Development of environmental quality indicators and objectives for SEPP (Waters)

EPA VICTORIA

Environment Protection Authority Victoria

VICTORIA State Government

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Contents

Abbreviations

ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AUSRIVAS	Australian River Assessment System
DELWP	Department of Environment, Land, Water and Planning, Victoria
EPA	Environment Protection Authority Victoria
FSANZ	Food Standards Australia New Zealand
NHMRC	National Health and Medical Research Council
PCB	Project Control Board
SAP	Science Advisory Panel
SEPP	State environment protection policy
SEPP (GoV)	State Environment Protection Policy (Groundwaters of Victoria)
SEPP (WoV)	State Environment Protection Policy (Waters of Victoria)
TDS	Total Dissolved Solids
WHO	World Health Organization
WQIP	Water Quality Improvement Plan

Executive summary

State environment protection policies (SEPPs) are statutory policies established under the *Environment Protection Act 1970*. They help establish the basis for maintaining environmental quality sufficient to protect beneficial uses (such as protecting aquatic ecosystems or people's drinking water). SEPPs aim to safeguard environmental values and people's activities in Victoria that need protection from the effects of pollution and waste. SEPPs achieve this by:

- expressing in law the expectations, needs and priorities the community has for using and protecting the environment
- setting out values and uses of water environments that Victorians want to protect, and the environmental quality indicators and objectives required to protect them
- describing the management actions and programs that will ensure that the necessary environmental quality is protected and, where possible, improved.

The Department of Environment, Land, Water and Planning (DELWP) and the Environment Protection Authority Victoria (EPA) have developed a new SEPP that covers surface waters, marine waters, estuarine waters and groundwater. This new SEPP, known as SEPP (Waters), replaces SEPP (Waters of Victoria), five regional schedules, and SEPP (Groundwaters of Victoria), with a new single policy.

The development of SEPP (Waters) has involved an extensive scientific review conducted by EPA, including a review of the segments (areas with common environmental conditions), beneficial uses, and environmental quality indicators and objectives for different beneficial uses in different water environments. As part of this process, EPA prepared extensive technical papers explaining the justification for the proposed changes, why they were proposed, and the evidence behind the decision making.

This report summarises those extensive technical papers to assist stakeholders to understand the process EPA followed in developing the environmental quality indicators and objectives in the SEPP (Waters).

This publication updates and replaces EPA publication 1688 *Development of environmental quality indicators and objectives for the draft SEPP (Waters),* reflecting changes to indicators, objectives, load targets, segments and beneficial uses in response to public submissions on the draft SEPP.

1. Introduction

1.1. What are state environment protection policies (SEPPs)?

Victorians value our diverse water environments. The primary regulatory mechanism for protecting these waters from pollution is the *Environment Protection Act 1970*. The Act defines the high-level objectives for the protection of Victoria's water environments and gives EPA roles, responsibilities and powers to protect the environment.

State environment protection policies (SEPPs) support the Act by providing environmental standards and obligations for different parts of the environment. SEPPs have been a core component of environmental protection in Victoria since the 1970s.

Previously, several SEPPs for water were established at different times to protect surface waters and groundwater across Victoria. These included regional schedules, which had environmental quality indicators and objectives, and policy obligations set at a regional scale for particular catchments or water environments. The former water SEPPs include:

- SEPP (Waters of Victoria) 2003
    - Schedule F3 (Waters of the Gippsland Lakes and Catchment) 1988
    - Schedule F5 (Waters of the Latrobe & Thomson River Basins & Merriman Creek Catchment) 1996
    - Schedule F6 (Waters of Port Phillip Bay) 1997
    - Schedule F7 (Waters of the Yarra Catchment) 1999
    - Schedule F8 (Waters of Western Port and Catchment) 2001
- SEPP (Groundwaters of Victoria) 1997

1.2. Key elements of the SEPP

The purpose of SEPPs are to establish the basis for maintaining environmental quality sufficient to protect existing and anticipated beneficial uses. The *Environment Protection Act 1970* lists the main components that are required for a SEPP. These include identifying:

- beneficial uses to be protected within the boundaries of the policy
- environmental indicators to be used to measure and define environmental quality
- environmental quality objectives
- programs, processes, tools and mechanisms by which the environmental quality objectives are to be attained and maintained.

The focus of this summary report is on the science components of SEPP (Waters). The report presents information on the beneficial uses, segments, and environmental quality indicators and objectives of the SEPP, where:

- **Beneficial uses** define the values or uses of water environments that Victorians want to protect, and which are dependent on suitable quality water.
- **Segments** define geographic areas that share common environmental conditions and natural characteristics (or levels of total dissolved solids (TDS) for groundwater). Segments include cleared foothills and coastal plains, wetlands and lakes, and estuaries. Natural characteristics, including baseline water quality, vary across different segments of the environment, so objectives need to reflect this variation.

- **Environmental quality indicators** are physical, chemical and biological conditions that are characteristic of healthy water environments and can be used to determine if a threat to beneficial uses is present. For example, an environmental quality indicator for rivers and streams is the measured amount of total phosphorus. This is because phosphorus indicates nutrient levels in water, and elevated nutrient levels can lead to problems such as toxic algal blooms.
- **Environmental quality objectives** define the level of water quality necessary to protect beneficial uses. Environmental quality objectives describe the concentration, level or biological state/condition of an indicator for different segments that would *not* cause harm or pose a significant risk to beneficial uses.

1.3. National Water Quality Management Strategy

To understand SEPP (Waters), it is helpful to understand the broader water quality management framework in which the SEPP operates.

The National Water Quality Management Strategy is an Australian Government initiative in partnership with state and territory governments to provide a national, strategic direction for the management of Australia's surface water, groundwater and coastal water.

The strategy is based on nationally agreed policies and principles for water quality management. This strategic direction forms the basis for plans to manage water quality while allowing for local conditions in particular catchment areas.

The strategy has also driven the production of a range of guidelines covering key elements of the water cycle. In particular, the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*[1] (ANZG) establishes water quality 'trigger values' for the protection of a range of environmental values for water resources, such as drinking water, recreation and ecological values.

1.3.1. ANZG Guidelines

The ANZG Guidelines provide a nationally consistent framework for water quality management. Many aspects of this framework have been adopted in the SEPP (Waters), and this framework largely informed the scientific work undertaken by EPA in the SEPP (Waters) Review ('the Review').

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality were revised in 2018, updating and replacing the previous guidelines published in 2000 (commonly referred to as the ANZECC Guidelines). EPA considered the most recent science informing the revision of these guidelines in developing SEPP (Waters).

Throughout this document both the ANZG and ANZECC Guidelines are referred to. ANZECC Guidelines are referred to when describing what was included in SEPP (Waters of Victoria), SEPP (Groundwaters of Victoria) and the schedules, as these were the guidelines that were contemporary at the time and that these policies reference. The ANZG is referred to when describing what is adopted, or informs, SEPP (Waters), as these are now the most contemporary guidelines. It should be noted that in many cases the ANZG did not make substantial revision to what was in the ANZECC guidelines and so the impacts of adopting

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[1] ANZG 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

the new guidelines are minimal. This is particularly true for most toxicant guideline values and guidelines values for primary industries and aquaculture.

Community values

An early step of the ANZG Guidelines framework involves identifying ‘community values’. Community values are values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health, and which require protection from the effects of pollution, waste discharges or waste deposits. These could include values such as the protection of aquatic ecosystems, drinking water, recreation, cultural and spiritual values, visual amenity, and agricultural water for irrigation, livestock and aquaculture.

SEPP (Waters) adopts the concept of community values, which are known as beneficial uses in the SEPP.

Water quality guidelines

Once the community values are identified, there is a need to identify the level of environmental quality required to protect these values. The ANZG include a range of values for chemical, physical and biological indicators found within water environments and sediment. A guideline value is a numerical concentration limit, a biological state or condition, or a narrative statement that is recommended to support and maintain a particular use of water. Levels above water quality guideline values may have a direct toxic effect on organisms (such as heavy metals), can adversely affect environmental values when levels are too high (due to effects of excessive nutrients), or too low (due to low oxygen).

Exceedance of these guideline values indicates a potential for an impact to occur, or that it has occurred. Hence the guideline values are intended to be ‘triggers’ to prompt a management response, such as further investigation to identify the source of pollution or contamination. The indicators and objectives of SEPP (Waters) are used in the same way as guidelines values, as indicators of potential impacts to beneficial uses and triggers for further investigation.

Levels of ecosystem protection

For some community values, it may not be feasible to protect all water resources to the same level, and the community may wish to aim for different levels of protection. The ANZG recognise three levels of protection for aquatic ecosystems, based on the condition of the ecosystem. These are: *high conservation or ecological value systems*; *slightly to moderately disturbed ecosystems*; and *highly disturbed ecosystems*.

Using this concept, SEPP (Waters) sets environmental quality objectives at different levels of ecosystem protection for *largely unmodified, slightly to moderately unmodified* and *highly modified water environments* for surface waters. For example, environmental quality objectives for rivers and streams are set for a higher level of protection in largely unmodified areas that have high ecological values, such as the Highlands and Uplands A or Uplands B segments, while objectives are set for a lower level of protection for areas that have been modified by agriculture or development, such as the Central Foothills and Coastal Plains segments. Toxicant objectives are set at levels are that protective of 99% of species in *largely unmodified* water environments, 95% of species *slightly to moderately unmodified* and 90% of species in *highly modified* water environments.

Locally derived values

The ANZG provide a process for the determination of locally derived or site-specific values, which may be more representative of a waterway's local conditions. This is because ANZG provide broad, nationally applicable default guideline values that indicate ecosystem protection, but are not likely to reflect all local baseline conditions due to the variation in natural characteristics across Australia. Locally appropriate objectives are preferable as they better reflect the local conditions of Victorian waterways. As such, SEPP (Waters) adopts this approach where sufficient water quality data is available.

Victoria has extensive water quality datasets for some water environments, such as rivers and marine waters, to develop environmental quality objectives that are based on local water quality data. For example, for rivers and streams, water quality data from 1990-2013 was used to derive environmental quality objectives in SEPP.

The process outlined in ANZG involves identifying the most appropriate indicator relevant to the environmental threat.

Reference sites are used to derive local values for indicators. Ideally, reference sites are those that are considered to be near natural or minimally disturbed versions of that environment, such as where there is no intensive agriculture, mining or wastewater discharges. Water quality data from as many reference sites as practicable can then be used to derive local values for these indicators.

Reference sites can vary depending on the level of ecosystem protection. In highly disturbed or modified urban waterways, it may be more appropriate to use the least disturbed of the highly disturbed streams to derive values. In this review, objectives for highly modified rivers and streams were based on reference sites in an agricultural land-use setting. While these sites have experienced a high degree of disturbance, their environmental quality is better than that achieved in most urban streams and is protective of their beneficial uses. Such values provide a more realistic expectation of water quality in an urban situation, compared with reference sites from less modified environments, as the latter may create unrealistic water quality expectations.

Where there are no water quality datasets of sufficient size to set locally derived objectives, such as for groundwater or water-based recreation, the SEPP uses values from the most relevant national or international guidelines that are typically based on biological cause-effect data (e.g. toxicity data).

1.4. Development of the new SEPP (Waters)

The Victorian Government committed to a review of the water SEPPs to ensure that Victoria has clear and relevant environmental objectives and appropriate legal obligations necessary to protect and improve the health of water environments.

The Review was led by DELWP in collaboration with EPA. The Review involved:

- evaluating the intent, implementation and effectiveness of policy obligations
- reviewing and revising environmental quality indicators and objectives to ensure that they reflect contemporary science, and
- developing approaches to drive the improvement of water quality across Victoria.

1.5. SEPP science review

SEPPs have an important role within the regulatory framework in Victoria, as they are used to set standards to protect the environment. The environmental quality indicators and objectives in SEPP (Waters) are used for several purposes, including:

- assessing the long-term condition of water environments
- assessing the success of management activities
- determining if pollution of waters has occurred
- assessing EPA works approval and licence applications
- assessing environmental audits and notices
- identifying zones for the management of groundwater quality
- setting regional targets and environmental objectives to sustain or improve water quality.

An important component of the Review has been the review of science underpinning the environmental quality indicators and objectives in the water SEPPs. As the current water SEPPs were developed at different times between 1988 and 2003, the environmental quality indicators and objectives were inconsistent between these previous policies.

Moreover, there was recognition that the SEPPs no longer represented contemporary science and understanding of risks to water environments. In addition, much more monitoring and experimental data have been collected for most environments since these policies were released, improving understanding of the potential impacts to ecosystems.

The science component of the Review was led by EPA, and involved the following steps:

- identifying the main indicators and major threats to surface water and groundwater
- defining the environmental quality required to protect and improve surface water and groundwater in Victoria
- development of clear and updated statutory environmental quality objectives that are based on the latest science.

1.6. Science Advisory Panel

A Science Advisory Panel (SAP) was established to provide independent advice and direction to EPA on the scientific components of the Review. The purpose of the SAP was to:

- guide and provide expert advice on the development of environmental water quality indicators and objectives
- identify gaps and advise on improvements to EPA’s scientific approaches in developing environmental water quality indicators and objectives
- undertake review of the scientific work completed by EPA.

The SAP included leading experts in different fields of water science relevant to the scope of the SEPP (Table 1). During the Review, the SAP met eight times from 2014 to 2016, to provide initial advice on the scope and direction for the science review, to test methodologies and confirm approaches, and to review the technical work to ensure it was reflective of the latest science.

Table 1. Membership of the SAP

SAP Member	Affiliation	Expertise
Dr Jenny Stauber (Chair)	CSIRO	Aquatic ecotoxicology
Professor Ian Cartwright	Monash University	Hydrogeology and geochemistry
Professor Jenny Davis	Charles Darwin University	Wetland ecology
Professor Gerry Quinn	Deakin University	Coastal marine ecology
Associate Professor Ian Rutherfurd	University of Melbourne	River management
Associate Professor Chris Walsh	University of Melbourne	Stream ecology

It was recognised during the Review that the SAP lacked sufficient expertise in human health. To support the revision of the SEPP's standards for water-based recreation, a separate Technical Review Group was established involving experts from Monash University, Melbourne Water, the Department of Health and Human Services, and EPA. This group provided advice and recommendations to the SAP for this component of the SEPP.

In addition, a range of expert advisory groups were established to provide technical advice on different water segments or particular environmental threats, including groups of experts on groundwater, estuaries, inland waters and marine environments.

1.7. Project Control Board

Overseeing the Review was a Project Control Board (PCB) involving senior executives from DELWP and EPA. As components of the science review were formally approved by the SAP, they were considered by the PCB before being endorsed. The PCB had a particular focus on ensuring that EPA had consulted appropriately, that it had followed an appropriate process in developing new environmental quality indicators and objectives, and that the implications of any changes were understood.

1.8. Public consultation

In February 2018, the draft SEPP (Waters) was released for a four-month public consultation period. During this time public submissions were received, and any issues raised were considered in the finalisation of SEPP (Waters). A range of submission suggested changes to the indicators and objectives, segments and beneficial uses. In some cases, changes to indicators, objectives and segments were made where a submission was able to provide a strong scientific rationale with scientific evidence and data that supported the need. In other cases, changes were not made where the scientific rationale was lacking and evidence/data did not support the suggested change.

This publication represents an updated version of EPA publication 1688 *Development of environmental quality indicators and objectives for the draft SEPP (Waters)* which reflects changes to indicators, objectives, load targets, segments and beneficial in response to public submissions.

2. Overview of the science review

2.1. Beneficial uses

An important goal of the Review was to develop a consistently defined set of beneficial uses. This involved reviewing the intent behind the beneficial uses in previous policies for surface water and groundwater, seeking feedback from stakeholders as to whether new beneficial uses were required, and developing a harmonised set of beneficial uses for SEPP (Waters).

A process for reviewing and assessing each beneficial use against agreed criteria was undertaken to ensure that any changes were adequately considered. This included considering if the beneficial use had relevance to different segments across Victoria, required a certain quality of water to protect it, and had an existing set of suitable indicators available for appropriately monitoring quality.

The previous water SEPPs identified 30 beneficial uses. These were streamlined in SEPP (Waters) to 14, including the addition of a new beneficial use for geothermal processes for groundwater. These beneficial uses are described in Schedule 2 of SEPP (Waters) and are provided in Table 2.

Table 2. Beneficial uses in SEPP (Waters)

Water dependent ecosystems and species	Human consumption of water after appropriate treatment
Agriculture and irrigation	Aquaculture
Buildings and structures	Cultural and spiritual values
Industrial and commercial use	Geothermal properties
Human consumption of aquatic food	Navigation and shipping
Potable water supply	Potable mineral water supply
Tradition Owners cultural values	Water-based recreation

The report *Beneficial Uses – Proposed Changes*[2] provides more details of the proposed changes to beneficial uses for inclusion in SEPP (Waters) and explains how they were selected.

2.2. Segments

SEPP (Waters) uses segments to define geographic areas that have broad difference in their natural characteristics, baseline water quality and beneficial uses to be protected. As part of the Review, EPA largely continued the approach used to define segments in the previous water SEPPs.

For surface waters, SEPP (Waters of Victoria) classified 14 broad statewide segments. The regional schedules also contained additional local segments specific to their regions.

[2] Department of Environment, Land, Water and Planning 2017, Beneficial Uses – Proposed Changes. Available on request.

In reviewing these surface water segments, EPA used a consistent approach based on criteria developed by technical experts. This approach was adopted to address the inconsistencies that resulted from the previous water SEPPs being developed at different times.

The criteria used by EPA included:

- characteristics of the water quality, such as pH, nutrients, salinity and dissolved oxygen
- physical characteristics, such as waves, currents, substrate and altitude
- character of the environment, such as ecological features and biological communities
- climatic influences, such as rainfall, temperature, and climate variability
- population pressure and surrounding land use.

The changes to surface water segments in SEPP (Waters) largely reflect changes resulting from an updated understanding of the criteria described above. Figure 1 indicates the segments for surface waters in SEPP (Waters). The main changes, include:

- inland water segments defined in the various regional schedules are incorporated into the broader statewide segments, with some minor changes to segment names
- an expansion of the *Urban waterways* segment in Schedule F7 to incorporate the rest of the urban waterways in Melbourne
- new sub-segments used to define open coasts and wetlands
- revised sub-segments for Port Phillip Bay, Gippsland Lakes and Western Port
- a new segment for Corner Inlet.

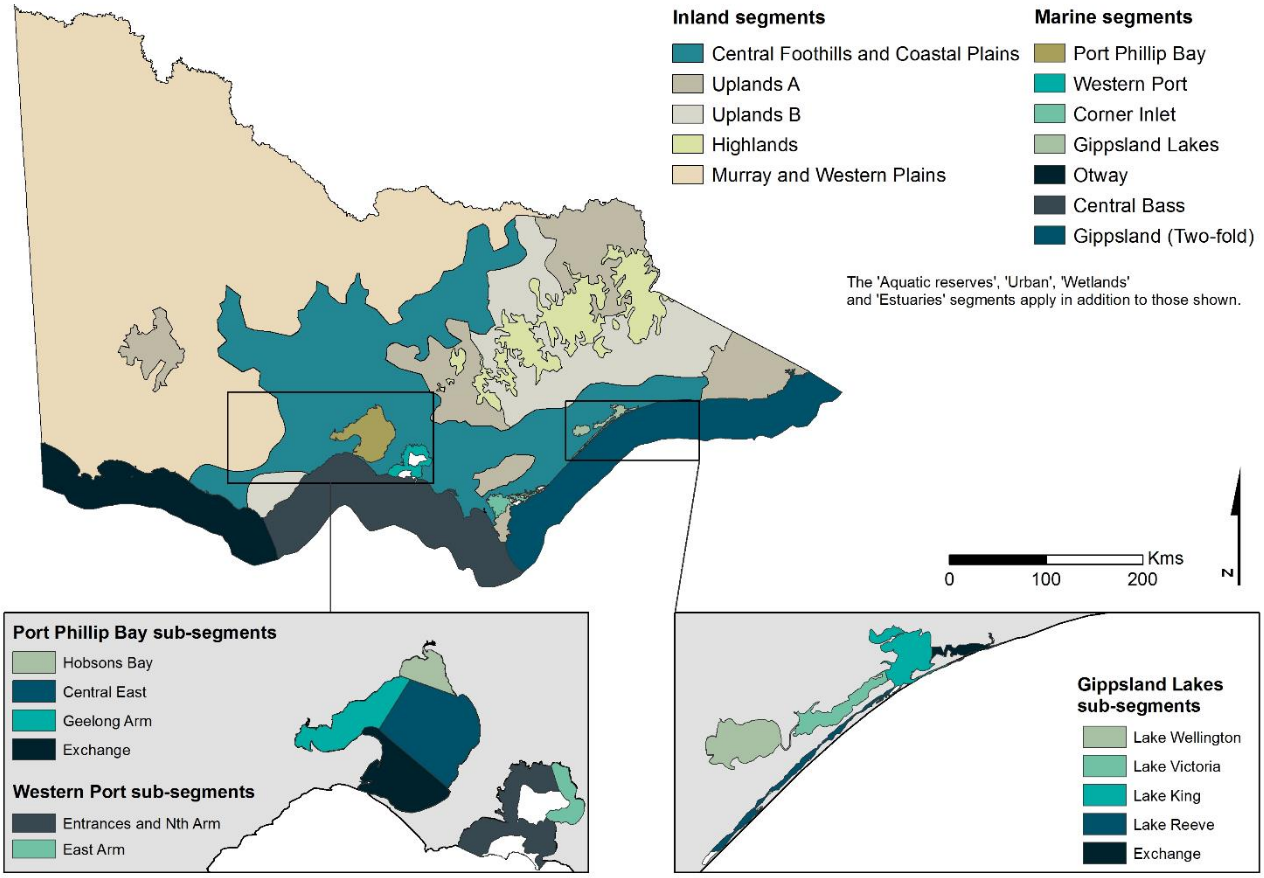

Figure 1. Segments for rivers and streams and marine embayments in SEPP (Waters)

Groundwater segments continue to be classified based on the background level of TDS. While the Review considered other options for defining groundwater segments, such as spatially or geographically, or using other indicators, TDS remains the most practical option. This is because TDS can easily be measured in all groundwater and is the most common determinant of uses.

While the approach to defining segments in groundwater has not changed, EPA made changes to segment classifications based on a review of national standards, guidelines, or data about groundwater use. The segments for the groundwater environment are provided in Table 3.

Table 3. Segments for groundwater environments

Segment (TDS mg/L)						
A1 (0-600)	A2 (601-1,200)	B (1,201-3,100)	C (3,101-5,400)	D (5,401-7,100)	E (7,101-10,000)	F (>10,001)

2.3. Applying segments to beneficial uses

Extensive stakeholder consultation identified which beneficial uses should be protected in Victorian waters. The beneficial uses were then assigned to each segment based on the suitability of the environmental quality to support that use or value. The Review explored a range of options for assigning beneficial uses to segments and assessed which would result in a more accurate or meaningful allocation of beneficial uses across Victorian waters to meet community expectations.

All options were compared to current policy implementation (that is, would a change in the approach result in easier assignment of beneficial uses, or make it more effective in terms of being able to implement the SEPP). Qualitative criteria and information used to rank each option were obtained from a combination of literature review, consultation with relevant departments, and workshops with government agencies. The criteria were then tested with stakeholders through the report *Beneficial Uses – Matching beneficial uses to segments*[3].

The approach for surface waters largely involved deciding where a beneficial use should be protected, and identifying how that can be represented.

Options for groundwater were more limited, reflecting the ability of management to influence the system, the data available and the way groundwater is used. A literature review of legislative, regulatory and policy instruments, as well as guidance materials from Victoria, elsewhere in Australia and internationally, concluded that the approach to setting groundwater segments and the application of beneficial uses in the previous SEPP (Groundwaters of Victoria) is still appropriate. TDS remains the most appropriate primary indicator for segment definition. This is because the salinity of groundwater affects its use and TDS has proved to be an effective way to classify groundwater for beneficial uses.

[3] Department of Environment, Land, Water and Planning 2017, Beneficial Uses – Proposed Changes. Available on request.

2.4. Environmental quality indicators and objectives

The Review process, with oversight from the SAP, revised the environmental quality indicators and objectives for the SEPP. Environmental quality indicators and objectives have changed due to:

- new science
- improved understanding of the aspects of environmental quality that matter for different beneficial uses
- improved long-term water quality monitoring data
- changes to national or international guidelines, or
- changes to beneficial uses and segments.

The environmental quality indicators and objectives in SEPP (Waters) have been developed in line with, and to complement, the nationally agreed approach outlined in the ANZG (section 1.3).

The main changes to environmental quality indicators and objectives in SEPP (Waters) include the following:

- A consistent suite of indicators which represent the key threats to environmental quality in surface waters adopted across rivers, streams and marine water segments.
- Revised environmental quality objectives for surface water segments based on expanded water quality monitoring datasets, encompassing droughts and floods.
- Revision and update of groundwater environmental quality indicators and objectives based on relevant national and international standards.
- New indicators introduced for sediment toxicology for surface waters.
- New marine bio-indicators for application across all marine embayments.
- New locally derived objectives introduced for estuaries and wetlands.
- Inclusion of revised indicators for aquaculture based on national guidelines.
- Revised indicators and objectives for water-based recreation based on contemporary science and relevant national and international guidelines.

Most of the proposed objectives are designed to protect the beneficial use of water-dependent ecosystems and species. If this beneficial use is being protected, then the other beneficial uses are assumed to be protected. The exception is aquaculture and water-based recreation, for which specific objectives have been proposed. There are four main types of indicators adopted in SEPP (Waters) that when exceeded indicate a risk to beneficial uses (Table 4).

Table 4. Categories of SEPP (Waters) indicators

Indicators	Description and examples
Physical and chemical parameters	Typically, the 'default indicators' for monitoring and evaluating the ecological health of water environments include, among others, nutrients, turbidity, salinity, dissolved oxygen and toxicants. Objectives for physical and chemical parameters specify an upper or lower limit for a given indicator. Limits are typically set based on an upper percentile of values observed from long term data in a healthy or reference water body where beneficial uses are known to be supported. For toxicants, the upper limits are based on concentrations that are known to be harmful to aquatic organisms based on experimental studies.
Biological indicators	Provide integrative measures that respond to the effects of multiple physical and chemical stressors acting together and provide measures of longer term impacts and responses of environmental condition. Objectives specify a condition or state that, when not met, indicates beneficial uses are potentially at risk. Include freshwater macroinvertebrates, *chlorophyll-a*, algal abundance and seagrasses.
Microbial indicators	Include *E. coli* and enterococci in freshwater systems and enterococci only in estuarine and marine systems that indicate the presence of faecal contamination and risk to human health.
Weight of evidence indicators	Indicators use multiple lines of evidence from physical, chemical and biological indicators as well as the results of toxicity testing. This includes the use of new sediment ecotoxicity objectives for identifying risk due to sediment contamination.

3. Detailed summary of the science review

3.1. Rivers and streams

Segments remain largely unaltered

Segments for rivers and streams remain largely unchanged from SEPP (Waters of Victoria). These segments are based on the structure of macroinvertebrate community living in waterways. There are many different types of macroinvertebrates, including dragonfly larvae, mosquito larvae, water fleas and beetles.

Macroinvertebrates are commonly used around the world as indicators of water quality because they integrate all aspects of water quality. They provide information about long-term water quality rather than just reflecting conditions at the time of sampling. Some macroinvertebrates are sensitive to pollution, whereas others can live in polluted waters. This variability in sensitivity to pollution makes macroinvertebrates good biological indicators of pollution impacts. By assessing both the types and numbers of animals present, researchers can determine the health of a waterway.

Because *water-dependent ecosystems and species* is considered to be the most sensitive beneficial use, defining segments based on macroinvertebrate community structure is an effective way to identify areas of similar environmental condition. This approach was adopted for rivers and streams as there is a good database of macroinvertebrate information for this water environment in Victoria.

Reference sites chosen via spatial analysis and professional judgement

For rivers and streams, environmental quality objectives have been developed using extensive data from local reference sites.

The process of identifying and selecting reference sites for rivers and streams in SEPP (Waters) was more formal and transparent than that used in SEPP (Waters of Victoria), which was largely based on professional judgement using informal criteria and spatial analysis. Since the development of SEPP (Waters of Victoria), geographic information system (GIS) techniques and datasets have improved. As such, as part of the science review, EPA adopted structured criteria to select references sites in a more quantitative manner.

The main criteria to select reference sites were that:

- any site used for defining near-natural reference condition must be representative of the major characteristics of the water from which it is sampled
- it must be subjected to as little human disturbance as possible.

The criteria used to identify reference sites were as follows:

- *Level of ecosystem protection 1 (natural)*

  There is no human land use within the catchment of the waterbody or adjacent to the waterbody unless it does not affect ecosystem condition; no alterations to natural hydrologic regime including for estuaries and embayment marine inflows through dredging or mouth opening.

- *Level of ecosystem protection 2 (largely unmodified)*

  Within 20 km upstream of a river reach or in catchments for wetlands, estuaries and embayments, no intensive agriculture, major extractive industry, major urban area or significant point source wastewater discharge; no obvious stock access; and high continuity of riparian vegetation cover and good bank stability.

- *Level of ecosystem protection 3 (highly modified)*

  Highly modified reference sites were assessed using the same variables as for 'largely unmodified' above, with each variable showing a greater degree of disturbance.

EPA applied these criteria using the spatial data available in the Geofabric[4], which include more than 80,000 stream or river expanses. On both sides of rivers or streams, EPA defined a 20 km x 1 km buffer upstream of each of the Melbourne Water and DELWP water quality monitoring stations. Within each buffer, EPA calculated the approximate proportion of the area subject to the criteria listed above. The approach identified 95 reference sites, most within the State's less disturbed forests.

In order to obtain additional reference sites outside of these areas, EPA used satellite maps and information from the Victorian data warehouse to include an additional 36 'best available sites' from areas that would otherwise be poorly represented. However, some of these sites were eliminated because the water quality was not suitable.

Objectives set via commonly measured water quality parameters

The environmental quality indicators adopted for rivers and streams are based on standard, widely adopted measures that provide cost-effective and measurable proxies of threats to beneficial uses from pollution. They consist of:

- salinity (measured as electrical conductivity; µS/cm at 25°C)
- dissolved oxygen (as percentage saturation corrected for altitude and temperature)
- pH
- turbidity (as nephelometric turbidity units)
- total phosphorus (as µg/L)
- total nitrogen (as µg/L).

Environmental quality objectives for these indicators were calculated from monthly data extending from 1990 to 2013 for most sites, encompassing a broad range of environmental conditions ranging from droughts to floods. Objectives for toxicants – such as heavy metals, polycyclic aromatic hydrocarbons and biocides – adopt the ANZG guideline values.

SEPP (Waters) adopts the same approach as SEPP (Waters of Victoria) with objectives based on a 75th percentile[5] of reference data for physical and chemical indicators. A 75th percentile was selected as an appropriate statistic to set objectives because it can be estimated using 12 monthly water quality samples per year with 95 per cent confidence. Using higher percentiles would require additional samples (for example, 30 samples are

[4] http://www.bom.gov.au/water/geofabric/

[5] Percentiles are summary statistics that identify the value of a variable within a data set, below which a certain percent of observations fall. For example, the 75th percentile is the value (or score) below which 75 per cent of the observations may be found. Percentiles are often used to gain an understanding of the range without including extremes. The use of 75th percentiles requires a minimum of 11 samples for adequate confidence. Therefore, an annual monthly monitoring program should be sufficient for assessment against SEPP objectives.

required to calculate a 95th percentile with 95 per cent confidence), which are likely to be too high in number and costly for monitoring programs to reasonably obtain over a year.

SEPP (Waters) recognises that natural variability will affect water quality. Setting environmental quality objectives that all reference sites need to meet would result in objectives being set very high, as they would need to accommodate extreme events. Instead, the bioassessment system AUSRIVAS (Australian River Assessment System) allows 20% of reference sites to fail the objectives. EPA has adopted a similar approach, developing environmental quality objectives where approximately 80 per cent of reference sites pass and 20% fail. Adopting this approach means that the resultant objectives will be higher in most cases than just using a simple percentile. Thus, exceeding the objectives indicates a greater likelihood of serious impacts to waterways.

Biological objectives based on more reference sites, single season data and the same four macroinvertebrate indices

SEPP (Waters) adopts macroinvertebrates as biological indicators and objectives. This follows the approach recommended by the ANZG that biological indicators be used to complement the use of physical and chemical indicators, where the protection of aquatic ecosystem is the environmental value, or beneficial use to be protected.

The direct assessment of macro-invertebrate communities indicates that if ecosystem integrity is being maintained, threatened or compromised, thereby providing more sophisticated information on aquatic ecosystem health.

The new macro-invertebrate objectives use the sampling protocol and taxonomic resolution adopted for the environmental quality objectives in SEPP (Waters of Victoria). Objectives have been calculated for the same indices as the environmental quality objectives in SEPP (Waters of Victoria) except for ‘Number of key families’, which was excluded as it was developed prior to the AUSRIVAS model, and is now considered to be redundant.

The environmental quality objectives in SEPP (Waters of Victoria) were calculated using data from 199 reference sites (with different reference sites being used for macroinvertebrates and physical/chemical indicators). In comparison, the objectives in SEPP (Waters) are based on data from 254 reference sites across Victoria.

Objectives are based on single season samples, with either autumn or spring being suitable, rather than on samples combined from autumn and spring, as was the case in SEPP (Waters of Victoria). This is because streams that flow intermittently are often dry in autumn; also, research shows that there is no significant difference in macroinvertebrates present in flowing streams in autumn and spring.

Unlike SEPP (Waters of Victoria), SEPP (Waters) objectives will be based on data combined from river edge and riffle habitats, rather than on single habitats. This change will result in more data, and reduced sampling errors.

3.2. Wetlands and lakes

SEPP (Waters of Victoria) included a broad definition for wetlands and lakes but it did not set specific environmental quality indicators and objectives, other than those provided in the ANZECC Guidelines.

Recognising this limitation, two programs of research were undertaken within Victoria to develop environmental quality indicators and objectives that were more relevant to Victorian wetlands and lakes. These were the Index of Wetland Condition, and the development of the

Environmental Quality Guidelines for Victorian Lakes[6] by EPA in 2010. Both work programs were important for informing the development of the new SEPP (Waters).

Creation of wetlands segment and lakes and swamps sub-segments

Victoria has over 23,000 natural wetlands across the state, covering approximately 604,000 hectares, with over 600 of these being recognised as 'high value'. SEPP (Waters) introduces a new segment for wetlands, with two sub-segments for lakes and swamps. This is a key step forward and recognises the importance of these ecosystems.

The Lakes sub-segment includes systems specified in the *Environmental Quality Guidelines for Victorian Lakes*. The swamps sub-segment includes those defined in the Victorian Inventory of Wetlands as 'palustrine' and includes swamps, marshes and meadows. SEPP (Waters) continues to exclude constructed storm water wetlands from this segment, as such assets were built for a purpose and should be maintained accordingly.

The inclusion of a new segment in SEPP (Waters) for wetlands, with corresponding environmental quality indicators and objectives, provides a valuable tool for waterway managers and catchment management authorities to assess wetlands.

Indicators and objectives based on EPA Guidelines

The environmental quality indicators and objectives for the Lakes sub-segment in SEPP (Waters) were based on the *Environmental Quality Guidelines for Victoria Lakes.* The guidelines provided objective values for indicators of macroinvertebrates, nutrients, salinity, dissolved oxygen, pH, turbidity and toxicants. The only changes from these guidelines were:

- The adoption of the 95th percentile toxicant guidelines as proposed in the new ANZG Guidelines, rather than the 99th percentile. This was done to better align the wetlands segment with the rivers and streams segments. However, the 99th percentile was adopted for bioaccumulating toxicants given the significance of this stressor. Adoption of the 99th percentile for bio-accumulating toxicants is a change that has also been adopted more generally across all segments.
- Removal of the *chlorophyll a* objectives for three lake subtypes (riverine terminal and floodplain, and shallow inland), as feedback received by the SAP was that these values were too low to be useful.

3.3. Estuaries

The development of SEPP (Waters) provided an opportunity to set environmental quality indicators and objectives that are appropriate for Victorian riverine estuaries.

SEPP (Waters of Victoria) indicators and objectives for estuaries adopted the trigger values in the ANZECC Guidelines, which were based on data from well mixed, predominately marine estuaries. However, most of the estuaries in Victoria are riverine, often stratified and typically have closed mouths that only open intermittently. Due to these differences, it was recognised that the trigger values in the ANZECC Guidelines are not appropriate for Victorian estuaries.

Retention of single statewide estuary segment

While differences in the physical, geographic and ecological settings of estuaries can create natural variations in the ecological condition, including background water quality and

[6] *Environmental Quality Guidelines for Victorian Lakes* (EPA publication 1302).

sensitivity of these environments to human impacts, there was insufficient information on estuaries available in Victoria to differentiate sub-segments. Instead, SEPP (Waters) retains a single segment for estuaries across Victoria.

Environmental quality indicators and objectives based on EPA Guidelines

In recognition of differences between Victorian estuaries and those used to derive ANZECC Guidelines, EPA examined water quality across 31 Victorian riverine estuaries between 1999 and 2005 to better understand their condition.

The objectives from data collected from reference estuaries were found to be much higher than objectives in SEPP (Waters of Victoria) and likely to lead to greater exceedances of objectives – even in estuaries that are in good ecological condition. It is likely that high levels of phosphorus and turbidity found in Victorian estuaries are naturally occurring and linked to geological and hydrological characteristics of Victorian catchments. These characteristics may include small river/estuary size, long periods of estuary mouth closure, and frequent stratification of fresh and marine water layers typical of Victorian estuaries.

This work led to the development of the *Environmental Water Quality Guidelines for Victorian Riverine Estuaries*[7], known as the 'estuary guidelines'. The values in the estuary guidelines were derived from 14 ecologically healthy reference condition estuaries, which have minimal to intermediate catchment modification, minimal to intermediate physical modification to the estuary, and good biological health immediately upstream of the estuary.

These values have been derived from estuaries located in the west and central part of Victoria, which may not reflect the conditions of all estuaries, particularly those situated in eastern Victoria, where most near-pristine estuaries occur. The assessment of data from estuaries in eastern Victoria against a small number of indicators suggested that water quality did not differ significantly from the guideline values. However, this could not be tested for most other indicators due to a lack of available data. In instances where the environmental quality of estuaries is better than objectives set out in the policy, then SEPP (Waters) provides that background levels (i.e. levels predominantly outside the influence of pollution and waste) are to become objectives. This ensures that the characteristics of high-quality estuaries are protected.

SEPP (Waters) adopts these guideline values as environmental quality indicators and objectives for estuaries. These are considered to better represent Victorian estuaries than those in the ANZG/ANZECC Guidelines. However, toxicant and sediment toxicant indicators and objectives have been adopted from ANZG Guidelines, as there are insufficient data from long-term monitoring of estuaries.

3.4. Marine bays and Gippsland Lakes

Marine embayments are some of the most iconic and valued water environments in Victoria, and their protection has been a focus of the water SEPPs since they were first introduced. Many of the regional schedules to SEPP (Waters of Victoria) have been focused on these environments and their surrounding catchments to drive management interventions and protect these important water environments. In particular, Schedule F3 and Schedule F5 relate to the Gippsland Lakes, Schedule F6 to Port Phillip Bay and Schedule F8 to Western Port.

[7] Environment Protection Authority Victoria 2011, *Environmental water quality guidelines for Victorian riverine estuaries* (EPA Publication 1347).

A focus of the science review of marine waters was to develop revised segments and environmental quality indicators and objectives which better characterised the natural characteristics of these waterbodies using contemporary science and extensive water quality monitoring datasets.

This section provides an overview of the work that was undertaken collectively for marine systems, and then provides more specific details about Western Port, Port Phillip Bay, the Gippsland Lakes and Corner Inlet.

Segment and sub-segments for Western Port

SEPP (Waters) has retained Western Port as a segment with two sub-segments. These are the East Arm, and the Entrances and North Arm. Table 5 outlines the criteria that were used to determine the segments for Western Port.

Table 5. Criteria used to set segments in Western Port

Segment criteria					
Region	**Ecological character**	**Key influence for water quality**	**Physical system**	**Climate/relative variability**	**Population pressure and land use**
East Arm	Sediment dominated	Sediment inputs, catchment inflows	Tidal confluence, high wave energy on unstable shorelines	High sea-level rise, increased tidal exchange, temperature and salinity increases	Future urban growth area Intensive agriculture
Entrances and North Arm	Seagrass and reefs	Seagrass, marine inflows	Strong tidal flushing	Increased tidal exchange	Future urban growth area Intensive agriculture

Segment and sub-segments for Port Phillip Bay

SEPP (Waters) includes a segment for Port Phillip Bay with four sub-segments that are based on differences in water quality, physical-system characteristics and ecosystem character and climate. Table 6 shows the sub-segments and the criteria used for setting segments.

Table 6. Criteria used to set segments in Port Phillip Bay

Segment criteria					
Region	**Ecological character**	**Key influence for water quality**	**Physical system**	**Climate/relative variability**	**Population pressure and land use**
Exchange	sand, reefs, fur seals	Bass Strait	Tidally dominated	Low, mitigated by Bass Strait	Low pressure Rural land use
Hobsons Bay	silt, penguins	Yarra River	Estuarine	High, river discharges	High pressure Urban land use
Geelong Arm	silt, seagrass, King George Whiting	Western Treatment Plant	Western gyre, Low waves	High, hypersaline	Moderate to high pressure Urban, rural and industrial land use
Central	sand and silt, snapper, flathead	Diffuse: Storm water, Yarra and Patterson Rivers	Main gyre, high waves	Moderate, diffuse sources	Moderate to high pressure Suburban land use

Segment and sub-segments for the Gippsland Lakes

SEPP (Waters) includes five sub-segments for the Gippsland Lakes: Lake Wellington, Lake Victoria, Lake King, Lake Reeve and Exchange. These sub-segments are based on water quality, climatic influences, physical characteristics, ecosystem character and population pressure, plus analysis of spatial gradients and system dynamics. Table 7 shows the segments and the criteria used to distinguish them.

Table 7. Criteria used to set segments in the Gippsland Lakes

Segment criteria					
Region	**Ecological character**	**Key influence for water quality**	**Physical system**	**Climate/relative variability**	**Population pressure and land use**
Wellington	Fine sediment dominated	Fresh: Latrobe/ Thompson	High evaporation	High River discharges	Low pressure Rural land use
Victoria	Sand Bream, prawns	Brackish	Wind mixing	Moderate	Low pressure Rural land use
King	Silt bream	Brackish: catchment inflows, sediment and nutrient releases	Stratification	Moderate	Low pressure Rural land use
Entrance	Sand dolphins, marine algae	Marine: Bass Strait	Tidally dominated	Low Mitigated by Bass Strait	Moderate pressure Urban, rural and industrial land use
Lake Reeve	Shallow, water birds	Limited freshwater input, hypersaline	High evaporation	High Evaporation	Low pressure Rural land use

Inclusion of a segment for Corner Inlet

Corner Inlet is Victoria's third largest and most south-eastern embayment, adjoining Wilsons Promontory in the west and extending eastwards to Ninety Mile Beach.

In SEPP (Waters of Victoria), Corner Inlet was included in a state-wide estuaries and inlets segment. However, Corner Inlet is a well flushed, tidally-dominated embayment with significant sections that are well mixed and predominantly marine, therefore the environmental quality objectives may not be appropriate. Instead, SEPP (Waters) introduces Corner Inlet as a new segment.

Formulating indicators for marine systems

The selection of indicators for marine bays involved the development of conceptual models to identify and map threats across marine systems in Victoria and pinpoint indicators that can best measure the factors affecting environmental quality.

The development of these conceptual models was informed and validated with reference to the scientific literature. Indicators were selected that are broadly applicable across all marine systems in Victoria and provide measures of common types of pollution.

Figures 2 and 3 present examples of the conceptual models developed to identify environmental quality indicators for marine systems. Potential indicators and metrics were then developed in consultation with the SAP. The selected indicators largely reflect those in SEPP (Waters of Victoria), which enables a continuation of existing water quality datasets.

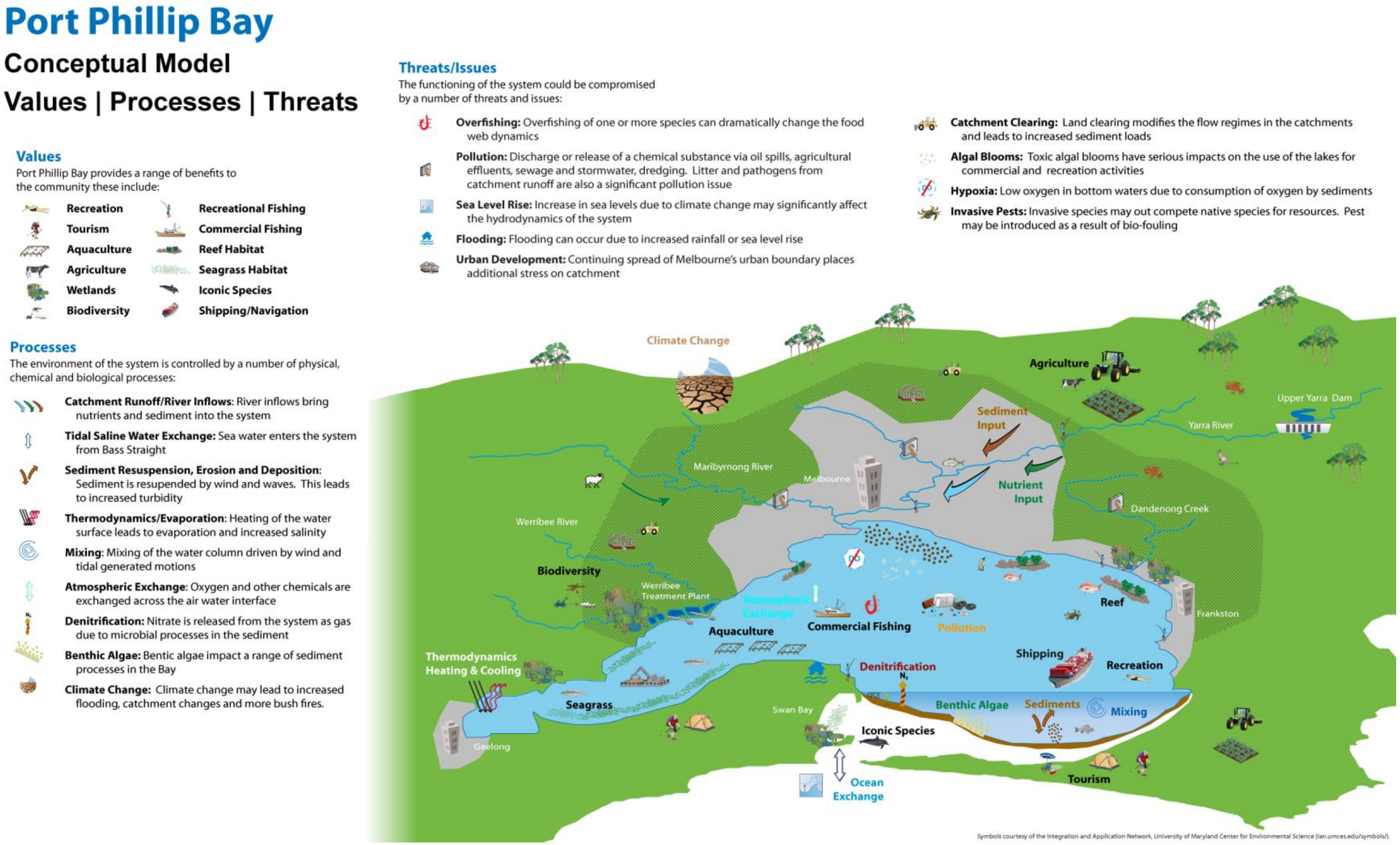

Figure 2. Conceptual model of the values, processes and threats to water quality in Port Phillip Bay

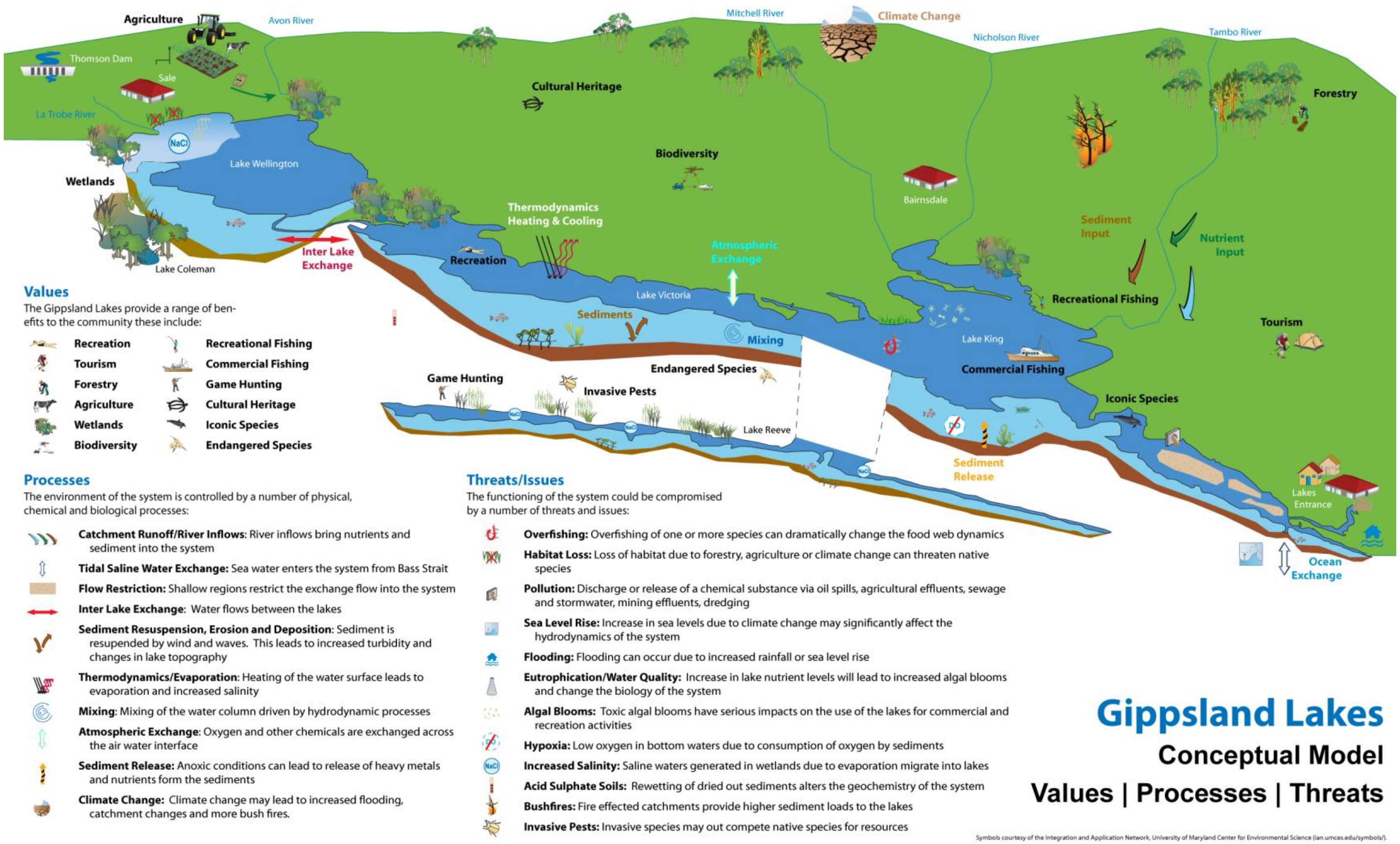

Figure 3. Conceptual model of the values, processes and threats to water quality in the Gippsland Lakes

Developing objectives for physical and chemical indicators based on extensive monitoring

The various schedules to SEPP (Waters of Victoria*)* were developed at different times between 1988 and 2001, resulting in inconsistencies between the indicators and metrics adopted, and these no longer represented contemporary science.

For example, the environmental quality objectives in Schedule F3 were based on less than two years' worth of data, collected during a particularly wet period from 1976 to 1978. Since the 1990s, EPA has routinely monitored two sites in Western Port, six sites in Port Phillip Bay and five sites in the Gippsland Lakes (Figure 4 and 5). The development of SEPP (Waters) provided an important opportunity to update objectives based on this more extensive water quality monitoring data.

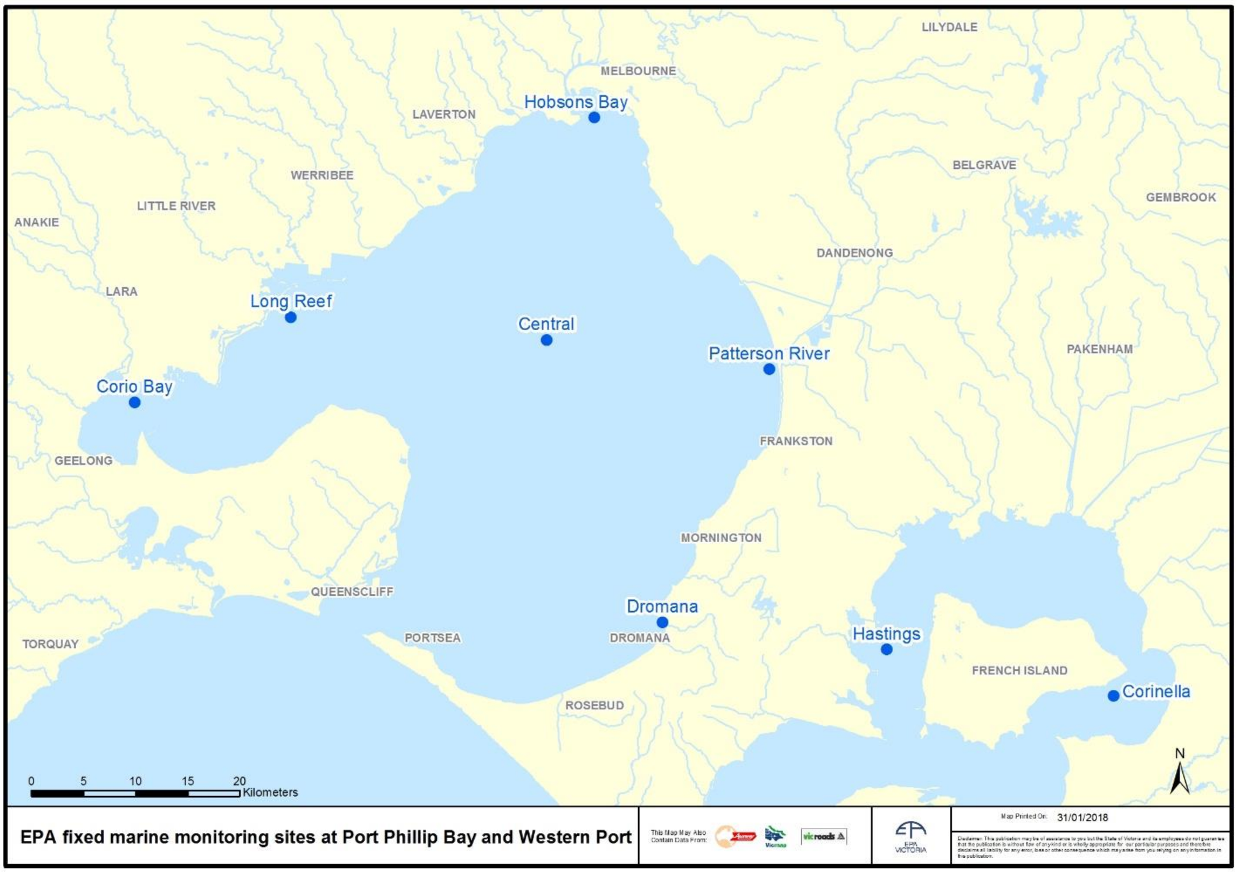

Figure 4. Location of EPA fixed site marine monitoring locations at Port Phillip Bay and Western Port

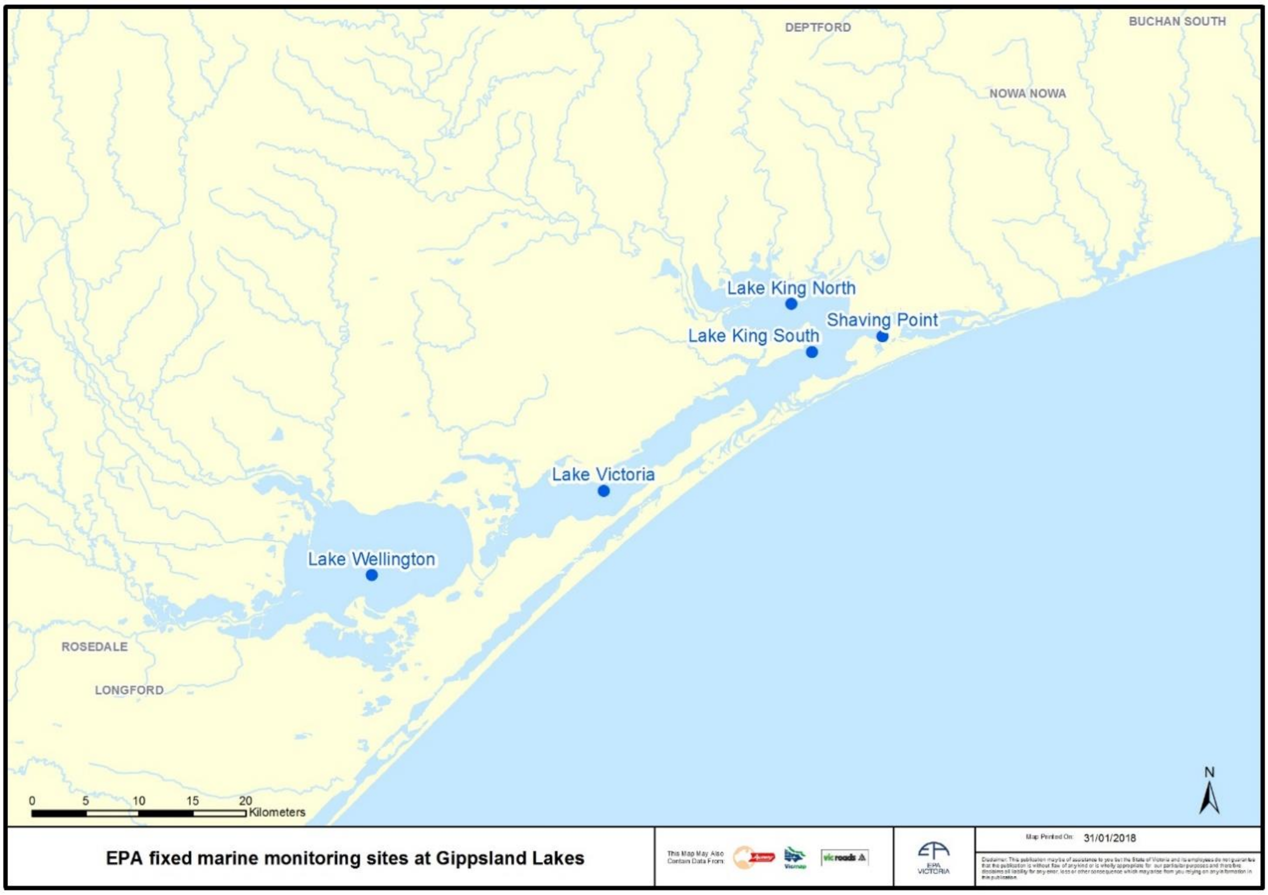

Figure 5. Location of EPA fixed site marine monitoring locations at the Gippsland Lakes

Historical water quality monitoring data from these sites was used to characterise baseline reference conditions that represented a 30-year time series of environmental condition. This includes capturing broadscale climate patterns and periods of high and low rainfall (for example the Millennium drought) that have an important influence on baseline water quality.

The objectives were developed from relatively unimpacted sites within bays where beneficial uses are known to be protected, based on the assumption that maintaining water quality at these levels will protect beneficial uses.

For Port Phillip Bay, Western Port and the Gippsland Lakes, monthly data reporting was used to calculate the 75th percentile value for each environmental quality indicator within each year of sampling between 1990 to 2013. This period includes floods and droughts, which means that the data is a better baseline for assessing environmental conditions.

3.4.1. Pollutant load reduction targets

Victoria’s embayments receive large amounts of nutrient and sediment pollution from sources in the surrounding catchments and coast. Over time, this can damage the health of ecosystems and compromise other beneficial uses. Urban and agricultural runoff, land-clearing, river bank erosion and the discharge of wastes and wastewater are just some of a wide range of activities that cause this pollution.

Load-based targets (which specify the mass of pollutants entering the water body over time) are, in some circumstances, a more appropriate target than concentration to manage water quality entering large receiving waters, which are often more sensitive to the overall quantity of nutrient and sediment pollutants. These are considered one of the most effective ways for driving management interventions and investment to reduce pollution from diffuse sources.

This approach is recommended by the ANZG and the National Water Quality Management Strategy and has been used effectively to protect marine, freshwater and estuarine water bodies across Australia over the last 15 years.

Currently these targets are incorporated into regional planning frameworks that include development of implementation activities, management actions and monitoring actions within a separate, discrete management plan.

Ensuring that targets remain relevant and effective

The existing load targets were established and set in the schedules to SEPP (Waters of Victoria) over 20 years ago for Port Phillip Bay, and the Gippsland Lakes[8], and over 16 years ago in Western Port. At the time, they were based on the best available scientific understanding of these systems, their responses to pollution impacts and the targets required to protect them.

Since then, extensive management actions have been taken to meet these targets. Threats from pollution have changed and, in some cases, increased, because of increasing urbanisation and changes to the location and intensity of agriculture in the surrounding catchments. There have also been significant advances in scientific understanding of these areas, including understanding of pollution threat and impacts, and the scientific tools available to understand the load limits that will protect beneficial uses.

Even where existing load targets have been achieved, for example in Port Phillip Bay, there is still a need to continuously manage activities that generate pollution to prevent future increases in pollutant loads, particularly in response the pressures of urban growth and changes in land use. Future nutrient and sediment loads entering Victoria's major bays and the Gippsland Lakes are predicted to become more pronounced because of climate change and population growth.

While existing load targets have driven actions to reduce loads for some pollutants, the current schedules do not provide targets for other pollutants that are now known to be a significant threat. For example, the risks associated with excessive sediments are comparable to those associated with nitrogen in some bays. However, the absence of a sediment load target has limited management actions to directly address sediment issues. This greatly contrasts with the extent of effort and investment that has been directed to the management of nutrients over the last 15 years.

[8] Lake Wellington in the Gippsland Lakes is recognised as being a highly stressed system requiring significant rehabilitation to protect its values. For this reason, the Schedules included load targets for Lake Wellington, and the Macalister Irrigation District, as one of the major sources of nutrient pollution in the catchment.

Development of the pollutant load reduction targets

The process of developing pollutant load reduction targets involved the following steps:

- Identifying water-quality dependent beneficial uses based on ecological character, and social and economic values. This entailed characterising and documenting the values of the waterway.
- Identifying pollution threats to beneficial uses, drawing on research, investigation, spatially dynamic catchment-to-bay hydrodynamic and biogeochemical models, long-term water quality monitoring data and anecdotal local knowledge, and quantifying these threats.
- Determining actions to protect the sites and modelling a range of management scenarios to understand and predict the impacts and effects of management actions on loads.
- Development of the targets. This involved community and stakeholder consultation, supported by the above steps.

The pollutant load-reduction targets were developed using hydrological, hydrodynamic and biogeochemical models that simulate the physical and ecological behaviour of catchments and marine bay waters. Different modelling platforms were used based on what was available and could be developed at the time of the Review. However, each of these modelling platforms consisted of the same basic components, though these varied in sophistication.

The use of these models helped to understand the nitrogen, phosphorus and sediment loads entering the marine bays from particular sub-catchments, the way in which different types of land use contributed to these loads, and how tide, wind and river flows affected the mixing and behaviour of settling particles and ecological processes once they reach the marine bays. They also enabled management scenarios to be tested based on changes in land use and practices to understand what load reductions would be achievable over the life of the SEPP.

The results from these models were calibrated against water quality and quantity data to ground truth model predictions and outputs with real world data.

Targets for Port Phillip Bay

The science review and modelling undertaken for the Port Phillip Bay Environmental Management Plan 2017-27 indicated that nitrogen loads entering the Bay should not exceed current levels to reduce the risk of frequent and intense algal blooms. However, catchment modelling estimated that nitrogen loads would double without management interventions to reduce inflows of nitrogen.

The modelling indicated that the Western Treatment Plant would remain the main contributor of nitrogen loads, with loads expected to increase over the coming decades due to increased sewage flows. Urban development, particularly in the Werribee and Dandenong catchments, are also expected to have the greatest proportional increase in loads in the catchment, with other pollutants increasing because of increased stormwater run-off.

SEPP (Waters) also introduces a pollutant load reduction target for total suspended solids to improve water quality and reduce pollutants that are typically bound to sediment particles.

Targets for Western Port

Excessive sediment loads within the marine waters of Western Port have been associated with large scale seagrass losses in the East Arm. Consequently, SEPP (Waters) includes a target aimed at reducing the amount of fine sediment within the waters of the bay, with the goal of improving water clarity.

High levels of sediment within Western Port are due to both past high sediment loads entering Western Port from the catchment as well as the associated loss of seagrasses, which have a stabilising effect on sediments. The loss of seagrasses means that fine sediments are more readily re-suspended by waves and currents which reduces light available for seagrass growth and survival. In turn, reduced light availability causes further seagrass loss and further sediment re-suspension.

Western Port is a highly energetic and tidal bay. Over time sediments are removed to Bass Strait by the exchange of waters via tides and currents. For there to be a net removal of sediments from Western Port, sediment loads need to be well below the amount being removed from the bay via exchange with Bass Strait.

Modelling indicated that improved land use practices aimed at capping sediment inflows from the catchment at their current (2017/2018) levels, coupled with measures to prevent coastal erosion are the most appropriate management levers for reduce sediment in Western Port. Preventing an increase in sediment loads at current levels will ensure that there is a net loss of sediment from Western Port Bay over time. Meanwhile, modelling also showed that reducing sediment loads from current level will have little additional benefit to removing sediment from Western Port, due to the proportionally small contribution of current catchment sources of sediment relative to the amount of sediments within Western Port. The load target for Western Port is intended to prevent an increase in catchment sediment inputs to allow in-bay sediments to be naturally removed by tides and currents.

Improvements in water clarity are likely to take time to achieve, and modelling indicates that the time required to see meaningful changes in the levels of in-bay sediments from Western Port is ~ 20 years. However, such a target will be important for reducing the accumulation of sediments available for resuspension over the long term, which will improve the amount of light in the water column and therefore help to improve seagrass growth.

Targets for Lake Wellington (Gippsland Lakes)

Excessive nutrient loads, particularly phosphorous, are a major driver of nuisance plant growth and harmful algal blooms that can have significant impacts on the beneficial uses of the Gippsland Lakes.

Lake Wellington prevously had a load target of 115 tonnes per year, which was aimed at driving Lake Wellington down from a highly nutrient polluted (eutrophic) state to a healthier, less nutrient polluted state (mesotrophic). While the load reduction target of 115 tonnes per year of total phosphorus has been met, the large stores of phosphorus in lake sediments have kept the lake in a eutrophic state and further load reduction are required.

Modelling was used to define levels of phosphorus reduction that are needed to continue to push Lake Wellington into a mesotrophic state, and can be achieved over the life of the SEPP.

As such, SEPP (Waters) introduces a revised load target for Lake Wellington, which replaces the previous targets for Lake Wellington and the Macalister Irrigation District.

Achieving this target will require management interventions both from irrigation activities, as well as both dryland agriculture and waterways.

Targets for Corner Inlet

The Corner Inlet Water Quality Improvement Plan (WQIP) was developed in 2013 by the West Gippsland Catchment Management Authority, in recognition of the threat that poor water quality in the catchment was having on the marine environment in Corner Inlet. In particular, the plan identified that excessive nutrient and sediment loads were contributing to the large-scale loss of seagrass ecosystems in the bay.

Modelling undertaken in the development of the WQIP assessed contributions of major land use categories to the overall end-of-catchment loads to Corner Inlet and Nooramunga, and quantified the management actions and land use changes required to achieve nutrient and sediment load targets. These actions were then assessed by their technical feasibility, cost effectiveness and socio-political impact and were evaluated by an expert scientific panel.

SEPP (Waters) incorporates the nutrient and sediment loads developed through the WQIP into the SEPP, as it represents the best available science for establishing load targets in Corner Inlet.

3.4.2. Marine biological indicators

SEPP (Waters of Victoria) largely relied on physical and chemical indicators as the primary indicators for protecting marine and estuarine beneficial uses, adopting only one biological indicator (*chlorophyll-a*). SEPP (Waters) has provided an opportunity to expand this to include additional biological indicators for marine waters.

Selection of marine biological indicators

In developing marine biological indicators, biota was identified that reliably indicated threats to beneficial uses from pollution and waste, but not threats that are outside the scope of SEPP. For example, the abundance and size classes of some fish are known to be good indicators of ecosystem health but are heavily influenced by fishing and life-history processes outside Victoria's waters. So, while considered good indicators of ecosystem health, they were not considered reliable indicators of pollution for a SEPP.

For marine biological indicators to be considered suitable for the SEPP, they needed to be:

- sufficiently abundant
- likely to be affected by pollution and waste
- sensitive to changes in the environment within the timeframes of the SEPP
- indicators of the broader health of the ecosystem
- supported by a strong pre-existing scientific evidence base for use as an indicator.

Seagrass and phytoplankton condition introduced as marine biological indicators

SEPP (Waters) introduces seagrass and phytoplankton as marine biological indicators.

Seagrasses are critical habitats in Victoria's marine environments. They support a range of beneficial uses, including recreational and commercial fisheries, coastal protection from waves, and the maintenance of water quality through the stabilisation of sediments and nutrient cycling. There is recognition that seagrasses demonstrate changes in their condition and extent due to pollution, particularly excess nutrients and sediments.

Harmful algal (phytoplankton) blooms can have significant impacts on a range of beneficial uses. These include affecting human health through direct and indirect consumption, posing a direct risk to aquaculture and shellfish harvesting, killing fish and reducing light for other marine plants that provide ecosystem services and habitats.

Harmful algal blooms are often driven by excessive nutrients entering marine waters from polluted catchments. Metrics for phytoplankton such as biomass and diversity can be used as measures of environmental condition. Harmful algal blooms represent the extremes of these types of measures that pose a significant threat to beneficial uses. As such, these were considered to be suitable biological indicators for the purposes of SEPP.

Narrative objectives for marine biological indicators

The abundance and condition of marine plants and animals naturally varies greatly in space and over time because of normal changes in the environment or natural cycles of loss and recovery. Understanding when changes are outside natural patterns of variation is critical for identifying risks to beneficial uses.

A review of current scientific literature demonstrated that this level of understanding still does not exist for most biological indicators in Victoria, nor worldwide. Instead, most other jurisdictions use narrative objectives to describe a desirable or undesirable change in the condition of a biological indicator.

Narrative objectives are used in SEPP (Waters) to describe the condition of seagrasses and phytoplankton that would indicate an undesirable impact on marine systems from pollution. These sorts of objectives are used instead of quantitative objectives, because of the lack of suitable long-term data required to characterise quantitative change that would indicate a potential risk to beneficial uses.

These narrative objectives should be used as part of a framework similar to physical chemical indicators and biological indicators for inland waters, whereby failure to meet the conditions described in the narrative objective indicates there is a risk to beneficial uses and should trigger further actions.

3.5. Open coasts

SEPP (Waters of Victoria) previously had a single segment for open coasts with environmental quality indicators and objectives based on default values in the ANZECC Guidelines. SEPP (Waters) has provided an opportunity to set objectives based on locally derived data and to align segments with relevant national bioregions.

Three sub-segments based on geographic, biological and oceanographic differences

SEPP (Waters) introduces three distinct sub-segments for the Open Coast. The three sub-segments – Otway, Central Bass and Twofold – mark distinct ecological and oceanographic features along the coast. The sub-segments also match the provincial bioregions defined in the Integrated Marine and Coastal Regionalisation of Australia (IMCRA): Western Bass Strait, Bass Straight and Southeast.

Three sub-segments will mean more precise management of environmental quality. An example is the Bonney Upwelling in the Western Bass region which has a strong seasonal influence on the nutrient dynamics in this region. The naturally nutrient-rich waters sustain high productivity, which would exceed the nutrient and plankton (*chlorophyll-a*) water-quality objectives set in SEPP (Waters of Victoria), which has a single, simple ‘Open coast’ category for all waters within 12 nautical miles of Victoria’s territorial sea baseline.

Indicators for the open coast applied to all marine sub-segments

To ensure consistency across all marine systems, the same environmental quality indicators have been used for the Open Coasts as with the marine bays and the Gippsland Lakes. These indicators were selected based on issues affecting particular waterways and the main pollutants that might be generated by an activity being considered.

Water-quality objectives appropriate to local regions

A comparison of the objectives in SEPP (Waters) with the ANZECC Guidelines indicated that water quality in the open coasts naturally exceeded both the surface and bottom water values, in some cases by an order of magnitude. This indicated that locally derived objectives would be more appropriate for regional conditions than the ANZECC Guidelines.

To develop locally derived objectives, EPA used data collected as part of the CSIRO *Ecoregional Water Quality Guidelines and Guidance for Australia's Marine Waters*. This data was for the IMCRA bioregions and so aligned with the sub-segments in SEPP (Waters).

3.6. Sediment toxicants and ecotoxicity

New pharmaceuticals, personal-care products and endocrine-disrupting compounds pose risks to human health and the environment that are not yet fully understood. The benthic environment – that is, the surface and sub-surface layers of sediment – stores, and has a role in transporting, toxicants such as these into parts of the environment where they can cause harm to biota.

Under SEPP (Waters of Victoria), these chemicals of emerging concern would not be investigated because they are not listed as a toxicant in the ANZECC Guidelines.

Internationally, the discovery and patenting of new chemical compounds is increasing exponentially and it is beyond the capacity of a state, or even national, regulator to set standards and testing practices for all of these in the way that the previous water quality guidelines have.

In addition, the potential toxicity of mixtures cannot be inferred by examining the toxicity of the compounds that make up the mixture. In recognition of this issue, SEPP (Waters) includes new weight-of-evidence objectives to provide a framework for the identification and assessment of toxicants. The setting of these objectives will allow for the detection of emerging contaminants and will provide a trigger for further investigation.

Weight-of-evidence testing for assessing the risks posed by sediment toxicants

A weight-of-evidence approach provides a sensitive indicator of emerging toxicants and identifies toxicity of complex chemical mixtures. Weight-of-evidence testing is useful because many toxicants frequently do not have well established aquatic ecosystem guidelines. If the uncertainty on any one indicator is high, the aggregation of different lines of evidence gives a greater degree of certainty in an assessment.

Weight-of-evidence testing incorporates the following five lines of evidence to assess the risk posed by sediment toxicants:

1. chemistry
2. ecotoxicity
3. ecology
4. bioaccumulation
5. other (including biomarkers).

While chemistry and ecology are already assessed to varying degrees, the introduction of the ecotoxicity line of evidence represents a change in SEPP (Waters). The ecotoxicity line of evidence involves the use of indicator species to test whether chemicals are toxic to biota. Benthic aquatic macroinvertebrates are considered the best taxonomic group to assess sediment toxicity, due to their exposure to sediment, the range of niches they occupy, and the important role they play in the functioning of sediment organic and nutrient cycles.

These indicator species will provide a sensitive indicator of emerging toxicants and identify toxicity of complex chemical mixtures. The value of this line of evidence is that if a chemical, or mixture of chemicals, found in sediments is toxic to biota, it will trigger further investigation.

The indicators, objectives and scoring system for this approach are largely based on Simpson and Batley (2016)[9]. The scoring system will help water managers assess, for each line of evidence, whether a sediment toxicant is a low, medium or high risk to the marine, estuarine or freshwater ecology. The objective in all systems is for ‘low risk’.

As there are currently no sediment ecotoxicity guidelines incorporated in similar statutory policies in other jurisdictions in Australia, this represents an important innovation in SEPP (Waters).

3.7. Aquaculture

SEPP (Waters) retains aquaculture as a separate beneficial use from the protection of aquatic ecosystems. This is because animals grown in aquaculture environments face additional threats compared to wild animals. For example, stocking levels in aquaculture are higher, making animals more prone to cumulative impacts; also, animals kept in fixed pens may be more exposed to fluctuations in oxygen, temperature and salinity.

The purpose of this beneficial use is to protect water quality so that it is suitable for the production of fish for human consumption. This beneficial use applies where environmental quality is suitable and an aquaculture licence has been approved in accordance with the Fisheries Act 1995.

In is important to note that the amount of *Escherichia coli (E.coli)* in the water was the only indicator of water quality related to the beneficial use of aquaculture included in the SEPP (Waters of Victoria). This is not considered to be enough to ensure that water quality is suitable for this activity.

As such, SEPP (Waters) has provided an opportunity to protect aquaculture against a broader range of toxicants and environmental stressors by including indicators and

[9] Simpson S & Batley G 2016, *Sediment Quality Assessment: A Practical Guide*, CSIRO Publishing.

objectives from the Food Standards Australia New Zealand (FSANZ) and the ANZG Guidelines.

Additional sets of indicators and objectives included

Physico-chemical stressors

The ANZG Guidelines list 11 physical chemical indicators for stressors that can affect aquaculture species. Of these, five are directly toxic to animals – dissolved oxygen, pH, salinity, suspended solids and temperature. The remaining stressors are not directly toxic to the animal but affect the five stressors which do.

Some of the indicators for the protection of aquaculture species are the same as those for the protection of aquatic ecosystems, which have distinct objectives. Where this is the case, the objective in the ANZG Guideline giving the most protection should be adopted, as this will ensure that both aquaculture species and aquatic ecosystems are protected. For example, if the chemical parathion is detected, water managers should follow the ANZG Guidelines for protecting aquatic ecosystems, which is more stringent than the one for protecting aquaculture species.

Toxicants

SEPP (Waters) refers to the ANZG for toxicants. For compounds that are not in the guidelines for the protection of aquaculture species, water managers should follow the values set for the protection of aquatic ecosystems. The assumption is that if the objectives are met, the potential for bioaccumulation is low.

Pathogens and biological contaminants

Pathogens and biological contaminants are a threat to human consumption because they can accumulate to harmful levels in an animal. These contaminants include toxicants, bacteria, viruses, and biotoxins from toxic algal blooms.

SEPP (Waters of Victoria) provided a single bacteriological indicator of *E.coli.* This has been replaced in SEPP (Waters) with faecal coliforms as this is more consistent with the FSANZ Food Safety Standards[10], the Australian Shellfish Quality Assurance Program Operations Manual[11] and the ANZG.

Off-flavour compounds

Off-flavour compounds can affect the palatability of aquatic food, which can adversely affect aquaculture. The ANZG Guidelines provide guidelines for off-flavour compounds and these are referenced in SEPP (Waters).

3.8. Water-based recreation

SEPP (Waters of Victoria) was released in 2003 and included microbial indicators and objectives for primary and secondary contact recreation. This included indicators for *E.coli* and enterococci, and corresponding objectives for marine, estuarine and fresh water environments.

[10] Food Standards Australia New Zealand (FSANZ) Australia New Zealand Food Standards Code – Schedule 19 – Maximum level of contaminants and natural toxicants.

[11] Australian Shellfish Quality Assurance Advisory Committee 2009, *Australian Shellfish Quality Assurance Program Operations Manual*.

These objectives were based on a median and 75th percentile, using the environmental criteria set out in the ANZECC Guidelines and guidelines from the World Health Organization (WHO)[12]. Additionally, Schedule F6 and Schedule F7 also included objectives for *E.coli*, but used the geometric mean rather than the 75th percentile. Schedule F7 also included objectives for coprostanol, as another indicator for faecal pollution.

These objectives were based on the best available information at the time they were developed, but were not linked to health outcomes derived from epidemiological or similar studies. As such, the Review provided an opportunity to develop more contemporary and consistent indicators and objectives.

Comprehensive review of relevant national and international standards

To support this review, EPA established a Technical Reference Group involving experts from Melbourne Water, the Department of Health and Human Services, and Monash University. The purpose of this review was to ensure Victoria had contemporary objectives based on current science and which reflected the relevant national guidelines.

As there have not been comprehensive local studies, such as an epidemiological study assessing the risks of water quality of illness from recreational activities in Victoria, it was not possible to develop locally derived objectives, as was done for other environmental quality objectives in SEPP. Instead, the first stage of the review involved a comprehensive literature review to look at existing international guidelines on recreational water quality and to make recommendations on suitable microbial indicators and objectives for primary and secondary contact in Victoria. The recommendations of the literature review were considered in conjunction with the National Health and Medical Research Council (NHMRC) Guidelines (2008)[13].

The NHMRC Guidelines provide guidance relevant to local conditions by combining much of the international consensus on healthy recreational water use with current understanding of Australian waters. These guidelines are not mandatory. They have been developed as a tool for state and territory governments to develop legislation and standards appropriate for local conditions and circumstances.

While the NHMRC Guidelines are the most relevant national guidelines to refer to for water-based recreation, and are the guidelines to which other states and territories in Australia refer, there was a recognition that there were only a limited number of epidemiological studies on water-based recreation available in the literature at the time the guidelines were drafted, and none were conducted in Australia.

This means that the NHMRC Guidelines were established based on overseas datasets, without locally relevant information. This was recognised as a limitation due to the potential differences in climate, population characteristics, and stormwater and wastewater infrastructure in Victoria. For example, Port Phillip Bay is recognised as being a unique system, with very high median retention times, and inputs from stormwater, river water and discharges from wastewater treatment plants.

To validate the values in the NHMRC Guidelines, another literature review was conducted. This review looked at contemporary epidemiological studies in water bodies similar to Port

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[12] World Health Organization 2001, ‘Bathing water quality and human health’, World Health Organization Sustainable Development and Healthy Environments.

[13] National Health and Medical Research Council 2008, *Guidelines for managing risks in recreational water*.

Phillip Bay with similar enterococci levels. The purpose of this study was to assess whether the values in the NHMRC Guidelines were comparable with more recent findings.

The results from this review confirmed that although the cause is not being reported, illnesses are likely occurring in Port Phillip Bay due to poor water quality. As such, the values in the NHMRC Guidelines were considered to be relevant and appropriate to use for SEPP (Waters). However, it was recognised that there would be value in undertaking further local studies to better under the specific risks to water-based recreation in Victoria in the future.

Microbial quality indicators

Human faeces can contain pathogenic bacteria, viruses, protozoa and parasites. However, the variety and often low concentrations of pathogens in ambient waters makes them difficult to test for individually. Instead, the presence of other more abundant and more easily detected faecal bacteria are often used as indicators of the presence of faecal contamination. While these microbial indicators are not themselves dangerous to human health, that can be used to indicate the presence of a health risk.

The NHMRC Guidelines recommend the use of enterococci as the microbial indicator for fresh and marine waters. As *E.coli* is not as persistent in marine waters, because it is less tolerant to salt water, enterococci is recognised as the preferred indicator for marine waters. However, the Technical Reference Group recommended that SEPP (Waters) allow the use of either enterococci or *E.coli* for freshwater. This was because there was less evidence to justify the use of one indicator over the other for freshwater, and that this would have enabled the continued use of historical datasets for *E.coli* in freshwaters.

As the NHMRC Guidelines do not provide objective values for *E.coli*, values from the New Zealand Government *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas*[14] were used.

As such, SEPP (Waters) includes indicators and objectives for primary and secondary contact recreation that are mostly based on the NHMRC Guidelines and the New Zealand Government guidelines:

- Marine and estuarine waters: As with SEPP (Waters of Victoria), the indicator is enterococci and objectives are based on those in the NHMRC Guidelines. *E. coli* can be used for estuarine waters if there is a saltwater wedge creating a freshwater top layer.
- Freshwaters: *E. coli* or enterococci can be used for freshwaters. Water managers can select either indicator, but are recommended to use *E. coli* if they have been doing this previously, to maintain a historical dataset.

SEPP (Waters of Victoria) also only had indicators for microbial water quality, but none for broader water quality. As such, the technical reference group recommended that SEPP (Waters) include indicators for cyanobacteria and algae, chemical hazards and aesthetic effects, as recommended by the NHMRC Guidelines.

Risk-based framework for environmental quality objectives

The objectives in SEPP (Waters) are more conservative than SEPP (Waters of Victoria), as they are linked to health outcomes and reflect the conservatism in the NHMRC Guidelines.

[14] Ministry for the Environment, Ministry of Health, New Zealand Government 2003, *Microbiological water quality guidelines for marine and freshwater recreational areas*.

The contemporary scientific advice is to use the upper bound statistic (that is, the 95th percentile) due to intra-day variability of microbial concentrations potentially exposing users to different levels of risk, and to represent a microbial level where there may be a risk of disease outbreak (that is, to capture the higher microbial results from monitoring that are more likely to cause outbreaks).

These conservative statistics are favoured over medians and geometric means (such as were used in previous SEPPs) which represent endemic levels of disease, but are less informative about high risk conditions. The 95th percentile statistic is also used by the WHO Guidelines (2003)[15] and in the United States and Europe.

Rather than objectives being presented as either pass/fail, as they were in SEPP (Waters of Victoria), SEPP (Waters) presents objectives as a sliding scale of risk based on risk of illness. This approach is based on the NHMRC Guidelines, and is consistent with approaches used in New Zealand and Europe. A sliding scale of risk sets aspirational targets for water managers, providing incentives for them to manage faecal pollution risks and improve water quality grades. It also allows recreational users to make more informed decisions on swimming based on a sites water quality and risk of illness.

Another departure from SEPP (Waters of Victoria) is the introduction of both short-term and long-term environmental quality objectives for water-based recreation, as the previous SEPP only provided long-term objectives. Short-term objectives for water-based recreation are for public warnings of immediate health risk. These include consecutive and single sample objectives, with values based on microbial assessment category values in the NHMRC Guidelines and New Zealand Government guidelines.

The addition of short-term objectives in SEPP (Waters) adds an additional barrier of protection for protecting public health when recreational sites are in use. It is recommended that they are assessed against samples collected weekly during the bathing season.

The Technical Reference Group recognised the value in providing both short-term objectives, to inform swim advisories during the summer season, as well as long-term objectives, to determine whether water quality is suitable to protect water-based recreation in the long term.

SEPP (Waters) also includes objectives for secondary contact recreation, which are not provided for in the NHMRC Guidelines. These objectives are based on likely ingestion levels, with secondary contact users assumed to ingest 10 times less water than primary contact users, therefore tolerating exposure to microbial levels 10 times higher. The provision of objectives for secondary contact recreation with a link to human health outcomes is useful to advise the public about suitability of water quality for other activities when waterbodies are not suitable for swimming.

Validating departures from the NHMRC Guidelines

While SEPP (Waters) was largely based on the NHMRC Guidelines, as noted above, there were some aspects which represented a departure from these guidelines. To provide confidence about this, three international experts were invited to peer review the work undertaken to develop SEPP (Waters). These experts were Graham McBride from the National Institute of Water and Atmosphere Research in New Zealand, Timothy Wade from the US EPA, and Professor Charles Gerba from the University of Arizona. The feedback

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[15] World Health Organization 2003, *Guidelines for safe recreational water environments,* Volume 1 Coastal and fresh waters.

received by the reviewers supported the work undertaken by EPA, and the reviewers considered that it was sound in substance, rational, and scientifically defensible.

3.9. Groundwater

Surface water and groundwater combined

SEPP (Groundwaters of Victoria) was gazetted in 1997 and set a consistent approach to the protection of groundwater throughout Victoria. It aimed to maintain and, where necessary, improve groundwater quality to a standard that protects potential and existing beneficial uses of groundwater.

SEPP (Waters) combines surface water and groundwater within a single policy, and so includes segment classification, and defines groundwater's beneficial uses, environmental quality indicators and objectives.

TDS retained to define groundwater segments

When SEPP (Groundwaters of Victoria) was gazetted in 1997, the natural level of TDS was chosen as the most appropriate indicator to define groundwater segments. This was because it can be easily measured in all groundwater and is the most common determinant of uses of groundwater (for example, the salinity of groundwater highly affects what it can be used for). In general, the lower the TDS level of groundwater, the greater the number of beneficial uses that can be realised by the use of that water.

Compared with surface waters, groundwater is slow moving, relatively inaccessible in the subsurface and exhibits a range of water quality. This can mean that groundwater from some parts of an aquifer may be suitable for a beneficial use, while groundwater from other parts may not be. This is another reason TDS was selected as the most effective basis for distinguishing groundwater segments.

As part of the science review, EPA commissioned a literature review to evaluate whether TDS was still the most appropriate way to define groundwater segments in SEPP (Waters). This literature review considered other options for defining groundwater segments, including identifying segments spatially or geographically, or using other indicators. The review concluded that TDS remained the most practical option because: it can be easily measured in all groundwater; it is the most common determinant of uses of groundwater; and other approaches would require a significant amount of work to collect, collate, analyse and map other groundwater environmental quality indicators.

Changes to groundwater segment thresholds

EPA undertook a review of relevant national standards and guidelines, and state-specific groundwater licence use data in Victoria, to determine if the TDS ranges, which define the thresholds between groundwater segments and the protected beneficial uses, remained appropriate. The purpose of this review was to confirm the ranges of TDS in SEPP (Groundwaters of Victoria) and verify these against actual groundwater use data to better understand how Victorians were using groundwater.

Based on this review, SEPP (Waters) groundwater segment ranges and upper limits for each beneficial use have changed, and two additional segments have been introduced. There have also been changes to the names of some beneficial uses for better alignment with surface waters. The choice of state-specific data or guideline use was made based on the robustness of data, better alignment with national guidelines and the precautionary principle.

Application of Beneficial Uses

SEPP (Groundwaters of Victoria) included a provision that allowed EPA to determine that a specific beneficial use may not apply in specific circumstances (due to insufficient aquifer yield, background (or natural) levels, soil characteristics, or groundwater quality restricted use zones). This was provided for circumstances where it may be impractical to protect groundwater beneficial uses.

EPA completed a review to confirm the purpose of the clause. Individual parts of the clause were reviewed from a scientific perspective for current relevance. The reviews determined that all parts were still relevant and there were a series of recommendations to confirm definitions and provide additional guidance.

Updates to environmental quality indicators and objectives for groundwater

As there are very limited groundwater quality datasets currently collated or available in Victoria, it was not possible for EPA to develop locally-derived objectives, as was done for most other water segments. Instead, the environmental quality indicators and objectives for groundwater were based on the most relevant national and international guidelines and standards, as was the approach adopted in SEPP (Groundwaters of Victoria).

To inform this work, EPA undertook a literature review to determine whether national standards or guidelines had changed since SEPP (Groundwaters of Victoria) was released in 1997. The beneficial uses that apply to groundwater were then reviewed to identify the appropriate environmental quality indicators and objectives to apply.

SEPP (Waters) refers to standards contained in the Australian Drinking Water Guidelines, the Australia New Zealand Food Standards Code, and the ANZG for different indicators and objectives for groundwater based on the beneficial use. However, the microbial objective for water based recreation in groundwater has been revised to provide more appropriate protection, based on expert opinion. The revised objectives are more appropriate because they account for the removal of the bacterial indicator due to filtration through the soil while pathogens such as viruses may persist.

In addition, since SEPP (Groundwaters of Victoria) was gazetted, other jurisdictions in Australia have adopted the National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPM) to set groundwater indicators and objectives. SEPP (Waters) allows for consideration of the NEPM groundwater investigation levels and confirms a risk assessment methodology for the derivation of indicators and objectives where they are not provided for in SEPP (Waters).