the removal of microplastics after downstream treatment processes. Media filtration (post secondary treatment) was observed to increase the total removal of microplastics entering the plant from 90% up to 97%. Furthermore, an MBR process (post preliminary treatment only) was observed to increase the total removal of microplastics entering the plant up to 99%.
- The largest proportion of microplastics in effluent was found to be fibres.
- Secondary treatment plants are typically capable of removing microbeads, however fragments more readily pass through secondary treatment.
- MBR processes are effective in removing microbeads and fragments, however some fibres are still able to pass through.
- MBR or sand filtration is believed to be the most effective method to remove microplastics, however there is still no guarantee that 100% will be removed.

Screening experience in Australia

Summary of experiences across Australia

Australia has 129 STPs with ocean outfalls. A survey of a number of Australian water authorities revealed (plants listed in following slides):

- Most STPs in Australia with an ocean discharge have no dedicated effluent screening for microplastics and other inert material. Any screening of these materials is incidental e.g. as a result of nitrogen polishing.
- All STPs that discharge to the South East Outfall (Melbourne Water and South East Water) have tertiary treatment prior to discharge. This was in response to a number of aesthetic and environmental issues.
- Sydney Water recently commissioned a ‘screening strategy’. However, this study was primarily concerned with screening influent to protect downstream infrastructure and did consider screening influent/effluent to minimise the risk of inert particles passing through their treatment processes.
- Following the nurdle incident in Warrnambool, general interest as to any changes that Wannon Water will make to respond and prevent further incidents was evident following a survey of water corporations across Australia.

Australian STPs with ocean discharges

Victoria

- Eastern Treatment Plant (S.E suburbs) now has tertiary treatment with biological media filtration (south east outfall).
- Boneo STP (Mornington Peninsular) – tertiary treatment with UF membranes (south-east outfall).
- Mt Martha STP (Mornington Peninsular) tertiary treatment with UF membranes (south-east outfall).
- Black Rock STP – influent fine screens (no effluent screening).
- Anglesea STP – influent fine screens (no effluent screening).
- Lorne STP – influent fine screens (no effluent screening).
- Apollo Bay STP – influent fine screens (no effluent screening).

Australia has 129 STPs with ocean discharges.

Australian STPs with ocean discharges

South Australia

- Bolivar STP (upgrading now) – 3mm influent drum screens, but has lagoon sedimentation prior to outfall.
- Glenelg (upgraded 2017) – 3mm wedge wire band screens.
- Christies Beach (upgraded in 2013) – 3mm wedge wire drum screens, multiple process trains, one MBR train with additional 2mm screening (major operational expenditure costs).
- Finger Point, Mount Gambier (Upgraded 2007) – 3 mm step screen and grit vortex removal.
- All plants have outfalls >1km.

New South Wales

- Deep ocean outfalls for Sydney plants.
- Currently have no dedicated effluent screening.
- Screening strategy being undertaken.

Australia has 129 STPs with ocean discharges.

Australian STPs with ocean discharges

Queensland
- South Caboolture STP - MBBRs and disc filters provide effluent polishing (primarily for nitrogen removal) prior to discharge into the Caboolture River.
- Wynumm STP (discharge to river mouth) - 5mm influent band screens
- Luggage Point STP (discharge to river mouth) - 5mm influent band screens.

Western Australia
- Beenyup STP – 6mm influent step screens.
- Wooman Point STP – 6mm influent step screens.
- Subiaco STP (upgraded 2018) – 5mm influent band screens.
- Kwinana STP – 5mm influent band screen.
- East Rockingham STP – 5mm influent band screen.

Australia has 129 STPs with ocean discharges.

Warrnambool STP Screening

Current screening process

The current screening process at the Warrnambool STP is shown on the next slide and consists of influent and effluent screening

Influent screening

Influent from the sewerage network is screened through a 3 mm step screen. The step screen has a bypass with a manually raked bar screen; this is used only in the event of peak flows or when the step screen is offline (e.g. for maintenance for 2-3 hours bi-annually). Septage passes through a dedicated septage receival unit that contains a drum screen with a 6mm aperture. The septage mixes with the main influent stream upstream of the step screen.

All screened effluent passes through an aerated grit removal channel, after which point the sewage is treated in the IDEA tanks. There is also a manually operated bypass around the aerated grit removal channel, which is only used when the channel must be taken offline for maintenance (not routine).

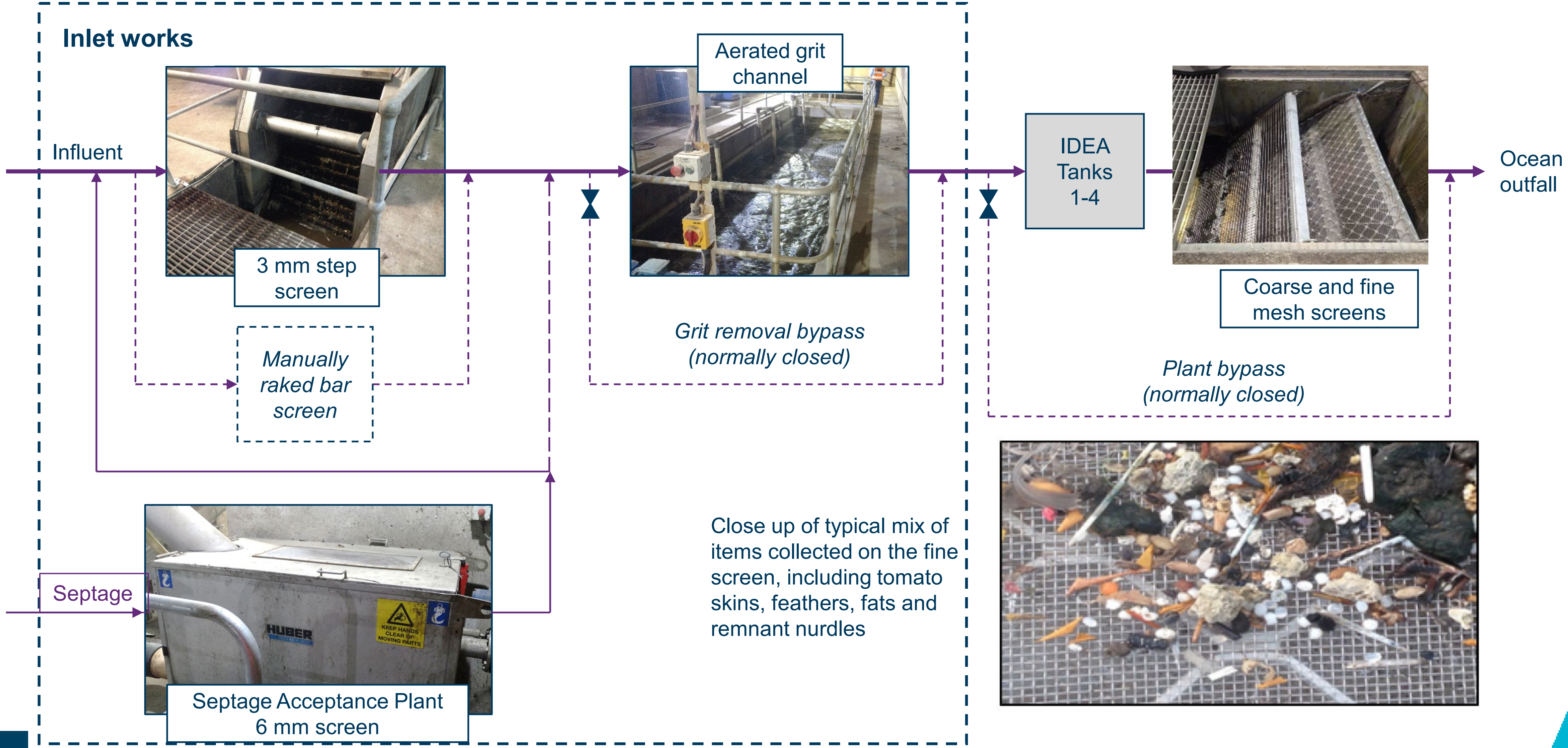
Effluent screening

Following the recent nurdle incident, Wannon Water installed a coarse mesh screen and a fine mesh screen in the effluent channel. These screens are manually cleaned approximately twice per day. These screens capture a low volume of solids, with a 20-litre bucket filled approximately every month. The screenings typically consist of fats, ear buds and organics (such as tomato skins). When the screens were first installed, a number of nurdles were also captured.

Plant bypass

The old outfall pipeline extends from the influent pump station to the ocean outfall, and can be used as an emergency bypass in the event of a power outage at the plant. This has not been used since the plant was built in the mid 1990s and the condition of this pipeline is unknown.

Current



Close up of typical mix of items collected on the fine screen, including tomato skins, feathers, fats and remnant nurdles

Note: Septage was re-routed following the nurdle incident to be mixed with main influent stream upstream of the step screen. Screening waste streams are not shown.

Screening options considered

Following the nurdle incident, Wannon Water installed a fine mesh screen on the effluent channel. This screen is manually cleaned and captures some of the inert material prior to discharge, but due to the manual nature of the cleaning process is not considered suitable long-term. Furthermore, the aperture of the screen is not considered sufficient to mitigate the risk of microplastics being discharged to the ocean.

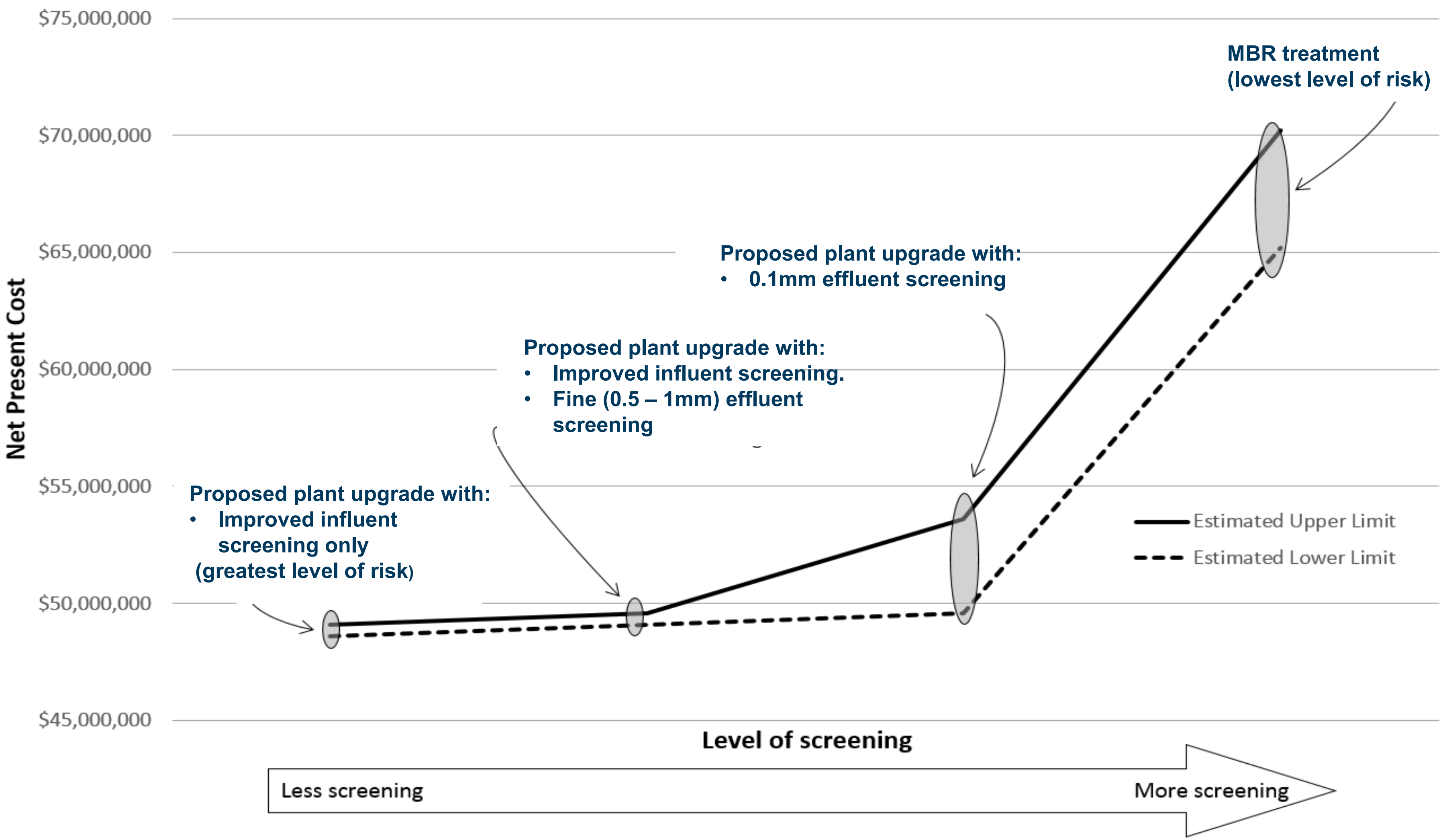
Engineering solutions for the Warrnambool STP to manage the risk of microplastics and inert particles entering the marine environment need to be considered as a strategy that is implemented over time. This enables Wannon Water to adapt to new research and investigations into the environmental impacts, but also consider how financial investment can achieve the best overall environmental benefits.

While microplastics in particular are becoming a prevalent issue in the media, it is important to remember that investment to reduce energy consumption or the release of nutrients may provide similar or greater overall environmental benefit. Further, investment in reducing pollutants at the source (e.g. customer behaviour change, commercial trade waste pre-screening) may be more cost-effective than capture at the STP.

Four engineering solutions for the Warrnambool STP have been considered.

- **Influent screening only:**
  - Enhanced influent screening i.e. band screens and improved septage receival with permanent back-up.
- **Influent and fine effluent screening:**
  - Enhanced influent screening i.e. band screens and improved septage receival with permanent back-up.
  - Effluent screens with 0.5 to 1mm aperture.
- **Influent and <u>ultra</u> fine effluent screening:**
  - Enhanced influent screening i.e. band screens and improved septage receival with permanent back-up.
  - Effluent screens with 0.1 mm aperture.
- **Influent screening and membrane filtration:**
  - Enhanced influent screening i.e. band screens and improved septage receival with permanent back-up.
  - Conversion of the entire plant to a membrane bioreactor (MBR) based process.

Level of screening and cost graph



This graph show high-level cost estimates for engineering solutions specific to the Warrnambool STP. Net present cost has been used as opposed to capital cost to better reflect the whole of life cost.

Discussion of options

The net present cost for the four options was calculated over a 20-year period and is presented in the figure on the previous page. It is based on preliminary investigations undertaken by GHD and includes the ability for Wannon Water to increase the plant’s capacity in the event of a sudden increase in flow or load.

From the figure, it can be seen that there is a significant increase in cost with improved “screening”. The inclusion of 0.5 mm to 1 mm effluent screens only marginally increases the cost of the upgrade over a 20-year period, but significantly lowers the risk of release of microplastics and other inert material to the ocean. Effluent screens with larger apertures are likely to provide lower performance at a similar cost.

After a thorough analysis of operational issues, risks and environmental performance, Wannon Water has commenced procurement of a 1 mm aperture band screen for the existing section of the plant (tanks 1-4).

Reducing the effluent screen aperture to as low as 0.1 mm would provide additional benefits, but at an increased cost. There is a greater level of uncertainty in the cost of this option, as there are a number of unknown risks, including increased head loss in the effluent channels, reduced channel area available for future effluent disinfection (if channel UV is employed in future), increased pumping of backwash water, and disposal of additional solids.

Further screening by way of conversion to MBR would almost eliminate the discharge of microplastics or other inert material to the ocean. However, this option would increase energy use and this negative environmental impact would need to be considered. Furthermore, this corresponds to a step increase in cost, largely due to increased operating costs and the need to provide flexibility to rapidly respond to major unforeseen changes to influent loads (a key objective for Wannon Water). The cost for this option does also not consider the separation of these particles from biosolids, which may incur additional costs.

As stated above, this initial investment to protect the environment must be considered in the context of other opportunities for reducing environmental impacts. Given that the environmental benefits that would be achieved from increasing effluent screening from fine (0.5 mm to 1 mm) to ultra-fine (<0.01 µm) are not readily quantifiable, and whether this investment achieves the greatest environmental benefit, at this time adoption of a membrane-based process is not recommended.

However, it is recognised that the performance of the effluent screening system is paramount to managing risk for the environment and Wannon Water. Therefore it is recommended that a dedicated performance based contractual approach is adopted for the delivery of this infrastructure that enables selection of a robust process. Pilot trials are also suggested to inform equipment selection if time permits.

Proposed process for 2019-2022 upgrade

Influent screening

- 5mm band screens (with standby) which would remove a greater (75-85% capture) volume of screenings than the current step screen (e.g. ear buds would need to line up perfectly with a 5 mm hole rather than pass through a long, 3 mm slit).
- Septage would be screened with a 10 mm perforated drum screen and continue to be mixed with the main influent stream upstream of the band screens. Increased monitoring and security meaures are also proposed at the septage receival point.
- Vortex grit chamber for all effluent.

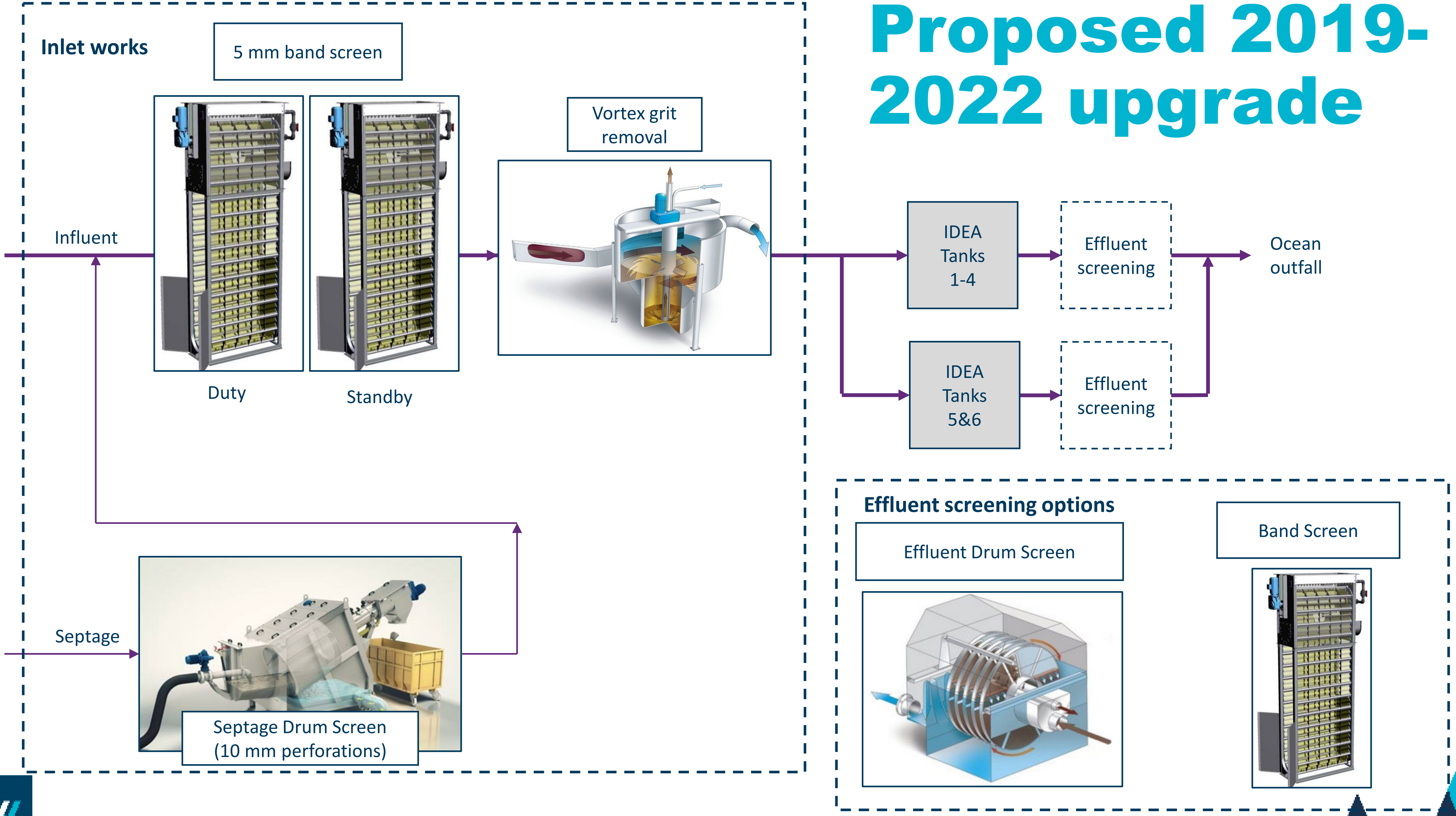
Effluent screening

- Fine screens downstream of IDEA tanks 1-4, 1 mm aperture band screen (2019)
- Fine screens downstream of IDEA tanks 5-6, 0.5 to 1 mm aperture, drum or band (2022).

Provisions for future screening

- Channels in inlet works to allow space for additional band screens if required as part of a future MBR upgrade.

Proposed 2019-2022 upgrade



Note: Screening waste streams not shown

Proposed future screening process - MBR

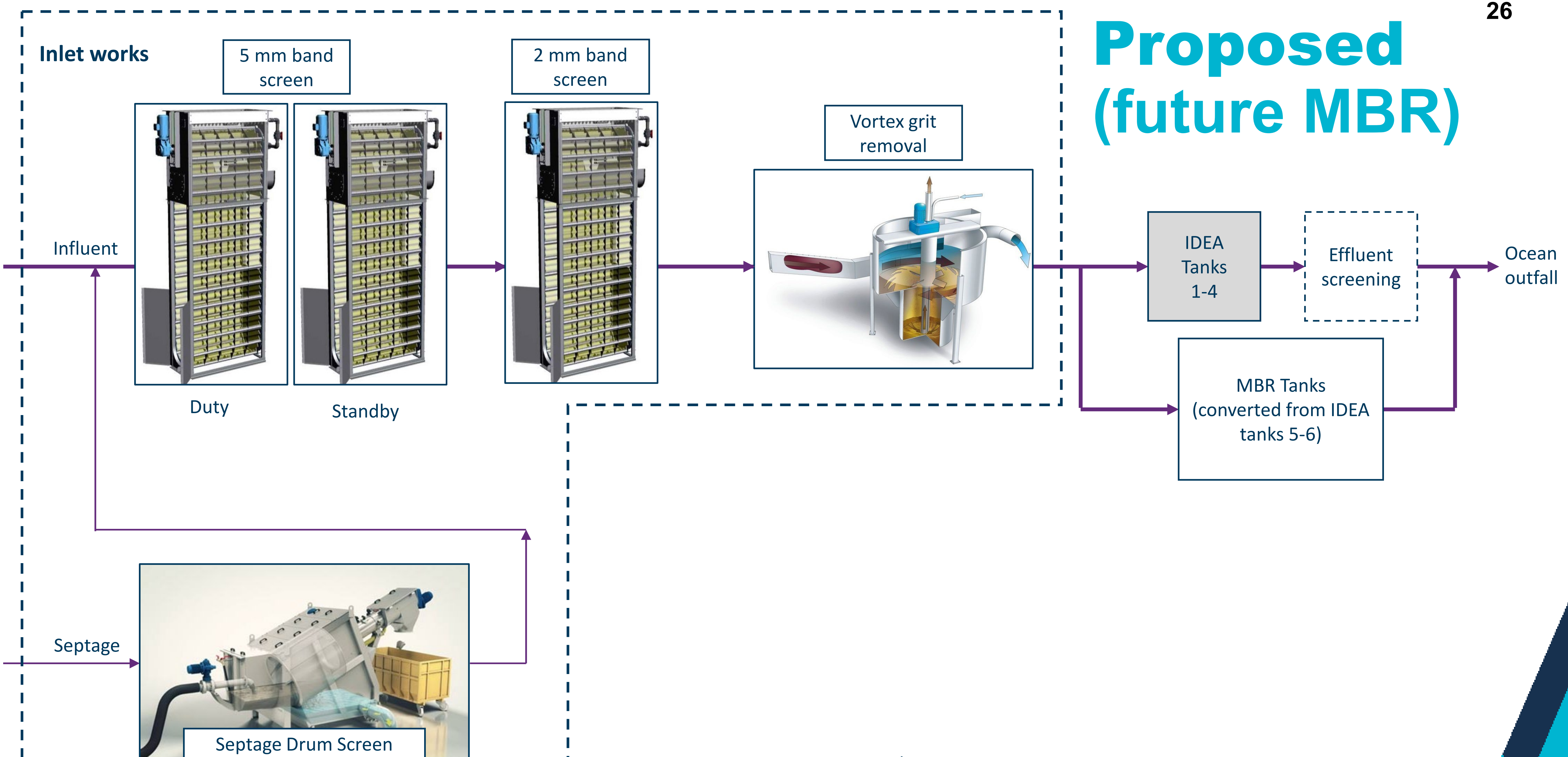
MBR screening

- MBRs to provide incidental screening of microplastics and other suspended solids (up to 99% of microplastics entering the plant).
- Microplastics in MBR tanks diverted to Waste Activated Sludge (WAS).

Additional influent screening option

- 2 mm band screens downstream of the 5 mm band screens.
- 2 mm aperture band screens will remove a greater proportion of particulate organic matter which impacts the ability of the process to reduce nitrogen levels in the wastewater.

Proposed (future MBR)



Note: Screening waste streams not shown

Screening strategy over time

As stated, the screening strategy for the Warrnambool STP would be implemented over time as new research and information becomes available, and low cost solutions (such as effluent screening) are implemented to provide a practicable and cost effective solution for Wannon Water's customers and community in the short-medium term.

The proposed strategy is outlined below, and includes a staged approach to moving towards membrane filtration in future. This approach is also considered to provide a level of screening that is consistent or greater than what most other treatment plants with full discharge (no reuse) are employing. It can therefore be considered at or better than the industry standard for managing the release of microplastics and inert material into the ocean environment.

Pre Nurdle Incident

- 3mm step screen - 30-40% capture
- No standby units - manually raked bar screen
- 6 mm screening for septage

Nurdle Incident
Nov 2017

Current

- 3mm step screen - 30-40% capture
- No standby units - manually raked bar screen
- 6mm screening for septage plus routing via step screen (double screening)
- Effluent screening – Coarse and fine mesh screens

2019 Upgrade – accelerated works for existing plant

- Effluent screening 1 mm band

2022 Upgrade

- 5mm band screen - 75-85% solids capture rate, full duty/ standby
- Double screening of septage
- Effluent screening, 0.5 to 1 mm drum or band

Future Upgrade (MBR) - New IDEA tanks

- 5mm band screen - 75-85% solids capture rate
- Full duty/ standby
- 2mm band screen – full duty/standby (all influent)
- Double screening of septage
- Membrane filtration of ~30% effluent

Future Upgrade (MBR) - All IDEA tanks

- 5mm band screen - 75-85% solids capture rate
- Full duty/standby
- 2mm band screen – full duty/standby
- Double screening of septage
- Membrane filtration of ~100% effluent

Conclusion

With the current manually cleaned fine mesh effluent screen and dual screening of septage, effluent from the STP has been enhanced and led to increased level of protection of environmental values of the local marine environment. Considering this, it would be irresponsible for any future upgrade of the plant to have a lower level of screening. However, this process must also be made safer and easier to operate by means of automation rather than manual cleaning.

This screening strategy should not be seen as an endpoint, rather a response to a specific issue, with potential improvements in the future once screening technology becomes more efficient and the environmental impacts on the marine environment from STP effluent are better understood.

There is also a balance between other positive environmental impacts that Wannon Water could be making, especially as the quantifiable effects of microplastics in the marine environment is a growing area of research.

The proposed approach for the Warrnambool STP is to install an effluent screening system with 1 mm band screen for the existing part of the plant in 2019 and 1 mm or finer screen for the new section of the plant in 2022. This is considered to be a practicable way forward as it does not significantly impact system hydraulics and will further improve the capture of inert materials. However, there is an opportunity to explore smaller aperture screens as part of a dedicated procurement process that includes performance guarantees around head loss and solids capture so that the theoretical cost versus screening can be tested to maximise environmental risk mitigation.

In time, a greater response may be required to protect the marine environment from particles smaller than those that would be screened out based on the current proposed approach.

In parallel, Wannon Water has an opportunity to be a leader for the water industry with its response to the nurdles incident. Robust engineering solutions should only form part of this response, and other activities that build on the *Be Clever, Never Ever* initiative (including further engagement with industry, further education of its customers and contribution to relevant research programs and beach clean-up programs) also seem worthy of further consideration.

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