Better Bays and Waterways

A Water Quality Improvement Plan for Port Phillip Bay and Western Port

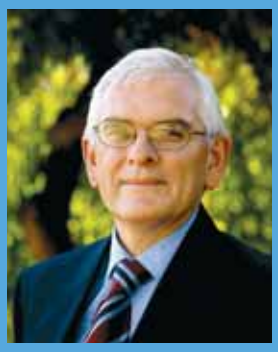
Australian Government

EPA VICTORIA

Victoria The Place To Be

Melbourne Water

Foreword



Rob Skinner

Terry A'Hearn

The quality of the water in our catchments cannot be taken for granted. It underpins our local ecology, our social fabric, our economy and our lives. As such, government agencies, industry, and each and every person within our community have a collective responsibility to protect, and where possible, improve the condition of our creeks, rivers, estuaries and marine waters.

Over the past few decades, the waters of the Port Phillip and Western Port region have greatly benefitted from protective legislation such as the Environment Protection Act 1970, associated statutory policies and a suite of Environmental Management Plans, as well as significant investment in on-ground works. However, the catchments' waterways and bays are still threatened by diffuse pollution, urban expansion and climate change, each of which presents significant management challenges. To address these challenges, we have developed a comprehensive plan to identify and address the current and emerging factors threatening the region's water quality.

Four years ago, Melbourne Water and EPA Victoria were provided with a great opportunity with the receipt of Australian government funding. The funding was provided to develop a Water Quality Improvement Plan for the Port Phillip and Western Port region, regarded by the Commonwealth Government as a coastal 'hotspot'. Through the development of this plan, we considered where we thought water quality in the region should and could be in five years time, and how to ensure we move towards long term improvements in regional water quality through the delivery of well thought out programs.

What followed was the development of *Better Bays and Waterways*, a 5-year plan that contains 93 actions within a series of management programs. Six background projects have informed the development of the plan. The plan is also supported by sophisticated predictive catchment and receiving waters modelling to forecast the potential impacts of climate and land use change scenarios. The subsequent management actions and their programs focus on the challenges of point and diffuse source water pollution, localised impacts, urban expansion and climate change, and aim to mitigate the impacts of human activities on water quality. They collectively address the impacts of nutrients (predominantly nitrogen) on Port Phillip Bay and sediment loads on Western Port. The plan provides for improved protection of core values including Marine National Parks and Sanctuaries, Ramsar listed wetlands, and key habitats supporting important local ecology. *Better Bays and Waterways* complements the range of strategies, plans and programs already put in place by Government involved in water quality management and environment protection.

Better Bays and Waterways has been a true partnership, not just by a dedicated team of staff from our respective agencies, but through the collaborative support and input by members of the plan's Steering Committee and Stakeholder Advisory Group. We thank them for their efforts. Their commitment to seeing this plan come to fruition is symbolic of how we can all work together to drive change.

We are pleased to release *Better Bays and Waterways*, a 5-year Water Quality Improvement Plan for the catchments, creeks, rivers and bays of the Port Phillip and Western Port region.

Rob Skinner
Managing Director,
Melbourne Water Corporation

Terry A'Hearn
Acting Chief Executive Officer,
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Executive Summary

Better Bays and Waterways is a Water Quality Improvement Plan with a specific focus on water quality issues in the Port Phillip and Western Port region. As water quality is only one aspect of managing aquatic health, *Better Bays and Waterways* is one component of a range of policies and plans that each contributes to the maintenance and improvement of waterway and marine health.

Better Bays and Waterways defines our economic, social and environmental values, the threats to these values, and our commitments through an adaptive management approach to improve the water quality of our rivers, creeks, and marine environments for a more sustainable future.

The region

The Port Phillip and Western Port region is situated in south-central Victoria. The region covers some 13 440 km^2 and includes more than 8 800 km of waterways, including rivers, creeks and estuaries. There are seven catchments in the region. The Yarra, Maribyrnong, Dandenong and Werribee catchments drain into Port Phillip Bay, and the Western Port catchment drains into Western Port. The Bellarine Peninsula has two ephemeral streams that flow into Port Phillip Bay via Swan Bay, and the Mornington Peninsula catchment has streams that flow into both Port Phillip Bay and Western Port.

Values

Our bays and waterways are highly valued for their ecological importance. The region supports internationally recognised wetlands and a diverse range of flora and fauna. The waterways within these catchments are popular recreational destinations for Melbournians and tourists with over 100 million visits to our rivers, streams and creeks each year.

Port Phillip Bay and Western Port support a rich variety of invertebrate, fish and bird life. More than 100 species of fish have been recorded from Victorian bays, inlets and estuaries. Port Phillip Bay and Western Port play a pivotal role in the recreational activities of many of the region's inhabitants and visitors due to their accessible beaches and diverse aquatic environments.

The region is also important economically with the catchments including both the metropolitan areas of Melbourne and Geelong as well as numerous smaller regional townships. The bays support commercial and recreational fishing, aquaculture operations, port operations and a number of ecotourism enterprises including the Phillip Island Penguin Parade.

Protecting our values

Water quality in the waterways, Port Phillip Bay and Western Port is threatened by several key pollutants (see table below) and challenges such as urban growth and climate change. The waterways are threatened by nutrients and toxicants, generated by our use of the catchment. These pollutants affect in-stream ecosystems. As waterways flow to the bays, they transport these pollutants into Port Phillip Bay and Western Port, affecting marine ecosystems. In Port Phillip Bay, nitrogen is the key nutrient affecting algal growth and must be managed to maintain the health of the bay. In Western Port, high suspended sediment and nutrient loads disrupt the natural growth of seagrasses and other aquatic plants and animals.

Key pollutants affecting water quality in the *Better Bays and Waterways* region

Bay or waterway	Key pollutant	Other pollutants
Waterways	Phosphorus	Nitrogen, suspended solids, toxicants (varies by waterway), pathogens
Port Phillip Bay	Nitrogen	Phosphorus, suspended solids, toxicants (varies)
Western Port	Total suspended solids	Nitrogen, phosphorus
Waterways and beaches (recreational use)	*E. coli* (waterways) Enterococci (marine and beaches)	Litter

Executive Summary

Targets

Better Bays and Waterways sets out a number of targets to protect water quality in the region. Overcoming the impacts of urban growth will be a huge challenge and achievement of the plan. This challenge, along with others, will be overcome by addressing the committed actions within the plan.

There is a high level of confidence that the plan's proposed outcomes and water quality improvements can be achieved (see Appendix 1: Reasonable Assurance Statement). If funding is secured, the additional actions will contribute significantly towards achieving the long term target. The targets are outlined in the table below.

Type	Committed target	Long-term target
Port Phillip Bay nitrogen loads target	Reduce the nitrogen loads to Port Phillip Bay by at least 40 t/y from diffuse catchment sources (offset urban growth) by 2014	1000 t/y reduction from 1996 baseline from diffuse catchment sources (500t/y reduction achieved from WTP, 500t/y from catchments remaining)
Western Port sediment loads targets	Reduce the sediment loads to Western Port by 1000 tonnes per year by 2014	No quantitative targets have been established. Awaiting further research on required reduction to protect environmental values
Western Port nitrogen loads target	Reduce the nitrogen loads to Western Port by 5 tonnes by 2015	A long-term catchment target will be developed through the research and investigation phase of *Better Bays and Waterways*. In the interim, actions to reduce the sediment load will have a double benefit in that they will reduce the nitrogen load entering the waters of Western Port. Loads based on dry and average year nitrogen loads will assist in prioritising actions to reduce nitrogen in the longer term
Waterway water quality targets	The State Environment Protection Policy (Waters of Victoria) outlines waterway water quality objectives. Appendix 2 describes a process for establishing regionally specific water quality targets.	State Environment Protection Policy (Waters of Victoria) outlines waterway water quality objectives.
Environmental flow targets	Bunyip/Tarago – By 2012 the Environmental Water Reserve for the Bunyip/Tarago system will be increased by 3GL* Yarra – By 2015 the Environmental Water Reserve for the Yarra system will be increased by 17GL* Maribyrnong – By 2010 the Environmental Water Reserve for the Maribyrnong system will be increased by 3GL** Werribee – By 2015 the Environmental Water Reserve for the Werribee system will be increased by 6GL** By 2013, the environmental flow condition of the waterways within eight out of 63 management units will have improved as outlined in the RRHS*** By 2013, the environmental flow condition of the waterways within the remaining 55 management units will be maintained as detailed in the RRHS*** * This entitlement has been granted however due to the current water shortage the flows will not be delivered until 2012, when the Melbourne water supply system is augmented or until water restrictions in the region return to Stage 1 or less. ** Work is progressing toward this target however extreme drought conditions may impact on timelines for delivery of the Environmental Water Reserve. *** Work is progressing towards this target however extreme drought conditions may impact on timelines	These targets will be set through other mechanisms and are outside the scope of *Better Bays and Waterways*.
Urban flow target	No quantitative targets have been established. Targets will be set through the BPEM review (action 7.9).	Maintain flows at pre-urbanisation levels in urbanised areas.

Management programs

Better Bays and Waterways is a five year plan from 2009 to 2014 and outlines actions for improving water quality in a number of different management programs. These programs are:

- Catchment actions for managing water quality
  - Rural diffuse source management
  - Urban diffuse source management
  - Point source management
  - Management of 2009 Black Saturday bushfire effects on waterways
  - Environmental flows
- Marine influences
- Understanding our rivers and bays
  - In-stream monitoring
  - In-bay monitoring
  - Research and investigations
- Effective management
  - Community engagement
  - Governance
  - Reporting, evaluation and review

All actions and commitments made within *Better Bays and Waterways* are subject to the availability of funding. Additional investment from the Commonwealth Government is required for the implementation of actions in the Additional Investment Opportunities sections of the management programs and may be required for actions that are listed as either partially funded or not funded in the action tables. Further explanation about the management programs, actions, commitment and funding is contained in Chapter 6.

Community engagement

The concept of integrated catchment management has brought about a greater recognition by all parts of the Victorian community of the many contributions we can make to protect and enhance the aquatic environment. There is recognition that everyone makes a contribution to catchment management and that water quality is a shared responsibility.

Better Bays and Waterways recognises and acknowledges the important role the community plays in protecting water quality in the bays and waterways of the region. Management programs highlight the need to consult with and engage community members, groups and local government to improve water quality in the region. The lead agency implementing each action in the management programs is required to assess the level of community engagement needed for the action's implementation.

Coordinating Committee

A partnership of key agencies and local government involved in water quality improvements will be formed to oversee implementation of *Better Bays and Waterways* resulting in improved coordination of activities and better information sharing.

The coordinating committee will also hold an annual forum to engage with the community on the progress of *Better Bays and Waterways*, providing the opportunity to raise current and emerging water quality-related issues.

Reporting

An annual water quality and loads update will be developed to inform the community about the condition of water quality in the region. An annual implementation report will also be developed to inform the *Better Bays and Waterways* coordinating committee and assist with the adaptive management of the plan's actions. Together with water quality monitoring, this will build our ability to assess how actions have effected environmental change.

Better Bays and Waterways Vision

Better Bays and Waterways will add significant value to our collective efforts to protect and enhance the quality of water in Port Phillip Bay, Western Port and the catchments' waterways. It is an investment plan and will provide government, business and community with the opportunity and confidence to invest in practical and measurable improvements to the health and environment of these assets.

Contents

Acronyms and Abbreviations

µg/l	Micrograms per litre
2030 A1FI	Climate Change Scenario for 2030, where the focus is on continued reliance on fossil fuel-intensive economic structures
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BCLN	Bass Coast Landcare Network
BMP	Best Management Practices
BOM	Bureau of Meteorology
BPEM	Best Practice Environmental Management
CALP Act	Catchment and Land Protection Act 1994
CBD	Central Business District
CCMA	Corangamite Catchment Management Authority
CMA	Catchment Management Authority
CSIRO	Australia's Commonwealth Scientific and Industrial Research Organisation
CWW	City West Water
DEWHA	Department of Environment, Water, Heritage and the Arts
DHS	Department of Human Services
DNRE	Department of Natural Resources and Environment
DO	Dissolved oxygen
DPCD	Department of Planning and Community Development
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
EC	Electrical conductivity
EDC	Endocrine disrupting compounds
EI	Effective imperviousness
EMP	Environmental management plan
EPA Victoria	Environment Protection Authority Victoria
eWater CRC	eWater Cooperative Research Centre
EWR	Environmental Water Reserve
IPCC	The United Nations Intergovernmental Panel on Climate Change
IRC	Index of River Condition
LG	Local Government
MAR	Managed Aquifer Recharge
MAV	Municipal Association of Victoria
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
MWMG	Metropolitan Waste Management Group
N_2	Nitrogen gas
NHMRC	National Health Medical Research Council
NOx	Nitrogen oxide
NRM	Natural Resource Management
NWQMS	National Water Quality Management Strategy
OEM	Office of the Environmental Monitor
PCB	Polychlorinated biphenyls
PIC	Plumbing Industry Commission
PoMC	Port of Melbourne Corporation
PortsE2	PortsE2 is a freshwater catchment-based model that estimates point and diffuse loads from the catchments of Port Phillip Bay and Western Port, and models scenarios such as changing land use
PPB	Port Phillip Bay
PPWCMA	Port Phillip and Westernport Catchment Management Authority
RCS	Regional Catchment Strategy
RRHS	Regional River Health Strategy
SEPP (WoV)	State Environment Protection Policy (Waters of Victoria)
SEW	South East Water
SIGNAL	Stream invertebrate grade number – average level
SS	Suspended Solids
STP	Sewage treatment plants
SWS	Sustainable Water Strategy
The Framework	Framework for Marine and Estuarine Water Quality Protection
TKN	Total Kjeldahl Nitrogen
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
VCS	Victorian Coastal Strategy
VLAA	Victorian Litter Action Alliance
VSAP	Victorian Stormwater Action Program
WHO	World Health Organisation
WP	Western Port
WSRD	Water Sensitive Road Design
WSUD	Water Sensitive Urban Design
WTP	Western Treatment Plant
YRIRP	Yarra River Investigations and Response Program
YVW	Yarra Valley Water

Part 1: Setting the scene

Chapter 1 Overview

Introduction

Victoria's water environments are some of the state's most important natural assets and the waters of Western Port, Port Phillip Bay and their catchments are vital to sustaining the way we live now and in the future. The region is highly valued for the diversity of its habitats and ecosystems, comprising extensive terrestrial and marine habitats that support more than 1800 species of native plants and 600 species of native animals. Of these, 296 plant species and 128 animal species are listed as threatened. The rivers, wetlands, estuaries and marine waters support millions of plants and animals including microscopic organisms (phytoplankton and zooplankton), marine and coastal plants, and a diverse range of animals including fish, penguins, local and migratory birds, platypus and dolphins.

The region includes three Ramsar-listed sites for wetlands of international significance and seven (four marine national parks and three marine sanctuaries) marine protected areas.

In addition, the region contains several important habitats such as the pupping grounds for school shark, the seagrass beds of Western Port, Swan Bay and the San Remo marine community, each of which is considered to be of critical importance in the protection of endangered or threatened marine species. Healthy ecosystems provide essential biological services, such as the ability to process nitrogen and other nutrients, and provide a sustainable food supply.

With more than 5 million people living in the catchments of Western Port and Port Phillip Bay, our natural assets are under constant threat from human activities. As such, the catchments are listed by the Australian Government as 'coastal hotspots', due to long-identified water quality issues in the bays. Key issues of current concern include the effects of sediment on ecosystems within Western Port and nutrients on ecosystems in Port Phillip Bay.

Healthy waterways underpin our lives. They provide drinking water and support the agricultural productivity and commercial and recreational fisheries that are essential to the wellbeing and economic prosperity of our community. It follows that protection of water quality is essential, as it directly affects the uses and values of our waterways.

Better Bays and Waterways is a Water Quality Improvement Plan (WQIP) for Port Phillip Bay and Western Port and their surrounding catchments. It builds on an extensive history of environmental monitoring and research and has been designed to help implement and extend existing policy. *Better Bays and Waterways* has been developed using the results of research into the current condition of the waterways and bays. It documents the current condition, sets targets for water quality improvements and outlines actions to maintain and improve the quality of the region's bays and waterways.

Better Bays and Waterways reflects the environmental values and objectives identified in legislation such as State Environment Protection Policies (SEPP). This legislation was developed through extensive consultation with Victorian government agencies and the community. The values defined in *Better Bays and Waterways* are also consistent with values identified in many other regional strategies and policies, with particular links to SEPP (Waters of Victoria) and Schedules F6 (Waters of Port Phillip Bay), F7 (Yarra River), and F8 (Western Port).

Better Bays and Waterways will add significant value to our collective efforts to protect and enhance the quality of water in Port Phillip Bay, Western Port and the catchments' waterways. The Port Phillip and Western Port Regional Catchment Strategy, the Port Phillip and Western Port Regional River Health Strategy and the Yarra River Action Plan each identify *Better Bays and Waterways* as a key plan to address water quality in the region. It will provide governments at all levels, business and community with the recommendations and direction to invest in practical and measurable improvements to the health and environment of Port Phillip Bay and Western Port and their waterways.

Context to *Better Bays and Waterways*

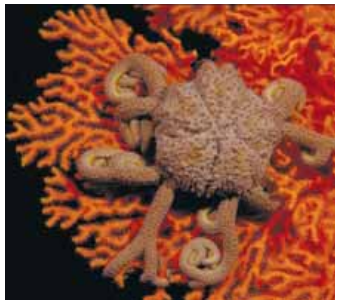
In 1992, the National Water Quality Management Strategy (NWQMS) was developed to guide the protection and enhancement of Australia's surface, ground and coastal waters while maintaining economic and social development. The NWQMS was developed collaboratively by the Australian federal, state and territory governments through the Natural Resource Management Ministerial Council, in association with the Environment Protection and Heritage Council, the National Health and Medical Research Council and the Australian Health Ministers Conference. It provides a nationally consistent approach to water quality management. The NWQMS contains the principles for managing key elements of the water cycle and provides guidance in establishing the ecological, social and environmental values of waterways, assessing risks to the values and ensuring protection of the values through a comprehensive set of guidelines. The guidelines include water quality objectives that define indicators and trigger values (above or below which there is an elevated risk of adverse biological effects) to ensure the protection of the waterways' values.

A number of policies and strategies have been developed to protect, maintain and enhance the waterways within Victoria including for the Port Phillip and Western Port region, and in doing so have addressed various elements of the NWQMS. These policies and strategies have identified the environmental values, water quality objectives (see Appendix 3), and a range of management actions to assist in protecting the values and achieving the objectives. These policies have been developed through extensive consultation with agencies and the community. Rather than duplicate this significant work, *Better Bays and Waterways* has been developed by building on the existing legislation, strategies and plans.

Through the application of the NWQMS, federal and state governments are working in collaboration to develop water quality improvement plans to reduce pollution being released into coastal hotspots across the country. The Port Phillip and Western Port region contains the major industrial and commercial centres of Victoria and was identified as a hotspot potentially at risk from increasing land-based pollution.

Better Bays and Waterways is consistent with the Framework for Marine and Estuarine Water Quality Protection (the Framework). The Framework has been used to identify cost-effective and timely projects (in accordance with a suite of criteria – see Appendix 4) for investment by Australian federal, state and local governments, and community and environment groups, forming an agreed approach to pollution reduction.

1 Overview



The Federal Government also funded a series of interim projects designed to assist in the preparation of *Better Bays and Waterways*, address institutional barriers to the implementation of the plan, and establish monitoring and decision-support systems.

The interim projects (and their lead agencies) were:

- Institutionalising Water Sensitive Urban Design and Best Practice Management in Greater Melbourne (Melbourne Water)
- A Decision Support System for Improving Water Quality in Port Phillip and Western Port (Melbourne Water)
- Review of the Operation of Melbourne Water's Revised Pollutant Loads Monitoring Program for Port Phillip and Western Port (Melbourne Water)
- Environmental Offsets (EPA Victoria)
- The Port Phillip Bay and Western Port Beach Water Quality Monitoring Program and Priority Source Investigations (EPA Victoria)
- Identifying and Evaluating Agricultural Practices to Reduce Nitrogen and Phosphorus Exports in the Port Phillip and Westernport Region (Department of Primary Industries).

Other key investigations were:

- Community Perceptions Research of Water Quality and the Bays (Melbourne Water and EPA Victoria /Parks Victoria)
- Community Perceptions and Expectations of Water Quality (Melbourne Water)
- Port Phillip Bay and Western Port Marine Condition report (EPA Victoria)
- Port Phillip Bay and Western Port Waterways Condition Report (Melbourne Water)
- Predicted Impacts of Climate Change and Urban Growth on Water Quality (Melbourne Water)
- Statutory and Institutional Arrangements (EPA Victoria – Appendix 5).

Better Bays and Waterways identifies actions requiring investment by the Australian federal, state and local governments, and community and environment groups. The plan focuses on projects that are most likely to deliver cost-effective water quality improvements, while seeking management strategies to sustain these improvements in the long term.

Better Bays and Waterways was funded by the Australian Government in partnership with EPA Victoria and Melbourne Water.

Regional context

Within the Port Phillip and Western Port region (and more broadly within Victoria), several existing strategies, policies, provisions and plans have links to *Better Bays and Waterways*, by influencing its development and/or being influenced by the proposed management programs. These are:

- *Our Water Our Future* — government policy on water resources
- Victoria planning provisions
- State environment protection policies – subordinate legislation of the *Environment Protection Act 1970* (to safeguard environmental values that need protection)
- Victorian Coastal Strategy 2008
- Regional catchment strategies — framework for natural resource management in the region, sets water quality targets (10 year)
- Regional river health strategies — five-year blueprint for river health, sets river health condition targets (10-year)
- Port Phillip Bay Environmental Management Plan
- Melbourne Water Water Quality Strategy — internal high level framework to guide Melbourne Water investment for waterway management
- Stormwater management plans.

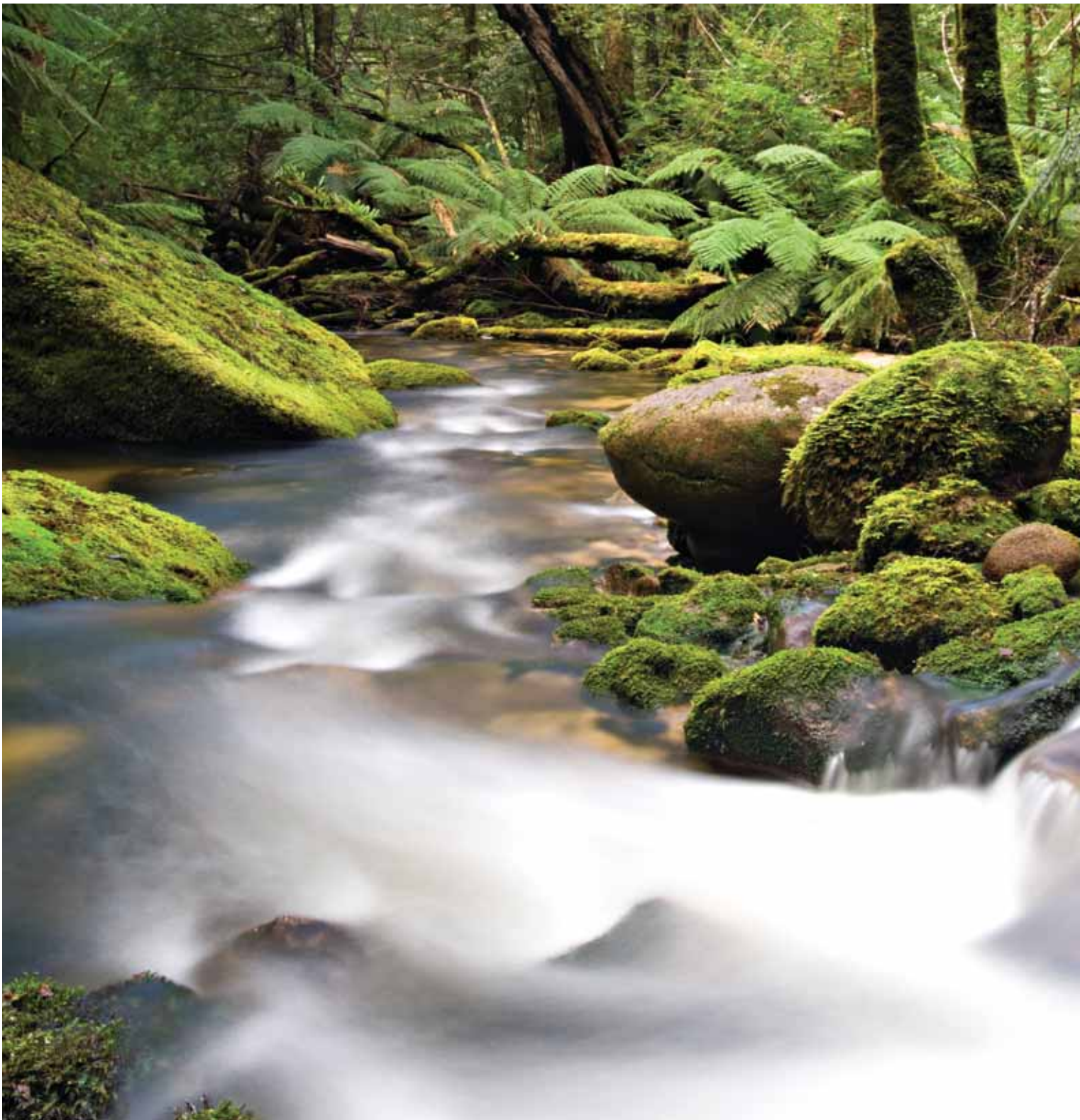
Water quality is managed by a number of different agencies and authorities. The responsibilities of each are outlined in Table 1.1.

Table 1.1: Water quality management in the region – responsibilities

Organisation	Responsibilities
Department of Sustainability and Environment (DSE)	DSE leads the Victorian Government's efforts to sustainably manage water resources and catchments, climate change, bushfires, parks and other public land, forests, biodiversity and ecosystem conservation. DSE administers a number of Acts of Parliament including the Water Act 1989, which establishes rights and obligations in relation to water resources, provides mechanisms for the allocation of water resources, governs the statutory powers and functions of all water authorities outside the metropolitan area, and provides for integrated management of the water resource and for environmental and consumer protection. DSE supports the Minister in administering the Land Act, as well as several other Acts applying to land and waters in the bays (e.g. Crown Land (Reserves) Act, National Parks Act). The seabed, and therefore the water above the seabed, is mostly unreserved Crown land managed under the Land Act. Use of "coastal Crown land", including the seabed, also requires consent under the Coastal Management Act. DSE also supports the Minister in administering the Coastal Management Act. DSE establishes statewide policy on river health and manages government investment in river and bay health. DSE performs its range of functions in close partnership with its service delivery partners, including local government and state government agencies. DSE coordinates the overall management and review of the Port Phillip Bay Environmental Management Plan (EMP) through the Port Phillip Bay State Environment Protection Policy (SEPP).
Melbourne Water	Caretaker of river health in the Port Phillip and Western Port region. Responsible for floodplain and major drainage (catchments >60ha). Provides bulk water and bulk sewerage services in the Melbourne metropolitan area (including managing the Eastern and Western Treatment plants). Manages water supply, water harvesting and diversion licensing in the Yarra and Lower Maribyrnong. Manages the environmental water reserve management and the development of streamflow management plans for the Yarra and Lower Maribyrnong. Hosts Waterwatch and manages a range of community engagement mechanisms. Conducts water quality monitoring and reporting for waterways. Advocates for and provides capacity building in Water Sensitive Urban Design (WSUD). Develops and implements the RRHS and other key strategies including the Estuaries Strategy and the Floodplain Strategy and the Water Quality Strategy. Undertakes works to provide erosion control and in-stream waterway stability, coordinates the stream frontage management program, which provides grants for on-ground works, and oversees large-scale riparian and aquatic improvement programs. Responsible for flood protection works across the catchment and works with developers to ensure subdivisions do not impede floodwater flow paths or affect river health. Partner in the Yarra River Action Plan and the development of *Better Bays and Waterways*. Leads the Lower Yarra Litter Strategy.
Environment Protection Authority Victoria (EPA Victoria)	The regulatory body to set long-term water quality objectives, manage licensed discharges, investigate industrial pollution incidents and take enforcement action if necessary. EPA Victoria is also responsible for conducting water quality monitoring in Port Phillip Bay and Western Port. EPA Victoria is responsible for reporting Yarra water quality data collected by Melbourne Water. EPA Victoria is also a partner in the Yarra River Action Plan and the development of *Better Bays and Waterways*.
Water Authorities: City West Water Ltd, South East Water Ltd and Yarra Valley Water Ltd	These retailers are holders of water and sewerage licences issued under the Water Industry Act 1994 and provide retail water supply and sewerage services to customers in the Melbourne metropolitan area. Main regulated responsibility in relation to water quality is in the quality of treated water returned to the environment from the seven small sewage treatment plants. Retailers are responsible for managing trade waste flows into their system.
Southern Rural Water	Responsible for surface water and groundwater licensing, establishing water supply protection areas, streamflow management plans and groundwater management plans (with the exception of surface water in the Yarra and Lower Maribyrnong). Responsible for irrigation water distribution in the Werribee Irrigation District and Bacchus Marsh Irrigation District.
Local government (LG)	Has a role in water management as a local planning authority, public land management and public health authority and as a representative of diverse communities. Develops municipal strategic statements, which reflect many issues relating to the Catchment and Land Protection Act 1994, CMA's regional catchment strategies and Victorian coastal strategies, including water quality. Responsible for regulating the installation and management of septic tanks in their municipality. Responsibility for drainage in catchments less than 60 hectares. Local government also plays an active role in the installation of raingardens and water sensitive urban design (WSUD) to minimise pollutant-laden stormwater runoff into waterways and the bays. Plays a key role in the management of litter in catchments from installation of litterbins in public areas, collection of rubbish, green waste and recycling bins (where available) and removal of litter from parks, gardens and beaches. Many councils employ litter education officers to educate the community about waste management. Maintains and upgrades roads in the municipality (apart from major roads that are VicRoads' responsibility).

Organisation	Responsibilities
Port Phillip and Western Port Catchment Management Authority (PPWCMA); **Corangamite Catchment Management Authority (CCMA)**	Responsible for the coordination of natural resource management within the Port Phillip and Western Port region and Corangamite region respectively. Prepare and coordinate implementation of regional catchment strategies. These strategies identify the regional environmental, social and economic values of surface waters and after consideration of environmental, social and economic needs, set appropriate goals, priorities and environmental targets for catchment and coastal environments. Support a range of major integrated projects and provide grants to community groups. The CCMA also develops the Regional River Health Strategy (RRHS) for the Corangamite region.
Department of Human Services (DHS)	Responsible for Victorian Government programs to enhance and protect health and wellbeing. In addition to administering the Health Act 1958, Food Act 1984 and the Safe Drinking Water Act 2003, DHS provides policy advice to local and state government agencies about protecting public health. DHS endorses Class A water recycling schemes under the provisions of the Environment Protection Act 1970 to ensure scheme proponents have appropriate controls in place to minimise health risk to those exposed to the water.
Parks Victoria	Under the Water Industry Act 1994, responsible for the care, protection, management and use of the Yarra and Maribyrnong Rivers for the purposes of recreation, leisure, tourism and water transport. Litter collection in the Yarra River below Dights Falls and in the Maribyrnong River below Canning Street Ford. Custodian of a diverse range of parks in the region. Administers marine parks and sanctuaries through Victoria's System of Marine National Parks and Marine Sanctuaries Management Strategy 2003-2010.
Port of Melbourne Corporation (PoMC)	State owned enterprise responsible for activities in the port area of the Port Phillip Bay and both the Yarra and Maribyrnong rivers.
Central Coastal Board (CCB)	Responsible for preparing guidelines for coastal planning and management which may have implications for marine water quality. The CCB is also involved in the development and implementation of the Victorian Coastal Strategy, coastal action plans and approved coastal guidelines.
Department of Primary Industries (DPI)	Legislative responsibility for implementation of the Fisheries Act 1995, sustainable management of fisheries and development of the aquaculture sector (including management, research and compliance). Institutional responsibilities in the catchment including providing expertise to natural resource managers in the region. Involved in some animal welfare activities that could affect water quality. Influences improvement in primary industry performance by providing information and advice on the use and management of resources, guided by science and technology. Encourages the adoption of new agricultural technologies and practices through a range of community education and extension programs. In water management, this includes programs on nutrient and salinity reduction in rural areas.
Department of Environment, Water, Heritage and the Arts (DEWHA)	The Australian Government Department of the Environment, Water, Heritage and the Arts develops and implements national policy, programs and legislation to protect and conserve Australia's environment and heritage and to promote Australian arts and culture. The Environment Protection and Biodiversity Act 1994 is the Australian Government's central piece of legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. Key national policies and programs impacting on Port Phillip and Western Port catchments include the National Water Management Strategy, The Framework for Marine and Estuarine Water Quality Protection, the National Water Initiative and Caring for our Country.
Department of Planning and Community Development (DPCD)	Implements state policies through the planning system where it relates to land use and development. This includes integrated water management practices.
Sustainability Victoria	Responsible for waste management and recycling. Sustainability Victoria's purpose is to demonstrate how to use resources more efficiently and reduce everyday environmental impact. Develops and administers litter campaigns and programs.
Vic Roads	Maintain and manage major roads to minimise erosion and sediment and pollutant transport, particularly along urban, unsealed roads.

Chapter 2
Describing our Bays and Waterways



The region's heritage

Aboriginal heritage

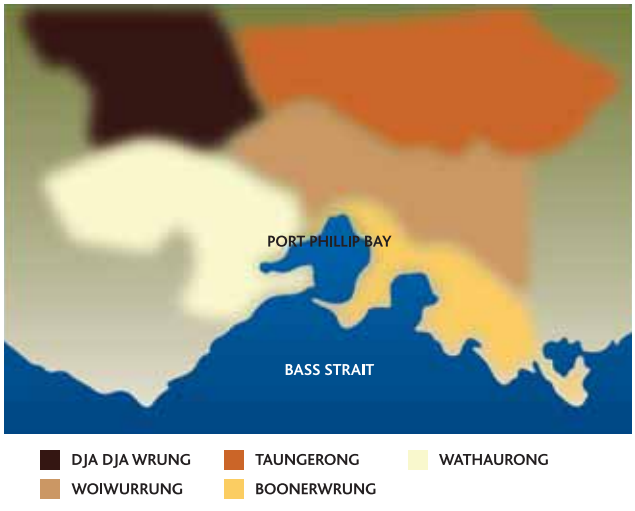
Western Port and Port Phillip Bay and their associated catchments are within the traditional country of the Kulin Nations. The Kulin Nations comprise five Indigenous communities: the Woiwurrung (Wurundjeri), Boonerwrung, Wathaurong, Taungerong and Dja Dja Wrung (Figure 2.1).

The *Better Bays and Waterways* regions are mapped primarily within Woiwurrung (Wurundjeri), Boonerwrung and Wathaurong country:

- Woiwurrung (Wurundjeri) Country covers the Yarra catchment area, the Yarra River and its tributaries
- Boonerwrung Country takes in the Mornington Peninsula, Western Port and extends further east down the coastline to Wilson's Promontory. The northern reaches extend to the south of the Dandenong Ranges
- Wathaurong Country covers the Bellarine Peninsula and into the Otway Ranges and east as far as the Werribee River.

The Taungerong and Dja Dja Wrung country sit outside the regions described by *Better Bays and Waterways*, but Taungerong and Dja Dja Wrung tribes travelled to other Woiwurrung, Boonerwrung and Wathaurong country to corroboree on significant meeting grounds, such as on the Yarra near the site of the CBD. The country of the Kulin Nations was also central to trade and corroboree for tribes within present day Victorian boundaries (Presland, 1985).

Figure 2.1: Indigenous communities in the region



Archaeological records show that the traditional owners have inhabited this region for over 40 000 years. Over this extended time the Kulin Nations have witnessed significant environmental and climatic transformations, not least the Ice Age. The Kulin explain the creation and transforming of the bays and waterways through Dreamtime stories.

This image has been reproduced courtesy of the State Library of Victoria.

Carolyn Briggs, Elder with the Victorian Boonerwrung Elders Land Council Aboriginal Corporation told her people's story at the Aboriginal (Boon wurrung) Heritage and Coastal Protection community workshop in 2005 (Briggs 2005):

'Many years ago this land we now call Melbourne extended right out to the ocean. Port Phillip was then a large flat plain where Boon wurrung hunted Kangaroo and cultivated their yam daisy. But one day there came a time of chaos and crises. The Boon wurrung and the other Kulin nations were in conflict. They argued and they fought. They neglected their children. They neglected their land. The native yam was neglected. The animals were killed but not always eaten. The fish were caught during the spawning season. As this chaos grew, the sea became angry and began to rise until it covered their plain and threatened to flood the whole of their country.

The people went to Bunjil, their creator and spiritual leader. They asked Bunjil to stop the sea from rising. Bunjil told his people that the people would have to change their ways if they wanted to save their land. The people thought about what they had been doing and made a promise to follow Bunjil. Bunjil walked out to the sea, raised his spear and directed the seas to stop rising. Bunjil then made the Boon wurrung people promise that they would respect the law.

The place the Kulin then chose to meet as a means of resolving these differences is where Melbourne's Parliament is now located. The Kulin nations met here regularly for many thousands of years. They debated issues of great importance to the nation, they celebrated, they danced.'

The waterways and bays of Port Phillip and Western Port were central to the economy of the Kulin, providing subsistence through fishing, eeling and gathering shellfish, and from the broader environment supported by the marine and freshwater ecologies of the regions. The Kulin have a continuing and dynamic connection to the land and waterways of the Port Phillip and Western Port region. The Woiwurrung, Boonerwrung and Wathaurong have strong associations with the national parks, sanctuaries and marine protected areas in their respective countries. The Two Bays project (Box 2.1) is one example of ongoing use and cultural engagement with waterways.

Box 2.1
Introduction to Two Bays

The Two Bays program provides a unique opportunity for waterway and bay managers to build knowledge, engage coastal communities, form partnerships to better understand and protect bay values, and to highlight the links between catchment activities and the bays.

Two Bays is an annual program delivered by Parks Victoria and Pelican Expeditions, first launched in January 2007. It incorporates a collaborative marine science and community engagement program operated from the vessel Pelican 1, a 62 ft catamaran. The vessel sails over a continuous 10-day period around Port Phillip Bay and Western Port, to highlight the links between catchment-based activities and the health of the bays. The Two Bays project uses Pelican 1 to conduct marine research, community engagement activities, and provide opportunities for dialogue and information sharing on key bay environmental themes (Parks Victoria and Pelican Expeditions 2009).

The program has a strong Indigenous program with significant contribution from Boon wurrung Elders, Indigenous Rangers and Koorie trainees. Part of the 2009 program was developing a curriculum for Victorian schools that links marine research from Two Bays with Boon wurrung Sea Country knowledge and stories of the bays (Koori Heritage Trust, pers comm. 2009).

During this exchange the marine science component of Two Bays mapped the Boon wurrung Waterfall story from Port Phillip heads. Before the flooding of the basin, now Port Phillip Bay, the Yarra extended to the heads to a waterfall, which shrouded the area in mist. At this time the Boon wurrung people were known as the 'people of the mist.' The traditional name for the Yarra is Birrarung, which means 'river of mists'. The marine mapping located the original waterfall site and discovered that the falls are flowing underwater through changed water conditions in the bay. Boon wurrung Elder, Faye Stewart Muir commented in The Koori Mail, 28 January 2009 'The story of the waterfall and science study that I have witnessed today needs to be available for all kids to learn and not just Indigenous kids.' This cultural dialogue provides opportunity for targeted engagement with young Victorians through the developing curriculum and the broader community by bringing Two Bays activities into communities around the bay, and raising the profile of the bays and the knowledge exchange through the media.

Elders and young Kooris will continue to share stories about sea country in the 2010 Two Bays program and develop digital stories that record these exchanges. These exchanges promote both the values of the bays and also shared responsibility between community and agencies for the health of the bays. Two Bays 2010 hopes to incorporate young Koori trainees already engaged in an environmental management pathway.

European heritage

Historically, Port Phillip and Western Port's bays and waterways have experienced significant transformations. To accommodate urban and industrial expansion, the courses of rivers and waterways have been altered and used as sewers, swamps have been drained and seabeds dredged.

From the 1860s, the Public Works Department significantly altered the course of waterways. The course of the Yarra particularly, experienced significant intervention, beginning with the removal of the falls upstream from William Street and the straightening of two bends near the Botanical Gardens. This resulted in the incursion of salt water upstream.

As industries expanded in the developing Melbourne suburbs, the Yarra and the Maribyrnong rivers and creeks became the township's sewers and drainage system, threatening both the ecology and the water supplies of the colony.

The affluence and relative economic stability of the 1880s led to increased use of the waterways for leisure and recreation. Activities such as rowing, sailing and fishing became entrenched in the colonial lifestyle. Following this, the public became increasingly concerned about the condition of their waterways and bays. There was particular outcry about industrial waste discharged to the Yarra upstream of burgeoning middle class suburbs south-east of the river. This outcry led to the relocation of industries producing highly toxic waste, such as the tanneries and abattoirs.

In 1890 the Melbourne Metropolitan Board of Works was established. One of its first projects was to provide Melbourne with much needed sewerage infrastructure, curtailing both the effect of sewage on the waterways and the death toll from typhoid and diphtheria (Dingle, 1984).

In Western Port, one of the earliest environmental interventions was a decision by the Lands Department in 1870 to drain the Koo Wee Rup Swamp to open up land for selection. The work to open up the swampy region to agriculture continued through the latter half of the 19th century. Extensive drainage systems were developed, beginning with a main channel being dug in 1876 to divert Cardinia Creek. This was followed by the Bunyip Main Drainage scheme in 1889. Work was ongoing in the region, which continued to be prone to flooding.

Erosion and increased runoff resulted from land clearing to extend farming and meet the demand for timber. This resulted in increased soil and sediment deposits to the waterways and bays (DPI, 2009).

Key shifts in community perception toward the health of the environment in the 1960s and 1970s led to the Environment Protection Act 1970, and the subsequent forming of the Environment Protection Authority. This significant shift in the perceived value of the environment and water quality since the 1960s has gone a long way to redressing the damage incurred since European settlement (Unglik, 1996). From this shift in community understanding and engagement with the environment, many community-based environment and conservation groups have emerged, among them the Landcare Network, WaterKeepers and Friends groups.

2 Describing our Bays and Waterways

Catchments

The Port Phillip and Western Port region is situated in south-central Victoria. The region covers some 13 440 km^2 and includes more than 8800 km of waterways, including rivers, creeks and estuaries. Of the seven catchments in the region, the Yarra, Maribyrnong, Dandenong and Werribee catchments drain into Port Phillip Bay, and the Western Port catchment drains into Western Port. The Bellarine Peninsula has two ephemeral streams that flow into Port Phillip Bay via Swan Bay. The Mornington Peninsula catchment has streams that flow into both Port Phillip Bay and Western Port (Figure 2.2).

The catchments in the Port Phillip and Western Port region have significant environmental, social and economic values. The waterways within these catchments are popular recreational destinations for Melbournians and tourists with over 100 million visits to our rivers, streams and creeks each year (Melbourne Water, 2004). However, our use of these catchments is harming water quality and threatening many of the aspects we value.

Figure 2.2: Port Phillip and Western Port catchments

Within the region, a reasonably consistent pattern of water quality degradation can be seen. Upland forested areas generally have excellent or very good water quality, but this degrades as land use changes to agricultural and urban activities. The greatest effects from agricultural areas come from direct stock access to streams, intensive horticulture, dairy effluent and pesticide use. The most severe water quality effects come from urbanised areas, with pollutant sources coming from stormwater runoff, septic tanks and industrial and sewage treatment plant discharges.

Assessing waterway condition

The condition of our waterways is assessed in several ways. One is by comparing water quality data with legally required standards within state legislation (e.g. SEPPs under the Environment Protection Act 1970 – see Appendix 3 for SEPP criteria). Overall river health in the region is measured using the Index of River Condition (IRC) (SKM, 2007a). The IRC assesses a number of key river health indicators, of which water quality is just one. These indicators are:

- physical form (river bank and bed condition, presence of and access to physical habitat, presence of artificial barriers)
- streamside zone (quality and quantity of streamside vegetation and condition of billabongs)
- hydrology (flow volume and seasonality of flow)
- water quality (key water quality indicators compared against SEPP water quality objectives)
- aquatic life (diversity of macroinvertebrates).

For 2002-03, IRC ratings showed that in the Melbourne region, 25% of rivers and creeks were in good or excellent condition, 30% were in moderate condition and 45% were in poor or very poor condition (Melbourne Water, 2007b). These results are considered to reflect major land use patterns. The IRC ratings for waterways in each catchment are shown on maps under each catchment heading.

Better Bays and Waterways is a water quality improvement plan and therefore focuses on the water quality aspects of river health rather than the whole suite of river health indicators that are covered in Regional River Health Strategies.

Port Phillip catchment

Port Phillip Bay's catchment covers an area of 8656 km^2 and encompasses several river catchments. From west to east these are known as:

- Bellarine Peninsula catchment
- Werribee catchment
- Maribyrnong catchment
- Yarra catchment
- Dandenong catchment
- Mornington Peninsula catchment.

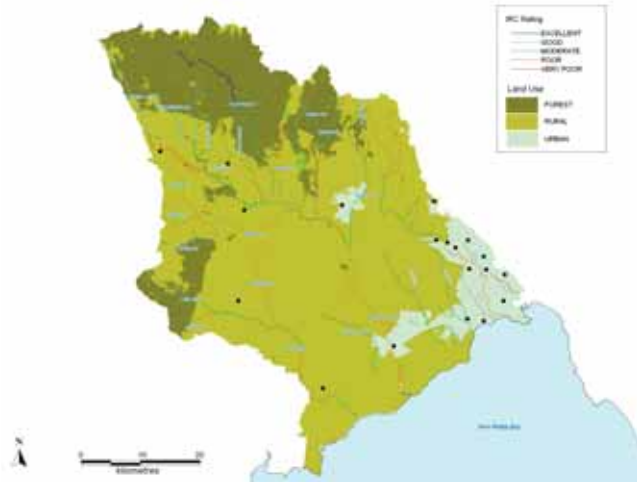
The Bellarine Peninsula catchment

Figure 2.3: Bellarine Peninsula

The Moorabool Basin (Geelong region) contains a number of small streams including Hovell Creek and the Limeburners Bay estuary that discharge into Corio Bay, and Yarram Creek which discharges into Swan Bay (part of Port Phillip Bay). The major rivers of this catchment, however, flow to Bass Strait via the Barwon River catchment. Along the Bellarine Peninsula (Figure 2.3) are key sites of international importance for the protection of migratory water birds under the Ramsar Convention. These sites are Swan Bay, Mud Island, Avalon airfield and Point Wilson to Limeburners Bay (Table 2.6).

The Werribee catchment

Figure 2.4: The Werribee catchment and Index of River Condition (IRC) ratings



The Werribee and Little rivers drain the Werribee catchment, which covers an area of 2718 km^2 (Figure 2.4). The Lerderderg River and its tributaries can be found in the upper reaches of the catchment. In addition, several smaller waterways such as Kororoit Creek, Skeleton Creek and Cherry Creek flow directly into the bay. Located to the south-west of Melbourne, the catchment stretches from the central highlands of the Wombat Forest and the Blackwood Range to Port Phillip Bay. The majority of land use in the Werribee catchment is rural and/or agricultural, with the lower reaches containing intensive agriculture and horticulture. This catchment also encompasses the rapidly developing urban corridor from Melton to Hoppers Crossing. The south-western corner of the Werribee catchment contains Melbourne Water's Western Treatment Plant (WTP), which treats approximately half of Melbourne's sewage.

Many valuable environmental assets are located within the Werribee Catchment including Ramsar wetlands of international significance. Such wetlands include Melbourne Water's Western Treatment Plant, Point Cooke Marine Sanctuary and the Spit Wildlife Reserve (Fletcher and Deletic, 2006). These wetlands contain a number of important plant and animal species and are popular destinations for bird watchers.

The Lerderderg River, a major tributary of the Werribee River is one of two Victorian Heritage Rivers and the only 'representative river' in the Port Phillip and Western Port region, reflecting its significant geological, landscape and conservation attributes (Melbourne Water, 2007b).

Recreational use of the catchment is high with passive recreation and fishing common activities, especially in the Lerderderg River sub-catchment. Water is also supplied from the catchment through the Melton, Pykes Creek and Merrimu Reservoirs (Fletcher and Deletic, 2006). In addition to the general recreational activities that occur in the catchment, there are significant links between the social and environmental values of the catchment.

2 Describing our Bays and Waterways

Historical effects on water quality

In the late 19th century, cleared grazing land in the Werribee catchment was readily converted to cropping and dairying.

In 1892 the newly-established Melbourne Metropolitan Board of Works began buying land at Werribee and developing a sewage farm to improve Melbourne's public health: the Western Treatment Plant. Previously, Melbourne's sewage was collected in open channels and discharged into the Yarra River and Hobsons Bay. The first Melbourne homes were connected to the sewerage system in 1897 (Melbourne Water website, 2009).

In 1904 the Victorian Government acquired land for closer-settlement farms, and irrigation improvements brought about successful settlement eight years later. This led to the development of a community of market gardeners, as well as orchardists and poulterers (Melbourne Water website, 2009).

In 1983, the western shores of Port Phillip Bay, including the Bellarine Peninsula, were designated a Wetland of International Importance under the Ramsar Convention. This classification included Lake Borrie and its surrounding lagoons and coastal mudflats. Lake Borrie was originally a small swamp with paperbark trees and a few red gums, but it is now a part of the Melbourne Water sewage treatment lagoon series. It is now the most significant wetland in Victoria for migratory shorebirds and one of the most significant drought refuges for ducks (Melbourne Water website, 2009).

Current water quality issues

The current condition for waterways in the Werribee catchment is detailed in Appendix 6. Table A6.2 (Appendix 6) outlines specific water quality issues for the Werribee catchment as identified in Fletcher and Deletic (2006) with additional information from SKM (2007a).

The results of an analysis of water quality trends at four sites in the Werribee catchment during 1990 to 2004 is shown in Table 2.1. There has been less monitoring, investigation and modelling of water quality in the Werribee catchment than in many of the catchments in the region, as most of the catchment was only incorporated into Melbourne Water's area of responsibility in November 2005. Only two sites on Kororoit Creek (one site on Skeleton Creek and one site on Cherry Lake) have been assessed.

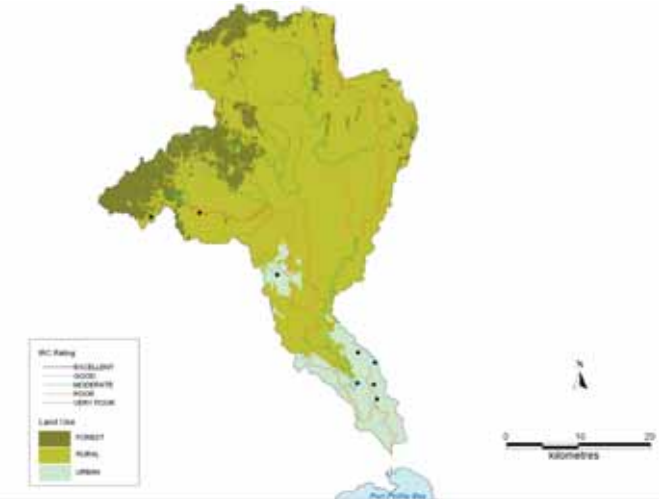
Table 2.1 Werribee catchment water quality trends 1990-2004 (Source: Webb, 2004)

Variable	Trend
Dissolved oxygen	In Skeleton Creek levels have remained relatively constant but substantial reductions have occurred in Kororoit Creek.
pH	There have only been small reductions in pH towards neutral.
Electrical conductivity	Electrical conductivity levels have remained relatively constant although there have been some small increases in Kororoit Creek.
Nutrients	In Skeleton Creek total nitrogen concentrations have increased while substantial reductions have occurred in Kororoit Creek. In Skeleton Creek phosphorus concentrations were increasing in the 1990s but have since levelled off. Phosphorus concentrations at one location in Kororoit Creek have decreased substantially.
Turbidity	Skeleton Creek has become more turbid while one site in Kororoit Creek has had a substantial reduction in turbidity levels.
Suspended solids	Changes similar to those observed for turbidity have occurred for suspended solids.
E. coli	In the creeks *E. coli* levels have remained relatively constant but at Cherry Lake there have been substantial increases.
Metals	The results for metals were variable with some reductions in lead concentration observed in Kororoit Creek while copper and nickel concentrations increased.

The results for Kororoit Creek show reductions in nutrient concentrations, turbidity and suspended solids, but dissolved oxygen and electrical conductivity have worsened. For Skeleton Creek, the results were the opposite, with nutrient concentrations, turbidity and suspended solids increasing, and dissolved oxygen and electrical conductivity levels improving (Table 2.1).

The Maribyrnong catchment

Figure 2.5: The Maribyrnong catchment and Index of River Condition ratings



The Maribyrnong catchment, in the central north-west of Port Phillip, covers an area of 1409 km^2 (Figure 2.5). The upper reaches of the Maribyrnong River are mostly rural and/or agricultural in nature. The lower half of the Maribyrnong River winds through the north-western suburbs of Melbourne before it joins up with the Yarra River in Footscray. The urban section of the catchment is predominantly used for industrial and residential purposes. The Maribyrnong catchment also contains the Melbourne International Airport at Tullamarine, which receives the majority of international and domestic air traffic for Melbourne. Along the banks of the Maribyrnong River is a large tract of parkland that provides valuable walking and cycling paths and recreational land, including popular fishing sites. Cherry Creek, a smaller tributary of the lower reaches of the Maribyrnong catchment, forms Cherry Lake, a popular spot for picnicking.

Cherry Lake and Truganina Swamp both provide valuable habitat for fauna such as waterbirds and the vulnerable Altona Skipper Butterfly, and have a diverse range of indigenous vegetation (Melbourne Water, 2007b)

Throughout the catchment water is extracted for agricultural purposes, and the Rosslynne Reservoir (located on Jacksons Creek) supplies water for both irrigation and domestic users (Melbourne Water, 2007b). These are important water sources, and, like the waters within the Yarra Catchment, can be threatened by high contaminant levels. Popular recreational areas include Mount Macedon and the surrounding Macedon Ranges. In urban areas, parks and recreational areas such as Brimbank Park and Pipemakers Park are found on the banks of the Maribyrnong River and its tributaries.

Historical effects on water quality

During the late 19th century the Maribyrnong River was used by a range of industries for waste disposal causing a decline in water quality. During the 1960s and 1970s, expanding industrial and unsewered urban development resulted in further decreased water quality (Melbourne Water, 2004). Today the catchment is sewered and industrial discharges are diverted to sewer resulting in greatly improved water quality.

Current water quality issues

The current condition for waterways in the Maribyrnong catchment is detailed in Appendix 6. Table A6.4 (Appendix 6) outlines specific water quality issues for the Maribyrnong catchment as identified in Fletcher and Deletic (2006) with additional information from SKM (2007a).

The results of an analysis of water quality trends at ten sites in the Maribyrnong catchment undertaken during 1990 – 2004 is shown in Table 2.2.

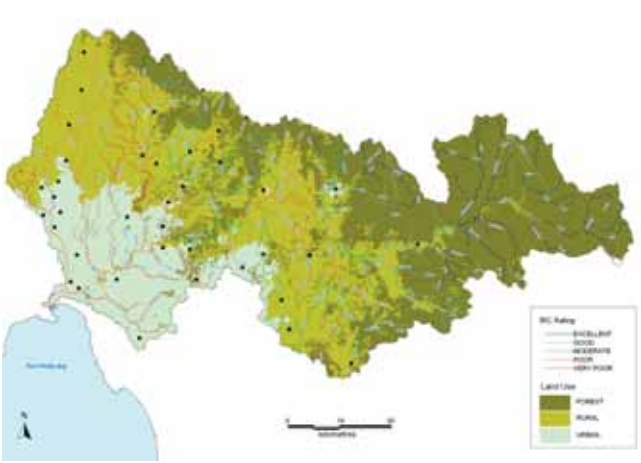
Table 2.2 Maribyrnong catchment water quality trends 1990-2004 (Source: Webb, 2004)

Variable	Trend
Dissolved oxygen	Reductions in dissolved oxygen levels were observed at all but two sites.
pH	Substantial reductions in pH were observed at all sites in the Maribyrnong catchment except for one site where no change was observed.
Electrical conductivity	Two sites in the catchment displayed substantial increases in electrical conductivity, while others displayed only small increases or no change.
Nutrients	Results for nitrogen were mixed with some sites showing substantial reductions and others showing increases. Changes in phosphorus concentrations were also mixed but generally showed a reduction in levels.
Turbidity	Turbidity was not measured at all sites, but where it was, improvements were observed.
Suspended solids	Overall reductions in suspended solid levels were observed, with only a few sites showing minor increases in levels.
E. coli	*E. coli* levels generally showed no substantial changes, except for two sites in the catchment where small reductions were observed.
Metals	Data for metals generally showed an increase in metal concentrations particularly for nickel and copper.

In the Maribyrnong catchment, decreasing dissolved oxygen concentration and increasing electrical conductivity and concentration of some heavy metals (such as copper and nickel) are of concern (Table 2.2). Conversely, reductions in nutrient concentrations (particularly phosphorus) and turbidity and suspended solids are encouraging and suggest that water quality is improving with respect to these indicators (SKM, 2007a). The closure of the Keilor sewage treatment plant in 1998 is a likely cause of the reduced nutrient concentrations (Fletcher and Deletic, 2006).

The Yarra catchment

Figure 2.6: The Yarra catchment and Index of River Condition ratings



The Yarra catchment covers an area of 4047 km², starting within the Great Dividing Range and meandering down to the top of Port Phillip Bay (Figure 2.6). The upper reaches of the Yarra River and catchment contain some of Victoria's most pristine environments. There are 867 km² of native forest in the upper reaches of the Yarra catchment, an important feature in maintaining the quality of Melbourne's water supply.

The Yarra Basin provides approximately half of Melbourne's drinking water, with the remainder secured from the Bunyip, Tarago and Thomson catchments. Water storages in the Yarra catchment include the Upper Yarra, Sugarloaf, Maroondah, O'Shannassy and Yan Yean Reservoirs. It is important to recognise that the condition of waterways will affect the quality of our drinking water (SKM, 2007a).

The rural sections of the Yarra catchment contain large tracts of agricultural land, used for cattle and sheep grazing, fruit orchards, flower gardens, market gardens and berry farms. The Yarra Valley is a prime agricultural region producing world-class wines and gourmet food (SKM, 2007a). There are also many hobby farms in the region.

Along its entire length the river is valued for its environmental, social and economic assets. The Yarra and its tributaries are home to threatened and iconic species such as Murray Cod and platypus, and contain Victoria's only self-sustaining population of Macquarie Perch. The broader catchment, particularly the Yarra Valley and Yarra Ranges, is a significant tourist attraction (Melbourne Water, 2004).

The lower reaches of the Yarra River run through the centre of Melbourne's CBD. It is estimated that 30% of Melbournians live within 1 km of a waterway or creek and over one third of Victoria's population live within the Yarra basin (Melbourne Water 2007b). The Yarra River plays an important role in recreation and relaxation for Melbournians. Water skiing, rowing and various other aquatic activities are popular, particularly during the annual Moomba Festival in March. Recreational fishing is common along the Yarra and its tributaries, with common catches including native and introduced species such as blackfish, brown trout, perch, redfin, eel and carp. Parkland along the Yarra at Westerfolds Park, Warrandyte State Park, Studley Park and Westgate Park provides an important asset for Victoria as a location for picnics, walking, cycling and other recreational activities.

The Port of Melbourne, Victoria's largest shipping port, is located at the mouth of the Yarra.

Historical effects on water quality

Our attitudes and expectations of the Yarra River and its tributaries have changed significantly over time. Historically, the Yarra was used as a dumping ground for industrial and domestic waste, resulting in very poor water quality and earning Melbourne the title of 'Marvellous Smellbourne'. Now the river is a valuable and integrated part of the city (Melbourne Water, 2004). Over time the discharge of industrial waste to the Yarra River has been banned, the sewerage system has been progressively extended and upgraded to reduce the risk of overflows to the waterways, and Melbourne Water, EPA Victoria, local councils and the community have worked hard to improve the quality of stormwater entering waterways (Melbourne Water, 2004). These changes have significantly improved water quality in the catchment over the last 20 or 30 years.

Current water quality issues

The current condition for waterways in the Yarra catchment is detailed in Appendix 6. Specific water quality issues for the Upper and Middle Yarra and in the Lower Yarra are outlined in Tables A6.6 and A6.7 respectively as identified in Fletcher and Deletic (2006) with additional information from SKM (2007a).

The results of an analysis of water quality trends at 36 sites in the Yarra catchment undertaken for the period 1992 – 2006 is shown in Table 2.3.

Table 2.3 Yarra catchment water quality trends 1992-2006 (Source: Webb, 2006)

Variable	Trend
Dissolved oxygen	There have been widespread reductions in dissolved oxygen throughout the catchment, with both highly modified (Moonee Ponds Creek) and more rural waterways (Olinda and Arthurs Creeks) affected. An obvious cause for this deterioration has not yet been determined.
pH	The waterways in the upper catchment are becoming more alkaline, whereas pH in the lower catchment has been increasing towards a neutral level
Turbidity and suspended solids	There has been a general decrease in turbidity and suspended solids, although increases were observed in the Yarra River at Warrandyte, Darebin Creek and Plenty River.
Nitrogen	In the upper reaches of the Yarra and its tributaries there have been some increases in total nitrogen, while some of the lower tributaries have shown improvement.
Phosphorus	Phosphorus concentrations have decreased at a majority of sites.
E. coli	Levels of harmful *E. coli* have decreased at three out of five sites in the Yarra River and in many tributaries, although the levels in Brushy and Woori Yallock Creeks have increased.
Metals	Trends in metal concentrations have varied across sites.

Trend analysis indicates improvements (i.e. decreased concentrations) in suspended solids, phosphorus, turbidity and *E. coli* since 1992 (Table 2.3). However, there are also instances of declining water quality over time, such as decreasing dissolved oxygen levels in both urban and rural tributaries and increases in nitrogen concentrations in the Upper Yarra and tributaries.

Aquatic life within the Yarra catchment is closely related to water quality. However, despite poor water quality in a number of sub-catchments a surprising range of fish species can be found, including Common and Climbing Galaxias in Gardiners Creek (SKM 2007a).

Platypuses are common in the Yarra catchment and have been found as far downstream as Heidelberg. However, the effects of catchment imperviousness and elevated nutrients are likely to restrict their distribution in the Lower Yarra and heavily urbanised tributaries like Merri Creek (SKM 2007a).

Many waterways within the Yarra catchment are of significant value to the community, in particular for passive recreation. Waterways such as Mullum Mullum Creek, Gardiners Creek, Scotchmans Creek, Merri Creek, and the main stem of the Yarra are all highly valued. In the upper catchment, ecological values of waterways need to be protected from sediment loads, nutrients and pesticides.

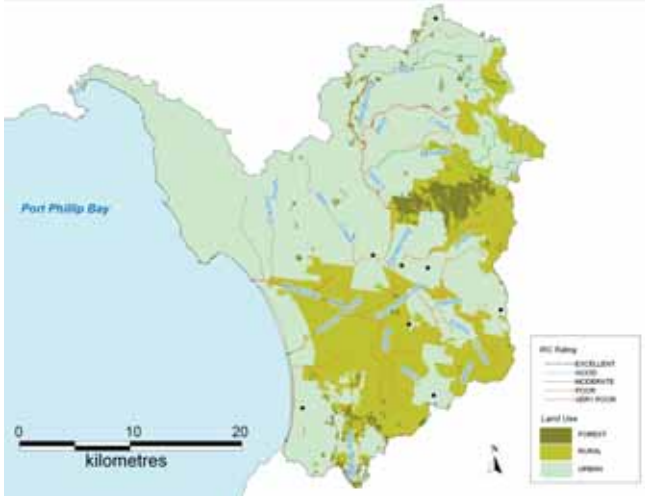
The Lower Yarra is highly valued by the community for both active and passive recreation. The Lower Yarra is a particular focal point for large-scale recreational activities. However, community satisfaction is dependent largely on perception of litter loads as litter threatens the perception of the river as 'clean and well managed' (SKM 2007a).

Similarly, management of bacterial contamination remains a considerable challenge, especially after high rainfall, with community perception of water quality very tightly connected to faecal indicator levels.

Management of stormwater, including inputs of heavy metals and addressing faecal inputs, are critical to protecting the very high social values of this catchment and rivers.

The Dandenong catchment

Figure 2.7: The Dandenong catchment and Index of River Condition ratings



The Dandenong catchment encompasses 882 km^2 (Figure 2.7) stretching from the Dandenong Ranges in the east of Melbourne, to the Carrum breakwater at the mouth of the Patterson River in the west. Dandenong Creek is the major waterway in the catchment. It begins in the Dandenong Ranges and discharges into Port Phillip Bay via both Mordialloc Creek and Patterson River. Other major tributaries include:

- Bungalook Creek
- Blind Creek
- Eumemmerring Creek
- Corhanwarrabul Creek
- Mile Creek.

Additionally Kananook Creek discharges directly to Port Phillip Bay within the Dandenong catchment near Frankston.

The Dandenong catchment supports the second largest reservoir in the Port Phillip and Western Port region, the Cardinia Reservoir, which holds a capacity of 287 000 million litres.

The Dandenong catchment is Melbourne's most urbanised catchment with approximately 45% of the land devoted to urban uses (Fletcher and Deletic, 2006) and includes the south-eastern growth corridor from Cranbourne to Pakenham. This degree of urbanisation is expected to increase with the growth areas of Kilsyth and Bayswater located within the catchment. Dandenong was also identified as an activity centre in the blueprint for Melbourne's development, *Melbourne 2030*.

Extensive modifications have been made to the rivers and creeks for flood protection. The floodplains of the Patterson River have been developed into several different ventures that add economic and social value to the region including:

- Melbourne Water's Eastern Treatment Plant, which treats sewage and wastewater from all households in the eastern part of metropolitan Melbourne;
- Patterson Lakes – a suburb constructed around artificial canals. This development also contains a marina that services the south-eastern end of Port Phillip Bay; and
- The National Water Sports Centre, which provides an international standard facility for aquatic activities such as rowing and water skiing.

There are several protected wetlands across this floodplain including the Ramsar-listed Edithvale-Seaford Wetlands and Braeside Park.

Recreational use of the Dandenong catchment's waterways is restricted in some areas by industrialisation, but high social values still exist in the upper catchment including the areas within the Dandenong Ranges National Park. In the lower reaches of the catchment there are some areas that have a good network of parks associated with the creeks, but this varies significantly among suburbs. The lack of recreational use of the catchment is an identified problem with efforts being made to improve the amenity of the catchment and create more open space and recreational facilities (Melbourne Water, 2004).

Historical effects on water quality

Before settlement, the waterways of the Dandenong catchment drained to the large coastal Carrum Carrum Swamp. The swamp has been significantly modified now with the building of artificial channels such as at Patterson River (Melbourne Water, 2004). A number of natural waterways were also modified, many of which still remain as cement-lined channels.

The upper catchment, which extends into the Dandenong Ranges, remains well forested, although there are some areas of urban development. The middle parts of the catchment were once covered by red gum and eucalypt woodlands and remained relatively rural until the post-World War II boom (City of Greater Dandenong, 2006). Growth continued in the 1950s and 1960s when factories, shops, houses and schools rapidly replaced the farmyards and paddocks. More recently, development in the catchment has included urban development in Rowville and Scoresby, and freeway construction (Fletcher and Deletic, 2006).

Current water quality issues

The current condition for waterways in the Dandenong catchment is detailed in Appendix 6. Table A6.9 (Appendix 6) outlines specific water quality issues for the Dandenong catchment as identified in Fletcher and Deletic (2006) with additional information from SKM (2007a).

The results of an analysis of water quality trends at twenty sites in the Dandenong catchment undertaken for the period 1980s to 2002 is shown in Table 2.4.

Table 2.4 Dandenong catchment water quality trends 1980-2002 (Source: SKM, 2002)

Variable	Trend
Dissolved oxygen	Overall trend showed small increases in levels, although several sites showed reductions, one of which was substantial.
pH	Of the sites monitored only one site showed a substantial change with a small increase in pH.
Electrical conductivity	Substantial reductions occurred at many locations. Any increases were small.
Nutrients	Nitrogen concentrations in the lower reaches of Dandenong Creek tended to decrease. There was an overall decrease in phosphorus concentrations, with all sites showing small or moderate reductions in phosphorus levels or no change.
Turbidity	Stable, with few sites having any significant change.
Suspended solids	The general trend was a reduction in levels, although most changes were relatively small.
E. coli	Large, consistent reductions in the upper reaches of Dandenong Creek.
Metals	Very few of the sites in the catchment were monitored for metal concentrations and of those that were, changes were only small and mixed.

Substantial improvements were recorded for nutrients, suspended solids, electrical conductivity (salinity) and *E. coli* concentrations at sites across the Dandenong catchment between 1975 and 2000 (SKM, 2002). Trends for dissolved oxygen concentration were mixed, with some sites recording an improvement in concentration while others recorded a decline (Table 2.4).

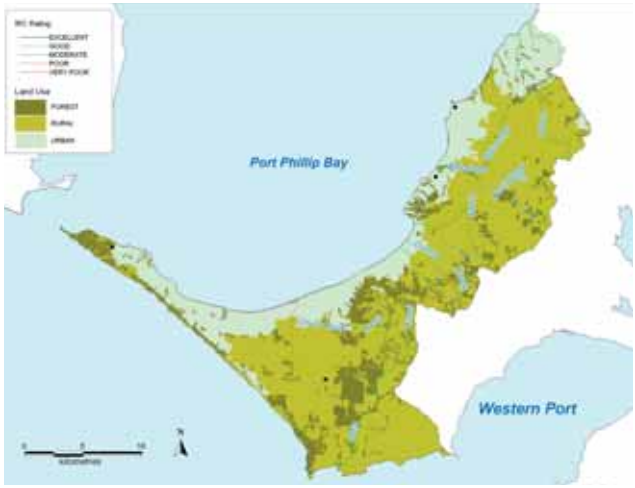
Aquatic life within the Dandenong catchment is closely related to land use and water quality. The Dandenong Amphipod inhabits streams within the Dandenong Ranges, and is very sensitive to the effects of stormwater, as is the large platypus population found within Monbulk Creek. Specific efforts are needed to protect these important stream reaches and their inhabitants from the effects of stormwater. Dwarf Galaxias are found in a number of creeks, drains and wetlands in the catchment, and while relatively tolerant of poor water quality, they require protection from loss of habitat and competition from introduced species. In general, urbanisation and the effects of stormwater are the major threat to biodiversity values of waterways within and draining the Dandenong Ranges.

In the Lower Dandenong catchment, waterways do not meet the standards for swimming and boating. Poor water quality, including litter, in waterways such as Elster Creek, Elwood Canal and Mordialloc Creek, also restricts recreational use of the area.

2 Describing our Bays and Waterways

The Mornington Peninsula catchment

Figure 2.8: Mornington Peninsula catchment



The Mornington Peninsula catchment covers an area of 358 km^2 (Figure 2.8) and is more rural and sparsely inhabited compared to the other catchments bordering Port Phillip Bay. Land use in the catchment is mostly small farming ventures, hobby farms and several small tourist towns that attract hundreds of thousands of visitors over the summer months. The region is a combination of rural and smaller urban centres. It also includes the Mornington Peninsula National Park and Arthurs Seat State Park. The western side of the peninsula (referred to as Western Peninsula rivers and creeks) consists of several small coastal waterways that flow into Port Phillip Bay between Mount Martha and Rosebud. Creeks in this area include Balcombe, Devilbend, Brokil, Dunns, Sheepwash and Drum Drum Alloc. The eastern side of the peninsula includes small waterways that flow into Western Port and Bass Strait (Melbourne Water, 2007c) and are discussed as part of the Western Port catchment.

Social use of the catchment is significant as the Mornington Peninsula is a popular tourist destination. Important social values of the catchment are closely tied to Port Phillip Bay and Western Port, which are used for a range of recreational activities including boating, swimming and fishing.

There are several parks and reserves, including The Briars Park and Arthurs Seat State Park. These rivers and creeks include populations of threatened Swamp Skinks, Growling Grass Frogs, Dwarf Galaxias and native orchids. Passive recreation is valued in many of these rivers and creeks (Melbourne Water, 2007b).

Current water quality issues

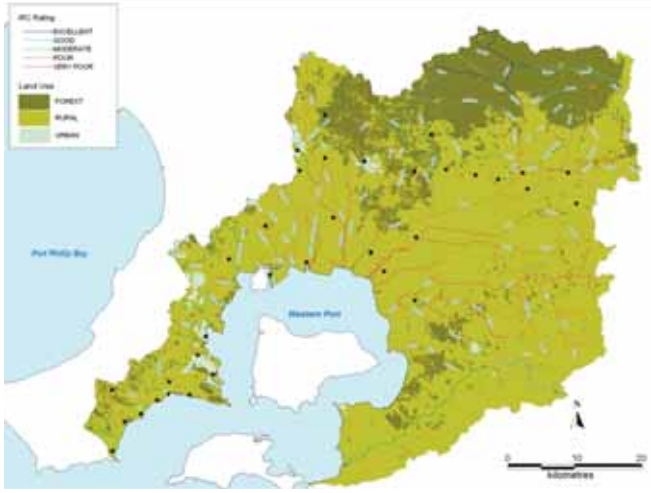
Stormwater is an emerging source of pollution from catchments within the Western Peninsula (between Mount Martha and Rosebud) (PPWCMA 2004; Melbourne Water 2007c).
The Mornington Peninsula Stormwater Management Plan (WBM Oceanics Australia, 2002) identified a number of key threats to water quality in the region. These included:

- Leakage from septic tank systems in the Nepean Peninsula polluting the groundwater within the Nepean and Chinamans Creek catchments;
- Poor sediment and erosion control practices in new residential subdivisions within the Balcombe Creek, Hastings and Mt Martha sub-catchments generating high sediment loads that have the potential to affect downstream receiving environments;
- Farming practices associated with the market garden areas in Chinamans Creek resulting in the export of nutrients, thereby affecting groundwater resources, Tootgarook Swamp and Port Phillip Bay;
- Building sites throughout the municipality, and in Balcombe Creek and Mt Martha in particular, that are often poorly managed and generate large loads of sediment and litter;
- Existing residential areas within Mt Eliza, Nepean and Balcombe Creek sub-catchments have been identified as posing threats to receiving environments;
- Several waterways in Mt Martha suffer from ongoing erosion, with bed and bank erosion extending further upstream;
- The Nepean catchment contains several commercial areas that are located adjacent to Port Phillip Bay and have significant potential to deliver pollution to the foreshore; and
- The municipality contains many unsealed roads, which have the potential to generate large sediment loads.

A burst sewer main polluted Balcombe Creek in September 2008. While this event was isolated and action was undertaken to minimise the effects on the health of the creek, such events have the potential to cause damage to environmental values.

Western Port catchment

Figure 2.9: The Western Port catchment and Index of River Condition ratings



The Western Port catchment area is 3365 km^2 (Figure 2.9) and is bounded by The Strzelecki Ranges to the east, the Yarra Ranges to the north and the Mornington Peninsula. Major waterways in Western Port are:

- Cardinia Creek
- Toomuc Creek
- Bunyip River
- Tarago River
- Lang Lang River
- Bass River.

The waterways in the area are diverse in both their form and health (Fletcher and Deletic, 2006). The Koo Wee Rup Swamp once covered extensive low-lying areas in the Western Port hinterland. With settlement, the swamp was drained for agricultural use and, as a result, many of the waterways in the lower catchment consist of channelised drains (Melbourne Water, 2007b).

The Western Port catchment area is mostly used for agricultural activities, with the remaining approximately 20% consisting of Crown land, national parks and 25 urban townships. There are also significant wetlands in the former Koo Wee Rup Swamp at the head of the bay, which provide important agricultural resources for the region.

Western Port is ecologically diverse and is home to an array of significant flora and fauna. Native fish (such as the Australian Grayling, River Blackfish, and Dwarf Galaxias) are found in several waterways. The presence of fish in this catchment makes recreational fishing a high social value. Other fauna include established and re-introduced populations of platypus, Warragul Burrowing Cray, Southern Toadlets, Swamp Skinks, frogs (including the Growling Grass Frog), the Giant Gippsland Earthworm, Swamp Antechinus, Azure Kingfishers and Powerful Owls. Significant flora include the Strzelecki gum and native orchids. The former Koo Wee Rup Swamp also has significance for Aboriginal communities because it provided a wide range of native animals and plants.

The catchment also contains the Tarago and Cardinia reservoirs. The Tarago Reservoir currently supplies drinking water to the towns of Warragul, Drouin, and Neerim South, and is scheduled to be connected to Melbourne's supply network from December 2009. Cardinia Reservoir is an important seasonal storage for Melbourne's south-east, including the Mornington Peninsula. It is supplied with forested catchment water from the Upper Yarra, and is thus unaffected by surrounding land uses. The Bunyip water supply catchment does not contain a reservoir, but a small weir is located in the upstream reaches of the Bunyip River, in the Bunyip State Park.

The most significant threats to the health of rivers and creeks in the Western Port catchment are rapid residential growth and major road building. Additional issues include the effects of agriculture, industry and septic tanks on water quality, reducing sediments, ensuring that planting continues along the banks of the waterways, improving habitat, removing barriers that hinder native fish migration and protecting threatened flora and fauna (Melbourne Water, 2007c).

Eastern Mornington Peninsula waterways

Waterways within the Mornington Peninsula catchment that flow into Western Port include Merricks, Coolart, Watsons, Olivers, Kings, East, Warringine, Stony, Manton and Main creeks. Creeks in the northern part of the catchment have mostly rural-urban catchments while those to the south have mainly rural catchments, with some urban centres and remnant forest (particularly associated with the Mornington Peninsula National Park). River Blackfish, Mountain Galaxias, Swamp Skink, Southern Toadlet and the Growling Grass Frog have all been recorded in this area. These rivers and creeks also contain sites of significant Aboriginal and European heritage. Reserves in the Hastings area include the Warringine Heritage Park.

The region is a combination of rural and urban areas, with some industry. Urban areas are growing, and the amount of intensive agriculture (particularly viticulture) has increased in recent years. Key issues in the region are the protection of threatened flora and fauna, poor water quality in intensive agricultural regions, stock access to waterways, stormwater runoff and changes to natural stream flows, the continued extension of the sewerage system, lack of habitat, and weeds and loss of vegetation along the edge of the waterways (Melbourne Water, 2007c).

Poor water quality from Watsons Creek poses a risk to Yaringa Marine National Park and market gardens contribute to the high nutrient and pesticide levels in the creek (Melbourne Water, 2007b).

Although the peninsula's rural districts contribute only a small proportion of the area's pollutant loads (10%), market gardens and intensive horticulture pose a threat to the region's tourism and recreation social values (SKM, 2007a), and increases in viticulture represent an increasing threat to nutrient and sediment loads (Fletcher and Deletic, 2006).

Cardinia, Toomuc, Deep and Ararat creeks

These are largely agricultural waterways that are generally in good condition near the source, and moderate to poor condition downstream of the Princes Highway. Key issues in the region are protecting threatened flora and fauna (such as Dwarf Galaxias, Australian Grayling and Growling Grass Frog), damage to water quality from agriculture, stormwater runoff, septic tanks, loss of vegetation and barriers to fish movement (Melbourne Water, 2007c). Grazing land in the Cardinia Creek catchment contributes high nutrient and sediment loads to Western Port associated with stock access to waterways (Melbourne Water, 2007b).

Bunyip River

The Bunyip River is the largest waterway in the Western Port catchment and includes the Tarago River as one of its tributaries. Its lower sections have formed into a major drainage outlet to Western Port and the Bunyip Main Drain, where Melbourne Water is undertaking extensive stabilisation works. Waterway health tends to be very good near the source, but as agricultural practices intensify and the natural form of the channel is changed, there is a damaging effect on waterway health. A key challenge is to reduce the amount of sediment entering the river by controlling erosion sites in gullies higher in the catchment, as well as along the river itself (Melbourne Water, 2007c). A key water quality issue is high levels of nutrients, organic matter and sediment associated with dairying in the Tarago River catchment (Melbourne Water, 2007b).

Dalmore Outfalls

The Dalmore Outfalls consist of a number of creeks and drains that flow into Western Port via the Pearcedale, Devon Meadows, Clyde and Tooradin areas. Rivers and creeks include Langwarrin Creek, and the Christies, Wylies, Tooradin Road and the Western Outfall drains. The catchment is predominantly rural and most of the rivers and creeks have been modified or are constructed agricultural drains. While environmental values tend to be low to moderate, passive recreation is valued in areas such as the Cranbourne Botanic Gardens. Swamp Skinks, Southern Toadlets and Growling Grass Frogs are among the significant fauna in the area. The area also contains significant Aboriginal and European heritage sites. Risks to river health include lack of streamside vegetation, modification of riverbeds and banks, weeds and changes to natural stream flows. Water quality in the drains is poor and poses a risk to the health of Western Port (Waterwatch Melbourne, 2008). Market gardens in the Koo Wee Rup Irrigation District contribute nutrients to several major drainage channels in this area (Melbourne Water, 2007b).

Lang Lang River

The Lang Lang River is in an agricultural area where there has been significant clearing of trees and other plants. Waterway health is generally moderate to poor and key management issues include protecting vegetation and habitat for platypus and fish, improving the quality of runoff from agriculture, provision of environmental flows, removing barriers to fish movement and stabilising the gullies that are a major source of sediment flowing into Western Port (Melbourne Water, 2007c). A key water quality issue is high nutrient loads from grazing land in the Lang Lang River catchment as well as sediment loads to Western Port associated with stock access to waterways and other dryland grazing practices (Melbourne Water, 2007b).

Bass River

The Bass River begins near Poowong and flows through Glen Forbes and Bass before joining Western Port, north of San Remo. The catchment is predominantly rural. The river has pockets of good condition as well as sites of significant geological, Aboriginal and European heritage. The Bass River is valued for recreational fishing, and its estuary provides important fish and bird habitat. Sediment and nutrient loads may affect both of these values. The lower reaches of the Bass River include a saltmarsh community that is important for bird and fish populations. Key risks to river health include stock access and weed infestations. Sediment contributions from the Bass River pose a risk to the health of Western Port (Waterwatch Melbourne, 2008). High nutrient loads from grazing land and sediment loads to Western Port associated with stock access to waterways and other dryland grazing practices are also an issue in this catchment (Melbourne Water, 2007b).

French and Phillip Islands

The small creeks of French Island are isolated from the mainland. The upper sections of creeks on French Island are ecologically healthy. While there is no formal IRC data for Phillip Island, studies have shown that some of the creeks on Phillip Island are in poor to moderate condition (Waterwatch Melbourne, 2008). Risks to the creeks on French Island include stock access, while the creeks on Phillip Island have issues with water quality, lack of streamside vegetation and weeds (Waterwatch Melbourne, 2008).

Historical effects on water quality

The former Koo Wee Rup Swamp was drained for agricultural use after European settlement. Previously, the swamp extended for some 400 km^2 and much of it was dense tea tree scrub. It once intercepted a high proportion of river flows before entering Western Port. But as a result of the draining, many of the rivers and creeks in the lower catchment have become channel drains and much of the surrounding swamp vegetation has been lost. Resulting erosion issues have taken many years to address. Although urbanisation is still low, the catchment is undergoing rapid urban growth along the south-eastern growth corridor (including Berwick and Pakenham) and the Mornington Peninsula (Melbourne Water, 2004).

In recent history, Western Port creeks have continued to undergo significant intervention in their natural course and flow. In the rapidly expanding urbanisation of Western Port, Watsons Creek has been moved underground to accommodate the development of a shopping centre. Watsons Creek has also been extensively modified as a result of rural agriculture, residential and commercial development (Condina & Assoc, 2002). While suffering from rapid urban growth, Watsons Creek, like the bay and other waterways in Western Port, benefits from increased community awareness and concern for the health and water quality of waterways.

Current water quality issues

The current condition for waterways in the Western Port catchment is detailed in Appendix 6. Table A6.11 (Appendix 6) outlines specific water quality issues for the Western Port catchment as identified in Fletcher and Deletic (2006) with additional information from SKM (2007a).

The results of an analysis of water quality trends at twenty sites in the Western Port catchment undertaken for the period 1990 to 2005 is shown in Table 2.5.

Table 2.5 Western Port catchment water quality trends 1990-2005 (Source: King and Webb, 2005)

Variable	Trend
Dissolved oxygen	The overwhelming trend was declines in dissolved oxygen levels, including some quite large declines.
pH	pH levels remained relatively constant at most locations with one site showing significant improvement.
Electrical conductivity	One site showed an improvement in EC levels with many others showing insignificant changes. Nine sites, however, did show unfavourable increases in levels.
Nutrients	The general trend in total nitrogen levels was an increase with some large changes observed. Two sites showed minor reductions while others had no significant change.
Turbidity	The majority of sites showed no significant change in turbidity levels but most of the remainder showed substantial increases in levels. Only two sites showed improvements in levels. Changes in total phosphorus levels were variable: four sites showed significant reductions, four showed significant increase and the remainder showed no significant changes.
Suspended solids	All but four sites showed no significant change, with three of the remaining four showing increases in levels.
E. coli	The majority of sites showed no significant change in *E. coli* levels, but five sites showed improvements and only one site showed an increase in levels.
Metals	The results for metal were mixed with most sites for most metals showing no significant changes but at the sites where changes were observed, these changes were all increases in concentrations. Large, consistent increases were observed for copper, nickel and zinc.

Significant declines in dissolved oxygen and increases in electrical conductivity and metal concentrations were observed between 1990 and 2005 (Table 2.5). Phosphorus and pH levels showed some signs of improvement, while the results for nitrogen, turbidity and suspended solids varied among sites.

Waterways in the upper catchment of Western Port are very important, providing habitat for 14 species of native fish, 11 species of frog, and platypuses and many native plants. Rare or threatened species include Dwarf Galaxias, Australian Grayling and the Growling Grass Frog. Agricultural land use, including stock access, is the main threat to water quality in these upland streams.

Creeks within the peninsula region have particularly high social, tourism and recreation values, but these are threatened by poor water quality, particularly from urban stormwater runoff and rural runoff from market garden and intensive horticulture. The Mornington Peninsula Stormwater Management Plan (WBM Oceanics Australia, 2002) identified a number of key threats to water quality in the region including:

- High nutrient levels in Watsons Creek generated from intensive agricultural activities such as market gardens;
- Ongoing waterway degradation within the Merricks Creek and Shoreham sub-catchments and the generated sediment and nutrient loads affecting estuarine environments;
- Merricks, Shoreham and Flinders are unsewered and overflow from septic systems has the potential to affect the recreational amenity associated with the foreshore and adjacent aquatic environments; and
- The municipality contains many unsealed roads, which have the potential to generate large sediment loads.

2 Describing our Bays and Waterways

Estuaries

Estuaries are the lower reaches of rivers where there is mixing of fresh and marine water and where there is tidal influence on the waterway. There are approximately 125 waterways discharging to Port Phillip Bay and Western Port. The lower reaches of many do not necessarily classify as estuarine. Many have minimal tidal influence and minimal mixing of marine and freshwater due to local topography however, at least 30 waterways have an estuarine section.

The hydrological regime and physical features of an estuary largely determine the physicochemical environment and habitats available. Environmental conditions can be stable over a long period or can rapidly and frequently change. The timing and extent of freshwater and tidal inputs are a key factor.

Melbourne Water collects water quality samples regularly from eight estuaries, monthly flow data from eight estuaries, and water levels from nine. However, reference conditions have not been described for estuarine reaches and thus there is no base to compare this data to.

A recent literature review prepared for Melbourne Water (Arundel and Barton, 2007) identified numerous knowledge gaps in our understanding of estuarine values, processes and condition in the region. Melbourne Water is developing an estuary strategy to determine how to address these knowledge gaps.

The *Better Bays and Waterways* project Determination of Environmental Flow Objectives in Maintaining Water Quality for Major Estuaries in Port Phillip Bay and Western Port (SKM, 2007b) examined the water quality of seven key estuaries in the region and considered environmental flows required to manage water quality issues.

Water quality

The estuaries of rivers draining urban catchments (such as the Yarra and Maribyrnong) typically exhibit poor water quality attributed to urban runoff from tributary streams and stormwater drains. Nutrient and heavy metal concentrations are high and typically fail ANZECC water quality objectives and SEPP criteria. While industrial discharges into these estuaries have ceased over the last 30 years, some aspects of water quality (such as heavy metals contamination) have not shown the expected improvement over the past ten years. However, dissolved oxygen (DO), pH and turbidity in surface water samples have complied with SEPP objectives.

The combination of estuary hydrodynamics and catchment sources of pollutants can also lead to poor water quality. Tidal influence is important because it mitigates the harmful effects of poor quality stormwater. However, prolonged freshwater flows that result in long periods of saline bottom waters can lead to anoxic conditions. This can result in the release of nutrients and toxicants from sediments, further exacerbating water quality problems.

Salt wedge estuaries draining rural and developing residential areas such as the Little, Werribee and Bass rivers also experience poor water quality, mainly due to high levels of nutrients coming from the catchment. In recent years, over-extraction and drought have reduced base and flushing flows, which have caused nutrient accumulation in the estuaries. Along with the development of stratified conditions, this has contributed to poor water quality within the estuary and occasional periods of low dissolved oxygen concentrations. Increased flows are needed to maintain mixing patterns and to help mitigate water quality issues.

Smaller estuaries, such as the Bunyip and Lang Lang river estuaries tend not to show prolonged poor water quality because the entire estuary is flushed during each tidal cycle. On the outgoing tide, all seawater is expelled from the estuary and freshwater flows in from upstream, while on the incoming tide, the entire estuary fills with fresh seawater. While the freshwater from upstream may contribute nutrient loads to the bays, the estuaries themselves are well mixed and flushed.

Yarra River Estuary

The Yarra River Estuary is classified as a salt wedge estuary (Beckett *et al.*, in SKM 2007). The salt wedge extends to the mid-upper reaches of the estuary with corresponding low DO concentrations.

Long-term water quality monitoring data (1994-2006) collected at Princes Bridge, Melbourne, shows that water quality was generally poor in the Yarra Estuary and McGuckin (2003) attributes this to urban runoff from tributaries and stormwater drain outfalls directly into the estuary. Nutrient and heavy metal concentrations throughout the estuarine reach were high and generally failed ANZECC water quality objectives. Conversely, DO, pH and turbidity in surface water samples typically complied with SEPP objectives (McGuckin, 2003). In addition, time series analysis from 1992-2002 concluded that the levels of contaminants are increasing in the estuary (McGuckin, 2003). An investigation of contaminants in fish in the Yarra and Maribyrnong estuaries was undertaken in 2006 (Box 2.6).

The Yarra River Estuary is a depositional area for suspended solids under low flow conditions (Ellaway in SKM, 2007b). The sediments contain low levels of organic matter. The fine-grained estuarine sediments contain substantially higher concentrations of cadmium, copper, lead and zinc than the sediments in the freshwater reaches and Hobsons Bay (Ellaway in SKM, 2007b). Samples collected in 2006 showed copper, mercury, nickel, lead, tin and zinc to be of concern in the estuarine sediments (GHD in SKM, 2007b).

Maribyrnong River Estuary

Water quality in the Maribyrnong River estuary is considered poor. The estuary has a history of DO stress and ANZECC/SEPP exceedences and algal blooms (SKM, 2007b). WBM (in SKM 2007b) identified this system as ecologically unhealthy.

Heavy industrial and urban activity in the area has resulted in contaminated groundwater that discharges into the estuary. The groundwater contains toxicants, namely copper and ammonia, that are in excess of the river ecosystem protection levels (GHD in SKM 2007b).

Tidal flushing provides a high level of dilution to the incoming groundwater and reduces concentrations of contaminants in the estuary. These contaminants may be bioavailable to fish and eels, raising health concerns for the human consumption of such species (SKM, 2007b). Some eels caught in the estuary contained levels of polychlorinated biphenyls (PCB) above the Food Standard Australia and New Zealand Maximum Residue limit (Melbourne Water and EPA Victoria, 2005). More recent EPA Victoria data (2007f) support these concerns and further highlight dieldrin (an insecticide that is persistent and bioaccumulates) and polybrominated diphenyl ethers (organic compounds structurally akin to PCBs and used widely as flame retardants) as contaminants of concern.

Sediments in the Maribyrnong were sampled in late 2005. Low levels of contamination by copper, cobalt, mercury, nickel, lead and zinc were found in these samples (GHD in SKM 2007b). Contaminant levels are generally attributed to urban runoff. Localised sediment samples in the industrialised area of the Maribyrnong River had elevated levels of cadmium, arsenic, mercury, nickel, lead, tin and zinc. The presence of these toxicants poses a potential threat to water quality and the health of the estuary (SKM, 2007b). Dissolved oxygen stratification and the establishment of anoxic pools in the absence of adequate freshwater inflow are likely to provide a physicochemical environment suitable for the release and mobility of these toxicants from the sediment.

Box 2.2: Yarra and Maribyrnong Estuary Fish Contaminant Study

The Yarra River and its catchment have a long history of industrial, agricultural and urban activities. These activities have led to concentrations of contaminants being recorded in the river sediments and in the fish that live in the Yarra River.

Over the past decade, the lower Yarra River has increasingly been used for recreational activities including fishing. The community's interest in the concentrations of contaminants in fish that may be caught and eaten from the lower Yarra River has led to studies being undertaken. Furthermore, approval of the Channel Deepening Project in December 2007 required the inclusion of a monitoring program to examine contaminant concentrations in fish from the lower Yarra River.

In 2005 a pilot study of contaminant concentrations in fish from the lower Yarra and Maribyrnong Rivers by EPA Victoria and Melbourne Water found contaminant concentrations in fish were below the recommended Maximum Residue Limits in food and that some eels had concentrations of polychlorinated biphenyls (PCBs) above the recommended Maximum Residue Limits in food.

In 2006, a second study of fish from same rivers by EPA Victoria found that where contaminants were present, none were above the Australian and New Zealand Food Standard levels.

In January 2009, a third study by EPA Victoria examined if the contaminant concentrations in fish from the lower Yarra River had significantly changed since the previous study in 2006. The results confirmed that fish from the lower Yarra River are still safe to eat. The study found that the contaminant concentrations in fish sampled from the lower Yarra River in January and February 2009 were generally lower than the concentrations recorded in 2006. The results mean that the current health advisory for people who catch fish from the lower Yarra and Maribyrnong Rivers remains in place.

In accordance with the advisory, recreational anglers are still advised to limit themselves to four serves of fish a month and one serve of eel a month, and children and women of child bearing age should limit themselves to one serve of fish per month and should not eat eels caught from the lower Yarra and Maribyrnong Rivers.

For more information, see http://www.epa.vic.gov.au/water/rivers/fish_sampling.asp

Werribee River Estuary

Water quality is considered poor in the Werribee River Estuary. The estuary shows recent evidence of DO stress and SEPP exceedences (SKM, 2007b). There are deeper sections in the mid-upper estuary where hypersalinity has been observed.

The Werribee River Estuary is highly stratified in its upper reaches, with the lower estuary being strongly marine (Sherwood *et al.*, in SKM 2007b). The middle section and bottom waters contained intermediately saline water. Monthly DO measurements varied substantially, both spatially and temporally (Sherwood *et al.* in SKM 2007b). Sampling by Sherwood *et al.* shows that the estuary and adjacent freshwaters are enriched in nutrients, possibly contributing to the high algal cell counts. pH values were in a range typical for estuarine and freshwater components of the estuary. Water clarity was high, and chlorophyll-*a* concentrations were generally below detection limits.

Little River Estuary

Water quality in the Little River Estuary is considered very poor. The estuary has a history of DO stress and ANZECC/SEPP exceedences and algal blooms (SKM, 2007b).

In the past, the water quality within the Little River Estuary was heavily influenced by the Western Treatment Plant's Winter Outlet discharge (decommissioned in 1991), which introduced 40 ML/day between 1960 and 1990. Scarcity of estuarine monitoring data has made it difficult to accurately assess the past and current conditions within this system. Based on available data, in addition to investigations undertaken by SKM, it is clear that the Little River Estuary is a eutrophic system.

The estuary is stratified throughout its length, however sampling during low tide has showed salinity to be relatively uniform. This type of trend is likely to be linked to the amount of freshwater flow the system is receiving. Salinity profile measurements taken by SKM have indicated that the estuary is currently starved of freshwater flow. The salinity within the estuary is effectively the same as in the adjacent Port Phillip Bay, further supporting the evidence of freshwater flow stress in the estuary.

Sampling indicates pH increases with distance away from the estuary mouth. The relatively high pH, especially in the upper reaches of the estuary, is likely to be linked to the very high rates of algal production, which leads to alkalisation of the water (SKM, 2007b). Turbidity was relatively low in the entrance and increased sharply in the upper reaches where visible signs of algal production were clear. Temperature increased gradually with distance from the estuary mouth.

There appears to be active accumulation of sediment in the estuary, which can be exacerbated by reduced freshwater inflows to actively flush sediment out (Brown in SKM 2007b). In 1983, a flood appeared to effectively remove most of the polluted anoxic sediments from the estuary floor (Newman in SKM 2007b). However, these sediments appear to have re-accumulated to some extent since (SKM, 2007b).

Metals introduced by the Winter Outlet ultimately accumulated in the sediments. No firm understanding of the current heavy metal concentrations in the estuary sediments exists. The restricted freshwater flow, combined with the limited tidal flushing, increases the high likelihood of elevated trace metal concentration in the sediments. Organic content of the sediment is relatively low at the estuary mouth but rapidly increases in the mid and upper sections. There are trends of accumulating organic matter in the deeper basin (where organic matter is trapped). These remain until significant flows move through the system and flush the bed content into Port Phillip Bay.

Bunyip River Estuary

Water quality in the Bunyip River Estuary is considered acceptable. The estuary has no signs of DO stress, but some signs of nutrient and turbidity problems are evident (SKM, 2007b).

From the limited monitoring data available for this estuary, DO concentrations appear acceptable (i.e. no signs of hypoxia), but the estuary has high turbidity and high nutrient loads that exceed the SEPP (WoV) objectives (SKM, 2007). The source of the high nutrients and turbidity levels are high fertiliser use in the catchment and animal waste and erosion caused by the presence of cattle and other livestock on agricultural land (EarthTech in SKM 2007b). The estuary is stratified at higher water levels, but is well mixed during the flood and ebb stages of the tide when water velocities are greater. The estuary appears to be well oxygenated, with recent DO levels at 70-80% saturation indicating good conditions for aquatic biota (EarthTech in SKM 2007b). Efficient flushing reintroduces oxygenated water during flood tides and prevents deoxygenation (EarthTech in SKM 2007b).

The estuary sediment is coarse sandy gravel, with the banks having typically finer grained clay/silt (EarthTech in 2007b). Due to high hill slope erosion rates, a layer of sand 60 cm thick is present at the base of the Bunyip River. Sediment loads to Western Port are estimated at around 22,000 tonnes per year (SKM, 2007b).

Bass River Estuary

Water quality in the Bass River Estuary is considered to be poor with medium-high levels of nutrients, DO stress and medium turbidity (EPA Victoria, in SKM 2007b).

Based on the limited water quality data, it appears there is inefficient flushing in the mid to upper reaches of the Bass Estuary, leading to DO depletion. pH was relatively uniform throughout the estuary and considered to be relatively acidic for coastal waters. Turbidity increased distinctly with distance from the estuary mouth and overall clarity of the water column was very poor, inhibiting light availability (SKM, 2007b).

The lower reaches of the estuary are subject to deposition of silt and fine sand (Wallbrink in SKM 2007b). These fine sediments have an extremely high ability to capture and store nutrients (particularly phosphorus) and contaminants that are discharged from catchment sources (SKM, 2007b).

Lang Lang River Estuary

Little water quality data is available for the Lang Lang River Estuary, however, based on the limited data available it is considered poor. The estuary has a history of DO stress, and ANZECC/SEPP exceedences (SKM, 2007b).

DO levels are low in the upper estuary, which has been linked to the breakdown of organic matter, effluent or stagnation from low flows (EPA Victoria, in SKM 2007b). There are high nutrient loads being discharged from the Lang Lang River, which cause the growth of algal mats that have been observed on the mudflats of the estuary. Water quality in the estuary is difficult to measure as there is very little water in it most of the time, but inflowing tidal water has been measured as hyper-saline (SKM, 2007b).

The bays

Port Phillip Bay and Western Port (Figure 2.11) are classified as part of the Victorian embayments bioregion (IMCRA, 1998) and are characterised as 'confined bodies of marine water'. Whilst Western Port is not technically a true 'bay' as it has more than one opening, for the purpose of simplicity, Port Phillip Bay and Western Port are referred to collectively as 'the bays'.
The bays have lower wave energy than the open coast, restricted water exchange patterns and their floors are generally covered in soft sediments. Port Phillip Bay and Western Port contain sandy beaches, rocky reefs and islands. Mangroves and intertidal flats occur within the bays and their associated inlets and estuaries.

Figure 2.11: Satellite imagery of Port Phillip Bay and Western Port

Port Phillip Bay and Western Port support a rich variety of invertebrate, fish and bird life. More than 100 species of fish have been recorded from Victorian bays, inlets and estuaries.
Some fish, such as Black Bream, are normally found only in bays, inlets and estuaries, whereas other fish use these areas during only part of their life cycle. Port Phillip and Western Port's bays, inlets and estuaries are important breeding and nursery areas for several fish species of commercial and recreational importance, such as snapper, King George Whiting, and flathead (Edmunds *et al.*, 2006). Islands within the bays support important breeding colonies for species of birds and seals. Intertidal flats and adjacent shorelines provide feeding areas and sheltered roost sites that are needed by large numbers of migratory and resident wading birds and waterfowl.

There is great variation in the subtidal and intertidal communities; for example, benthic assemblages in the muddy central region of Port Phillip Bay are distinct from those in adjoining sandy areas to the west and east. The turbid conditions in Western Port allow many subtidal animals to live in shallower water than is usual.
A highly diverse intertidal community has developed on the soft basalt reefs near San Remo, which differs from the intertidal communities found on basalt rock in Port Phillip Bay (Pope and Dommisse, 2008). In Port Phillip Bay and Western Port the dominant seagrasses are *Zostera muelleri* (intertidal) and *Heterozostera nigricaulis* (formerly H. tasmanica) (subtidal).
In the more oceanic areas *Halophila australis* (subtidal) and *Amphibolis antarctica* (subtidal) are present.

Natural habitats have been modified in many areas. Fringing mangrove and saltmarsh habitats have been cleared and there have been significant declines of various seagrasses in both Swan Bay and Western Port.

Areas of conservation significance in Port Phillip Bay and Western Port

The Convention on Wetlands, signed in 1971 in Ramsar, Iran, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Western Port and parts of Port Phillip Bay have been listed in the treaty and are known as 'Ramsar sites' due to their unique representation of one or more attributes related to their zoology, botany, ecology, hydrology and/or limnology (Table 2.6).

Table 2.6: Ecological character of Ramsar sites in Western Port and Port Phillip Bay

Ramsar site	Area (ha)	Ecological character
Port Phillip Bay (western shoreline) and Bellarine Peninsula	22 897	More than 579 non-marine plant species, of which 332 are native including the nationally endangered Spiny Rice flower (*Pimelea spinescens*) More than 304 animal species, of which 285 are native including 50% of the global population of the endangered Orange-bellied Parrot (*Neophema chrysogaster*) An important drought refuge for waterbirds when inland lakes and wetlands dry out Abounding in sites of cultural heritage due to wetlands, plentiful in resources that have attracted and sustained Aboriginal tribes for thousands of years
Port Phillip Bay (Edithvale wetlands) (Seaford wetlands)	103 158	Last remnants of the once extensive Carrum Carrum Swamp, which was drained in the 19th century Rich bird biodiversity including populations of Australasian Bittern *(Botaurus poiciloptilus)*, which is a threatened species 41 significant plant taxa and have active hydrological management programs. Identified threats include altered water regimes
Western Port	59 297	More than 350 native plant and 330 native animal species including reptile, amphibian, mammal, fish and bird species Importance as habitat for migratory shorebirds frequenting Victoria One of the largest breeding populations of Pied Oystercatchers *(Haematopus ostralegus)* is found on French Island A refuge for waterbirds during summer and drought. Due to its marine nature, the site provides habitat year-round Recently listed on the Register of the National Estate under the Natural Environment section for its outstanding marine and coastal environmental values.

Marine National Parks and Sanctuaries

In 2002, Victoria established 13 marine national parks and 11 marine sanctuaries to provide statutory protection of representative areas of Victoria's diverse marine environment. In total, 5.3% of Victoria's coastal waters are now protected, safeguarding important marine habitats and species, significant natural features, cultural heritage and aesthetic values. Western Port and Port Phillip Bay have four marine national parks and four marine sanctuaries protecting a range of different values (Table 2.7 and Figure 2.12).

Table 2.7: Ecological character of marine national parks and marine sanctuaries in Western Port and Port Phillip Bay

Marine National Parks	Area (ha)	Bay	Ecological character
Port Phillip Heads	3580	Port Phillip Bay	Comprises six separate marine areas (Swan Bay, Point Lonsdale, Point Nepean, Popes Eye, Mud Island and Portsea Hole) and waters within 100m of South Channel Fort. Includes seagrass meadows, intertidal platform, waterbird habitat and outstanding dive sites
Yaringa	980	Western Port	Features significant mudflats, extensive mangroves and saltmarsh areas, and supports many waterbirds, waders and marine species
French Island	2800	Western Port	Protects significant mangrove and saltmarsh habitats, deep channels and seagrass beds
Churchill Island	670	Western Port	Includes seagrass beds, mangroves and saltmarsh, and hosts beds of lamp shells (an ancient group of animals)
Marine Sanctuaries	**Area (ha)**	**Bay**	**Ecological character**
Point Cooke	290	Port Phillip Bay	Features basalt reefs that support many diverse communities of algae, invertebrates and fish species
Jawbone	30	Port Phillip Bay	Supports several habitats including rocky basalt reef, seagrass beds, saltmarsh and the largest occurrence of mangroves in Port Phillip Bay
Ricketts Point	115	Port Phillip Bay	Contains sandstone rock platforms extending from the shore, creating a diverse marine environment
Mushroom Reef	80	Outer coast - Western Port	Supports the most diverse intertidal rocky reef in Victoria, with the exposed ocean area providing a rich variety of microhabitats

Source: Park Notes (Parks Victoria website, 2009).

Figure 2.12: Marine National Parks and Marine Sanctuaries in Western Port and Port Phillip Bay (source: Parks Victoria website, 2009)

Marine monitoring

In 1984 EPA Victoria commenced monitoring water quality in both Port Phillip Bay and Western Port to assess trends and the condition of water quality with respect to SEPP objectives (EPA Victoria, 2002). In addition to SEPP objectives, marine water quality can also be compared with recent ANZECC criteria for ecosystem health, which form SEPP criteria where no locally specific objective is defined (ANZECC/ARMCANZ, 2000) and with World Health Organisation (WHO) criteria for human health with respect to contact with pathogens (WHO, 2003).

The Port Phillip Bay Environmental Study highlighted the importance of sediment nutrient cycling processes in maintaining the health of Port Phillip Bay and the risk high nutrient load inputs pose to these processes. SEPP (WoV) Schedule F6 Waters of Port Phillip Bay (State of Victoria 1997) recognised the need for the development of a Port Phillip Bay Environmental Management Plan (EMP), to outline an overarching framework for managing the bay's environment. An EMP was developed by the Department of Natural Resources and Environment (now DSE) in 2002.

The EMP introduced complementary monitoring to build on the EPA Victoria program with the specific aim of providing an early warning of detrimental changes to bay nutrient cycling processes (through monitoring sediment nutrient cycling supported by continuous monitoring of physico-chemical parameters at key sites). The EMP monitoring framework also included monitoring of input nutrient loads from the waterways and progress with implementation of nutrient reduction actions.

The water quality in the two bays is generally good, although ammonia, arsenic, copper and zinc have failed to meet SEPP and ANZECC objectives on occasions.

Port Phillip Bay

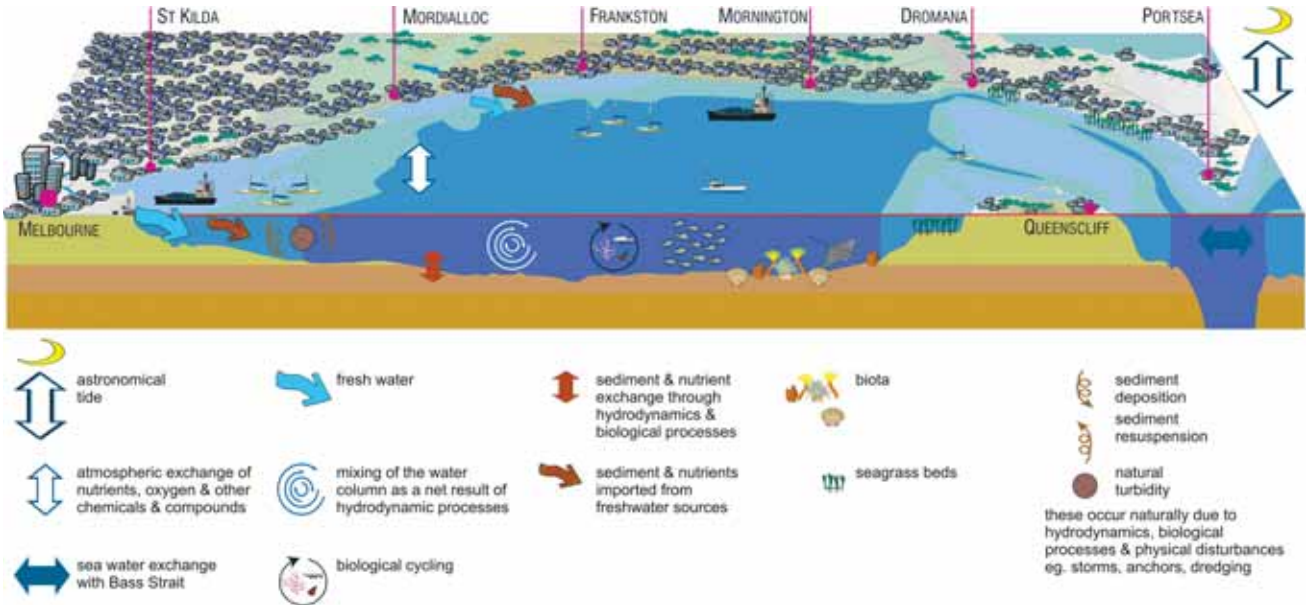
Port Phillip Bay is Victoria's largest marine embayment and covers 1950 km^2 surrounded by 250 km of coastline. The shoreline stretching from Point Nepean in the east to Point Lonsdale in the west is mostly residential suburbs dotted among rural landscapes.

Containing a diverse range of urban and rural environments, including the major cities of Geelong and Melbourne, Port Phillip Bay's catchments influence the health and wellbeing of the bay, which is important in the social, economic, environmental and cultural identity of Victoria (CCMA, 2005).

Port Phillip Bay is a broad, shallow embayment with an average depth of 13 m and a restricted opening to Bass Strait. The bay consists of a central basin, which is relatively steep sided and deep, and where wind driven currents are the primary source of vertical and horizontal mixing. The central basin is enclosed by sandy shoals (the Great Sands), beaches and fringing reefs with limited access to Bass Strait via the Entrance at Port Phillip Heads (Edmunds *et al.*, 2006). It was formed from the drowned river valley of the Yarra and throughout time the ecology of the bay has been influenced and modified by human activity, especially in the 150 years since European settlement through the change in the course of the Yarra, deepening of the shipping channel, and blasting and rock removal at the bay entrance to allow improved shipping access (Edmunds *et al*., 2006).

The many, varied ecosystems in Port Phillip Bay are home to unique flora and fauna, many of which depend on natural ecological processes, such as nutrient cycling, to maintain environmental quality (Figure 2.13). Nutrient cycling and the process of denitrification is an important ecological value of Port Phillip Bay. These processes moderate events that cause a deficiency of oxygen or excessive loads of nitrogen. In particular, the three major primary producers in Port Phillip Bay, phytoplankton, microphytobenthos and macroalgae/macrophytes (some of which are responsible for algal blooms) are limited in their rates of production and growth by nutrient cycling processes. Port Phillip Bay has several marine pest species, some of which can pose a risk to denitrification. These need to be considered in future bay nutrient management strategies.

Figure 2.13: Conceptual diagram of Port Phillip Bay (Image provided by Port of Melbourne Corporation).



Port Phillip Bay ecosystems

Over the past 15 years, Port Phillip Bay has been the focus of some significant studies, although knowledge gaps remain. In 1995 the CSIRO conducted the Port Phillip Bay environmental study, which informed the SEPP Schedule F6 and associated Port Phillip Bay EMP from 2002. In 2006 a very large body of targetted research was conducted for the Environmental Effects Statement to the Channel Deepening Project (CDP) (Edmunds, *et al.*, 2006). While the CDP studies were environmental assessments for a specific project rather than a holistic study of the bay's ecosystems, the research has added to the knowledge about the bay. A large component of both studies was assessing the bay's physical characteristics (e.g. depth, substratum and hydrodynamic processes), sources and volumes of nutrient load inputs, biological community composition, and ecological variability.

Environmental conditions in the bay are influenced by freshwater inflow from rivers and drains (especially in the north); tidal exchange with Bass Strait coastal waters in the south; the sheltered western shoreline; organic muds in the central deep region and sand in the shallower perimeter and nutrient rich inputs from the catchment including the Western Treatment Plant, Kororoit and Mordialloc Creeks, and the Yarra, Maribyrnong and Patterson rivers. Hydrodynamic processes drive water movement and transport sediment throughout the bay. The key hydrodynamic features are sea and tide levels, tidal currents, wind-driven water circulation, waves and water exchange between the bay and Bass Strait (Edmunds *et al.*, 2006; Harris *et al.*, 1996).

Water quality is primarily influenced by turbidity (suspended sediments in the water), contaminants and nutrients. Turbidity levels in the bay vary with changing condition and inflows. The presence of contaminants in the water is influenced by the chemical composition of sediments, which in turn reflect historic pollution. Nutrients critical to the bay ecology are transferred through the bay system and released into the atmosphere through a nutrient cycling process which 'digests' organic matter and releases nitrogen as N_2 gas (Harris *et al.*, 1996; Longmore, 2008b).

Port Phillip Bay provides important breeding and feeding grounds for fish and many species of birds, supporting the largest number of migratory wader birds in the state of Victoria (DPUG,1990). The bay itself contains many different biological communities. The seabed and water column support many plants and animals. Microscopic plants such as phytoplankton provide food for zooplankton and other marine animals that live in the seabed and water column. These in turn are consumed by fish and other organisms further up the food chain.

Some key ecological assets of Port Phillip Bay are protected in statute via its Marine National Parks and Sanctuaries, and as protected species. In addition, various habitats are considered to be assets of the bay due to the role they play in maintaining the health of the bay's ecosystems or their contribution to the bay's biodiversity and ecosystem services.

Several marine animals within Port Phillip Bay are listed as protected species, or have been identified as likely to require protection in the future. These include seahorses and pipefish, invertebrates, marine mammals, sharks and various fish species (Edmunds *et al.*, 2006).

Social values

Port Phillip Bay plays a pivotal role in the recreational activities of many of Melbourne's 3.5 million inhabitants (ABS 2006). During summer, its beaches (including inner city beaches such as those at St Kilda and Port Melbourne) attract millions of visitors. The diverse aquatic environments of Port Phillip Bay make it popular for snorkelling and scuba diving. Some of the most popular areas for diving include the Ricketts Point Marine Sanctuary at Beaumaris and the rock pools off Point Lonsdale. Portsea Pier, Portsea Hole, Pope's Eye and the canyons of the Rip provide many opportunities to explore and appreciate the flora, fauna and habitats of these southern waters.

Public and private marinas are located around the bay and along several of the major rivers, opening up vast marine areas to recreational and aesthetic appreciation. Port Phillip Bay is one of the premier salt-water recreational fishing locations in Victoria, attracting approximately 25% of all Victorian recreational fishing each year. Annual recreational catches of flathead, snapper, King George whiting and other species add up to more than 500 t of fish per year (DPI Fisheries Victoria, *pers. comm.* 2008).

Economic values

Port Phillip Bay supports commercial finfish catches of 400-800 t/y per year with a wholesale market value of $2-4 million (DPI Fisheries Victoria, *pers. comm.* 2008). Aquaculture operations, including *in situ* mussel farming, have been in the bay for around 30 years. There are also several land-based aquaculture operations, which remove bay water for use in their aquaculture farms.

Port Phillip Bay is also the gateway to the Port of Melbourne. This major Australian port handles $90 billion in trade each year, contributes $5.4 billion to the Victorian economy annually and provides significant large-scale employment opportunities (PoMC, 2008). The Port of Geelong is Victoria's second largest port handling 25% of Victoria's export (Geelong Port *et al*., 2008). There were 543 ship visits by commercial cargo vessels to the Port of Geelong in 2004-05, with more than 12 million tonnes of bulk cargo passing through the port (*The Age*, 2005). Station Pier at the top of the bay is the terminus for the Spirit of Tasmania, the daily passenger ship between Melbourne and Devonport in Tasmania. Station Pier also hosts a wide variety of cruise ships throughout the year with nearly 60 cruise ships visiting over the 2008-09 summer season (PoMC website, 2009).

Seven major industries use Port Phillip Bay water in their production processes and/or use the bay for waste disposal. These include Shell's Corio Refinery and Melbourne Water's Western Treatment Plant, which discharges treated effluent into the bay under licence from EPA Victoria.

Recent trends in Port Phillip Bay's water quality

The EMP identified that increased nutrients and exotic marine pests were particular priorities for long-term management of Port Phillip Bay. The EMP nutrient program sets out a range of objectives and actions to monitor and reduce nutrients in the bay. DSE has detailed the progress made against the EMP objectives in Bay Action Reports which are available on the DSE website (www.dse.vic.gov.au).

Since 1983 EPA Victoria has monitored water quality in Port Phillip Bay at a control (Central) and fixed sites potentially affected by industry sources (Hobsons Bay, Long Reef off Werribee, Patterson River and Corio Bay). The program was set up to identify trends in water quality in the bay and changes in effects from specific catchments. The key parameters measured are nutrients, metals, turbidity, DO and physicochemical parameters such as salinity, temperature and turbidity. Between 1999 and 2007, the monitoring did not include metals, focusing instead on nutrients, identified in the Port Phillip Bay study as the key issue for the ecological health of Port Phillip Bay.

In 2007 the channel deepening baywide water quality monitoring program reintroduced metals monitoring at the EPA Victoria fixed sites plus an additional five locations. In addition to adding to the long-term trend assessment the data is used to ensure the effects of the channel deepening dredging remain within acceptable limits.

In addition to the fixed sites monitoring program, EPA Victoria has a long-established program monitoring bacterial (pathogen) contamination at popular recreational beaches in Port Phillip Bay (known as Beach Report). Beach Report assesses the suitability of water quality at beaches for swimming and communicates this to the public.

Monitoring of Port Phillip Bay waters indicates that generally water quality is good, with poor water quality relating to discharges from the catchment, usually as stormwater via rivers, creeks and drains and often associated with rainfall. The Port Phillip Bay study (Harris *et al*., 1996) concluded that management of nutrients and toxicants was important to the health of the bay and that the ecosystems, habitats and resources must be protected for the bay to be sustainably managed.

Nutrients

Denitrification efficiency has been monitored in Port Phillip Bay since the Port Phillip Bay study confirmed the importance of this process to maintaining the ecological health of the bay (Harris *et al.*, 1996). Monitoring sites were established in 2002 through the EMP (DNRE, 2002b), with the sites in Hobsons Bay and Central providing the most comprehensive dataset over the past seven years (Longmore, 2008). Longmore (2008) found that for the 2006-07 sampling period, water quality complied with SEPP objectives for chlorophyll-*a* (100%) and DO (90%). This is a significant improvement on compliance of only 20% for Hobsons Bay bottom water DO levels during 2002-05. Longmore (2008) suggested that the recent high-level compliance might be due to minimal salinity stratification in the absence of major freshwater flows, in a period of below- average rainfall.

The nutrient load entering Port Phillip Bay from all sources has decreased significantly since the Port Phillip Bay study (BMT WBM 2009), due to a combination of factors that include a significant decrease in nitrogen loads from the Western Treatment Plant (from major process upgrades) as required by the EMP, and the prolonged period of below average rainfall. The impact of peak flooding has been difficult to estimate, but the effect on bay water quality and ecological processes is evident in the 2005 autumn figures (Figure 2.14).

The nitrogen cycling data shows generally higher rates of nitrogen removal in spring than in autumn at both sites, and higher rates of nitrogen removal (denitrification efficiency) in central Port Phillip Bay in both seasons than in Hobsons Bay. The spatial differences are thought to reflect the generally higher supply of organic matter to the sediments in Hobsons Bay than in the centre of Port Phillip Bay, while seasonal differences are thought to be due to the influence of temperature on the rates of metabolic processes (Longmore, 2008).

The ongoing nutrient monitoring program established by DSE in the Port Phillip Bay EMP has not revealed any evidence of a baywide decline in nitrogen removal efficiency since 2002; nor have there been changes to the other indicators (chlorophyll or DO concentrations) that would be expected to accompany such a change (Longmore, 2008).

Annual minimum and maximum water temperatures have increased by about 2-3°C since 2004, and observations since then may give insights into the changes we could expect to see in Port Phillip Bay as a result of global warming (Figure 2.14).

Figure 2.14: Mean denitrification efficiencies (+ 1 standard deviation) at the Central and Hobsons Bay sites, by season (source: Longmore, 2008)

Toxicants

Ammonia concentrations have generally been decreasing across Port Phillip Bay (EPA Victoria, 2002), although Dromana Bay has been an exception, with the long-term ammonia median value of 0.54 µg/l above the ANZECC, and hence SEPP, objective of 0.50 µg/l (Table 2.8). There is no evidence of this affecting the ecological values of the bay, but the trend is under ongoing scrutiny. There have also been occasions when the SEPP objective for arsenic has not been achieved. Risk assessments, including assessment of the form of arsenic in the water, have indicated that the source of the elevated levels is within the underlying sediments and is in a non-toxic form (Fabris and Longmore, 2005).

Trend monitoring by EPA Victoria through the 1980s and 1990s indicated a downward trend in lead concentrations in Port Phillip Bay, with all sites except Hobsons Bay having levels close to background by 1998 (Brown *et al.*, 1998). The Yarra was identified as the primary ongoing source of lead entering Port Phillip Bay, with stormwater identified as the source. The availability of unleaded petrol from 1986, followed by the total phasing out of leaded petrol in 2002, has resulted in lead levels in air being below detection (EPA Victoria, 2008a). There has been a subsequent decrease in lead levels in Hobsons Bay with all sites now close to the limits of detection (Table 2.8) and well below the SEPP/ ANZECC trigger values (OEM, 2008).

Zinc is a common contaminant in stormwater, with historic trends (Brown *et al.*, 1998) being downwards for all sites except Dromana, and elevated concentrations at the Dromana and Patterson River sites suggesting surface water runoff as the input source. The data from the 2007-08 monitoring (OEM, 2008) indicates that elevated levels persist at some sites with Dromana and Patterson River sites failing to meet SEPP objectives (Table 2.8).

Table 2.8 Data table on water quality SEPP 2007-08 compliance for selected parameters (source: OEM, 2008)

Indicator	Long Reef	Patterson River	Dromana	Corio Bay	Central	Hobsons Bay
Ammonia	78	100	100	100	100	90
Lead	100	100	100	100	100	100
Arsenic	46	57	66	31	26	60
Zinc	82	50	50	90	73	100

– = no data
Green – *Frequent compliance* (4-5 out of 5 years)
Yellow – *Occasional compliance* (2-3 out of 5 years)
Red – *Rare compliance* (0-1 in 5 years)

Salinity

Monitoring conducted as part of the Port Phillip Bay EMP showed that salinity remained at historically high levels in 2007-08. The slight reductions observed at the three monitoring sites in the bay (Central, Hobsons Bay and Long Reef) through October–November 2007 arose from a slight increase in stream flows. Salinity at all sites remained high compared to 1990–2005 (Longmore, 2008a).

Recreational water quality – pathogens

EPA Victoria monitors beach water quality to provide the public with comprehensive and up-to-date information about beach water quality at 36 beaches around Port Phillip Bay. The annual reports can be found on the EPA Victoria Beach Report web page. Generally the water quality meets SEPP objectives (Table 2.9) and where problems are noted, investigations are undertaken to find and fix the pollution sources (EPA Victoria, 2007c).

Table 2.9 Port Phillip Bay attainment of objectives shown as percentiles and ratings with respect to environmental objective values for pathogens at selected beaches 2001-2005 (EPA Victoria, 2008c)

Indicator	Objective Source	Queens-cliff	Eastern Beach	Altona	St Kilda	Mentone	Rose-bud	Rye
Entero-cocci	SEPP median	80%	100%	40%	80%	100%	60%	80%
	75th percentile	100%	100%	80%	80%	100%	80%	100%
	WHO 95th percentile	100%	80%	80%	60%	80%	80%	80%
E. coli	SEPP WOV median	–	100%	80%	80%	100%	-	100%
	SEPP 42d mean	–	93%	80%	87%	93%	-	100%

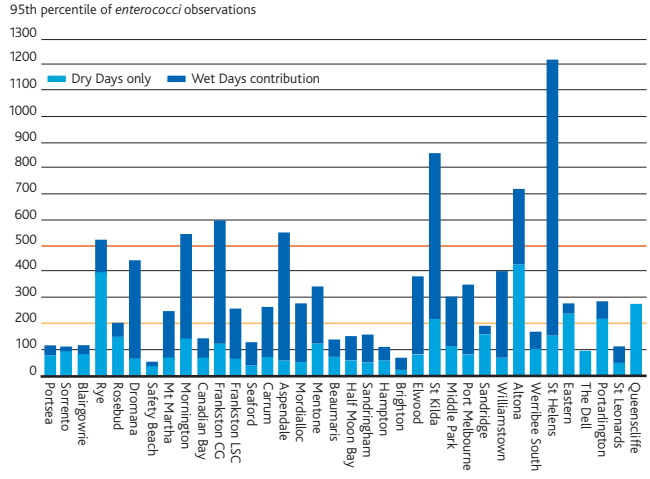
– = no data
Green – *Frequent compliance* (4-5 out of 5 years)
Yellow – *Occasional compliance* (2-3 out of 5 years)
Red – *Rare compliance* (0-1 in 5 years)

When assessed against the WHO and NHMRC guidelines, most bay beaches exhibit good water quality during fine weather. EPA Victoria found mostly good water quality at Port Phillip Bay beaches over the 2007-08 Beach Report season. All beaches met policy objectives in 2007-08. This reflected the fine weather over summer.

Historical results show that rain can temporarily cause poor water quality at bay beaches. As a general precaution, EPA Victoria advises against swimming near stormwater drains, rivers, streams and other outlets into Port Phillip Bay during rainfall and for at least 24 hours afterwards.

The long-term bacterial levels indicate the effect that wet weather has on beach water quality (Figure 2.15). All beaches were classified 'fair' (below red line) or 'good' (below orange line) in dry weather. It is only in wet weather that some beaches become unacceptable for recreational use (where dark blue bars are above the red line). A number of beaches are largely unaffected by wet weather and require little remedial work. Beaches that are classified 'fair' in dry weather are the focus of current investigations to identify sources to progressively improve water quality and ensure that in dry weather they are consistently suitable for recreational use (EPA Victoria, 2008b).

Figure 2.15: Port Phillip Bay Beaches – 95th percentiles of *Enterococci* results (orgs/100 ml) collected over the past five years (2003-04, 2004-05, 2005-06, 2006-07 and 2007-08). The dark blue segment represents the relative contribution of wet weather days (EPA Victoria, 2008b)



Dry weather events (<1 mm rain) separated from the dataset using BOM data from Avalon, Laverton, Melbourne, Moorabbin and Cerberus stations. No follow-up results included in data set.
The red line indicates 500 orgs/100mL, above which sites are classified as 'poor' as per WHO classifications.

Western Port

Western Port is a shallow, ecologically diverse embayment approximately 70 km south-east of Melbourne. It covers 680 square kilometres, has two entrances and contains two main islands – Phillip Island and French Island – and a few smaller islands. It is also a large tidal bay with extensive mudflats and seagrass beds occurring in the north and south-east, with 40% of the bay exposed as mud flats at low tide. Western Port's coastline, including the islands, is approximately 263 km in length. Further details on the key features of Western Port can be found in *Western Port Research Coordination: Stage 1* published by the Western Port Research Coordination project and available on the Central Coastal Board's website (www.ccb.vic.gov.au/westernportresearch.htm). While an Environmental Management Plan has not been developed for Western Port, SEPP objectives have been set.

Phillip Island is an important tourist destination and significant breeding ground to a colony of Little Penguins. North of Phillip Island, French Island, a former penal colony, is now protected as the French Island National Park, and includes a small farming community. Since its European discovery in 1798 by George Bass, Western Port has played a continued and sustained role as a safe port and southern shipping base.

Western Port's diverse habitats include extensive mud flats, seagrass meadows, mangroves, reefs, salt marshes and open water, supporting thousands of plant and animal species, including many that are rare or endemic to Western Port. The near shore intertidal and subtidal seagrasses and mangroves provide important habitats, breeding grounds and safe nurseries for many fish, invertebrate and plant species. This vegetation also plays an important role in stabilising the shores and benthic sediments of Western Port, preventing erosion, reducing turbidity in the water column and protecting the fragile seagrass ecosystem (Figure 2.16). These important areas have suffered from degradation, with current concerns relating to the effects of vegetation loss, increased turbidity and erosion on the ecosystem.

Several areas in the Western Port region are listed on international conservation treaties including the Ramsar and China-Australia Migratory Bird Agreement as areas of environmental significance.

Figure 2.16: Western Port conceptual model (Counihan *et al*, 2003)

Recreational fishing, boating, shipping, aquaculture and tourism are all significant values of Western Port. In late 2007, the Victorian Government removed commercial fishing from Western Port in order to enhance recreational fishing.

Western Port ecosystems

In Western Port, 30% of the water volume is exchanged with each tidal cycle; hence, water quality generally reflects a mixture of the neighbouring marine waters and the large intertidal flats that they drain. The net water flow is in a clockwise direction around French Island (Shapiro, 1975; Marsden, 1979). Water exchange with Bass Strait via the Western Entrance is high, because of the great width of the entrance. Water exchange via the Eastern Entrance is considerably less. The tidal flux of Western Port is significantly greater than freshwater inflows. An average of 1100 ML of freshwater flows into Western Port per day via 17 waterways, which represents less than 1% of the total volume of water in Western Port at high tide (Shapiro, 1975).

The waters of Western Port and its catchment are an interconnected system, meaning the quality of the water environment in the catchment affects the water quality of Western Port. To properly manage Western Port and its catchment, the linkages between the catchment and the bay need to be considered. The major streams draining the catchment include the Bunyip, Bass and Lang Lang Rivers, which together contribute approximately 75% of the total freshwater inflow (Dale and Pooley, 1979). These waterways deliver a significant load of sediment from the catchment to the bay. The sediment originates from erosion of gullies and stream banks in the catchment. Erosion of the shoreline in the Upper North Arm basin also contributes a significant sediment load (mostly fine sediment) to the bay.

The nature of the hydrodynamic system means that the residence time for pollutants entering Western Port ranges from only days in the larger Western Entrance to months in the smaller East Arm (Hinwood, 1979). Consequently, pollutants entering the eastern part of the bay from the catchment or from other sections of the marine environment are likely to remain in that area for some time. The northern catchment of Western Port was substantially modified by the construction of drains through the Koo Wee Rup Swamp from the 1880s to the 1930s. Before this drainage work, few streams discharged directly into the Upper North Arm of Western Port. Instead, the water was filtered through the wetlands systems and entered the underlying groundwater.

The consequences of this varied and significant history of human activity upon the ecology of the embayment are many and complex. These direct and indirect effects have manifested in many ways including significant seagrass loss, a decline in fish catch, degraded water quality and waterways, and loss of wetlands.

Recent trends in Western Port water quality

The relatively small surface area of Western Port, coupled with the two entrances, means that the tides travel all the way across the bay, resulting in good flushing that affects the bay's water quality and ecosystems (Brown *et al.*, 1998). Evaporation and freshwater inputs have little effect on this.

Western Port has received less scientific investment than Port Phillip Bay, although there has been a range of independent research undertaken to better understand the ecology of Western Port. This research has improved knowledge of hydrodynamics (especially tidally-influenced hydrodynamics); seagrasses (especially distribution and condition, and some knowledge of the relationship of these to environmental factors and effects); sediment sources, loads and re-suspension dynamics; nutrient loads and subsurface biological nutrient processing; toxicant concentrations and macroinvertebrate populations (species inventories and ecology).

Increased nutrient, sediment and toxicant loads from the surrounding catchment have been key indicators and drivers of the increasing pressures upon Western Port. As a consequence, water quality is assessed by routinely monitoring several different types of parameters. The main parameters monitored include chlorophyll-*a*, nitrogen, phosphorus, suspended solids and turbidity. Monitoring has occurred approximately monthly since 2001 at Hastings, Barriliar Island (an islet off the north-west coast of French Island) and Corinella.

The western part of Western Port is relatively well-flushed and sites at Hastings and Barriliar Island have tended to have good compliance with SEPP objectives (Table 2.10). This has been assisted by prevailing circulation and sedimentation patterns. Due to the net clockwise direction of water flow in the bay, much of the sediment delivered into the north-east of the bay is transported into the Corinella and Rhyll basins, where much of it is deposited (Hancock *et al.*, 2001). As a result, poor water quality can occur in the eastern side of the bay at the Corinella site, where material from numerous catchment discharges often settles following recirculation. Between 2001 and 2005, the sampling site at Corinella frequently did not meet objectives for chlorophyll-*a*, total nitrogen, total phosphorus and suspended solids.

Table 2.10 Attainment of objectives in Western Port shown as percentiles and ratings with respect to environmental objective/ trigger values for water quality using data from 2001 to 2005 (EPA Victoria, 2008c)

Indicator	Objective source	Hastings	Barriliar Is	Corinella
Chlorophyll-*a*	SEPP Annual median	78%	63%	42%
	SEPP Annual 75th percentile	96%	87%	84%
	ANZECC Single value	100%	100%	63%
Total Nitrogen (TN)	ANZECC Single value	100%	100%	57%
Total Phosphorus (TP)	ANZECC Single value	100%	100%	47%
Nitrogen oxide (NOx)	SEPP Annual median	45%	50%	68%
	SEPP Annual 75th percentile	68%	96%	90%
Filtered Reactive Phosphorus (FRP)	SEPP Annual median	82%	96%	76%
	SEPP Annual 75th percentile	100%	100%	97%
Water clarity (Secchi depth)	SEPP Annual median	74%	54%	45%
	SEPP Annual 75th percentile	97%	89%	53%
Suspended solids	SEPP Annual median	89%	82%	51%
	SEPP Annual 75th percentile	100%	96%	84%

ANZECC objective is taken from Table 3.3.2 ANZECC (2000). ANZECC 99 is the objective for the protection of 99% of species. Note that for nutrients the ANZECC guideline values are provided for comparison purposes only as SEPP Schedule F8 specifically excludes nutrient objectives in favour of ecologically relevant Chlorophyll-*a* objectives.

– = no data
Green – *Frequent compliance* (4-5 out of 5 years)
Yellow – *Occasional compliance* (2-3 out of 5 years)
Red – ***Rare compliance*** (0-1 in 5 years)

Pathogens – faecal contamination

Faecal inputs have also been monitored in Western Port but less frequently than the SEPP parameters, as faecal contamination in Western Port has been identified as a lower risk than in Port Phillip Bay. *E. coli* and *Enterococci* have been monitored infrequently at Flinders, Pt Leo, Shoreham, Balnarring, Coronet Bay and Cowes, with 100% compliance from sampling undertaken during 1987, 1992 and 2005-2007 (Table 2.11).

To check the validity of the assumption that faecal inputs are a lower risk, an additional monitoring program was conducted as an interim project associated with *Better Bays and Waterways*. Beach water quality in Western Port was monitored fortnightly from the end of November 2006 until the end of March 2007. Testing occurred at 10 sites (Flinders, Shoreham, Point Leo, Merricks, Balnarring, Somers, Coronet Bay, Silverleaves, Cowes, Ventnor).

Combined results from the monitoring programs show that beach water quality in Western Port is generally good (Figure 2.18). Pathogen levels (*E. coli* and *Enterococci*) have consistently met SEPP objectives (Table 2.11). Most beaches have low levels of pathogens, but can occasionally be affected by stormwater from creeks and drains, discharges from boats, and other intermittent sources, such as emergency releases from the sewerage system.

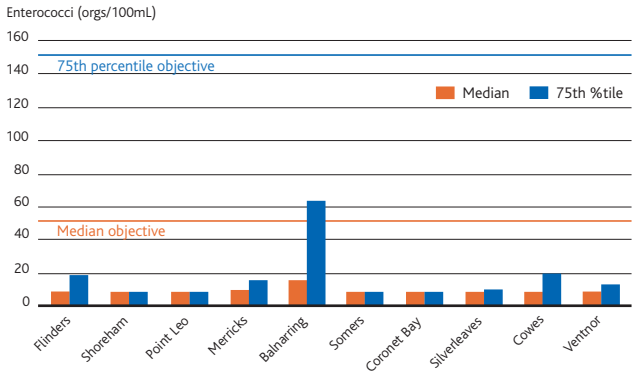
Table 2.11 Western Port attainment with environmental objective/trigger values for pathogens at priority beaches 1987, 1992 and 2005-2007 (EPA Victoria, 2008c)

Indicator	Objective source	Flinders	Pt Leo	Shore-ham	Bal-narring	Coronet Bay	Cowes
Entero-cocci	SEPP median	100%	100%	100%	100%	100%	100%
	SEPP 75th percentile	100%	100%	100%	100%	100%	100%
	WHO 95th percentile	100%	100%	100%	100%	100%	100%
E. coli	SEPP 42d mean	100%	100%	100%	100%	100%	100%

– = no data
Green – *Frequent compliance* (4-5 out of 5 years)
Yellow – *Occasional compliance* (2-3 out of 5 years)
Red – ***Rare compliance*** (0-1 in 5 years)

All sites in Western Port met the SEPP and WHO objectives for the 2005-06 and 2006-07 summer periods. The summer of 2006-07 was generally dry but sampling did include two days when there was over 5 mm of rain in 24 hours. Wet weather temporarily reduces water quality in Port Phillip Bay and a similar trend of elevated bacterial levels was observed in Western Port. All sites met both the median and 75th percentile policy objectives for recreational water quality.

Figure 2.17: SEPP compliance of Western Port beaches (EPA Victoria, 2007e)



The monitoring data for Western Port beaches indicates that, similar to Port Phillip Bay beaches, the major cause of poor water quality is stormwater runoff. However, unlike Port Phillip Bay beaches, the water quality is almost always very good.
The Western Port beaches are monitored less frequently than Port Phillip Bay beaches as the risk of poor water quality is much lower, but the factors underpinning the good water quality include a lower density of urban development, and for this reason the risks need to be continually reassessed as the Western Port catchment is within a major urban growth corridor.

Social values

Western Port provides an ideal environment for recreational activities. The region has a long history of recreational fishing and was declared a 'Recreational Fishing Haven' in December 2007 by the Department of Primary Industries after imposing a ban on commercial fishing. Sailing and boating are a popular past-time, and Western Port is home to several yacht clubs. The region includes several National Parks and reserves that are ideal for bushwalking and bird observation.

Western Port is home to Victoria's highly popular tourist attraction, the Penguin Parade on Phillip Island. In 1996 the Victorian Government established the Phillip Island Nature Park, which hosts the nightly parade of Little Penguins returning to shore, as well as other ecotourism ventures.

There are also several resort beaches around the edge of the bay. The shallow, calm nature of the inner beaches (Ventnor and Silverleaves on the north of Phillip Island and Merricks on the Mornington Peninsula) attracts many day visitors from Melbourne. In contrast, the beaches on Phillip Island that face Bass Strait, such as Woollami and Smiths Beach, are renowned for their spectacular surf conditions, attracting several international surf competitions each year.

Economic values

In addition to the ecotourism of Western Port, a number of industries support the local economy. Most of the catchment area of 3000 km^2 supports agricultural activities. The majority of agricultural industries in the region are sheep and cattle grazing, with smaller niche horticultural industries of orchards and market gardens operating in the area. Logging is conducted in the Tarago State Forest in the north-eastern corner of the catchment region. The Western Port catchment is also the centre of Victoria's chicken broiler industry.

Major industry has also played a significant role in the economy of the catchment. Its international shipping facilities coupled with its closeness to Melbourne mean that several international companies, including BlueScope Steel and ESSO, have established plants on the western shores. The easily accessible natural deepwater port is a major feature for the location and the Port of Hastings has approximately 200 vessels visiting each year with plans for future expansion of the port (Port of Hastings Corporation, 2006).

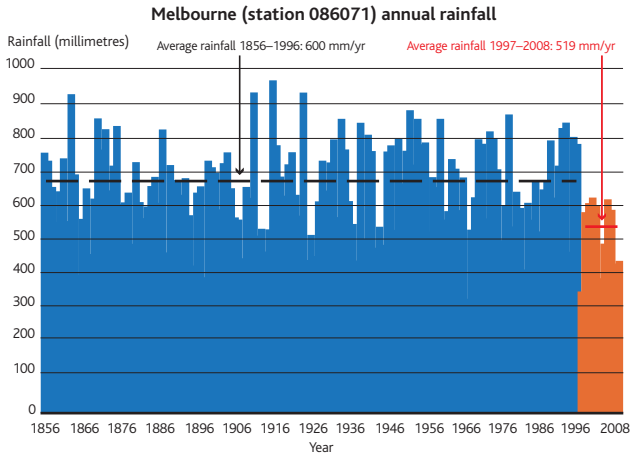
There are several open quarries in the catchment, mostly concentrated between Lang Lang and Grantville. These quarries provide sand and gravel for domestic and international use.

Western Port also supports a small aquaculture industry, which is currently based in the waters between Phillip Island and Flinders.

The change in climate over the past twelve years

The past twelve years have seen annual rainfall totals and hence stream flows significantly below the long-term average in Melbourne and across much of Victoria. This period of lower rainfall could be a prolonged drought, though it is possible that Victoria is suffering a major long-term reduction in average rainfall – a step-change in water availability due to climate change (DSE, 2007b). Regardless, the significant reduction in rainfall has affected water quality in our bays and waterways. Figure 2.18 shows the annual rainfall in Melbourne from 1856 to 2008.

Figure 2.18: Annual rainfall at Melbourne Regional Office weather station 1856-2008 (source BoM, 2009)



The reduction in rainfall has had a positive effect on pollutant loads as less runoff from rural and urban catchments means fewer pollutants are washed into waterways and drains. However, the reduction in rainfall also reduces flows in waterways and has resulted in some smaller creeks becoming little more than dry creek beds with a chain of ponds. These ponds usually have low DO levels and are stagnant.

A return to either higher average rainfall (signalling the end of a drought) or a move towards more frequent high rainfall events (storms) as is predicted as a result of climate change will result in increased loads being delivered to waterways and the bays.

Effects on waterways

Melbourne Water's Draft 2008/09 Drought Action Plan (Melbourne Water, 2008a) identifies that some of the effects of the past twelve years on waterways are:

- many creeks have ceased to flow for the first time (e.g. Diamond Creek) or have ceased to flow earlier in the year than previously (e.g. Running Creek, many tributaries in the west area);
- the duration of 'cease to flow' events is more extended than previously (e.g. Bass River, Maribyrnong River (Jacksons and Deep creeks) and Werribee River);
- waterways that were historically permanently flowing are being reduced to a series of pools; and
- frequency of freshening flow events is significantly reduced.

Some of the effects of significantly below average rainfall and flows on water quality are low oxygen, high temperatures, salinity, turbidity in refuge pools from pool stratification, decay of organic matter/pollutants, stagnation leading to fish kills, concentration of nutrients and pollutants following storms or pollution events or concentration from wastewater treatment plants, blackwater events and increased potential of algal bloom prevalence (Melbourne Water, 2008a).

No sites in the Melbourne Water region met the SEPP objectives for dissolved oxygen in the period April 2007 to March 2008 (Melbourne Water, 2008a). Dissolved oxygen is a good indicator of the effect of dry conditions on water quality due to its importance for sustaining life.

Extended low flows can exacerbate other sources of poor water quality. An example of this is that nutrient-enriched waters discharged from wastewater treatment plants are predicted to increase nutrient concentrations in the Yarra River during low flows, as there is less water in the river for dilution. Stormwater discharges also lead to poor water quality in the Yarra River (Melbourne Water, 2007e).

Extensive blue-green algal blooms have occurred in the Maribyrnong River near Brimbank Park in recent years, including 2006/07 (Melbourne Water, 2007a) and at sites in the Werribee catchment including the Werribee River in 2007 (Melbourne Water, 2007d). Flows have ceased through most of the Maribyrnong River system with some deep pools remaining as refuge habitat.

Melbourne Water has developed environmental emergency contingency plans for the Yarra and Maribyrnong rivers to enable access to a freshwater flow ('flush') for the environment should an emergency situation arise (Melbourne Water, 2008a). Triggers have been set targeting poor water quality, pollution events and algal bloom formation for the implementation of these plans.

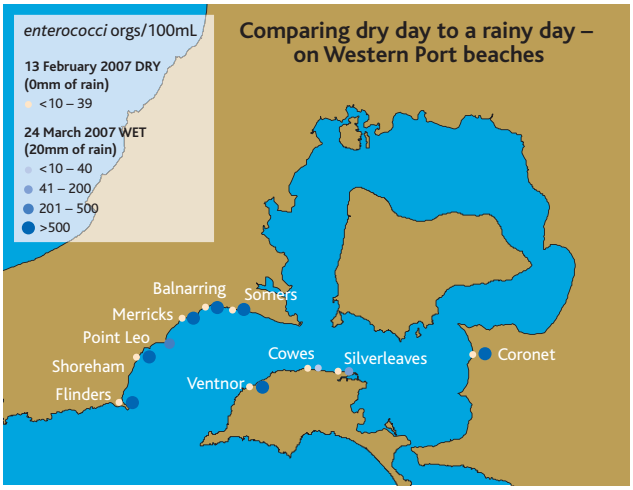
Impacts on bay water quality

Climate change is expected to affect beach water quality in the future, with projected effects including increased frequency and intensity of storms. An increase in rainfall or in storm frequency will increase pulse flows, which would increase pollutant loads to waterways and the bays.

The effect of storms on beach water quality was demonstrated, to a limited extent, on the rainy day of 24 March 2007. According to the Bureau of Meteorology over 20 mm of rain fell on this day. The highest recorded *Enterococci* level was 1900 organisms/ 100 ml at Shoreham. Of the 10 beaches sampled on that day, six recorded levels above 500 organisms/100 ml, compared to a median value ranging from 9 to 20 organisms per 100ml for the summer (EPA Victoria, 2007a).

The difference between dry weather and wet weather at each site is displayed in Figure 2.19. The results indicate that, like Port Phillip Bay beaches, there is a strong relationship between high rainfall and deterioration in beach water quality in Western Port. As with Port Phillip Bay beaches, some Western Port beaches are more susceptible to poor water quality from rainfall and the associated inputs from creeks and drains. The limited information available indicates that Balnarring, Somers and Shoreham beaches are more susceptible to poor water quality after rain than other Western Port beaches. Generally, the beaches had lower levels of effect for similar rainfall than is typically found at Port Phillip Bay beaches.

Figure 2.19: Dry versus wet weather — *Enterococci* results (EPA Victoria, 2007e)



Chapter 3
Where pollutants come from

The key factors that affect water quality in Port Phillip Bay and Western Port are pollutants discharged directly or indirectly to the bays and the environmental processes that distribute and/or transform these materials.

While most of the pollutants to the bays are delivered from the catchments, activities in the bays also contribute to water quality issues. These include aquaculture, shipping, recreation (e.g. boating) and dredging. All have the potential to contribute to the input and distribution of pollutant loads, however mechanisms to address these activities are managed outside *Better Bays and Waterways*.

Although natural events such as bushfires and floods can reduce water quality, human pressures such as land use change are the predominant sources of water quality degradation in the Port Phillip and Western Port region, and present significant risks to the beneficial uses of our waterways (SKM, 2007a).

Pollutants

Several key pollutants are known to affect water quality in Port Phillip Bay and Western Port (Table 3.1). In Western Port, high suspended sediment and nutrient loads disrupt the natural growth of seagrasses and other aquatic plants and animals. In Port Phillip Bay, nitrogen is the key nutrient affecting algal growth and must be managed to maintain the health of the bay.

Table 3.1: Key pollutants affecting water quality in the *Better Bays and Waterways* region

Bay or waterway	Key pollutant	Other pollutants
Waterways	Phosphorus *E. coli* (recreational use)	Nitrogen, suspended solids, toxicants (varies by waterway), pathogens
Port Phillip Bay	Nitrogen	Phosphorus, suspended solids, toxicants (varies)
Western Port	Total suspended solids	Nitrogen, phosphorus
Beaches (recreational use)	*Enterococci* (marine and beaches)	Litter

The ways pollutants enter waterways and the bays are referred to as via 'point source' and 'diffuse (non-point) source' inputs. Point source pollution occurs when waste from a readily identifiable source is discharged to receiving waters from a single point, such as a pipe or large drain. Most point source waste discharges are controlled by EPA Victoria through its works approval and licensing system.

Diffuse (non-point source) loadings can be attributed to many minor catchment activities as well as groundwater discharge and atmospheric fallout. Diffuse source pollution can be numerous small inputs such as stormwater that enters a stormwater drain. Although the drain itself becomes a single point of discharge, the source of the pollution (i.e. the stormwater from roads and properties) is diffuse. Minimising diffuse pollution requires different approaches to minimising point source pollution.

There are two key factors involved in water pollution – the source of the pollution and the connectivity between the source and the waterway. Reducing this connectivity (such as through building wetlands as part of new urban estates or revegetating along river banks) is one of the key methods to mitigate the impacts of pollution.

Point source inputs

Licensed discharge inputs

There are 26 licensed direct point source discharges (industrial, sewerage and aquaculture sources) to the bays (eight to Port Philip Bay, 16 to waterways in the Port Phillip catchment, three to Western Port and two to waterways in the Western Port catchment). The discharge of sewage effluent is the biggest contributor of nutrients and sediment.

The key point source discharges are detailed in Table 3.2 for Port Phillip Bay, Western Port and the adjoining open coast as well as those sites that discharge to a waterway in these catchments.

The discharges licensed by EPA Victoria specify the quality and quantity of the waste permitted to be discharged to a river, lake or the sea at a particular location. The most significant licensed discharge contributions in the Port Phillip and Western Port region are sewerage treatment discharges, with most industrial waste discharged to sewage treatment plants through trade waste agreements (see Box 3.1). The exceptions to this are discharges from quarries and saline wastes (ship bilge water and saline industrial cooling water).

Under the Environment Protection Act 1970, SEPPs require that EPA Victoria applies the waste hierarchy and particular SEPP requirements when issuing licences. This usually requires industries and other waste dischargers to treat their wastes to remove pollutants.

The open coast discharges are outside the region covered by *Better Bays and Waterways*, however the Mornington Open Coast site at Boags Rocks was included in the marine modelling. Under certain wave conditions the modelling indicates minor intrusion of effluent from this site into Western Port, and to a lesser extent into Port Phillip Bay.

Table 3.2: Point sources to the bays and waterways and the adjacent open coast for 2006-07 (Source: Individual company annual reports to EPA Victoria)

Region	Type	Flow (ML/yr)	TN load (t/yr)	TP load (t/yr)	TSS load (t/yr)
Open coast					
Mornington open coast	Sewage	105120	2628	840	1367
Phillip Island open coast	Sewage	3139	Not measured	47.1	62.8
Port Phillip Bay					
Corio Bay*	Industrial	13780	14.4	0.14	69
Exchange segment	Aquaculture	40150	4.6	0.68	48.2
Exchange	Aquaculture	299	0.05	0.008	0.98
Geelong arm	Aquaculture	17520	3.5	1.8	175.2
Geelong arm *	Aquaculture	8760	0.6	0.2	17.5
North Western - Altona STP	Sewage	5840	116.8	58.4	87.6
South-east arm	Sewage	29.2	Not measured	Not measured	0.4
Werribee	Sewage	90303	1560	903	2312
Discharges to waterways in the Port Phillip Bay catchment					
Sunbury – Jacksons Creek	sewage	1898	2.8	1.8	56.9
Gisborne – Jacksons Creek	sewage	876*	Not measured	1.8*	26.3*
Brushy Creek	sewage	3629.5	27.2	0.5	3.6
Craigieburn	sewage	927.6	7.6	0.5	3.7
Healesville	sewage	321.9	2.1	0.1	0.6
Upper Yarra	sewage	607.1	3.9	0.3	0.6
Lilydale	sewage	1798	14.0	0.2	1.8
Monbulk	sewage	13.3	0.09	0.06	0.2
Eastern	Industrial	438	No discharge	No discharge	No discharge
Eastern	Industrial	31.5	No discharge	No discharge	No discharge
Eastern *	Sewage	3.7*	0.04*	0.004*	0.05*
Yarra estuary* (thermal)	Industrial	573026	Not measured	Not measured	57
Yarra estuary (thermal)	Industrial	96.9	Not measured	Not measured	326
South-east arm	Industrial	47	Not measured	Not measured	0.7
Eastern	Industrial	365*	Not measured	Not measured	7.3*
Yarra estuary	Industrial	912.5	Not measured	Not measured	<73*
Western Port					
Lower north arm	Industrial	620	0.2	0.2	18.6
Lower north arm*	Industrial	510	20	10	4.6
Coastal western	Sewage	14.6	Not measured	Not measured	15
Discharges to waterways in the Western Port catchment					
Eastern	Industrial	7.8	Not measured	Not measured	0.1
Eastern	Industrial	412.45	Not measured	Not measured	33

Notes: Based on actual monitored data (flows and loads) except for sites marked with * where discharge has temporarily ceased and flows are based on licence flows and median concentrations.

'Not measured' indicates this parameter is not required to be reported under the terms of the discharge licence.

In addition there are five licensed discharges with intermittent flows that are rainfall dependant (stormwater discharges) where the TSS is based on concentration and a load can not be calculated.

Box 3.1
Trade waste – reducing the discharge of waste from industry

Most industries now discharge their liquid effluent, referred to as 'trade waste', into the sewerage system for treatment at either Western Treatment Plant (WTP) or Eastern Treatment Plant under agreements with Yarra Valley Water, City West Water and South East Water. Some industries need to treat their wastes in order to comply with Trade Waste Acceptance Standards. These arrangements have resulted in a major reduction in the number and significance of industrial discharges into the rivers, creeks and drains that ultimately lead to the bay. Other industries are required by EPA Victoria to treat their effluent to an acceptable standard before it is discharged to a waterway or bay.

Under the conditions within a licence, EPA Victoria may also approve a mixing zone. A mixing zone is an area within a water body where effluent from a point source is mixed, usually by natural means, with cleaner water. Within this area, the level of pollutants is allowed to be higher than the designated acceptable concentration. However, outside the mixing zone, the indicator levels must meet environmental quality objectives, or the background water quality. When a mixing zone is approved, EPA Victoria requires an environment improvement plan (EIP) to progressively reduce the mixing zone over time as technology and management advances occur.

If the levels of pollutants in the waste and/or the quantity of waste discharged exceed the limits specified in the licence, the person or company responsible for that discharge can be prosecuted. EPA Victoria officers inspect waste discharges periodically and take samples to determine whether the licence conditions are being met. The issuing and enforcement of licences for industrial waste discharges has vastly improved the quality of Port Phillip Bay and Western Port and their waterways.

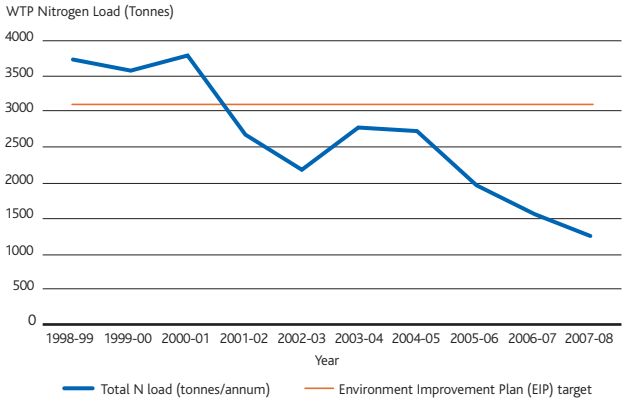
While EPA Victoria has a robust and effective licensing system in place for point source pollution, changing circumstances such as population growth and climate change will require adaptive management of effluent volumes from licensed discharges in the future.

The WTP is the major sewage treatment plant for much of Melbourne, with a licence to discharge treated waste to Port Phillip Bay at specified points along the north-western shoreline near the Werribee River (Figure 3.4). Significant areas of the WTP site and the adjacent shoreline are Ramsar-listed wetlands, of critical importance to migratory wading birds. The WTP can accommodate an estimated 65,000 birds at any one time. The plant is considered to be one of the top 10 birdwatching areas in Australia, with over one third of the country's species being recorded there (about 270 species). This is second only to Kakadu National Park (Melbourne Water website, www.melbournewater.com.au).

The SEPP (Schedule F6) requires a 1000 tonne reduction in nitrogen loads to Port Phillip Bay. The EMP subsequently set out a 500 tonne reduction in nitrogen loads from the WTP and a 500 tonne reduction from catchment sources. A $160 million environmental upgrade of the WTP was undertaken in the late 1990s and Melbourne Water's discharge monitoring indicates that as a result in improvements to denitrification efficiency at the WTP, nitrogen loads from this source have decreased by more than 500 tonnes annually. As a result of the significantly reduced inflows over the past twelve years, nitrogen discharge from WTP has been reduced by considerably more than the 500 tonnes required by the EMP. Recent studies of bird populations suggest that further reductions in nutrient discharges from WTP may be considered a 'threatening process' for the shorebirds and wader species associated with adjacent Ramsar wetlands at Lake Borrie (Dr William Steele, *pers. comm.*, 2009; Mustoe, 2009; GHD, 2009). The Port Phillip Bay study (Harris *et al.*, 1996) identified that reducing storm load inputs was more important than reducing nutrient load inputs during base flow conditions, supporting the rationale that reducing waterway nitrogen loads to Port Phillip Bay (particularly storm loads) is currently a much higher priority than further nitrogen load reductions from WTP. If a further reduction in loads from WTP becomes a priority with respect to broader bay impacts, then opportunities to mitigate effects of reduced nitrogen discharge on bird populations should be explored.

The monitoring results below (Figure 3.4) clearly indicate the significant reduction in nitrogen discharged to the bay, with levels reducing from approximately 3800 tonnes in 1998/9 to just over 1200 tonnes in 2007/8.

Figure 3.4 Nitrogen loads discharged from Western Treatment Plant to Port Phillip Bay 1998 to 2008 (Source: Melbourne Water monitoring data)



Oil and fuel spills

The Ports of Geelong and Melbourne in Port Phillip Bay receive the highest number of shipping visits of all the Victorian ports. While the possibility of a major oil spill in the bay is slight, small spills are a common occurrence. Estimations of the frequency of oil spills indicate that a spill of 5 L or less occurs almost daily, while spills of more than 100 L occur less than once a month. More oil is probably washed into the bay from road runoff than enters from oil spills. The proximity of the Port of Hastings (Western Port) to a Ramsar-listed wetland is a consideration in assessing the risk posed to beneficial uses by port activities.

3 Where pollutants come from

The effects of even a moderate shipping spill are potentially significant, especially in the short-term, through fouling of beaches and toxicity to and tainting of marine species (e.g. a small spill in Corio Bay in 1993 contaminated a mussel farm). The Cape Liptrap to Cape Otway region, which includes Port Phillip Bay and Western Port, is considered to be of high environmental sensitivity. This area attracts a large number of ship visits (3128 per year or 11.9% of the national total) and poses several hazards to navigation. Consequently, this region is included in the five most likely areas to have a major oil spill in Australia (Australian Maritime Safety Authority, 1993).

An oil spill in Western Port could damage its unique and fragile environment, but current prevention measures reduce that likelihood. There are risk reduction measures in place as well as emergency response systems to deal with any oil spills in the marine environment and therefore no further action is proposed in *Better Bays and Waterways*.

Diffuse source pollution

Diffuse sources of pollution occur over a wide area and are often associated with particular land uses, both urban and rural. Collectively, diffuse source discharges result from potentially millions of actions at thousands of locations within the catchment. Many result from road and transport use and vehicle emissions. Some result from deliberate polluting behaviour such as littering, but most are the by-product of day-to-day living and working (Melbourne Water website, December 2008).

Diffuse pollutant loads are closely linked to waterway flows entering the bays. In the last decade, drought has substantially reduced freshwater flows, reducing contaminant loads to waterways and to Port Phillip Bay and Western Port. A return to wetter conditions would see an increase in loads to waterways and the bays and possibly a deterioration in water quality. Both Port Phillip Bay and Western Port experience poorer water quality after rainfall.

The significance of sources such as atmospheric fallout and groundwater is unclear. These sources are difficult to quantify, manage and mitigate. Estimates on the contribution of these sources are outlined later in this chapter.

Managing and mitigating diffuse sources of pollution is the biggest challenge facing the region. In the Port Phillip catchment, diffuse pollution contributes over half (57%) the key pollutant (nitrogen) loads in wet years, and 26% of the loads in dry years. In the Western Port catchment, diffuse pollution contributes 47-85% of nitrogen loads entering the bay, while contributing 77-95% of sediment loads. Many nutrient and metal concentrations show an inter-annual seasonal variation.

Elevated levels of bacteria can threaten beach water quality for up to 24 hours following rainfall as loads from the catchment discharge to the bays via stormwater drains. Elevated levels of *E. coli* can also affect water quality in waterways following rain. In the Yarra River, water quality is generally suitable for recreational uses such as rowing, canoeing and kayaking, except in the days following heavy rain. From Warrandyte upstream, when recreational water quality is high, the river is also suitable for swimming (EPA Victoria, 2008d).

Modelling of pollutant loads (TN, TP and TSS) for an average rainfall year shows that:

For Port Phillip Bay:
- The Yarra catchment is the largest generator of contaminants, both in terms of total load and load per unit area, contributing 50-62% of the total contaminant load;
- The Dandenong catchment is the second largest source of contaminants, contributing 20-29% of the total contaminant load; and
- The Werribee catchment contributes 8-10%, and the Maribyrnong catchment contributes 5-8% of the total diffuse loads.

For Western Port:
- The Lang Lang catchment is the largest generator of contaminants, contributing 29-40% of the total diffuse loads; and
- The Tarago, Bass and South-East catchments generate similar proportions of the contaminant loads (12-24% each).

In urban areas, reticulated sewerage systems, stormwater treatment and adequate street cleaning are important pollution mitigation and prevention methods. In rural areas, soil conservation practices and the controlled application of pesticides and fertilisers in farming and forestry assist to reduce the pollution of waterways.

Diffuse source pollution is more damaging to the environment than point source pollution, with stormwater the most damaging source in the urban environment. The 1996 CSIRO study of Port Phillip Bay highlighted this by identifying catchment sources of pollutants as being of particular concern for the health of the bay. This is because of the volume and frequency at which large doses of pollutants can enter the bay from significantly increased flows during big storms, as opposed to the more steady state of discharge from point sources.

Land use

The type and volume of diffuse source pollutants in waterways depends on a range of factors, the most important of which is the type of land use of the surrounding catchment. Table 3.3 summarises contaminant sources linked to land use.

Table 3.3: Summary of contaminant sources linked to land use (SKM, 2007a)

Source	Contaminant
Forested areas	
Runoff (primarily roads)	Sediment, nutrients, faecal contamination
Forestry activities	Sediments and nutrients from all public land tenure
Leaf litter	Organic matter (which can result in reduced dissolved oxygen levels)
Bushfires	Suspended solids and nutrients
Soil properties	Salts, nutrients, acidic compounds (from acid sulfate soils)
Agricultural areas	
Agricultural runoff	Sediment, nutrients, faecal contamination, pesticides, agricultural chemicals
Stock access	Sediment, nutrients, faecal contamination
Inappropriate fertiliser use	Nutrients
Septic tanks	Faecal contaminants, nutrients
Agricultural chemical use	Pesticides, other toxicants
Urban areas	
Households	Paint, sediments, nutrients, heavy metals (e.g. zinc from roofs), toxicants
Roads and car parks	Heavy metals (including lead), nutrients, sediment, hydrocarbons, petrochemicals, toxicants
Industrial sites	Heavy metals, oils, other toxicants, sediments
Shopping centres	Litter, nutrients, sediments, toxicants, pathogens
Building sites	Sediment, building materials
Illegal connection of sewer to stormwater systems	Localised pathogens, nutrients, heavy metals, toxicants
Illegal connection of stormwater to sewerage system	Adds to the volume in the sewerage system so it may exceed system capacity resulting in sewer spills into creeks. Localised pathogens, nutrients, heavy metals

In addition to the type of land use, other factors that affect water quality include:

- natural characteristics of the catchment, such as the properties of the soil;
- level and intensity of rainfall, flow volume, frequency and peaks of runoff, and duration of events; and
- presence, type and location of vegetation.

The Port Phillip region is substantially more urbanised than Western Port: 19% of the land area is covered by Port Phillip Bay urban land uses, compared with 2% for Western Port. Both catchments have a similar proportion of forested land (26% for Port Phillip and 21% for Western Port) largely situated in the headwater areas. Rural land makes up 77% of the land area in the Western Port region compared with 55% in the Port Phillip region (Table 3.4). Figure 3.5 shows the distribution of land use across the *Better Bays and Waterways* area.

Table 3.4: Area and proportion of major land uses in the Port Phillip and Western Port catchments (Melbourne Water, 2009)

Land use	Land type	Port Phillip		Western Port	
		Area (ha)	%	Area (ha)	%
Urban residential (inc. roads)	Urban	135 034	13.5%	4 196	1.2%
Urban commercial (inc. roads)	Urban	14 834	1.5%	1 233	0.4%
Urban industrial (inc. roads)	Urban	20 569	2.1%	1 409	0.4%
Urban green space	Urban	17 876	1.8%	540	0.2%
Rural roads	Rural	24 032	2.4%	9 197	2.7%
Rural industrial	Rural	14 856	1.5%	3 000	0.9%
Rural green space	Rural	5 231	0.5%	2 145	0.6%
Rural township	Rural	11 455	1.1%	2 715	0.8%
Pasture irrigated	Rural	24 785	2.5%	10 051	3.0%
Pasture non-irrigated	Rural	445 177	44.5%	226 771	67.5%
Annual horticulture	Rural	15 912	1.6%	436	0.1%
Perennial horticulture	Rural	1 528	0.2%	78	0%
Water	Water/ Rural	8 635	0.9%	3 465	1.0%
Plantation	Forest	110 958	11.1%	17 497	5.2%
Forest	Forest	149 199	14.9%	53 071	15.8%
TOTAL		**1 000 081**	**100%**	**335 804**	**100%**
		Total Urban	19%		2%
		Total Rural	55%		77%
		Total Forest	26%		21%

Figure 3.5: Land use in the Port Phillip and Western Port catchments (Source: Melbourne Water, 2009)

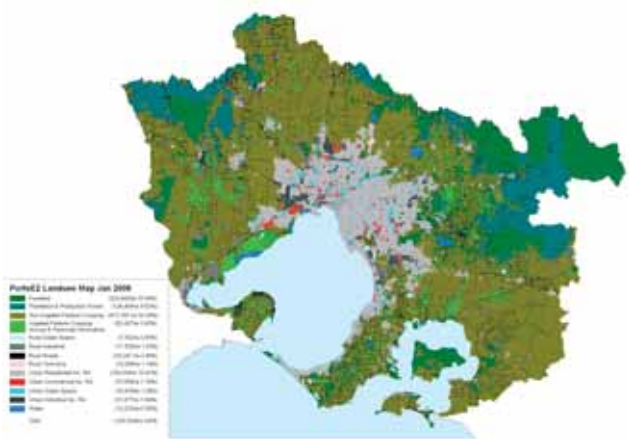
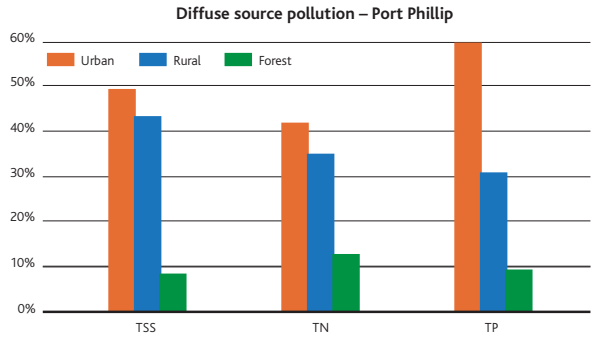
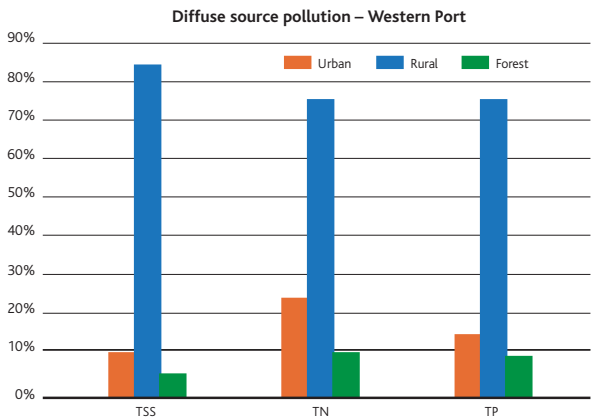


Figure 3.6 shows the distribution of diffuse source pollution by land use for Port Phillip Bay and Western Port as modelled and reported in PortsE2 (Melbourne Water, 2009). The PortsE2 model is described in Box 3.2 as is the receiving waters model developed as part of *Better Bays and Waterways*. Rural includes rural towns, rural roads and the full range of agricultural land uses. Urban includes residential, industrial and commercial along with urban greenspace. Forest includes all forested areas such as parks and reserves, as well as plantations.

Figure 3.6 – Distribution of diffuse loads for Port Phillip and Western Port catchments (Source: Melbourne Water, 2009)





Note: TSS - total suspended sediments; TN - total nitrogen; TP - total phosphorus

Box 3.2: Better Bays and Waterways Models

A catchment model and a receiving water quality model were constructed to model key pollutant export to the bays (nitrogen, phosphorus, suspended solids, chlorophyll-a, pathogens, toxicants and salinity). The receiving water quality model, modelled the export of pollutants in the marine environments of Western Port and Port Phillip Bay. The catchment model Ports E2, modelled pollutant generation from the various land uses in the catchment. These models formed part of a Decision Support System (DSS), to inform and support water quality decision making.

Catchments PortsE2 model

PortsE2 was built using the E2 catchment modelling framework, initially developed by the CRC for Catchment Hydrology and now supported by the eWater CRC.

The primary purpose of the PortsE2 model was to answer some fundamental questions to inform and guide the development of Better Bays and Waterways. *These questions included:*

- *What are the modelled nutrient, sediment and other contaminant (pathogens and toxicants) loads and concentrations for existing land use patterns and land management practices?;*
- *What are the major sources and loads of pollution to the bays and waterways of the region?; and*
- *Which land uses within the catchments generate the highest loading of modelled pollutants?*

A series of scenarios was run using the PortsE2 model, to measure the ability of management actions to reduce pollutants entering waterways and bays. Modelled actions included Water Sensitive Urban Design (WSUD), Agricultural Best Management Practices (Ag BMPs), climate change (bushfire) and population growth. These scenarios were compared to the current or base case scenario to demonstrate how management actions can alter and ideally reduce pollutant levels.

Measured water quality data was used to calibrate the PortsE2 model. The calibrated model provides key data sets and their uncertainties to estimate total pollutant loads, previously unavailable, from major sub-catchments in the modelled region.

Receiving water quality model

While the catchment model focussed on the principal sources of catchment based pollution (waterways, drainage, effluent disposal), the model for the bays focused on the fate of the contaminants entering the bay and their impact on overall water quality in the bays. These models are referred to as the receiving water quality model.

The primary aim of the receiving water quality model was to determine the impact of catchment generated pollutants (nutrients, zinc, lead, E. coli, *Chlorophyll-a and litter) on water quality at primary contact locations such as swimming beaches and other contact recreation areas. Secondary aims of the receiving water model were to understand impacts of future urban growth and climate change on marine water quality and to provide a tool to assist current and future management decisions.*

The receiving water quality model was made up of a suite of coupled hydrodynamic, particle tracer and bio-physical models. These simulated pollutant dispersal and behaviour (growth, decay, settlement, re-entrainment) in Port Phillip Bay and Western Port (Harrison et al, 2007). The models were developed from a commercially available package of marine modelling modules (3DD Suite©) that included 3DD (hydrodynamics), Pol3DD (pollutant dispersal), and 3DDLife (primary production). It was supported by a range of data analysis, boundary generation and graphical tools.

Urban land use

While urban land uses (residential, industrial, commercial) make up a relatively small proportion of total catchment area (19% of the Port Phillip region and 2% of the Western Port region), they contribute a disproportionately large amount of the total contaminant load generated across the regions. This was most pronounced for Port Phillip Bay, where stormwater runoff from urban land uses was the greatest source of contaminant load (49-60% of the modelled loads). While less pronounced, the proportion of contaminant loads generated by stormwater runoff from urban land uses in the Western Port region was still considerable (10-15% of the modelled loads). Across the region, 96% of the urban area is within the Port Phillip catchment with only 4% in Western Port.

In the Port Phillip and Western Port region, residential development makes up 70% of urban areas, while industrial and commercial areas make up 21% and greenspace makes up 9%. Urban areas also contribute elevated loads of suspended sediment and heavy metals, and detrimentally change hydrologic flow patterns from natural conditions through the change to impervious surfaces that are directly connected to waterways.

Urbanisation

Urbanisation results in replacement of vegetated surfaces with hard impervious surfaces (such as roofs, roads, car parks and other paved areas) that drain directly to waterways, often through piped stormwater infrastructure. Urban areas make up less than 20% of the Port Phillip Bay catchment by area, yet contribute over 50% of diffuse nitrogen loads and 60% of diffuse phosphorus loads. Urban areas make up around 2% of the Western Port catchment, and yet contribute 14% of diffuse nitrogen loads and 15% of diffuse phosphorus loads (Tables 3.5 and 3.6).

The impact of urbanisation on waterways can be measured though effective imperviousness (EI), a term that describes the proportion of the catchment made of hard surfaces that are directly connected via stormwater pipes to streams. EI is a useful catchment-scale indicator for predicting and managing the water quality and flow-related degradation caused by urban development. Desired waterway health is indicated by a 2% EI or lower. EI greater than 2% indicates degrading health of a waterway. An EI above 7% is deemed unhealthy. Remediation works are required to improve stream health were EI is >2% (Ladson *et al.*, 2005).

Only a very small part of a catchment needs to be developed and conventionally drained before the biological community of its receiving waterway is severely degraded (Walsh *et al*., 2004). The pollutant loading to estuaries and bays is directly proportional to the amount of connected imperviousness in a catchment. Therefore, any increase in directly connected impervious area will increase the loading to the bays. In urban catchments, the increased volume and frequency of runoff can be just as damaging to creek environments as pollution. As the population grows in outer suburban areas and unsurfaced roads become surfaced, there is the potential for directly connected impervious surfaces to increase.

Within the built-up areas of Melbourne, the catchments of many small streams have EI values well above 5% (e.g. Gardiners Creek, Koonung Creek and Mullum Mullum Creek). It would require significant resources and a long time to reduce EI values in these catchments to levels that would restore the health of the systems. A long-term strategy for these systems is needed and actions that target development in all catchments through management approaches such as planning and building frameworks can contribute. In the shorter term, however (i.e. next five to ten years), there is significant opportunity to target existing development in catchments that have lower EI and address effects from new development and redevelopment across the region.

A pilot catchment restoration project in the Little Stringybark Creek catchment is helping to determine new flow frequency objectives and assess the extent of works and costs required to restore the health of the stream. Further information on this project can be found in Chapter 7.

Drainage, stormwater runoff and other inputs

Freshwater inputs, particularly from rivers, creeks and drains, carry much of the load of sediments, nutrients and toxicants entering the bays. One of the other main inputs to Port Phillip Bay enters via the WTP. WTP provides inputs that are relatively higher in nutrients but lower in metals and suspended matter than inputs from the Yarra River and other sources.

Historically, stormwater systems were designed with the express purpose of transporting water as rapidly as possible. The hydrological changes in urban areas generally favour the transportation of contaminants to waterways and the bays. Sharper peaks in flow patterns and faster water velocities facilitate the transport of contaminant materials, including sediments. These increased velocities also physically erode streambeds and banks, carrying high sediment loads to the bays.

Stormwater entering waterways, Port Phillip Bay and Western Port carries pollutants generated by natural inputs and human activities including road runoff, motor vehicle deposits, atmospheric fallout, vegetation, litter and sediment from construction sites.

Stormwater runoff from roads within the catchment carries a range of toxicants including PAHs originating from car exhausts, and petroleum hydrocarbons from vehicle use and industrial spillage (Australian Maritime Safety Authority, 1993). Some companies and individuals exacerbate this problem by illegally using stormwater systems as a means of waste disposal.

The amount of stormwater delivered to waterways, Port Phillip Bay and Western Port at any particular time varies depending largely on the level of rainfall, the capability of drainage and sewerage infrastructure, and catchment activities and land use. A storm, particularly following a dry period, will move substantial amounts of accumulated material from the catchment.

Stormwater runoff, as urban drainage, is a particularly substantial source of the pollution and faecal contamination entering Port Phillip Bay because of the large, highly populated urban area in the Port Phillip catchment.

About 5000 drains collect runoff from rainfall across the greater Melbourne area (Figure 3.7). These drains discharge either into creeks and rivers or directly through more than 300 stormwater drains to Port Phillip Bay.

3 Where pollutants come from

Figure 3.7: The diffuse sources associated with drainage points for Port Phillip Bay and Western Port Source: Victorian Oil Spill Response Atlas

Council drains that discharge directly to Port Phillip Bay and Western Port or via a Melbourne Water pipe are considered catchment loadings. However, they are often too numerous to be measured as point source catchment loadings. They are shown in Figure 3.7 as regions of diffuse discharge (typically after significant rainfall).

Higher zinc levels from the catchment are probably linked to leaching from galvanised roofing and vehicle sources. Of the other sources, the highest pollutant loads enter from the Patterson River/Mordialloc main drain system.

Sewage management

The management of wastewater (sewage) in urban areas generally occurs via the sewerage system or septic tanks.

Sewerage systems operate in urban areas. Sewage is transported from homes and businesses to Melbourne's treatment plants via pipes and pumping stations. Commercial and industrial waste (trade waste) is also discharged under licence into the sewerage system.

Sewerage systems can be a source of pollution of urban drainage. During dry weather, illegal connections of sewerage systems to stormwater result in polluted base flows. During heavy rain, stormwater leakage into the sewerage system can result in sewer flooding.

Ageing infrastructure presents potential pollution problems as sewer collapses and system malfunctions can lead to substantial discharge of raw sewage to the environment. These threats are further exacerbated by increasing concentrations of sewage as a result of water conservation efforts in response to the ongoing dry conditions. Unless properly addressed, these failures and high-risk areas could counter the continuing investment in improving effluent quality.

Septic tanks treat domestic wastewater in the outer suburban and rural areas, usually where there is no reticulated sewerage system. Tanks that are overloaded, malfunctioning, poorly maintained or sited on unsuitable land can contribute to elevated levels of pathogens, nutrients, toxicants and suspended sediments in adjacent waterways and in the bays.

Litter

Litter is the most visible form of pollution, and currently is one of the key determinants of public perceptions and attitudes towards water quality. The *Better Bays and Waterways* marine and freshwater community perceptions surveys showed that the community judges the health of the waterways and bays by the amount and type of visible litter and the presence 'bad smells'. The presence of litter reduced the aesthetic appeal of waterways and beaches, thus reducing the potential for recreation and tourism.

It is well documented that litter is a key threat to marine life, particularly when it is mistaken for food and causes injury, intestinal blockages and strangulation when animals ingest and/or get caught up in plastics (VLAA, 2009). From November 1989 to January 1998, 10.5% of the platypuses captured along six representative waterways around Melbourne were entangled by litter that included fishing line, elastic bands, a canning jar seal, an engine gasket and a plastic tamper-proof ring from a commercial food jar (Serena and Williams, 1998).

Litter in aquatic environments can also smother habitats for animals and lead to low oxygen levels. Food scraps and other vegetative material in waterways contribute extra nutrients, adding to the nitrogen and phosphorus already in waterways, which then leads to excessive algal growth, depletion of oxygen levels and increased bacterial counts (VLAA, 2009). Reduced light penetration in the water column, from sediments and excessive algal growth, also adds to the problem of oxygen depletion, as does the decomposition of organic material in stormwater drains.

In addition to the effects on the local ecology, litter can also pose a risk to human health. Human health risks arise from syringes, broken glass and cans washing through stormwater drains onto creek banks and beaches. Cigarette butts on beaches present a temptation for unsuspecting toddlers to pick up and eat. Litter can also reduce the flood conveyance of the stormwater system, thus contributing to flooding, which carries its own set of health issues when there are resultant pressures on sewerage infrastructure.

The statistics

At a national level, data collection over the past three years suggests steady or slightly decreasing litter levels since 2005–06 despite the economy and waste volumes having grown over this period (Keep Australia Beautiful National Litter Index).

In Victoria, Keep Australia Beautiful Victoria undertakes annual beach litter surveys at 12 Port Phillip Bay beaches during summer on behalf of EPA Victoria. This has enabled litter sources to be identified and has helped to develop targeted litter-reduction initiatives. From 1999-2006, cigarette butts made up 55% of litter on beaches, followed by plastic (such as straws, confectionery wrappers and bottle tops) making up 22% (EPA Victoria, 2007d). Recent publications indicate that more than 350 000 cigarette butts make their way into Port Phillip Bay each day (VLAA Litter Compendium, 2008), with each butt containing more than 4000 chemicals that can leach into the environment.

Despite the installation of gross pollutant traps and the development of stormwater strategies across the catchment, the Parks Victoria Yarra River litter barges collect 1500 m^3 of litter and debris from the Yarra annually. A further 1500 m^3 of vegetation debris is removed each year in joint programs with Melbourne Water and local government.

Victoria currently spends more than $70 million annually in cleaning up litter (with the bulk of this expenditure borne by local government), making litter prevention a more cost effective approach (VLAA, 2009).

Managing litter

Litter remains an ongoing and pervasive problem with no 'quick fix' solutions. This is the case globally, nationally, and locally in Victoria. Each Australian state and territory has some type of legislative control on litter in place, accompanied by initiatives to address particular jurisdictional littering issues.

Jurisdictional programs and activities are run by a range of community and industry organisations, including the National Packaging Covenant, the Clean Up Australia Day Foundation, and the Keep Australia Beautiful Tidy Towns Awards. The programs serve to maintain or raise community awareness of the issues related to littering. Some campaigns promote litter avoidance as well as the mechanisms by which litterers can be identified and fined.

In 2008, concerns about the effects of littering led environment ministers in Australia to consider developing a national plan of action on litter reduction. Their current view is that a national plan would be unlikely to significantly reduce litter and may disrupt existing activities. However, there is certainly opportunity to learn from successful initiatives adopted by other states and territories (EPHC, 2008).

It is accepted that to properly combat litter we need to focus our efforts on changing behaviours, both at an individual and business level, and from the perspectives of long-term litter management and shorter-term clean up actions. It is important to be aware that litter dropped in the catchment will make its way via stormwater drains to waterways and into Port Phillip Bay and Western Port. Litter prevention strategies are important throughout the catchments as well as for beaches. The Victorian Litter Action Alliance is the peak body for litter management and prevention in Victoria. Its charter is to provide a coordinated approach to litter prevention across state and local governments, industry and community sectors.

The Victorian Government's 2005 *Sustainability Action: Towards Zero Waste Strategy* sets targets for litter reduction and prevention. The strategy includes the target for a 25% reduction in litter by 2014 (from the 2003 baseline). Litter surveys are conducted every two years and reported to the community in the annual Victorian Litter Report (www.resourcesmart.vic.gov.au, March 2009). It is also a legislative requirement in Victoria that the Metropolitan Waste and Resource Recovery Strategic Plan specifies measures for litter prevention and control to meet the Towards Zero Waste litter target for Melbourne. The Plan (currently being finalised) points to the new strategy/future directions paper to meet this requirement.

To improve the effectiveness of programs that aim to reduce the litter entering waterways, a multi-faceted approach is being trialled in the lower reaches of the Yarra River. The Lower Yarra Litter Strategy deals with source reduction as well as existing end-of-catchment programs, combining infrastructure, education and enforcement programs that focus on litter prevention strategies. This strategy is further discussed in Chapter 7 – Urban Management Actions.

3 Where pollutants come from

Rural land use

Rural land accounts for approximately 55% of land use in the Port Phillip catchment and 77% in the Western Port catchment, including rural roads, towns and agricultural land. It includes large areas of high quality native forest, mainly in the hilly upper catchments and within reserves such as the Brisbane and Yarra Ranges national parks and the Wombat, Lerderderg and Bunyip state parks. Outside of the forested reserves, land use is dominated by agriculture, particularly dryland grazing, and includes non-irrigated cropping, plantations and intensive production systems such as market gardens, nurseries, orchards, piggeries and poultry farms. Despite significant modification, the land and waterways in agricultural areas support a diversity of native plants and animals, including the nationally threatened fish Dwarf Galaxia and the Growling Grass Frog. Rural waterways supply drinking water to rural and urban settlements and many of the region's reservoirs are important recreational assets (Melbourne Water, 2007b).

Rural land is a significant source of annual diffuse source loads delivered to waterways and Port Phillip Bay and Western Port. PortsE2 catchment modelling (Melbourne Water, 2009) indicates that runoff from rural land may contribute up to 35% of nitrogen loads, 31% of phosphorus loads and 43% of sediment loads to Port Phillip Bay, and 76% of nitrogen loads, 76% of phosphorus loads and 85% of sediment loads to Western Port (Tables 3.5 and 3.6).

In addition to nutrients and sediments, some rural land uses are a source of toxicants, such as heavy metals (e.g. from fertilisers (Melbourne Water, 2007b)), pathogens such as *E. coli*, and agricultural chemicals including insecticides, fungicides and herbicides. Pathogens may enter rural waterways from effluent systems and carcasses, or poorly sited and maintained septic tanks and grey water discharges. Agricultural chemicals can be transported via air, soil and water into surface waters and groundwater, and may potentially harm aquatic ecosystems because of toxic effects on aquatic species (DPI, 2007).

Some rural land use practices may disrupt ground and surface water hydrology. For example, poor pasture care and grazing practices can reduce the soil's ability to absorb water and may increase erosion. As less water is stored in the soil, there may be more runoff to the stream during rainfall, and there may be less groundwater discharged to the waterway during dry months. Waterway regulation such as dams, weirs and reservoirs, ground and surface water diversions and in-stream dams affect water quality by altering natural stream flow regimes.

Agricultural land makes up the greatest proportion of rural land use in the Port Phillip and Western Port region, with the land use group 'non-irrigated pasture – cropping' alone occupying 671 962 ha or 50% of the total catchment area. Of the agricultural land uses modelled (Melbourne Water, 2009), non-irrigated pasture and cropping is predicted to contribute the greatest loads of diffuse source pollutants to rural waterways, while irrigated horticulture and crops, plantations and forestry are also sources of pollutants (Tables 3.5 and 3.6). Urbanised land uses (roads, industry and rural settlements) are also significant contributors in some rural sub-catchments.

Across the region, river and stream water quality typically declines in association with land use change, from 'good' or 'very good' in forested headwaters to 'poor' in the rural agricultural districts (Melbourne Water, 2007b). Waterway bed and bank erosion and aquatic and riparian weed infestations, particularly willows, also threaten rural water quality in many of the region's waterways (Melbourne Water, 2007b).

At the regional scale, pollution via rural runoff is diffuse. However, at the local and property scale, contaminated rural runoff may be linked to point sources such as effluent ponds, or management practices such as poor fertiliser application. In addition to contributing to poor water quality, there are direct economic costs to land managers through the loss of soil, water and nutrients resulting from poor primary industry practices. These costs flow on to the wider community through increased costs for food and fibre, and the use of public funds for land and waterway repair programs.

Agriculture in the Port Phillip and Western Port region contributes over $1 billion to Victoria's economy and 15% of Victoria's gross value of agricultural production. Systems of production vary from extensive paddock or field-based enterprises through to intensive production processes such as feedlots, short cycle intensive cropping and greenhouse systems. Nutrients on farms are closely linked with productivity, with both nitrogen and phosphorus applications on land being important for the productivity of agriculture in the region. Landholders are under increasing pressure to improve the productivity of their farms while minimising environmental impacts. Programs aiming to prevent the loss of nutrients and sediment from farms to waterways must provide solutions that maintain and improve the economic, social and environmental sustainability of rural production.

Major sources of rural pollution

Dryland grazing and cropping

Non-irrigated pasture and cropping activities occupy approximately 445,191 ha (45%) of the Port Phillip catchment and 226,771 (68%) of the Western Port catchment (Tables 3.5 and 3.6). Modelling indicates that this land use grouping contributes 16% of TN, 10% of TP and 18% of TSS annual diffuse loads to Port Phillip Bay and 52% of TN, 45% of TP and 55% of TSS annual diffuse loads to Western Port (Melbourne Water, 2009). Within the region non-irrigated pasture and cropping is generally dominated by broad acre dryland grazing (with associated fodder crops), including beef, sheep and dairy herds, niche industries (e.g. deer), hobby or lifestyle farms and recreational animals. The majority of graziers run beef cattle, although commercial dairying is a significant industry in the Western Port region. There is only a small number of broad acre dryland cropping (e.g. grain) farms, although cropping is also undertaken on mixed enterprise farms.

The *Better Bays and Waterways* Agricultural Best Management Practices (BMPs) project (DPI, 2007) examined the likely risk of exporting nutrients from dairy and beef farms in the Western Port catchment. The level of risk of exporting TN, TP and TSS into waterways depends on a combination of management practices and local variables such as rainfall, slope and soil type. However, the risk is elevated by poor farm practices including (DPI, 2007):

- grazing and pasture management decisions that lead to soil compaction or pugging;
- excessive fertiliser use and poorly timed or placed fertiliser applications;
- poor farm track design and maintenance on dairy farms;
- inadequate dairy effluent management; and
- stock access to waterways.

A risk assessment conducted to inform of the development of *Better Bays and Waterways* (GHD, 2007) considered the environmental, economic and social values of waterways, and sources of threats to those waterways, and provided a broad picture of water quality issues for the Port Phillip and Western Port region. Two high-risk threats across the rural districts were found to be:

- perennial horticulture/non-irrigated pasture runoff (a similar land use grouping to pasture/non-irrigated cropping); and
- uncontrolled stock access to streams associated with non-irrigated pasture.

Uncontrolled stock access to waterways presents a high risk to values over the majority of the rural districts where dryland grazing occurs. Stock access to riparian zones and waterways leads to riparian vegetation loss, increased sediment and nutrient inputs through damage to streambed and banks, runoff from adjacent paddocks and animal tracks, and the direct input into waterways of pathogens and nutrients via faeces and urine (Statton and O'Sullivan, 2006).

There are many regulations relevant to dryland grazing such as for agricultural chemical use. However regulations relevant to the generation and export of nutrients and sediments are generally not prescriptive. Legislation outlines the goals of land management and imposes certain specific requirements, but how this is undertaken is largely up to the discretion of the landholder.

Table 3.5: Rural land use diffuse load contributions for an average rainfall year – Port Phillip Bay (PortsE2) (Source: Melbourne Water, 2009)

Parameter	Urban segments TOTAL	Rural segments TOTAL	Forest segments TOTAL	Non-irrigated pasture cropping	Irrigated pasture cropping, annual & perennial horticulture	Rural roads	Forest	Plantation	Rural township	Rural industrial	Rural greenspace & water
Area (ha)	187 882	551 614	260 073	445 191	42 223	24 023	149 132	110 941	11 455	14 856	13 866
Area (%)	19%	55%	26%	45%	4%	2%	15%	11%	1%	1%	1%
TN loads (+/- 100%)	52%	35%	13%	16%	5%	5%	7%	6%	4%	4%	1%
TSS loads (+/- 100%)	49%	43%	8%	18%	5%	16%	4%	4%	0.5%	3%	1%
TP loads (+/- 100%)	60%	31%	9%	10%	3%	8%	5%	4%	5%	4%	1%

Table 3.6: Rural land use diffuse load contributions for an average rainfall year – Western Port (PortsE2) (Source: Melbourne Water, 2009)

Parameter	Urban segments TOTAL	Rural segments TOTAL	Forest segments TOTAL	Non-irrigated pasture cropping	Irrigated pasture cropping, annual & perennial horticulture	Rural roads	Forest	Plantation	Rural township	Rural industrial	Rural greenspace & water
Area (ha)	7378	257 854	70 566	226 771	10 564	9197	53 070	17 496	2715	3000	5607
Area (%)	2%	77%	21%	68%	3%	3%	16%	5%	1%	1%	2%
TN loads (+/- 100%)	14%	76%	10%	52%	6%	7%	7%	3%	4%	5%	2%
TSS loads (+/- 100%)	10%	85%	5%	55%	4%	20%	3%	2%	1%	4%	1%
TP loads (+/- 100%)	15%	76%	9%	45%	4%	14%	6%	3%	5%	7%	1%

Intensive agriculture

Intensive agriculture in the Port Phillip and Western Port region includes intensive animal industries and irrigated horticulture (both annual and perennial) and cropping.

Intensive animal industries are operations where animals are concentrated for the purpose of agricultural production, such as feedlots, milking sheds, stock containment areas, piggeries, and poultry farms. The area of land occupied by intensive animal production has decreased over the past two decades, however this may be due to consolidation and the intensification of production methods. Intensive animal production facilities can be a source of water quality pollutants, however they are generally subject to more prescriptive regulatory control than extensive agricultural practices. Permits may be necessary under Local Council planning schemes, and a works approval and/or a licence may be required under the Environment Protection Act 1970 and the Environment Protection (Scheduled Premises and Exemptions) Regulations 2007. Intensive Animal Industries Codes of Practice have been developed for beef feedlots, piggeries and broiler (chicken meat) farms and can be effective in addressing issues relating to the location, operation and expansion of these types of agricultural industries. The Codes, which are incorporated into the Victorian Planning Provisions under the Planning and Environment Act 1987, are mandatory and apply to all new farm development and expansions. They require that waste and wastewaters from such operations must not be discharged to surface and groundwater.

Irrigated horticulture and cropping occupies 52 787 ha (4%) of rural land. The Ports E2 modelling indicates that this land use grouping contributes 5% of TN and TSS annual diffuse source loads and 3% of TP annual diffuse source loads to the bays. While the total annual loads are relatively small in comparison with those of dryland grazing. They contribute more kilograms of pollutant per hectare (Melbourne Water, 2009).

Irrigated horticulture and cropping occurs in many districts across Port Phillip and Western Port and includes vegetable, flower, fruit, berry and wine grape production, tree farms and nurseries. Major centres of production include the Werribee Irrigation District, the Bacchus Marsh Irrigation District, the Woori Yallock Creek sub-catchment of the Upper Yarra River, and the Koo Wee Rup Irrigation District of Western Port (Melbourne Water, 2007b). Seventy percent of Victorian vegetables are grown on Melbourne's urban fringe (Vegetable Growers Association of Victoria website, 2009).

Ports E2 modelling (Melbourne Water, 2009) indicates that the greatest pollutants load contributions can be expected from irrigated crops and crops with shorter production cycles (annual horticulture), as they are likely to require greater nutrient inputs and greater soil disturbance due to more frequent cultivation.

The *Better Bays and Waterways* Agricultural BMPs interim project (DPI, 2007) examined the likely risk of exporting nutrients and sediment from strawberry farms in the Yarra catchment, where approximately 150 growers produce about one-third of Victoria's strawberry crop. Pollutant export is likely to be similar for other short cycle row cropping industries with similar production practices. The risk of exporting phosphorus, nitrogen and sediment from strawberry farms increases with poor practices (DPI, 2007); such as:

- tillage that leads to soil compaction or erosion;
- irrigation systems and management that lead to excessive runoff;
- inadequate surface drainage, capture and treatment systems, and direct runoff from drains and production areas into waterways or in-stream dams; and
- fertiliser regimes where fertiliser is poorly applied (timing, rate and location) and nutrient inputs exceed crop requirements.

Intensive horticulture is included in the definition 'intensive agriculture', with intensive animal industries. There are many regulations relevant to irrigated agriculture, such as regulations relating to agricultural chemical use, however those relevant to the generation and export of nutrients and sediments are generally not prescriptive. Legislation outlines the goals of land management and imposes certain specific requirements, but how this is done is largely up to the discretion of the landholder. Some horticultural industries have developed voluntary best practice guidelines and accreditation schemes, and the *Horticulture for Tomorrow "Guidelines for Environmental Assurance in Australian Horticulture"* provides an industry-wide approach to developing and recognising sound environmental and natural resource management in the horticultural sector.

Plantations and forestry

Plantations and forestry occur primarily in the Upper Yarra and Upper Werribee catchments. Forestry operations (including native and plantation forests) may contribute to non-point source pollution of streams by increasing soil erosion and sediment runoff. Forestry has only small effects on water quality in the upper reaches of the Werribee catchment (Fletcher and Deletic, 2006), however the *Better Bays and Waterways* water quality risk assessment (GHD, 2006) identifies plantation operations as a potential threat to values, with this land use having a very high risk rating in the sub-management units where it occurs.

Plantations and forestry operations are governed by statewide codes of forest practice and guidelines that apply to timber harvesting, extraction, roads and regeneration, and the planning and operation of softwood and hardwood plantations. Implementation of the codes of forest practice can reduce loads generated by plantation forests (URS, 2007).

Rural roads and settlements

Rural roads are often a source of sediment and toxicants. Unsealed rural roads can be a source of sediment, however they are also often associated with swales (shallow vegetated ditches that capture road runoff) allowing sediments and nutrients to be captured rather than enter a waterway. Sealed roads in rural areas can allow sediment and toxicants associated with road traffic to wash into drainage lines that are connected to waterways. In some cases this can lead to erosion adjacent to the road. When unsealed rural roads are sealed, they can have a greater impact on a waterway if the road is effectively drained into a drainage line that enters waterway, taking with it sediments, nutrients and toxicants.

Rural roads occupy a relatively small area of land, but are a significant contributor of diffuse source TN, TP and TSS to the waterways and bays of Port Phillip and Western Port, for example, contributing 20% of TSS to Western Port and 16% to Port Phillip Bay, despite only comprising 33 247 ha (2%) of the rural land area (Melbourne Water, 2009). In 1999 CSIRO study by Lowe identified unsealed rural roads as a significant source of sediment in the Western Port catchment. In this plan, road management is discussed earlier in this chapter and in the urban section of Chapter 7.

Rural settlements (towns) generally occupy a relatively small area (about 1% of both the Port Philip and Western Port catchment area), but their total diffuse source loads and relative contributions per unit of land (kilograms per hectare) can be significant where they occur. For example, PortsE2 modelling shows that rural settlement occupies only 9% of the Woori Yallock Creek catchment (compared to 48% occupied by non-irrigated pasture and cropping), but it contributes 22% of TN, 38% TP and 35% TSS annual diffuse source loads (compared to non-irrigated pasture and cropping which contributes 45% TN, 34% TP and 41% TSS annual diffuse source loads). The sources of pollution in rural settlements are similar to urban areas and may include septic tanks. These issues are discussed in Chapter 7.

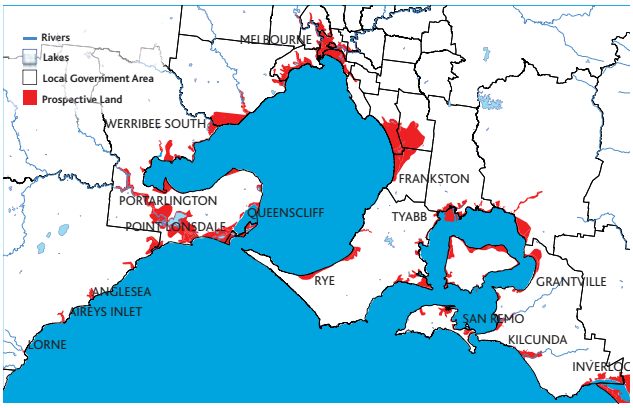
Other diffuse sources

Acid sulfate soils

Acid sulfate soils (ASS) are found in low-lying coastal areas and contain high concentrations of sulphide minerals, mainly iron pyrite, FeS_2.

ASS are relatively harmless in their undisturbed (submerged) state but may generate large quantities of sulphuric acid when exposed to the atmosphere through excavation, dredging or lowering of the water table. In addition, iron and aluminium metals may become soluble under acidic conditions and enter rivers and estuaries, where they may harm aquatic organisms. Figure 3.8 shows the indicative distribution of acid sulfate soils in Victoria.

Figure 3.8: Indicative distribution of acid sulfate soils in Victoria (source: DPI, 2003)



In the Port Phillip and Western Port region, acid sulfate soils that are releasing acid have been found in the Coode Island silts in the Yarra River and coastal acid sulfate soils (CASS) with the potential to release acid have been found underlying parts of Frankston (DSE, 2008c).

DSE has previously estimated there are 55 000 ha of CASS in Victoria. However, current geomorphology maps estimate that there are 280 000 ha of coastal land in Victoria that were inundated by the sea in the mid-Holocene. It appears that the area of land with CASS in Victoria may have been significantly underestimated (DSE, 2008c).

Victoria has little reported history of CASS causing environmental degradation. However, anecdotal evidence is emerging that past acid events may have occurred but the environmental effects have been attributed to other causes (DSE, 2008c). Actions to address the issues associated with CASS are outlined in the draft Strategy for Coastal Acid Sulfate Soils in Victoria (DSE, 2008c) and no further action is proposed in *Better Bays and Waterways* to address this issue.

Groundwater

The direct input of groundwater into Western Port and Port Phillip Bay is difficult to quantify, but it has been estimated at 5.5 x 100 m^3/yr (Otto, 1992) or 55 billion litres each year. This does not include estimates of groundwater flowing directly into the bay's central zone, or to Corio Bay and the Bellarine Peninsula. This estimate also does not include groundwater contribution to stream inputs as a base flow component, which has been estimated to be as high as 20% of base flows (O'Rourke *et al.*, 1995).

3 Where pollutants come from

A network of 2500 bores across Victoria monitors groundwater availability, quality, flow and linkages to surface water systems.

Poor industrial and land use practices in the past have resulted in a wide array of toxic chemicals and nutrients contaminating groundwater, particularly under the western suburbs (HydroTechnology, 1993). It is estimated that between 2% and 12% of these contaminants reach the bay by an underground route, while the rest (88–98%) reach it via waterways such as the Maribyrnong River and Kororoit and Skeleton creeks. Although the practices that produced this legacy of toxic contamination have long since ceased, the flow of contaminant loads to the bay is gradual and may have not yet peaked.

Analyses by HydroTechnology (1993) and Otto (1992) found that while the load of nitrogen and phosphorus from groundwater was not estimated to be large, the concentration of nitrates in some aquifers was particularly high. It was predicted that there would be a minor rise in nutrient load via groundwater as historical loads moved slowly into Port Phillip Bay (Harris *et al.*, 1996). Predicted annual inputs of phosphorus and nitrogen were in the order of 8-25 tonnes and 34-82 tonnes respectively (Otto, 1992; HydroTechnology, 1993).

It is possible that there is inflow of contaminated groundwater into stormwater and sewerage systems in some areas, particularly where they flow through contaminated sites. Contaminated groundwater will eventually discharge to the bays and waterways, although at least where it enters sewerage systems it can be treated prior to reaching the bays.

Mechanisms to address groundwater quality are mostly managed outside the scope of *Better Bays and Waterways* (two exceptions to this are described in Chapter 9).

Atmospheric fallout

Airborne nutrients and toxicants can be added to bays and waterways via rainfall or fog and via fallout of gases or particulates. While atmospheric phosphorus loads are considered to be minimal (Harris *et al.*, 1996), there is some conjecture over the contribution of atmospheric sources of nitrogen with significant variance between the limited modelled and experimental results for Port Phillip Bay.

Atmospheric sources of nitrogen were estimated by CSIRO (Harris *et al.*, 1996) to contribute 1000 t to Port Phillip Bay. Of this, 600 t was estimated to be from wet deposition (e.g. via rainfall) and 400 t from dry deposition (e.g. via wind). This is supported by the work of Lansdown (2009) who calculated the atmospheric load of nitrogen via measurements of nitrogen in rainfall over many events and determined a volume weighted, median nitrogen concentration of 0.5mg N/L. This translates to 627 t of nitrogen falling directly to Port Phillip Bay via rainfall each year. This correlates very well with the figures from the CSIRO study and represents a significant contribution to nitrogen loads in the bay.

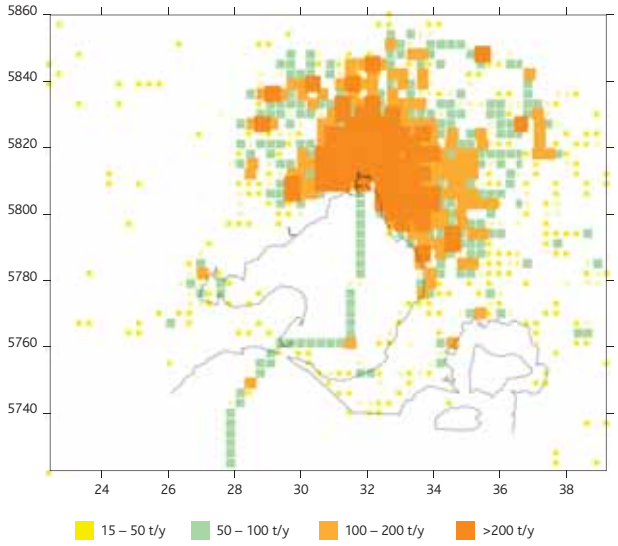
However, modelling undertaken by Hearn (2001) suggests that the atmospheric sources of nitrogen are significantly less at around 155 t/y, comprising 150 t/y from dry deposition and 5 t/y from wet deposition. A CSIRO model also calculated annual deposition rates to Port Phillip Bay at 193 t/y for dry and 10 t/y for wet deposition (Hurley *et al.*, 2003) which is only slightly more than those calculated by Hearn.

Given the uncertainty over the contribution of atmospheric sources of nitrogen, further research is needed to provide a definitive conclusion as to how important atmospheric inputs are to the loads in the bays.

It is expected the loads for Western Port would be significantly less than those for Port Phillip Bay due to their relative areas and the much lower contaminant loads from vehicles and industry in Western Port.

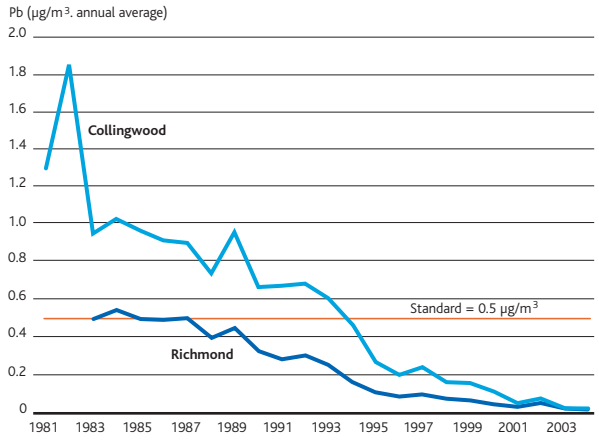
Figure 3.9 shows annual nitrogen oxide emission rates across the region and demonstrates the significantly lower rates around the Western Port catchment compared with the Port Phillip catchment.

Figure 3.9: Annual NOx emission rates per 3 km grid square (t/y) as extracted from the emissions inventory (Hearn, 2001)



When the Port Phillip Bay environmental study was completed in 1996, lead was expected to be the only significant metal input to the bays from atmospheric sources due to its widespread use in petrol (Harris *et al*, 1996). Carnovale *et al*. (1992) had estimated lead fallout to Port Phillip Bay to be around 500 t annually. Since then, lead has been removed from petrol (nationally phased out in 2002) and this has become only a minor pollution source. As Figure 3.10 shows, the levels of atmospheric lead have dropped significantly over the past twenty years and there are now very low levels of lead in the atmosphere. As such, EPA Victoria no longer monitors atmospheric lead.

Figure 3.10: Annual average atmospheric lead concentrations



Actions to reduce the loads of atmospheric nutrients are beyond the scope of *Better Bays and Waterways*. Atmospheric lead, which was previously a significant source of lead to the bays, has been reduced to very low levels due to the banning of leaded petrol. Changes to policy and legislation on emissions from industry such as emissions trading will assist in reducing levels of other atmospheric sources of pollutants.

Sediment and erosion

Bed and bank erosion of waterways is a significant source of sediment, and fencing and revegetation of waterways is an important part of reducing the input of sediment. Sediment enters coastal waters in the form of silt, mud and organic debris and can smother natural ecosystems, limiting or preventing growth. Sediments can also transport other contaminants such as phosphorus, heavy metals, bacteria and toxicants.

Most of the toxicants delivered to Port Phillip Bay are deposited along with sediments in limited areas near the mouths of creeks, rivers and major inputs to the bay (Harris *et al.*, 1996).

Modelling indicates that urban areas contribute 49% of sediment to Port Phillip Bay yet only 10% to Western Port, while rural areas contribute 43% of Port Phillip Bay sediment and 85% of Western Port sediment (Melbourne Water, 2009). The total input of sediment entering Port Phillip Bay has been estimated at 85 000 t/y, the largest single source being the Yarra River (Harris *et al.*, 1996).

The input of fine sediment to Western Port from tributary catchments has been estimated at 62 000 t/y with the dominant source of the fine sediment being subsoil from channel and gully erosion of the Bunyip and Lang Lang catchments (Wallbrink *et al.*, 2003a). Erosion from the clay banks to the north-west of the Lang Lang jetty also appears to be an important local source of fine sediment. Erosion of topsoil is most significant in the Bass catchment and accounts for 21% of deposited sediments in the Bass River, however the Bass River contributes less than 10% of fine sediments to the southern segment of Western Port (Wallbrink *et al.*, 2003a).

The most obvious effect of suspended sediment is to reduce light penetration through the water column and therefore reduce the level of photosynthetic activity. In the marine environment this can threaten seagrass beds. Elevated suspended sediment loads can affect fish and benthic organism respiration, feeding, reproduction and change in community structure (DEWHA, 2007).

Invasive exotic species such as willows can also cause bank erosion as the roots cause water to be diverted around dense infestations in high water flows. Willows cast heavy shade rather than the filtered light required for provision of food for aquatic organisms. They also drop all their leaves over a short period of time in autumn resulting in a large influx of organic material that leads to excess nutrients in the system, a reduction in dissolved oxygen and increased turbidity. Melbourne Water has been working with landholders since 1996 through its Stream Frontage Management Program to rehabilitate waterways in targeted catchments across the Port Phillip and Western Port region. Through this program, willows are removed and land is revegetated, reducing erosion and preventing sediment and nutrients entering waterways.

Redistribution of sediment (including dredging) in the bays

The distribution and redistribution of sediment in Port Phillip Bay and Western Port can be caused naturally and artificially. While sediment redistribution (either naturally or via dredging) is not strictly a 'load' of new contaminants, it can disturb and move contaminants previously held in the sediment, with associated threats to the ecosystem.

Dredging in Victoria is managed through the Guidelines for the Management of Dredging and the Commonwealth Ocean Disposal Guidelines, with major capital programs being subjected to review and assessment through the Environment Effects Statement provisions of the Planning and Environment Act 1987.

Dredging activities pose a small risk to the bays in comparison to other threatening activities, but dredging remains an issue of considerable concern to bay users. Maintenance dredging takes place to maintain safe access for shipping and recreational boating. Areas of sediment accumulation can act as sinks for toxicants, nutrients and other contaminants. Dredging activities can disturb and redistribute these materials, however mechanisms to address these activities are managed outside the plan and there is no further action proposed by *Better Bays and Waterways*.

Port Phillip Bay Channel Deepening Project

Approval was given in December 2007 for the Port of Melbourne Corporation to dredge 22.9 million m^3 of material from the existing shipping channels, including some contaminated material in the north of the bay, as part of the channel deepening project (CDP). Dredging is to be completed by December 2009 with dredged material to be deposited in dredged material grounds in the north and south of the bay.

Environmental impacts arising from the Port Phillip Bay CDP are managed under the Port Phillip Bay Channel Deepening Environmental Management Plan. An independent monitor has also been appointed by the Victorian Government to oversee the environmental performance of the project and assess whether the dredging is being undertaken in accordance with the environmental management plan.

Mechanisms to address these activities are managed outside this Plan and there is no further action proposed by *Better Bays and Waterways*.

Aquaculture

Mussel aquaculture leases can provide a source (for underlying benthic communities) and a sink (phytoplankton and detritus) of nutrients and particulate matter. Although mussel aquaculture has a complex interaction with nitrogen cycling processes in coastal waters, there is a net removal of nutrients from the ecosystem through the harvesting of the mussels.

Gavine and Gooley (2003) have estimated this as approximately 6.6 kg N/t of mussels. With current operations harvesting approximately 1000 t/y of mussels, this equates to 6.6 t/y of nitrogen reduction (<0.1% of nitrogen input to the bay). In contrast, the point source land-based aquaculture discharges are licensed at approximately 40 t/y of nitrogen (Gavine and Gooley, 2003), but are currently operating at 28 t/y. Hence, bay leases would require a four-fold increase in operation to offset the land-based aquaculture discharges based on a range of assumptions including a simple mass-balance approach to offsets at a bay-wide scale.

To date, all aquaculture leases in the bays (Figure 3.11) are passive feeding operations so their impact is either through a reduction of natural nutrient levels or their predominant waste discharge as detritus to underlying sediments.

Figure 3.11 Aquaculture Fisheries Reserves in Port Phillip Bay and Western Port (Source: DPI Fishing and Aquaculture, 2009)

Aquaculture leases are managed through DPI Fisheries and no further action is proposed through *Better Bays and Waterways*.

Predicted threats

Historically, threats to waterways were identified after a major event had occurred (such as a sewage spill), or when monitoring programs identified poor water quality and the pollution was traced back to the source (such as industrial activities or land use practices). These days, our understanding of the causes and effects of poor water quality is much improved, allowing modelling to predict potential threats and address them, where possible, before the problem actually occurs. These potential threats include climate change and population growth.

Two models have been used in the development of *Better Bays and Waterways*, each of which relates to pollutant export and receiving water quality. The models were constructed during the preparation of the decision support system (DSS) interim project (see break out box 3.2).

These models can be used to predict the effects of threats such as climate change and population growth on water quality.

Climate change

There have been numerous studies exploring the potential effects of climate change on water quality, both internationally and nationally. These studies indicate that the effects of climate change on our region may include:

- Air temperatures in Victoria are predicted to rise from 1.8°C to 3.8°C by 2070 (DSE, 2008b). Air temperature rise can lead to increased water temperatures, and increased evaporation from waterways, wetlands, and other water bodies. These conditions favour riparian and aquatic weeds and algal blooms, and affect in-stream processes by reducing dissolved oxygen;
- Higher water temperatures and stratification may also reduce zooplankton and increase the incidence of jellyfish blooms, leading to drastic effects on organisms further up the food chain (CSIRO Marine and Atmospheric Research, 2006);
- Water quality is likely to be degraded by higher water temperatures (IPCC 2007) leading to more frequent and persistent toxic algal blooms (IPCC, 2008). Algal blooms threaten human health through recreational and consumptive means, and can kill fish and livestock (Falconer, 1997);
- IPCC 2020 climate scenarios for Australia show that the structure, function and species composition of freshwater ecosystems may be significantly affected (IV IPCC Special Report Emissions Scenarios (SRES));
- The effects of acidification on the world's oceans will affect the processes of marine species such as molluscs, echinoderms, and some crustaceans. Zooplankton have already exhibited some of the largest range shifts of any marine group (Hays *et al.*, 2005);
- Rainfall patterns are predicted to change from between a 25% reduction to a 3% increase by 2070 (CSIRO, 2007). The intensity and frequency of extreme storms are expected to increase, despite expected declines in overall rainfall and base flows. These changed conditions will have a number of significant effects on water quality, including longer periods for pollutants to build up on impervious surfaces and therefore increased levels of pollutants being delivered to our waterways and bays during heavy rainfall;

- Sea levels are predicted to rise by between at least 26 and 59 cm by 2090-2099 (A1F1 scenario, IPCC, 2007), with precautions that the upper limits of this prediction may be even higher. The VCS (VCC, 2008) suggests the adoption of a precautionary strategy in which we should plan for sea levels to rise no less than 80 cm by 2100. More frequent storm surges are expected to cause coastal flooding, shoreline realignment and erosion, and degrade estuarine, freshwater, and marine environments. When increased storm surges are coupled with sea level rise, a significant threat is posed to water quality. It is estimated that for every 1 m of sea-level rise there will be 50 to 100 m of horizontal erosion (Church *et al.*, 2006). Both Port Phillip Bay and Western Port contain large areas of low-lying land with vulnerable ecosystems and infrastructure;
- Saltwater spread as a result of sea level rise, decreased river flows, and increased periods of low rainfall are very likely to alter species composition in current freshwater habitats, with consequent effects on estuarine and coastal fisheries (IPCC, 2008); and
- The risk and occurrence of bushfires in Melbourne is predicted to increase with climate change (Hennessy *et al.*, 2005). A CSIRO study predicted that the average number of days when the Forest Fire Danger Index rating is very high or extreme is likely to increase 4-25% by 2020 and 15-70% by 2050 (Hennessy *et al.*, 2005). Following bushfires, water quality can be severely affected by sediment runoff during rainfall.

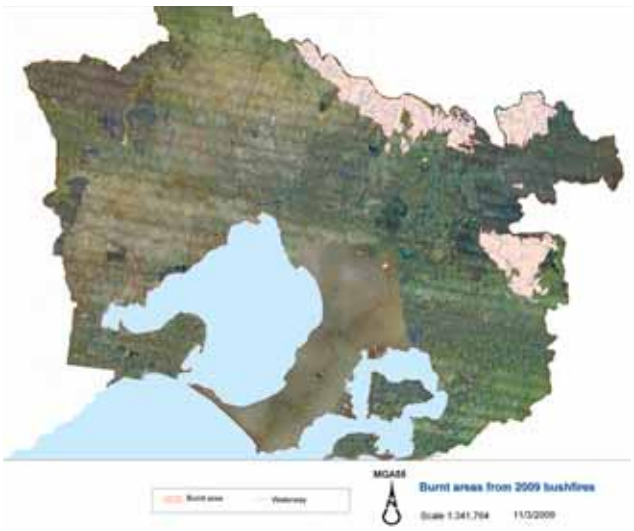
The Victorian Government is developing a climate change White Paper to set a new direction for action on climate change into the future. As part of the process, a climate change Green Paper outlines the climate change risks facing Victoria, presents potential policies and approaches and seeks new ideas on how Victoria can reduce its greenhouse gas emissions and become a leading low carbon economy. In particular, the Green Paper considers the Victorian Government's role in the context of Australia's Carbon Pollution Reduction Scheme (CPRS). The Green Paper was released in mid 2009 with the White Paper expected later in the year. *Better Bays and Waterways* will not duplicate this process but highlight the need to implement actions from the White Paper once published (see Chapter 9 Research and investigations).



Impacts of the 2009 Victorian bushfires (Black Saturday)

In February 2009, bushfires swept across Victoria, devastating 78 communities and 400,000 hectares of land (Victorian Bushfire Reconstruction and Recovery Authority, 2009) across the state. These intense fires burnt large areas of the Port Phillip and Western Port catchments (Figures 3.12 and 3.13) and claimed 173 lives and resulted in extensive property damage. Around 940 km of waterways in the Port Phillip and Western Port region were directly within the fire affected area.

Figure 3.12: Burnt areas from the 2009 Black Saturday bushfires



Potential impacts on water quality

The effects of these fires on water quality will be seen over the short and medium term with even small volumes of rainfall resulting in inputs of sediment, ash and burnt organic material from the burnt parts of the catchment, which can result in very high levels of turbidity and nutrient loads in the waterways. Over the long term there is the potential for sediments to continue to be transported through the system for more than 80 years.

Following the 2003 Alpine fires in Gippsland, research undertaken by the University of Melbourne for the Murray-Darling Basin Commission, estimated load increases for TSS at up to 1400 times above usual levels during the year following the fires (Sheridan *et al*, 2007). Phosphorus loads increased up to 400 times and nitrogen increased up to 94 times the usual levels. There was significant variability in load changes between catchments.

The 2006-07 Great Divide fires in Gippsland burnt 80% of the upper Thomson, Macalister and Avon catchments and 58% of the upper Mitchell catchment. In June 2007, floods in these catchments resulted in massive volumes of sediment and debris (including 15 tonne trees) being washed into waterways, leading to extremely high turbidity. The floodwaters made their way to the Gippsland Lakes. The following summer a prolonged blue-green algal outbreak occurred lasting even through the winter months.

The research after the 2003 Alpine fires also found that the sediment and nutrient loads calculated for rivers in the upper catchment were likely to be substantially higher than the loads actually delivered to receiving waters in the lower catchment (in this case Port Phillip Bay). This is because sediment and nutrients are stored within stream channels in the lower reaches of the stream network in reaches with lower slope, although some of this material may be remobilised during subsequent high flow periods (Sheridan *et al*, 2007). Additionally the current burnt areas (Table 3.7) only represent relatively small proportions of the total catchment area for Port Phillip Bay (and a very small proportion of Western Port), so the percentage increases at a whole-of-catchment scale are expected to be small, but there will be some localised effects in waterways.

Table 3.7: Area burnt within the Port Phillip and Western Port region during the 2009 bushfires by catchment (as at 4 March 2009)

Catchment	Burnt area (ha)	Total catchment area (ha)	Percentage burnt (%)
Yarra (upper)	29 113	404 700	8
Western Port (Tarago, Bunyip)	8 727	336 500	2.6
TOTAL	**37,840**		

Condition assessments of waterways indicates that approximately 63% of fire affected waterways were good or excellent condition prior to the fires. The effects of the 2009 bushfires are likely to include periods of poor water quality in and downstream of the catchments that have been burnt, with pulses of poor water quality likely following rainfall in the catchment. The effects on Port Phillip Bay and Western Port will probably be limited due to water supply dams downstream, which will trap much of the sediment, but some of the burnt catchments flow into waterways downstream of dams.

Following bushfires such as these, a number of changes are likely to be seen in creeks and rivers across the region. Some of these may include:

- Rainfall in the catchments may cause the movement of soils, ash, nutrients and debris into creeks and rivers. Waterways may appear blackened, turbid and scummy from the increases input materials;
- Potential for landslips and soil erosion to occur, which may cause sediment deposits in waterways affecting aquatic life;
- Increased sedimentation in waterways, leading to smothering of habitat and reduced oxygen levels, which may result in localised fish kills;
- Blue-green algae outbreaks may occur due to increased nutrient levels and increased light due to riparian vegetation being burnt;
- Burnt vegetation and cleared ground may provide an opportunity for increases in weed diversity and abundance, often out-competing the regenerating native flora;
- Changes in stream flow. Immediately after the fire stream flows may increase. In the short term, high and rapid peak flows are likely to be more apparent. In the longer term, regrowth of some forest types may cause lower stream flows; and
- Reduced riparian vegetation leads to less available habitat for native species such as fish, reptiles, frogs, aquatic mammals, and invertebrates, and reduces vegetation cover against predators such as foxes.

The extent of the effects of most recent and any future bushfires on water quality in the waterways and bays is unknown, but they are likely to be greater in the future, with a drier climate increasing fire risk, and increasing intensity and frequency of storms transporting sediments and burnt organic matter to waterways.

Recovery response

The primary aim for fire rehabilitation works in water supply catchments is to protect water quality (and, where possible, quantity) in reservoirs. For waterways, the focus of fire rehabilitation works is on protecting natural values, supporting the community and protecting built infrastructure, such as bridges, if they are impacted by changes in fire affected waterways.

Melbourne Water's fire recovery response includes the following steps:

- Understand the fire impacts (including fire intensity and post fire rainfall events);
- Assess key values to be protected;
- Establish monitoring programs to inform priorities and to trigger action when results indicate management action/ intervention is required;
- Focus on re-establishing relationships with stakeholders (including private landholders) and delivering on-ground works (such as fencing off riparian zones);
- Determine cross agency/land tenure partnerships required to implement other actions to protect waterways (such as pest plant and animal control works); and
- Continue monitoring program and use this monitoring to inform actions.

Melbourne Water's Waterways Group recovery response to the Black Saturday fires has centred around two key areas:

- The protection of key natural values, especially the Yarra River 'main stem'; and
- Supporting rural landholders in their management of fire affected waterways.

Significant work was undertaken by Melbourne Water immediately following the fires to ensure maintenance of the potable water supply, particularly to towns in the bushfire-affected areas. Ongoing maintenance of sediment controls will be required until sufficient regeneration occurs to protect water quality in reservoirs. Additionally, work has been focussed on clearing fire debris from in and around waterways where it was impacting on built infrastructure such as bridges. There has also been assistance provided to landowners, such as fencing to keep stock out of waterways to enable riparian vegetation to regenerate and protect riverbanks from further erosion. Weed control will be undertaken during spring 2009 to assist regeneration of native vegetation.

Actions to manage the impacts of the 2009 Black Saturday bushfires on waterways are detailed in Chapter 7.

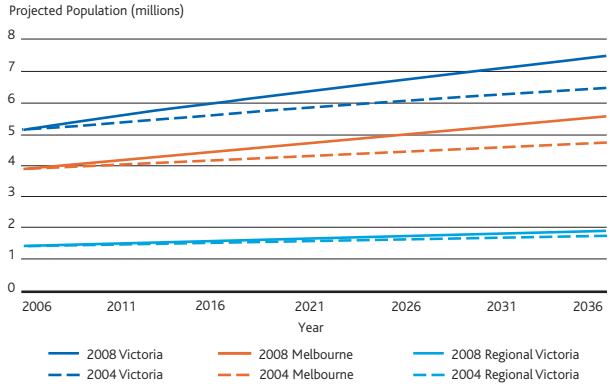
Future expansion of marine infrastructure

Any future expansion of marine infrastructure has the potential to affect water quality in the bays. New marinas, coastal developments and port expansions may require dredging and the construction of infrastructure. There is the potential for the operation of these facilities to increase the risk of oil spills and introduce pollutants and exotic marine organisms into the bays. Mechanisms to address these activities are managed outside this Plan, therefore no additional actions are proposed in *Better Bays and Waterways*.

Population growth

The population of the Port Phillip Bay catchment is currently approximately 3.5 million, while the population of the Western Port catchment is more than 580 000 (ABS, 2008). In December 2008, the Victorian Government released updated population growth projections that indicated that Melbourne was likely to reach a population of 5 million by 2026, 10 years sooner than previous projections (DPCD, 2008). This increase in population will put further pressure on our bays and waterways (Figure 3.14). An increased population will increase pressure on existing sewerage and stormwater systems, and will lead to an increase in litter, sediment and nutrient loads entering the bay unless substantially improved management practices are implemented. Predicting the effect of future population and urban growth on sewage production is needed to better inform a review of sewage management.

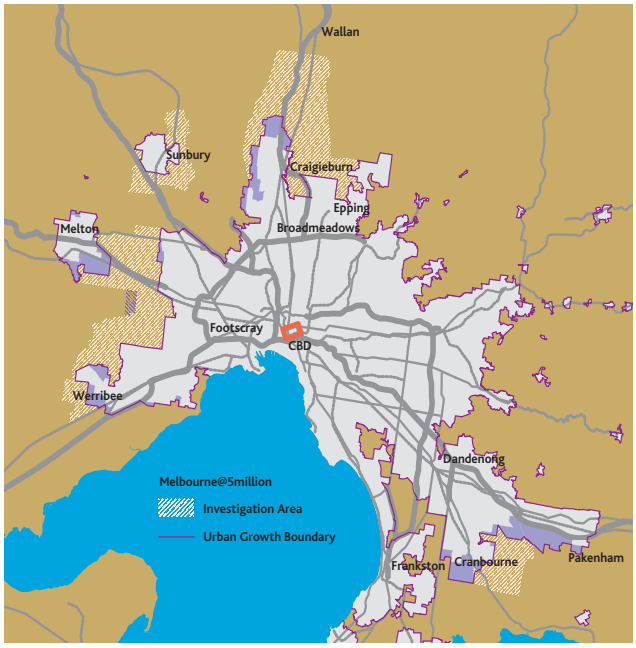
Figure 3.14: Updated population projections for Melbourne and Victoria (Source: DPCD, 2008)



3 Where pollutants come from

In late 2008, the Victorian Government proposed four areas to be investigated for potential inclusion in an extended Urban Growth Boundary for Melbourne (Figure 3.15). Until these investigations are undertaken, it is unknown as to whether the boundary will be extended in these areas. As such the modelling that has been undertaken as part of *Better Bays and Waterways* is based on the current boundary. The PortsE2 model will need to be updated to reflect any future changes to the urban growth boundary.

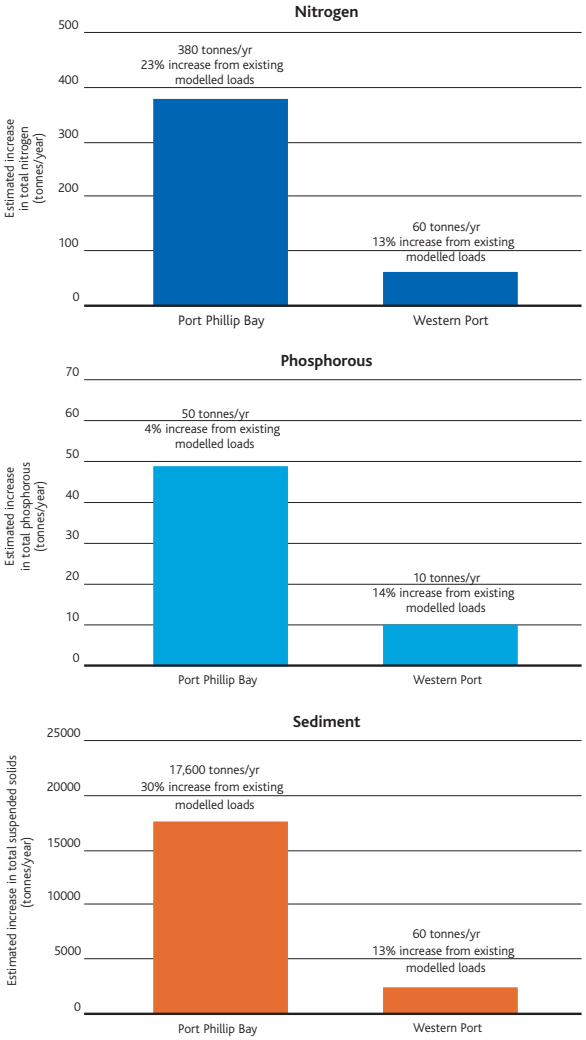
Figure 3.15: Investigation areas for proposed extension of the Melbourne Urban Growth Boundary (Source: DPCD, 2008).



Greenfield development in the Port Phillip and Western Port region and intensification of existing urban areas (infill development) will also be significant over this period. This will result in an increase in impervious surfaces, increasing runoff and pollution through the stormwater system.

Predicted increases in pollution entering the two bays due to future urban development were made using the PortsE2 model. Estimates are reported for a typical average year and draw upon Melbourne 2030 future land zoning data. As shown in Figure 3.16 the increase in pollution from urban development is predicted to be greater in the Port Phillip catchment compared to the Western Port catchment. There is likely to be an additional 380 t/y of total nitrogen, 250 t/y of phosphorus and 17 600 t/y of suspended sediment entering Port Phillip Bay by 2030 if urban development is not adequately managed. This increase is significantly less in Western Port with a likely increase in total nitrogen of 60 t/y, a 10 t/y increase of total phosphorus, and a 2500 t/y increase in suspended sediment. This highlights the importance of action to reduce loads, as doing nothing will result in an increase in loads due to population growth.

Figure 3.16: Estimated increase in pollutant loads from expected greenfield and infill development by 2030 from 1996 – based on Melbourne 2030 (after Melbourne Water, 2009).



Urbanisation will affect local waterways as well as the bays, particularly in relation to increased effective imperviousness and consequent increases in pulse events in waterways.

To cope with these pressures, it is vital that adequate stormwater treatment infrastructure, water supply and wastewater treatment are integral parts of new developments, and that the bays and their waterways are monitored, preserved and improved to maintain their environmental, social and economic values.

The actions proposed in this plan aim to offset the impact of population growth, however as new data becomes available, the management actions will need to be reviewed and adapted accordingly to ensure we continue to meet the challenges of a growing urban population.

In addition, urban growth planning provides an opportunity to minimise the effects of future population growth. Victorian Government documents such as *Melbourne 2030* and *Victoria in Future 2008* and structure plans prepared by local government contribute to sustainable future development.

If appropriate actions, including relevant *Better Bays and Waterways* actions are not implemented, population growth effects will not be offset; and loads to our waterways, Port Phillip Bay and Western Port will continue to increase despite actions already undertaken to reduce them. The 1996 CSIRO study of Port Phillip Bay predicted that if the critical nutrient load is reached, the end result could be a massive algal bloom in the bay and the loss of most benthic macrofauna with the bay becoming visibly green (Harris *et al.*, 1996). For Western Port, where sediment loads are the critical water quality issue, failure to address loads to the bay could result in the loss of remaining seagrass and a subsequent loss in associated marine fauna.

Chapter 4
Engaging the broader community in water quality issues

With the accumulated effects on our waterways over the past 170 years since European settlement, an enormous amount of work is required to effect changes in personal and broader community behaviours with respect to their impacts on water quality, and to build long-term support for initiatives and investment in water quality protection and improvement. Successful community engagement is critical, not just because activities at community level have a direct causal link to water quality (such as littering and pouring paint wash water into stormwater drains), but because the wishes of the community can be major drivers of action for change. It is a process that involves the whole community (including businesses, environment groups, individuals, industry, farmers and schools) in understanding water quality issues, effects and required actions to protect the values at risk.

Many places and features of the region are highly valued and cared for by individuals, groups and organisations, who protect and enhance those places for environmental, social and economic reasons. Some of these places and features are under threat from population growth and other threats like climate change. There needs to be a strong level of awareness, knowledge and active participation by increasing numbers of the community in the protection and enhancement of its water resources.

In determining the priority needs for attention in *Better Bays and Waterways*, community perception surveys were conducted to determine how the general public perceives water quality in freshwater and marine environments in the region. Members of the community were presented with a range of questions designed to determine their general understanding of water quality issues, and how the aquatic environment and habitats are valued. In general, while management of waterways and bays was considered to be good, ongoing issues such as litter, odours, and other pollution caused concern (Researchwise, 2006; Ipsos, 2007). The research also found that water quality is not well understood by the community, with a general lack of awareness about how individuals can contribute to driving improvements.

The community perceptions surveys recommended that the community needs to be involved in water quality issues in order to improve understanding and continued support (Ipsos, 2007). As such, *Better Bays and Waterways* commits to facilitating a better understanding of water quality issues by the community. This will lead to community support and participation in actions that aim to resolve those issues.

Managing water quality through community engagement

Better Bays and Waterways encourages and supports the involvement of integrated management in the delivery of its management programs (Part 2). Several management programs highlight the need to consult with and engage community members, groups, and local government to achieve water quality improvement in the region (Chapters 7, 8, and 9). The lead agency implementing each management action in Part 2 must assess the level of community engagement required for its implementation (Chapter 6). The work of Victorian government departments and agencies such as the departments of Victorian Communities, Human Services, Education, Sustainability and Environment and Primary Industries, EPA Victoria, Parks Victoria, PPWCMA and Melbourne Water is likely to be enhanced by better community engagement, participation and usage of the region's bays and waterways.

The concept of integrated catchment management has brought about a greater recognition by all parts of the Victorian community of the many contributions we can make to protect and enhance water quality. There is recognition that everyone makes a contribution to catchment management and that water quality is a shared responsibility. More holistic, integrated approaches deliver broader benefits than those undertaken by one group operating alone.

Community groups and their programs

There are more than 480 volunteer Landcare, friends and community groups in the Port Phillip and Western Port region, each of which is actively involved in contributing to natural resource management (PPWCMA and DPI, 2003).

Community groups in the region contribute to improving water quality and the health of the environment. Many community groups participate in activities such as local promotion, education and on-ground works that provide direct benefits to water quality. These activities raise the awareness of participating local community members through educational campaigns and local actions that directly encourage the broader community to connect their activities with water quality outcomes.

The wide range of community groups across the Port Phillip and Western Port region is a valuable asset when it comes to engaging the community in water quality improvement awareness and action. Recognition that these groups are comprised of volunteers is fundamental to establishing good working relationships. The capacity of individual groups is highly variable and the development of their capacity to engage their community, think strategically, plan at a catchment scale and form beneficial relationships with other land and water managers (see the additional investment opportunities section of chapter 10) is critical to success.

A reciprocal relationship between community groups and land and water managers is a crucial component of successful integrated management. To facilitate this relationship, land and water managers must provide a foundation on which various groups, managers, and individuals can be supported, to ensure projects and their goals are aligned and complementary. This is done through a support framework for Port Phillip and Western Port community groups and relevant NRM agencies.

4 Engaging the broader community in water quality issues

Box 4.1: The Bellarine Catchment Network supporting Bellarine Peninsula environmental community groups

This community-driven project recognises that all sections of the community need to play an active role in caring for the environment. This is best achieved on a catchment-wide basis.

Their vision is that:

The Bellarine Catchment Network region will work towards healthy, well connected and resilient wetlands, waterways and native vegetation ecosystems; sustainable agricultural and land management practices; and a community which is engaged and involved in protecting and managing the natural environment.

Since inception, the Bellarine Catchment Network (BCN) (formerly Swan Bay Integrated Catchment Management Committee) and project has achieved significant environmental and educational outcomes on the Bellarine Peninsula and has become widely recognised as the peak community environment committee. These outcomes include assisting in the protection of Swan Bay, pest plant and animal control, erosion control, remnant habitat protection, revegetation, and coastal dune and saltmarsh protection and enhancement. The BCN has grown and strengthened over ten years of operation with a wide cross section of community groups and agencies. It now has 13 community groups and seven agencies represented on the committee. It is this integration and diverse representation of community, agency and industry that has led to the level of achievement and joint outcomes on the Bellarine Peninsula. The project works with the community to focus on several main aims to:

- *Protect and enhance Ramsar wetlands and connecting wetlands;*
- *Promote and apply Ramsar values and guidelines;*
- *Protect, enhance and link remnant vegetation;*
- *Protect indigenous fauna and enhance existing habitats;*
- *Facilitate community awareness and participation;*
- *Advocate for adaptive management to climate change;*
- *Rehabilitate and protect watercourses and improve water quality (in-stream and stormwater);*
- *Increase the adoption of sustainable agricultural and land management practices;*
- *Promote pest plant and pest animal control; and*
- *Be an active, engaged and well-supported network.*

Box 4.2: Werribee Plains Waterwatch

Werribee Plains Waterwatch began in February 2006 with funding from the Department of Sustainability and Environment's Victorian Water Trust's Vision for Werribee Plains. In that time it has involved over 26,000 people, including 100 schools and over 30 community groups.

The program has been recognised both nationally and internationally for its evaluation techniques and use of multi-disciplinary teaching, in particular incorporating art into the program.

The program has built strong connections across Werribee Plains, strengthening Melbourne's western community by engaging all sectors of the community in river health education. This form of engagement has subsequently contributed to the long-term protection, conservation and management of the natural environment in the region.

Werribee Plains Waterwatch has been extremely successful at educating the community about their waterways and the steps they can take to improve waterway health. Preliminary evaluation indicates that as a result of participation in Werribee Plains Waterwatch, 90% of participants are confident they know what they can do to improve the health of waterways.

At the time of writing, Melbourne Water was awaiting the outcome of its submission for Stage Two funding of the program. If received, Werribee Plains Waterwatch will look to extend this successful program so that participants use the knowledge and skills they have gained to develop and implement action plans that contribute to improving the biodiversity, social and sustainability outcomes of the Werribee Plains. See chapter 9 for further details.

Supporting Port Phillip and Western Port community groups

Agencies across the region, including the PPWCMA, Melbourne Water, local government, Parks Victoria, EPA Victoria and the Department of Sustainability and Environment are working in partnership to establish effective ways to support the hundreds of volunteer groups that focus on public land in the urban areas of the region.

These collaborations aim to build the capacity of community groups by:

- Developing the ability of groups to engage and influence their landholders;
- Helping groups understand the national, state and regional natural resource management priorities relevant to their area;
- Supporting the establishment of new groups and networks;
- Keeping groups informed of learning and funding opportunities;
- Creating opportunities for groups to establish beneficial relationships with other groups and agencies;
- Bringing resources to the region to fund a range of activities; and
- Reporting on, celebrating and recognising the achievements of community groups.

In 2008, Melbourne Water and the PPWCMA jointly established a Port Phillip and Western Port CatchmentCare team to enhance support and development of volunteer-based groups working to care for land and water across the region.

The program aims to continue supporting community groups associated with private land. Groups with a focus on public land typically have an established supportive relationship with the agency responsible for the management of that land, whereas groups with a focus on private land (ie Landcare groups) do not. Groups focused on private land typically occur in the rural and peri-urban parts of the region.

Other partnership initiatives exist such as the Western Port Seagrass Partnership, a partnership between EPA Victoria, industry and community to accelerate the implementation of restorative works in the catchment and Western Port.

The community groups in the region include:

Landcare groups and networks

Landcare groups are typically non-urban and are comprised of private landholders voluntarily collaborating to care for and enhance the natural assets of their local area. In many cases, a number of Landcare groups have come together to form Landcare Networks. Landcare networks are able to take a more strategic view and plan at a landscape or catchment scale which in turn helps guide and coordinate the efforts of their member groups.

There are more than 80 Landcare groups in the Port Phillip and Western Port region. Their strength lies in the networks they form, and their connection to local communities making them important players in engaging the community in water quality improvement. Two excellent examples of the potential of Landcare to actively engage private landholders in managing their properties are the Bellarine Peninsula Catchment Network (Box 4.1) and the Bass Coast Landcare Network (Box 4.3).

'Friends' groups

'Friends' groups are typically urban and comprised of local residents voluntarily working together to care for the natural assets of a local piece of public land such as a bushland reserve or a creek. There are an estimated 250+ 'Friends' groups in the Port Phillip and Western Port region. Some excellent examples of groups using a waterway focus to work with each other and with local government are the Merri Creek Management Committee and the Kororoit Creek Catchment Coordination Committee.

In the Werribee and Maribyrnong catchments, which have low levels of networking cultures in peri-urban areas and new suburbs, the government initiative 'Vision for Werribee Plains' will help feed into the development and survival of further Landcare and other urban or coastal networks (Box 4.2).

Volunteer Committees of Management/ Coast Action and Coastcare

It is estimated that over 75 volunteer-based groups in the region have a coastal focus. These groups are typically Coast Action/ Coastcare groups and volunteer Committees of Management that have management responsibilities for parcels of coastal Crown Land. As such many have activities that directly care for and improve the health of the waters of Western Port and Port Phillip Bay, and especially on stormwater quality.

Other groups

Other groups include:

- Traditional owners and their Indigenous community networks;
- Community run nurseries;
- Local branches of state and national organisations, such as Birds Observers Club, Fields Naturalists Club of Victoria, marine and coastal community programs (e.g. Reefwatch); and
- Non-government organisations such as Conservation Volunteers Australia, and Greening Australia.

There is also a range of other bodies and organisations such as schools, water authorities, CERES and Gould League, that have demonstrated very effective practical and proven water quality improvement work with the community.

Advocacy and engagement organisations such as Waterkeepers Australia and Environment Victoria are important partnerships between various community members who, by working together, provide a large range of environmental services. These services include awareness raising, education and environmental advocacy, and assist and empower the community to understand and contribute to improving water quality.

4 Engaging the broader community in water quality issues

The broader community

Several existing programs are raising the profile of water quality in the community. Many government agencies run programs that facilitate change in different groups, such as businesses, landowners, and farmers. Some of these programs and their targeted groups include:

- Waterwatch – an interactive river health education program that supports community members, schools and businesses to be actively involved in monitoring and protecting the health of our rivers and creeks. It also operates at community events, festivals and open days to engage and interact with the general public and to promote water quality issues;
- Reefwatch – aims to develop local knowledge in the dive community and higher values of marine environments in the broader community, and encourages effective policies and actions to protect and enhance these environments;
- Two Bays Partnership Program (Box 2.1) – activities include water quality sampling and marine processes studies, and promoting awareness for the environmental and cultural assets of Port Phillip Bay and Western Port. Two Bays is a multi-agency partnership involving Parks Victoria, EPA Victoria, the Port Phillip and Western Port Catchment Management Authority, the Australian Government, and the Association of Bayside Municipalities;
- The Stream Frontage Management Program (SFMP) – addresses degradation of rural waterways in targeted areas across the region. The program supports landowners to undertake rehabilitation works on private, freehold and leased land. This is done through grants for fencing, revegetation, weed control, off-stream stock watering and minor stabilisation; and
- The rural land program (see Chapter 7) – has a major focus on engaging with rural land holders. The program facilitates sustainable land use practices, leading to improved water quality in rural waterways;

Government agencies work with local councils and businesses to raise awareness of water sensitive urban design and stormwater quality (see Working with the Community – under Chapter 7).

State and local governments work together to offer incentives to property owners, such as rebates for rainwater tanks, and encourage the installation of raingardens, as well as manage emerging incentives for building owners (such as a green roofs competition sponsored by Melbourne Water).

Communications teams within agencies also explore avenues for engaging with the public, such as advertising campaigns, and sponsorship of public events (e.g. Moomba) to promote waterway health through education and entertainment.

Chapter 10 describes the management program proposed by *Better Bays and Waterways* to engage with both environmental community groups and the broader community.

Box 4.3
Bass Coast Landcare Network

The Bass Coast Landcare Network (BCLN) was established in 2003, drawing together 11 Landcare groups in the region. The role of the BCLN is to promote land use and management that ensures the integrity and sustainability of land, water and biodiversity and support the groups and members to fulfill their aims. There are four Landcare groups from the Network within the Western Port region.

Landcare has undertaken significant on-ground works to improve water quality in the Bass catchment through projects such as Western Port Ecosystems Services., This project assists landholders to protect and link native vegetation throughout the catchment and was developed in partnershi[p with the Port Phillip and Westernport CMA,. Landcare staff also work closely with Melbourne Water field staff to jointly support landholders where bigger and better projects result from this three way collaboration.

Landcare began in the Bass Coast region in 1987 and since that time has had a strong focus on improving water quality. The members of one of the Landcare groups all come from within the catchments of the two local water reservoirs – Candowie and Lance Creek. This group formed strong partnerships early on with the two local Water Authorities and Monash University, with research underpinning much of the work their members have done. Operational Plans between Landcare and the Water Authorities now set out the annual works and monitoring programs in the two water catchments.

BCLN undertakes community-based water quality monitoring as part of the Bass Coast Landcare Network Monitoring Strategy. The BCLN aims to engage the community in monitoring as much as possible, recognising that community input and local knowledge is extremely important. Further, by involving the community, the knowledge of catchment processes and the management of natural resources is increased. The Strategy sets out methods to collect data from nine environmental indicators that aims to measure changes in catchment health across the network. Volunteers are trained in the monitoring of five of these indicators, including water quality.

The volunteer-based community water quality monitoring is supported by annual training and quality assurance days provided by BCLN. The first Bass Coast Landcare Monitoring Training Day attracted over 50 participants, 19 of whom undertook specific water quality monitoring training. These volunteers and additional Landcare Group members are allocated sites on streams and rivers across the Network area to monitor in spring and autumn each year.

Undertaking monitoring in catchment health provides a great feedback loop for landholders, and in particular Landcare members, who have worked for many years on re-establishing native vegetation, fencing off streams and better accounting of nutrients, all in order to improve water quality in our bays and waterways.

Source: Bass Coast Landcare Network 2008

Photograph below: Group working on soil health to reduce nutrient and sediment runoff into Western Port.

Chapter 5
Water Quality Objectives and Targets

Objectives

In Victorian legislation, the word 'Objectives' refers to benchmarks for particular indicators to ensure that the environmental values (referred to as 'beneficial uses') are adequately protected. In Victoria's SEPP (Waters of Victoria), the objectives are defined as:

'The concentration or level of an indicator that describes the environmental quality required to protect designated beneficial uses.'

This legislation has been designed so that when an objective is not met (e.g. if a concentration or level of an indicator is too high or low), an investigation is triggered so that the risk to the environmental value in question can be properly assessed.

In accordance with the NWQMS, Victoria uses the Australian and New Zealand Environment and Conservation Council (ANZECC) National Guidelines for Fresh and Marine Waters (2000) as the basis for establishing water quality objectives in its environment protection policies (SEPPs).

Water quality objectives for Port Phillip Bay and Western Port

Several existing objectives (See Appendix 3 for details) are defined in Victorian legislation. These are specified in:

- SEPP (Waters of Victoria (WoV)) 2003;
- Schedule F6 (Waters of Port Phillip Bay) 1997;
- Schedule F7 (Waters of the Yarra Catchment) 1999; and
- Schedule F8 (Waters of Western Port and Catchment) 2001.

Victoria's SEPP (WoV) sets most of the objectives relating to water quality in Western Port and Port Phillip Bay and their catchments. These objectives are based on long-term water quality monitoring and reflect considerable local knowledge of water quality requirements to ensure protection of the identified 'beneficial uses'. Where such data is not available, objectives are based on the ANZECC water quality criteria.

The water quality objectives referred to in *Better Bays and Waterways* have been developed in legislation to maintain the water quality in Western Port, Port Phillip Bay and their catchments in accordance with existing legislation, and to improve water quality where the objectives are not currently being met.

Water quality targets

Several guiding documents were used to define water quality targets for *Better Bays and Waterways*. These include the statutory objectives established in Victorian SEPPs (State of Victoria, 1997, 1999, 2001 and 2003) and further elaborated for Port Phillip Bay in the EMP, the targets listed in the Port Phillip and Western Port Regional Catchment Strategy (PPWCMA, 2004), the Central Region Sustainable Water Strategy (SWS) (DSE, 2006), and the Regional River Health Strategy Addendum (Melbourne Water, 2007c).

The development of the targets was aided by the modelling from the PortsE2 catchment model and Receiving Water hydrodynamic model (Box 3.2 and Appendix 2).

SEPPs set the objectives required to ensure protection of the values: the ultimate goal for water quality. By attaining SEPP objectives, the values and uses of the waterways are protected. The challenges associated with water quality in the region are recognised in SEPP (WoV), which recognises that not all beneficial uses will be able to be fully protected and not all environmental quality objectives will be fully met for all regions, within the lifetime of the policy. In these cases, targets to drive the progressive rehabilitation of environmental quality need to be developed (State of Victoria, 2003).

The current condition of our waterways (Chapter 2) clearly identifies areas where conditions do not currently meet the SEPP objectives. *Better Bays and Waterways* has identified the need to set regional targets for the following:

- nitrogen load targets for Port Phillip Bay;
- sediment load targets for Western Port;
- water quality targets in rivers and streams in the Port Phillip and Western Port region; and
- community engagement targets.

Committed and long-term targets have been set. The committed and funded actions within *Better Bays and Waterways* (chapters 7-10) will meet the committed targets. The *Better Bays and Waterways* Management Actions include modelled individual actions that contribute to achieving the committed targets as well as a number of unquantified, but committed and funded actions that will result in exceeding the committed targets and progressing towards the long-term targets. Given the nature of these unquantified actions, accurate modelling of their predicted effects has not been possible. The long-term targets are generally statutory targets (such as in SEPPs or the Port Phillip Bay EMP) and are based around the long-term protection of environmental values. Appendix 2 outlines how the targets have been set.

An adaptive management framework accompanies the monitoring, research and management actions within *Better Bays and Waterways*. An adaptive approach ensures a continually updated understanding of the effectiveness of our management actions and the targets required to protect environmental values, particularly as our climate and environment change.

5 Water Quality Objectives and Targets

Port Phillip Bay nitrogen loads target

Committed target:

Prevent the addition of at least 40 tonnes of nitrogen per year over five years, by reducing diffuse source load contributions by 2014. This is equivalent to the overall increase in nitrogen loads due to urban population growth based on Melbourne 2030 estimates.

Long-term statutory target:

Protect environmental values by achieving a 1000 tonne reduction from the 1996 baseline established by EPA Victoria through the gradual reduction of diffuse source load contributions.

SEPP Schedule F6 required a reduction in the annual load of nitrogen discharged from the catchment to the bay by 1000 tonnes from the 1996 baseline. The EMP further clarified this, requiring a 500 tonne reduction from the WTP and a 500 tonne reduction from catchment sources, particularly focussing on storm event loads. A reduction of 500 tonnes per annum has been achieved from upgrades to the WTP leaving a remaining target of 500 tonnes. This is likely to be achieved from catchment sources rather than the WTP. Melbourne Water aims to achieve a 100 tonne reduction in nitrogen loads from urban stormwater by 2010.

The EMP highlighted the challenge of achieving nutrient reduction from catchment sources with continued urban development adding to nitrogen loads entering the bay. The committed and funded actions within *Better Bays and Waterways* meet the committed target of mitigating the contribution of nitrogen loads from additional urban population growth. Delivery of a number of unquantified (unmodelled), but committed and funded actions will ensure that the committed target is exceeded and will contribute significantly towards achieving the long-term target. There are also several actions outlined in the Additional Investment Opportunities sections of each management program that, if funded, will further contribute towards achieving the long-term target.

Western Port sediment loads targets

Committed target

Reduce the average annual sediment loads to Western Port by 1000 tonnes per year by 2014.

Long-term target

Given the limited understanding of the coastal inputs and effects of sediment, and of the required sediment load reduction to protect environmental values, quantitative targets have not been established. Chapter 8 includes a recommendation for further investigations in Western Port to assess the issues and recommend appropriate targets.

Western Port nitrogen load targets

Committed target:

Reduce the nitrogen loads to Western Port by 5 tonnes by 2015.

Long-term catchment target

A long-term catchment target will be developed through the research and investigation phase of *Better Bays and Waterways*. While the target will be developed to ensure long-term protection of environmental values, the timing for the implementation of the target needs to also consider social and economic implications. In the interim, actions to reduce the sediment load will have a double benefit in that they will also reduce the nitrogen load entering the waters of Western Port. Loads based on dry and average year nitrogen loads will assist in prioritising actions to reduce nitrogen in the longer term.

Waterway water quality targets

The process for developing interim waterways water quality targets is still underway. Appendix 2 outlines the method for establishing interim water quality targets developed through *Better Bays and Waterways*. When the interim water quality targets are finalised they will be incorporated into Melbourne Water's 20-year vision templates and the review of the Regional River Health Strategy due in 2012.

Flow targets

Environmental flow targets

- By 2012 the Environmental Water Reserve for the Bunyip/ Tarago system will be increased by 3GL*
- By 2015 the Environmental Water Reserve for the Yarra system will be increased by 17GL*
- By 2010 the Environmental Water Reserve for the Maribyrnong system will be increased by 3GL**
- By 2015 the Environmental Water Reserve for the Werribee system will be increased by 6GL**
- By 2013, the environmental flow condition of the waterways within eight out of 63 management units will have improved as outlined in the RRHS***
- By 2013, the environmental flow condition of the waterways within the remaining 55 management units will be maintained as detailed in the RRHS***

* This entitlement has been granted however due to the current water shortage the flows will not be delivered until 2012, when the Melbourne water supply system is augmented or until water restrictions in the region return to Stage 1 or less.

** Work is progressing toward this target however extreme drought conditions may impact on timelines for delivery of the Environmental Water Reserve.

*** Work is progressing towards this target however extreme drought conditions may impact on timelines.

Once major water supply augmentations come on-line (such as the desalination plant and Tarago reconnection), they could assist towards meeting environmental flow targets.

Environmental flow is one of the major factors affecting river health. As another measure of waterway health, environmental flow can affect the concentrations of pollutants and the preservation of ecological habitats.

In many streams and estuaries, reduced flows and/or changed flow patterns are an issue. In urban catchments the significant increase in flow volume and frequency of runoff can be as damaging to creek environments as pollution.

Urban flow target

In addition to environmental flow targets, which are focussed on the provision of additional flows to provide required environmental conditions, there are urban flow targets, focussed on reducing damaging flows through urbanisation.

Urban flow target:

Long-term target: Maintain flows at pre-urbanisation levels.

Increased flows due to urbanisation are a significant threat to the health of urban waterways. The Best Practice Environmental Management Guidelines set the flow target to maintain flows at pre-urbanisation levels. Flow best practice management objectives will be reviewed through the Stormwater Best Practice Environmental Management Guidelines review (See Chapter 7).

Estuarine flow targets

The SKM (2007b) report *Determination of Environmental Flow Objectives in Maintain Water Quality for Major Estuaries in Port Phillip Bay and Western Port* was an initial step towards better understanding our estuaries. The study included the determination of preliminary environmental flow objectives for priority estuaries in the region (SKM, 2007b).

The report also established principles that should underpin flow requirements. The principles are that diversions should not disturb major features of the hydrodynamic cycle and that key characteristics of the estuary should be maintained.

The report summarised the available flow and water quality data for several key estuaries and provided the basis for improved understanding of the links between flows and water quality in estuaries such as in the Yarra River. Preliminary estuarine environmental flow objectives were developed for the Yarra, Maribyrnong, Werribee, Little River, Bunyip, Bass and Lang Lang estuaries. They ensure that water mass movement between estuary entrances and adjacent open coasts supports channel entrance behaviour and provides sufficient freshwater environmental flows to:

- reduce the incidence of hostile water quality conditions in the estuary;
- reduce the incidence of pollution aggravation problems along the estuary;
- ensure water mass exchange between the segments within the estuary to reduce the potential for contaminant accumulation;
- ensure deeper sections in the mid and upper estuary are flushed of organic material;
- ensure adequate inputs of nutrients and organic material are delivered to the estuary; and
- ensure salinity gradients are maintained along the length of the estuary.

Refer to Appendix 2 for more information on establishing estuarine flow objectives and targets.

Community engagement target

The Port Phillip and Western Port community has an active role in contributing towards the *Better Bays and Waterways* water quality targets and in the delivery and implementation of the management programs.

The views and perceptions of the community influence the values prescribed to waterways. For *Better Bays and Waterways* to succeed, community involvement is essential in driving positive change in water quality and achieving the region's water quality targets and the adoption of management actions.

Water quality projects throughout the region need to address this when tackling water quality issues. Each project should identify the type of community engagement required and the project plan should justify the intended level of community engagement (See Chapter 10).

Part 2: The next 5 years and beyond

Chapter 6 Introduction to Management Programs

Part One of the *Better Bays and Waterways* has described the past and current state of waterways, estuaries and bays within the Port Phillip and Western Port region. This description has outlined the geo-physical features of the catchments and bays, their values, current condition, threats and targets for improvement. Part Two of the plan details actions that will deliver improvements to water quality.

The twelve *Better Bays and Waterways* management programs are grouped into four main categories described in detail over the following four chapters;

Chapter 7 – Catchment actions

- Rural diffuse source management
- Urban diffuse source management
- Point source management
- Management of 2009 Black Saturday bushfire effects on waterways
- Environmental flows

Chapter 8 – Marine influences

Chapter 9 – Understanding our rivers and bays

- In-stream monitoring
- In-bay monitoring
- Research and investigations

Chapter 10 – Effective management

- Community engagement
- Governance
- Reporting, evaluation and review

The management programs within each group are structured in the same manner. Each program contains actions, each of which is described in terms of its aims, links to targets, and other environmental, economic and social benefits. Within each action, detailed activities are described. Each action is assigned lead and support agencies for implementation, and states a timeframe, commitment level, funding and predicted costs.

Lead and support agencies

The lead agency will be responsible for ensuring the associated action is implemented and reported on. The lead agency will also assess the level of community engagement for successful program delivery. Lead agencies will be accountable for providing annual updates on the progress of their designated actions within *Better Bays and Waterways*. The role of support agencies will vary depending on the action and the agreed commitment between all involved. Support agency involvement may vary from funding contributions to equal partnership responsibilities.

Commitment

An action is defined as 'committed' if an agency/department/ organisation has agreed to be responsible for its delivery. This might be through commitments in an organisation's operating plan, or from a decision to commit to the action as part of the *Better Bays and Waterways* plan development. An action can otherwise be rated as partially or not committed. In most instances, partially or uncommitted actions are dependant on currently unsecured funding or other resources to secure their delivery.

Funding

An action is noted as funded if all required funding for the action has been committed by the relevant organisation. An action can otherwise be noted as partially funded if a portion of the funding has been committed. If no funding has yet been assigned to an action it is not funded. Where there is no funding or only partial funding, investment must be sought. All actions and commitments made within *Better Bays and Waterways* are subject to the availability of funding.

Cost

Costs are described in ranges. The 'low' range is where actions have been costed below $100 000, 'medium' is between $100 000 and $1 million and 'high' is for amounts greater than $1 million. Costing ranges have been used instead of precise figures as exact costs have not yet been finalised. Determining exact costs will require detailed scoping of actions and the scope of activities is subject to change over the implementation period of the plan as the adaptive management approach is applied. Stated costs are cumulative over the five years of the plan.

Water quality, environmental, social and economic benefits

In many cases, the delivery of management programs will provide multiple benefits. These are described in each relevant section.

Additional investment opportunities

Management programs also contain a section outlining additional investment opportunities that are not currently funded, but have been identified by stakeholders as required to fill identified gaps. The actions listed in this section do not represent a comprehensive list and there may be other priority actions that have not yet been identified.

Additional investment opportunities require detailed scoping, provide the opportunity to improve or extend existing programs, and scope new programs that will improve water quality in the region. Where known, the expected lead agency has been identified. No funding is currently available for the implementation of these supplementary actions and are dependant on additional funding from the Commonwealth Government to be undertaken.

Additional investment opportunities differ from 'unfunded' actions, which have already been scoped and committed to by a lead agency.

Reporting

Each action within *Better Bays and Waterways* will be reported on annually to agencies and an implementation report will be prepared. This report will be made publicly available on Melbourne Water's website.

6 Introduction to Management Programs

Adaptive management

Figure 6.1 Adaptive management framework

Adaptive management is an integral component of each management program and its actions in Part 2.

An adaptive management approach was applied throughout the development of *Better Bays and Waterways* in accordance with Victorian natural resource management policy (such as the Victorian River Health Strategy (DNRE 2002a)). The major elements of an effective adaptive management framework involve a combination of planning, management, research and monitoring (see Figure 6.1)

The key feature of adaptive management is the ability to adapt actions and programs based on new information on how the system responds to specific management interventions (DNRE, 2002a). It also provides the flexibility necessary for dealing with changing socio-economic or socio-ecological relationships.

An adaptive management framework is ideally suited to situations where there are complex interactions. They require high quality baseline information and ongoing monitoring and evaluation to develop an understanding of how the system responds to the management actions. Assessment of the data from the monitoring will indicate progress towards targets.

Adaptive management reflects the 'Precautionary Principle'. Actions are developed based on the 'best available information' at the time, and then monitored and evaluated to inform management and progressively improve the response to the problem.

The Precautionary Principle states: "if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation." (United Nations, 1992) The lack of knowledge on management action effectiveness should not postpone the delivery of actions that would prevent further environmental degradation.

There will always be uncertainty surrounding the effectiveness of management actions in achieving the required pollutant load reductions, reflecting the need for adaptive management.

Prioritisation

The following chapters contain a range of actions that have been refined through workshops and discussions with various stakeholders. These discussions provided a basis for prioritising actions. The approach used is consistent with that used in the Victorian River Health Strategy (DNRE, 2002a). It sets priorities for actions to protect existing high value areas or areas in good condition, and to restore areas with highest environmental or community gain for the resources invested, and where there is real community commitment towards long-term improvement in waterway health.

Raingardens are an effective method of removing pollutants that are present in urban runoff such as litter, sediments, nutrients and metals. At Federation Square Car Park the rain falls on the upper level car park, collecting pollutants from cars and human activities and then runs into gutters and downpipes. It is then spread onto the raingarden and filtered by the soils and plants. A perforated pipe under the raingarden collects the treated water which then flows back into the stormwater drain and finally to the Yarra River. By treating the stormwater in this way, the raingarden is helping to tackle stormwater pollution and improve the health of the Yarra River.

Part 2: The next 5 years and beyond

Chapter 7
Catchment Actions

Rural diffuse source management

The Rural Water Quality Program

The Rural Water Quality Program aims to improve the water quality of bays and waterways by reducing the mobilisation and export of pollutants (TN, TP, TSS and pesticides) from rural enterprises, and managing flows and pollutants in-stream. The program is an integrated approach to water quality management and draws together a range of existing actions and new activities to focus on achieving improvements in water quality through sustainable actions.

This program includes the waterway stabilisation and vegetation management actions currently undertaken across the region, as they are proven activities that achieve on-ground results and multiple benefits. The program includes market-based incentives such as EcoTender as an alternative method of delivering incentives for on-farm practice change. The new Rural Land Program will deliver two agricultural pilots in priority sub-catchments to achieve action on key pollutant sources in these districts. The learnings from the Rural Land Program and other actions in the catchment can be extended to other priority areas in the future.

Waterway stabilisation and vegetation management

Waterway bed and bank erosion and aquatic and riparian weed infestations threaten rural water quality in many of the region's waterways (Melbourne Water, 2004; Melbourne Water, 2007b). These problems are exacerbated by farm practices such as allowing uncontrolled stock access to riparian zones and waterways. Significant river health improvement works are planned and carried out by Melbourne Water to achieve the river health and water quality targets set out in the Port Philip and Westernport Regional River Health Strategy (Melbourne Water, 2007b) (action 7.1).

RURAL Actions	
No.	**Waterway stabilisation and vegetation management**
7.1	Implement Regional River Health Strategy Addendum (5 year) actions

Some of these works are undertaken through the Melbourne Water Stream Frontage Management Program (SFMP), where landowners are offered funding assistance, technical advice and educational opportunities to improve and manage their stream frontage.

Local governments, private landholders and community groups also undertake waterway and vegetation improvement projects with funding from Australian, state or local regional incentive programs. Current programs do not necessarily address water quality as a primary objective, but are well placed to contribute through existing delivery mechanisms of capital or operational works programs and landholder incentive programs.

The Port Phillip and Westernport CMA runs four flagship programs in association with a range of partner organisations to improve catchment condition (action 7.2). Each of these projects plays a role in helping to improve water quality. The four flagship projects are Grow West, Living Links, Yarra 4 Life and Spirit of the Bunyip.

RURAL Actions	
No.	**Waterway stabilisation and vegetation management**
7.2	Implement PPWCMA flagship programs

Grow West is a project to rehabilitate degraded farmland west of Melbourne. This involves a range of approaches including tree planting, education, improving farming techniques and adoption of alternative land uses. The Grow West project is initially working in an area of 50 000 ha of land between Bacchus Marsh and Ballan.

Living Links is a master plan for a web of living parks, wetlands, pathways and open spaces in Melbourne's south-east. It seeks to establish a series of habitat corridors linking existing open space, conservation reserves, recreation areas and fragmented patches of native vegetation; improve the condition of waterways and coastal zones in the catchment; improve connectivity between fragmented social and recreational assets; and increase community participation and investment in the catchment. Living Links aims to contribute to environmental protection, improved land management practices, waterway management, improved stormwater quality, eradication of noxious pests and regional economic development.

Yarra 4 Life focuses on 40 000 ha of Yarra Valley countryside between Lilydale, Gembrook and Woori Yallock. It has four specific goals focusing on land and water improvement, protecting the endangered Helmeted Honeyeater, improving the Yarra Valley as an enjoyable recreational space and destination, and maximising the economic viability of the Yarra Valley.

Spirit of the Bunyip encompasses 136 000 ha of land north of Western Port between Berwick and Drouin, and takes in the Bunyip River and Cardinia Creek catchments. It is a 20-year program to create more than 100 km of habitat links from the headwaters of the Bunyip River and Cardinia Creek to the coast. Its goal is to reduce the amount of sediment flowing into Western Port and prevent degradation of its coastal and marine environments.

Agricultural best management actions and farm plans

The *Better Bays and Waterways* study *Identifying and Evaluating Agricultural Practices to Reduce Nitrogen and Phosphorus Exports in the Port Phillip and Western Port Region* (DPI, 2007) identifies the agricultural BMPs that are most likely to prevent or minimise the export of sediments and nutrients from dairy, beef and row cropping (strawberry) farms. The key BMPs identified include limiting stock access to waterways, improving fertiliser use, installing nutrient retention systems and improving irrigation system design and management. The report proposes that BMPs that require significant initial capital investment are the least likely to be implemented by land managers unless financial incentives, offsets and/or significant additional benefits, such as productivity or lifestyle gains, can be demonstrated. It also identified a number of mechanisms by which adoption can be encouraged or assisted, including industry-developed self-assessment and educational tools, government funded incentive programs such as grants and tenders, and market-based initiatives such as branding initiatives.

7 Catchment Actions

The *Cost-effectiveness of Water Quality Management Final Report* (URS, 2007) assessed urban and rural water quality actions and identified the most cost-effective options. The report found that agricultural BMPs are typically the most cost-effective means of achieving load reductions to both Port Phillip Bay and Western Port. The BMPs evaluated were whole-farm plans, fertiliser management, grazing management, riparian buffers, buffer strips, conservation tillage, effluent management, irrigation re-use and codes of forest practice.

Agricultural BMPs cost significantly less to implement compared with urban water quality management options, with treatment of rural runoff generally less than 10% of the cost of urban programs (URS, 2006; Read Sturgess and Associates, 2001). Unpublished analysis by Melbourne Water of a DPI case study of sediment traps installed on strawberry farms indicated nitrogen removal costs of around $100/kg (capital cost effectiveness). Urban wetland treatments currently cost around $1100/kg.

Reasons for cost savings from rural water quality programs include:

- the simplicity and smaller scale of rural water treatment solutions compared to constructed urban water quality treatment wetlands;
- increasing urban land prices driving up the costs associated with building urban wetlands;
- achieving many BMPs through low-cost non-structural measures and behavioural change, rather than expenditure on infrastructure; and
- primary producers receiving direct or long-term savings and productivity gains from implementing BMPs.

Both the URS (2007) and DPI (2007) reports note the importance of farm planning to the delivery of effective agricultural BMPs. According to URS (2007), whole-farm planning is an important enabling tool that can be used as an initial step in managing diffuse rural water pollution from agricultural land. The farm planning process is an education tool and can also connect land managers to BMP support mechanisms such as financial assistance (URS, 2007). Similarly, DPI (2007) observes that undertaking appropriate planning, such as a whole-farm plan, is essential to identify the combination of actions that a farmer can undertake to prevent the export of pollutants from the farm.

While the adoption of all available BMPs on every farm would be ideal, it is unlikely to be cost-effective or feasible for land managers. Incentives for infrastructure and technological improvements must be informed by whole-of-farm nutrient and sediment management strategies, and the emphasis in nutrient management should be on balancing farm inputs with outputs and preventing the generation and mobilisation of pollutants, rather than managing capture and treatment once they have been mobilised (DPI, 2007). Structural or technological treatments such as irrigation, nutrient retention and effluent systems can be the most expensive BMPs to install, maintain and operate, however they may also be necessary if long-term water quality and river health targets are to be achieved. Due to the current prolonged dry conditions, a major limiting factor for health in many rural streams is lack of environmental flow. The amount of water available for the environment and the timing and volume of flows are each affected by agricultural use and practices. Using water efficiently and capturing and re-using wastewater on farms may benefit both rural producers and rural water quality.

Positive incentives

There are many fixed-grant incentive programs delivered by various government and community-based organisations within the Port Phillip and Western Port region. Positive incentives based on tender and auction processes, such as EcoTender, may offer an additional method of delivering cost effective incentives to rural land managers for the adoption of agricultural BMPs (action 7.3). An evaluation of the usefulness of incentive programs, including market based incentives (MBI), in achieving on-ground change is required.

RURAL Actions	
No.	**Positive incentives**
7.3	Deliver the Western Port Pilot EcoTender Demonstration

The Melbourne Water Rural Land Program

As funding is currently limited, the Melbourne Water Rural Land Program will start with two pilot programs, with future expansion into additional priority areas if the pilots are successful and funding becomes available. The pilot programs will run in priority sub-catchments of the Western Port and Yarra catchments, to address diffuse pollution from privately owned agricultural land. The pilots will focus on dryland grazing in the upper Lang Lang/ Bass region and intensive agriculture and dryland grazing in the upper Yarra Catchment (action 7.4). These subcatchments have been chosen as they are priority hotspots for water quality, based on monitoring and a range of reports.

RURAL Actions	
No.	**The Melbourne Water Rural Land Program**
7.4	Develop the Melbourne Water Rural Land Program and implement pilots in a minimum of two priority sub-catchments

The pilots will integrate farm planning and extension with financial incentives, monitoring and evaluation. The pilots will trial the concept of 'Water Sensitive Farm Design', farm planning and acting for the protection of waterways and water quality. The pilots will provide whole-of-farm planning including nutrient, soil, and irrigation management. They will assist with planning farm layout and activities to minimise the generation of pollutants and will encourage stock and crop exclusion from waterways, riparian land and other sensitive areas such as gullies and natural wetlands.

The pilots will emphasise 'avoidance' over 'interception' and 'education' over 'construction'. A major focus will be the delivery of extension and planning services. While many group learning and self-assessment programs and tools are already available and playing an important role in improving sustainable farm management, more intensive one-on-one extension that provides ongoing support to the farmer may be necessary to achieve the desired outcomes.

Inter-agency approach to rural land management

Increasingly, government funding is linked to a multi-agency approach to land and water management and emphasis is on partnerships for delivery. An inter-agency consortium bid between the PPWCMA, government and community agencies will be developed for Caring for our Country funding to tackle water quality impacts on Western Port (action 7.5).

RURAL Actions	
No.	**Inter-agency approach to rural land management**
7.5	Develop a consortium bid for Caring for our Country funding between CMA, government and community agencies to tackle water quality effects on Western Port

7 Catchment Actions

Rural water quality program	
Aim	To provide an integrated approach to improve the water quality of the bays and waterways by minimising the mobilisation and export of pollutants (including TN, TP, TSS and pesticides) from rural enterprises, stabilising waterways and managing flows and pollutants in-stream
Water quality benefits: *quantified load impact*	2.5 t N and 345 t SS across the region over five years
Water quality benefits: *additional*	Phosphorus, pesticides, *E. coli*, heavy metals, herbicides, fungicides
Additional environmental benefits	Improvements in river health values associated with wetland and floodplain protection, revegetation and management
Economic benefits	Resources for rural landholders in the Port Phillip and Western Port region for implementing sustainable production
Social benefits	Social values associated with improved wetland and riparian condition, recreational benefits from improved water quality

Actions:

No.	Description	Modelled contribution to pollutant reduction	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
7.1	Implement Regional River Health Strategy Addendum (5 year) actions		Melbourne Water	2008/09 – 2012/13	High	Committed	Funded
7.2	Implement PPWCMA flagship programs		PPWCMA	Ongoing over the 5 years of the plan	High	Committed	Partially funded
7.3	Deliver the Western Port Pilot EcoTender Demonstration		DSE (Melbourne Water, PPWCMA, BCLN)	2008/09 – 2011/12	High	Committed	Funded
7.4	Develop the Melbourne Water Rural Land Program and implement pilots in a minimum of two priority sub-catchments	Mitigates 2.5 t of N into Port Phillip Bay Mitigates 345 t of SS into Western Port	Melbourne Water (DSE, DPI, PPWCMA, LG)	2008/09 – 2013/14	High	Committed	Funded 2008-12 Partially funded 2012-14
7.5	Develop a consortium bid for Caring for our Country funding between PPWCMA, government and community agencies to tackle water quality effects on Western Port		PPWCMA (Melbourne Water, DPI, DSE, LG, LandCare)	2008/09 – 2012/13	High	Partially committed	Unfunded

Additional investment opportunities

There are further actions to be undertaken in the rural area that would build on the actions detailed above and benefit water quality. Delivery of these actions would contribute towards achieving the long-term target and benefit both the waterways and the bays. These actions require detailed scoping and funding must be sought for implementation. They would fit into the integrated framework of projects as detailed above, but either represent the next stage or provide opportunity for expanded actions to improve rural water quality.

Agricultural best management practices (BMPs)

A suite of practice change tools is available to implement BMPs on rural land. This includes whole-of-farm planning, market-based instruments and offset purchases. The suitability of each of these tools should be explored, as the tool selected may vary according to the situation, the outcome being sought and the natural resource management asset to be protected. DSE is currently undertaking an EcoTender pilot in the Western Port catchment. The success of this pilot and the suitability of this type of market-based incentive program as a tool for achieving on-ground outcomes, including improving water quality, should be assessed. If successful and suitable, this pilot should be extended to other catchments where multiple benefits, including water quality improvements, can be achieved.

As noted above, farm planning is an important enabling tool that may be the first step in achieving water quality improvements in rural agricultural runoff, as well as private gains for the land manager.

Local governments, industry groups and Landcare currently deliver voluntary agricultural BMP and farm planning programs that may aim to improve water quality as a primary or secondary outcome. Rural farming audiences are heterogeneous and no single program or delivery method will suit all land managers. However, while flexible delivery is essential, BMP messages and outcomes must be consistent. An accredited whole-of-farm or property planning process would provide the basis for sustainable and potentially enforceable land management practices in the Port Phillip and Western Port region.

Farm planning requires staff with the technical skills and time required to deliver support in a number of formats, from group learning to case management. Additional staff may be required in districts or industries where landholders are currently unable to gain sufficient assistance through existing agency, industry or community based programs.

RURAL Additional Investment Opportunities	
No.	**Agricultural BMPs**
R1	Assess EcoTender pilot and its suitability for roll-out in other catchments
R2	Explore opportunities for co-investment in rural areas where priorities and desired environmental outcomes overlap as a means to seek investment for unfunded or partially funded actions
R3	Develop minimum standards for agricultural BMPs and work with industry and growers to integrate into supply chain QA systems
R4	Commence and advance the creation of a public statement of the minimum and enforceable management standards expected of landholders and land managers to avoid causing irreversible environmental harm, including damage to water quality
R5	Evaluate existing education and capacity building programs and ensure that water quality outcomes are incorporated and support successful programs and activities in high priority areas
R6	Evaluate, and if successful, expand the Rural Land Program into other priority water quality hotspot rural sub-catchments based on identified areas of poor water quality affected by rural land management (expected lead: Melbourne Water)
R7	Employ additional agricultural extension staff to coordinate and facilitate agricultural BMP delivery in the Port Phillip and Western Port region

Dairy Audits Program

The vast majority of Port Phillip and Western Port's dairies are in the Western Port catchment. In the West Gippsland Catchment, a program that audited the compliance of West Gippsland dairies with EPA dairy effluent regulations, established a benchmark of compliance in that region, and outlined key drivers and impediments to action by landholders. A similar program could be undertaken in the Port Phillip and Western Port region, as a first step to improved effluent management through regulation or alternative incentives such as improved industry quality assurance systems.

RURAL Additional Investment Opportunities	
No.	**Dairy Audits Program**
R8	Extend dairy audits across the Port Phillip and Western Port region

The Rural Water Quality Treatment Scoping Project

The adoption of agricultural BMPs will rely on behavioural change by rural land managers and is likely to take some years to achieve water quality improvement. In addition to current pressures, intensifying land use through rural subdivision and the growth of rural settlements are likely to affect rural waterway flows and pollutant loads. Regional wetlands help to manage flows by slowing and detaining stormwater runoff, allowing settling and biological processes that improve water quality before it enters waterways (URS, 2007). Due to their large size, wetlands have a high capital delivery cost, but as they treat large volumes of pollutants they have been the most cost-effective urban water quality measure to date (URS, 2007). The construction of rural regional wetlands may allow the treatment of rural water and may have the additional benefits of providing important habitat for wetland animals and birds, and adding regional amenity and recreational opportunities.

If poorly planned and sited, rural water treatments such as constructed wetlands could harm river health, for example by altering stream flows. They are unlikely to be constructed unless multiple outcomes can be achieved and will be unsuitable in many areas due to constraints such as existing high biodiversity values or deeply incised stream channels. Constructed wetlands should not be viewed as a substitute for farm-based solutions, but may be a complementary mechanism for water quality improvement in some priority districts.

The Rural Water Quality Treatment Scoping Project will identify and evaluate sites for the potential construction of regional water quality treatment wetlands using desktop analysis, expert opinion and field assessment. Sites with suitable characteristics will be modelled to determine a wetland's cost effectiveness for treating nitrogen, phosphorus and suspended solids. Suitable sites, if identified, will be constructed through Melbourne Water's capital works program.

RURAL Additional Investment Opportunities	
No.	**Rural Water Quality Treatment Scoping Project**
R9	Construct regional water quality treatment wetlands if the Rural Water Quality Treatment Scoping Project determines they are an effective method of managing flows and in-stream pollutants in priority rural catchments and if suitable sites are identified (expected lead: Melbourne Water)

Education and extension

Providing information to landholders and the wider rural community about the current state of water quality in rural areas will improve understanding about water quality hotspots, sources of pollutants and how on-ground actions can affect water quality in waterways and the bays. Educating landholders about the impacts of rural land management practices on waterways is important to the adoption of sustainable land management practices. It is particularly important to assist landholders in understanding how actions on their properties can contribute to improvements in water quality and how an integrated catchment management approach is necessary for the protection of waterway and bay health.

Werribee Plains Waterwatch is committed to recruiting a minimum of ten land owners to monitor water quality over the next three years. It is anticipated that the data will inform action plans to improving biodiversity outcomes. If this is successful, similar education activities should be extended into other areas to improve understanding of the links between actions and water quality.

RURAL Additional Investment Opportunities	
No.	**Education and extension**
R10	Identify and recognise farmers demonstrating management practices resulting in improved water quality outcomes and evaluate the potential for demonstration to other farmers
R11	Provide information to enable rural landholders to understand the impacts of rural land management practices on water quality in waterways and bays
R12	Develop and disseminate information materials incorporating BMPs, decision support tools, land use and pollutant hotspots into existing and new education and capacity building programs for rural areas
R13	Develop or extend existing community-based water monitoring programs to provide fit-for-purpose data collection processes and integrate the data into rural landholders and managers' education programs and decision support tools

Waterway stabilisation and vegetation management

Existing actions to stabilise waterways (e.g. erosion control measures, fencing to exclude stock access to streams and protect streamside vegetation, removal of exotic vegetation such as willows and revegetation of waterways) have been, and will continue to be, successful methods to protect river health.

Additional resourcing can extend Melbourne Water programs such as Melbourne Water's successful Stream Frontage Management Program to address key water quality issues such as gully erosion and farm drainage in priority water quality catchments. Catchments of less than 60 ha are currently not within Melbourne Water's area of operation.

Community organisations such as LandCare groups have a long and successful history of delivering vegetation and waterway management programs in the Port Phillip and Western Port region. The South Gippsland LandCare Network and Bass Coast LandCare Network's joint initiative '*Solutions at Source, slowing the flow to Western Port*' has evolved over the past decade and continues to develop with Caring for Our Country funding. The Mornington Peninsula and Western Port Biosphere Reserve Watsons Creek Project is a collaborative project between environment agencies, local government, industry and the community to tackle the water quality problems in Watsons Creek, which flows into Yaringa Marine National Park, Western Port. This program is trialling community-based social marketing as a method of gaining commitment to sustained practice change by all stakeholders.

Increasing support for existing community-based erosion and vegetation control projects and new Landcare initiatives would assist such groups to provide their rural communities with consistent and long-term support for on-ground projects, with positive outcomes for rural water quality.

RURAL Additional Investment Opportunities	
No.	**Waterway stabilisation and vegetation management**
R14	Extend existing riparian improvement and protection programs to address water quality in priority catchments and continue support for community-based erosion and vegetation control projects (expected lead: Melbourne Water).

Regulation and planning

While incentives and on-farm assistance are very effective tools, in some instances regulation is required in order to bring about effective change. Management of Crown land abutting waterways and the use of water for stock and domestic, dairy wash and irrigation purposes are examples of areas where a consistent multi-agency approach is needed.

Specific areas to address include:

- The unregulated use of water for stock and domestic purposes;
- Surface water diversions and ground water extraction;
- Stock access to riparian zones and waterways;
- Protecting natural values (vegetation, soil, air, water);
- Nutrient and sediment export from farms;
- Rural road construction standards, maintenance and drainage;
- Septic tank and grey water discharge;
- Wastewater reuse best practice; and
- Industry quality assurance system.

RURAL Additional Investment Opportunities	
No.	**Regulation and planning**
R15	Develop and apply a consistent multi-agency approach to protecting rural water quality through the alignment of policies and practices such as local government planning zones and works programs, Crown land water frontage management, agricultural water diversions and industry quality assurance systems

Eco-branding

Eco-branding provides industries with the potential to charge a premium for environmentally credentialed produce. The organic food industry has done this very successfully. Eco-branding appeals to consumers' green concerns and may be a method for sharing costs to improve environmental performance with consumers.

The Rural Water Quality Program has the potential to expand into eco-branding and create an accredited brand for produce grown in a way that protects the environment. It would also raise the profile of the area. This would provide further incentive for landholders to participate in the program.

The PPWCMA has plans for eco-branding of their Yarra 4 Life program and the Melbourne Water Rural Land Program Pilots may be an avenue for investigating market branding.

RURAL Additional Investment Opportunities	
No.	**Eco-branding**
R16	Investigate the potential to use eco-branding as a mechanism to encourage on-ground practice change for environmental (including water quality) outcomes

Urban diffuse source management

As demonstrated in Chapter 2, urban land use contributes the majority of pollutant loads into Port Phillip Bay and a disproportionate amount to Western Port. Given the forecasts for urban growth in both the Western Port and Port Phillip catchments, the effects of urban land use are predicted to increase across the region.

The key tool for the management of urban diffuse pollution is the application of Water Sensitive Urban Design (WSUD) to manage runoff from impervious areas. WSUD integrates urban planning and development with the management, protection and conservation of the water cycle as a whole. WSUD can operate at a regional scale through wetlands or retarding basins, at street scale through swales and raingardens and at house scale through rainwater tanks, raingardens or infiltration. Each of these treatments reduces peak flows and contributes to clean stormwater runoff from urban areas, delivering benefits for waterways in urban areas including reducing damaging pollutants and the frequency of high flow events, and for the bays through reduced pollutant loads including nitrogen and sediment.

The key principles of WSUD, as stated in the Urban Stormwater – Best Practice Environmental Management (BPEM) Guidelines (Victoria Stormwater Committee, 1999) are to:

- Protect natural systems – protect and enhance natural water systems within urban developments;
- Integrate stormwater treatment into the landscape – use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments;
- Protect water quality – improve the quality of water draining from urban developments into the receiving environment;
- Reduce runoff and peak flows – reduce peak flows from urban development by local detention measures and minimise impervious areas; and
- Add value while minimising development costs – minimise the drainage infrastructure cost of the development.

In addition to the significant water quality benefits that WSUD delivers, many WSUD techniques also present opportunities to harvest and use the stormwater for a range of beneficial uses, which in turn reduces the demand on the potable water supply. Other benefits of distributed treatment may include flood mitigation and reduction in pressure on stormwater system capacity. The integration of WSUD with water supply is one aspect of working towards creating water-sensitive cities.

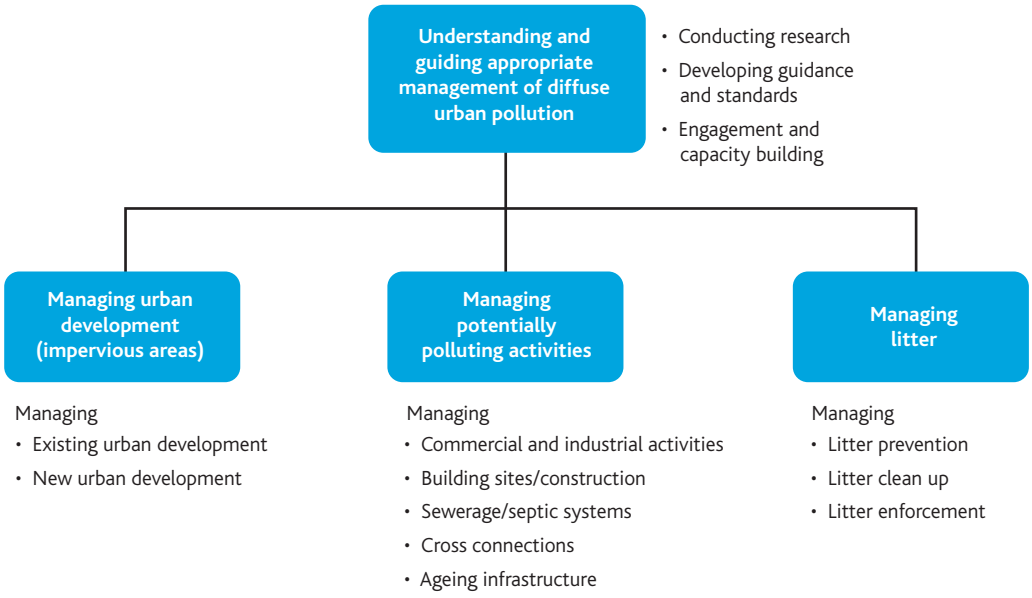
There are three main groups responsible for the environmental management of urban stormwater in Victoria. They are local government, state agencies and the urban development industries. Householders also have the ability to contribute through installation of rainwater tanks and raingardens, and by taking responsibilty for what goes into the stormwater system.

Methods of treating stormwater in the urban areas of Port Phillip and Western Port are relatively well established, but coverage is currently limited at all scales of development and across all land uses, resulting in limited treatment coverage. Management techniques are needed at precinct, streetscape and lot scale. Already there are widely distributed constructed wetlands across Melbourne. It is now necessary to provide treatments to impervious surfaces close to source at both street scale and house scale.

The best current approach to managing urban diffuse pollution is to understand its effects, improve technologies and standards, ensure appropriate guidance and regulation are in place, maximise the uptake of WSUD, minimise the effect of polluting activities, and work with the community and industry through education and providing assistance.

The *Institutionalising Water Sensitive Urban Design and Best Management Practice* interim project funded through *Better Bays and Waterways* provided direction for many of the actions. The project piloted programs with local government for employing BMPs for industrial areas, developed tools for the building and construction industry, and advanced regulatory reform to place minimum standards for stormwater management on all urban development.

The actions are presented under four management programs as follows:



Understanding and guiding appropriate management of diffuse urban pollution

Stormwater pollutants and treatment research

Over the past decade, scientific understanding of the importance of WSUD in mitigating the effects of urban development on urban water systems has increased significantly, along with development of WSUD treatments appropriate to a range of scales. The management of diffuse pollution needs further research into its effects and optimal management actions, and the development of appropriate guidance material. It is necessary to manage flow changes associated with urbanisation due to the effects on stream health.

There are gaps in our understanding of pollutant sources, in-stream processing and resultant loads, and the most effective treatments for different pollutants. Ongoing research in these fields will assist in improved management of these systems and reduce pollution to our bays and waterways (action 7.6).

To further improve the implementation of WSUD, additional information is needed on the most effective systems and the best methods of implementation for new developments and retrofits of existing development along with capacity building and targeted implementation of treatments. Evaluating the effectiveness of targeted treatment and exploring models such as market mechanisms (see Box 7.1) will aid the development of targeted programs to achieve the most efficient and effective implementation of WSUD in different situations (action 7.7).

URBAN Actions	
No.	**Stormwater pollutants and treatment research**
7.6	Undertake research into stormwater pollutant sources and appropriate treatment systems
7.7	Evaluate the effectiveness of WSUD treatments in a targeted environment through a pilot project. Explore a variety of models including market mechanisms for their potential in the application of WSUD in retrofit situations

Education and training

The adoption of effective stormwater management practices requires continual support, training, guidance and the development of organisational capacity (action 7.8). Organisational capacity ensures the implementation of appropriate stormwater management, in particular the principles that apply to the Victoria Planning Provisions. Maintaining capacity feeds into developing and implementing new tools. Several partners assist in the delivery of these training programs.

URBAN Actions	
No.	**Education and training**
7.8	Provide awareness, education and training to local government and the development industry to build institutional capacity to achieve improved stormwater management practices

Best Practice Environmental Management Guidelines

The Victoria Stormwater Committee developed the Urban Stormwater Best Practice Environmental Management Guidelines (BPEM) in 1999. This BPEM provides guidance in determining the level of stormwater management needed to assist in meeting the SEPP requirement for runoff from urban areas. Best practice performance objectives were developed for pollutants and flows for construction and post construction phases. These include a 45% reduction in the typical annual urban load for total nitrogen and phosphorus and an 80% reduction in suspended solids. In addition, there is a receiving water objective to maintain flows at pre-urbanisation levels.

Clause 56 (residential subdivisions) of the Victoria Planning Provisions was revised in 2006 and now includes a requirement that residential subdivisions meet the BPEM performance objectives for environmental management of stormwater.

Since the introduction of the BPEM guidelines, research has found that the application of flow management targets (and potentially other targets) may provide a more effective means to reduce the effect of stormwater on receiving waters. A review of the BPEM guidelines is required to ensure that they continue to reflect current best practice (action 7.9).

URBAN Actions	
No.	**Best Practice Environmental Management Guidelines**
7.9	Develop new standard for urban stormwater management and publish an updated best practice environmental management (BPEM) guideline for urban stormwater

Establishing targets across the region

Local government plays a significant role in reducing the effects of stormwater on our bays and waterways. It has responsibility for urban stormwater systems with catchments of less than 60 ha. Melbourne Water manages stormwater within catchments greater than 60 ha.

Over the past ten years, Melbourne Water has worked towards a target to reduce catchment loads by 100 tonnes per year of nitrogen in the Port Phillip Bay catchment by 2010, in response to the nitrogen reduction target outlined in the Port Phillip Bay EMP. This target is now accompanied by additional *Better Bays and Waterways* targets outlined in Chapter 5. Local governments have produced stormwater management plans and are increasingly applying WSUD through internal actions and through management of WSUD built through their planning schemes. The investment in WSUD closer to the source maximises the benefits for waterways.

Melbourne Water will work with the 38 councils within its service area to enable 50% of them to commit to WSUD implementation targets for pollutant loads, flow and effective imperviousness (action 7.10) that quantify the benefits of their works.

URBAN Actions	
No.	**Establishing targets across the region**
7.10	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

7 Catchment Actions

City of Melbourne has already committed to a target through The *Total Watermark – City as a Catchment* adopted by council in September 2008, which established municipality-wide and council targets for water efficiency, stormwater quality and alternative water use (action 7.11).

URBAN Actions	
No.	**Establishing targets across the region**
7.11	Implement the City of Melbourne's *Total Watermark – City as a Catchment*. This policy established municipality-wide and council targets for water efficiency, stormwater quality and alternative water use

Onsite Domestic Wastewater Management Policy and Regulatory Review

The need to review Victoria's onsite domestic wastewater management and regulatory framework has been established by a number of processes, including feedback from stakeholders during the MAV Smart Septics Roadshows (SD Environmental Management, 2005), actions identified from the Yarra Catchment Domestic Wastewater Management Forum (March 2006) and the recommendations from the Auditor-General's report *Protecting our Environment and Community from Failing Septic Tanks* (June 2006).

The joint DSE/EPA Victoria Onsite Domestic Wastewater Management Policy and Regulatory Review project will make recommendations to government for a new or amended onsite domestic wastewater management framework (action 7.12).

These recommendations will be developed through a discussion paper and consultation process that will look at the issues associated with onsite wastewater management and options for addressing these issues.

The objectives for the review are to develop a proposed regulatory framework for onsite domestic wastewater management that:

- facilitates the safe use of onsite domestic wastewater systems
- ensures the protection of public health and the environment and maintains community confidence;
- provides appropriate processes, including enforcement and cost recovery mechanisms, to those charged with administering the framework;
- provides clear roles and responsibilities and allows relevant parties to work together;
- enables Victorians to access comprehensive information about onsite domestic wastewater systems and management; and
- creates a system in which it is easy for Victorians to navigate and participate.

URBAN Actions	
No.	**Onsite Domestic Wastewater Management Policy and Regulatory Review**
7.12	Review legislative framework for on-site domestic wastewater

Review of diffuse pollution management and compliance

Key diffuse pollution sources include commercial and industrial operations and construction. Management responsibility for diffuse pollution rests with several authorities including EPA Victoria, local government and water authorities. The dispersed nature of the pollution sources and the management of these creates issues in effective pollution management.

An example of this is the management of building sites, where despite the availability and promotion of best practice tools, current site practice across the metropolitan area remains poor. The *Regulating Building Sites Practices to Reduce Stormwater Pollution Project* (City of Kingston and Melbourne Water, 2003) identified local government enforcement as a successful management approach and recognised the benefits of a consistent regulatory approach.

The current enforcement of building sites by local government is *ad hoc*. Where enforcement is undertaken, it is with a mix of council specific local laws or the litter provisions under the Environment Protection Act 1970. There is a recognised need to apply a consistent statewide approach to regulate pollution from building sites (Keep Australia Beautiful Victoria, 2005).

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 (action 7.13), assessing the effectiveness of the prevention of diffuse source pollution from industrial, commercial and construction operations. The review will include consideration of current arrangements for tradewaste, cross connection and stormwater pollution education and enforcement.

A discussion paper will be prepared covering the current issues and management options, including appropriate regulatory amendments and agency responsibilities. Consultation with relevant stakeholders will cover issues such as clarification of roles and responsibilities and improved enforcement.

A number of recent projects will inform the review. These include the Victorian Stormwater Action Program (VSAP) funded project – *Regulating Building Site Practices to Reduce Stormwater Pollution* – and the City of Kingston *Better Bays and Waterways* project – *Industry Stormwater Project*. The review will also be informed by the Reducing Commercial Pollution Sources – Food Businesses report (see action 7.27).

URBAN Actions	
No.	**Review of diffuse pollution management and compliance**
7.13	Review and improve diffuse source pollution management and compliance arrangements

Box 7.1: Restoring Little Stringybark Creek – Stormwater Tender Project

Auctions and tenders are increasingly being applied as an alternative to the traditional grants approach of providing financial incentives for environmental improvement. The University of Melbourne in conjunction with Monash University secured a grant from the Victorian Water Trust to trial the use of market-based instruments to encourage community based participation in implementing water savings and stormwater treatment. A stormwater treatment auction fund was provided by Melbourne Water and SmartWater to install raingardens and rainwater tanks in up to 800 households in Mt Evelyn. The aims of the project are to raise awareness of the impacts of stormwater on creek health and to engage the community to actively participate in restoring the health of Little Stringybark Creek.

Monitoring and research has shown that Little Stringybark Creek, like many other streams around Melbourne, is degraded because of excess stormwater affecting water quality. Retaining or using this excess stormwater on private properties through the use of rainwater tanks or raingardens will go a long way towards fixing this problem. Works at the street-level will also be undertaken and funded by Melbourne Water's Living River's program.

A web-based tool, www.urbanstreams.unimelb.edu.au has been developed to assist residents in optimising their Environmental Benefit Index. Residents can calculate their maximum environmental benefit for treatments such as rain gardens and tanks and compare it with the average benefit for the entire catchment, gaining an understanding of how easy it might be to achieve a high score.

Understanding and guiding appropriate management of diffuse urban pollution	
Aim	To continually improve the scientific understanding of urban effects on water quality and develop management tools and standards to manage these effects
Water quality benefits: *quantified load impact*	Port Phillip Bay nitrogen contribution – 7 t over 5 years Western Port suspended solids contribution – 15 t over 5 years Western Port nitrogen contribution -1 t over 5 years Note: Not all actions that contribute to these are fully funded.
Water quality benefits: *additional*	Reduction of other pollutants to waterways and bays including phosphorus, toxicants and pathogens
Additional environmental benefits	Improved river health through the reduction of urban flow effects in urban waterways Protection of ecological assets
Economic benefits	Reduction in the need for stormwater capacity upgrades in established areas and allowing for the design of reduced systems in new areas Reduction in the need for stream remediation works Protection of waterway and bay beneficial uses including economic uses such as fishing, tourism and industrial water usage
Social benefits	Improvement of aesthetics and amenity of waterways Protection of recreational assets

Actions:

No.	Description	Modelled contribution to pollutant reduction	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
7.6	Undertake research into stormwater pollutant sources and appropriate treatment systems	Not modelled	Melbourne Water (EPA Victoria, DSE, eWater CRC, Facility for Advancing Water Biofiltration II, National urban water governance program, Research Universities, LG)	2008-2013	Medium	Committed	Partially funded
7.7	Evaluate the effectiveness of WSUD treatments in a targeted environment through a pilot project. Explore a variety of models including market mechanisms for their potential in the application of WSUD in retrofit situations	Not modelled	Melbourne Water (Melbourne University, YVW, DSE)	2008-2013	High	Committed	Partially funded
7.8	Provide awareness, education and training to local government and the development industry to build institutional capacity to achieve improved stormwater management practices	Not modelled	Melbourne Water (DSE, LG, Clearwater, eWater CRC, MAV, DPCD, EPA Victoria)	2008-2013	Medium	Partially committed (Guidance required will depend on outcome of future stormwater policy)	Partially funded (depends on outcome of future stormwater policy)
7.9	Develop new standard for urban stormwater management and publish an updated best practice environmental management (BPEM) guideline for urban stormwater	Mitigates 6 t of N to Port Phillip Bay Mitigates 15 t of SS to Western Port Mitigates 1 t of N to Western Port	EPA Victoria (Melbourne Water, DSE)	2009 – 2011	Medium	Committed	Partially funded (Melbourne Water funding for contributing projects – geomorphic flow objectives/ flow frequency objectives)
7.10	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	Not modelled	Melbourne Water (LG)	By 2013	Medium	Committed	Funded
7.11	Implement the City of Melbourne's *Total Watermark – City as a Catchment*. This policy established municipality-wide and council targets for water efficiency, stormwater quality and alternative water use	Mitigates 1 t of N to Port Phillip Bay	City of Melbourne (Melbourne Water)	Ongoing over the 5 years (until 2020).	High	Committed	Partially funded – through capital works budget
7.12	Review legislative framework for on-site domestic wastewater	Not modelled	EPA Victoria (Melbourne Water, DSE, DHS, LG, water authorities)	To be completed in 2009	Medium	Committed	Funded
7.13	Review and improve diffuse source pollution management and compliance arrangements	Not modelled	Melbourne Water (LG, water authorities, EPA Victoria)	2010-2011	Medium	Committed	Funded

Managing urban development (impervious areas)

Developing a stormwater strategy

Working with local government and the stormwater industry, the Victorian Government intends to develop a statewide stormwater strategy to establish a strategic policy framework that identifies current drivers and objectives for stormwater management in the context of integrated urban water management and climate change (action 7.14).

The strategy may include:

- Objectives to better manage impacts of urban runoff on waterway health;
- Reviewing institutional and legal arrangements for stormwater management and development of a harvesting and allocation framework;
- Addressing urban flood impacts (particularly in relation to new developments); and
- Promoting innovative and sustainable stormwater technologies and practices.

URBAN Actions	
No.	**Developing a stormwater strategy**
7.14	Develop a statewide stormwater strategy

Achieving best practice water quality objectives

Over the past decade, significant technical guidance, compliance assessment tools, industry training and grant programs have been provided to build capacity and skills in stormwater management within the development industry. However, despite this significant investment, there is ineffective implementation of stormwater management standards across all forms of urban development and there is little incentive for the development industry to deliver best practice stormwater management. This is due in part to a lack of direct incorporation of these environment protection requirements into the systems that control urban development.

All new residential subdivisions (developments with multiple private properties) across Victoria are required to meet the Victorian Stormwater Best Practice Performance Objectives (Victoria Stormwater Committee, 1999). Not all allotment scale (individual private properties) and non-residential subdivision developments are effectively regulated to meet the objectives.

The stormwater quality runoff requirements for all new residential subdivisions apply under Clause 56.07 of the Victoria Planning Provisions, reviewed in 2006. The responsible authority, (in most cases local government) is responsible for ensuring that the conditions of the relevant authority are placed on planning permits. This ensures that urban stormwater management systems are designed and managed in accordance with the requirements and to the satisfaction of the relevant authority. Also, Clause 56.08 requires a plan for appropriate site management controls before and during construction of subdivision works.

The introduction of Clauses 56.07 and 56.08 is a significant improvement in reducing the effects of urban development and clearly acknowledges the need to protect all local waterways. Further improvements can be gained by applying stormwater standards to developments at the allotment scale and to non-residential subdivision developments (actions 7.15 and 7.16). Implementation of this would result in higher consistency and environmental standards leading to improved water quality.

Managing the impacts of stormwater from residential development is under consideration by the Victorian Government (Victorian Government, 2008; DSE 2006).

URBAN Actions	
No.	**Achieving best practice water quality objectives**
7.15	Establish Victorian stormwater standards for new allotment scale residential and non-residential developments to ensure consistent application of environmental standards for all forms of development
7.16	Ensure all new non-residential subdivisions meet the Victorian stormwater standards thereby applying environmental standards across all forms of subdivision development

Implementing on-ground WSUD

In established urban areas, opportunities for WSUD are restricted compared to new developments, due to a combination of limited available space and the cost of retrofitting to existing infrastructure. However, several activities have the potential to achieve environmental benefits at low cost in suitable areas. Over the past decade, Melbourne Water's Nitrogen Reduction Program, EPA Victoria's Victorian Stormwater Action Program (VSAP), Melbourne Water's Stormwater Offsets Program, the Yarra River Action Plan and Melbourne Water's Living Rivers program have each made significant investment into the retrofitting of WSUD.

Melbourne Water will continue its stormwater management program, working with local government to build institutional capacity, and invest in the design and construction of stormwater treatment (action 7.17).

The City of Manningham is exploring an innovative approach with Yarra Valley Water and the Plumbing Industry Commission to retrofit septic tanks as residents connect to mains sewer networks (action 7.18). A septic system – typically a 3600L tank and sand filter – could be used to hold and treat onsite stormwater. This reduces the effect of stormwater runoff, provides residents with a storage system for re-use and maintains moisture in the soil through filtering stormwater through the sand filter.

URBAN Actions	
No.	**Implementing on-ground WSUD**
7.17	Undertake the Melbourne Water stormwater management programs, working to improve capacity within local government. Activities include: · building institutional capacity within local government authorities · funding for the design and construction of stormwater treatment measures
7.18	Evaluate the benefits, constraints and regulatory changes needed to retain septic tanks and sand filters for stormwater retention and treatment as an alternative to decommissioning when properties connect to sewer

7 Catchment Actions

Working with the community

A significant proportion of impervious areas is contained in private ownership within the community.

Roofs make up around 50% of the hard surfaces in urban catchments, and hence contribute a significant proportion of pollution from urban areas. As such, the community has the ability to make a significant contribution to managing the effects associated with private property.

Installing rainwater tanks can provide significant benefits through improving water quality and reducing the detrimental effects of stormwater. Where they capture the majority of roof surfaces and are connected to multiple internal uses, rainwater tanks have the potential to meet both water quality and flow reduction objectives while providing other water conservation and flood mitigation benefits. In Victoria, allowable urban rainwater uses currently include toilet flushing, hot water services, laundry and irrigation.

Managed appropriately, rainwater tanks can provide benefits to stream health through peak flow reduction, flow frequency reduction, pollutant load reduction, and potable water conservation and flood mitigation. Appropriate management includes ensuring tanks are sized correctly and use of the water is maximised.

Community knowledge of these additional benefits and how to operate the tank efficiently to optimise yield will provide environmental benefits. Current rebates make no requirements as to the amount of roof area connected to the tank. Environmental benefits can be achieved for minimal additional capital expenditure (action 7.19).

Raingardens are another effective small-scale water retention and treatment system that can be installed into household gardens. Raingardens can help to restore the natural hydrological cycle, and remove sediments and nutrients through filtration and plant uptake. We need to raise community awareness of measures that can directly benefit downstream environments (action 7.20).

URBAN Actions	
No.	**Working with the community**
7.19	As part of the review of the Water Smart Gardens and Homes Rebate Scheme, recognise the environmental benefits of water saving products especially in regards to rainwater tanks
7.20	Work with the community to encourage the uptake of WSUD in established developments. Encourage the community to install raingardens and other infiltration and reuse options through education and incentive programs Investigate opportunities and considerations to implement household downpipe disconnection program, including: · map land capability for land infiltration; · review statutory and institutional considerations; and · establish a pilot program with local government

Urban wetland construction

Wetlands are a useful treatment measure for managing the quality of water entering water bodies. Before 1999, the only significant wetlands across Melbourne were a few remaining natural wetlands. Since that time, constructed wetlands have been widely created and are highly valued by the community and support a diverse range of aquatic life.

In response to the Port Phillip Bay Environmental Management Plan (EMP), in 2000, Melbourne Water committed to a multi-million dollar 10-year program to reduce nitrogen loads by 100 t/y by constructing wetlands to treat existing urban areas. In addition, over this same period, Melbourne Water incorporated wetlands into developing catchments as part of developer services schemes where developers contribute towards new stormwater infrastructure. Developers have embraced the concept of treatment wetlands as they provide valued passive recreational areas close to where people live and in some cases are being used as a source of water for irrigating neighbouring parks and sporting ovals.

Melbourne Water now manages 116 constructed wetland treatment systems, 41 litter traps and 73 sediment ponds that collectively remove significant amounts of pollution. Local government also manages significant numbers of litter traps as well as wetlands and sediment ponds.

Opportunities to construct wetlands are becoming scarce in existing urban areas due to the limited availability of the large areas of land required and escalating land costs. While continuing to construct regional wetlands is proposed within Melbourne Water's recent Waterways Water Quality Strategy (Melbourne Water 2008b) (action 7.21), there is now a recognised need to manage new developments at source to protect all downstream waterways and to build partnerships with local government, industry and the community to assist in the installation of distributed WSUD (as outlined in the other actions within this section of *Better Bays and Waterways*).

URBAN Actions	
No.	**Urban wetland construction**
7.21	Construct urban wetlands to reduce pollutant loads to waterways and the bays

Water sensitive road design (WSRD)

VicRoads is a key stakeholder in the management of stormwater runoff and has become a leader in WSRD, investing in both on-ground works and research and development of new technologies and the development of WSRD guidelines. A recent example of WSRD is the 39 km Eastlink tollway, where all paved areas drain to treatment systems such as swales, wetlands and raingardens before runoff reaches local creeks. VicRoads has the potential to extend their existing leadership role in WSRD (action 7.22).

Melbourne Water works with local government to implement treatments to address the effects of local roads. Many roads in the outer areas of Melbourne are designed as 'rural roads' – that is, instead of having curbs, channels and underground pipes, they use swales (spoon drains). There is a significant risk that as these roads are upgraded, they will lose the water treatment that was being effectively provided by the swales. Education and capacity building in these councils is needed to ensure adequate treatment of the stormwater is retained and/or improved in any road maintenance or upgrade works (action 7.23).

URBAN Actions	
No.	**Water sensitive road design**
7.22	VicRoads to incorporate Water Sensitive Road Design and meet best practice standards for all new major roads and major road upgrades under their responsibility where practical and feasible
7.23	Undertake capacity building and awareness programs with local government for best management of unsealed roads and road upgrades

Managing urban development (impervious areas)	
Aim	Protect receiving waterways from the effects of urbanisation
Water quality benefits: *quantified load impact*	Port Phillip Bay nitrogen reduction – 39 t over 5 years Western Port suspended solids reduction – 547 t over 5 years Western Port nitrogen reduction – 5.5 t over 5 years Note: Not all actions that contribute to these benefits are funded
Water quality benefits: *additional*	Reduction of other pollutants to waterways and bays including phosphorus, toxicants and pathogens
Additional environmental benefits	Improvement of river health through the reduction of urban flow impacts in urban waterways; Protection of ecological assets; Increased area of greenspace
Economic benefits	Increased alternative water supply, improved reliability of the urban water system; Reduction in the need for stormwater capacity upgrades in established areas and allowing for the design of reduced systems in new areas; Reduction in the need for stream remediation works; Protection of waterway and bay beneficial uses, including economic uses such as fishing, tourism and industrial water usage
Social benefits	Improved capacity to maintain gardens; Potential to mitigate urban heat island effect; Protection of recreational assets

7 Catchment Actions

Actions:

No.	Description	Modelled contribution to pollutant reduction	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
7.14	Develop a statewide stormwater strategy	Not modelled	DSE (Melbourne Water, LG, EPA Victoria)	Over the 5 years of the plan	Medium	Committed	Funded
7.15	Establish Victorian stormwater standards for new allotment scale residential and non-residential developments to ensure consistent application of environmental standards for all forms of development	Mitigates 25 t N to Port Phillip Bay Mitigates 201 t SS to Western Port Mitigates 3 t N to Western Port	DSE – policy development DPCD – implementation (Melbourne Water, EPA Victoria)	Establish standard by 2011	Medium	Committed	Partially funded (Policy development funded)
7.16	Ensure all new non-residential subdivisions meet the Victorian stormwater standards thereby applying environmental standards across all forms of subdivision development	Not modelled	DSE – policy development DPCD – implementation	Implement standard by 2011	Medium	Committed	Partially funded
7.17	Undertake the Melbourne Water stormwater management programs, working to improve capacity within local government. Activities include: · building institutional capacity within local government authorities · funding for the design and construction of stormwater treatment measures	Mitigates 4 t N to Port Phillip Bay Mitigates 166 t SS to Western Port Mitigates 1 t N to Western Port	Melbourne Water (LG)	2008-2013	High	Committed	Funded
7.18	Evaluate the benefits, constraints and regulatory changes needed to retain septic tanks and sand filters for stormwater retention and treatment as an alternative to decommissioning when properties connect to sewer	Not modelled	Manningham (Yarra Valley Water, Plumbing Industry Commission, Melbourne Water, EPA Victoria)	Over the 5 years of the plan	Low	Committed	Unfunded
7.19	As part of the review of the Water Smart Gardens and Homes Rebate Scheme, recognise the environmental benefits of water saving products especially in regards to rainwater tanks	Mitigates 2 t N to Port Phillip Bay Mitigates 28 t SS to Western Port Mitigates 0.2 t N to Western Port	DSE	2010	Low	Committed	Funded
7.20	Work with the community to encourage the uptake of WSUD in established developments Encourage the community to install raingardens and other infiltration and reuse options through education and incentive programs	Mitigates 1 t N to Port Phillip Bay Mitigates 13.8 t SS to Western Port Mitigates 0.1 t N to Western Port	Melbourne Water	2008-2013	High	Committed	Partially funded (community engagement funded, implementation not funded)
	Investigate opportunities and considerations to implement household downpipe disconnection program, including: · map land capability for land infiltration; · review statutory and institutional considerations; and · establish a pilot program with local government		Melbourne Water (LG, DSE, PIC, DPDC)	3 years	Medium	Committed	Partially funded (Mapping funded, guidance materials funded)
7.21	Construct urban wetlands to reduce pollutant loads to waterways and the bays	Mitigates 7 t N to Port Phillip Bay Mitigates 138 t of SS to Western Port Mitigates 1 t of N to Western Port Note: Does not include Melbourne Water's existing 100 tonne by 2010 wetland target.	Melbourne Water	2008-2013	High	Committed	Funded
7.22	VicRoads to incorporate Water Sensitive Road Design and meet best practice standards for all new major roads and major road upgrades under their responsibility where practical and feasible	Not modelled	VicRoads (Melbourne Water)	Ongoing	High	Committed	Funded
7.23	Undertake capacity building and awareness programs with local government for best management of unsealed roads and road upgrades	Not modelled	Melbourne Water (LG)	2009-2013	Medium	Committed	Funded

Managing potentially polluting activities

Providing support and guidance

Alongside the review of diffuse source management and compliance, there is a need to provide assistance to local government to undertake proactive pollution prevention/ reduction measures in industrial and commercial areas and on building sites.

Action 7.24 will include the development of tools and guidance and capacity building for local government to assist with the prevention of pollution and the appropriate enforcement for diffuse pollution.

URBAN Actions	
No.	**Providing support and guidance**
7.24	Improve local government's capacity to prevent diffuse source pollution.

Improving practices on industrial sites

The lack of awareness of the nature of stormwater and its impacts on receiving waters has led to significant pollution issues within industrial sites. Small to medium sized enterprises often have poor stormwater management practices and often require face to face interaction to inform and influence behavioural change. Capacity building, education and improved regulation are critical for enabling positive behaviour change by these businesses (City of Kingston, 2008).

The Kingston Industry Stormwater Project was undertaken as part of *Better Bays and Waterways* and trialled an education and enforcement program in small to medium sized industrial businesses. This pilot project developed a model where local government officers undertook site audits and enforcement activities to improve site practices. The success of the pilot program was monitored using a new, cost effective, water quality monitoring technique. Significant pollution issues were referred to EPA Victoria. This has produced a good management model for application in other local government areas. Melbourne Water will work with interested local government to expand this model (action 7.25). The expanded industrial program will be accompanied by two sweeps of industrial areas by EPA Victoria (action 7.26).

URBAN Actions	
No.	**Improving practices on industrial sites**
7.25	Implement an education and enforcement program for small to medium industrial sites within targeted municipalities, based on the pilot project with Kingston Council.

Yarra River Investigation and Response Program (YRIRP)

A large number of industrial and commercial estates within the Yarra River catchment pose a threat to the water quality and the health of the Yarra River and its tributaries.

In 2006, the Victorian Government committed $4.5 million to tackle sources of pollution in the Yarra River's hotspots through EPA Victoria's Yarra River Program. Its charter was to identify pollution sources, enforce pollution regulation and educate the community to improve the health of the Yarra River and its tributaries.

The Yarra River Investigation and Response Program (YRIRP) complements the Yarra River Action Plan, a $600 million package of priority programs that builds on existing work in the Yarra catchment to deliver long-term improvements to the water quality of the Yarra River.

YRIRP will continue to focus on the prevention of pollution by conducting two "sweep" (audit) activities in priority industrial areas (action 7.26).

URBAN Actions	
No.	**Yarra River Investigation and Response Program (YRIRP)**
7.26	Complete at least two sweep activities to reduce pollution from priority industrial and commercial areas.

Reducing commercial pollution sources – Food businesses

Diffuse pollution is often associated with commercial and retail businesses where site management and waste storage activities are deficient. The Yarra Faecal Investigation Program (2005-2008) traced pollution sources to commercial premises, which were found to be a significant source of microbial pollution.

The Yarra Faecal Investigation Program traced microbial pollution to a number of sources including food-related businesses, and the Lower Yarra Litter Strategy (LYLS) identified pollution issues associated with back-of-house operations within food businesses. Subsequently Melbourne Water and EPA Victoria conducted social research to better understand the stormwater management practices and views of food businesses in targeted commercial areas in inner Melbourne (Ipsos-Eureka, 2008). Further analysis will identify opportunities for improving communications and enforcement frameworks in relation to food-related premises.

A pilot program (action 7.27) will lead improvements in the delivery of an education and enforcement approach to commercial food businesses. The pilot will improve communications with food businesses and equip local government Environmental Health Officers with additional skills and capacity to enforce compliance with the Environment Protection Act 1970. Enforcement will be undertaken by local government officers with additional enforcement support from EPA Victoria where requested. Coordination and support will be provided by Melbourne Water. Trade waste issues will be referred to water authorities.

URBAN Actions	
No.	**Reducing commercial pollution sources – Food businesses**
7.27	Develop a pilot project working with local government to trial an improved communications and enforcement framework in relation to commercial food enterprises – encompassing site management issues including waste management and washdown, trade waste and cross connections.

Addressing ageing sewerage infrastructure

The Yarra Faecal Investigation Program (2005–2008) highlighted the significance of leaking sewerage infrastructure as the key faecal pollution source in the urban stormwater system. In most cases this issue arises from ageing infrastructure.

Water Authorities will redesign or alter their sewerage infrastructure programs to progress towards an elimination of dry weather spills, sewer overflows and chronic leaks associated with flow volumes of up to 1 in 5 year rainfall events (as described in SEPP (WoV)) (action 7.28).

URBAN Actions	
No.	**Addressing ageing sewerage infrastructure**
7.28	Water Authorities will redesign or alter their sewerage infrastructure programs to progress towards an elimination of dry weather spills, chronic leaks, and sewer overflows caused by storms not exceeding 1 in 5 year storm events.

Septic tank management

Local government has responsibility for identifying areas where poor performing septic tanks result in environmental health risks. Septics are managed through inspections, maintenance and replacement and through decommissioning following connection to sewerage systems.

The retail water authorities (i.e. South East Water, City West Water and Yarra Valley Water) provide sewerage facilities to existing developed properties that are not suitable for continued use of on-site septic tank systems for wastewater management. This information, in conjunction with consultation with local councils and EPA Victoria, is used to develop a backlog sewerage program (action 7.29).

In several critical areas outside the backlog program area Melbourne Water will work with local government to address failing septic tanks through education and investment in septic maintenance (action 7.30). This will include prioritising 'hotspots' for action, the review of innovative on-site treatment systems, undertaking appropriate education programs, improving land capability assessments, and addressing spilt systems as a priority.

Third party funding will be sought to further increase local government capacity to address failing septic tanks, support landholders to install appropriate technology and commit to long term management practices.

South East Water is involved in assessments of decentralised systems and groundwater modelling to investigate and prove alternative systems. This has lead to a VicWater discussion paper on decentralised systems and research with Melbourne University on sustainable septic tank management, and research with RMIT on sewer blockage environmental risks. This will assist in targeting programs and maximise environmental benefits.

Septic management will also be informed through the bacterial budget research outlined in Chapter 9.3.

URBAN Actions	
No.	**Septic tank management**
7.29	Implement the backlog upgrade of septic systems, through continued investment and creating capacity for innovation.
7.30	Address failing septic tanks through education and investment in septic maintenance.

Addressing chronic hotspots

The Yarra River Action Plan started a major investigation program to determine the extent of water quality problems and to identify and rectify any illegal connections in the Yarra River catchment. Whilst *E. coli* levels are typically higher during and immediately after rainfall events, intensive monitoring has revealed several stormwater drains with elevated *E. coli* concentrations during dry weather. The sources were tracked to a range of businesses and operations associated with poor site management of contaminants, aging infrastructure and illegal connections of sewer pipes to the stormwater system. While this program is drawing to a close, it has confirmed that sources of stormwater pollution are widespread and the result of poor site management and enforcement of regulation of potentially polluting practices. Reliance on tracking pollutant sources through water quality monitoring programs is extremely costly, time consuming and inefficient as a means of driving actions to improve water quality across the catchment.

Options to rectify this problem will be considered after the implementation of targeted research into source distribution. This research will include the remobilisation of pollutants by high flows, assessment of septic impacts and examination of social research and behavioural patterns in the catchment. Related actions in *Better Bays and Waterways* include the management of septics (actions 7.29 and 7.30), improving Practices on Industrial Sites (action 7.25), and reducing commercial pollution sources – Food businesses (action 7.27).

In the short term, where sources of pollution cannot be determined and managed adequately, there is a need for alternative solutions such as diversion of low flows to sewer or construction of specific toxicant traps that can treat highly polluted but diffuse discharges (action 7.31). This expands the approach developed through the Yarra River Action Plan across the region.

URBAN Actions	
No.	**Addressing chronic hotspots**
7.31	Identify and address 8 chronic faecal and/or toxicant pollution hotspots in priority catchments

Managing potentially polluting activities	
Aim	Protect receiving waterways through the management of potentially polluting diffuse urban activities
Water quality benefits: *quantified load impact*	Not modelled
Water quality benefits: *additional*	Improvements in water quality by decreasing pollutants entering waterways
Additional environmental benefits	Protection of ecological assets
Economic benefits	Reduction in cost of managing pollution through prevention
Social benefits	Improvements in public amenity around commercial and industrial precincts due to odour reduction and refuse management

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
7.24	Improve local government's capacity to prevent diffuse source pollution	Melbourne Water (EPA Victoria, LG)	2008-2013	Low	Committed	Funded
7.25	Implement an education and enforcement program for small to medium industrial sites within targeted municipalities, based on the pilot project with Kingston Council	Melbourne Water (EPA Victoria, LG)	2008-2013	Medium	Committed	Funded (by Melbourne Water)
7.26	Complete at least two sweep activities to reduce pollution from priority industrial and commercial areas	EPA Victoria (Local government)	2009-2010	Medium	Committed	Funded
7.27	Develop a pilot project working with local government to trial an improved communications and enforcement framework in relation to commercial food enterprises – encompassing site management issues including waste management and washdown, trade waste and cross connections	Melbourne Water (EPA Victoria, LG, DSE, Water authorities)	By 2011	Medium	Committed	Funded
7.28	Water Authorities will redesign or alter their sewerage infrastructure programs to progress towards an elimination of dry weather spills, chronic leaks, and sewer overflows caused by storms not exceeding 1 in 5 year storm events	Water authorities	By 2014	High	Partially committed	Partially funded
7.29	Implement the backlog upgrade of septic systems, through continued investment and creating capacity for innovation	Water authorities	Ongoing over the life of the plan	High	Committed	Partially funded (funded through Water Plan, subject to ongoing funding)
7.30	Address failing septic tanks through education and investment in septic maintenance	Melbourne Water (Yarra Ranges Shire, Baw Baw Shire)	2009-2013	Medium	Partially committed	Partially funded
7.31	Identify and address 8 chronic faecal and/or toxicant pollution hotspots in priority catchments	Melbourne Water (EPA Victoria, water authorities, LG)	By 2013	High	Committed	Funded

Managing Litter

State litter campaigns focus on litter prevention through the Victoria Litter Action Alliance's (VLAA) litter prevention kits, Sustainability Victoria's litter prevention grants and the 'Don't be a tosser' cigarette butt litter campaign.

In addition to the state-wide campaigns to prevent littering, several litter management and prevention programs are operating across Melbourne. These include:

- Lower Yarra Litter Strategy;
- Local government litter management, prevention and enforcement programs;
- Metropolitan Waste Management Group's support and capacity building for local government;
- Melbourne Water's regional wetlands program – installation of litter traps or Gross Pollutant Traps (GPTs) in strategic locations (such as Prahran Main Drain); and
- Parks Victoria floating litter traps in the lower Yarra River.

Lower Yarra Litter Strategy

The Lower Yarra Litter Strategy (LYLS) was developed as part of the Yarra River Action Plan (2006). Its aim is to reduce litter loads in the Lower Yarra River and build ongoing strategies to improve the overall water quality in the Yarra catchment. The LYLS is a partnership project between Melbourne Water, Sustainability Victoria, EPA Victoria, Parks Victoria, Victorian Litter Action Alliance, Metropolitan Waste Management Group, City of Melbourne, City of Stonnington, City of Boroondara, and City of Yarra (action 7.32).

The strategy comprises a selection of projects to encourage an integrated regional approach to litter prevention and management. All projects address litter prevention in targeted 'hotspots' (areas where litter generation is high) such as commercial precincts. The litter prevention projects include infrastructure improvements, education and enforcement programs, and involve engaging with traders groups, local community groups and departments within local councils.

The program is currently supporting three projects:

- The Chapel Street project involves traders in an engagement and incentives program, offering traders the opportunity to care for newly constructed WSUD features (raingardens), assist in keeping the street clean and obtain incentives such as wind proof ashtrays and rebates for cigarette butt bins (City of Stonnington);
- The Queen Victoria Market project is focussed on improving waste management practices of stall holders and promoting litter prevention messages to market visitors through training, compliance activities and educational posters (Queen Victoria Market); and
- The Victoria Street project has involved three phases – trader and community education, installation of cigarette butt bins to every rubbish bin and a comprehensive enforcement program focused on back-of-house waste management practices(City of Yarra).

Two new projects are being planned to run over the next 12-18 months; these will focus on Melbourne's Chinatown Laneways (City of Melbourne) and Brunswick and Smith Street in Fitzroy (City of Yarra).

The LYLS is run in conjunction with other programs such as the Living Rivers Stormwater Quality Program. There is commitment to continue the program until July 2010 and promote the litter prevention project models and the partnership approach to other councils.

URBAN Actions	
No.	**Lower Yarra Litter Strategy**
7.32	Continue the Lower Yarra Litter Strategy partnership program until July 2010. The program will involve undertaking litter prevention projects in priority litter hotspots and facilitating institutional arrangements that enable a collaborative approach to litter prevention.

Metropolitan Waste Management Group (MWMG)

The MWMG is responsible for coordinating municipal waste management activities in metropolitan Melbourne and provides support to local government to work together to address litter related issues (action 7.33).

Current multi-Council projects include:

- Stage 2 of the Butt Litter Campaign – councils are working together to continue Sustainability Victoria's campaign to reduce cigarette butt litter in streets;
- Residential Dumping at end of tenancy – the project focuses on working with real estate agents and developing a kit to assist them to manage tenants' waste disposal at the end of tenancy. (The VLAA Illegal Dumping Kit: People at Home has been completed and is now available online); and
- Establishment of a Litter Leaders Group – a small group of council officers is working with MWMG to identify key litter program issues and opportunities to implement cooperative initiatives. Projects might include seeking joint funding or partnerships to develop targeted resources, training or capacity building programs.

MWMG is also working with Councils and Sustainability Victoria to develop a litter strategy template. The strategy template will help member Councils to develop a Litter Strategy that is consistent with State government direction and will use data that is already collected for state government reporting. A series of 'SMART' Litter Strategy workshops was offered in 2009 where several councils were mentored through the development of their strategies. A Litter Data Checklist and a Council Litter Strategy template were generated as a result of these workshops and are available from MWMG. The 'SMART' Litter Strategy workshop series is likely to be offered each year for a small group of interested Council officers.

MWMG have also set up a 'CLEAN' Litter network to provide support for councils to promote their achievements and take on new technologies and approaches in key areas of litter management. Education, Enforcement and Catchment Management Officers meet at regular CLEAN meetings (held on the first Tuesday in alternate months) to share ideas and discuss key litter themes such as "Butts", Dumping" and "Transport Litter" with guest presenters.

URBAN Actions	
No.	**Metropolitan Waste Management Group (MWMG)**
7.33	Work with local government to collaboratively develop prevention strategies

Melbourne Water

When Melbourne Water plans for a wetland or large bioretention system, the potential litter loads that may be entering the system is considered. If the catchment is likely to produce large amounts of litter that will affect the functioning of the system, a Gross Pollutant Trap (GPT) is installed upstream of the sediment basin and wetland (action 7.34).

Melbourne Water also has a program where actions raised within local government stormwater management plans are implemented. In some cases a council will nominate a catchment where they wish to target litter. Melbourne Water in consultation with local government will examine the merits of a GPT at the end of pipe verses GTP installation near litter 'hotspots'. This process may result in an end-of-pipe solution or a solution closer to the source being implemented.

Melbourne Water's maintenance team removes litter from waterways when they are undertaking waterway maintenance activities.

URBAN Actions	
No.	**Melbourne Water**
7.34	Install gross pollutant traps (GPTs) upstream of sediment basins when installing a constructed wetland or large bio-retention system in areas with high litter generation rates

Sustainability Victoria

Sustainability Victoria intends to develop a Roadside Litter and Resource Recovery Kit (action 7.35). They will work with project partners to effect behaviour change in road users to prevent litter and increase resource recovery from roadsides.

The deliverables will be:

- Development of a pilot Roadside Litter Prevention and Resource Recovery Kit which will provide a model and set of tools for other road corridors around Australia which other land managers and user groups could implement;
- Trial of the program on two major Victorian highways;
- A target to reduce roadside litter by 30% and increase resource recovery during the program;
- An increase in litter reports to EPA Victoria on the targeted highways;
- Evaluation of the program to determine what is effective in preventing litter on highways including full scale litter surveys;
- Finalisation of the Roadside Litter Prevention and Resource Recovery Kit including a skills-based program planning and evaluation workshop package;
- Release and promotion of the kit on the VLAA website for use in Victoria and across Australia; and
- Involvement of stakeholders who are not members of the Victorian Litter Action Alliance.

URBAN Actions	
No.	**Sustainability Victoria**
7.35	Develop a Roadside Litter and Resource Recovery Kit and trial and evaluate the program

EPA Victoria

EPA Victoria's Litter Report Line (1800 35 25 55) provides an important avenue for the community to take action against littering (action 7.36). In the 2006/07 financial year, 20,745 fines were issued across Victoria. Over the past five years, the number of fines issued has increased by 155% from the 8,142 fines issued in 2001/02. These results continue to reinforce our belief that the Victorian community does not support littering and will take action to stop this illegal activity. While the vast majority of reports (about 90%) relate to cigarette butts, food packaging, beverage containers and rubbish that is poorly secured to cars and trailers are also reported.

URBAN Actions	
No.	**EPA Victoria**
7.36	Continue operation of Litter Report Line for public reporting of littering from cars

Managing litter	
Aim	To reduce the impact of litter on waterway and the bays
Water quality benefits: *quantified load impact*	Not applicable
Water quality benefits: *additional*	Fewer toxicants leaching from litter such as cigarette butts and affecting aquatic systems
Additional environmental benefits	Reduction in impact on aquatic fauna
Economic benefits	Reduction in clean up costs
Social benefits	Improvements in health hazards and community perceptions with a reduction in litter. People are more likely to use and appreciate aquatic environments that are free from litter

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
7.32	Continue the Lower Yarra Litter Strategy partnership program until July 2010. The program will involve undertaking litter prevention projects in priority litter hotspots and facilitating institutional arrangements that enable a collaborative approach to litter prevention.	Melbourne Water (Sustainability Victoria, EPA Victoria, Parks Victoria, Metropolitan Waste Management Group, Victorian Litter Action Alliance, City of Melbourne, City of Stonnington, City of Boroondara, City of Yarra)	2009-2010	Low	Committed	Funded
7.33	Work with local government to collaboratively develop prevention strategies	MWMG (LG)	Ongoing	Medium	Committed	Funded
7.34	Install gross pollutant traps (GPTs) upstream of sediment basins when installing a constructed wetland or large bio-retention system in areas with high litter generation rates	Melbourne Water (Local government)	2008-2013	Low – Medium (depending on size of GPT)	Committed	Funded
7.35	Develop a Roadside Litter and Resource Recovery Kit and trial and evaluate the program	Sustainability Victoria	By 2014	Low	Committed	Funded
7.36	Continue operation of Litter Report Line for public reporting of littering from cars	EPA Victoria	Ongoing	Medium	Committed	Funded

Additional investment opportunities

Further actions to be undertaken in the urban area would build on the actions detailed above and benefit water quality in the future. These actions would contribute to the long-term target of water quality protection, and require detailed investigation, scoping and additional funding for implementation.

Implementing Water Sensitive Urban Design (WSUD)

A broad range of tools is available to implement WSUD. Significant commitments to implement WSUD are included within *Better Bays and Waterways* and a range of additional investment opportunities would contribute further to protecting waterway health in the long term.

URBAN Additional Investment Opportunities	
No.	**Implementing Water Sensitive Urban Design (WSUD)**
U1	Conduct a cost – benefit study of a stormwater backlog program (including roads), exploring willingness to pay and the potential use of rebates or levies
U2	Investigate alternative funding sources to increase funding available to assist local government with the backlog of WSUD
U3	Increase investment in retrofitting in priority catchments
U4	Increase the funding available for market-based retrofit trials
U5	Increase investment in large scale harvesting projects
U6	Assess how WSUD can be included in all road upgrades and commence implementation
U7	Explore the inclusion of local government urban flow and pollutant targets into municipal strategic statements

Encouraging householder WSUD uptake

There are significant benefits for householders who install rainwater tanks and gardens. In large numbers, these actions also provide significant benefits to waterways. While action 7.20 aims to encourage additional uptake of WSUD, improving public education on the multiple benefits of WSUD is an area for further development.

URBAN Additional Investment Opportunities	
No.	**Encouraging householder WSUD uptake**
U8	Improve public education on household installation of rainwater tanks to ensure the multiple benefits of tanks for flow management, pollutant reduction and water conservation are recognised

Upgrading on-site systems

While the sewerage upgrade backlog program has been recently fast-tracked for 20-year completion, significant additional investment could see this program fast-tracked further.

URBAN Additional Investment Opportunities	
No.	**Upgrading on-site systems**
U9	Increase investment to further fast-track the sewerage upgrade backlog

Reduce cross-connections

The Yarra River Action Plan identified that significant resources are required to identify and correct cross-connections between the sewerage and stormwater systems. To ensure a systematic scheme to investigate and manage cross-connections, a property 'roadworthy' process has been proposed.

URBAN Additional Investment Opportunities	
No.	**Reduce cross-connections**
U10	Scope the development of a house 'roadworthy' to include audits of plumbing connections on sale of property

Litter prevention

Much of the litter-related activity occurring across Australia focuses on its management. There is less activity focused on the prevention of littering. It is important to understand the extent of the problem through litter counts, but it is also essential that we better understand littering behaviours, the types of infrastructure and regulation that reduce littering, as well as social and cultural aspects and impacts of littering in order to reduce littering behaviour across our communities.

Parks Victoria has installed floating litter traps along the lower Yarra River which are emptied regularly. While the litter traps are useful for collecting litter that has entered the river, they do not solve the litter problem. The most cost-effective solution is to prevent littering, and where necessary, capture litter close to its source before it reaches waterways.

The NSW Department of Environment and Climate Change has conducted a wide range of social research into littering behaviour and has drawn on the significant body of ongoing research on littering behaviour in Australia. This found that the following approaches result in a decrease in littering:

- broadening the legislative options for litter fines combined with more effective enforcement;
- installing anti-littering signs and providing littering and recycling facilities;

- encouraging people to take responsibility for preventing littering through community education;
- social marketing through mass media advertising;
- funding community-based litter prevention programs; and
- educating children via school education and by parents.

Integrated, multi-strategy programs based on rigorous research and including sound evaluation are most likely to be successful.

The research on successful litter reduction demonstrates the value of integrating several approaches including:

- community involvement;
- education;
- fines;
- infrastructure, such as signs, bins and recycling facilities; and
- financial incentives.

Future research needs to focus on the effectiveness of litter reduction campaigns and strategies.

Cigarette butt litter still remains a major challenge.

URBAN Additional Investment Opportunities	
No.	**Litter prevention**
U11	Research/monitoring into the effectiveness of litter reduction campaigns and strategies
U12	Continue and expand the approach of the Lower Yarra Litter Strategy to develop strong partnerships with local government to implement best practice litter prevention programs in litter hotspots
U13	Develop comprehensive behavioural change program for littering
U14	Work with Quit to develop strategies to minimise/eliminate smoking in public areas to reduce cigarette butt litter
U15	Investigate funding sources for the continuation of the Lower Yarra Litter Strategy (or an expanded program) beyond 2010

Local government litter prevention and enforcement programs

Local government is also undertaking a range of activities to reduce litter generation and remove litter. For example, the City of Melbourne has been actively involved in the Butt Free Business Program and the Butt Free City campaign.

Local government in NSW has formed two Regional Illegal Dumping (RID) Squads to combat illegal dumping of waste. The NSW RID squads solely focus on and tackle the problem of illegal dumping and operate across member Council boundaries to investigate and enforce breaches of NSW regulations on illegal dumping and land filling.

Specifically the RID Squad aims to:

- encourage a more strategic coordinated approach to dumping incidents;
- investigate incidents and take action against offenders;
- organise clean-ups;
- track down illegal landfills;
- identify changes and trends in illegal dumping across a regional area; and
- deter and educate community members about illegal dumping.

URBAN Additional Investment Opportunities	
No.	**Local government litter prevention and enforcement programs**
U16	Conduct targeted litter enforcement exercises
U17	Investigate formation of a Regional Illegal Dumping Squad in Melbourne

Managing litter

The Victorian Litter Action Alliance (VLAA) is the peak body for litter management and prevention in Victoria and aims to provide a coordinated approach to preventing litter in Victoria across state and local government, industry and community sectors.

Sustainability Victoria has recently released the Victorian Litter Strategy, developed in consultation with the Victorian Litter Action Alliance (VLAA) and other key industry, community and government stakeholders. The strategy is an important part of the Victorian Government's overall commitment to delivering the *Towards Zero Waste Strategy*. In partnership with VLAA and other key stakeholders, Sustainability Victoria will develop a Litter Action Plan in 2009-10 to implement the strategy. This plan will integrate the current and proposed government, industry and community action to prevent and manage litter in our public places.

URBAN Additional Investment Opportunities	
No.	**Managing litter**
U18	Support the Victorian Litter Action Alliance
U19	When developed, seek funding to implement the Victorian Litter Action Plan

Litter education

Many successful litter campaigns have been run in Victoria including 'Bin it or Swim in it', 'Don't be a Tosser' and 'Do the Right Thing'. Effective behaviour change programs require a long term commitment rather than a one-off limited campaign (Sustainability Victoria, 2007).

URBAN Additional Investment Opportunities	
No.	**Litter education**
U20	Conduct a targeted public awareness campaign about litter and its impact on waterways

Point source management

The threats posed to water quality from point source pollution were discussed in Part 1. The point source management program described here outlines the actions necessary in managing existing licences (including mixing zones). It ensures that beneficial uses (environmental values) of the waters of the Western Port and Port Phillip region are protected.

Compliance with licence requirements

Licence conditions require the licence holder to monitor and report on waste discharge parameters such as volume and quality to EPA Victoria. The issuing and enforcement of licences for industrial waste discharges has been important in improving the quality of the region's waterways, Port Phillip Bay and Western Port. Monitoring needs to continue to assess the compliance of persons and companies with the legal requirements of a licence (action 7.37). Entities that do not comply can be prosecuted.

Point Source Actions	
No.	**Compliance with licence requirements**
7.37	Assess reports of monitored licensed discharges for compliance with requirements and take appropriate action to address any issues found

Review mixing zones

Sewage Treatment Plants in the region have EPA Victoria approved mixing zones and environmental improvement plans. As mixing zones do not achieve SEPP and water quality objectives, regular reviews are needed to ensure any impact on the environment is minimised through improving processes and minimising their size. Although many licence holders take action to reduce their mixing zones, further assessment is needed to prove their effectiveness and identify future actions required to further reduce them (action 7.38).

Point Source Actions	
No.	**Review mixing zones**
7.38	Review mixing zones for major licensed discharges (where it is a condition of the licence) to ensure that the impact of mixing zones is minimised

Sewerage strategy

A sewerage strategy for the region that aligns it with a whole water cycle approach is needed. The strategy will need to outline the adaptive approaches essential to account for climate change as our knowledge increases. Melbourne Water, with the Metropolitan Water Authorities, is developing such a strategy (action 7.39).

Point Source Actions	
No.	**Sewerage strategy**
7.39	Together with the Melbourne metropolitan retail water businesses, develop a sewerage strategy for Melbourne that specifies the actions required to build a robust sewerage system to cope with future sewage production and effluent discharge taking into consideration population and urban growth as well as climate change

Point source management program	
Aim	To manage existing licences (including mixing zones) to ensure that beneficial uses of the waters of the Western Port and Port Phillip region are protected
Water quality benefits: *quantified load impact*	Not measurable at this stage
Water quality benefits: *additional*	Phosphorus, *E. coli* and heavy metals
Additional environmental benefits	Reduction in the impacts of licensed discharges will also reduce the stress on local aquatic environments
Economic benefits	Protection of economic values of the affected aquatic environments by aiming to protect the beneficial uses of the region through managing licensed discharges.
Social benefits	Reduction in impacts of licensed discharges, improving the safety of discharge output locations to recreational users.

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
7.37	Assess reports of monitored licensed discharges for compliance with requirements and take appropriate action to address any issues found	EPA Victoria	Ongoing	Low	Committed	Funded
7.38	Review mixing zones for major licensed discharges (where it is a condition of the licence) to ensure that the impact of mixing zones is minimised	EPA Victoria	2012	Medium	Committed	Funded
7.39	Together with the Melbourne metropolitan retail water businesses, develop a sewerage strategy for Melbourne that specifies the actions required to build a robust sewerage system to cope with future sewage production and effluent discharge taking into consideration population and urban growth as well as climate change	Melbourne Water (YVW, CWW, SEW)	2009	High	Committed	Funded

Management of 2009 Black Saturday bushfire effects on waterways

Once the fires affecting catchments and waterways in the region were brought under control and burnt parts of the catchments were safe to enter, Melbourne Water completed damage assessments and prioritised areas for works to protect waterways and water quality in water supply storages.

Melbourne Water will be undertaking the following activities to support the natural recovery of creeks and rivers in the Port Phillip and Western Port region through reducing risks to natural recovery:

- Rapid prioritisation of systems for emergency response (action 7.40);
- Weed suppression and control activities to enable indigenous vegetation to regenerate and re-establish, providing habitat for displaced species and creating a buffer that reduces erosion, sediment and nutrients entering into waterways (action 7.41);
- Repair and replace Melbourne Water assets as well as assisting landowners to repair and replace their fire-damaged assets such as riparian fencing, off-stream stock watering and riparian plantings. This will lessen the impact of erosion and nutrients entering the waterways, and will also provide habitat for animals, and protect regenerating indigenous vegetation (action 7.42);
- Where appropriate, undertake stream stabilisation works to maintain waterway stability with a focus on protecting built infrastructure, e.g. bridges (action 7.43);
- Undertake additional monitoring of waterways to gain an understanding of future effects on wildlife and river health, including monitoring for dissolved oxygen, nutrients and sediment loads (action 7.44);
- Undertake longer-term study into the effects of the fires on the system's biodiversity (action 7.45); and
- Conduct specific investigations on platypus, blackfish and other highly affected species (action 7.46).

Engagement with the community is critical to the success of waterway rehabilitation works in fire affected areas.

There is a range of actions that are currently being undertaken by relevant agencies to assist with the rehabilitation of fire affected areas and protect water quality. Immediate priorities included the installation of sediment nets to trap sediment entering priority waterways and dams from fire affected catchments and assessments of damage as well as rehabilitation of firebreaks. At the time of writing much of this work had been completed.

The bushfires occurred at a time when waterways in the region were already under stress from a prolonged period of below average rainfall (potentially a combination of drought and climate change). Understanding the impact of the bushfires on critical in-stream drought refuge sites is important for the long term recovery of aquatic fauna. Melbourne Water will determine which actions can be undertaken to protect and/or enhance these refuge sites through utilising known information about drought refuges and undertaking monitoring to determine priority areas for intervention, when intervention will be required and which actions can be undertaken (action 7.47).

At the time of writing, agencies were formulating their medium-term fire response based on the damage assessments undertaken by the Burnt Area Emergency Recovery teams and agencies. Additional actions will be undertaken as a result of these assessments. These actions have not been included in *Better Bays and Waterways* but will be undertaken outside of the plan.

Adaptive management will be a critical component of the bushfire response. There are significant elements of the unknown regarding the recovery of bushfire affected areas, particularly given the already drought affected state of the catchments prior to the bushfires. Rainfall patterns will also influence the level of response required in different areas as runoff from burnt catchments will mobilise sediments, ash and debris and affect in-stream water quality.

Bushfire rehabilitation program	
Aim	To minimise the effects of the 2009 Black Saturday Victorian bushfires on the health of waterways (and the bays) in the Port Phillip and Western Port region
Water quality benefits: *quantified load impact*	Not quantified, though loads are likely to significantly increase in waterways following rainfall in fire-affected catchments. Any works undertaken to reduce sediments, debris and ash entering waterways will reduce loads to waterways (and in some catchments, also the bays)
Water quality benefits: *additional*	Reduction in sediments, phosphorus, nitrogen, debris
Additional environmental benefits	Improved river health values associated with bank stabilisation, riparian zone protection, revegetation, riparian fencing reinstatement, provision of habitat, weed suppression
Economic benefits	Reduced effects on water quality in water supply dams, assistance to private landholders to reinstate riparian fencing and plantings to exclude stock from waterways
Social benefits	Social values associated with improved riparian condition, assistance to landholders affected by fire

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
7.40	Undertake damage assessments in fire affected catchments and prioritise areas for works to protect water quality in waterways and storages	Melbourne Water	2009	Low	Committed	Funded
7.41	Conduct weed suppression and control activities in fire affected catchments	Melbourne Water	2009-2011	Medium	Committed	Partially funded
7.42	Repair and replace Melbourne Water assets as well as assisting landowners to repair and replace their fire-damaged assets, such as riparian fencing, off stream stock watering and riparian plantings	Melbourne Water	2009-2010	Medium	Committed	Funded
7.43	Where appropriate, undertake stream stabilisation works to maintain waterway stability in fire affected catchments with a focus on protecting built infrastructure	Melbourne Water	2009-2010	Medium	Committed	Funded
7.44	Undertake additional monitoring of waterways in fire affected catchments to gain an understanding of future effects on wildlife and river health, including monitoring for dissolved oxygen, nutrients and sediment loads	Melbourne Water	2009-2010	Medium	Committed	Funded
7.45	Conduct a longer term study into the effects of the fires on the system's biodiversity	Melbourne Water	2009-2011	Medium	Committed	Unfunded
7.46	Conduct specific investigations for platypus, blackfish and other highly affected species in fire affected catchments	Melbourne Water	2009-2010	Medium	Committed	Funded
7.47	Assess the impact of the 2009 bushfires on critical in-stream drought refuge sites and identify actions to protect or enhance these refuges.	Melbourne Water	2009	Low	Committed	Funded

Environmental flows

The environmental flows management program aims to ensure the environmental flow requirements of waterways, estuaries and aquifers are regularly reviewed and protected through appropriate management.

This aim is being achieved through various guiding documents to protect or enhance the environmental allocation of water supplies. These include:

- the Water Act 1989;
- the Central Region Sustainable Water Strategy (SWS) 2007;
- the Port Phillip and Westernport Regional River Health Strategy 2007;
- bulk entitlements;
- stream flow management plans;
- local management rules; and
- drought response rules.

These documents form the mechanism by which the Environmental Water Reserve (EWR) (see Box 7.2) for estuaries, waterways and aquifers can be protected currently and into the future.

Central Region Sustainable Water Strategy

The Central Region Sustainable Water Strategy (SWS) (DSE, 2006) outlined the Victorian Government's commitment to increasing the EWR of rivers across the region to ensure sustainability. Table A2.8 (Appendix 2) outlines these commitments for the rivers within the Port Phillip and Western Port region.

Other commitments of the Central Region SWS relevant to improved water quality through environmental flows are to:

- Undertake further work on documenting the volume and use of small catchment dams; understanding their effects and ways of mitigating these effects. Within the Port Phillip and Western Port region, Maribyrnong is a priority catchment. This work will be completed in consultation with affected communities;
- Review operating and harvesting rules to store and release environmental water in a pattern that better meets the needs of the environment; and
- Enhance environmental flows in the Werribee and Maribyrnong Rivers by 2015. The benefits of the increased environmental flows will be monitored and assessed to determine whether water quality has improved and whether further enhancements are required.

The commitments of the Central Region SWS (DSE, 2006), include enhanced environmental flow volumes for the Yarra, Bunyip/Tarago, Maribyrnong and Werribee Rivers. This covers most of the major rivers in the Port Phillip and Western Port region. All enhanced flows are being progressed, however the extended period of low rainfall is causing delays in delivery of many of these actions (see Yarra River Case Study Box 7.3).

Still outstanding is the need to further develop and implement estuarine flow objectives across the region, with particular focus on the estuarine objectives developed as part of the *Better Bays and Waterways'* estuarine environmental flow objectives report (SKM, 2007). These estuaries are the Yarra, Maribyrnong, Werribee, Little and Bunyip river estuaries.

The primary mechanism for delivering estuarine environmental flows is through the provision of flows to the upstream reaches of rivers. However, these sources of water can be many kilometres upstream and releases may have negligible delayed effects on estuarine segments. In managing estuarine flows, the additional effect of EI needs to be managed in modified, urban areas to reduce the damage of high flow frequency and volume on estuaries. Actions in the urban diffuse management program (Chapter 7.2) contribute to reducing the damage of EI on urban waterways and estuarine flows.

Actions within the Central Region SWS will be implemented as described in the strategy (action 7.48). In addition to the estuaries addressed in the estuarine flow objectives report (SKM, 2007b) and the rivers considered in the Central Region SWS, both the local community and SKM (2007b) identified a need to review the environmental flow needs of Little River (action 7.49). The recommendations from the SKM (2007b) report will be considered when developing the objectives and flow requirements for Little River.

Review periods have been established for most guiding documents and management plans to ensure an avenue for improvement and adaptive management exists. Review cycles provide an opportunity for the EWR to be enhanced further and for science and research to inform current management actions. Changes to these guiding documents that would improve management of the EWR can be implemented through these review cycles.

In addition to regular reviews every seven to ten years, the actions within the Central Region SWS (DSE, 2006) are reported on annually by DSE (action 7.50). Annual reports are made available at www.ourwater.vic.gov.au. The implementation of these actions will be delivered by a number of agencies responsible for environmental flow management in the Port Phillip and Western Port region, including DSE, Melbourne Water, Western Water and Southern Rural Water.

The Port Phillip and Western Port Regional River Health Strategy (RRHS) has set short-term (five year) targets for either maintaining or improving the environmental flows of all the reaches within the region (see Chapter 5 Targets). The RRHS has a five-year lifespan (2007-2012), and will be reviewed and updated at the end of this period (action 7.51). A component of the RRHS review will consider management actions that improve environmental flows throughout the region.

Environmental Flows Actions	
No.	**Central Region Sustainable Water Strategy**
7.48	Implement improved environmental flows for the Port Phillip and Western Port catchments as prescribed in the Central Region SWS
7.49	Review flow objectives and requirements for Little River by 2013
7.50	Annually report on the progress of the actions within the Central Region SWS
7.51	Begin the review of the Port Phillip and Westernport Regional River Health Strategy by 2010.

Box 7.2: Yarra River Case Study

An environmental flow investigation was undertaken for nine reaches of the Yarra River from the Upper Yarra Reservoir to the estuary in central Melbourne (including the Plenty River and Watts River) in 2006. The recommendations from the study included a full range of environmental flow components specifically to meet agreed ecological objectives for all identified aquatic flora and fauna, riparian vegetation and for geomorphic processes.

The Victorian Government's Central Region Sustainable Water Strategy made a commitment to deliver all of the recommended environmental flows required to meet the objectives for a healthy Yarra River.

A significant amount of supply system modelling went into the resulting negotiation and entitlement process. The Yarra River had previously been identified as a fully allocated catchment and all allocations within it were capped at existing levels. For additional water to be provided to the environment, another allocation must be reduced accordingly. Modelling supported an environmental entitlement of 17 000 ML/year to be held in storage in the Melbourne Headworks Reservoirs to be used to provide flows to meet critical objectives. In doing so, Melbourne agreed to accept a lower security of supply and the long-term cap for harvest to the Melbourne supply system from the Yarra River was reduced by the equivalent volume.

Bulk entitlements held by Melbourne metropolitan water retail businesses for the Yarra River include provision for the recommended minimum passing flows to be achieved at each location within the Yarra River.

The Yarra Environmental Water Reserve (EWR) was established in 2006. The implementation of improved flows has been temporarily deferred due to prolonged dry conditions. The enhanced environmental flows will be delivered when Melbourne returns to Stage 1 water restrictions or alternative water sources become available.

An environmental operating strategy and annual watering plan will be developed for the Yarra EWR each year, which will help prioritise flow objectives for that year. This will allow environmental flows to be adaptively managed from year to year and provide a greater understanding of the delivery of flow objectives.

Environmental flows in the Yarra River are subject to a rigorous monitoring and evaluation program. The Victorian Environmental Flows Monitoring and Assessment Program is a statewide program with the specific objective of linking the delivery of environmental flow components with the intended ecological objective. The eWater CRC is coordinating the collection of monitoring data from across the state and will be investigating the collective outcomes of the program to build a library of knowledge about the capacity of environmental flows to meet specific ecological objectives.

The Yarra EWR will be reviewed with the review of the Central SWS within seven to ten years.

7 Catchment Actions

Adaptive management and review mechanisms

The EWR is adaptively managed where an environmental entitlement is held in storage to ensure optimal use of environmental water allocations. The remainder of the EWR is passively managed. Several mechanisms exist for reviewing and improving the allocations for the EWR. These include:

- a legislated 15-year long-term water resource assessment review;
- development and review of RRHSs every five years;
- review of Central Region SWS every seven to ten years;
- review of stream flow management plans every five years;
- review of local management rules as prescribed; and
- bulk entitlements.

Adaptive management of the EWR occurs through the development and implementation of the above mechanisms. Most have an established review period, with the exception of bulk entitlements. *Better Bays and Waterways* has adopted an adaptive management approach to aid in the delivery of its environmental flows and other management programs (described in Chapter 6 Introduction to Management Programs). The review of legislation, strategies, plans and rules aligns with this approach and allows for improved processes and management activities to be developed and implemented.

Additional investment opportunities

Further actions would build on the actions detailed above and benefit water quality and environmental flow, and contribute towards the long-term flow targets (see Chapter 5) and benefit waterways, estuaries and the bays.

These actions would fit into the integrated framework of projects as detailed above, but either represent the next stage or provide an opportunity for expanded actions to improve water quality. They require detailed scoping and funding must be sought for implementation.

Most review periods for guiding documents fall outside the life of *Better Bays and Waterways*. At the time of review, the outstanding gaps listed below should be considered. For some, commitment and funding by groups and agencies could result in earlier action.

Environmental flows management program	
Aim	To ensure environmental flow requirements of all waterways, estuaries and aquifers are regularly reviewed and environmental flows improved through appropriate management.
Water quality benefits: *quantified load impact*	Not quantified
Water quality benefits: *additional*	Prevention of stagnation, ensuring water is well mixed and oxygenated, and diluting toxic concentrations of pollutants. Improving flow condition links to nitrogen and sediment reduction targets and the implementation of the Central Region SWS.
Additional environmental benefits	Helps meet targets and objectives from the Regional River Health Strategy and Central Region Sustainable Water Strategy (SWS) that aim to reduce the risk of low/no flows and insufficient environmental allocation.
Economic benefits	Ensuring the longer term sustainability of agricultural practices that rely on stream flows
Social benefits	Providing recreational benefits to the community by providing water for recreational purposes such as fishing, swimming, and boating.

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
7.48	Implement improved environmental flows for the Port Phillip and Western Port catchments as prescribed in the Central Region SWS	Various (Refer to the Central Region SWS)	Ongoing to 2055	Medium	Committed	Not funded
7.49	Review flow objectives and requirements for Little River by 2013	Melbourne Water	By 2013	Low	Committed	Funded
7.50	Annually report on the progress of the actions within the Central Region SWS	DSE	Ongoing	Low	Committed	Not funded
7.51	Begin the review of the Port Phillip and Westernport Regional River Health Strategy by 2010.	Melbourne Water	2010	Medium	Committed	Funded

Local management rules

Local management rules ensure that water resources are managed in an equitable manner to ensure long-term sustainability. Local management rules have been developed for several waterways. These include Darebin, Moonee Ponds, Gardeners, Kororoit, Mullum Mullum and Merri Creeks. Local management rules should:

- prevent further decline in environmental values due to water extraction;
- provide reasonable reliability of water access to licence holders; and
- demonstrate compliance with the Water Act 1989 and associated guidelines.

For these reasons, it would be beneficial to develop local management rules for the management of diversion licences in unregulated waterways where rules have not yet been developed.

ENVIRONMENTAL FLOWS Additional Investment Opportunities	
No.	**Local management rules**
EF1	Develop local management rules for management of diversion licences in unregulated reaches/waterways where none exist

Bulk entitlements

Bulk entitlements are rights to using and supplying water. They can be granted to water corporations, the Minister for Environment and other specified bodies. Bulk entitlements can be held in relation to water in a waterway, in storage works and groundwater. Current bulk entitlements generally cover surface water systems. They contain a number of conditions and obligations that are set out in the Water Act 1989 (DSE 2008a). Although these conditions and obligations exist, bulk entitlements do not have any formal review period. A formal review and assessment process for bulk entitlements would be beneficial to adaptively managing the environmental needs of waterways.

ENVIRONMENTAL FLOWS Additional Investment Opportunities	
No.	**Bulk entitlements**
EF2	Determine and legislate review periods for bulk entitlements (expected lead: DSE)

Strategies and policy

The guiding documents listed under the adaptive management section of *Better Bays and Waterways* have varying review dates. In acknowledging a continually changing environment, we recognise the need to evolve, adapt and respond effectively to changing conditions.

Establishing more regular review dates for strategies can ensure the documents are up-to-date and provide the opportunity to improve them.

ENVIRONMENTAL FLOWS Additional Investment Opportunities	
No.	**Strategies and policy**
EF3	Review strategies and policy review dates to ensure they reflect current needs

Estuarine flows

The estuarine flow objectives report (SKM, 2007b) made recommendations for the management of estuarine flows for several estuaries across the region using the Estuarine FLOWS methodology. The recommendations include the development of estuarine flow targets and the development of ongoing flows regime strategies for all estuaries across the region. Further research and investigation is needed when considering these recommendations.

ENVIRONMENTAL FLOWS Additional Investment Opportunities	
No.	**Estuarine flows**
EF4	Review recommendations and suggested management activities from the *Better Bays and Waterways* estuarine flows study in light of the newly completed Estuarine FLOWs methodology (expected lead: Melbourne Water)
EF5	Develop estuarine flow targets (expected lead: Melbourne Water)
EF6	Research and develop ongoing flows regime strategies for priority estuaries across the region (expected lead: Melbourne Water)

Alternative water supplies for engaging wetlands

The FLOWS method outlines the need to protect high flows for engaging with wetlands and floodplains. In a changing climate, alongside human safety issues, it may not be practical or even possible to provide for natural high flows. Alternative water supplies need to be considered if these environments are to be adequately protected. Examples include pumping river water or redirecting stormwater inflows to wetlands rather than providing flows through engaging entire floodplains.

ENVIRONMENTAL FLOWS Additional Investment Opportunities	
No.	**Alternative water supplies for engaging wetlands**
EF7	Research alternative water supply for wetlands and floodplains (expected lead: Melbourne Water)

Impacts of low flows on river health

Lower flows have a marked impact on the health of our ecosystems. Research conducted by EPA Victoria on in-stream biology demonstrates the direct impact of climate change on our ecosystems over the extended period of low rainfall for the past twelve years (EPA 2007; Rose *et al*. 2008). Lower flows are a significant issue in many rural streams while, conversely, significant damage is done to our urban streams by the unnaturally high flows generated by urban runoff. Climate change predictions of drier landscapes parallel conditions experienced through the current extended period of low rainfall. There is therefore a need to investigate climate change effects on targeted aspects of river health including identification, prioritisation and protection of refugia.

ENVIRONMENTAL FLOWS Additional Investment Opportunities	
No.	**Impacts of low flows on river health**
EF8	Identify opportunities to undertake works to improve the resilience of waterway ecosystems to enable them to adapt to climate change

Chapter 8
Marine Influences

Many of the actions to improve marine water quality will be undertaken in the catchments; the source of most pollutants. Catchment actions are detailed in Chapter 7. Marine actions for managing water quality are described here. Actions for monitoring, researching and investigating marine environments are discussed in Chapter 9 – Understanding our Rivers and Bays.

Aligning with the Victorian Coastal Strategy 2008

The Victorian Government developed the Victorian Coastal Strategy 2008 (VCS) as its policy commitment for coastal, estuarine and marine environments in Victoria (VCC 2008). A major focus of the VCS is on "managing the pressures from increased urbanisation and the intensification of agriculture and commercial development within coastal catchments which threaten the integrity of marine ecosystems" (VCC 2008).

The VCS outlines several actions related to improving strategic understanding and management of marine environments. *Better Bays and Waterways* will link to these actions where appropriate (action 8.1).

MARINE Actions	
No.	**Aligning with the Victorian Coastal Strategy 2008**
8.1	Implement the actions relating to the marine environment in Port Phillip Bay and Western Port in the Victorian Coastal Strategy 2008

Port Phillip Bay Environmental Management Plan

SEPP (WoV) Schedule F6 (Waters of Port Phillip Bay) required the preparation of an EMP to provide a framework for:

- identification of responsibilities;
- coordination of management actions;
- determination of priorities;
- development of action plans for particular issues;
- development of long-term waste management plans for the protection of beneficial uses; and
- reporting of progress to the community.

The EMP was first released in 2002 and identified two priority issues – marine pests and nutrient reduction.

The EMP is currently being reviewed. Relevant elements of *Better Bays and Waterways* will be linked to the revised Bay EMP, including reporting, where appropriate, to provide a policy vehicle for implementation (action 8.2).

MARINE Actions	
No.	**Port Phillip Bay Environmental Management Plan**
8.2	Review the Port Phillip Bay EMP and ensure that the relevant *Better Bays and Waterways* actions clearly link to the statutory EMP framework to provide a policy vehicle for implementation and attainment of nutrient reduction actions

Western Port Research

The Port Phillip Bay Environmental Study (Harris *et al.*, 1996) had a significant effect on management programs and targets for Port Phillip Bay. In the mid 1970s, Shapiro conducted a preliminary study on Western Port (Shapiro, 1975). Since then, several studies on various ecosystems and processes within Western Port have been carried out, however, there is a need for a comprehensive analysis of current key knowledge and management gaps to improve strategic understanding of Western Port and inform management decisions, as a basis for future investment and action (action 8.3). Suspended solids have been identified as the key pollutant entering Western Port, however it is unclear how much sediment load reduction is required to protect environmental values of Western Port. Understanding this will enable long-term targets for sediment load reduction to be set.

MARINE Actions	
No.	**Western Port Research**
8.3	Undertake an analysis of current key knowledge and management gaps to improve strategic understanding of Western Port, with a clear focus on informing improved future environmental management as the basis for future investment and action Commence implementation of key priorities

Western Port sediment management

The SEPP (WoV) Schedule F8 (Waters of Western Port and Catchment) outlines the need to establish priority sources of sediment to Western Port. This was achieved through the CSIRO's sediment studies (Wallbrink and Hancock, 2003; Hughes *et al.*, 2003; Wallbrink *et al.*, 2003a; Wallbrink *et al.*, 2003b) which indicated priority activities to reduce turbidity in Western Port.

Actions within the Urban and Rural diffuse source programs of *Better Bays and Waterways* (Chapter 7) aim to reduce sediments and nutrients entering Western Port from the catchment. To address all sediment sources, it is important to undertake works in the marine environment. Planting mangroves along the shoreline has been identified as an effective method of preventing further erosion of the coastal cliffs and of reducing the resuspension of sediments in the bay. SEPP (WoV) Schedule F8 lists the protection and rehabilitation of coastal and marine vegetation as a key action in protecting the beneficial uses of Western Port. The SEPP includes a requirement to investigate factors limiting recovery of native marine vegetation (including seagrass), monitoring the health and diversity of native marine vegetation and a target for seagrass recovery to increase coverage by 5% in the Entrance and North Arm, and 10% in the East Arm by 2011. Since the development of the SEPP, there has been a significant increase in the understanding and awareness of climate change risks. It is now appropriate to consider the predicted implications of climate change for Western Port seagrass dynamics, including recovery capacity.

Targeted re-establishment of mangroves along Western Port shorelines identified as at risk of erosion should be undertaken with monitoring of the water quality in the vicinity of the plantings, and an assessment of the changes in seagrass condition in the vicinity of plantings (action 8.4) used to inform future investment in this area.

MARINE Actions	
No.	**Western Port sediment management**
8.4	Implement targeted re-establishment of shoreline vegetation, especially mangroves on Western Port shorelines identified as at risk of erosion, and monitor its effectiveness using water quality indicators and seagrass condition assessment to guide future investment

8 Marine Influences

Marine Influences	
Aim	To ensure integrated management and research of marine environments and processes in Port Phillip Bay and Western Port
Water quality benefits: *quantified load impact*	Total load reductions of nitrogen to Port Phillip Bay and sediment and nutrient loads to Western Port
Water quality benefits: *additional*	Other benefits such as phosphorus, *E. coli*, heavy metals, litter
Additional environmental benefits	A single framework for monitoring, reporting and managing actions within the individual bays will minimise duplication and provide for efficient reporting of management action implementation and effectiveness.
Economic benefits	Good water quality in the marine environments helps sustain many commercial industries including aquaculture, commercial fishing and tourism (e.g. diving, seal rocks)
Social benefits	Recreational activities – good water quality contributes to the continued use of the bays for fishing, diving and boating.

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
8.1	Implement the actions relating to the marine environment in Port Phillip Bay and Western Port in the Victorian Coastal Strategy 2008	VCC (DSE, CMA)	Ongoing beyond 2013 (5 year strategy)	High	Committed	Unfunded
8.2	Review the Port Phillip Bay EMP and ensure that the relevant *Better Bays and Waterways* actions clearly link to the statutory EMP framework to provide a policy vehicle for implementation and attainment of nutrient reduction actions	DSE (EPA Victoria)	2009-13	Medium	Committed	Unfunded
8.3	Undertake an analysis of current key knowledge and management gaps to improve strategic understanding of Western Port, with a clear focus on informing improved future environmental management as the basis for future investment and action Commence implementation of key priorities	DSE (Melbourne Water, EPA Victoria, PPWCMA)	By 2013	High	Partially committed	Partially funded (by Melbourne Water)
8. 4	Implement targeted re-establishment of shoreline vegetation, especially mangroves on Western Port shorelines identified as at risk of erosion, and monitor its effectiveness using water quality indicators and seagrass condition assessment to guide future investment	PPWCMA Seagrass partnership	2009-2010 ongoing	Medium	Committed (2009-2010)	Funded (2009-2010)

Additional investment opportunities

The following actions would contribute towards the long-term target for sediment and nutrient reduction. They require detailed scoping and funding must be sought for implementation.

SEPP denitrification objectives for Port Phillip Bay

The CSIRO Port Phillip Bay Environmental Study (Harris *et al.*, 1996) indicated the importance of nitrogen cycling in protecting the water quality and ecological condition of Port Phillip Bay. This study was completed 13 years ago and it would be of benefit to review the relevant data used to inform the 1996 study with a view to refining local SEPP objectives to protect the beneficial uses of Port Phillip Bay.

MARINE INFLUENCES Additional Investment Opportunities	
No.	**SEPP denitrification objectives for Port Phillip Bay**
MI1	Review monitoring data to refine objectives to protect the beneficial uses of Port Phillip Bay

Western Port investigations

Further research is required to identify the sustainable annual average and maximum sediment loads to Western Port to ensure protection of environmental values. While links have been made between sediment inputs to Western Port and seagrass decline, there is a need to understand the level of sediment reduction or stabilisation required to protect the values. This will assist in identifying priority works to reduce sediment loads and mobilisation.

MARINE INFLUENCES Additional Investment Opportunities	
No.	**Western Port investigations**
MI2	Undertake research to identify the annual average and maximum sediment loads to Western Port and the level of sediment reduction required to maintain environmental values
MI3	Identify and undertake works to improve water quality to protect the environmental values, including Ramsar values, of Western Port
MI4	Identify and undertake works to reduce mobilisation of sediment within Western Port

Reducing sediment export to Western Port

In 2003, Hughes *et al.*, studied the Suspended Sediment and Bedload Budgets for the Western Port Basin. They identified that more effective riparian zone management along the banks of the major streams will go a long way to improving water quality.

MARINE INFLUENCES Additional Investment Opportunities	
No.	**Reducing sediment export to Western Port**
MI5	Use a risk based approach to identify, and where appropriate implement, suitable methods to reduce sources of sediment to Western Port (e.g. stabilise the clay banks north of Lang Lang jetty and control subsoil erosion from Cardinia Creek and the Bunyip and Lang Lang rivers

Chapter 9 Understanding our rivers and bays

Regular monitoring of water quality occurs within the catchments and bays of the Port Phillip and Western Port region. Monitoring provides information on a variety of water quality parameters and helps us better understand the environmental and social aspects of our waterways and bays. Monitoring data is used to report on targets and to evaluate the effectiveness of management actions and programs. Monitoring data can be used to inform, report on and improve current processes, supporting adaptive management.

Better Bays and Waterways outlines current monitoring programs and gaps, and ties them together to present an overview of water quality monitoring across the region. The *Better Bays and Waterways'* monitoring program aims to measure the effectiveness of management activities described throughout Part 2 to meet the targets described in Chapter 5. The monitoring programs across Port Phillip Bay, Western Port and their catchments are described in this chapter. Water quality data from the monitoring programs will be reported on annually in a *Better Bays and Waterways* water quality update which is described in more detail in Chapter 10. The annual water quality update will provide an overall picture of progress towards meeting targets via the implementation of management actions.

In-stream monitoring program

Waterway water quality monitoring

Waterway water quality monitoring programs monitor different aspects of water quality within the freshwater and estuarine reaches of the region.

These monitoring programs fall into several categories:

- water quality network monitoring;
- community water quality monitoring (e.g. Waterwatch);
- recreational monitoring;
- loads based monitoring;
- estuary monitoring;
- macro-invertebrate monitoring; and
- sediment monitoring.

Through regular review of existing monitoring programs, missing data and knowledge are identified, the effectiveness of monitoring is assessed, progress towards attaining objectives and targets is measured and the programs are improved to strategically inform management decisions.

Water quality network monitoring

Within the region, Melbourne Water manages a network of long-term water quality monitoring sites within freshwater environments. The network is continually assessed and revised to accommodate changes in the environment and to technology, and to ensure reporting is indicative of environmental condition. In 2007, the network was reviewed and updated to cover over 100 sites. The updated network now includes sites throughout the Werribee and Maribynong catchments, and increased spatial coverage of the Western Port catchment. The update was based on a review of the monitoring network through the development of the RRHS (Melbourne Water, 2007b).

The network of sites is adaptively managed to continually improve the ability of the data to be ecologically meaningful and to measure improvements through the addition, deletion and/or movement of sites. Various physical and chemical analyses are performed at each site on a monthly basis and capture information on nutrients (phosphorus and nitrogen), pathogens (primarily *E. coli*), heavy metals (including zinc, lead and copper), turbidity, suspended solids, electrical conductivity and temperature. These measurements are reported to EPA Victoria and compared with SEPP objectives for water quality.

The addition of sites to Melbourne Water's water quality network monitoring program and Waterwatch's presence and data sampling, provides water quality information for areas more recently added to the network (such as the Maribyrnong and Werribee catchments). Monitoring needs to continue to build a better water quality knowledge base and report on trends in the region (action 9.1).

IN-STREAM MONITORING Actions	
No.	**Water quality network monitoring**
9.1	Regularly monitor, review and report on water quality monitoring programs across the region

Community water quality monitoring programs

Community groups play an important role in water quality monitoring. In addition to the data they collect, they foster community awareness and increase understanding and ownership of local water quality issues.

Waterwatch is a community education program that connects communities to their local waterways. It provides support to community groups and individuals to conduct monitoring activities at various sites across the catchment. Waterwatch involves water sampling and analysis to educate people on the condition of their waterway and draw the link between polluting activities and compromised water quality. In 2007-2008, Port Phillip and Westernport Waterwatch involved over 100 community groups in regular water quality monitoring programs at over 300 monitoring sites. *Better Bays and Waterways* encourages the enhancement and establishment of community water quality monitoring programs such as Waterwatch and EstuaryWatch. These programs and others like them will educate community members on water quality issues and develop publicly accessible reports and data interpretation (action 9.2).

There is great potential for community water quality monitoring programs to be enhanced by the synthesis of monitoring data into meaningful reports, summaries and trend analyses. Sharing community collected data and its meaningful interpretation will allow Waterwatch groups and the broader community to compare water quality across the region. In late 2008, Waterwatch launched their new website (www.waterwatchmelbourne.org.au), designed to make the collected data more accessible. Adaptive management of such databases will enhance coordinated access, storage and analysis of community gathered data (action 9.2).

IN-STREAM MONITORING Actions	
No.	**Community water quality monitoring programs**
9.2	Enhance and develop community water quality monitoring programs (such as Waterwatch) and develop accessible datasets to educate community members on water quality issues

9 Understanding our rivers and bays

Recreational health monitoring

There are potential health risks associated with recreational exposure to poor water quality in our waterways and bays. Monitoring programs targeting recreational risks can also benefit the management of drinking water supplies. Cross-discipline benefits could be through increased monitoring of common risks like eutrophication processes and the presence of faecal matter.

Over the next five years, a major focus for Melbourne Water will be working in partnership with EPA Victoria and DHS to improve our understanding of human health risks associated with river water quality (actions 9.3-9.5). The Waterways Water Quality Strategy (Melbourne Water, 2008b) identified the need for a greater understanding in this field. These monitoring initiatives will improve information on the suitability of fish for human consumption and of waterways and bays for recreational activities.

Regular monitoring is needed to measure chemical residue and other contaminants in fish from freshwater and estuarine waters in the region (action 9.3). Melbourne Water will lead a program of monitoring contaminant levels in fish from these waters.

Yarra Watch is an EPA Victoria program providing recreational water quality monitoring information for the Yarra River. Since March 2005 Yarra Watch has provided weekly reports on the water quality condition at various points along the Yarra River. Information is collected by Melbourne Water and is available publicly on the Yarra Watch website, www.epa.vic.gov.au/water/yarrawatch

Melbourne Water maintains a network of monitoring sites for faecal contamination of water quality along the Yarra River. The network was expanded in 2008 to include other rivers and creeks of high recreational value, such as the Maribyrnong River, Mordialloc Creek and Patterson River (action 9.4). The monitoring will continue to locate key sources of faecal contamination and to distinguish between human and non-human sources of this contamination (action 9.5).

IN-STREAM MONITORING Actions	
No.	**Recreational health monitoring**
9.3	Establish monitoring of contaminants in fish from freshwater and estuarine waters to understand human health risks associated with fish consumption
9.4	Undertake faecal contamination monitoring in the Yarra River, Maribyrnong River, Mordialloc Creek and Patterson River and expand the monitoring network to other rivers and creeks of recreational importance across the region
9.5	Investigate sources of faecal pollution in waterways and impacts on recreational activities

Loads-based monitoring

Information on pollutant loads is collected to measure total pollutants entering Port Phillip Bay and Western Port. Loads provide an indication of how much pollution is collectively generated within the catchment (compared with actual concentrations measured by the water quality network monitoring program).

The Nitrogen Input Loads Program is a key element of the Port Phillip Bay EMP nutrient program. There is also reporting on implementation of nitrogen load reduction actions and "early warning" monitoring of bay sediment nitrogen cycling processes. Two reviews of Melbourne Water's loads monitoring program were undertaken as interim projects to *Better Bays and Waterways* (Benchmark Environmental Consulting, 2008; Fletcher and Deletic, 2006). The reviews investigated the program's effectiveness to measure loads to:

- report against reduction targets;
- assess the performance of management strategies;
- assess if key *Better Bays and Waterways* actions relating to agricultural BPMs and WSUD are effective in reducing pollutant loads; and
- identify opportunities and methodologies to help resolve important knowledge gaps.

Before the reviews, loads were measured at seven sites for TSS, TP, TN, heavy metals, rainfall, flow and pathogens. Several recommendations came out of the reviews for improving the program, including:

- retrofitting existing sites to ensure consistent monitoring standards;
- installing seven additional sites to adequately capture loads data during extreme weather;
- relocating inadequately placed monitoring sites;
- installing additional auto-samplers; and
- appointing a data coordinator to ensure quality control.

The reviews of the loads monitoring program highlighted the lack of available and sufficient loads monitoring data from wet weather events. Pollution in waterways is known to significantly increase during storms, so to get an accurate estimate of pollution discharges into the bays, more data on wet weather events is needed. To fill this gap and address the recommendations of the reviews, all recommendations should be implemented. Subsequent reviews of the monitoring program should continue to assess the effectiveness of the monitoring program (action 9.6).

IN-STREAM MONITORING Actions	
No.	**Loads-based monitoring**
9.6	Implement recommendations from the loads monitoring program reviews and continue to review monitoring programs and measure loads across the region

Informing the model

Monitoring data can be used to improve confidence in model predictions. The PortsE2 catchments model (Box 3.2) estimates loads generated by different land uses across the catchments. The recently enhanced loads monitoring program (described above) provides data useful for updating the PortsE2 model. The more data available, both spatially and temporally, the more accurate the model becomes. The model will continue to be calibrated and validated with monitoring data as it becomes available (refer to action 9.16).

Estuary monitoring

A strategy is currently being developed by Melbourne Water to gain a better understanding of estuaries in the region and to set priorities for filling knowledge gaps. The estuary strategy will highlight the importance, current condition and management of estuaries in the Port Phillip and Western Port region. With at least 30 key estuaries in the region, understanding these waterways is an obvious knowledge and information need. Over the next five years, an estuarine monitoring program will be developed by Melbourne Water, starting by establishing sites at the highest priority estuaries. *Better Bays and Waterways* proposes that these water quality monitoring sites, along with the long-term and loads based monitoring sites, be incorporated into a dynamic and adaptable regional water quality monitoring program (action 9.7).

IN-STREAM MONITORING Actions	
No.	**Estuary monitoring**
9.7	Develop an estuarine monitoring program and integrate it with the waterway water quality monitoring program

Aquatic insects (macroinvertebrates) monitoring

Aquatic insects are an important component of a well-functioning freshwater ecosystem. They play an essential role in converting organic matter into smaller particles for consumption by bacteria and filter feeders. They are important food sources for larger organisms such as fish, platypus, water rats and birds. Collecting data on aquatic insects complements physical and chemical water quality measurements by highlighting the role of stream habitats and the effect of hydrology on waterway health.

Aquatic insect monitoring data has been routinely collected for over ten years. Data is collected in autumn and spring, and analysed using biotic indices. The number of insect families present provides information on the biodiversity at each site. A healthy stream will have a balance of sensitive and tolerant species. Tolerant species are more dominant in polluted streams. The stream invertebrate grade number – average level (SIGNAL) biotic index uses the different sensitivities of aquatic insects to calculate a score that shows the relative health of a waterway.

Information about aquatic insects can provide insight into the success of stream restoration and conservation measures and/or can indicate the effect of increased urbanisation on stream health. Before 2007, aquatic insect and water quality monitoring occurred only in the Yarra, Dandenong, Lower Maribyrnong and Western Port catchments. Since 2007, data has also been collected from the Maribyrnong and Werribee catchments. To complement water quality monitoring, aquatic insect monitoring will continue to ensure a dynamic picture of water quality across the region (action 9.8).

IN-STREAM MONITORING Actions	
No.	**Aquatic insects (macroinvertebrates) monitoring**
9.8	Monitor and analyse macroinvertebrate data to complement water quality and waterway health data

9 Understanding our rivers and bays

Pesticides, herbicides and heavy metals in sediments

Heavy metals and petroleum hydrocarbons are common pollutants in waterways and bays that receive runoff from urban areas, especially from industrial estates and roads. These chemicals are often present in sediments at elevated concentrations and can be toxic to aquatic biota.

Pesticides and herbicides are commonly used in residential gardens, for the control of weeds along roads and on rural land and waterways. Along with pesticides and herbicides, heavy metals and petroleum hydrocarbons usually enter waterways via diffuse sources.

Melbourne Water is funding a new monitoring program to measure toxicants (heavy metals and petroleum hydrocarbons) in sediments. The program also measures other factors such as toxicants in fish, to gain a better understanding of water quality and waterway health at targeted sites. A pilot program in early 2008 determined the best sampling regime for successfully detecting long-term changes in toxicants in sediments.

Research and monitoring programs will be implemented to detect sediment toxicity and measure pesticides, heavy metals and petroleum hydrocarbon concentrations in sediments (action 9.9).

Improving our understanding of these chemicals and metals will determine whether appropriate management measures are in place and if targets are being met.

IN-STREAM MONITORING Actions	
No.	**Pesticides, herbicides and heavy metals in sediments**
9.9	Establish and report on pesticide and toxicant monitoring and research programs to determine their concentrations in the environment, their environmental effect and major sources of contaminants

Adaptive monitoring

Monitoring is an important component of the adaptive management cycle. Targeted and adaptive monitoring and investigations provide a means to respond to emergency events and adjust to changes in the future. They include investigations into sewerage treatment plant discharges and oil spills as well as proactive monitoring to identify any unusual or unknown pollution sources. Continued monitoring of established programs, new programs and reactive investigations inform management programs. Regular review of monitoring programs ensures they are strategically designed to inform current and future management decisions (action 9.10).

IN-STREAM MONITORING Actions	
No.	**Adaptive monitoring**
9.10	Regularly review monitoring programs for freshwater and estuarine environments to ensure they are strategically designed to inform current and future management decisions and measure progress towards water quality targets

In-stream monitoring management program	
Aim	To maintain a regional monitoring program that fully assesses and reports on the freshwater and estuarine water quality of the Port Phillip and Western Port catchments and is relied upon to guide management decisions
Water quality benefits: *quantified load effect*	Measurements of load reductions for nitrogen and sediments
Water quality benefits: *other*	Measurements of load reductions for other pollutants of concern, such as phosphorus, heavy metals, *E. coli*.
Additional environmental benefits	The suite of parameters monitored allows managers to identify when any indicators threaten the environmental values of the system
Economic benefits	Information on the current condition of waterways to feed into the development of cost effective management programs
Social benefits	Community engagement for a better understanding of local water quality

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
9.1	Regularly monitor, review and report on water quality monitoring programs across the region	Melbourne Water	Ongoing	Medium-high	Committed	Funded
9.2	Enhance and develop community water quality monitoring programs (such as Waterwatch) and develop accessible datasets to educate community members on water quality issues	Melbourne Water	2009	Medium	Committed	Funded
9.3	Establish monitoring of contaminants in fish from freshwater and estuarine waters to understand human health risks associated with fish consumption	Melbourne Water (DHS)	By 2013	Medium	Committed	Funded
9.4	Undertake faecal contamination monitoring in the Yarra River, Maribyrnong River, Mordialloc Creek and Patterson River and expand the monitoring network to other rivers and creeks of recreational importance across the region	Melbourne Water (DHS, EPA Victoria)	2008-2014	Low	Partially committed	Funded
9.5	Investigate sources of faecal pollution in waterways and impacts on recreational activities	Melbourne Water (DHS, EPA Victoria)	2008-2014	Low	Committed	Funded
9.6	Implement recommendations from the loads monitoring program reviews and continue to review monitoring programs and measure loads across the region	Melbourne Water	2009	Low	Committed	Funded
9.7	Develop an estuarine monitoring program and integrate it with the waterway water quality monitoring program	Melbourne Water	Ongoing	Medium	Committed	Funded
9.8	Monitor and analyse macroinvertebrate data to complement water quality and waterway health data	Melbourne Water	Ongoing	Medium	Committed	Funded
9.9	Establish and report on pesticide and toxicant monitoring and research programs to determine their concentrations in the environment, their environmental effect and major sources of contaminants	Melbourne Water	2008-2014	High	Committed	Funded
9.10	Regularly review monitoring programs for freshwater and estuarine environments to ensure they are strategically designed to inform current and future management decisions and measure progress towards water quality targets	Melbourne Water	Ongoing	Low-Medium	Committed	Funded

Additional investment opportunities

The following action requires detailed scoping, commitment and funding for implementation.

Estuarine monitoring program

One particular monitoring gap in the region is an organised community monitoring program for estuaries. The Corangamite CMA runs an EstuaryWatch program, as does the City of Lake Macquarie in NSW. A similar program would greatly benefit the Port Phillip and Western Port region.

IN-STREAM MONITORING Additional Investment Opportunities	
No.	**Estuarine monitoring program**
IM1	Develop a community monitoring program for the estuaries within the Port Phillip and Western Port region like the EstuaryWatch program

In-bay monitoring

Monitoring and evaluation is an important part of all programs described in *Better Bays and Waterways*. The overarching program for marine water quality monitoring is described here.

Monitoring programs in both Western Port and Port Phillip Bay commenced in the mid-1970s, with initial monitoring focused on 'stemming the tide of pollution' (EPA Victoria, 1996). The programs progressively developed into studies into the long-term water quality trends in the major bays and waterways.

For Port Phillip Bay, with the growth of scientific understanding about key risks to bay water quality and the relevant ecological processes, this monitoring has been supplemented through the EMP, with the specific objective of providing an early warning of detrimental changes to bay nitrogen cycling processes. This monitoring forms part of an integrated monitoring and reporting framework associated with the EMP, which is based on a pressure-state-response framework and also includes monitoring of waterway nitrogen loads to the bay and of implementation of nutrient reduction actions.

The current in-bay monitoring programs differ markedly between Port Phillip Bay and Western Port. The Port Phillip Bay program is more comprehensive to that in Western Port and more specifically linked to a management framework.

Recreational water quality

A recreational water quality monitoring program was established for Port Phillip Bay in 2008. It was based on pre-existing programs, such EPA Victoria's Beach Report monitoring program, and addresses the concerns about the suitability of the bay for recreational uses while the channel deepening program is running. In addition, primary contact (swimming) is a beneficial use described under SEPP and requires monitoring to provide assurances around safety and suitability.

The recreational monitoring program builds on the long-established summer Beach Report monitoring program run by EPA Victoria, which monitors water quality for 36 Port Phillip Bay beaches. It is important to continue monitoring and reporting on the water quality at the selected beaches (actions 9.11 and 9.13).

Western Port swimming beaches are less likely to pose a health risk, as the marine waters are effectively flushed through the tidal action and currents operating in Western Port. For this reason, risks to water quality are assessed as being low and monitoring programs, especially at swimming beaches, are infrequent.

Mornington Peninsula Shire has recognised the relatively urban nature of its region, and the popularity of some of its beaches in Western Port. As a result, the Shire has initiated a monitoring program at Western Port beaches in its region (action 9.12).

IN-BAY MONITORING Actions	
No.	**Recreational water quality**
9.11	Undertake regular monitoring of water quality in Port Phillip Bay with appropriate QA/QC (including EPA's monitoring of beach water quality for swimming at Port Phillip Bay beaches) to inform future management
9.12	Undertake monitoring of beach water quality in Western Port at specific beaches within the Mornington Peninsula Shire region to inform future management
9.13	Interpret results and monitoring data for the marine environment and publicly report on findings. Where relevant use results to inform management

Fixed sites monitoring

EPA Victoria's water quality monitoring of 'fixed sites' and bacterial monitoring of beaches both commenced in the mid 1970s. The aims of the programs are to understand trends in water quality, factors influencing the trends and to ensure ongoing protection of the environmental values/beneficial uses of the waters.

Port Phillip Bay

The Port Phillip Bay Study (Harris *et al*, 1996) provided the first major integration of water quality and ecological condition programs in Port Phillip Bay. Since 2007, the Port Phillip Bay CDP monitoring has built on the existing monitoring programs under the Port Phillip Bay EMP to establish a comprehensive bay-wide monitoring program (as a component of the EMP). Monitoring associated with this program is scheduled to continue until 2012 (action 9.11). Implementation of the monitoring plan is overseen by the Office of the Environmental Monitor (OEM) and has resulted in an integration of the broad range of monitoring programs occurring in Port Phillip Bay.

The marine environmental condition assessment framework already identified as a priority in the Victorian Coastal Strategy 2008 (VCC 2008) will provide a structured context for identifying and reviewing monitoring objectives and priorities for Port Phillip Bay within a framework of management objectives and scientific understanding (action 9.14).

IN-BAY MONITORING Actions	
No.	**Port Phillip Bay**
9.14	Develop and implement a marine environment condition assessment framework (ECAF) and reporting approach that will inform monitoring approaches, supported by a scientific assessment of existing programs and future needs. e.g. Use the ECAF to undertake an environmental condition assessment for Port Phillip Bay to inform future monitoring approaches

Western Port

An analysis of water quality in Western Port in relation to protection of beneficial uses was undertaken for EPA Victoria in 1997 (Longmore, 1997). The analysis recommended that the monitoring programs should continue until the relative roles of external inputs and internal recycling of nutrients were determined. In lieu of this information, EPA Victoria has continued to monitor the parameters listed above, although metals have not been regularly monitored since 1999 because of the low risk posed in Western Port. Additionally, Western Port differs from Port Phillip Bay in having no EMP.

In relation to marine water quality, the Victorian State of the Environment Report (Environmental Sustainability Melbourne, 2008) recommended that water quality monitoring programs for marine and coastal waters should be methodologically sound, continuous and should provide an indication of water quality in all Victorian marine and estuarine waters (recommendation CES2.9). In addition, recommendation CES2.1 indicated that SEPP standards should be reviewed and strengthened as understanding of water quality under natural conditions increases and existing targets are met.

The presence and health of the seagrasses within Western Port is important in maintaining the water quality and ecosystem health. The decline in seagrass abundance is well known and documented with several studies published on seagrass cover, condition and possible factors responsible for its decline in abundance and biodiversity. Studies on the extent of seagrass cover occur periodically. Research such as that completed by Blake and Ball (2001) to map seagrass extent help in understanding the current condition of these communities, however this knowledge base would significantly benefit from more routine seagrass monitoring. A marine condition assessment framework would also benefit Western Port and assist in understanding the various habitats, including seagrass and mangrove communities, and influences such as sediment mobilisation (action 9.14).

IN-BAY MONITORING Actions	
No.	**Western Port**
9.14	Develop and implement a marine environment condition assessment framework (ECAF) and reporting approach that will inform monitoring approaches, supported by a scientific assessment of existing programs and future needs. e.g. Use the ECAF to undertake an environmental condition assessment for Western Port to inform future monitoring approaches

Assessing risk

The Marine Biodiversity and Ecosystems section of the Victorian Coastal Strategy identifies an action to develop and implement a marine ECAF and reporting approach that will inform monitoring approaches, supported by a scientific assessment of existing programs and future needs (action 9.14).

IN-BAY MONITORING Actions	
No.	**Assessing risk**
9.14	Develop and implement a marine environment condition assessment framework (ECAF) and reporting approach that will inform monitoring approaches, supported by a scientific assessment of existing programs and future needs. e.g. Use the ECAF to undertake an environmental condition assessment for Port Phillip Bay and Western Port to inform future monitoring approaches

Marine community monitoring programs

Several community-based programs relate to water quality in the marine environments of Western Port and Port Phillip Bay including:

- Two Bays – a government and community program (see Box 2.1); and
- Western Port Seagrass Partnership – undertakes programs to contribute to improving the condition of important ecological communities in Western Port, including studies of seagrass restoration, sediment stabilisation in the Western Port Ramsar Area and mangrove restoration to stabilise shorelines.

An important objective of these programs is to build community awareness and engagement, in addition to any specific data collection objectives. Where provision of data to inform decision-making is a key objective of these programs, quality assurance processes are an important consideration.

It is important to connect these programs to enhance and develop community based monitoring and build community engagement and understanding of water quality values (action 9.15).

IN-BAY MONITORING Actions	
No.	**Marine community monitoring programs**
9.15	Promote, enhance and develop community based monitoring programs that build community engagement and understanding of water quality and environmental values in Port Phillip Bay and Western Port

9 Understanding our rivers and bays

In-bay monitoring management program	
Aim	To implement marine monitoring programs for Port Phillip Bay and Western Port that assess and report on water quality and the protection of beneficial uses and is relied upon to guide management decisions
Water quality benefits: *quantified load effect*	Total load reductions of nitrogen and sediments to marine waters
Water quality benefits: *additional*	Assists in linking water quality to protection of beneficial uses (e.g. phosphorus, *E. coli*, heavy metals, litter)
Additional environmental benefits	Linkages to SEPP and national water quality strategy implementation and demonstrated progress on protection of Ramsar wetlands
Economic benefits	The beaches of Port Phillip Bay and Western Port are major recreational resources attracting significant numbers of tourists to the beaches and subsequently the quality of the water has an impact on the local economy
Social benefits	Healthy ecosystems and beach water quality are factors in social and economic benefits for both Port Phillip Bay and Western Port

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
9.11	Undertake regular monitoring of water quality in Port Phillip Bay with appropriate QA/QC (including EPA's monitoring of beach water quality for swimming at Port Phillip Bay beaches) to inform future management	EPA Victoria (DSE, DPI, OEM)	ongoing	High	Committed	Funded
9.12	Undertake monitoring of beach water quality in Western Port at specific beaches within the Mornington Peninsula Shire region to inform future management	Mornington Peninsula Shire	2009	Low	Committed	Funded
9.13	Interpret results and monitoring data for the marine environment and publicly report on findings. Where relevant use results to inform management.	EPA Victoria/DSE	ongoing	Medium	Committed	Funded
9.14	Develop and implement a marine environment condition assessment framework (ECAF) and reporting approach that will inform monitoring approaches, supported by a scientific assessment of existing programs and future needs. e.g. Use the ECAF to undertake an environmental condition assessment for Port Phillip Bay and Western Port to inform future monitoring approaches	DSE (EPA Victoria, DPI, Parks Victoria, PPWCMA)	ongoing	High	Committed (through Victorian Coastal Strategy)	Not funded
9.15	Promote, enhance and develop community based monitoring programs that build community engagement and understanding of water quality and environmental values in Port Phillip Bay and Western Port	PPWCMA	ongoing	Medium	Committed	Funded

Additional investment opportunities

The following action requires detailed scoping, commitment and funding for action.

Port Phillip Bay

The bay-wide program is detailed, along with monitoring results, on the OEM website: www.oem.vic.gov.au. The EMP for the CDP can be viewed at www.portofmelbourne.com.

The bay-wide monitoring program includes:

- Water quality monitoring has been expanded to 11 sites from the original 6 sites through EPA Victoria's Port Phillip Bay fixed sites monitoring program. These are monitored monthly for nutrients, chlorophyll pigments, physico-chemical parameters (including salinity, suspended solids and dissolved oxygen) and total and dissolved metals;
- Algal cell counts and species identification are undertaken in conjunction with the water quality monitoring program;
- Nutrient cycling monitoring has been expanded to include additional areas of the bay, and is being conducted at an increased frequency to ensure that the critical denitrification processes are running as expected during the CDP;
- Turbidity and plume intensity monitoring to ensure the extent and duration of elevated turbidity is within the predicted range;
- Programs are directly assessing any effects on environmental assets, including seagrass extent and condition, Little Penguin populations, Ramsar wetlands and marine park biodiversity assessment; and
- Assessment of fish stocks, contaminant levels in fish in the Lower Yarra and the Victorian Shellfish Quality Assurance program for aquaculture.

At the conclusion of this enhanced monitoring program, there will be an opportunity to assess the need to redesign the pre-existing water quality monitoring programs in Port Phillip Bay in the context of any changes to scientific understanding or to monitoring objectives (in the context of management questions and frameworks), within a continual improvement framework.

It is appropriate to continue to interpret and review incoming bay water quality monitoring data over time using a structured approach, within an adaptive management and continual improvement framework, to continue to inform management of catchment risks to bay water quality.

Western Port

Recent monitoring shows that Western Port water quality is currently good and continuing to improve (PPWCMA, unpublished data), however additional research and monitoring efforts will increase and improve both our understanding of current biological processes operating within Western Port, and our confidence that beneficial uses are being protected.

IN-BAY MONITORING Additional Investment Opportunities	
No.	**Port Phillip Bay and Western Port**
IB1	Undertake reviews of marine monitoring effectiveness and needs Port Phillip Bay: assess the need to review pre-existing monitoring programs at the conclusion of the enhanced Bay-wide monitoring program and implement reviews to program design as appropriate to inform management of key bay water quality risks from catchment sources and development of relevant, locally specific water quality objectives Western Port: Use a marine condition assessment to identify monitoring priorities to inform management of key Western Port water quality risks from catchment sources in the context of management objectives and available scientific understanding of relevant ecological processes

9 Understanding our rivers and bays

Research and investigations

Research and investigations contribute to the adaptive management approach adopted by *Better Bays and Waterways*. They are aimed at:

- filling existing knowledge gaps to better understand water quality in freshwater, estuarine and marine environments;
- improving water quality by continually assessing current actions and adapting them and future actions to improve their effectiveness; and
- improving tools for the management and restoration of water quality.

Research and investigations are undertaken by a wide variety of specialists and groups including collaborations between agencies, universities and research institutes. The latest advances in technology are used and developed, along with innovative tools and management techniques.

Research feeds into the development and enhancement of future actions to continually assess our methods and responses to change. However, as the scope of possible relevant research is immense, research investment needs to be carefully targeted.

Current research and investigations programs

The following is a selection of current programs that require further water quality research across the region.

Modelling

Together, the Receiving Waters and Ports E2 models can be used as tools to track and project changes associated with management programs. As a key component of the adaptive management approach, the models will be reviewed and updated regularly with monitoring and climate data. Continuing to use and improve the models can be extremely useful when making management decisions and prioritising activities (action 9.16).

RESEARCH AND INVESTIGATIONS Actions	
No.	**Modelling**
9.16	Continue to use and validate the PortsE2 and Receiving Water quality models with up-to-date monitoring and climate data to inform management

Offsets

The offsets research associated with *Better Bays and Waterways* identified several areas for further investigation. One such area was the fate of nitrogen in waterways by determining rates of denitrification (conversion to nitrogen gas) and assimilation (uptake by biota) in streams across the region (action 9.17). This will provide information on the optimum conditions for denitrification to take place as well as provide the information necessary for a budget of permanent nitrogen loss within streams of the Port Phillip and Western Port catchment.

RESEARCH AND INVESTIGATIONS Actions	
No.	**Offsets**
9.17	Investigate and report on the relative rates of denitrification and assimilation of nitrogen in waterways of varying size and condition across the region

Targeted investigations

In addition to the broader programs of *Better Bays and Waterways*, specific short-term studies will be conducted to isolate the sources of specific contaminants as required (action 9.18). One recent example is the investigation of polychlorinated biphenyls (PCBs), a class of organic compounds that are classified as persistent organic pollutants, and which bioaccumulate in animals. PCBs have previously been detected at levels unfit for human consumption in some eels. Investigations into PCB concentrations in sediments in the Lower Yarra and Maribyrnong estuary began in 2008 to try and identify the cause of PCB pollution in the catchment.

RESEARCH AND INVESTIGATIONS Actions	
No.	**Targeted investigations**
9.18	As required, undertake targeted studies to identify the sources of specific contaminants in waterways

Bacteria budget

Melbourne Water and EPA Victoria are developing a bacterial budget project that compares bacterial inputs and outputs of waterways (action 9.19). It will explore the possibility of reducing bacteria in receiving waters through intensive microbial source tracking and associated remediation works. Those works may be in-stream, infrastructure repair, compliance/enforcement, or by installation of stormwater treatment technologies. It will be necessary to identify faecal indicator bacteria for a defined waterway and calculate its mass balance. Treatment and mitigation options will be explored to identify changes in the levels of the selected bacteria.

RESEARCH AND INVESTIGATIONS Actions	
No.	**Bacteria budget**
9.19	Develop a bacteria budget program to understand the movement of bacteria in and out of the waterway network to reduce their presence in waterways and other receiving water bodies

Pollutant transformation

More work is needed to understand the processes that take place in drain networks, including large streams, estuaries and the WSUD systems. This has been identified by a panel of experts as one of the most important knowledge gaps to improve modelling and management of our systems (SKM 2007a). For example, transformations of suspended solids in waterways through erosion and deposition, have been measured in the past, but more comprehensive understanding is still needed. Information is also required on the transformation of other pollutants, particularly dissolved pollutants. The eWater CRC is a technology development initiative that explores water quality issues. Supporting eWater increases our understanding of in-stream nutrient dynamics for enhanced water quality improvement planning (action 9.20).

A better understanding of current stormwater treatment processes is needed to establish how and if natural and constructed wetlands and water sensitive designs are removing and retaining pollution from waters in both urban and rural areas. Research by Melbourne Water will further address this need (action 9.21).

The MUSIC model is a useful tool for estate-scale urban stormwater modelling. A review of the MUSIC model software is required to assess its use in Melbourne and whether any parameters require amending, including stormwater quality parameters. Version 4 of the MUSIC model is soon to be released and new guidelines will need to be developed for this version of the model. Additionally the MUSIC Online Auditor tool requires amendments to improve its usefulness (action 9.22).

RESEARCH AND INVESTIGATIONS Actions	
No.	**Pollutant transformation**
9.20	Support and collaborate with eWater in researching the in-stream dynamics of nutrients to enhance and inform management activities
9.21	Research and report on the effectiveness of natural and constructed stormwater treatment systems on treating urban and rural stormwater
9.22	Improve estate-scale urban stormwater modelling through, review validation and calibration

Estuary research

Melbourne Water is in the early stages of developing an estuary strategy (action 9.23). Several reports have highlighted the need for a better understanding of estuarine processes (e.g. Arunder and Barton, 2007).

Research is needed to provide a better understanding of the links between freshwater and marine systems, and the threats to their ecological, social and recreational values. Some of the key themes and avenues for research needed are:

- determining ecosystem indicators and processes and understanding trends through a monitoring program;
- understanding ecological values of fauna, habitat, vegetation, drought refuges;
- understanding the fate of chemicals, including nitrogen and phosphorus;
- understanding the fate of toxicants, including PCBs, EDCs;
- conducting hydrodynamic modelling;
- understanding estuarine environmental flows;
- understanding and managing pollutants; and
- understanding natural and artificial estuary opening cycles.

RESEARCH AND INVESTIGATIONS Actions	
No.	**Estuary research**
9.23	Develop an estuary strategy for the estuaries of Port Phillip Bay and Western Port

Fish contamination

Melbourne Water, DPI, Brunel University (UK), The University of Melbourne and RMIT are collaborating to assess the implications of endocrine disrupting chemicals (EDCs) on estuarine black bream and several freshwater species from the region. EDCs are substances that can affect the hormonal system of animals including humans. This assessment will involve identifcation of bio-indicators (fish and insects) and the development of specific techniques to measure exposure and to measure these contaminants in the environment (action 9.24).

RESEARCH AND INVESTIGATIONS Actions	
No.	**Fish contamination**
9.24	Collaborate between agencies and universities to better understand the presence and effect of EDCs on fish and other bio-indicators across the region

Sediment nutrient flux in Port Phillip Bay (nutrient cycling)

The efficiency of the denitrification process is the key ecological process maintaining the health of Port Phillip Bay and limiting available nitrogen associated with algal blooms. The existing denitrification efficiency monitoring program in Port Phillip Bay aims specifically to provide an early warning of detrimental changes to bay nitrogen cycling processes. Investment priorities for research and development to inform continual improvement of this program (action 9.25) include:

- identification of surrogate or more cost-effective monitoring approaches that would provide for more spatially and temporally intensive monitoring;
- improved understanding of effects of flood events on denitrification efficiency; and
- understanding implications of climate change on dynamics of bay nitrogen input loads and their effects on the bay.

RESEARCH AND INVESTIGATIONS Actions	
No.	**Sediment nutrient flux in Port Phillip Bay (nutrient cycling)**
9.25	Continue the nutrient flux monitoring program and review at regular intervals to inform management

Groundwater

The Victorian Government White Paper *Our Water Our Future* recognises the need to better understand our groundwater resources and how to manage them sustainably. Threats to groundwater quantity and water quality include extraction, pollution, drought, and climate change. Twelve years of below-average rainfall in Victoria has not only reduced water levels in dams and streams, but also in many groundwater systems. As such, the following research and investigation activities will strengthen the capacity to manage groundwater quality and quantity:

- map the extent and interaction between groundwater and surface water systems in various locations;
- develop conjunctive management plans where there is significant connection between groundwater and surface water;
- test the feasibility of the purposeful and actively Managed Aquifer Recharge (MAR) of water to aquifers in Victoria. Water can be subsequently recovered or provide environmental benefit. Several trial projects are currently underway in Victoria (Mernda Villages Stockdale Development, Rossdale Golf Course, Brauer College Warrnambool);
- review policy relating to the uptake and implementation of MAR and the technologies for treating groundwater such as desalination; and
- improve the monitoring of groundwater quality in areas of groundwater use.

The implementation of these projects will be coordinated through actions 9.26 and 9.27, which involve implementing a program to better understand groundwater.

RESEARCH AND INVESTIGATIONS Actions	
No.	**Groundwater**
9.26	Implement a program(s) to better understand how groundwater and surface water management can be integrated to enhance overall water resource protection in priority areas
9.27	Expand groundwater monitoring network and water quality monitoring in priority areas

9 Understanding our rivers and bays

Research and Investigations management program	
Aim	To conduct research and investigations programs that will stay abreast of emerging issues that present a threat to water quality. The program will also focus on improving water quality in a changing environment
Water quality benefits: *quantified load effect*	No measurable load reductions applicable
Water quality benefits: *additional*	Research programs link to improving our knowledge base and enable management to be refined and improved to allow targets to be met
Additional environmental benefits	Environmental benefits are associated with an improved understanding and knowledge base. Understanding issues links to the ability to achieve targets and improve methods and tools
Economic benefits	Economic benefits are gained through an improved understanding and knowledge base, driving more cost-effective management
Social benefits	Social benefits are associated with an improved understanding and knowledge base. Understanding issues links to the ability to achieve targets and improve methods and tools

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
9.16	Continue to use and validate the PortsE2 and Receiving Water quality models with up-to-date monitoring and climate data to inform management	Melbourne Water/EPA Victoria	2009-2013	Medium	Committed	Partially funded
9.17	Investigate and report on the relative rates of denitrification and assimilation of nitrogen in waterways of varying size and condition across the region	Melbourne Water (Monash University)	2013	Low	Committed	Funded
9.18	As required, undertake targeted studies to identify the sources of specific contaminants in waterways	Melbourne Water	As needed	Varies	Committed	Funded
9.19	Develop a bacteria budget program to understand the movement of bacteria in and out of the waterway network to reduce their presence in waterways and other receiving water bodies	Melbourne Water, EPA Victoria (PPWCMA)	2009	Medium	Committed	Funded
9.20	Support and collaborate with eWater in researching the in-stream dynamics of nutrients to enhance and inform management activities	Melbourne Water	2008-2013	Medium	Committed	Funded
9.21	Research and report on the effectiveness of natural and constructed stormwater treatment systems on treating urban and rural stormwater	Melbourne Water	By 2013	Medium	Committed	Funded
9.22	Improve estate-scale urban stormwater modelling through review, validation and calibration	Melbourne Water	By 2013	Medium	Committed	Partially funded
9.23	Develop an estuary strategy for the estuaries of Port Phillip Bay and Western Port	Melbourne Water	2009	High	Committed	Funded
9.24	Collaborate between agencies and universities to better understand the presence and effect of EDCs on fish and other bio-indicators across the region	Melbourne Water (DPI, Melbourne University)	2008-2013	High	Committed	Funded
9.25	Continue the nutrient flux monitoring program and review at regular intervals to inform management	DSE (EPA Victoria, DPI, Melbourne Water)	By 2013	Medium	Committed	Partially funded
9.26	Implement a program(s) to better understand how groundwater and surface water management can be integrated to enhance overall water resource protection in priority areas	DSE Office of Water	2011	Medium	Partially committed	Partially funded
9.27	Expand groundwater monitoring network and water quality monitoring in priority areas	DSE	2012	High	Not committed	Not funded

Additional investment opportunities

Additional actions will fill existing and future knowledge gaps. These activities will build on the actions detailed previously and require detailed scoping and funding for them to be implemented.

Atmospheric fallout

The uncertainty over the contribution of atmospheric sources of nitrogen to Port Phillip Bay and Western Port highlights the need for further research. To accurately understand the effects of nitrogen to marine environments in this region, it is important to know where nitrogen comes from and how much is being contributed. Further research will provide a definitive conclusion as to how important atmospheric inputs are to the nitrogen loads in the bays.

RESEARCH AND INVESTIGATIONS Additional Investment Opportunities	
No.	**Atmospheric fallout**
RI1	Determine the contribution of atmospheric sources of nitrogen to loads in Port Phillip Bay and Western Port

Climate change vulnerability mapping

The Receiving Waters model shows the sensitivity of Port Phillip Bay to excessive salinity arising from a combination of reduced rainfall/catchment flows and increased evaporation. This can alter bay circulation patterns and constrain coastal discharges (Lee *et al.*, 2007). It is therefore important to understand where the regions of greatest vulnerability will occur, based on predicted pollutant distributions, and consider what can be done to improve environmental resilience by reducing non-climate related stressors.

RESEARCH AND INVESTIGATIONS Additional Investment Opportunities	
No.	**Climate change vulnerability mapping**
RI2	Generate vulnerability maps of climate indicators relevant to water quality parameters used in *Better Bays and Waterways*, based on modelled climate projections and catchment discharge behaviour

Climate change white paper

Following the release of the Victorian Government's Green Paper on climate change, a broad public consultation program is underway prior to finalising the climate change White Paper. This will provide a good opportunity to have proposed mitigation/adaptation actions linking the actions within the White Paper and *Better Bays and Waterways*.

RESEARCH AND INVESTIGATIONS Additional Investment Opportunities	
No.	**Climate change white paper**
RI3	Implement relevant actions related to water quality from the Victorian Government's Climate Change White Paper

Improving model resolution

As concluded by the IPCC (2008), there remains a scale mismatch between the large-scale climatic models and the catchment scale – the most important scale for water management. Higher-resolution climate models (including statistical and physical downscaling models), with better land surface properties and interactions, are needed to obtain information of more relevance to water management. The following actions will require commitment and support from several agencies.

RESEARCH AND INVESTIGATIONS Additional Investment Opportunities	
No.	**Improving model resolution**
RI4	Consider the data needs for model validation when reviewing existing monitoring program design, including practical climate change adaptation options
RI5	Improve models to inform future management decisions including practical climate change adaptation options

Adaptive management

Reviews of values, condition, trends and threats to waterways and the bays is necessary to ensure management actions are targeting the highest priority threats and locations. It is also important to use monitoring data to ascertain the effectiveness of management actions and enable actions to be adapted as needed to provide protection of environmental values.

RESEARCH AND INVESTIGATIONS Additional Investment Opportunities	
No.	**Adaptive management**
RI6	Use research and monitoring data to enable review of values, conditions, trends, effectiveness of management actions and threats to the water quality of waterways and the bays as part of an adaptive management framework

Linking land management practices to water quality

It is well recognised that land management practices can impact on bay and waterway water quality, however the relative impacts of different land management practices are not as well known. Additionally whilst BMPs such as fencing and revegetating buffer strips along waterways clearly reduce the impacts of land management practices on water quality, these reductions have not yet been quantified. Improved understanding of the impacts these activities have on waterways will assist in targeting future investment to improve water quality.

RESEARCH AND INVESTIGATIONS Additional Investment Opportunities	
No.	**Linking land management practices to water quality**
RI7	Undertake research and monitoring to better understand the water quality impacts of various land management practices
RI8	Undertake research to enable quantification of the water quality benefits of improved land management practices

Chapter 10
Effective management

Community engagement

The aim of the community engagement management program is for the broader community in the Port Phillip and Western Port region to recognise the value of good water quality and participate in maintaining and improving it through understanding the issues and becoming actively involved in changing behaviour.

Better Bays and Waterways recognises this as a continual and ongoing process that is dynamic and qualitative. To work towards achieving this aim, measurable, shorter-term activities are needed to drive change and improvements in water quality.

The management actions described in this chapter fall into two categories. The first category is engagement with community members who are already actively involved in groups working to improve the health of their local ecosystems. The second category is all-encompassing and focuses on engaging with members of the general public.

Community groups

There are more than 480 volunteer community organisations and groups in the region with a primary or major interest in the environment (PPWCMA and DPI, 2003). Community involvement in water quality issues is essential to achieving the region's water quality targets. Community groups can influence the values prescribed to waterways, and the uptake of management actions. Government agencies need to work collaboratively with community groups that are already working hard towards driving and achieving environmental improvements.

Broader community

While their potential to drive change is large, the membership of community groups is only a small proportion of the population. Water quality affects and is affected by the whole population of the region – more than 5 million people. The *Better Bays and Waterways* community perceptions surveys (ResearchWise, 2006 and Ipsos, 2007) identified that water quality was not well understood by the broader community, who tend to focus on visual and sensory indicators of water quality, such as the presence of litter, bad smells and oils, or fish, frogs and platypus.

Community perceptions surveys

Regularly surveying the community gives us a measure of success of management programs. Regular surveys can measure change in perceptions, knowledge and ownership of water quality issues by the community. Melbourne Water regularly surveys the community about its perceptions of waterways. The information from these surveys will be used to report changes in community perceptions every two years (action 10.1).

COMMUNITY ENGAGEMENT Actions	
No.	**Community perceptions surveys**
10.1	Regularly survey community members through Melbourne Water's waterways market research program to measure their ownership and understanding of local waterways

Targeted community education

It is important that Government supported community programs like Waterwatch (Chapters 4 and 9) continue to provide support for community members, schools and businesses to be involved in and educated on protecting water quality. Of equal importance are community education programs at festivals such as Moomba and with schools as well as tours of facilities such as the Western Treatment Plant to educate the community about water issues (action 10.2).

COMMUNITY ENGAGEMENT Actions	
No.	**Targeted community education**
10.2	Continue educational programs run by Melbourne Water at schools and festivals to promote understanding of water quality

Community engagement through program implementation

Responsibility for delivering the actions of *Better Bays and Waterways* sits primarily with government agencies, who will implement actions as outlined in each management program. It is critical that the broader community understands the opportunities for individuals to act to improve water quality as outlined in this plan. The mechanisms for delivery may be varied, as stakeholders have different motivations and avenues for achieving water quality outcomes. The development of a single, overarching approach would therefore be inappropriate.

Specific programs to improve water quality have been outlined throughout Part 2 of *Better Bays and Waterways*. All management programs will need to identify the type of community engagement that is needed to implement the actions within the programs (action 10.3).

COMMUNITY ENGAGEMENT Actions	
No.	**Community engagement through program implementation**
10.3	Identify the type of community engagement that is needed to successfully implement the management programs within *Better Bays and Waterways*

Reporting to the community

The Reporting, Evaluation and Review section of this chapter outlines the method for reporting on the management activities within *Better Bays and Waterways*. A water quality report will be published annually to report to the community on water quality in the region – including in the bays and waterways.

Community engagement management program	
Aim	For the community to recognise the value of good water quality and participate in maintaining and improving it through understanding the issues
Water quality benefits: *quantified load impact*	Not quantifiable
Water quality benefits: *additional*	Although not quantifiable, effective community engagement will contribute to reductions in pollutants including nutrients, toxicants, and pathogens such as *E.coli*
Additional environmental benefits	Improved community awareness of environmental issues
Economic benefits	Effective community engagement and consultation ensures actions align with the values and needs of the entire community. Engagement and consultation throughout action implementation ensures budgets and spending are cost-effective.
Social benefits	Community understanding and ownership of waterways improvements can lead to changed behaviours to improve water quality. Good water quality benefits the community by making waterways and bays safe and available for recreational purposes and aesthetic enjoyment

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
10.1	Regularly survey community members through Melbourne Water's waterways market research program to measure their ownership and understanding of local waterways	Melbourne Water	Ongoing	Low	Committed	Funded
10.2	Continue educational programs run by Melbourne Water at schools and festivals to promote understanding of water quality	Melbourne Water (Waterwatch Melbourne)	Ongoing	Medium	Committed	Funded
10.3	Identify the type of community engagement that is needed to successfully implement the management programs within *Better Bays and Waterways*	Refer to lead in each Part 2 management action	2009-2013	NA	Committed	NA

Additional investment opportunities

Further community engagement actions would build on the activities detailed above and benefit water quality into the future. These activities would contribute towards the targets outlined in Chapter 5 and benefit both waterways and the bays. These actions require detailed scoping and funding must be sought for implementation.

These actions would fit into the integrated framework of projects as detailed above, but either represent the next stage or provide opportunity for expanded actions to improve water quality.

Public availability of water quality data

Existing water quality data is publicly available through several avenues. Organisations publish water quality data in various forms for the projects mentioned above. On a state-wide scale, the Victorian Water Resources Data Warehouse aims to be a central internet-based repository for both raw and summary data on water quality and quantity throughout Victoria. However, there still appears to be a lack of regionally meaningful and easily accessible water quality data and interpretation to actively inform the broader community about water quality in this region. To improve water quality across the region, it is important to have water quality targets and current water quality information accessible by the broader community.

It is also important to explore the different avenues available for reporting this data to maximise the potential number of people receiving the information. Greater numbers of people who understand the importance of good water quality, will drive more motivation and pressure to support commitment and investment into management decisions.

COMMUNITY ENGAGEMENT Additional Investment Opportunities	
No.	**Public availability of water quality data**
CE1	Regularly report and publicise scientific and community collected water quality data for the waterways, estuaries and bays of the Port Phillip and Western Port region using a variety of media channels

Marine monitoring

Freshwater environments have well established community monitoring programs such as Waterwatch. Community monitoring programs for marine environments are becoming established. Current programs can play an important role in engaging the community in marine water quality issues.

COMMUNITY ENGAGEMENT Additional Investment Opportunities	
No.	**Marine monitoring**
CE2	Regularly publicise opportunities, including community monitoring, to enhance community engagement in water quality issues for Port Phillip Bay and Western Port

Engaging the broader community

Engaging the broader community will require a coordinated approach to ensure any future projects align with and complement existing programs. An audit of past and current water quality programs, including responsibility for delivery, will prevent duplication of actions, build capacity to achieve outcomes, highlight gaps and available resources, and identify which parts of the community have/have not been engaged, and how current programs can be enhanced to engage them.

The audit is likely to identify existing tools that can be used to convey messages to broader audiences. Examples could be messages in water bills from water authorities and council rates notices and 'report cards' in community centres.

COMMUNITY ENGAGEMENT Additional Investment Opportunities	
No.	**Engaging the broader community**
CE3	Assess the existing community engagement programs that relate to water quality across the region and identify opportunities for alignment and co-messaging

Supporting the community

Chapter 4 described the current arrangements for supporting community groups. Strategic support is essential for ensuring alignment between community goals and regional NRM goals align and will aid in the attainment of water quality outcomes. It is important for this support to continue into the future.

COMMUNITY ENGAGEMENT Additional Investment Opportunities	
No.	**Supporting the community**
CE4	Provide strategic support to community groups in the Port Phillip and Western Port region (expected lead: PPWCMA and Melbourne Water)
CE5	Build the capacity of the community to undertake actions to enhance and protect water quality in Western Port and Port Phillip Bay, including actions to improve water quality in waterways within the bays' catchments.

Community perceptions

Both the marine and waterways community perceptions reports listed recommendations to improve the community's understanding of water quality issues and to bring about positive behaviour change.

The recommendations from the waterways community perceptions report are:

- Awareness and understanding – simplify the cause and effect and separate from conservation issues; regularly and simply report water quality indicator information; tie measures into the public's experiences/actions with waterways and remove the science. Focus on identified misconceptions and knowledge gaps such as clarifying the difference between stormwater and wastewater/sewage. Within stormwater educational campaigns, educate the public on the main pollutants of concern (i.e. nitrogen, phosphorus, heavy metals, etc.);
- Association with local community context – good/bad information on various sites coordinated and publicised to raise awareness and coordinate information between authorities; and
- Connect to the individual – focus on areas where people can make a day-to-day difference; use community-friendly terminology when engaging with community to highlight its importance; remind community of positive behaviours and tie to complementary measures they can employ.

The recommendations from the marine community perceptions report are to:

- Clarify policy and management issues by: researching specific desired behaviours for the community and target groups; linking government water saving campaigns to reducing stormwater inputs to bays; developing leadership in environmental practices through local and state governments including raingardens; and providing toilet and rubbish facilities near around the bays, including recycling and incentives;
- Improve communications by: developing a communications campaign that includes engagement and encouragement, and enables community to adopt practices that contribute to improving water quality; providing information needed on simple day-to-day activities that can contribute; providing detailed information explaining the difference between stormwater and sewage; developing a communications strategy that includes five steps of change; and providing visual and aural communications targeted at the various community groups; and
- Conduct further research to: better understand the drivers and barriers associated with desired behaviours; explore avenues for the need and development of future community group segmentation and targeted behaviour change intervention programs (i.e. interviews with individual households to explore behaviour drivers and barriers); campaign strategies that are both focused on broad and more targeted community groups; and develop a community behavioural change campaign that includes communication concept and execution testing.

Many of these recommendations need further scoping, funding, and commitment before they can be implemented. It is clear from the recommendations that some issues are common perceptions to both marine and freshwater water quality, and it may be possible to address some of these in a program targeting the region as a whole.

COMMUNITY ENGAGEMENT Additional Investment Opportunities	
No.	**Community perceptions**
CE6	Prioritise and implement the recommendations from the waterways and marine community perceptions reports

Comprehensive social marketing

As with the other management programs of *Better Bays and Waterways*, there is a need to adaptively manage community engagement. This involves investing in several actions to ensure that targeted messages are reaching and affecting their audiences, agencies are aware of behaviour change strategies, and community perceptions of waterways and bays are continually monitored and understood from regular surveys.

COMMUNITY ENGAGEMENT Additional Investment Opportunities	
No.	**Comprehensive social marketing**
CE7	Invest in social marketing (e.g. by using newsletters, media and websites) to improve the public's knowledge of water quality issues
CE8	Improve agency awareness of the motivational factors for community engagement on water quality issues through a regional approach that engages communities sector by sector
CE9	Establish a holistic survey and education program to inform and direct management of the community's perception of freshwater, marine and estuarine water quality

Governance

Current governance arrangements comprise several government agencies and departments undertaking a range of different actions that affect water quality, often in a disparate manner. Those involved in investment in on-ground actions are not always those involved in target setting, monitoring or reporting. A coordinated approach is required to guide the implementation of *Better Bays and Waterways* to provide better linkages between on-ground actions, target setting, monitoring and reporting on water quality in the region.

In January 2006, the Victorian Government released the *Yarra River Action Plan: Securing Water Quality for a Healthy Future*. The Yarra Coordinating Committee was set up by the Minister for Water to guide the delivery of around $600 million of initiatives to improve the health of the river over the long term. The Committee comprises the heads of key agencies involved in delivering water quality results and is independently chaired.

A similar structure comprising a partnership of key agencies, departments and local government involved in water quality improvements will be formed to oversee implementation of *Better Bays and Waterways* (action 10.4). Under the *Better Bays and Waterways* structure, agencies would maintain control of their own funding, however improved coordination of activities and better information sharing would result from a regional partnership approach.

This approach, together with the monitoring and reporting outlined in *Better Bays and Waterways*, will ensure that the approach to managing water quality issues in the region is informed, coordinated and adaptive. This will provide significant value to our collective efforts to protect and enhance the quality of water in our region.

This model requires high-level support across all agencies to work effectively and requires senior representatives from each agency as well as administrative support. An established committee will ensure participation in priority setting and coordinated investment in actions that affect water quality and loads.

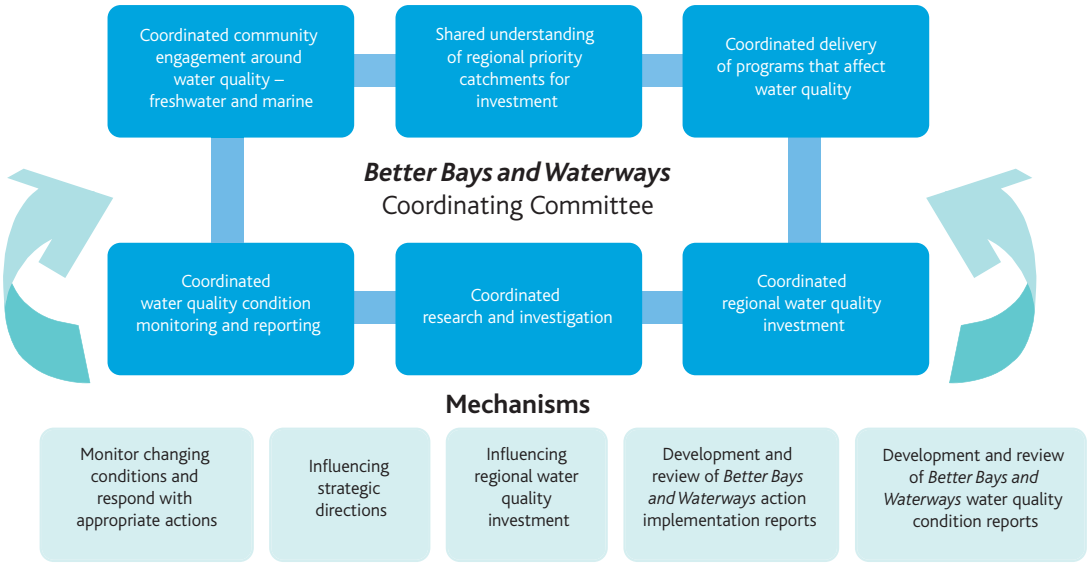
The committee's aims and the mechanisms for delivery of these aims are shown in Figure 10.1.

The committee as described will be supported by administrative resources (action 10.5). This support will provide communication, coordination and administrative assistance to the committee. Specific responsibilities will include the coordination of the committee and the delivery of the annual *Better Bays and Waterways* water quality update and implementation report (see actions 10.6 and 10.7).

The coordinating committee will also hold an annual forum to engage with the community on the progress of *Better Bays and Waterways*. These annual meetings will provide the opportunity for the community to raise water quality-related issues.

GOVERNANCE Actions	
No.	**Governance**
10.4	Initiate a coordinating committee to oversee the implementation of *Better Bays and Waterways*
10.5	Establish and engage a resource to support the administrative needs of the coordinating committee

Figure 10.1: Coordinating Committee aims



Governance program	
Aim	To provide a coordinated approach to reporting on and steering water quality outcomes
Water quality benefits: *quantified load impact*	N/A
Water quality benefits: *additional*	The coordinating committee will monitor the progress of actions to ensure water quality targets and outcomes are achieved.
Additional environmental benefits	N/A
Economic benefits	N/A
Social benefits	N/A

Actions:

No.	Description	Lead agency (support agencies)	Action timeframe	Cost	Commitment	Funding
10.4	Initiate a coordinating committee to oversee the implementation of *Better Bays and Waterways*	Melbourne Water (DSE, EPA Victoria, DPI, PPWCMA, Parks Victoria, LG and others)	Inception by 2010	Medium	Committed	Funded
10.5	Establish and engage a resource to support the administrative needs of the coordinating committee	Melbourne Water	2009-2014	Medium	Committed	Funded

10 Effective management

Reporting, evaluation and review

The reporting, evaluation and review program comprises three areas of actions:

- Water quality reporting: reporting on water quality condition against waterway targets, bay load targets and flux targets, including analysis of water quality monitoring and reporting on progress towards the plan's resource condition targets;
- Implementation reporting: reporting on implementation of the *Better Bays and Waterways'* management actions and progressive attainment of the management programs, including evaluation and review of the actions and programs; and
- Review: review of water quality actions and incorporation of future actions of the management programs into the future Regional Strategy for Healthy Rivers, Estuaries and Wetlands (currently the Regional River Health Strategy), Regional Catchment Strategy and environmental management plans as these documents are reviewed.

Water quality reporting (water quality and loads)

The PPWCMA produces a catchment condition report in the form of an annual report card. It presents catchment conditions as letter-based grades supported by a brief interpretive text. It is aimed at general public readership and has been distributed through a mass-circulation daily newspaper. It is proposed that this design be adapted for general public reporting on water quality and loads by *Better Bays and Waterways*.

The *Better Bays and Waterways* water quality report card will be an annual, water quality-focussed update reporting on water quality and loads (action 10.6).

The update will use the knowledge developed through *Better Bays and Waterways'* development, such as recommendations on nitrogen load reporting and waterway target setting. The primary aim of the update will be to inform the community about the condition of water quality in the region.

REPORTING, EVALUATION AND REVIEW Actions	
No.	**Water quality reporting (water quality and loads)**
10.6	Develop an annual water quality and loads update, possibly in the form of a report card

Implementation reporting

Better Bays and Waterways' actions will be led and undertaken by up to five state agencies and departments and 38 local governments. Reliable and informative tracking of actions will be critical for:

- reporting on progress;
- creating and reinforcing accountability; and
- creating a functional 'history book' about *Better Bays and Waterways*.

The primary function for the implementation report will be to inform the coordinating committee and assist with the adaptive management of actions (action 10.7). Together with water quality monitoring, this will build our ability to assess how actions have effected environmental change.

In order to provide implementation reporting, all lead agencies will need to provide annual implementation progress reporting in a consistent format (action 10.8).

Implementation reporting will be coordinated through a database such as the PPWCMA's Action Tracking database.

REPORTING, EVALUATION AND REVIEW Actions	
No.	**Implementation reporting**
10.7	Develop an annual *Better Bays and Waterways* implementation report
10.8	Annually report on the implementation of *Better Bays and Waterways* actions

Coordinating with existing reporting

DSE reports annually on the Port Phillip Bay EMP, through the Bay Action Report. As *Better Bays and Waterways* will also report on nitrogen loads and catchment actions to reduce loads, it will be important for there to be coordination between the EMP and *Better Bays and Waterways* reporting to reduce duplication (action 10.9).

REPORTING, EVALUATION AND REVIEW Actions	
No.	**Coordinating with existing reporting**
10.9	Coordinate the Port Phillip Bay EMP review and reporting with *Better Bays and Waterways* reporting

Review

The water quality objectives will be reviewed as part of the SEPP (WoV) review scheduled to be undertaken in 2013 (action 10.10). The progress towards attainment of the SEPP (WoV) objectives, reduction in nutrient and total suspended solids loads and the achievement of actions through *Better Bays and Waterways* will inform the review of the SEPP (WoV) objectives.

The need to review and update *Better Bays and Waterways* will be determined, and will depend on any water quality gaps following the review of the:

- Regional River Heath Strategy (to become the Regional Strategy for Healthy Rivers, Estuaries and Wetlands) which is intended to incorporate a larger focus on water quality;
- Regional Catchment Strategy; and
- Port Phillip Bay Environmental Management Plan.

The review of these strategies will need to incorporate the relevant actions and their outcomes from *Better Bays and Waterways* (action 10.11).

REPORTING, EVALUATION AND REVIEW Actions	
No.	**Review**
10.10	Review the SEPP (WoV) water quality objectives
10.11	Incorporate the actions and outcomes from *Better Bays and Waterways* into the reviews of the Regional Strategy for Healthy Rivers, Estuaries and Wetlands (currently Regional River Health Strategy) and Regional Catchment Strategy

Reporting, evaluation and review program	
Aim	To track and report on the implementation of the management actions and programs in *Better Bays and Waterways* and report on progress towards the targets
Water quality benefits: *quantified load impact*	N/A
Water quality benefits: *additional*	N/A
Additional environmental benefits	N/A
Economic benefits	N/A
Social benefits	Education, engagement

Actions:

No.	Description	Lead (support) agency	Action timeframe	Cost	Commitment	Funding
10.6	Develop an annual water quality and loads update, possibly in the form of a report card	*Better Bays and Waterways* coordinating committee	2010-2014	Medium	Partially committed	Partially funded
10.7	Develop an annual *Better Bays and Waterways* implementation report	*Better Bays and Waterways* coordinating committee	2010-2014	Low	Partially committed	Partially funded
10.8	Annually report on the implementation of *Better Bays and Waterways* actions	All lead agencies	2010-2014	Low	Committed	Unfunded
10.9	Coordinate the Port Phillip Bay EMP review and reporting with *Better Bays and Waterways* reporting	DSE (Melbourne Water, EPA Victoria)	2010-2014	Low	Committed	Unfunded
10.10	Review the SEPP (WoV) water quality objectives	EPA Victoria (Melbourne Water, DSE)	2013/14	Medium	Committed	Funded
10.11	Incorporate the actions and outcomes from *Better Bays and Waterways* into the reviews of the Regional Strategy for Healthy Rivers, Estuaries and Wetlands (currently Regional River Health Strategy) and Regional Catchment Strategy	Melbourne Water/CMA	RCS - 2009/10 RRHS - 2012	Low	Committed	Funded

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Glossary

Adaptive Management
A cyclical process that regularly reviews management approaches and takes account of new data and emerging technologies.

Annual Horticulture
The cultivation of seasonal plants (e.g. vegetables, fruits or flowers).

Anoxic
Relating to or marked by a severe deficiency of oxygen in tissues or organs.

Aquaculture
The cultivation of aquatic animals and plants.

Aquifer
A layer of underground sediments that holds water and allows water to flow through it.

Atmospheric fallout
The sedimentation of dust or fine particles from the atmosphere.

Average Annual Load
Load generated from the 1998 rainfall record, which was considered to be an 'average' rainfall year for the scenario period, which used rainfall records from 1990 to 2005.

Baseflow
The component of streamflow supplied by groundwater discharge.

Beneficial Use
A use of the environment that is conducive to public benefit, welfare, safety, health or aesthetic enjoyment and which requires protection from the effects of waste discharges.

Benthic
Pertaining to bottom. Hence, benthic macroinvertebrates are organisms living at the bottom of a water body.

Benthic flux
The rate that chemicals dissolved in water flow out of or into the bottom of aquatic systems; represents the transport of dissolved chemical species across the solid-liquid interface at the bottom of aquatic systems. The flux of solutes can be either positive (into the water column from the sediment) or negative (out of the water column into the sediment) and can vary over multiple temporal and spatial scales.

Bioaccumulation/Bioavailable
The accumulation of a substance, such as a toxic chemical, in various tissues of a living organism. Bioaccumulation takes place within an organism when the rate of intake of a substance is greater than the rate of excretion or metabolic transformation of that substance. Substances are said to be bioavailable to an organism when they can be bioaccumulated.

Bulk Entitlement (BE)
The right to water held by water and other authorities defined in the Water Act 1989. The BE defines the amount of water that an authority is entitled to from a river or storage, and may include the rate at which it may be taken, and the reliability of the entitlement.

Catchment
The area of land drained by a creek or river system, or a place set aside for collecting water which runs off the surface of the land.

Contaminant
A substance found in water that if present in excessive quantities may have harmful effects.

Denitrification
Microbially facilitated process of converting nitrate to N_2 gas.

Denitrification efficiency

Percent of the ammonia that is produced by organic matter remineralisation in the sediment which is released to the atmosphere as N_2 gas.

Diffuse source pollution
Pollution that can be attributed to many minor catchment events and subsequent flows (even after only minor rainfall in urban catchments), groundwater discharge and atmospheric fallout.

E. coli
Bacteria (*Escherichia coli*) normally found in the human gastrointestinal tract and existing as numerous strains, some of which are responsible for diseases and symptoms like diarrhea.

Ecosystem
A dynamic complex of plant, animal, fungal and micro-organism communities and the associated non-living environment interacting as an ecological unit.

EcoTender
A process aimed at improving native vegetation management by landholders competitively tendering to improve the quality or extent of their native vegetation. The benefit offered by these contracts is assessed according to a range of environmental outcomes being sought including terrestrial biodiversity, reduced saline land and riverine health (water quality and quantity). Carbon sequestration is also factored into revegetation tenders.

Effective Imperviousness (EI)
The combined effect of the proportion of constructed impervious surfaces in the catchment, and the 'connectivity' of these impervious surfaces to receiving water bodies.

Enterococc
A usually non-pathogenic streptococcus that inhabits the intestine, but is often used as an indication of other disease-causing bacteria.

Environmental flows
A regime of designated flows in a stream or river needed to satisfy specified ecological requirements.

Environmental Water Reserve (EWR)
The share of water resources set aside to maintain the environmental values of a water system and other water services which are dependent on the environmental condition of the system.

Eutrophic/Eutrophicatio
A condition where a water body has high levels of nutrients leading to accelerated plant growth and reduced oxygen availability, often leading to algal blooms.

Filtered Reactive Phosphorus (FRP)
The biologically active form of phosphorus that influences plant growth (such as algae and seagrass).

Greenfield
A piece of usually semi-rural property that is undeveloped except for agricultural use, especially one considered as a site for expanding urban development.

Greenspace
Open urban space for recreation.

Greywater
Household water which has not been contaminated by toilet discharge and includes water from bathtubs, dishwashing machine and clothes washing machines.

Groundwater
All sub-surface water, filling the porous spaces in soils. It is the source of water for aquifers and springs.

'High pulse' event
An irregular weather events that generates high volumes of water that channel down waterways to the bays.

Horticulture
The cultivation of plants.

Hypoxia
Inadequate supply of oxygen.

Impervious Surface
Mainly constructed surface – rooftops, sidewalks, roads, and parking lots – covered by impenetrable materials such as asphalt, concrete, brick, and stone.

Infill
The planned conversion of empty lots, underused or rundown buildings, and other available space in densely built-up urban and suburban areas for use as sites for commercial buildings and housing, frequently as an alternative to overdevelopment of rural areas.

Load
Quantity of a contaminant measure in kilograms.

Macroinvertebrate
An animal without a backbone that can be seen by the naked eye, including most insects.

Glossary

Maximum Residue Limit
For some types of chemical pollutants in food, regulatory authorities publish standards called Maximum Residue Limits (MRLs). They are used as regulatory standards to control the level of allowable contamination in food. There is no specific implication that consumption of food where the MRL is exceeded would necessarily result in adverse health effects. However, the setting of such levels would take into account the assumption that it represents a safe level in relation to the potential for adverse health effects when food at the MRL is consumed.

Mixing Zone
Zone where discharged water and natural water combine.

Nitrogen cycling
The biogeochemical cycle that describes the transformations of nitrogen and nitrogen-containing compounds in nature.

Nitrogen flux
Is the movement of nitrogen and nitrogen-containing compounds within a sphere and from one sphere to another, and is computed from concentration, mass, and time.

Nutrients
Elements and compounds (e.g. nitrogen and phosphorus) required to support beneficial plant growth. In high concentrations, nutrients can contribute to nuisance plant growth and potentially toxic algal blooms (SKM 2007). In addition, the death and decay of algal blooms can reduce the amount of dissolved oxygen available to aquatic life, sometimes causing extensive fish kills.

Outfall
The site of discharge of a liquid from a pipe. Applied particularly to the point at which a sewer discharges to a treatment works or receiving water (such as river, creek or bay).

Pasture irrigated
Plants for feeding livestock that are watered artificially by diverting streams, flooding, or spraying.

Pasture non-irrigated
Plants for feeding livestock that are not watered artificially by diverting streams, flooding, or spraying.

Pathogens
An agent that causes infection or disease, especially a microorganism, such as a bacterium, protozoan, or a virus.

Pathogens such as faecal coliforms (e.g. *E. coli*) and *Enterococci* enter waterways and bays from a number of sources including sewage effluent, people using the water for recreational activities, livestock, industrial processes, farming activities, domestic animals and wildlife. Levels of micro-organisms commonly increase after rainfall when they get washed into rivers from the catchment and occasionally from overflows from the sewerage system (SKM 2007). As a result, human health may be at risk from direct contact with contaminated waters, such as when swimming, or from eating contaminated aquatic life, such as oysters and fish. These types of pathogens threaten human health by causing diseases like gastroenteritis, hepatitis and other diseases.

Perennial horticulture
The cultivation of persistent/everlasting plants (e.g. vegetables, fruits or flowers).

Point Source
Discharge to receiving waters from a single point, such as a pipe or drain. Point sources of pollution enter receiving water at a discrete, indentifiable location and can be measured (Fletcher and Deletic, 2006).

Pollutant
A substance or item that contaminates the water, air or land.

Ramsar Convention
The Ramsar Convention on Wetlands is an international agreement signed in 1971 in the city of Ramsar, Iran.

Receiving water
The marine environment within the Port Phillip and Western Port catchments that receive freshwater inflows from catchment waterways.

Refugia
Refuges; an area where special environmental circumstances have enabled a species or community of species to survive.

Regulated system
System where the flow of the river is regulated through the operation of large dams or weirs.

Representative water
Rivers that are representative of the classes of rivers that were present at the time of European settlement.

Reticulated sewerage system
The system of pipes, sewers and drains that are used to convey sewage from a property to a sewage treatment plant.

Riparian
Of, pertaining to, or situated or dwelling on the bank of a river or other body of water.

Run-off
Precipitation or rainfall that flows from a catchment into streams, lakes, rivers or reservoirs.

Sediment Load
The transportation of sediment is a natural and vital function of rivers and creeks and during floods large amounts of sediment can be deposited on floodplains providing fertile soils for vegetation growth (SKM 2007). However, excessive sediment loads have many undesirable effects on receiving waters, such as siltation, smothering of aquatic ecosystems and reduced light penetration, which cause changes to primary production and ultimately impacts the entire food chain. Sediments may also transport considerable loads of nutrients, heavy metals and organochlorines, as these materials are commonly attached to sediment particles. Soil erosion is the major contributing factor to the discharge of sediments to coastal waters, and is exacerbated by land clearing, poor cultivation practices and urban development.

Sewage
The waste matter that passes through sewers.

Sewage Treatment Plant
A plant where sewage is treated and disposed.

Sewerage
A system of sewers that removes wastewater.

Stormwater
Rainfall that runs off roofs, roads and other surfaces where it flows into gutters, streams, rivers and creeks, and eventually into the bays. This water can carry contaminants such as plastic bags, detergents, nutrients, heavy metals, pathogens and other toxicants.

Stratification
Formation of layers in an estuary, freshwater and saltwater stratification means they are in distinct layers.

Suspended solids/sediments
Solid particles transported in a liquid; a water quality parameter.

Toxicants/Toxins
A chemical compound that can have negative effect on organisms.

Tributary/Tributaries
A stream or streams which flow into a larger waterway.

Turbidity
The presence of fine suspended matter such as clay or silt in water causing the water to be cloudy or muddy in appearance.

Unregulated system
A river system where no major dams or weir structures have been built to assist in the supply or extraction of water

Viticulture
The cultivation of grapes and grape vines; grape growing

Wastewater
Water that has been used domestically or commercially.

Working together to create healthy bays and waterways

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