Protecting water quality in the Bays and Waterways of Melbourne, Australia, by managing Nitrogen outputs in stormwater and sewage effluent

Protéger la qualité des eaux des baies et voies navigables de Melbourne (Australie) par la gestion des rejets azotés dans les eaux pluviales et les eaux usées

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RÉSUMÉ
Afin de protéger les baies et voies d'eau de la région de Melbourne, la Société des Eaux de Melbourne (the Melbourne Water Corporation) a accompli un grand nombre de travaux et réalisé d'importants programmes sur la base des recommandations apportées par une étude scientifique de premier plan. Ces travaux comportaient un certain nombre d'aspects comme un programme de zones humides à grande échelle, et ont veillé à ce que l'impact des constructions privées sur les voies d'eau dans les bassins versants de la ville soit bien compris et réduit au mieux en vertu de la législation, ce afin de minimiser les rejets azotés. La Société des Eaux de Melbourne a également atténué l'impact de ses activités sur les baies et les voies d'eau grâce à un programme de réhabilitation environnementale de 160 millions de dollars destiné à sa principale station de traitement des eaux usées. Les logiciels de modélisation des bassins versants se sont révélés importants pour mesurer et modéliser les principaux polluants et évaluer l'efficacité des mesures envisagées.

ABSTRACT
To protect the bays and waterways of the Melbourne region, the Melbourne Water Corporation has carried out a number of major works and programs, based on the recommendations of a major scientific study. These works have involved a number of aspects including a large scale wetlands program, and ensuring that the impacts on waterways of private development in the Melbourne catchments are understood and mitigated, using regulation to achieve Nitrogen reduction targets. Melbourne Water has also reduced the impacts of its own operations on bays and waterways through a $160 million environmental improvement program at its main sewage treatment plant. The availability of catchment modelling software has been important to measure and model key pollutants and the effectiveness of proposed solutions.

KEYWORDS
Development impacts, Nitrogen reduction, Regulation, Wetlands.
1.0 INTRODUCTION

Melbourne, Australia, is expected to grow from its current population of four million to a population of five million by 2020, placing additional demand on its water resources and environment. This Paper looks at the programs put in place by the Melbourne Water Corporation, on both public and private land, to address issues of waterway and bay protection in a city experiencing considerable growth, especially in relation to minimizing the impacts of Nitrogen inputs from stormwater and sewage.

Melbourne Water is a statutory corporation fully owned by the State Government of Victoria, Australia, and has had responsibility for delivery of waterways, drainage and floodplain management in the Melbourne region since the 1920s. It is a water resources manager, providing water, sewerage and recycled water services to retail water businesses and waterways and drainage services to the greater Melbourne community and managing approximately $8 billion in water supply, sewerage and drainage assets. Its assets include 156,756 hectares of protected water supply catchments, 8,400 kilometres of waterways, 221 water quality treatment systems, comprising 107 wetland systems; 67 sediment traps; 32 litter traps and 15 combined sediment and litter traps; nine major water supply reservoirs, with a total capacity of 1,773 GL; 64 service reservoirs; 1,030 kilometres of water distribution mains; more than 200 kilometres of aqueducts and tunnels; 44 water treatment plants; 343 kilometres of sewers, two main sewage treatment plants (the Western Treatment Plant and the Eastern Treatment Plant), three major sewage pumping stations and several minor pumping stations; and 46 drainage, sewage and water pumping stations.

The Victorian Government, in its *Our Water Our Future* action plan (Government of Victoria 2004) designated Melbourne Water as the caretaker of river health with responsibility for waterways, drainage and floodplain management. This requires Melbourne Water to demonstrate leadership in river management, protecting the health of the region’s rivers and providing an integrated overview of all activities impacting on river health.

Melbourne Water’s vision is “working together to ensure a sustainable water future”. A key part of achieving this vision will be implementing more sustainable forms of urban water management. As has been noted by Brown, Keath and Wong (2008), across Australia and internationally a growing body of urban water professionals are focussed on transitioning to a more sustainable urban water management as they respond to the challenges associated with environmental degradation, rapidly growing urban populations and the impacts from climate change. Numerous terms have been coined to describe the application of this new paradigm of sustainable water management including water sensitive urban design (WSUD) and integrated urban water management (Taylor 2008). The key principles of WSUD as stated in the Urban Stormwater - Best Practice Environmental Management Guidelines (CSIRO, 1999), and adopted by Melbourne Water, are to protect natural systems, integrate stormwater treatment into the landscape, protect water quality, reduce runoff and peak flows, and add value while minimising development costs.

As part of implementing WSUD, Melbourne Water has put in place a number of programs and policies to manage impacts on bays and waterways, particularly to address the Nitrogen loads in stormwater and sewage outfalls; these include new regulatory regimes, a large scale wetland building program and minimising the impacts of its own sites including its largest sewage treatment plant.

2.0 PROTECTING OUR BAYS AND WATERWAYS

Melbourne is situated on Port Phillip Bay, and the Bay is Melbourne’s playground and one of Victoria’s most precious natural assets. Over four million people live around the Bay, which is one of Australia’s busiest ports and the focus of a growing tourism industry.

Port Phillip Bay covers 1,950 square kilometres. While relatively large in area, the Bay is shallow with an average depth of 13 metres. The Bay’s catchment covers over 9,790 square kilometres in area, and consists of 21 natural drainage basins. The Bay consists of a variety of habitats including sandy seafloor, seagrass beds and rocky reefs. Most of the seafloor is sand and silt which is home to a diverse assemblage of invertebrates. These vast areas of sand are in some parts covered by dense seagrass meadows that provide important habitat for much marine life, especially juvenile fish. The Bay supports approximately 300 species of fish, several hundred species of molluscs, several hundred species of crustaceans, at least 200 species of seaweeds, several hundred species of polychaetes
Map One - Location map for Melbourne, Victoria

Map Two - Location of the Western Treatment Plant, and Melbourne’s Bays.
(bristle worms), 2 species of seagrass, several hundred species of cnidarians (jellyfish, corals, etc), and several hundred species of sponges (Department of Natural Resources and Environment 2002). The Bay is of significant social, economic and environmental value to Victoria and Australia.

In the late 1980s and early 1990s, Melbourne was growing quickly, and Melbourne Water decided it needed to better understand how population increases would affect the Bay’s capacity to assimilate treated effluent and urban run-off. Consequently, in 1992, Melbourne Water initiated a landmark, four-year study to identify ways of protecting the long-term health of the Bay.1

The $12 million Port Phillip Bay Environmental Study (“the Study”), (Harris 1996), sponsored by Melbourne Water and managed by the Commonwealth Scientific and Industrial research organisation (CSIRO), consisted of more than 40 projects carried out by 29 research institutions - government agencies, private consultants and universities in four states, as well as the University of Southern California.

The Study found the Bay was healthy by world standards, with good water quality, productive fisheries and healthy populations of dolphins and seals. It was, however, recognised that unchecked nutrient loads, particularly Nitrogen, would take the Bay close to the point where significant ecological changes would occur through increased algal blooms and, eventually, eutrophication.

Nutrient inputs have long been recognised as a key risk to Port Phillip Bay’s environmental management objectives. Nitrogen is the key limiting nutrient for biological processes in the Bay. The Study emphasised the critical nature of the Nitrogen risk, and made several recommendations to guide future Nitrogen management including reducing annual Nitrogen loads to the Bay by 1000 tonnes – this reduction was to be achieved by focusing on stormwater and catchment inputs (500 tonnes) and also on Melbourne Water’s sewage treatment plant at Werribee on the western edge of Port Phillip Bay (the additional 500 tonnes).2

The action to achieve the 500 tonne reduction from the sewage treatment plant at Werribee is discussed further in section 6.0 of this Paper. In relation to the 500 tonnes from catchment waterways focusing on stormwater loads, the Port Phillip Bay Environmental Management Plan (Department of Natural Resources and Environment, Victoria, 2002) stated that: ‘the Port Phillip and Westernport CALP Board (CALP Board) has responsibility for coordinating planning, implementation and reporting of the tasks involved across various agencies’. This Paper examines the key components of this program that were carried out by Melbourne Water.

3.0 MELBOURNE WATER’S WETLANDS PROGRAM

Mention has already been made of the Port Phillip Bay Environmental Study, and the actions arising out of this for Melbourne Water in relation to reducing the Nitrogen outputs entering into the Bay, both from the major point source of the Western Treatment Plant and from the entire catchment and its numerous creeks and drains entering the Bay.

In relation to the catchment targets, Melbourne Water’s contribution to meeting this target involved undertaking targeted stormwater actions within urban areas. A key program to achieve this commenced in 2000 when Melbourne Water committed to a $60 million wetlands program aimed at achieving a 100 tonne reduction in nitrogen loads by 2010. This program is on track to reach its goal of a 100 tonne reduction by late 2010.

Wetlands built to date for this program include wetlands at Carrum Downs, Clayton South, Dandenong

1 The 1996 study was the third detailed environmental study of Port Phillip Bay; the first study carried out between 1968 and 1973 was instrumental in the development of the first Victorian State Environmental Policy (SEPP) (Fam et al 2009).

2 The annual Port Phillip Bay Nitrogen load is strongly influenced by inter-annual variation in rainfall and currently generally ranges from 6000–8000 tonnes, but can be much higher. Historically the relative contributions of major input sources have very roughly been: catchment waterways, 35–45%; WTP, 40–50%; atmospheric inputs, 10–15%; and groundwater, 5%.
South, Keysborough, Knoxfield, Noble Park, Roweville, Scoresby and Wonga Park. The wetland currently under construction at Scoresby will be Melbourne’s largest wetland and, once completed, will capture and prevent 28 tonnes of Nitrogen from flowing into Port Phillip Bay each year.

This program of using constructed wetlands is one of the key options that Melbourne Water has implemented, along with a suite of other WSUD treatment measures, to improve stormwater quality. Melbourne Water’s program of implementing a large scale wetlands program to protect its waterways and bays is based on wetland science from around the world.

Storm runoff from urban areas has been recognized as a major contributor to pollution of the receiving urban watercourses in many parts of the world eg Scholz and Lee, 2005. Constructed ponds and wetlands are widely used for control of stormwater and in addition to being effective in the removal of sediment and pollutants, they can also contribute to flood attenuation and landscape amenity (Li, Deletic and Fletcher 2002). As noted by Babatunde et al (2008), constructed wetlands have now been successfully used for environmental pollution control, through the treatment of a wide variety of wastewaters including industrial effluents, urban and agricultural stormwater runoff, animal wastewaters, leachates, sludges and mine drainage.

Beute et al (2009) have also reported that constructed treatment wetlands have been shown to be an effective, economical, and ecologically sustainable method to treat Nitrogen contaminated wastewaters and non-point sources. Similarly, Melbourne Water has stated what its design objectives are for its constructed wetlands: “constructed wetlands satisfy a range of urban design objectives such as improved water quality and flow control; enhanced ecological, habitat and landscape values; and provide a range of passive recreational and aesthetically pleasing benefits to the community. The priority of design criteria for constructed wetlands are: stormwater treatment, enhanced aesthetic, recreational and cultural values, and habitat provision” (Melbourne Water 2005).

Melbourne Water has described constructed wetlands as artificially created shallow marsh systems, which regularly fill and drain; and that the dominant feature of wetlands is the presence of emergent aquatic macrophytes containing marsh, swamp and pond features (Melbourne Water 2005).

In relation to the science of wetland operations, especially in relation to Melbourne Water’s key priority of Nitrogen removal, it has been noted that while plant uptake is a minor Nitrogen removal mechanism, microbial transformations provide the majority of total Nitrogen removal (Faulwetter et al 2009). In relation to wetlands, Vymazal (2007) has noted that Nitrogen has a complex biogeochemical cycle with multiple biotic/abiotic transformations involving seven valence states (+5 to −3), and that the most important inorganic form of Nitrogen in wetlands are ammonium (NH4 +), nitrite (NO2 −) and nitrate (NO3 −). Similarly, Beute et al (2009) have noted that the Nitrogen biogeochemical cycle within wetland ecosystems is complex and involves numerous transformations including ammonia volatilization, ammonification, Nitrogen fixation, burial of organic Nitrogen, ammonia sorption to sediments, nitrification, denitrification, anammox, and assimilation.

4.0 MINIMIZING THE IMPACTS OF DEVELOPMENT USING PLANNING REGULATIONS

A key challenge for Melbourne Water has been to ensure that the impacts that development in the catchments has on waterways and bays are minimised, and that an appropriate regulatory regime is in place to ensure that these impacts were assessed and appropriately addressed. In Victoria, this has primarily been achieved through the introduction of new planning regulations.

The State Environment Protection Policy (SEPP) for the Waters of Victoria (Environment Protection Authority 2003) sets out base statutory requirements for the quality of stormwater runoff. The Port Phillip Bay Study was followed by revision of the Bay SEPP in 1997. This established the 1000 tonne reduction target for annual Bay Nitrogen loads as a statutory policy objective (Environment Protection Authority 2003).

To help ensure the achievement of the SEPP’s objectives, Clause 56.07 was introduced into the Victoria Planning Provisions on 9 October 2006 and forms the Integrated Water Management provisions relating to residential subdivision. This clause aims at managing water more responsibly and sustainably, and is vital in protecting the health of Melbourne’s waterways and bays by reducing pollutants and excessive flows. The Clause requires that all new subdivisions of greater than two lots
must treat stormwater onsite to the best practice standard, as defined in the Urban Stormwater Best Practice Environmental Management Guidelines (CSIRO, 1999). The relevant objectives of Clause 56.07 in relation to urban run-off are: to minimise damage to properties and inconvenience to residents from urban run-off; to ensure that the street operates adequately during major storm events and provides for public safety, and to minimise increases in stormwater run-off and protect the environmental values and physical characteristics of receiving waters from degradation by urban run-off (Department of Sustainability and Environment 2006).

Clause 56-07 mandates the treatment of stormwater to achieve best practice objectives for all residential subdivisions. To assist in achieving these objectives, the Best Practice Environmental Management Guidelines for Urban Stormwater describes the level of stormwater treatment necessary to comply with these regulatory requirements; the pollutant performance objectives required are:

- Suspended solids 80% reduction from typical urban load'
- Total phosphorus 45% reduction from typical urban load'
- Total nitrogen 45% reduction from typical urban load'
- Litter 70% reduction from typical urban load.

Melbourne Water’s area includes 38 local government areas, and given the important role that Councils play in managing stormwater in their communities, achieving success with Councils has always been seen as critical for the sustainable stormwater program. To help Councils implement Clause 56, a Melbourne Water Stormwater Policy Advisor is available to Councils to help improve processes and systems relating to Clause 56.07 implementation. In addition, Melbourne Water and its training provider partner, Clearwater, have developed an Implementation Toolkit to assist Councils with these planning provisions. As part of its Living Rivers Stormwater Program, Melbourne Water is also working to build the capacity of local government and inform relevant stakeholders and processes, and to assist in the successful implementation of Clause 56.07 of the Victoria Planning Provisions.

5.0 STORMWATER OFFSETS PROGRAM

Melbourne Water has established a stormwater quality offset program in the Port Phillip Bay and Westernport catchments. Essentially, if developers cannot treat their stormwater to best practice within the development, they are required to pay an offset to Melbourne Water, and treatment can either be at an individual lot scale or at the streetscape scale (Francey et al 2006).

Nitrogen has been established as the offset “currency” and a price has been established which is currently Aus$1,100 per tonne. Nitrogen is typically the limiting pollutant and hence if objectives for Nitrogen are met, then objectives for Phosphorus and suspended solids will be usually met also.

An offset is calculated based on the kilograms of nitrogen required to achieve best practice for the site. Sites greater than five hectares do not have the option of purchasing off-site treatment and are expected to treat within the development site.

Nitrogen has been chosen as the unit of measurement for the offsets strategy for two principal reasons: it was identified as the critical pollutant for Port Phillip Bay (CSIRO 1999), and then enshrined into Nitrogen reduction targets; and Nitrogen has been found to be the critical factor in sizing the dimensions and capital cost of water quality treatment infrastructure. As mentioned above, it is assumed that effective removal of nitrogen will imply an effective removal of all other typical stormwater pollutants (Wong et al 2002).

In relation to the Offsets program operated by Melbourne Water, this provides flexibility for developers where best practice performance objectives cannot be achieved on site, or where water quality works are planned as part of a drainage scheme. For residential subdivisions, the responsible authority, (council) will determine whether stormwater treatment must be provided on site or whether compliance may be achieved through offsets.

To be successful, an offset scheme must be measurable, as noted by Francey et al (2006), and this is examined in the section below on catchment modelling software.
6.0 USE OF CATCHMENT MODELLING SOFTWARE

To fully understand the impacts of development on stormwater quality and quantity, it has been essential to have catchment modelling software available. Recognised user-friendly modelling tools are now available for modelling key pollutants and the effectiveness of proposed solutions.

The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) software is used as the main tool for assessing performance of both on-site treatment measures and regional off-site works constructed by Melbourne Water. MUSIC is a conceptual design tool that estimates both stormwater pollutant generation and the performance of stormwater treatment measures. It supports decision-making and enables users to evaluate conceptual designs and to demonstrate the performance of particular designs.

Generally Melbourne Water requires treatment of stormwater so that annual pollutant loads achieve targets set out in the Best Practice Environmental Management Guidelines, as mentioned previously these include a 45% reduction in Total Nitrogen from typical urban loads.

There are however many cases where individual treatment measures will have different targets, for instance if the receiving aquatic ecosystem is identified as being of very high value, then Melbourne Water may require a higher treatment level. Melbourne Water uses MUSIC to assess the impacts of proposed development against performance targets. If alternative methods or models are used, the developer must demonstrate to Melbourne Water's satisfaction that performance targets can be achieved.

The MUSIC software assists in the evaluation of conceptual designs of stormwater management systems to meet water quality objectives for their catchment, and was developed to operate at a subdivision, neighbourhood or regional level.

MUSIC was developed by the Cooperative Research Centre for Catchment Hydrology\(^3\), as a decision support system for stormwater management, and has been in development since 1999. From 2000-2002, MUSIC's development has benefited from intensive testing by Brisbane City Council and Melbourne Water staff. Since its public release in May 2003, over 300 urban stormwater professionals are using MUSIC around Australia. The use of MUSIC is recommended by Melbourne Water in order to optimise the conceptual design and to demonstrate its performance against Best Management Practice targets. To assist developers in using MUSIC, Melbourne Water has prepared guidelines on the input parameters for MUSIC (Melbourne Water 2004).

7.0 REDUCING NITROGEN IMPACTS FROM SEWAGE TREATMENT PLANTS

Melbourne Water's Western Treatment Plant (WTP) at Werribee provides an essential public health service, treating about 52% of Melbourne's sewage, or about 500 million litres a day. The plant is a world leader in environmentally friendly sewage treatment, is one of the world’s most significant wetlands, and covers a total area of 10,815 hectares.

Treated effluent is used at the WTP to irrigate 8,500 hectares of pasture for grazing 15,000 cattle and 40,000 sheep. It is also supplied to the Werribee market garden area to grow vegetables and to irrigate sports grounds, parks and gardens. The remaining effluent is discharged to the bay under an accredited licence from the Environment Protection Authority of Victoria.

The WTP is one of Australia's best-known sites for recreational birding, with about 270 species of birds recorded there. The sewage treatment lagoons, Lake Borrie, creeks, saltmarsh, and coast host large numbers of sedentary and migratory waterbirds and waders. It is one of the few wintering sites for the Critically Endangered Orange-bellied Parrot. Lake Borrie, with adjacent lagoons and coastal mudflats, is protected as a wetland of international importance under the Ramsar Convention\(^4\). The

\(^3\) Now known as the eWater Cooperative Research Centre.

\(^4\) Several international treaties cover the Western Treatment Plant; the most prominent of these agreements is the International Convention on Wetlands launched in Ramsar, Iran, in 1971. The Ramsar Convention promotes the conservation, wise use and repair of wetlands and obliges member

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wetlands, which draw expert ornithologists from around the world, attract an amazing array of birdlife including thousands of migratory waders that fly 12,000 kilometres south from Siberia to avoid the harsh northern Winter.

As mentioned previously, part of Melbourne Water’s commitment emerging from the Port Philip Bay study was to reduce the amount of Nitrogen entering the Bay from the Treatment Plant by 500 tonnes a year. Subsequently a major $160 million upgrade of the plant was carried out in 2006 to increase Nitrogen removal, maximise water recycling and capture methane gas from the sewage treatment process to generate power for the plant.\(^5\)

The plant relies partly on lagoon-based processes, in which naturally-occurring bacteria and sunlight digest sewage. Under the major upgrade, these natural processes have been complemented by new technology to increase Nitrogen removal. When the upgrade works were finished in 2007, Nitrogen inputs entering the Bay were reduced by 500 tonnes a year.

### 8.0 FUTURE PROJECTS

In October 2009, Melbourne Water finalised Better Bays and Waterways, a Water Quality Improvement Plan for the Port Phillip and Westernport region (Melbourne Water 2009). This is a joint project with Environment Protection Authority of Victoria and the Federal Department of Environment, Water Heritage and the Arts aimed at creating an integrated water quality plan for Western Port, Port Phillip Bay, and the rivers and estuaries within the catchment. The plan sets out actions for improving water quality across the whole region, particularly catchment based actions. This five year water quality improvement plan has been developed in collaboration and consultation with a wide and diverse group of stakeholders from Government (Australian, State and Local), industry (predominantly water retailers), environment groups and the community.

In the Better Bays and Waterways Water Quality Improvement Plan, Melbourne Water has detailed the measures it will take to further address the issue of sustainable stormwater management including reducing the amount of Nitrogen entering the bays and waterways.

Given the key importance of better controlling diffuse source pollution due to the adverse impacts on waterway health, Melbourne Water has included actions in Better Bays and Waterways that extend Melbourne Water’s involvement in diffuse source pollution issues. In relation to diffuse source pollution, the Better Bays and Waterways Plan notes that “effective management of diffuse sources to prevent pollution will be improved through collaboration and establishment of clear lines of responsibility amongst authorities, improved education and appropriate enforcement. A review of the existing management and compliance framework for the management of diffuse source pollution will be undertaken, assessing the effectiveness of the prevention of diffuse source pollution from industrial, commercial and construction operations. The review will include consideration of arrangements for tradewaste, cross connection and stormwater pollution education and enforcement.” This review will be led by Melbourne Water.

Other relevant actions in Better Bays and Waterways that Melbourne Water has committed to include: implementing a stormwater pollution education and enforcement program for small to medium industrial sites within targeted municipalities, undertaking research into stormwater pollutant sources and appropriate treatment sources; improving local government’s capacity to prevent diffuse source countries to list Wetlands of International Importance (commonly known as 'Ramsar sites') and protect their ecological character. The Port Phillip Bay, western shoreline site, which includes the Western treatment Plant, was designated under the Ramsar Convention in 1982. In addition, several of the migratory waterbird species that frequent the WTP are listed under other international treaties. These include: the Japan – Australia Migratory Birds Agreement (JAMBA); the China – Australia Migratory Birds Agreement (CAMBA); and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

\(^5\) As part of the upgrade, massive membrane covers trap about 30 million cubic metres a year of methane gas from the sewage treatment process, helping to generate electricity for the plant’s operations.
pollution; evaluating the effectiveness of WSUD treatments in a targeted environment through a pilot project; providing awareness, education and training to local government and the development industry to build institutional capacity to achieve improved stormwater management practices; continuing to work with the 38 Councils in Melbourne Water’s service area to enable 50% of them to have a commitment to WSUD implementation targets for pollutant loads, urban flow and effective imperviousness; undertaking the Melbourne Water stormwater management programs, working to improve capacity within local government - activities will include building institutional capacity within local government authorities, and funding for the design and construction of stormwater treatment measures; working with the community to encourage the uptake of WSUD in established developments; encouraging the community to install rain gardens and other infiltration and reuse options through education and incentive programs; and investigating opportunities and considerations to implement household downpipe disconnection program including mapping land capability for land infiltration, reviewing statutory and institutional considerations, and establishing a pilot program with local government.

The key issues of Nitrogen reduction was also addressed in the Better Bays and Waterways Strategy. The Strategy noted the long term statutory target of achieving a 1000 tonne reduction from the 1996 baseline figures, and the progress that had been made towards achieving this target. The Strategy also noted that the long term objective had not yet been met, and as part of moving towards achieving this target, recommended a short term target of preventing the addition of at least 40 tonnes of Nitrogen per year for five years (equivalent to the projected overall increase in Nitrogen loads due to urban population growth).

9.0 CONCLUSION

The bays and waterways of Melbourne Australia are an extremely important community resource; maintaining their health requires action on a number of fronts including programs to reduce the amount of Nitrogen impacting on them. Minimising the impacts of development and ensuring that regulatory processes are in place that assess these impacts and result in the appropriate mitigation works being implemented have been a key part of Melbourne Water’s approach to date. Melbourne Water has also needed to lead by example in reducing the impacts of its own operations on bays and waterways.

Some good progress has been achieved to date in reducing the amount of Nitrogen entering the bays and waterways of Melbourne. Melbourne Water will need to continue its current work of protecting Melbourne’s bays and waterways by tackling Nitrogen inputs on a wide range of scales and with a wide range of partners, especially local government. Further leadership and innovation will be required to maintain and improve the bays and waterways of the Melbourne region; this will need to continue to be based on extensive science and research and to further engage the broader community on the key issue of managing inputs, especially Nitrogen, to protect Port Phillip Bay and other natural waterway assets.

The protection of water quality in Melbourne’s bays and waterways needs to also deal with the realities of climate change and population growth. Melbourne Water needs to continue to be a strong advocate for further innovation and integration across all parts of government, and to continue to show leadership to protect these natural assets.

10.0 LIST OF REFERENCES


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