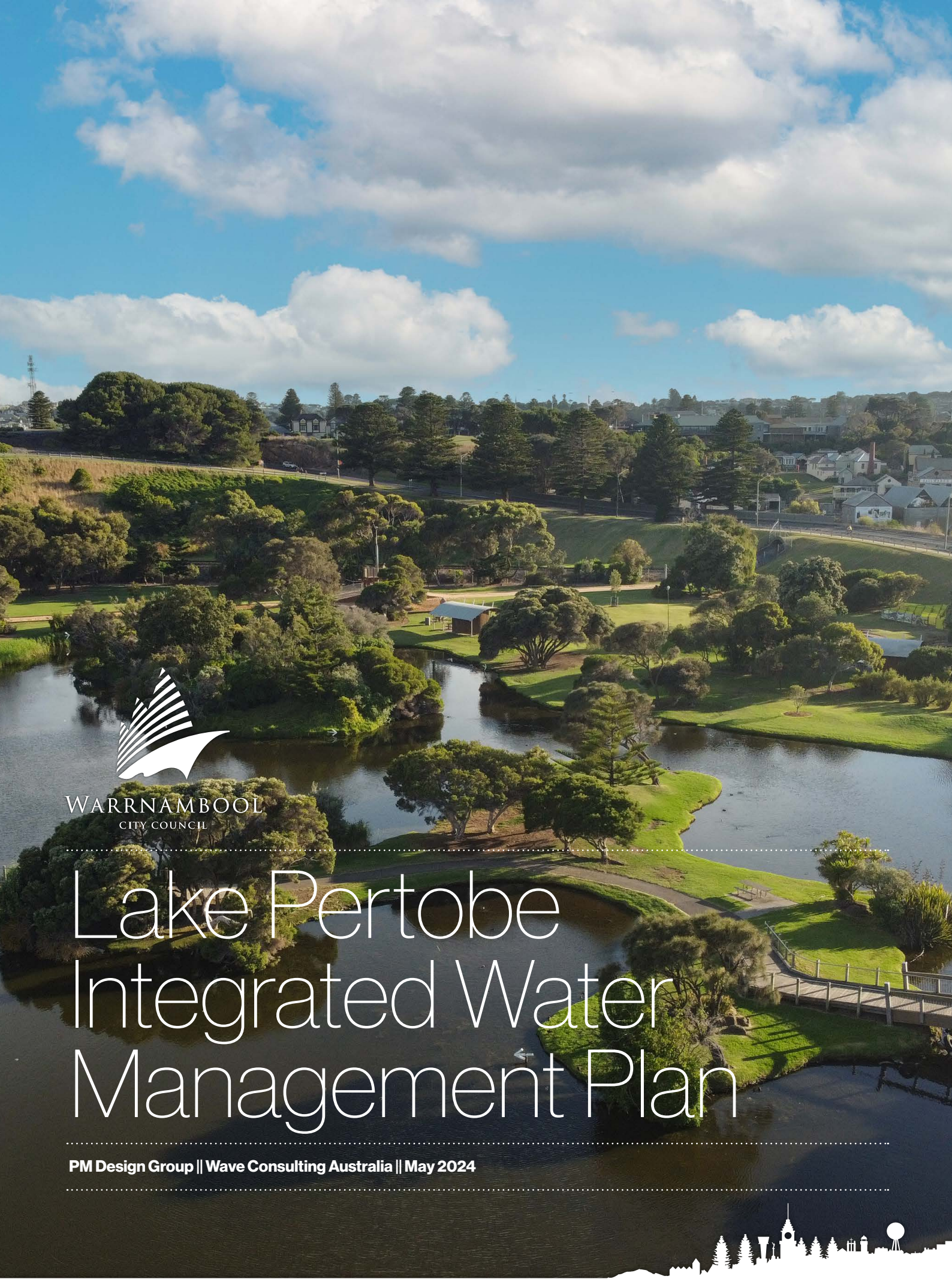


WARRNAMBOOL
CITY COUNCIL

Lake Pertobe Integrated Water Management Plan

PM Design Group || Wave Consulting Australia || May 2024

Pareeyt Poondee-teeyt.
Water is Life.
Dhauwurd Wurrung language group

Pa poonteeyt paman paman.
And life is sacred.
Keerray Wurrung language group

Integrated Water Management is a collaborative approach to water planning and management that brings together organisations with an interest in all aspects of the water cycle.

It has the potential to provide greater value to our communities by identifying and leveraging opportunities to optimise outcomes.

Figure 1: Excerpt from Great South Coast Strategic Directions Statement

Acknowledgements

Lake Pertobe is situated on the lands of the Traditional Owners, the Eastern Maar People and Aboriginal communities of the Maar Nation.

This project was supported by the Victorian Government.

The Working Group included:
Warrnambool City Council (WCC)
Wannon Water (WW)
Eastern Maar Aboriginal Corporation (EMAC)
Department of Energy, Environment and Climate Action (DEECA)
Southern Rural Water (SRW)
Glenelg Hopkins Catchment Management Authority (GHCMA)

Version: Final
Distributed: May 2024
All photos and images by PM Design and Wave Consulting unless otherwise stated.

Contents

Figure

1. Executive Summary

The Lake Pertobe precinct of Warrnambool has major potential for an all-inclusive Integrated Water Management (IWM) approach within its highly regarded open space.

The IWM consultation process involving stakeholder engagement and community involvement, has highlighted water management factors of Lake Pertobe, specifically its low-lying lakes and land, the substantial influx of over 1000 ML of stormwater per year, and the utilization of potable water for irrigation. Notably, recent weather patterns, characterized by two years of relatively cool conditions and above-average rainfall (in 2021 and 2022), have shifted the community's focus towards flooding and drainage issues, with water security and scarcity taking a backseat. It is worth noting that the path between the Mill and Main Lakes was temporarily closed during the development of this IWM Plan due to these concerns.

Key opportunities for Lake Pertobe's IWM strategy include enhancements in treatment, storage, and flow control within the lakes, as well as harnessing stormwater resources. The plan identifies prospects for education and recreation and introduces initiatives in the catchment area to promote rainwater infiltration, thereby restoring a more natural, predevelopment water cycle.

To effectively reach IWM opportunities further research and knowledge development through the direct measurement of stormwater flows, monitoring changes in lake and groundwater levels over time, and assessing water and sediment quality is a priority. The acquisition of improved data and information will not only support the management of water resources in Lake Pertobe but will also facilitate more comprehensive planning of identified initiatives, including the construction of a new water basin, enhancements to lake connectivity and levels, improved public access to recreational water activities, and community education on the intrinsic value of water.

2. Parreeyt (Water)

Eastern Maar assert the right to be a part of a review of parreeyt management within our Ancestral Territory.

Eastern Maar Nation Statement - Water is Life: Traditional owner access to water Roadmap

Parreeyt is our lifeblood and as Maar people have always had a strong spiritual connection to it. For us, we continue to remain resilient to fight and care for these waters today. Let's hope we can all work together to fix the land and water issues of the past, for our future' generations to enjoy.

Eastern Maar Traditional Owner.

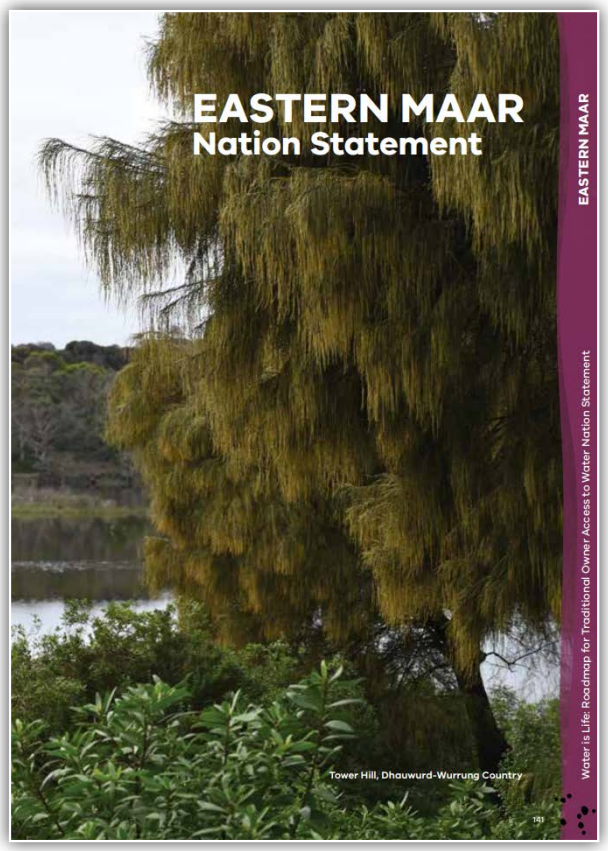


Figure 2: Eastern Maar Nation Statement cover as featured in Water is Life: Traditional Owner Access to Water Roadmap

3. Introduction

The Warrnambool Lake Pertobe precinct is described as a highly valued open space.

Following the successful completion of the Albert Park precinct Integrated Water Management Plan in 2019, Lake Pertobe was identified to have great potential for integrated water management (IWM) in 2022, given its characteristics including;

- receiving significant volumes of stormwater,
- providing natural treatment of stormwater prior to water flowing into the Merri River estuary,
- using significant volumes of reticulated potable water for irrigation and toilet flushing,
- using significant volumes of groundwater for irrigation and suppling park water features,
- addressing the area's proneness to drainage and flooding issues, and
- utilising area's current and potential for tourism, recreation, environmental and cultural values.

The highly valued Lake Pertobe has opportunities for all outcomes and objectives of IWM to be investigated, from safe, secure and affordable water supplies to economic benefits and innovation.

3.1 Lake Pertobe Catchments

The Fairy, Gillies, and Japan St catchments at over 100 Ha of urban area generate the vast majority of stormwater entering Lake Pertobe.

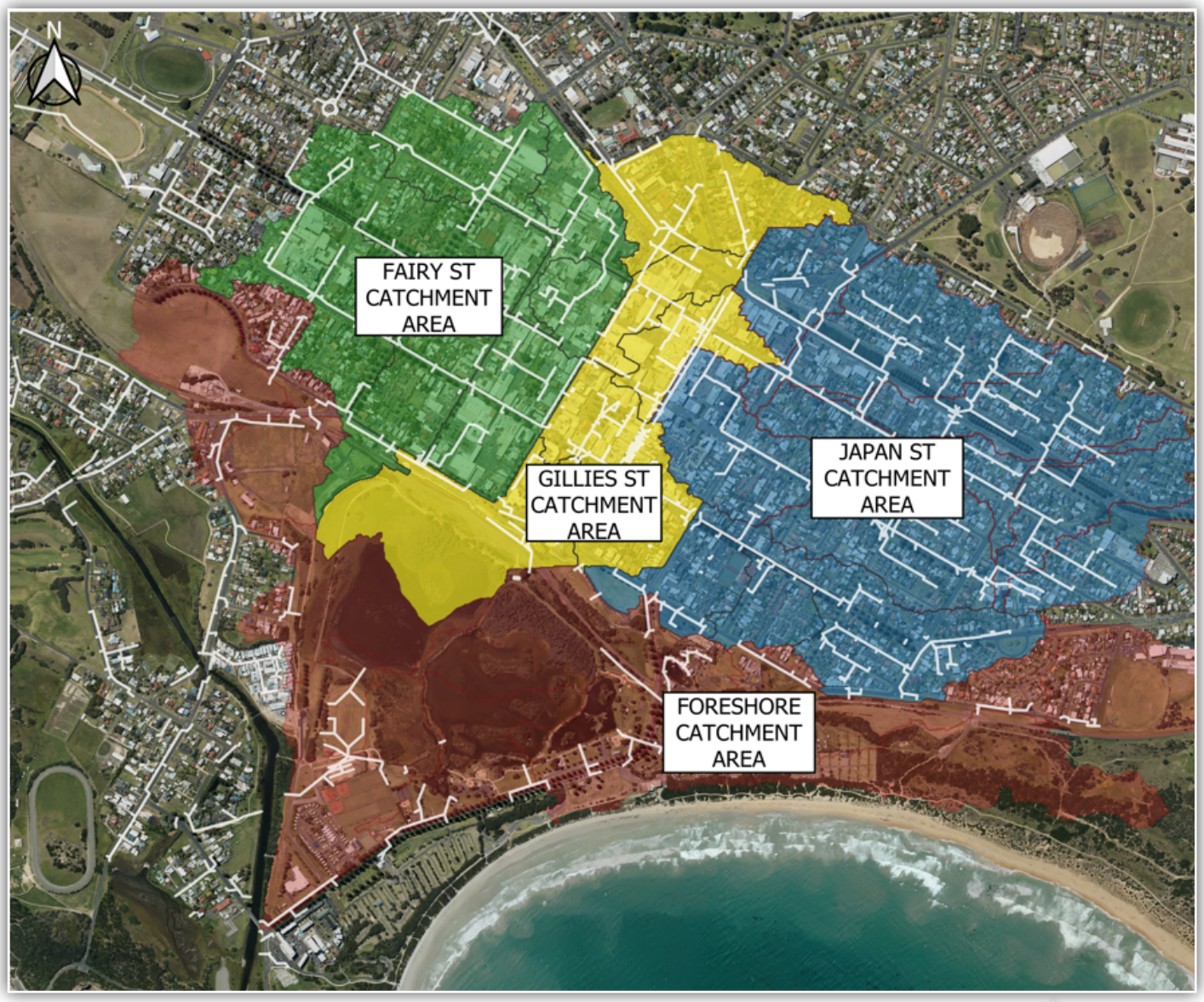


Figure 3: Stormwater catchments fbwing into Lake Pertobe (small white lines indicate the stormwater pipe network)

3.2 Integrated Water Management - what is it?

The Department of Energy, Environment and Climate Action define IWM as:

Integrated Water Management (IWM) is a holistic and collaborative approach to the way we plan for and manage all elements of the water cycle. IWM considers how the delivery of water, wastewater and stormwater services can contribute to water security, public and environmental health and urban amenity. It fundamentally shifts the way water, land use planning and urban development opportunities are understood and undertaken in Victoria (DEECA 2024).

Lake Pertobe has been identified as an opportune location for addressing a diverse range of water cycle management issues through an integrated water management approach. This location has the potential to act as a demonstration precinct to:

- Utilise rainwater or treated stormwater/wastewater to supplement potable drinking water usage.
- Implement water-efficient technologies.
- Raise community awareness of holistic water cycle management at Lake Pertobe.
- Incorporate stormwater retention and treatment systems to mitigate downstream flooding and pollution impacts.
- Enhance and protect Lake Pertobe's unique ecological and biodiversity features.

This IWM Plan aims to transform the landscape and enhance the visitor experience at Lake Pertobe through delivering integrated water management actions consistent with the seven IWM Outcome Areas outlined in the Great South Coast Strategic Directions Statement 2023. This plan will build on improving water cycle management for Warrnambool and build on the previously delivered projects outlined in the 2019 Albert Park IWM Plan, including the Warrnambool Roof Water Harvesting Initiative and the installation of raingardens throughout the city to support a more liveable, sustainable, and economically prosperous region.

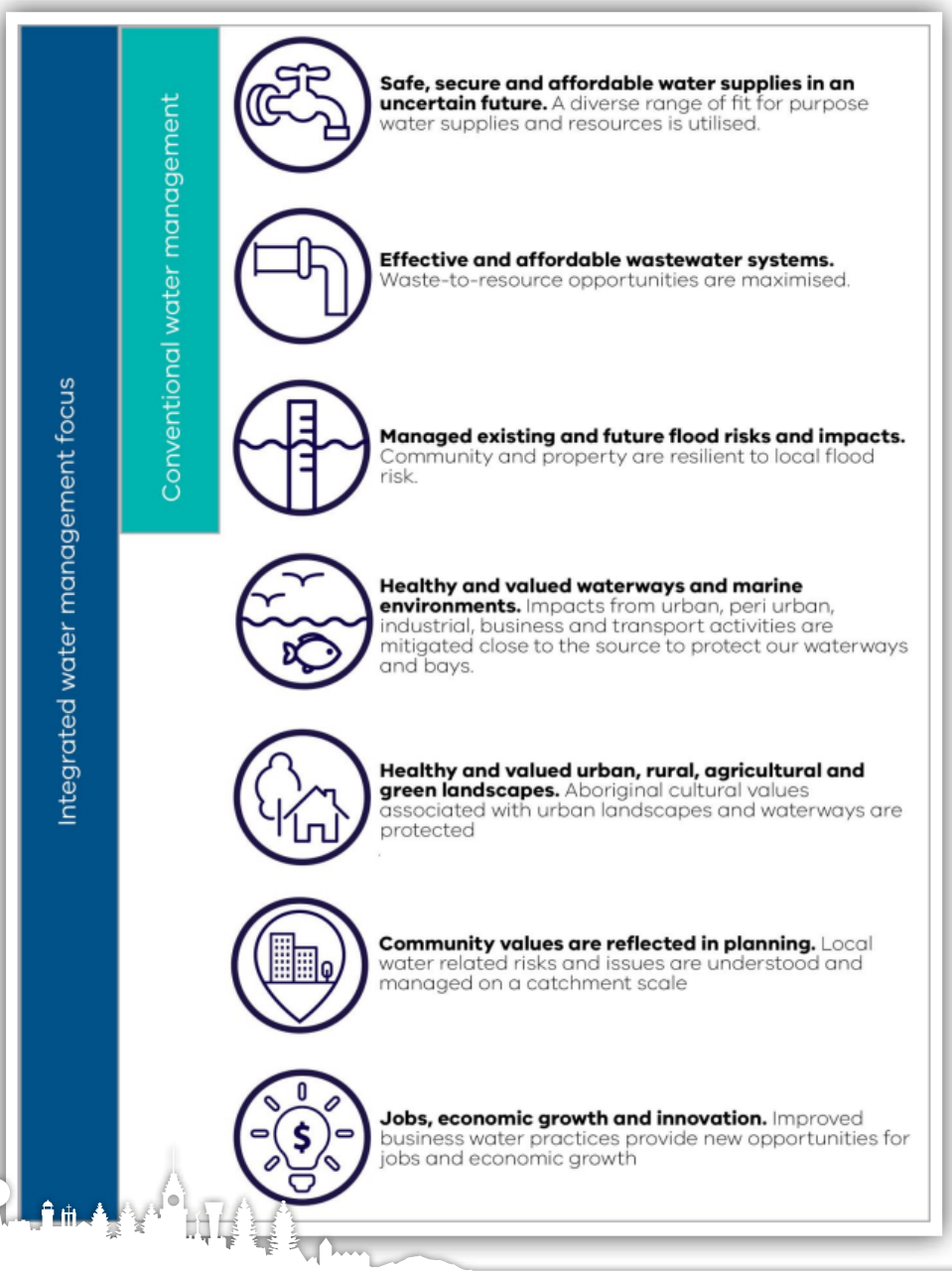


Figure 4:
Excerpt from Integrated Water Management Progress Report March 2022

Water play space at Lake Pertobe

4. Lake Pertobe

The name "Lake Pertobe" originates from the local Gunditjmara/Dhauwurd Wurrung language, where "pirtup" means "Small Sandpiper". The area spans 58 hectares (Lake Pertobe Masterplan 2018).

It is situated between the city's central business district (CBD) and the beachfront. Evolving from ephemeral wetlands in the 1970s, it has transformed into a popular attraction with recreational lakes and an adventure playground and is known for its diverse play options and extensive social spaces. Over the past four decades, Lake Pertobe has emerged as Warrnambool's most prominent visitor destination.

Lake Pertobe is at the end of the terrestrial (land) portion of the water cycle, situated just a metre above sea level, adjacent to the saline southern ocean. It is comprised of three lakes - Mill, Main, and Kids Lakes - with relatively shallow depths and fringed with a diverse array of vegetation, including indigenous, native, and noxious species.

Stormwater from upstream catchments, including the Warrnambool CBD, is the largest flow of water into the lakes, namely at the Fairy, Gillies and Japan Street outfalls. Direct rainfall and runoff from park grounds also contribute to the lakes' water inputs. Groundwater lies at a depth of approximately 1-2 meters below the current surface level, and the prevailing notion is that the lakes sit above the groundwater table. This is evident during hot, dry periods, such as the summer months, when the lakes exhibit signs of drying out. Groundwater serves a year-round role, supplying water for features like splash pools and water play areas, and is used to maintain adequate water levels in the lakes throughout the summer months.

Flowing out into the Merri River, the lakes discharge at the southern edge of Mill Lake. During periods of elevated water levels in the Merri River estuary, water may reverse its course and flow back into the Lake Pertobe system. Drainage and flooding issues typically arise during the winter season, characterized by extended periods of rain that saturate the ground.

Figure 5: Key IWM related features at Lake Pertobe

5. Vision

Lake Pertobe IWM Plan Vision

Lake Pertobe is Warrnambool's most iconic thriving open space precinct.

Integrated Water Management enables Lake Pertobe to be more liveable, resilient, sustainable, ecologically diverse, and prosperous. Lake Pertobe inspires Warrnambool's residents and visitors to gather, play and enjoy the lakes and surrounds.

Challenges by our changing climate include resilience and sustainability of community assets

6. Objectives

The Lake Pertobe IWM Plan has eight key objectives;

1. Engage and support the land and water managers in the precinct in more sustainable water use.
2. Identify opportunities to reduce demand on potable supply.
3. Identify opportunities to improve the quality of stormwater discharge to the Merri River.
4. Identify opportunities to reduce stormwater and ground water pollution.
5. Identify opportunities for integrated water management to improve the open space and other community amenities of the precinct.
6. Identify opportunities to value the ecological and hydrological characteristics of the precinct.
7. Identify opportunities to value the bio-cultural landscape that Lake Pertobe is a part of.
8. Identify opportunities for this highly utilised site to support broader community awareness and education about where our water comes from and associated impacts.

These objectives have been taken into account by the project working group when developing the IWM options for Lake Pertobe. IWM options typically try to meet one or more of the objectives.

Opportunity to reduce pollution

Rubbish, such as beverage containers, is common at stormwater outfalls into Lake Pertobe. Opportunities to reduce pollutants entering the lakes are addressed in the IWM Plan.

7. Water and Pollutant Balance

The Lake Pertobe precinct provides a unique hydrological setting, located between the Warrnambool township and Southern ocean, and adjacent to the Merri River with multiple conservation, economic and recreational values.

An annual water balance has been developed using available data, noting that IWM should consider the impacts of climate change, including more variable rainfall. Water components used in the water balance are:

- Direct rainfall = 776 mm/yr (averaged over 50 years data BOM).
- Evapotranspiration = 1308 mm/yr (averaged over 50 years data BOM).
- Stormwater inflows = 1133 ML/yr (averaged over 50 years data, modelled & BOM).
- Groundwater use = Tennis Club (license for 9 ML) 2-3 ML/yr, WCC Staff shed bore 50-60 ML/yr, WCC Playground bore 16-36 ML/yr. (SRW data)
- Potable water use = 37-52 ML/yr Major users include, the Harris St Reserve, WCC and Commercial caravan parks, and Lawn Tennis Club. (WW - Warrnambool's recent average potable water use is 3450 ML/yr, i.e. major users consume 1-2 % of Warrnambool's annual demand).
- Wastewater* to sewer = 237 ML/yr (WW)
- Lake Pertobe and Merri River estuary connection flows = unknown (as no measurements are made).

*some of this is likely to be stormwater / groundwater infiltration to sewer)

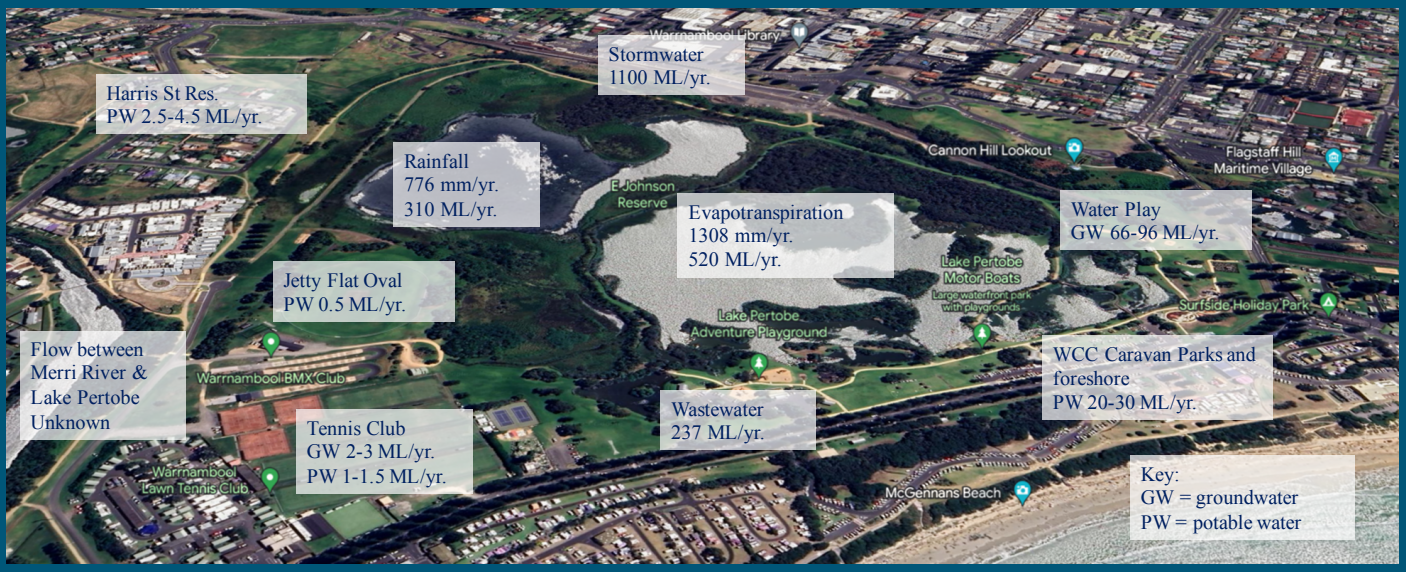


Figure 6: Water use, infbws and outfbws at Lake Pertobe

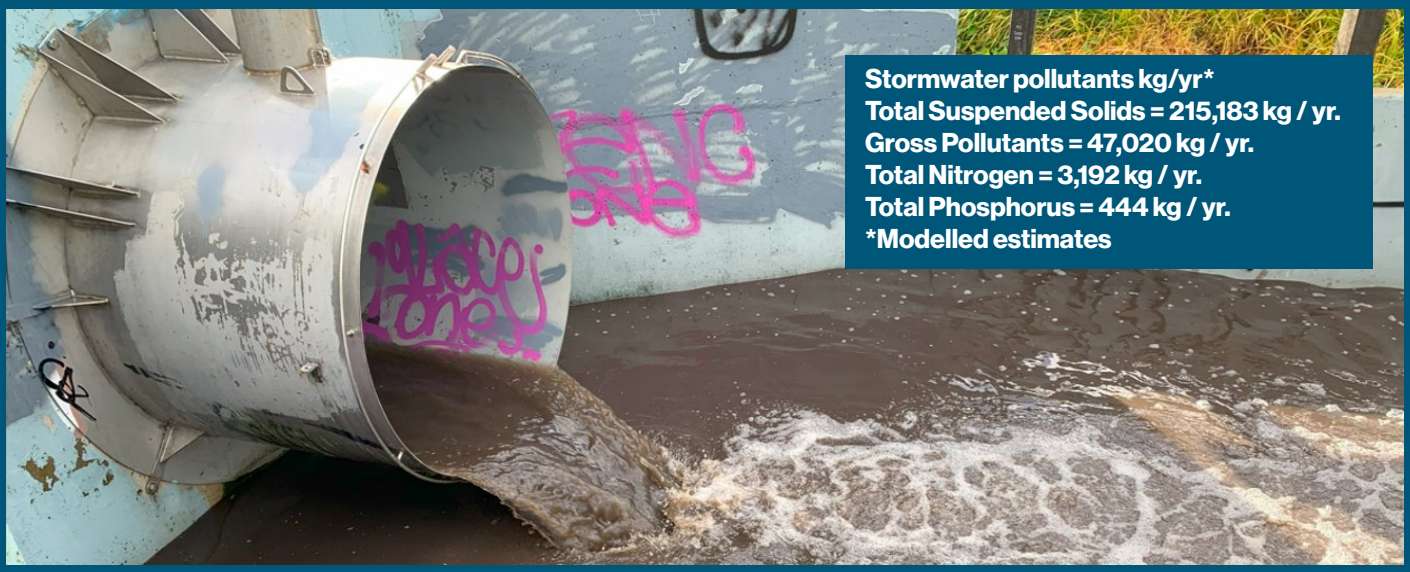


Figure 7: Stormwater and sediment entering Lake Pertobe

Are the lakes getting smaller from pollution?

Lake Pertobe is continually accumulating sediment derived from stormwater inflows and from aquatic primary production, e.g. algal blooms. Models estimate that over 100 cubic meters of sediment enters the system every year from stormwater alone.

8. Knowledge Gaps

Through the development of the IWM Plan, several knowledge gaps have been identified, as well as areas where improved data and information may be beneficial for future projects and longer-term management.

Some of the gaps may be addressed by the IWM opportunities developed in this plan. Gaps where more information could be gathered include:

- **Water levels –** lake water heights are observed to fluctuate; however, no actual recording of the lake water heights have been made. This information, combined with rainfall and tide data, could assist with longer term drainage and flood management.
- **Water volumes –** some water inputs are measured, such as pumped groundwater inputs; however, the largest inflow stormwater, volumes are unknown. Computer modelling has estimated inflows (approx. 1100 ML/yr.); more accurate inflow information should be gathered if required in the future.
- **Groundwater heights and quality –** groundwater heights and quality around Lake Pertobe are somewhat unknown. As an example, the tennis club uses groundwater for irrigation then reverts to potable town water once the groundwater becomes too salty, noting that the bore is near the ocean.
- **Function of Lake Pertobe –** the various roles / functions of Lake Pertobe were discussed, from stormwater basin to valuable ecological habitat to human activity centre. Deliberations on how to balance its various functions are ongoing.
- **Water quality and sediment accumulation –** data on stormwater or lake water quality is limited. It is likely the lakes are filling up with sediment; however, the rate and type of contaminants (e.g. lead) in the sediment is not well understood.

Figure 8: Kids Lake Jetty in January and June 2023, example of fluctuating water levels in the lakes

Knowledge gaps identified through the IWM include water levels over time in the lakes. Such information combined with rainfall and other data could be used to help plan and design future developments.

9. Community Values

The 2018 Lake Pertobe Master Plan lists the top five things loved and valued by the community, being:

- The variety of play equipment and barbecue facilities.
- Its spaciousness and size.
- Open, grassed areas.
- The wildlife and environment.
- Walking tracks and accessibility.

Additionally, it lists the top five things that people would like to see changed or improved, being;

- Add and update play areas (including shade and water elements).
- Update and link paths and trails.
- More native plants and wildlife.
- Signage and wayfinding.
- Better access for all (Refer to Master Plan for more details).

A summary of 2023 IWM Plan community engagement and feedback is listed below.

Early phase

- Flooding, drainage and lake water heights.
- Maximising visitation and experience.

Formal Consultation Phase

- Loss of grassed areas to new infrastructure.
- Negative effects on birds if lakes are all connected.
- Would an education App be available to Warrnambool residents or will they need to pay for it?
- Is Lake Pertobe suitable for fishing?
- Better definition around boats and watercraft. Motorised craft not suitable for the Lake.
- Increasing recreation in the area will put extra pressure on traffic management.

Variable conditions can impact values

Lake water heights and the impact on visitor experience were voiced by some of the community in the consultation phase of preparing the IWM Plan. Photos taken in April and June 2023 show how water levels can fluctuate.

10. IWM Opportunities within the Lake Pertobe Catchment

Several IWM opportunities were identified by the Working Group based on Lake Pertobe's characteristics and features, the shared vision for Lake Pertobe, and objectives of IWM. They are listed on the below image and their approximate location at Lake Pertobe shown. The opportunities listed are not ranked in preference. Each opportunity is explored in terms of its benefits, risks and further analysis requirements.

Figure 9: Outline of where each opportunity could occur throughout Lake Pertobe

10.1 Water Quality Improvement

The three main stormwater inflows along the north of Lake Pertobe have the opportunity for improved stormwater treatment.

Stormwater carries a range of pollutants that can adversely affect the values of Lake Pertobe from visual amenity to human and animal health risks. Previous engineering efforts to reduce gross pollutants (litter and large organic matter) entering Lake Pertobe were not successful due to a numbers of reasons including resources to clean and maintain the pollutant traps.

To ensure effective ongoing water quality improvement critical consideration to cleaning & maintenance requirements for both pollutant traps and sediment accumulation zones is needed. Weed control, such as deciduous trees is also critical to reduce organic and nutrient inputs into the lakes. Additionally, preventive efforts such as community education, street cleaning and the newly started Victorian container deposit scheme will also contribute to managing stormwater pollution. This option also aligns with Lake Pertobe Master Plan recommendations 6.7.5, improve the reserves habitat values through weed control and works to improve water quality.

Foreseen benefits:

- Reduced gross pollutants – litter, rubbish and large organics such as leaves and fronds.

Drink containers pooling below Gilles St stormwater outfall.

- Reduced nutrient and sediment loads into Lake Pertobe.
- Improved water quality.

Potential risks:

- Capital Costs.
- Lack of maintenance will result in minimal water quality improvement.
- Cost of maintaining asset may require an increase in budget allocation.

Further analysis:

- Design of purpose-built gross pollutant traps.
- Consider interventions higher in the catchment, such as the CBD.

10.1 Water Quality Improvement – concept

The stormwater inflows to Lake Pertobe create some specific challenges for Gross Pollutant Traps (GPTs) functioning effectively, including location, accessibility and peak hydraulic flows. Opportunity exists to improve utilization of on ground resources, staff and tractor at Lake Pertobe to better manage gross pollutants.

It is proposed to design and install purpose built GPTs for Fairy St and Giles St stormwater outfalls. Drawing on design concepts from weeping wall dairy effluent treatments systems (cleaned by tractors), a drive through i.e. two-way GPT, with a filter wall system with removeable / changeable aperture (various sizes could be trialed) screen panels. Operation would entail WCC staff cleaning the GPT as needed, i.e. in autumn it may need daily cleaning, and or on a regular basis. Pollutants removed would be placed into a nearby bund or container skip and this would be emptied as required. High flows however, would most likely overload the GPTs and spill over and around the screens. Images below show an indicative layout plan and sketch of the drive through concept for the Fairy St outlet.

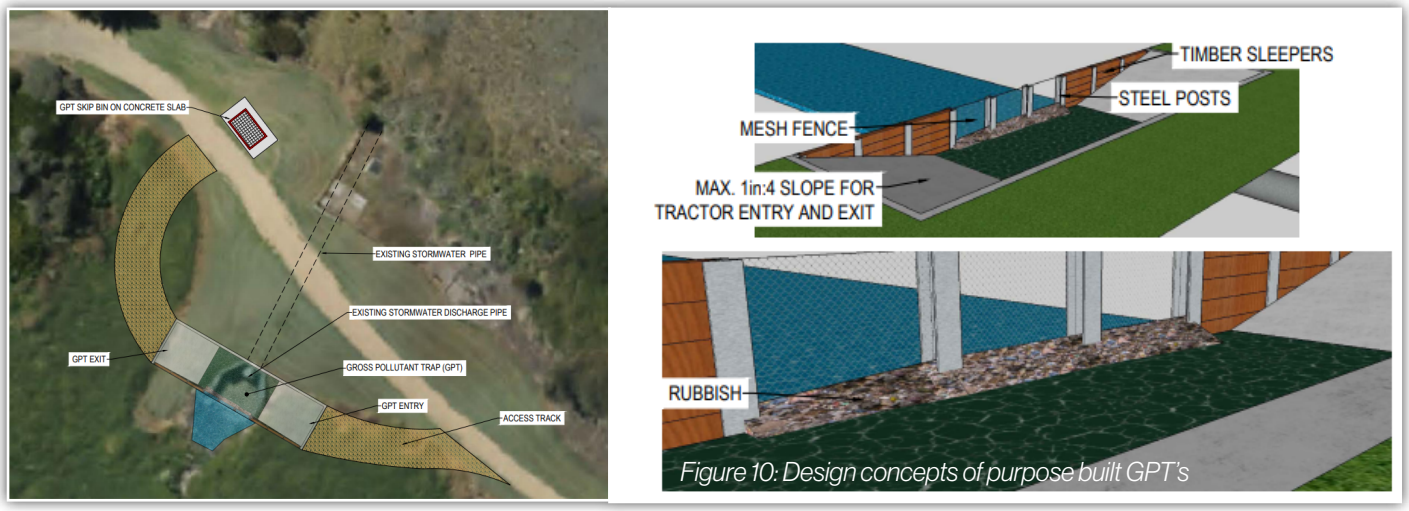


Figure 10: Design concepts of purpose built GPT's

10.2 Multi Benefit Basin

The large area between the Fairy St stormwater outfall and the north edge of Mill Lake has scope for a new multi purpose / benefit water basin to be constructed.

The new water body functions would include; stormwater treatment improving water quality entering the existing lakes, water storage for later use in summer for irrigating Harris Street Reserve and other possible uses, excess stormwater diversion directly to the Merri River, and simply creating more aquatic habitat for further ecological enhancement of Lake Pertobe. This option also relates to numerous Lake Pertobe Master Plan recommendations and values of the community. Images Adjacent show the LiDAR (Light detection and ranging) height data indicates there is likely enough fall 2-3 m from the Fairy Street stormwater outfall to the Merri River for a gravity diversion (via approx. 1.3 km pipe) of excess stormwater from a new basin.

Foreseen benefits:

- Improved water quality for Lake Pertobe, reduced sediment, nutrients and pathogens.
- Alternate water supply for Harris Street irrigation (reduced potable water consumption).
- High / excess stormwater flow bypass has the potential to alleviate flooding.
- More water in the landscape has community and ecological value.

Potential risks:

- Capital costs.
- Maintenance requirements / costs.

Further analysis:

- Feasibility study due to likely significant capital costs.
- Stakeholder engagement to consider relative costs and benefits for each stakeholder.

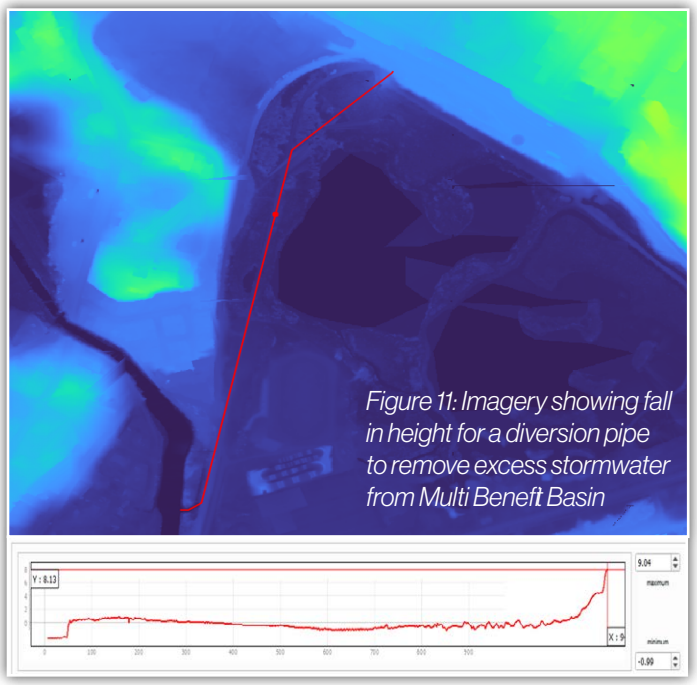


Figure 11: Imagery showing fall in height for a diversion pipe to remove excess stormwater from Multi Benefit Basin

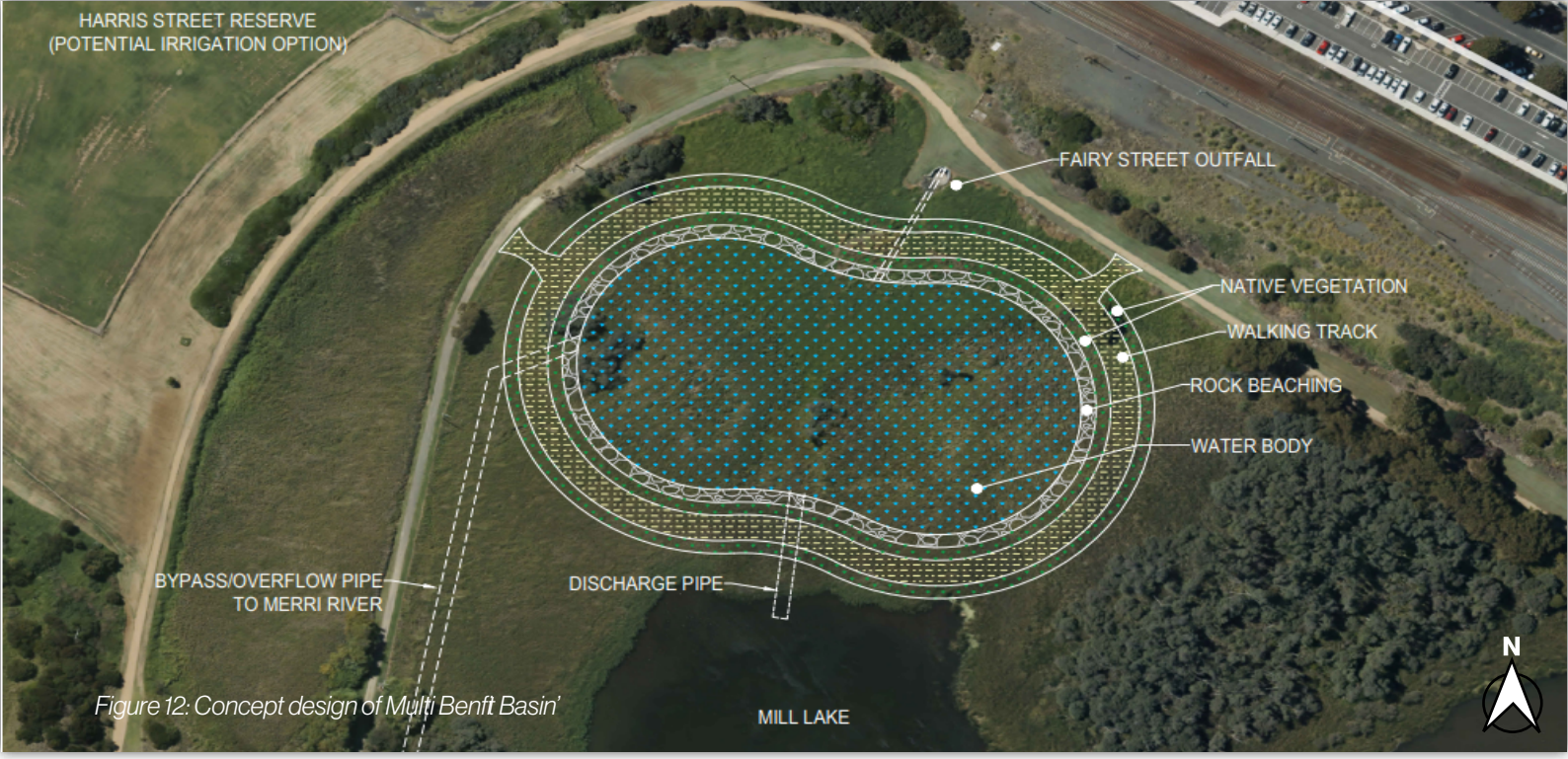


Figure 12: Concept design of Multi Benfit Basin'

10.2 Multi Benefit Basin - proposal

The concept of the new basin will enable multiple functions to be performed including sediment trap, water treatment and storage, and water diversion (conveying water via a new pipe to the Merri River).

Initial estimates suggest a basin size of potentially 10,000 m2 by 2 m deep (working volume), thus storing 20,000 kL or 20 ML of water. Concept design sketches are shown in the above image. Disturbance of contaminated sediment (identified by the working group) may complicate the project, and sediment quality will need to be determined at the next planning stage. This will inform the options for sediment use or disposal.

10.3 – Lakes Links and Levels

Currently water levels in the three lakes are marginally managed, more so the lake levels fluctuate due to water inflows (bore and stormwater), water outflows (limited by pipe size), and Merri River heights (i.e. impeding outflow and at times back flow may occur from the estuary).

Water levels can somewhat be controlled using existing drop board structures, however the effectiveness of the method is uncertain. Potentially the lakes could be openly connected with passageways (that could be shut if required, i.e., to isolate a lake) large enough for watercraft, i.e. canoes, that would result in having only one lake water height to manage rather than three. Feedback from community consultation highlighted drainage and inundation as key concerns and this may be alleviated by improved capacity for outflow/discharge to the Merri River and water level control. Additionally, given the ability to control water levels may facilitate the use of lake water for irrigation or other uses. The option also links with Lake Pertobe Master Plan recommendation 6.10.1 Develop and implement a drainage maintenance program to ensures that the lakes important drainage function is sustained.

Foreseen benefits:

- Reduction of poor drainage and inundations of areas.
- Prevention of backflow of water from a flooded Merri River and flooding of Lake Pertobe.
- Reduced groundwater pumping to maintain water levels in the Kids and Main Lakes.
- Potential to use the Lakes as a storage reservoir for irrigation water over summer.

Potential risks:

- Management challenges if Lake Pertobe is underwater (and infrastructure flooded).

Further analysis:

- Consider options for water removal while estuary is high and lake in flood to reduce time of inundation.
- Modelling to understand and optimisation management of system.

10.3 Lakes Links and Levels - proposal

This option has a scope that ranges from simple to complex, from creating channel connections that could allow canoe passage, to replacing pipe culverts and upgrading to a box culvert (larger area and improved hydraulic and ecological connection) to advanced computer modelling, sizing of automated gate systems, and potentially installation of a pump station to remove excess floodwater.

Alternatively, a more intermediate measure could be to upgrade current hydraulic control structures with more modern equivalents, as outlined.

Main Lake - Mill Lake Connection (refer to image 1)

- Current: Wooden drop boards / stop logs – age unknown, usability unknown.
- Upgrade: Segmented Stopboards – marine grade aluminum stopboards in stainless steel frame.
- Benefits user friendly, control the flow between Mill and Main Lakes.

Mill Lake Outlet (refer to image 2)

- Current: Bluestone headwall concrete weir with wooden drop boards / stoplogs.
- Upgrade: Down opening penstock decant gate – stainless steel, manual handwheel operation.
- Benefits user friendly, can set minimum water level in Mill Lake, excess water overtops gate.

Merri River Outlet (refer to image 3)

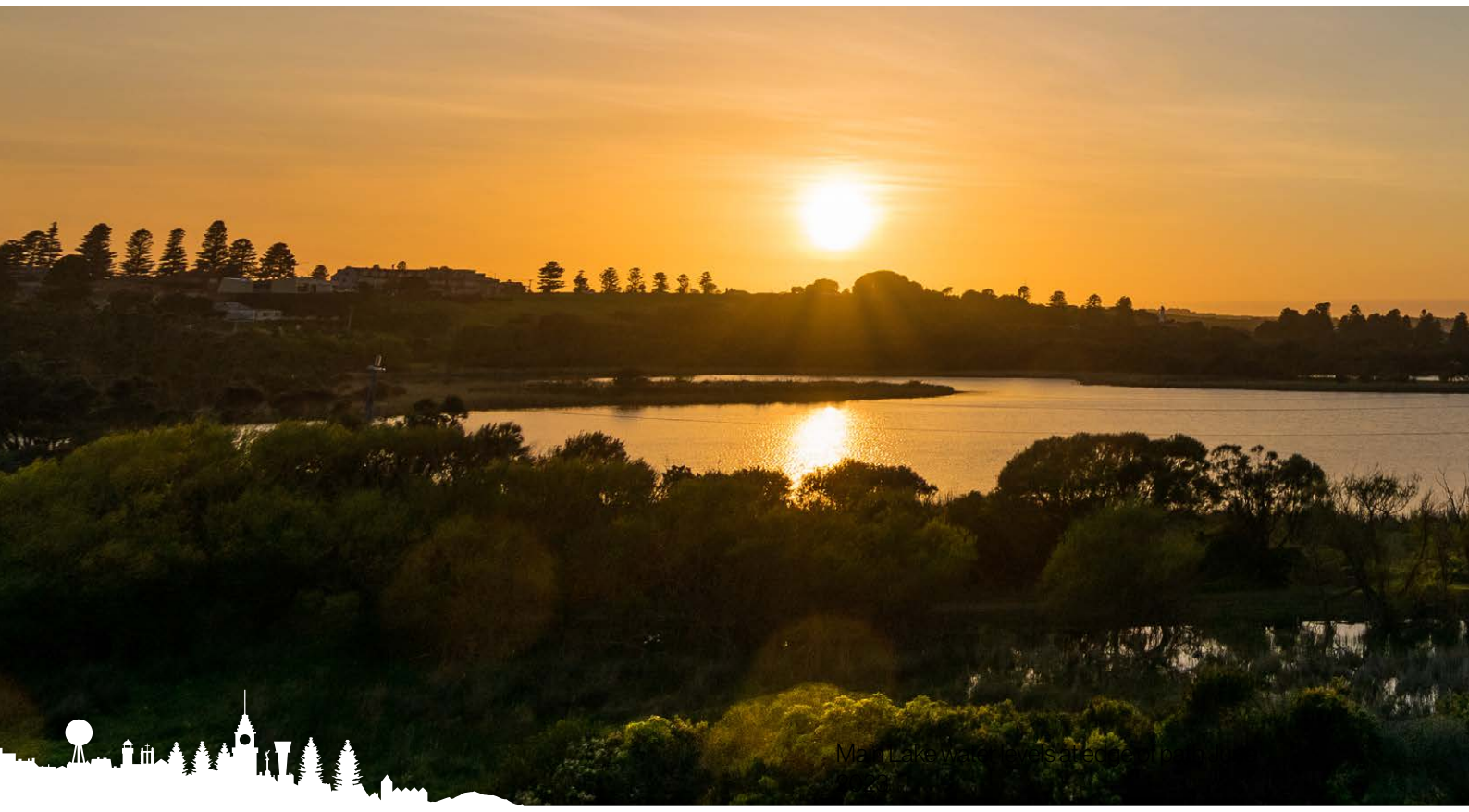
- Current: 600 mm pipe open (flap valve previously installed).
- Upgrade: Up lift penstock gate – stainless steel, new head wall and manual handwheel operation.
- Benefits user friendly and installed to prevent Merri River floods backflowing into the Lake Pertobe system.

(*Aluminium gate photos sourced from; https://www.awmawatercontrol.com.au/)

1.

2.

3.



Main Lake water levels are regulated

10.4 Stormwater Irrigation

As outlined in the previous section, given the size of Lake Pertobe there is opportunity to use the Lake/s as a storage reservoir for water that then can be drawn down to irrigate nearby sports facilities and other possible uses such as toilet flushing.

Based on preliminary calculations, if Mill Lake had a 30cm water depth allocation for irrigation approximately 25 ML of water could be available, i.e. a summers irrigation requirements. Additionally, the construction of an additional Basin (Option 2) directly below the Fairy St stormwater outfall could be considered. Design concepts estimated a new basin could have a capacity of 20 ML that would likely to be able to supply sports fields irrigation requirements most years. It should be noted that in both scenarios further treatment of the stormwater is likely to be required prior to use, this should be determined following discussion with Authorities. The option also links with Lake Pertobe Master Plan recommendation 6.10.2 Explore alternate for potable water use for irrigation.

Foreseen benefits:

- Reduce potable water demand and drought resilience contingency.
- Use of a fit for purpose water to meet community needs.
- Possible creation of a new water basin (Option 2).
- Improved water quality for Mill Lake.
- Nutrient diversion for beneficial use i.e. irrigation of grass fields.

Potential risks include:

- Dry hot years may limit stormwater availability and hence limit irrigation volumes.
- Costs, the unit costs, i.e. $/KL of stormwater irrigated may be high.

Further analysis:

- Verify opportunities for potable water offsets and demands in precinct.
- to maximise the potential alternate water scheme, potentially reducing unit costs.

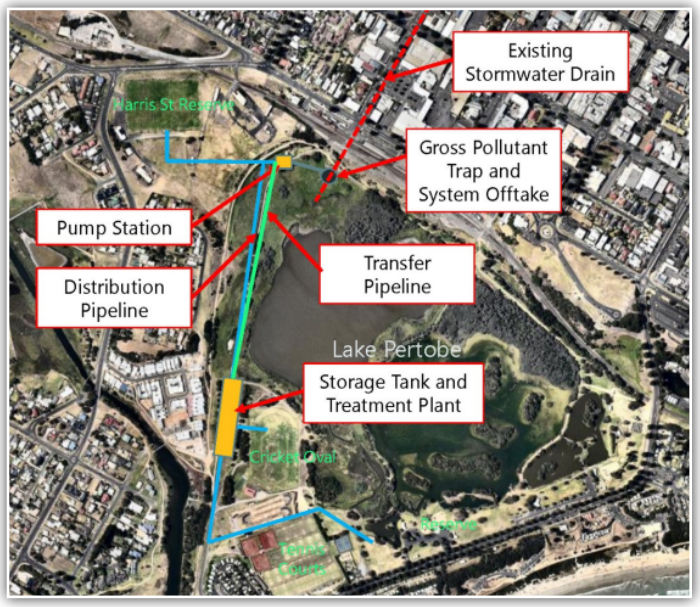


Figure 13: Excerpt from Lake Pertobe Master Plan 2018 showing schematic of a potential stormwater irrigation scheme

10.4 Stormwater Irrigation – case comparison

As detailed in the State Government IWM Progress Report March 2022, a sports field irrigation project using stormwater is being constructed in the Baw Baw Shire. The project has many similarities with the opportunity proposed at Lake Pertobe as outlined in the table below.

Baw Baw Shire – Western Park Ovals	Warrnambool City Council – Harris St Reserve and Jetty Flat Oval
Irrigation of ovals used 600,000 L/week (600 kl) forecast to increase with a hotter drier Climate, annual volume use not stated.	Data indicates usage between 400,000 to 500,000 L/week (500 kl) in summer (12 weeks).Annual volume use approximately 5 ML / yr.
Dichotomy between water conservation and maintaining the ovals.	Comparable circumstances – conservation vs use.
2.5 Ha wetland adjacent to ovals, capturing and treating stormwater from upstream residential development.	Approx 20 Ha of water surface at Lake Pertobe – volume of lakes unknown, stormwater from commercial and residential catchments.
Plan developed to divert a portion of stormwater to irrigate sporting ovals, involving; an off-take pump station, inline sediment filter, UV filtration system and a 600,000 L underground storage tank.	Similar concepts plans developed in Lake Pertobe Master Plan.
Projected to save 20 million litres of drinking water every year.	Unknown, Warrnambool climate does not require irrigation year-round.
Decrease pollution entering the creek downstream of the wetland.	Comparable circumstances. Lake Pertobe decreases pollution from entering the Merri River compared to the other pollution sources from the greater Catchment (900 km2 approx.) But this decrease would be negligibly.
Drought proof a valuable community space.	Comparable circumstances – likelihood of water restrictions low in the short term.
Funding Victorian Government IWM Program ($425,000), Baw Baw Shire($195,000) and Gippsland Water ($10,090).	Lake Pertobe Master Plan concept costing in the order of $1.5 - $2 million dollars.

10.5 Education and Value of Water

Education, awareness and appreciation of the water cycle is an ongoing exercise in working towards sustainable water use.

The working group with reference to Lake Pertobe Master Plan Arts and Culture Recommendations 6.1.11 "Develop an App to increase engagement and enjoyment..." and 6.5.1 "Include and share stories about Lake Pertobe's heritage, Indigenous culture, stormwater and drainage function and environment" propose a digital self-guided tour App be developed for Lake Pertobe. The tour would utilise and build on current wayfinding and signage at Lake Pertobe and could also link with the Pirtup Meeting Place Project that is currently underway and Wannon Water summer water saving campaigns. Other education opportunities include; use of a QR code trail, signage at any new infrastructure that is built such as passageways between the lakes and ensuring schools are aware of and utilise the digital self-guided tour once developed.

Foreseen benefits:

- Overall community awareness of the water cycle and Lake Pertobe role in the cycle.
- Promotion of the value of water and the "water is life" vision.

Potential risks:

- Vandalism of signs.
- Digital self-guided tour App not utilized, App becoming dated.

Further analysis:

- Test user experience and messaging to ensure education is targeted and uses the right terminology.
- Consider options to increase and maximise uptake of App, i.e. launch campaign, permanent signage, etc.

10.6 Water Recreation

Current water-based recreation at Lake Pertobe consist of two hire operations and informal public use, such as school/youth groups undertaking canoeing or raft building activities.

The hire businesses, a small petrol driven engine boat and a paddle boat and canoe hire have been operating at Lake Pertobe for decades and typically only open in peak tourist times. Given the abundance of personal watercraft such as kayaks (including the recreational fishing type) and paddle boards, the relatively "safe" environment of Lake Pertobe provides great opportunity for increased public and access use. Additionally, stand up paddle board businesses have expressed interest in being able to run classes on the lake.

Improved access could range from simply a turning circle with "boat / craft drop off and pick zone" in proximity of the lake to an actual boat ramp where craft could directly launch into water with a more accessible canoe launcher. This option would also benefit from improved lake connectivity, i.e. channels between lakes, however in the short term "portage" sites could be established for watercraft to be carried from one lake to the other. Any approved access points would need to stipulate which types of watercraft are suitable to enter the lake and their times of operation. Motorised watercraft would not be suitable. Lake Pertobe Master Plan links include 6.1.2 Provide access to the water, and 6.3.1 Accessible destination points.

Foreseen benefits:
- Greater use and appreciation of the lake.
- Healthier community (physical, mental, etc.).

Potential risks:
- Expensive asset if not well utilised.

Further analysis:
- Optimisation of preferred location.
- Scoping the appropriate type and size of facility.

10.7 Roof Water to Aquifer Recharge

Building on the success of previous roof water harvesting initiatives in Warrnambool, this option proposes to extend and adapt this practice to facilitate managed aquifer recharge.

The concept is to divert rainwater collected from rooftops in Warrnambool's CBD to recharge the shallow sandstone groundwater aquifer. It is important to emphasize that only roof water is intended for this aquifer recharge, a measure taken to safeguard groundwater quality. Warrnambool sandstone is very porous, making it exceptionally well-suited for aquifer recharge. The aquifer overlies the extensive regional Port Campbell Limestone aquifer; therefore, the two units have the capacity to store a considerable volume of water.
This approach has the potential to be expanded or replicated over time, allowing for the construction of multiple recharge systems. Approximately 15,000 square meters of roof area, roughly equivalent to the rooftop space in a typical Warrnambool CBD block, could generate an annual yield of 10 megaliters for recharge. This recharged water would, in turn, help offset the water extracted from the existing bores at Lake Pertobe. Furthermore, this initiative aligns with Lake Pertobe Master Plan objective 6.10.2, which seeks to explore alternatives to potable water for irrigation.

Foreseen benefits:
- Recreating a more natural water cycle (i.e. when more water infiltrated into the land).
- Reducing hydraulic load on the stormwater system.
- Aquifers have very large potential storage volumes.
- Recharging the aquifer balances extracted water .

Potential risks:
- Dry years will reduce recharge volumes when demand is likely to increase.
- Poor performance or contamination concerns if the system is not maintained.
- Retrofitting costs.

Further analysis:
- Review regulatory requirements and approval process.

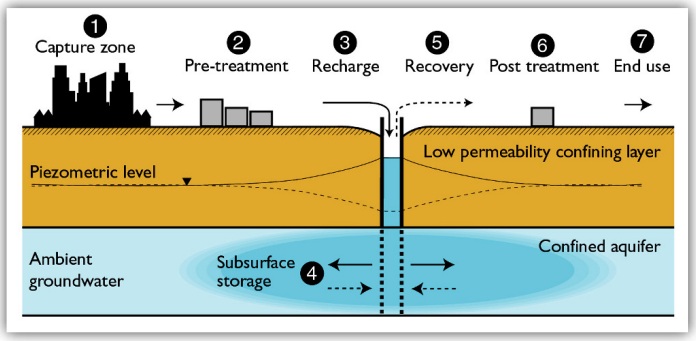


Figure 14: Concept diagram of how roof water can be harvested and used for aquifer recharge. (Source: https://www.csiro.au/en/news/all/articles/2016/october/managed-aquifer-recharge)

10.8 – Catchment Permeability

Another option for increasing recharge of the groundwater aquifer, like roof water aquifer recharge (Section 8.7), is to focus on nearby surrounds, i.e. the Warrnambool CBD, and aim to significantly increase urban permeability using infiltration trenches, passively watered trees, bioretention systems, and permeable pavements.

The filtered water recharges the local shallow upper aquifer and can be then extracted from the aquifer to effectively balance bore water use in the Lake Pertobe Precinct, i.e. the play space bore. This options links with the Lake Pertobe Master Plan 6.10.2 Explore alternative to potable water for irrigation.

Forecast benefits:

- Reducing hydraulic load on the stormwater system.
- Recreating a more natural water cycle (i.e. when more water infiltrated into the land).
- Recharging the aquifer that then can be drawn upon (pumped) when needed, i.e. over summer.
- Aquifers have very large potential storage volumes.

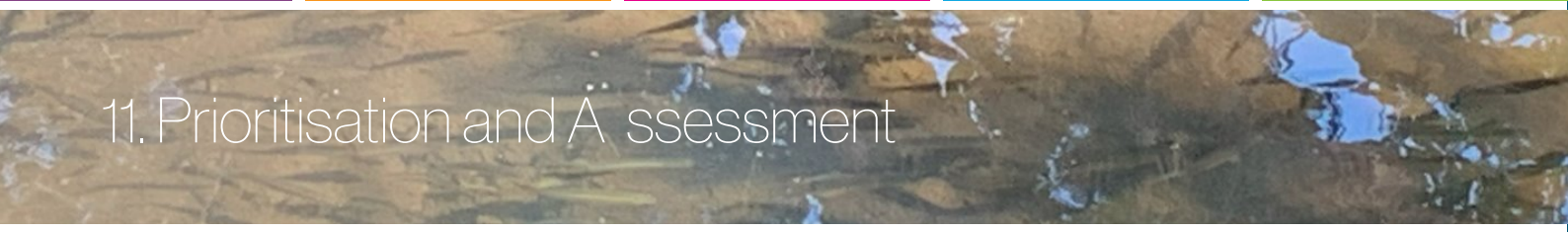
Potential risks:

- Maintenance of local WSUD assets.
- Monitoring of volumes of water that recharge the aquifer.

Further Analysis:

- Review associated risks of large-scale catchment permeability.

Permeable gravel allows water to soak into the ground, Koroit Street Warrnambool



11. Prioritisation and Assessment

11.1 Prioritisation of Opportunities

To help prioritise each Lake Pertobe IWM opportunity, each opportunity was scored by their relative contribution to the Lake Pertobe IWM objectives, Lake Pertobe Master Plan alignment and Climate Change benefits, as shown in the table below.

Total scores (colored to highlight the different scores) show that based on this assessment Stormwater Irrigation is the highest ranked opportunity (scoring a 3 +3 +1 +3 + 3 + 2 + 1 + 3 + 1 + 2 = 19), followed by the Multi Benefit Basin and Education and the Value of Water. The lowest ranked options are Water Quality Improvement and Water Recreation.

		LP IWM objective							Master Plan	Climate		
	Opportunity	Engage and support the land and water managers in the precinct in more sustainable water use	Reduce demand on potable supply	Improve the quality of stormwater discharge to the Merri River	Reduce stormwater and ground water pollution	Improve the open space and other community amenities of the precinct	Value the cultural, ecological and local aboriginal characteristics of the precinct	Support broader community awareness and education about where our water comes from and associated impacts	Aligns with Master Plan Recommendations	Sea Level Rise resilient?	Climate change (CO2) benefit	Total score
8.1	Water Quality Improvement	Low	Low	Medium	Medium	Low	Medium	Low	High	High	Low	13
8.2	Multi Benefit Basin	High	High	High	High	Medium	High	Medium	High	High	Medium	17
8.3	Lakes Links and Levels	Medium	Low	Medium	Medium	Medium	Medium	Low	High	Low	Low	15
8.4	Stormwater Irrigation	High	High	Low	High	High	Medium	Low	High	Low	Medium	19
8.5	Education and value of water	Low	Low	Low	Low	High	High	High	High	Medium	Medium	16
8.6	Water Recreation	Low	Low	Low	Low	High	Medium	Low	High	Low	Low	13
8.7	Roof Water to Aquifer Recharge	High	High	Medium	High	Low	Low	Low	Low	High	Medium	15
8.8	Catchment Permeability	High	High	Medium	High	Low	Low	Low	Low	High	Medium	15

Figure 15: Table showing prioritised opportunities

11.2 Climate Change Considerations

In preparation of this IWM Plan, the working group discussed climate change, sea level rise and Lake Pertobe's exposure to future changes.

The GHCMA is working on an updated South Warrnambool flood study at the time of developing this IWM Plan. Existing flood modelling (see image below) incorporating a 0.8 m sea level rise does show Lake Pertobe impacted by flooding in a 1% AEP Riverine Flooding event, i.e. a flood of this magnitude has a 1% chance of occurring in any given year. The potential for more regular estuarine / seawater incursion into the current freshwater system was also considered in this IWM Plan.

Thinking of current and future generations, IMW opportunities that minimize or reduce greenhouse emissions will be favored. The infographic shows predicted changes to Victorias climate in the 2050s.

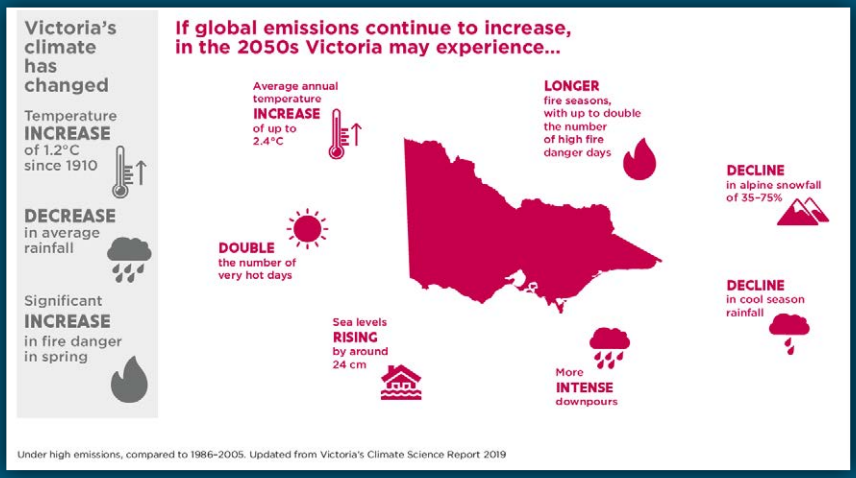


Figure 16: Victorian Climate Change Infographic (Source: https://www.climatechange.vic.gov.au/victorias-changing-climate)

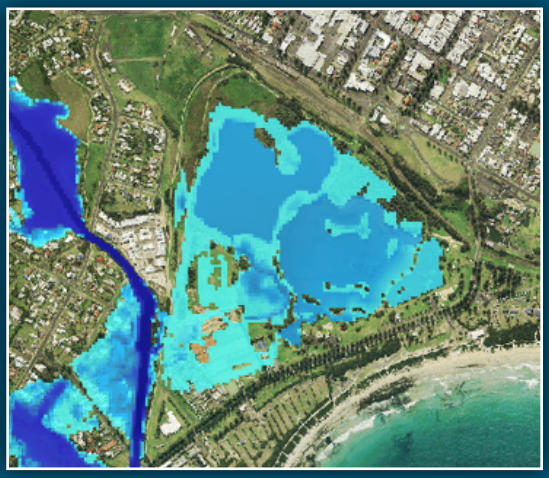


Figure 17: GHCMA fbod modelling for Lake Pertobe and South Warrnambool (Source: https://fbod.ghcma.vic.gov.au)

11.3 Merri River Water Heights and Lake Pertobe

The graph below displays maximum Merri River heights from June 2020 to April 2023.

The orange line at 0.6 m indicates the top of the pipe connecting Lake Pertobe to the Merri River and the grey line is the height of the retaining wall (right photo) at the Main Lake – Mill Lake connection. Merri River water levels strongly influence the flow of water in or out of Lake Pertobe, noting the outlet pipe diameter also dictates flow rates in and out. As outlined previously, climate change and predicted sea level rise will have a flow on effect, also likely increasing Merri River heights and therefore impacting flow of water in and out of Lake Pertobe.

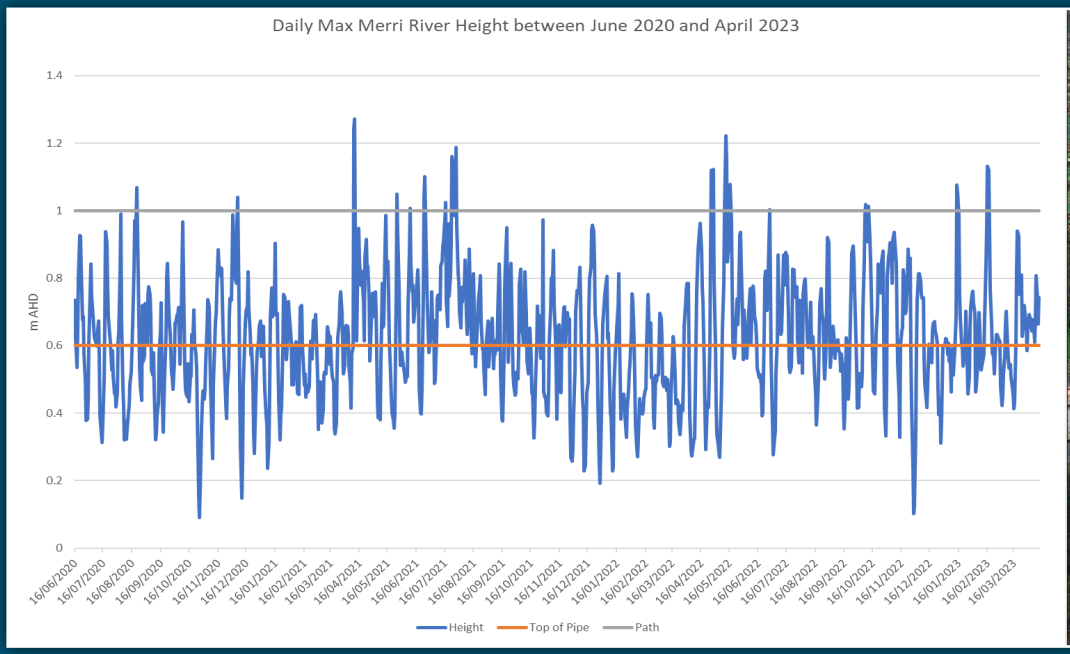


Figure 18: Merri River maximum water heights from June 2020 to April 2023

11.4 Cost Projections

Indicative costs for the opportunities are presented in the graph below and show a large range in costs from the Lake Links and Levels (approx. $200k) up to the Multi Benefit Basin (approx. $2.2M). Capital Expenditure (Capex) includes the initial project costs and the Operational Expenditures (Opex) includes the estimated running costs over 25 years (shown in present value), noting they are indicative only (costs could vary by plus or minus 50%).

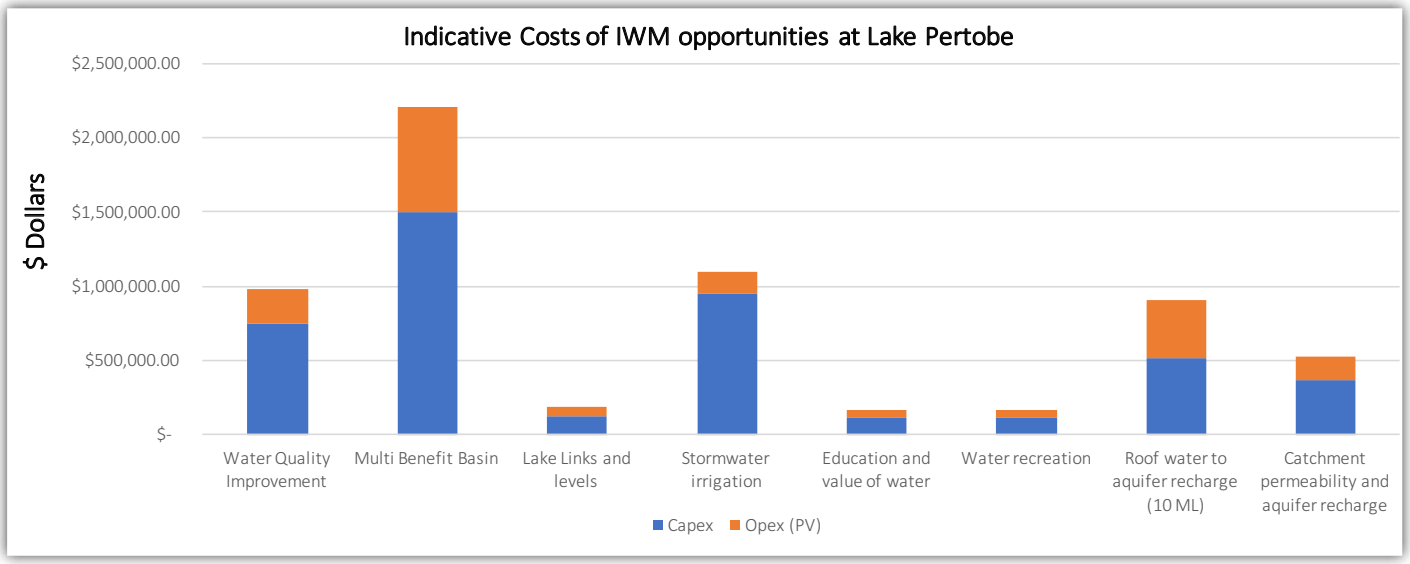


Figure 19:Indicative Costs of IWM opportunities at Lake Pertobe

11.5 IWM Holistic Assessment

The holistic assessment aims to capture both tangible and intangible economics of the options and also include the prioritisation tables on the next page (Figure 20) that consider opportunities to other factors, such as sensitivity to climate change.

The eight opportunities are presented in figure 20 on the following page with their associated assessments.

An effort was made to assign an economic value to all major benefits, including intangible benefits (e.g. improved community health and well-being). See Appendix One for further definition of each benefit, calculations, assumptions, and references.
Costs listed are combined capital and operating costs (estimate of dollar costs).

Benefit Cost Ratio provides a number to show overall value for money for each option. This is calculated by dividing the benefit of an option by its cost. For example if Option A benefits were $100 and Costs were $50 the ratio = $100/$50 = 2.

Comparatively if Options B ratio was $50/$100 = 0.5 the assessment would conclude that 2 is higher than 0.5 indicating Option A is better value for money.
Prioritisation is the scores from the IWM outcomes, local objectives and climate change factors.

Main Beneficiary is the organisation or person (people) who will benefit most from the option. The owner is usually the main beneficiary and is typically the principal funder of the project. Other parties may also contribute funds to the projects. Using the Water Recreation option for example, a canoe launch may be primarily a WCC asset however other stakeholders such as GHCMA may contribute to it's installation.

Holistic Rank is an intuitive ranking based on the information presented. It considers both the Prioritisation Combined and the Benefit Cost Ratio. The opportunities are ranked top down from 1 down to 5 with some options receiving the same rank.

Opportunity	Main beneficiary (Owner = bold)	Quantifiable benefits	Prioritisation	Benefit Cost Ratio (PV)	Holistic Rank (Intuitive)
8.1- Water Quality Improvement	**WCC** Community Environment	Nutrient reduction (TSS) Improved water clarity due to reduction of gross pollutants and TSS	13	Cost = $984,000 Benefit = $16,300,000 Ratio = 17	4
8.2- Multi Benefit Basin	**WCC** Community Environment Economic	Flood & drainage management Nutrient reduction (Total Nitrogen) Improved water clarity due to reduction of gross pollutants and TSS	17	Cost = $2,203,000 Benefit = $29,130,000 Ratio = 13	1
8.3- Lakes Links and Levels	**WCC** Community	Flood & drainage management	15	Cost = $181,000 Benefit = $8,026,000 Ratio = 44	2
8.4- SW harvesting and irrigation (Harris St and other demands)	**WCC** WW	Avoided potable water use for irrigation over summer Nutrient reduction (Total Nitrogen)	19	Cost = $1,093,000 Benefit = $474,000 Ratio = 0.43	4
8.5- Education and Value of Water	**WCC** Community	Increased community awareness and education Improved community health and well-being due to increased visitation	16	Cost = $165,000 Benefit = $909,000 Ratio = 6	4
8.6- Water Recreation	**WCC** Community	Improved community health and well-being Increased visitation / Additional boat and paddle board hire	13	Cost = $165,000 Benefit = $25,230,000 Ratio = 153	3
8.7- Roof Water to Aquifer Recharge	**WCC** / SRW / WW Environment	Offset of potable water use Offset of stormwater upgrades	15	Cost = $908,000 Benefit = $544,000 Ratio = 0.60	5
8.8- Catchment Permeability and Aquifer Recharge	**WCC** Environment	Offset of potable water use Offset of stormwater upgrades	15	Cost = $529,000 Benefit =$544,000 Ratio = 1	5

Figure 20: Table setting out IWM holistic assessment.

12. Water and Pollutant Balance (pre and post plan implementation)

Of the opportunities for IWM at Lake Pertobe some have readily quantifiable outcomes such as potable water substitution with stormwater and installation of pollutant treatment traps and basins.

Others such as water education and recreation have more intangible benefits and are harder to quantify. The table below outlines changes in the water volumes and pollutant loads, from pre (current situation) to post IWM opportunities i.e. all opportunities implemented. This is due to intangible benefits being subjective and difficult to measure.

Water	Pre	Post	% Change
Potable Water (ML)	36	30	17
Groundwater (ML)	99	99 +	Increased recharge Scale dependent.
Stormwater	1100	902	18
Wastewater	237	237	0
Pollutants (kg/yr)			
Total Suspended Solids	213,000	19,000	91
Gross Pollutants	47,000	0	100
Total Nitrogen	3,200	1750	45
Total Phosphorous	447	122	73

Figure 21: Table summarizing the changes to outcomes pre and post implementation of the option.

13. Recommendations

Considering the vision for Lake Pertobe, the holistic assessment, and community feedback, the IWM Plan recommends the following actions:

- Address knowledge gaps. It is recommended that all agencies work together to better monitor and understand the water cycle at Lake Pertobe. Improved data (specifically monitoring data of stormwater inflows and local rainfall pluvio data) would enable improved quantification of the design of new infrastructure and provide more confidence in delivering resilient and long-lasting assets through improved hydraulic modelling, in particular for the option of the multi-benefit basins or lake connection and level control.
- Implement the Multi Benefit Basin (8.2). This is a priority project to be considered for further design work and implementation. This project addresses many issues and opportunities and would result in a large array of potential benefits to several user groups and stakeholders. Benefits include improving water quality, reducing flooding via a high flow bypass, and offers the potential for stormwater to replace potable water for sport fields irrigation. As it is a relatively large project, it is recommended that project costs be allocated between all stakeholders and external funding considered.
- Consider changes to lake levels and connectivity (8.3). The Lake Pertobe vision is compromised when water levels are high, creating soggy and unusable areas and paths and negatively impacting lake users. Therefore, improved lake level control is recommended with the intent to reduce the risk of adverse highwater conditions. Conversely in dry times, the system could capture stormwater for reuse as a substitution for irrigation on local nearby ovals.
- Improve water recreation (8.6). A key recommendation with significant community benefits is a focus on opportunities for everyone to be "on water." This recommendation also links to education and the value of water, as well as having several other benefits, including health in well-being of residents and visitors.
- Implement education and value of water project (8.5). Community awareness of the water cycle and Lake Pertobe role in the water cycle is important to help the whole community understand their responsibility for good water outcomes, i.e. water conservation, pollution prevention, etc.
- Lastly, it is recommended to revisit four of the lower priority options in 5 years, to consider their relative priority and potential benefit. These actions are the Water quality Improvement (8.1), Stormwater harvesting and irrigation (8.4), Roof water to aquifer recharge (8.7) and Catchment permeability and aquifer recharge (8.8).

14. Implementation

Actions, lead agency for project management, indicative time frames, and budgets are shown below for the IWM opportunities.

Some of the opportunities, such as aquifer recharge, will require further consideration of legal requirements; others will require further modelling and design, geotechnical, environmental, flora and fauna considerations. External funding and partnerships with stakeholders will be needed to implement many of the opportunities.

#	Opportunity	Action	Who	Implementation Time (yr)	Feasibility / design budget ($ 000's)
8.1	Water Quality Improvement	Design specific gross pollutant traps for outlets	WCC	1 to 2	30
8.2	Multi Benefit Basin	Feasibility study and preliminary design	Multi Agency	3 to 5	60
8.3	Lakes Links and Levels	Preliminary design	WCC/GHCMA	1 to 2	40
8.4	Stormwater Irrigation	Feasibility study and preliminary design	WCC/Wannon Water	3 to 5	30
8.5	Education and Value of Water	Tour and education app development	WCC/GHCMA	1 to 3	50
8.6	Water Recreation	Preliminary design	WCC/GHCMA	1 to 2	10
8.7	Roof Water to Aquifer Recharge	Feasibility study and preliminary design	Multi Agency	3 to 5	50
8.8	Catchment Permeability and Aquifer Recharge	Ongoing by WCC	WCC	Ongoing	n/a

Figure 22: Table summarizing the implementation of each option.

15. References

Department of Environment, Land, Water and Planning, 2019, *Great South Coast Strategic Directions Statement, October 2019,* Department of Environment, Land, Water and Planning.

Department of Environment, Land, Water and Planning, 2022, *Integrated Water Management, Progress Report March 2022,* Department of Environment, Land, Water and Planning.

Department of Environment, Land, Water and Planning, 2022, *Water is Life, Traditional Owner Access to Water Roadmap, Section B: Traditional Owner Nation Statements. Pg 141 Eastern Maar Aboriginal Corporation*, Department of Environment, Land, Water and Planning.

Michael Smith and Associates, Landscape Architechture and Urban Desin, 2018, *Lake Pertobe Master Plan 2018*, Warrnambool City Council, Wannon Water, Department of Energy, Environment and Climate Action.

Spiire, 2019, *Albert Park Integrated Water Management Plan*, Warrnambool City Council, Wannon Water, Department of Environment, Land, Water and Planning.

16. Glossary

IWM	Integrated Water Management
BOM	Bureau of Meteorology
GPT	Gross Pollutant Trap, a structure that use physical processes to trap solid waste such as litter and coarse sediment
LiDAR	Light detection and ranging, a remote sensing method that uses light in the form of a pulsed laser to measure variable distances to Earth
Capex	Capital Expenditure, are purchases of goods or services to undertake a project
Opex	Operational Expenditure, are the costs incurred to maintain or operate an asset
CBD	Central Business District, the commercial and business centre of a city
PV	Present Value, when calculating the Benefit Coast Ratio present benefits and costs were used
Tangible Economics	Assets that are a physical object and have a monetary value such as equipment, furniture and products
Intangible Economics	Assets that are not a physical object and hard to value such as user experience, improved community health and well-being and branding

17. Appendices

17.1 Appendix 1. Benefits Calculations, References and Assumptions Table

Benefit Calculations, References, and Assumptions Table

Opportunity	Quantifiable benefits	Unit	Rate	Total (PV)	Reference	Assumptions
1- Water Quality Improvement	Nutrient reduction (TSS)	$/kg TSS	$43.50/kg TSS	$ 13,591	City of Ipswich (2023). Voluntary Stormwater Quality Offset Program. Ipswich, QLD: Ipswich City Council. https://www.ipswich.qld.gov.au/__data/assets/pdf_file/0004/239845/Stormwater-quality-offsets-report-2021-2022.pdf	Ipswich found the cost-benefit per kg TSS removed to range from $5 to $82 per kg TSS removed. Average of $43.50/kg is assumed.
	Improved water clarity (willingness to pay)	$/person/ year	$4.17/person/ year	$ 16,286,018	Gunawardena, A., Zhang, F., Fogarty, J., Iftekhar, M. S., (2017). Review of non-market values of water sensitive systems and practices: An update. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.	People's WTP for increased water clarity in the Karapiro catchment, New Zealand: mean annual WTP per household for water clarity from the current clarity (around 1 m) to: see up to 1.5, 2.0, and 4.0 m underwater were, respectively $4.17, $21.03, and $65.82. Assumed reduction of TSS and GPP will increase clarity up to 1.5m at a value of $4.17 per visitor
2- Multi Benefit Basin	Flood & drainage management	$/day	$34,250/day	$ 8,025,844	Tourism Australia (2018), Key Tourism Metrics for Warrnambool, 2014-2017 and Lake Pertobe Master Plan 2018.	Assumed 15 days of recreation lost per year due to flooding. Assumed visitors to Lake Pertobe spend $50/day in Warrnambool and there are 685 visitors per day on average (250,000 people/year divided by 365 to equal on average daily visitors) to equal $34,250 per day
	Nutrient reduction (TN)	$/kg TN	$3,323/kg TN	$ 4,818,350	Melbourne Water, "Stormwater offsets explained" https://www.melbournewater.com.au/building-and-works/developer-guides-and-resources/drainage-schemes-and-contribution-rates-2-0	Offset rate is $6,645/kg TN in Melbourne. Assume rate is half in Warrnambool due to lower land value. Nitrogen is measured for the Stormwater Offsets Program. If nitrogen (the limiting pollutant) targets are achieved, then phosphorus and suspended solid targets are also achieved. Offsets are paid once and are not an annual value.
	Improved water clarity (willingness to pay)	$/person	$4.17/person	$ 16,286,018	Gunawardena, A., Zhang, F., Fogarty, J., Iftekhar, M. S., (2017). Review of non-market values of water sensitive systems and practices: An update. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities.	Willingness to pay (WTP) for increased water clarity in the Karapiro catchment, New Zealand: mean annual WTP per household for water clarity from the current clarity (around 1 m) to: see up to 1.5, 2.0, and 4.0 m underwater were, respectively $4.17, $21.03, and $65.82. Assumed reduction of TSS and GPP will increase clarity up to 1.5m at a value of $4.17 per visitor.
3- Lakes links and levels	Flood & drainage management	$/day	$34,250/day	$ 8,025,844	Tourism Australia (2018), Key Tourism Metrics for Warrnambool, 2014-2017 and Lake Pertobe Master Plan 2018.	Assumed 15 days of recreation lost per year due to flooding. Assumed visitors to Lake Pertobe spend $50/day in Warrnambool and there are 685 visitors per day on average (250,000 people/year divided by 365 to equal on average daily visitors) to equal $34,250 per day.
4- SW harvesting and irrigation (Harris St and other demands)	Avoided potable water use ($/kL). Irrigation water use over summer.	$/kL	$2.24/kL	$ 266,418	Wannon Water, Price Submission 2023-28 - https://www.wannonwater.com.au/media/113418/final-wannon-water-price-submission-2023-2028.pdf	Current retail price is $2.24/kL. Retail price of water is assumed to grow at 2.1% each year.
	Nutrient reduction (TN)	$/kg TN	$3,323/kg TN	$ 207,688	Melbourne Water, "Stormwater offsets explained" https://www.melbournewater.com.au/building-and-works/developer-guides-and-resources/drainage-schemes-and-contribution-rates-2-0	Offset rate is $6,645/kg TN in Melbourne. Assume rate is half in Warrnambool due to lower land value. Nitrogen is measured for the Stormwater Offsets Program. If nitrogen (the limiting pollutant) targets are achieved, then phosphorus and suspended solid targets are also achieved. Offsets are paid once and are not an annual value. Assumes 25 ML of stormwater contains 62.5 Kg of TN, based on eWater MUSIC Guidelines and modelling of Option 2.
5- Education and value of water	Increased community awareness and education	$/person	$1.20/person	$ 93,732	Australian Bureau of Statistics (2016 Census) and Statista "Average prices for apps in the Apple App Store as of May 2023 (in U.S. dollars)"	Average purchase price of an app in the Apple App store (May 2023) was $1.20 AUD. This is used as a proxy for willingness to pay for an app. Assumed all school age kids in district (estimated 5000) have app.
	Improved community health and well-being due to increased visitation	$/person	$4.54/person	$ 815,629	Henderson-Wilson, Claire, Sia, Kah-Ling, Veitch, Jenny, Staiger, Petra K., Davidson, Penny and Nicholls, Peter 2017, Perceived health benefits and willingness to pay for parks by park users: quantitative and qualitative research, International journal of environmental research and public health, vol. 14, no. 5, Article number: 529, pp. 1-18.	Assumed app would increase lake interest by 10% for those using the app and their families (assume 11,500 people). In reference study, park users were willing to pay $45.40 per year for park. Assumed Lake Pertobe users would be willing to pay 10% of $45.40 based on app use.
6-Water Recreation	Improved community health and well-being	$/person	$4.54/person	$ 17,731,061	Henderson-Wilson, Claire, Sia, Kah-Ling, Veitch, Jenny, Staiger, Petra K., Davidson, Penny and Nicholls, Peter 2017, Perceived health benefits and willingness to pay for parks by park users: quantitative and qualitative research, International journal of environmental research and public health, vol. 14, no. 5, Article number: 529, pp. 1-18.	Assumed improved access would increase lake amenity by 10%. In study, park users were willing to pay $45.40 per year for park. Assumed users would be willing to pay 10% of $45.40 for improvement. Assumed Lake Pertobe has 250,000 visitors per year.
	Increased visitation (additional boat and paddle board hire)	$/person	$48/person	$ 7,498,598	Visit Victoria "Lake Pertobe Motor Boats Hire" https://www.visitvictoria.com/regions/great-ocean-road/see-and-do/outdoor-and-adventure/boating-and-kayaking/lake-pertobe-motor-boats-hire Go Surf School "Stand-Up Paddleboard Lessons" https://gosurf.com.au/lessons-hire/	Based on references, SUP lesson is $45 - $65 per person; boat hire is $30/30 minutes. Assumed average of $48 per person. Also assumed 100 days of use at 100 persons/day
7 - Roof water to Aquifer Recharge	Recharging groundwater assumes offsetting potable water use	$/kL	$2.24/kL	$ 444,030	Wannon Water, Price Submission 2023-28 - https://www.wannonwater.com.au/media/113418/final-wannon-water-price-submission-2023-2028.pdf	Current retail price is $2.24/kL. Retail price of water is assumed to grow at 2.1% each year.
	Offsetting stormwater upgrades	$/ha	$20k/ha	$ 100,000	Colac Stormwater Strategy 2019 - Colac Otway Shire.	Development fees range from $70 -100 K per Ha. Assumed will offset stormwater upgrades at 25% of new development rate of $80k/ha. Warrnambool CBD block is approx 5 Ha. Development fees are paid once and are not an annual value.
8- Catchment permeability and aquifer recharge	Recharging groundwater assumes offsetting potable water use	$/kL	$2.24/kL	$ 444,030	Wannon Water, Price Submission 2023-28 - https://www.wannonwater.com.au/media/113418/final-wannon-water-price-submission-2023-2028.pdf	Current retail price is $2.24/kL. Retail price of water is assumed to grow at 2.1% each year.
	Offsetting stormwater upgrades	$/ha	$20k/ha	$ 100,000	Colac Stormwater Strategy 2019 - Colac Otway Shire.	Development fees range from $70 -100 K per Ha. Assumed will offset stormwater upgrades at 25% of new development rate of $80k/ha. Warrnambool CBD block is approx 5 Ha. Development fees are paid once and are not an annual value.