Environment Protection Authority

Adelaide Coastal Water Quality Improvement Plan (ACWQIP)

Draft for public comment

Australian Government

Government of South Australia

EPA South Australia

For public comment
Adelaide Coastal Water Quality Improvement Plan (ACWQIP)
A plan that covers the issues, challenges and a way forward for water quality improvement for Adelaide's coastal waters

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Acknowledgments: We are grateful for the valuable input provided by individuals from the following groups to develop the ACWQIP: Adelaide Coastal Waters Steering Group members, Eco Management Services Pty Ltd and Strategic Matters; and Environment Protection Authority staff, particularly those in the Water Quality Branch and the extra efforts of Andrew Solomon, Sam Gaylard, Darren Green, Shiloh Gerrity and Trixie Tan in final completion and editing of the documents.

Some of the materials in this report are drawn from project work completed through Arup Pty Ltd undertaken by Eco Management Services Pty Ltd and Strategic Matters.

Cover picture – Adelaide metropolitan beach

Funding and resources for this project were provided by the Australian Government.

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ISBN 978-1-921495-17-5

September 2011

Printed on recycled paper

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Abbreviations

ABS	Australian Bureau of Statistics
ACWQIP	Adelaide Coastal Water Quality Improvement Plan
ACWS	Adelaide Coastal Waters Study
AMLR	Adelaide and Mount Lofty Ranges
AMLR NRM Board	Adelaide and Mount Lofty Ranges Natural Resources Management Board
ANZECC	Australian and New Zealand Environment and Conservation Council
CDOM	coloured dissolved organic matter
COAG	Council of Australian Governments
CPB	Coast Protection Board
Cu	copper
DEH	Department for Environment and Heritage (up to 30 June 2010)
DENR	Department of Environment and Natural Resources (from 1 July 2010)
DFW	Department for Water
DH	Department of Health
DPLG	Department for Planning and Local Government
EIP	environment improvement program
EP Act	Environment Protection Act 1993
EPA	South Australian Environment Protection Authority
EVs	environmental values
EWRs	environmental water requirements
ICLEI	International Council for Local Environmental Initiatives
ISQG	interim sediment quality guidelines
LGA	Local Government Association
MATs	management action targets
MBIs	market based Instruments
MERF	monitoring, evalaution and reporting framework
MOSS	Metropolitan Open Space Strategy
NRM	natural resources management
NTU	nephelometric turbidity units
NWQMS	National Water Quality Management Strategy
OWS	Office for Water Security

PAHs	polycyclic aromatic hydrocarbons
Pb	lead
PIRSA	Department of Primary Industries and Resources South Australia
PCBs	polychlorinated biphenyls
PEHMP	Public and Environmental Health Management Plan
PWWQIP	Port Waterways Water Quality Improvement Plan
SEWPaC	(Australian Government) Department of Sustainability, Environment, Water, Population and Communities
SMA	Stormwater Management Authority
SoE Reporting	State of Environment Reporting
TBT	tributyltin
TPHs	total petroleum hydrocarbons
WPA	Water Proofing Adelaide
WQIP	water quality improvement plan
WQOs	water quality objectives
WSUD	water sensitive urban design
WWTP	wastewater treatment plant
Zn	zinc

Glossary

chlorophyll	Chlorophyll is a green pigment found in most plants.
coloured dissolved organic matter	When plant material (eg leaves, grasses) decays, organic materials such as tannins are released and they dissolve in water, giving it a green, yellow-green or brown colour.
dissolved oxygen	Dissolved oxygen is a measure of the amount of gaseous oxygen dissolved in water.
environmental flows	An environmental flow is the amount of water needed in a watercourse to maintain healthy aquatic ecosystems.
environmental values (EVs)	Anything a community agrees a body of water should be protected for. This might include an ecosystem, industry, agriculture, recreation, and its spiritual and cultural uses/ importance. EVs help us prioritise the uses for which a local body of water should be protected. They are set after consultation with the community and provide a simple way of describing the things that are important in relation to the body of water. They reflect ecological, social and economic values and uses of water. Examples of environmental values include supporting aquatic ecosystems, drinking water, and primary recreation (eg swimming, water skiing).
estuary	An estuary is the body of water where rivers, creeks and streams flow into the ocean.
faecal micro-organisms	These are bacteria which are found in the intestinal tracts of mammals.
inshore/nearshore	Adelaide's coastal waters from the shore to a depth of five metres
metals	These are elements such as iron, manganese, copper, lead and zinc which occur naturally as part of the earth's crust. Through many industrial activities metals can become concentrated and end up in the coastal environment through stormwater, wastewater or industrial discharges.
nutrients	Nutrients, in context of the ACWQIP, are chemicals (particularly nitrogen and ammonia) which have a negative impact on water quality when present in large amounts.
offshore	Adelaide's coastal waters from five metres depth to the centre of Gulf St Vincent
subtidal	Subtidal is the marine zone which remains submerged at low tide.
suspended solids/ particulate matter	Suspended solids are the small solid particles (eg sediments) contained in water which are small enough not to settle out.
toxicants	These are poisons and can include metals, pesticides and other man-made chemicals.
turbidity	Turbidity is a measure of how light is scattered through a water body, measured by assessing how much light travels through the water (ie how cloudy or murky the water is).
water quality objectives	Measurable targets to protect environmental values and therefore, water quality. They include physical measures (eg turbidity), chemical measures (eg salinity), and/or biological measures (eg bacteria). This is where the technical expertise of the EPA and other scientific groups come into play. The objectives are defined using physical (eg turbidity, suspended sediment and temperature), chemical (eg phosphorous, nitrogen and toxicant levels), and biological (eg micro-organisms) measures. WQOs are the water quality targets that need to be achieved in order to protect the environmental values.

Executive summary

The Adelaide community has expressed concerns over the health of Adelaide's coastal waters for almost 40 years with investigations by a range of government agencies on seagrass loss and sediment instability. In the mid–1990s, a comparison of aerial photographs from different time periods for parts of the sea bed off Adelaide's coast was undertaken. It became clear that a considerable area of seagrass had been lost and the process of seagrass loss seemed to be continuing. This loss and concerns about poor water quality and sand movement resulted in the commencement of a scientific study titled the Adelaide Coastal Waters Study (ACWS) investigating seagrass loss, declines in water quality and sea floor instability for Adelaide's coast.

While the ACWS was being undertaken, the Environment Protection Authority (EPA) negotiated an interim improvement strategy to reduce nutrients from Adelaide's wastewater treatment plants (WWTPs) and to lower the sediment portion of the discharge from Penrice Soda Holdings in the Port River. The EPA has since completed the Port Waterways Water Quality Improvement Plan (PWWQIP) which has a focus on further reducing nutrients to the Port waterways (EPA 2008a).

The ACWS was undertaken from 2001 to 2007 and included the production of 20 technical reports and an ACWS Final Report. The final report containing 14 recommendations was released in February 2008 (Fox *et al* 2007). As a result of findings from the ACWS it has become evident the problems facing Adelaide's coast require a careful and strategic response, where the activities of a range of organisations including government, business and community are integrated and adaptively managed.

The Adelaide Coastal Water Quality Improvement Plan (ACWQIP) considers the new understanding provided by the ACWS and includes input provided by the Adelaide community about their expectations for water quality:

> The ACWQIP provides a long-term strategy for Adelaide's coastal waters to achieve and sustain a water quality consistent with community expectations.

Through the development of the ACWQIP, a clear community based vision has developed for Adelaide's coastal waters which can be summarised as:

> Healthy aquatic ecosystems where environmental, social and economic values are considered in a balanced management approach that aims to see the return of the 'blue line of seagrass' closer to shore.

This vision was developed based on input from people involved in local community groups; those working in local government, natural resource management (NRM), government agencies; those involved in business and industry; and individuals from metropolitan Adelaide.

The ACWQIP also provides strategies for the implementation of the 14 recommendations from the ACWS, and provides a monitoring and assessment framework for Adelaide's coastal waters.

The area encompassing Adelaide's coastal waters extends from Port Gawler in the north to Sellicks Beach in the south. The following waterways enter the Adelaide coastal waters: Northern Adelaide and Barossa creeks and rivers, Port River, River Torrens, Patawalonga River, Field River, Christies Creek, Onkaparinga River and the southern coastal catchments in the Aldinga area. This area is within the ancestral and traditional lands of the *Kaurna* the Aboriginal people of the Adelaide Plains and the Ramindjeri Nation. Current Kaurna Nation people have been included in targeted consultation in the preparation of the ACWQIP as well as members of the broader community.

Adelaide's coastal community recognises that achieving improvements in water quality and the return of seagrass will take time and the cost of necessary changes must be balanced by other social and economic considerations..

The ACWQIP has been developed in a manner consistent with the National Water Quality Management Strategy (NWQMS)—a system that has been used with success to resolve difficult water quality management issues across Australia. The NWQMS is endorsed through legislation in South Australia and is referred to in key strategic documents such as the *State Natural Resources Management Plan* (DWLBC 2006). The approach of setting environmental values (EVs) and water quality objectives (WQOs) and then developing regional water quality improvement plans is also

highlighted as a priority for the Adelaide and Mount Lofty Ranges (AMLR) NRM region and other high priority areas of South Australia in *Water for Good–a plan to ensure our water future to 2050* (Office for Water Security 2009).

The ACWQIP was developed using the following process:

- the findings of the ACWS were reviewed
- the views of the Adelaide community were sought, to obtain community aspirations for the coast and develop draft environmental values (EVs). The EVs were developed by identifying uses of our coastal waters that are important to the community and require specific water quality conditions (eg primary recreational uses such as swimming require suitable water quality to maintain public health)
- information compared with agreed standards to develop a working paper on 'Environmental Values, Water Quality Objectives, Pollution Reduction Targets and Environmental Flows' which was then referred to experts for review
- a process of stakeholder consultation and research was then undertaken to identify the long-term targets for water quality improvement for Adelaide's coastal waters, and identify actions required to achieve the set targets
- further research and modelling work was undertaken where uncertainty exists for issues such as climate change and population growth
- long-term strategies for bridging gaps were offered together with some indication of their likely success
- a monitoring plan was developed to integrate all of the information that we need to assess whether we are being successful in implementing the ACWQIP
- recommendations made for further work to resolve impediments to sustainably achieving an appropriate water quality for Adelaide's coast.

The ACWQIP has resulted in some important tools and background information being developed to guide in assessing appropriate courses of action. These include:

- a catchment model of inputs from Adelaide's watercourses
- a monitoring and assessment framework
- a statement of legislative issues
- a statement of reasonable assurance
- guidance about the effects of climate and population change.

Impacts of nutrients and sediments on Adelaide's coastal waters

The impact of nutrients, primarily nitrogen (N), suspended solids (or sediments) and to a lesser extent coloured dissolved organic matter (CDOM) on our coastal waters have been identified as key issues for water quality and seagrass health in the ACWS and in the process of developing the ACWQIP.

These pollutants are a direct result of the way that we have developed the Adelaide Plains, building stormwater systems to avoid flooding during periods of high rainfall, and wastewater treatment systems to protect the health of our population. The effects of the discharges from these systems were poorly understood and were understandably a secondary consideration at the time.

Adelaide's coastal waters cover a large area and include about 70 km of coastline. The recommendations of the ACWS with respect to the loads of key pollutants – nitrogen, suspended solids and coloured dissolved organic matter (CDOM) inevitably carry a degree of scientific uncertainty. It should be noted that the ACWS wording of 'around' is used with care by the report authors, indicating that there are a number of uncertainties involved in the calculation of the appropriate nitrogen load, and uncertainty is also implicit in the recommended load for suspended solids. There was sufficient uncertainty in the required load for CDOM that the authors did not feel justified in nominating an acceptable load. The required nitrogen and suspended solids loads may be somewhat smaller or larger, and the loads for the different parts of Adelaide's coastal waters are not specified.

The approach to these areas of uncertainty in other water quality improvement plans is often to derive a quanta for the level of uncertainty in the recommended long term loads and apply this as a margin of safety – typically 5 to 10% and reduce the target loads accordingly. While this approach has not been undertaken in this WQIP, managers of discharges such as Penrice Soda Holdings and SA Water recognise that long-term targets for the nitrogen content of their discharges will be based on local effects as well as the more diffuse effects of their discharges over a large area. The quality of the monitoring of these discharges will be very important in confirming long-term targets for each discharge. Without the further guidance to be provided through the implementation of the strategies in the ACWQIP, there is a risk of under or over capitalisation of improvement works at a considerable cost to the community.

Reducing nutrient loads

Recommendation 2 of the ACWS (Table 3) indicates that a reduction in nitrogen loads to around 600 tonnes per year (a 75% reduction from the 2003 value of 2,400 tonnes/year), is needed to halt current seagrass loss and create the conditions which support seagrass recovery.

Currently, nitrogen loads to Adelaide's coastal waters primarily come from three main sources: wastewater treatment plants (WWTPs), the Penrice Soda Holdings discharge in the Port River and stormwater from Adelaide's catchments.

The total 2008 nitrogen (N) load was 1,796 tonnes, a reduction of nearly 25% from the 2003 load of 2,357 tonnes/year. Since the information gathering work for the ACWS was completed in 2003 some improvements have already been made in treatment and industrial process that have resulted in improved water quality, but significant improvements are still required to achieve the recommended targets set in the ACWS and to see an improvement in water quality that creates the conditions where the blue line of seagrass can return closer to shore.

Existing committed nitrogen reduction and reuse projects will result in nitrogen load reductions for Adelaide's coastal waters by 2012 of about 50% from 2003 levels. Further nitrogen reductions should occur over time with reductions from Penrice Soda Holdings with successive environmental improvement programs (EIPs) and through potential further reductions from increased reuse.

It is important to view these targets in terms of the work that has been undertaken to date and the long-term opportunities for the reuse of water that are becoming apparent. SA Water embarked on highly effective programs in the 1990s to reduce the volume and the concentration of nitrogen in the wastewater discharged from the Bolivar WWTP. This work also enabled the WWTP to divert treated effluent to other uses including horticulture.

Reuse opportunities are increasing as water becomes more valuable and both the state and Australian governments have provided financial and institutional support for the development of reuse water projects. These often carry the additional benefit of economic and social outcomes, particularly when reuse water enhances horticultural or industrial development. It should also be noted that Penrice Soda Products obtain direct financial benefits from reducing the escape of ammonia to the Port River by optimising their plant processes and recovering this material.

While measures to reduce the concentration of the major sources of nitrogen discharge to Adelaide's coast can be costly both in terms of capital to build highly efficient WWTPs and nutrient recycling systems, and the cost and energy to run them, the adoption of a strategic approach by both dischargers will enable the required outcomes to be achieved in a cost-efficient manner. The focus of the ACWQIP is to provide a framework in the form of sustainable targets for the Adelaide coast against which the community can judge progress and against which regulatory agencies such as the EPA can assess improvement in performance of dischargers.

With increasing pressure on Adelaide's water resources, the reuse of stormwater and wastewater offer alternative water sources. However to be fully effective, far more reuse is needed in all seasons and the capacity to store water in one season for use in another season needs to be expanded. A comprehensive strategy to maximise the economic reuse of waste and stormwater is needed to resolve this situation.

Projects are being implemented across the Adelaide region that are driven by the *Adelaide and Mount Lofty Ranges Natural Resources Management (AMLR NRM) Regional Plan 2008*, the Water for Good Plan (Office for Water Security 2009) and *The 30-Year Plan for Greater Adelaide* (DPLG 2010) that will achieve some improvement in water quality for

Adelaide's coastal waters. It should be noted that the level of reuse required to achieve the ACWS nitrogen targets is higher than is currently planned. Depending on the level of future reuse, SA Water may need to include further reductions in discharge nitrogen concentration as plants are developed to cope with population increases over the next 30 years.

In the next few years, actions 16 and 19 in the Water for Good Plan provide an opportunity to support the development of integrated strategies for the reuse of stormwater and wastewater, taking into account requirements for water quality improvement for Adelaide's coastal waters and delivering multiple benefits such as greater water security and opportunities for economic growth.

Reducing sediment loads and coloured dissolved organic matter

The ACWS recommends a reduction in sediment loads of 50% from 2003 levels (over 10,000 tonnes/year) to allow sufficient light levels for seagrass to grow, and also recommends that to assist in the improvement of the optical qualities of Adelaide's coastal waters, steps should be taken to reduce the amount of coloured dissolved organic matter (CDOM) in waters discharged by rivers, creeks, and stormwater drains (Table 3).

The current major contributions of sediment and CDOM to Adelaide's coastal waters are primarily from stormwater originating from within Adelaide's catchments. In the past, sediment loads from WWTPs and Penrice were significant, but in recent years there have been substantial reductions in sediment from these sources (Table 10).

The AMLR NRM Board Plan includes a number of '20-year Regional Targets'which will result in the reduction of sediment and CDOM discharge into Adelaide's coastal waters (AMLR NRM Board 2008a). Particularly relevant are Targets T1, T2, T10, and T12. While achievement of these targets will yield sediment and CDOM loads which will be well below the ACWS recommended targets, these improvements are not expected to be noticeable during the first cycle of the ACWQIP implementation.

Until the constant feed of stormwater-driven loads of fine suspended solids particles decrease, Adelaide's coastal waters are likely to suffer ongoing water quality problems from constant inputs of both stormwater sourced suspended solids and CDOM. Recurrent dredging needed to maintain beaches and channel openings at Glenelg, West Beach and North Haven will redistribute and remobilise these fine sediments.

In the ACWQIP, reductions in stormwater flows and sediment inputs to the coast from utilising water sensitive urban design (WSUD) have been assumed for all greenfield developments. Adopting WSUD will reduce additional impacts from this type of development but this will not achieve any of the required improvements in water quality. However, WSUD techniques can also be applied to all infill development and redevelopment, together with improved practices and design/operation of public spaces, to further reduce the impacts of Adelaide's existing metropolitan area on coastal water quality.

The Water for Good Plan and The 30-Year Plan for Greater Adelaide call for mandating WSUD in a system that is appropriate for South Australia. This will assist in reducing the impact of sediments and CDOM on Adelaide's coastal waters.

Implications for water quality and seagrass

Evidence to date indicates that parts of Adelaide's seagrass meadows have typically taken many years to recover from the levels of harm experienced in the past. While seagrass recovery is likely to be slow initially, as nitrogen inputs reduce, recovery events will increase particularly in areas sustained through successive winter storms. A general recovery of the seagrass meadows, along with their associated ecosystem, is highly likely – but the process will be slow. Fox *et al* (2007) describes timeframes for the regrowth of seagrass in other parts of the world as 20 years or more once suitable conditions were re-established, with a return to a seagrass dominated system of local species over all of Adelaide's coast potentially taking over 100 years. Sediment stability will be a significant factor in determining the successful re-colonisation of seagrass. For this reason, the complex process of recovery is expected to be associated first with remnant existing seagrass beds, with an inshore movement of seagrass occurring over time. Due to the sparse pattern of seagrass recovery expected initially, reliable monitoring information will be needed to ensure that effectiveness of early nutrient and sediment load reductions are not under-estimated.

Nitrogen load reductions of 50% from 2003 levels are considered achievable in the next few years, which should arrest the loss of seagrass and perhaps allow for recovery in some areas. The outlook for further reductions is less clear until projects are developed and implemented by relevant agencies and groups. As these reductions are implemented, the shoreward progression of seagrass recovery will be slow initially, depending on how much sediment and CDOM are prevented from dominating nearshore water quality. As water clarity improves, regrowth can be expected during calmer years when seagrass seedlings are able to develop sufficient root mass to anchor them against storm periods and stabilise sediments. During this time, if reductions in the regular input of fine sediments are achieved, Adelaide's nearshore waters will become more attractive to swim in for most of the year.

Techniques to regrow seagrass have been developed by SA research and development efforts and, as further work allows these techniques to become more cost effective, the recovery of our seagrass meadows may be far quicker than is currently expected.

The ACWQIP has adopted targets to reduce the nutrient and suspended solid loads in Adelaide's coastal waters in line with recommendations of the ACWS. The key long-term targets for water quality improvement are:

- a reduction in nitrogen loads to around 600 tonnes/year (a 75% reduction from the 2003 value of about 2,400 tonnes/year)
- a reduction in sediment loads of 50% from 2003 levels (which were over 10,000 tonnes/year) to allow sufficient light levels for seagrass to grow.

If these targets are achieved, according to findings of the ACWS, they should result in improvements to Adelaide's coastal water quality, the halt of seagrass loss and eventual recovery of seagrass meadows.

In order to ensure these targets are met in the most cost and time effective manner, the ACWQIP includes recommended strategies to be undertaken (subject to funding) by a range of agencies to support its implementation. These strategies are summarised in the following table with further detail in Table 13a.

Strategies and actions proposed in the ACWQIP carry a high level of reasonable assurance in terms of meeting community agreed EVs for Adelaide's coastal waters in the longer timeframe of water quality improvement over the next 20 to 40 years. The timeframes for implementation fit with in the Water for Good focus to 2050 and The 30-Year Plan for Greater Adelaide focus to 2030.

The ACWQIP will be implemented adaptively so that as we learn more about our coastal system through monitoring, we will keep reassessing our strategies in the light of further knowledge. The first cycle of implementation of the ACWQIP actions is proposed for five years, but regular review of the strategies and actions will allow for appropriate modification upon each five-year review of the whole plan. The development of the ACWQIP has included the production of considerable background information as supporting documents available on the EPA website.

Note that the background reports include documents that have been developed to inform the development of the ACWQIP. These documents contain a large amount of technical and background information that stakeholders and the EPA are keen to make available to the public. Some of this information has undergone minor editing to remove names or other information to protect privacy. However, public comment is not directly sought on the reports and these will not be reprinted as part of the finalisation process for the ACWQIP. Most of the work for the reports was undertaken between 2006 and 2008 so some content is not necessarily current for 2011 and does not reflect the views of the South Australian government or current government policy.

ACWQIP strategies for improvement in water quality

Strategy no.	ACWQIP strategies for improvement in water quality and return of seagrass closer to shore	Details of specific actions required
1	Reduce nutrient, sediment and coloured dissolved organic matter discharges (CDOM)	1.1 EPA continue to work with SA Water and Penrice Soda Holdings to reduce nutrient and sediment loads 1.2 Encourage practical action for sediment reductions 1.3 Encourage uptake and implementation of water sensitive urban design (WSUD) across Adelaide region
2	Promote integrated use of wastewater and stormwater across Adelaide	2.1 Undertake further investigative work regarding options to facilitate greater integrated reuse of stormwater and wastewater (links to Actions 16 and 19 in Water for Good Plan) 2.2 Develop pilot or regional area projects for integrated use of stormwater and wastewater
3	Further investigate sources and volumes of sediment and CDOM	3.1 Further investigate sources of CDOM and sediments for catchment modelling 3.2 Identify practical and prioritised action that can be taken for reductions in CDOM and sediments from catchments
4	Integrate monitoring for cumulative impact assessment across Adelaide region	4.1 Facilitate integrated monitoring of cumulative impacts and emerging issues across agencies for Adelaide's coastal waters 4.2 Investigate and coordinate gap and operational funding for monitoring that needs to be done to meet recommendations of ACWS 4.3 Support ongoing monitoring of reef and seagrass condition to integrate with other monitoring activities.
5	Model and evaluate the impacts of climate change, new human impacts and population growth implications for Adelaide's coastal waters	5.1 Information from CDOM and sediment investigations and integrated monitoring activities to be fed into future modelling work 5.2 Model projection of wastewater treatment plant (WWTP) inputs and outflows as a result of population change

Strategy no.	ACWQIP strategies for improvement in water quality and return of seagrass closer to shore	Details of specific actions required
6	Establish planning and funding priorities for water initiatives for Adelaide's coastal waters	6.1 Identify priority funding areas for projects with multiple benefits (incorporate triple bottom line accounting into project planning) 6.2 Trial investigations for storage and use of water normally discharged to coast in winter months
7	Undertake seagrass mapping and rehabilitation work	7.1 Develop and update 'seagrass ready' maps that integrates water quality and sediment information 7.2 Further support for seagrass rehabilitation work
8	Build community capacity to take action to improve coastal water quality	8.1 Use existing Healthy Waters networks and other local government contacts to get messages across to community regarding how it can take local action for water quality improvement 8.2 Further develop linkages with Kaurna and Ramindjeri people regarding community water quality messages

Note: Access to supporting technical background reports that were produced as part of the development of the ACWQIP is available from the EPA website <www.epa.sa.gov.au>.

1 Introduction

With previous degradation and future population growth, Adelaide's coast can have two futures. It can continue to decline and become a cloudy, relatively lifeless body of water of no particular attraction, or it can be allowed to flourish and become an example of a coast that is cared for by its community—an asset that complements Adelaide's position as a preferred place to live, visit and do business into the future.

The Adelaide Coastal Water Quality Improvement Plan (ACWQIP) provides strategies that show how the South Australian community, including government agencies and industry, can work together to achieve and sustain a quality coastal ecosystem close to our city and enjoy the environmental, social and economic benefits derived from high quality swimming beaches adjacent to our metropolitan area.

Access to supporting technical background reports that were produced as part of the development of the Adelaide Coastal Water Quality Improvement Plan is available from the EPA website page on the ACWQIP <www.epa.sa.gov.au>

The strategies in the ACWQIP have significant commitment from those tasked with change. The ACWQIP can, and is likely to, succeed as this commitment is supported over time.

The decline in our coastal waters has taken place over many years with many actions, often well-intentioned, playing their part. In recent years we have taken steps to reverse this trend and much has been done. We can be proud of the work already done and currently being undertaken. While we now have the understanding and will to rehabilitate our coastal ecosystem, we must be prepared to be patient as we watch this happen over time, with some lags between effort and result.

The Environment Protection Authority (EPA) has prepared the ACWQIP which includes the metropolitan coast down to Sellicks Beach and the Port waterways (Map 1). The area covers a 70-km stretch of coastline from Port Gawler in the north to Sellicks Beach in the south. The management zone of the ACWQIP is from the shore to a few kilometres offshore, differing from the Adelaide Coastal Waters Study or ACWS (Fox *et al* 2007) which considered the same length of coast, but extended 20 km offshore.

The management zones adopted for the purposes of the ACWS have been modified as a result of community feedback during the development of the ACWQIP and also to include detailed segmentation of the Port Waterways Water Quality Improvement Plan (PWWQIP).

The ACWQIP provides information about sections of the coastal waters and Port waterways (management sections referred to in Map 1) and their environmental values (EVs). Developing draft EVs involved identifying uses of our coastal waters that are important to the community and require specific water quality conditions (eg primary recreational uses such as swimming must have suitable water quality to maintain public health).

The EVs were defined during a consultation program with stakeholders, the broader community, the ACWS and other sources. For the water quality management sections, the ACWQIP defines ambient water quality objectives and pollutant reduction targets necessary to protect the EVs and facilitate recovery where damage has occurred to marine ecosystems.

Water from the following waterways enters the Adelaide coastal waters (Map 1): Northern Adelaide and Barossa creeks and rivers, Port River, River Torrens, Patawalonga River, Field River, Christies Creek, Onkaparinga River and the southern coastal catchments in the Aldinga area. The coastal portion of these catchments is within the ancestral and traditional lands of the Kaurna, the Aboriginal people of the Adelaide Plains and the Ramindjeri Nation. Current Kaurna Nation people were included in targeted consultation for the preparation this ACWQIP as well as the broader community. Note that knowledge of the Ramindjeri Nation identifying themselves as a separate Aboriginal group to be consulted with for the Adelaide plains only became known to the EPA at the end of the process of developing the ACWQIP.

The ACWQIP considers the new understanding provided by the ACWS and includes input provided by the Adelaide community for establishing EVs and water quality objectives (WQOs) for Adelaide's coastal waters:

> The ACWQIP provides a long-term strategy for Adelaide's coastal waters to achieve and sustain a water quality consistent with community expectations.

Through the development of the ACWQIP a clear community based vision has developed for Adelaide's coastal waters which can be summarised as:

> Healthy aquatic ecosystems where environmental, social and economic values are considered in a balanced management approach that aims to see the return of the 'blue line of seagrass' closer to shore.

This vision was developed by people involved in local community groups, local government, natural resource management (NRM), government agencies, business and industry as well individuals from metropolitan Adelaide.

The ACWQIP has adopted targets to reduce the nutrient and suspended solid loads to Adelaide's coastal waters in line with recommendations of the ACWS and shows the commitment that key water quality managers have to achieve them. As these targets are achieved over time, there is a high expectation they will be accompanied by improvements to Adelaide's coastal water quality, the halt of seagrass loss and support the eventual recovery of our seagrass meadows.

The ACWQIP will be implemented adaptively so that as more is learnt about our coastal system through monitoring, management strategies can be reassessed in the light of further knowledge. The development of the ACWQIP included preparation of considerable background information in supporting documents which are available on the EPA website. This information is provided to assist with ongoing critical review of the plan and its implementation.

Note: Access to supporting technical background reports that were produced as part of the development of the ACWQIP is available from the EPA website <www.epa.sa.gov.au>.

2 Links with other plans

The development of the ACWQIP has involved compiling information from Adelaide's coastal community on environmental values (EVs) and water quality objectives (WQOs), reviewing findings and recommendations from the ACWS, understanding linkages with existing strategies and plans, and developing specific targets and strategies aimed at water quality improvements for Adelaide's coastal waters. The ACWS (Fox *et al* 2007) focused on water quality, seagrass and sediment issues. The ACWQIP has incorporated additional issues outside the scope of the ACWS such as the health of sub-tidal reefs and community views. Nitrogen reduction targets set in the Port Waterways Water Quality Improvement Plan (PWWQIP) [EPA 2008a], which covers the Port River–Barker Inlet system, have also been included into the ACWQIP.

The ACWQIP identifies EVs specific to Adelaide's coastal waters and the Port waterways after consulting with the community. Generic EVs have been identified for the coastal waters in other studies, including the Torrens and Patawalonga Catchment Water Management Plans and the PWWQIP (EPA 2008a).

The ACWQIP defines WQOs and long-term pollutant reduction targets needed for nutrients and suspended solids to enable Adelaide's coastal waters to achieve both these objectives and a water quality condition which is consistent with community expectations for EVs. Recent technical review of WQOs was also included as part of the Healthy Waters project which defined draft EVs for the entire Adelaide Mount Lofty Ranges Natural Resource Management (AMLR NRM) Board region (EPA in press).

The ACWQIP has also been developed in accordance or with direct regard to the following national, state and local plans including:

- *National Water Quality Management Strategy* (SEWPaC 2011)
- *South Australia's Strategic Plan 2007* (South Australian Government 2007)
- *Environment Protection Authority Strategic Plan 2009–2012* (EPA 2009)
- *State Natural Resources Management Plan 2006* (DWLBC 2006)
- *Water for Good–A plan to secure our water future to 2050* (Office for Water Security 2009)
- *Adelaide and Mount Lofty Ranges (AMLR) NRM Regional Plan* (AMLR NRM Board 2008a)
- *The 30-Year Plan for Greater Adelaide* (DPLG 2010)
- *Living Coast Strategy* (DEH 2004)
- *Adelaide's Living Beaches Strategy* (DEH 2005)
- *Adelaide Dolphin Sanctuary Management Plan* (DEH 2008)
- *Four Nations NRM Governance Group Strategic Plan and Consultation and Engagement Protocols* (Four Nations Governance Group 2007).

2.1 National Water Quality Management Strategy

The preparation of the ACWQIP was undertaken in a manner consistent with the National Water Quality Management Strategy (NWQMS), which contains nationally agreed policies, processes and guidelines [part of the Council of Australian Governments' (COAG) Water Reform Agenda–COAG 1994] that provide the information and tools for communities to plan for the sustainable management of their water resources (Figure 1). The NWQMS aims to achieve sustainable use of the nation's water resources by protecting and enhancing their quality while maintaining economic and social development (SEWPaC 2011).

The NWQMS requires the involvement of the community, who are central to the effectiveness of the process. Consultation throughout the development of a water quality improvement plan (WQIP) ensures the final strategies are accepted and adopted by the community. The initial processes in the development of a WQIP involve establishing EVs and WQOs. This consultation process has been followed in the development of the ACWQIP.

2.2 South Australia's Strategic Plan 2007

The six objectives of South Australia's Strategic Plan (South Australian Government 2007) have relevance to the work of the EPA and the ACWQIP as follows:

- *Growing prosperity*—economic benefits from fishing and other recreational activities and enhancement of the socio-economic status of coastal residential properties and commercial activities through proximity to a protected high quality coastal environment.
- *Improving well being*—public safety while swimming enhanced and the social benefits of recreational use of Adelaide's coastal waters protected.
- *Attaining sustainability*—residential, commercial and industrial impacts on coastal waters managed.
- *Fostering creativity and innovation*—stormwater and treated effluent reuse technologies developed, improved and disseminated.
- *Building communities*—all Adelaide residents and users of coastal waters encouraged and supported to work together to protect our marine environment.
- *Expanding opportunities*—large-scale reuse of treated effluent offering substantial opportunities for expansion of irrigated horticulture.

There are two specific relevant targets in the State Strategic Plan under Objective 3: Attaining sustainability that are relevant to the ACWQIP.

- *T3.9 Sustainable water supply*—note that greater reuse of wastewater and stormwater across metropolitan Adelaide should lead to better water quality for the marine environment and therefore will benefit the ACWQIP in achieving an improved water quality for Adelaide's coastal waters. A greater focus on reuse of wastewater and stormwater will assist in marine waters being managed within sustainable limits to support aquatic ecosystems, fisheries and recreation.
- *T3.4 Marine biodiversity*—the ACWS identified nutrients and suspended solids to be the primary cause behind the loss of thousands of hectares of seagrasses along the Adelaide metropolitan coastline. The targets for nutrient and suspended solid reductions in the ACWQIP seek to prevent further seagrass loss and support conditions for seagrass rehabilitation. This will in turn enhance marine biodiversity off the metropolitan coastline and the broader area of Gulf St Vincent.

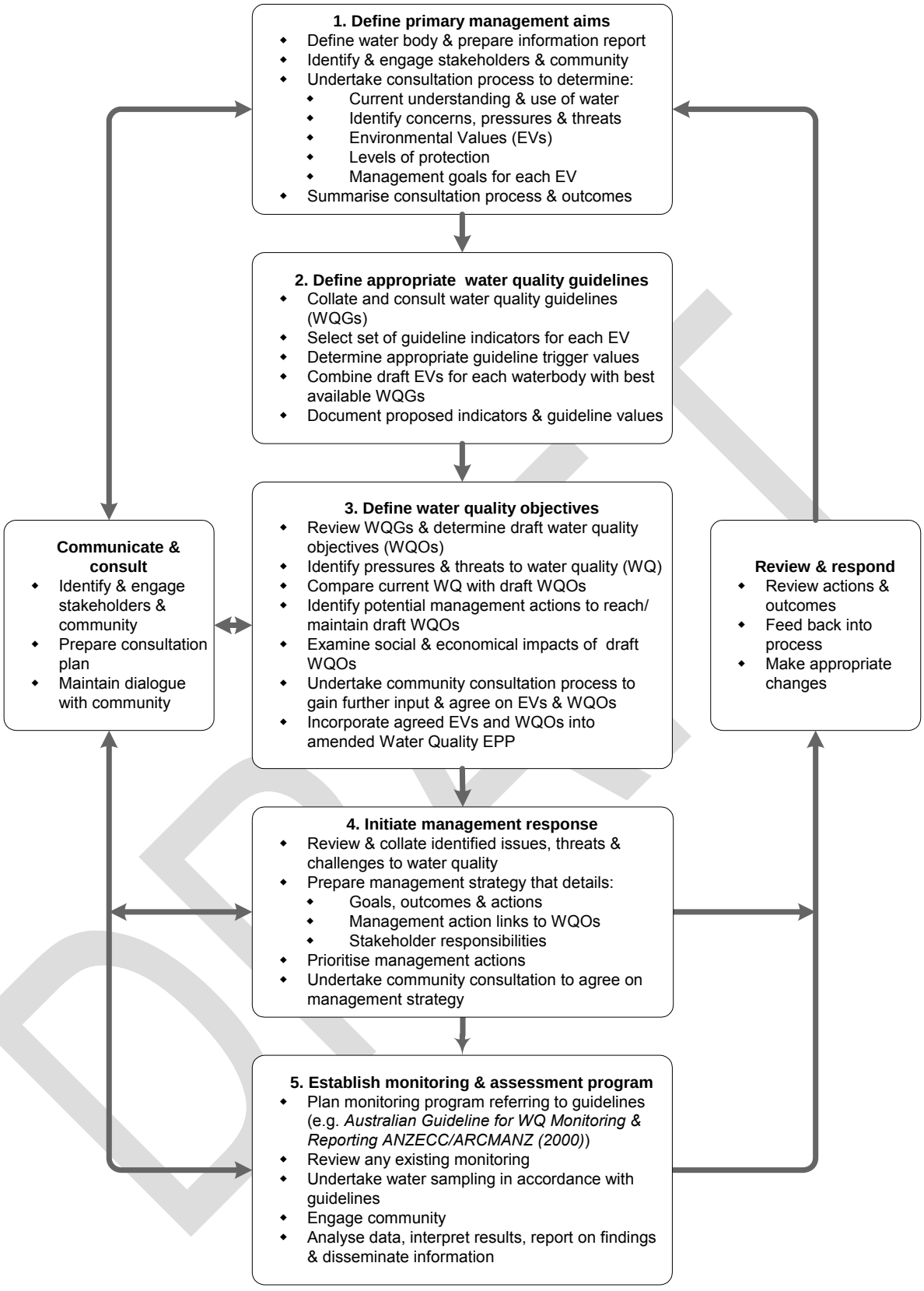

Figure 1 **National Water Quality Management Strategy (NWQMS) Water Quality Management Framework as applied to South Australia**

2.3 Environment Protection Authority Strategic Plan 2009–2012

The EPA Strategic Plan 2009–2012 *(*EPA 2009) has two environmental goals that relate specifically to the ACWQIP. These are:

- Land and water that is fit for purpose—protecting South Australia's water bodies and land from the adverse impacts of pollution and waste which might reduce their value to current and future generations. This includes a key performance indicator of the percent of water bodies meeting water quality objectives.

  The development of EVs and WQOs is an important first step as these are area-specific targets for water quality against which to assess progress. The implementation of the ACWQIP will provide measurable progress toward this goal with a highly important water body achieving sustainable water quality improvement consistent with community derived EVs.

- *Sustainable use of resources*—reducing costs to business and environmental impacts by promoting the efficient use of resources and waste minimisation.

  Attention to this environmental goal is actioned in the ACWQIP through its emphasis on the effective reuse of wastewater and stormwater to achieve multiple (environmental, social and economic) benefits.

The development of the ACWQIP has determined agreed EVs and WQOs for Adelaide's coastal waters and outlines the required water quality improvement targets to have 'land and water that is fit for purpose' in the AMLR NRM region. The completion of this work will contribute towards EPA work undertaken for Water for Good Actions 49 and 63 (Office for Water Security 2009).

The *Environment Protection (Water Quality) Policy 2003* (EPA 2003) as a part of the *Environment Protection Act 1993* is South Australia's principal legislation for the protection of water quality. It is linked to the NWQMS through the setting of default EVs and water quality criteria. The Water Quality Policy can be amended to include specific EVs and water quality criteria for particular bodies of water. The work of the PWWQIP, ACWQIP and Healthy Waters projects will work towards having the Water Quality Policy updated to include the community agreed EVs for specific waterways (in this case Adelaide's coastal waters), rather than the current generic default EVs and WQOs. This will enable the EPA to use the EVs as a legislative tool to guide appropriate development and use of waters so impacts to waters are managed.

2.4 State Natural Resources Management Plan 2006

The State Natural Resources Management Plan 2006 (DWLBC 2006) contains the goal, 'Prosperous communities and industries using and managing natural resources within ecologically sustainable limits', which is of particular relevance to this plan.

The State NRM Plan also contains the resource condition target, 'By 2011, an increase in net water quality compared to 2006' (W4); and the strategies, '2.3.1 Apply the National Water Quality Strategy policy and principles to protect marine water quality' and '2.7.1 Use the National Water Quality Management Strategy process to manage the quality of water resources including lakes, rivers, watercourses, wetlands, estuaries and underground water'.

The EPA is the lead agency for the latter two strategies in cross-government and NRM consultative processes for implementing the NWQMS by setting community agreed EVs and WQOs, establishing management strategies and facilitating ongoing monitoring and reporting for waters across South Australia.

2.5 Water for Good—a plan to ensure our water future to 2050

Some of the relevant actions to the ACWQIP from Water for Good (Office for Water Security 2009) include:

- Action 12—update, by 2010, state water recycling guidelines to reflect the *Australian Guidelines for Water Recycling*, and include stormwater.
- Action 16—develop a master plan for effectively managing stormwater in Adelaide.

- Action 18—develop state guidelines for grey water recycling, consistent with Australian Guidelines for Water Recycling, by 2010.
- Action 19—develop a master plan for effectively managing wastewater in Adelaide, in concert with the stormwater recycling master plan, to ensure optimum use of both water sources.
- Action 22—complete wastewater recycling projects, including Glenelg to Parklands (open space irrigation), Blakeview (housing development), Southern Urban Recycling Project (housing development), by 2013.
- Action 46—increase regularity of statewide data collation, assessment and reporting, where required.
- Action 63—the EPA will develop environmental values for priority water bodies across the state by 2014.
- Action 67—by 2013 develop and implement the best regulatory approach for South Australia to mandate WSUD, dovetailing with The 30 Year Plan for Greater Adelaide.
- Action 68—introduce WSUD targets by 2010.

In particular the ACWQIP is one of the water quality improvement plans being developed under Action 49 for critical waters across the state and its development has involved setting EVs for the priority waters off the Adelaide coast according to Action 63.

2.6 Living Coast Strategy

The Living Coast Strategy (DEH 2004) provides direction for the conservation, management and protection of the state's coast and marine environments. It sets out the policy directions that the state government will be taking to help protect and manage South Australia's coastal areas, estuaries and marine ecosystems. The programs are also shaped by a number of state and national strategies and policies, as well as international agreements and conventions referred to in the Living Coast Strategy. These programs are implemented in partnership with the Coast Protection Board, regional Natural Resources Management Boards, local government and community and industry.

The development of the ACWQIP supports the following objectives of the Living Coast Strategy:

- *Objective 3—To control pollution of our coastal, estuarine and marine environments* by providing for nitrogen, suspended solids and CDOM to be reduced to and remain at sustainable loads.
- *Objective 4—To protect our coastal, estuarine and marine assets* by protecting Adelaide's coastal seagrass and allowing for its natural recovery over time.
- *Objective 5—To improve understanding of coastal, estuarine and marine environments* which has been supported through the ACWS being undertaken. The implementation strategies in the ACWQIP provide support for this objective through the better understanding of the fate and transport of suspended solids and CDOM to and along Adelaide's coast (Strategy 3), and the support for further work to undertake seagrass mapping and rehabilitation work (Strategy 7).

2.7 Adelaide and Mount Lofty Ranges NRM Regional Plan

The AMLR NRM Board has developed a regional plan based on a long-term vision for the future of the region, titled *Thriving communities caring for our hills, plains and seas* (AMLR NRM Board 2008a). It also outlines what the stakeholders in the region (local, state and federal government, industry groups, non-government organisations and the community) are aiming to achieve in the next 20 years. For further details on the AMLR NRM Regional Plan for the region refer to section 6.6.

The regional plan has Management Action Target 18—three WQIPs developed and being implemented—including this ACWQIP.

2.8 The 30-Year Plan for Greater Adelaide

The 30-Year Plan for Greater Adelaide (DPLG 2010) is a dynamic spatial expression of South Australia's Strategic Plan 2007. As a volume of the South Australian Planning Strategy it will be used statutorily by the state government to guide the planning and delivery of services and infrastructure, such as transport, health, schools and community facilities.

The main aim of the plan is to outline how the government proposes to balance population and economic growth with the need to preserve the environment and the need to protect the heritage, history and character of Greater Adelaide.

Expansion of Adelaide's urban footprint through population growth would normally be expected to result in an increase in the amount of stormwater runoff and associated pollution. Attention to incorporating WSUD and other stormwater reuse principles in both greenfield infill development and development of appropriate reductions of wastewater discharges will be required to achieve the growth Adelaide needs without compromising the economic, social and environmental capacity of our city.

The biodiversity theme of the plan recognises the environmental, social and economic value of seagrass as a unique habitat adjacent to Adelaide's metropolitan area, including Target E:

> Minimise the discharge of stormwater, pollution and nutrients to freshwaters, coastal and marine environments through the adoption of appropriate water sensitive urban design (WSUD) and Adelaide coastal water quality improvement plan policies and targets into development plans.

The EPA will work with the Department for Planning and Local Government (DPLG) and other relevant agencies to ensure this is undertaken.

2.9 Adelaide Living Beaches Strategy

The Coast Protection Board and the Department of Environment and Natural Resources (DENR) have been managing Adelaide's beaches for over 30 years in response to sand erosion and sand movement north along the coast. The main strategies for the future management of Adelaide's beaches from 2005 to 2025 are as follows:

- continue beach replenishment
- recycle sand more effectively using sand slurry pumping and pipelines
- add coarse sand from external sources
- build coastal structures in critical locations
- integrate sand bypassing of harbours with beach management.

Sand movement, pumping and pipeline works are most likely to impact on the water quality of Adelaide's coastal waters and these activities need to be appropriately managed (see Section 6.9). For more information on these strategies refer to the Adelaide's Living Beaches–A strategy for 2005–2025 (DEH 2005).

2.10 Adelaide Dolphin Sanctuary Management Plan

The Adelaide Dolphin Sanctuary (ADS) Management Plan (DEH 2008), has six objectives with Objective 3 relating to water quality in the Port Waterways. The EPA has responsibilities under the four issues listed for Objective 3 and has been asked to report against this objective to the ADS Management Board. The four issues cover reduction of nutrients, reduction of pollutants, management of ballast waters and management of toxicants (DEH 2008).

The Port waterways are included in the area covered by the sanctuary. Objective 3 of the ADS Management Plan—improved water quality as indicated in the Adelaide Dolphin Sanctuary Act 2005 s8(1)(c):

> Water quality within the Port Adelaide River estuary and Barker Inlet should be improved to a level that sustains the ecological processes, environmental values and productive capacity of the Port River estuary and Barker Inlet.

Maintaining water quality at a level that supports the use of the environment by dolphins has been considered in setting EVs, WQOs and appropriate levels of protection for the Port waterways (EPA 2008a).

Also, under Part 2, Section 10A of the *Environment Protection Act 1993,* should an administrator of the Act take action within the boundaries of the sanctuary they must take into account the provisions of the (ADS) Management Plan.

2.11 Four Nations NRM Governance Group Strategic Plan and Protocol

The Four Nations NRM Governance Group were elected members from the Kaurna, Ngadjuri, Ngarrindjeri and Peramangk people, who worked together to support each other's NRM aspirations. The relationship shared by the groups stretched beyond NRM work and was inherently linked to the deep spiritual and cultural values Aboriginal people in the region share.

The Four Nations NRM Governance Group developed a Strategic plan and also a document of 'Consultation and Engagement Protocols' (Four Nations Governance Group 2007), as a 'one stop shop' to negotiate with all groups of interest to achieve NRM and employment outcomes that provide social and economic equity, encourage and support youth, through to senior Aboriginal people to fulfill cultural obligations to country.

The group supported the integration of NRM in the region. The objectives of the group (Four Nations Governance Group 2007) included achieving culturally appropriate outcomes for soils, water resources, geological features and landscapes, native vegetation, native animals, other native organisms and ecosystems.

The future goals for the Four Nations Ancestral or Traditional Lands are:

- To be acknowledged and respected by everyone.
- Lands, sea and waterways protected from pollution and from other damaging impacts, with past damage rehabilitated and natural environment restored.
- Healthy lands, sea and waterways = healthy people.
- Cultural awareness about land, sea and waterways and the cultural heritage significance of lands and waters protected.
- Good relationships with non-Aboriginal people and government.
- A strong network of Aboriginal landholders working and supporting each other.
- Increased resources for Aboriginal Traditional Owners for the ongoing joint management of their lands, sea and waterways, including resources which can make good the damage from the past unjust treatment of Aboriginal peoples, their land and waterways.
- Community members, especially young people well trained in environmental care and natural resource management, who understand both Aboriginal and non-Aboriginal knowledge about natural resources, and who have real opportunity for real jobs and good careers.

- A strong role for Aboriginal people in making decisions about all land and water management, employment, monitoring and recommending sustainable use of land, sea and waterways biodiversity.
- Cultural security for our grandchildren and future generations.

The ACWQIP was developed in accordance with the Four Nations NRM Governance Consultation and Engagement protocols (Four Nations Group 2007) and Strategic Plan 2006–2010. However, since this work commenced the Four Nations Group no longer is in operation under the AMLR NRM umbrella and the Ramindjeri people have asked to also be recognised as a traditional group within the bounds of the AMLR NRM region.

The ACWQIP deals with a part of the AMLNRM Board region that includes the traditional lands of the Kaurna and Ramindjeri Nations. Consultation undertaken with the Kaurna Nation as part of the development of this ACWQIP was undertaken consistent with the Four Nations NRM Governance Group Strategic Plan (Four Nations Governance Group 2007).

3 Stakeholder and community input

3.1 Adelaide Coastal Waters Steering Group

The ACWS Steering Group was established in late 2008 to support the development and implementation of the ACWQIP. Its membership consists of representatives from the following organisations and groups:

- Department of Sustainability, Environment, Water, Population and Communities (formerly Australian Department of the Environment, Water, Heritage and the Arts)
- Adelaide and Mount Lofty Ranges (AMLR) NRM Board
- Coast Protection Board
- Conservation Council of SA
- Department of Environment and Natural Resources (formerly Department for Environment and Heritage)
- Department of Planning and Local Government
- Department of the Premier and Cabinet
- Department for Transport, Energy and Infrastructure
- Department of Treasury and Finance
- Environment Protection Authority
- Local Government Association
- Department for Water (formerly Office for Water Security and Department for Water, Land and Biodiversity Conservation)
- Penrice Soda Holdings
- Primary Industries and Resources SA
- SA Water
- South Australian Recreational Fishing Advisory Council
- Stormwater Management Authority.

The Steering Group members have had to ensure key stakeholder requirements for the implementation of the recommendations of the ACWS are reflected and acknowledged in the ACWQIP. The Steering Group has also provided comment and feedback on the development of the ACWQIP at various stages. After the period of public comment on the ACWQIP, the group will play a role in supporting efforts to finalise the ACWQIP.

3.2 Adelaide's coastal community

Community and stakeholder consultation was undertaken in 2007 and 2008 to establish EVs and WQOs for Adelaide's coastal waters and to link with existing strategies, plans and actions. Community input in the development of the ACWQIP has been sought through public meetings, workshops and targeted discussions. Information from the Adelaide coastal community and stakeholders has been used to develop long-term targets for water quality improvement for Adelaide's coastal waters.

In 2007 public workshops were held to develop draft EVs and WQOs for Adelaide's coastal waters. In 2008 targeted stakeholder discussions were held with staff from the AMLR NRM Board, SA Water, Penrice Soda Holdings, Stormwater Management Authority, local government and state government agencies. Focus groups were held with business, industry, state and local government, and community representatives to confirm the EVs identified by the community in 2007, and to define targets for improvement for Adelaide's coastal waters. The reports on these community consultation workshops are provided in Report 1 on the EPA website.

For further information on the community input provided for the vision of Adelaide's coastal waters and the development of EVs, refer to section 4.2.

3.3 Aboriginal groups

As part of the development of the ACWQIP, information has been sought on the Aboriginal vision and aspirations for Adelaide's coastal waters. The Four Nation NRM Governance Group produced two documents that have information relevant to determining the Aboriginal vision, aspirations and environmental values for Adelaide's coastal waters.

Four Nations Natural Resources Management Governance Group Strategic Plan 2006–2010

The following aspirations (from *Four Nations Natural Resources Management Governance Group Strategic Plan 2006–2010*, pg 18) are of particular significance to determining the vision, aspirations and EVs for Adelaide's coastal waters:

- Lands, sea and waterways protected from pollution and from other damaging impacts, with past damage rehabilitated and natural environment restored.
- Healthy lands, sea and waterways = healthy people.
- Cultural awareness about land, sea and waterways and the cultural heritage significance of lands and waters protected.

However, note that since this work commenced the Four Nations Group is no longer in operation under the AMLR NRM umbrella and the Ramindjeri people have asked to also be recognised as a traditional group within the bounds of the AMLR NRM region.

The ACWQIP deals with a part of the AMLNRM Board region that includes the traditional lands of the Kaurna and Ramindjeri Nations. Consultation undertaken with the Kaurna Nation as part of the development of this ACWQIP was undertaken consistent with the Four Nations NRM Governance Group Strategic Plan (Four Nations Governance Group 2007). Note that knowledge of the Ramindjeri Nation identifying themselves as a separate Aboriginal group to be consulted with for the Adelaide plains only became known to the EPA at the end of the process of developing the ACWQIP.

3.4 Kaurna Nation

As part of the community and broad stakeholder consultation, a specific consultation process was undertaken in June 2008 with Kaurna Nation representatives to seek Aboriginal input into the development of the ACWQIP. Information on the ACWQIP was also presented at the Four Nations NRM Governance Group. Members of the Kaurna community were invited to attend a focus group to provide input into determining EVs for Adelaide's coastal waters. For the full report on the workshop refer to information provided in Report 1 on the EPA website.

Kaurna workshop key messages

- Aboriginal people cannot separate cultural and ecological values—they are the essence of the landscape.
- The coast is an integral part of the overall system and landscape for Aboriginal people and cannot be assessed and/or managed in isolation.
- The coastline is dying through a lack of respect for the integration of systems.
- Many small projects do not equate to a healthy overall system.
- All of the coast has cultural and ecological significance and cannot easily be simplified to a range of geographical locations.

A comment made at the workshop may sum up the intent of the Kaurna vision and aspirations for Adelaide's coastal waters:

> We want to leave a legacy to people and places.... Leave a deed to the people.

From reviewing the range of information, the key messages from the workshop highlight the interconnection of all aspects of the coastal system with the broader landscape and cultural and spiritual values. Cultural heritage and spiritual connections have been identified as important EVs for the Kaurna people (refer to section 4.2).

4 Water quality

4.1 Coastal and Port waterways management sections

Water quality management sections for the Port waterways were defined with community input as part of the PWWQIP. They were based on the degree of modification from their natural condition by development, the extent and condition of natural ecosystems, amenity and recreational use, conservation status and information from the modelling on water circulation patterns in the waterways. Similarly, water quality management sections defined in the ACWS, were generally accepted by the stakeholders and community. These ACWS sections have been integrated with the sections defined in the PWWQIP and adjusted to reflect the AMLR NRM Board northern boundary as shown on Map 1 and described below in Table 1.

Table 1 Adelaide coastal water quality management sections (modified from Fox *et al* 2007)

Adelaide Coastal Water Zones	General place names	Description
Adelaide Coastal Water Zone 1	Northern	Offshore Gawler River, to the northern AMLR NRM Board boundary
Adelaide Coastal Water Zone 2	North Barker Inlet	Barker Inlet from St Kilda to Gawler River
Adelaide Coastal Water Zone 3	Central Barker Inlet	Torrens Island Bridge to St Kilda
Adelaide Coastal Water Zone 4	Port River	West Lakes to end of Outer Harbor breakwater
Adelaide Coastal Water Zone 5	Central Metropolitan	Outer Harbor to Marino
Adelaide Coastal Water Zone 6	Southern	All remaining discharges from Marino to Sellicks Creek

The following sections detail the water quality management sections listed in Table 1 and shown on Map 1.

4.2 Environmental values

EVs identified by Adelaide's coastal community in the development of the ACWQIP are grouped into those relating to the environmental, social and economic uses of Adelaide's coastal waters. The nine EVs for Adelaide's coastal waters are indicated in Map 1 and Table 2.

Table 2 displays the community agreed EVs according to the relevant social, environmental and economic groupings and includes both current and potential future uses identified for Adelaide's coastal waters. Map 1 indicates the range of EV's for Adelaide's coastal waters on a map that includes the different management segments.

Some values are only relevant for certain segments of the Adelaide coastal waters (ie commercial and industrial use in the Port waterways). Other values, such as protection of aquatic ecosystems and cultural and spiritual values, relate to the whole coastline.

Vision for Adelaide's coastal waters:

> Healthy aquatic ecosystems where environmental, social and economic values are considered in a balanced management approach that aims to see the return of the 'blue line of seagrass' closer to shore.

This vision was developed through Steering Group discussions based on community and stakeholder quotes from the ACWQIP Stage 1 Community Consultation Executive Summary (see Report 1 on the EPA website). Some of these quotes included:

- 'go swimming and see my feet in afternoon sea waters'
- 'observe the sea floor'
- 'ability to see the blue line closer to shore'
- 'healthy reefs'
- 'coastal waters being free of stormwater discharge and nutrient rich outflows in the future'
- 'no species loss due to water quality issues'
- 'creative solutions to capture, clean and reuse stormwater'
- 'recreational activities including swimming, boating, walking and fishing to be enjoyed anywhere along the coastline'
- 'coliform levels be consistent with natural levels and cycles'.

Environmental values (EVs) were first identified through the 2007 community workshops for the development of the ACWQIP and confirmed through targeted workshops in 2008, and added in discussions with Steering Group members in 2009:

- aquatic ecosystems (protection)
- cultural and spiritual
- visual appreciation (aesthetics)
- primary recreation
- secondary recreation
- human consumption (seafood)
- industrial and commercial use
- raw drinking water (through desalination)
- aquaculture (potential).

Table 2 Draft environmental values (EVs) for Adelaide's coastal waters

Environmental values	Social values	Economic values
Ecological  Protection of aquatic ecosystems	**Aesthetic**  Visual appreciation	**Commercial (current and future)**  Human consumption (aquatic foods)  Drinking water supply—desalination  Fishing & aquaculture (tourism, related to recreational EVs)
	Recreational  Primary recreation (eg swimming & snorkelling)  Secondary recreation (eg fishing & boating)	**Industrial**  Industrial use
	Cultural and spiritual  Cultural heritage (Aboriginal and non-Aboriginal)	

The EVs of the coastal waters and Port waterways have been defined in a number of previous studies, in particular the earlier Torrens, Patawalonga and Onkaparinga Catchment Water Management Plans. Appropriate EVs from these studies include:

- the protection and maintenance of aquatic ecosystems (ecological)
- primary industries (industrial and commercial, in this case aquaculture/human consumption of aquatic foods)
- recreation (recreational) and aesthetics.

In addition, there is the EV of industrial use of water (also commercial such as cooling water for power stations and industrial processes) for the Port waterways. Cultural and spiritual values have also been identified as important EVs by the Adelaide coastal community including the Kaurna people, who had input to the development of the draft ACWQIP through a targeted workshop (see Report 1 of the supporting technical reports on the EPA website).

While the values are generally applicable throughout the study area, differences in emphasis are to be expected for the different water quality management sections in the Port waterways and Adelaide coastal waters. For example, it would not be appropriate to have EVs of primary water contact (ie swimming) adjacent to discharges of wastewater from wastewater treatment plants (WWTPs) or industry. Signage provided either by local and/or state government for specific locations may indicate where certain EVs are not appropriate. Signage may also be used to indicate certain times when the water quality is not suitable for certain EVs and activities (eg after large storm events, water in the vicinity of stormwater drains and catchment outflows would not be considered safe for swimming). The *Australian and New Zealand Water Quality Guidelines* (ANZECC 2000) also defines different levels of protection depending upon condition and area sensitivities.

An essential part of the development of the ACWQIP has been the community and stakeholder consultation program undertaken during 2007 and 2008 to assist in defining EVs and identifying community issues. The executive summary report from this consultation is included in Report 1 of the supporting technical reports on the EPA website.

4.3 Setting water quality objectives

Targeted community and stakeholder input to the development of the ACWQIP have been valuable in assisting and defining the level of protection that is appropriate in developing WQOs. This input continues to be sought and confirmed through public comment on this ACWQIP.

For the coastal waters, it was very apparent that equal importance is given to all locations along the coast by the community. Residents in the Port Adelaide area, for example, valued the amenity and habitats of the southern region as well as the nearby Port waterways. Not only was the coastline considered to be an important community asset, a clean functional environment is seen as part of their heritage. Another very clear message that came through in all community discussions was the need to allow for the recovery of seagrass along the Adelaide coastline even though this may take some decades to achieve.

Levels of protection for the different water quality management sections (Map 1) were derived from the EVs set by the community, and are briefly described below.

4.3.1 Port waterways

The Port waterways are included in the area covered by the Adelaide Dolphin Sanctuary (ADS). Objective 3 of the ADS Management Plan (DEH 2008) is 'improved water quality' and as indicated in the Adelaide Dolphin Sanctuary Act s8(1)(c):

> Water quality within the Port Adelaide River estuary and Barker Inlet should be improved to a level that sustains the ecological processes, environmental values and productive capacity of the Port River estuary and Barker Inlet.

Therefore maintaining water quality of a level that supports the ecosystem values of the Port waterways and capacity of the area to support the use of the environment by dolphins needs to be considered in setting EVs and WQOs for the Port waterways and appropriate levels of protection for these areas.

Levels of protection of water quality EVs defined for the three sections of the Port waterways are as follows:

- **Northern section, north of St Kilda and Torrens Island**

  Although described as an area severely impacted by nutrients in the PWWQIP from the discharges from the Bolivar WWTP and Penrice Soda Holdings, this area is a high value conservation area and ecological system and a high level of protection is considered appropriate by the community.

- **Central Barker Inlet section, which includes south of St Kilda in Barker Inlet, Angas Inlet, North Arm and North Arm Creek**

  This area has been significantly impacted by poor water quality and development in the past, and overall this section should be considered as moderately to highly disturbed. However, despite the historic impact, much of the natural aquatic ecosystem remains in a modified form. A high level of protection is required for this area if the natural aquatic ecosystem is to be protected and improved, but limitations associated with returning this area to its former condition need to be recognised in any restoration efforts.

- **Port River section**

  Due to the historic development of port facilities and industry in the Port River, this area has a history of being a highly degraded area. However, in recent years water quality has improved and is likely to further improve with work towards the water quality improvement proposed in the ACWQIP. While this area has a lower ecological value compared to the northern or central sections, it nevertheless has important recreational value (eg boating, amenity, fishing, etc) and a reasonably high standard of water quality is needed to maintain these uses. The inner harbour section of the Port River is now being further developed as a residential area, and consequently, amenity and

recreation (both contact and passive) are increasingly important. Therefore, there is continued pressure for water quality improvement in the Port River to ensure that the proposed EVs are achieved.

1 Nutrients

The PWWQIP focused on nutrients, particularly nitrogen as it was the most significant pollutant. With regard to the definition of WQOs for other parameters, it is important to recognise the differences between the more open coastal waters and the more enclosed waters of the Port waterways, reflected in habitat types, dispersion characteristics and sediment mobility.

Within the Port waterways, in some areas there is relatively limited sediment movement and due to historic uses and discharges into the Port River, sediment contamination still occurs at some sites. However, if sediments are not disturbed then this contamination is not an issue for water quality in the Port River. Within the Port waterways, there are current thermal and industrial discharges, issues with dissolved oxygen at certain times of the year and major economic activities relating to industry and port activities.

The Port waterways offer sustained environmental, economic and social value to South Australia. Important water quality aspects include the aquatic ecosystem (including habitat for dolphins), recreational uses, new urban development and amenity. Despite the high level of disturbances that have taken place in the past, providing a high level of protection to the waterways will reap substantial benefit and are well within the capacity of the community to achieve over time. The continued reduction of nutrients and impacts from other inputs and water quality parameters (eg toxicants, suspended solids, temperature and dissolved oxygen) will be required.

2 Levels of protection and water quality objectives for toxicants

The Australian and New Zealand Environmental and Conservation Council (ANZECC 2000) defines varying water quality criteria (trigger levels) for a range of water quality parameters, depending on the percentage of species expected to be protected, eg 99%–very high, 95%–high, 90%–moderate, and 80%–low.

As discussed in ANZECC for slightly disturbed ecosystems it may be more appropriate to apply the 99% level of protection and for moderately disturbed ecosystems the 95% level of protection as default values. ANZECC also considers a high level of protection (99%) should apply to the metals copper, lead, cadmium, chromium and zinc, which are included in the WQOs for this ACWQIP. High standards for toxicants are appropriate in consideration of:

- potential chronic (sub-lethal) as well as acute (lethal) toxic effects, particularly for the more sensitive juvenile stages of most fauna
- potential bio-accumulation effects
- the potential for additive or synergistic effects with other toxicants and also the potential interaction with other pollutants (suspended solids) and conditions such as elevated temperatures or low dissolved oxygen.

Using the ANZECC criteria a 99% level of protection is considered appropriate for the Port waterways' northern and central sections, and for the Port River section a 95% level of protection is considered appropriate. The higher value for the Northern and Central sections reflect the community driven environmental values for the work that has shown that when nutrient loads are reduced to appropriate levels the ecosystem is likely to recover over time.

3 Suspended solids, turbidity and colour

Suspended solids, turbidity and colour (coloured dissolved organic matter or CDOM) in the water column impacts on aquatic ecosystems and amenity/recreation. They are principally derived from stormwater and riverine sources, with suspended solids also being a transport mechanism for other pollutants.

For suspended solids and turbidity, the seasonal nature of the sources is recognised and the ambient water quality objectives take this into account by defining a target for the 90th percentile of results (ie they will be exceeded in about 10% of cases).

4 Temperature

There are three cooling water discharges, the main one being the Torrens Island Power Station, which discharges heated cooling water into Angas Inlet. The others at Osborne and Pelican Point have minimal effect. Recent monitoring of the effects of the cooling water on temperature indicate that, compared to studies undertaken in 1996, the overall impact has been reduced. The region of impact of the Torrens Island cooling water discharge was determined as part of an earlier Estuary and Lakes Hydraulic Flushing Model Study (Lord and Associates 1996). In summary, it was concluded that the Port River segment is largely unaffected, except for a small area of North Arm which is impacted by an average elevated temperature of 1^0C. This impacted area is west of the Grand Trunkway Bridge. The northern segment is not affected, however, the lower part of the central Barker Inlet is affected, particularly Angas Inlet.

Previously, it was found that sites on the Port River (cooling water intake), Broad Creek in the lower part of Barker Inlet and the junction of Magazine Creek in North Arm have a common modal temperature (Coleman *et al* 2007). During the period of monitoring there was no statistical difference between these sites. Sites within Angas Inlet still showed distinct temperature increases. The immediate discharge area had increases of 2^oC for 96% of the time. Elsewhere in the inlet it reduced to 48% of the time. Refer to Coleman 2007a and 2007b for further information.

The higher temperatures may exacerbate the effects of toxicants, such as metals and ammonia. The lower dissolved oxygen with higher temperatures would also have adverse effects. Higher temperatures and a plentiful supply of nutrients are conducive to the growth of nuisance algae and may give a competitive advantage to particular species. While no WQOs for temperature have been provided, further thermal inputs should only occur after review of project-specific information.

5 Dissolved oxygen

Occasionally low oxygen conditions occur, particularly at night during neap tides when waters are shallow with little movement. Low oxygen can occur as a result of plant respiration-photosynthesis, higher temperatures, fauna respiration, microbial decay of accumulated plant debris, sediment oxygen demand, dissolved organic matter, biological oxygen demand, etc. While some natural dissolved oxygen variation is to be expected, pollutant loads may increase the extent and frequency to the point that aquatic biota are adversely affected. The reduction of plant biomass that occurs as a result of reducing nutrient pollutant loads will decrease the occurrence and extent of low oxygen levels. While it is uncertain to what extent this will affect levels, an interim working target of a minimum 25% saturation during neap tide conditions over 24 hours in the summer is suggested. Monitoring to be undertaken as part of the implementation of the ACWQIP will provide data to define a long-term objective.

6 Faecal micro-organisms

In all sections, a Category A classification is given (95^{th} percentile for intestinal enterococci/100 mL); although it is acknowledged there are conflicts in uses as primary contact in this area is not advisable, but secondary contact does occur along with the discharge from the Bolivar WWTP. The standards of microbial quality to be applied in this area are currently under review by the South Australian Department of Health (DOH).

4.3.2 Adelaide coastal waters

The water quality management sections defined in the ACWS are used in this ACWQIP (refer to Map 1 and Table 1). The draft WQOs for Adelaide's coastal waters, suggested water quality improvement performance indicators and notes on the key water quality issues are included Report 2 of the supporting technical reports on the EPA website. Brief comments are as follows.

1 Levels of protection

For each of the sections of Adelaide's coastal waters, the highest level of protection is appropriate, considering:

- the importance placed on the coast for its ecosystems, recreational use, commercial use (tourism) and amenity

- the need to facilitate ecosystem recovery (seagrass, reef communities), where damage has occurred. Even though there has been a considerable loss of seagrass and recovery would be very slow, disturbed areas should not be written off.

While many locations of concern were noted the adoption of this level of protection was seen as consistent with the guidance for individual improvement projects.

2 Nutrients

Short- and medium-term 5–10 year objectives are suggested for nitrogen improvement, at which time they should be evaluated.

3 Suspended solids, turbidity and colour

As with the Port waterways, the seasonal nature of the sources is recognised for suspended solids and turbidity.

4 Faecal micro-organisms

In all sections, a Category A classification is given (95th percentile for intestinal enterococci/100 mL). However, it is understood this is difficult to achieve during and immediately following storm events, particularly in close proximity to outlets. Consequently, as indicated earlier, the DOH has signage advising of the need to avoid coloured water.

The recommendations of the ACWS have been incorporated in setting the WQOs and suggested targets for water quality improvement as summarised in Table 3, and outlined in more detail in Report 2 of the supporting technical reports on the EPA website. These ACWS recommendations and WQOs have been considered in setting the water quality improvement targets and developing management strategies outlined in chapter 7.

Table 3 Topics covered by the recommendations of the Adelaide Coastal Waters Study (ACWS)

Topic	No.	ACWS recommendation
Inputs of wastewater, stormwater & industrial inputs	1	As a matter of priority, steps must be taken to reduce the volumes of wastewater, stormwater, and industrial inputs into Adelaide's coastal environment. This should be done within the context of an overarching strategy designed to remediate and protect the metropolitan coastal ecosystem.
Nitrogen inputs	2	The total load of nitrogen discharged to the marine environment should be reduced to around 600 tonnes (representing a 75% reduction from the 2003 value of 2,400 tonnes).
Sediment inputs	3	Commensurate with efforts to reduce the nitrogen load, steps should be taken to progressively reduce the load of particulate matter discharged to the marine environment. A 50% load reduction (from 2003 levels) would be sufficient to maintain adequate light levels above seagrass beds for most of the time. The reduced sediment load will also contribute to improved water quality and aesthetics.
CDOM inputs	4	To assist in the improvement of the optical qualities of Adelaide's coastal waters, steps should be taken to reduce the amount of CDOM (coloured dissolved organic matter) in waters discharged by rivers, creeks, and stormwater drains.
Toxicant inputs	5	While the available data suggests that toxicant levels in Adelaide's coastal waters pose no significant environmental risk, loads from point sources such as the Port River, WWTPs, and drains should continue to be reduced. Routine monitoring of toxicant loads and concentrations should be undertaken every 3–5 years.

Topic	No.	ACWS recommendation
Monitoring	6	Develop and implement a comprehensive and integrated environmental monitoring program that will enable natural resource managers and all stakeholders to evaluate changes in the coastal marine environment over time and at various spatial scales.
Monitoring	7	Maintain and develop the comprehensive database of historical inputs generated by this study. It is suggested a single entity be created to oversee the administrative functions associated with data collection, storage/retrieval, analysis, and reporting. This entity should also assume responsibility for the ongoing maintenance and application of the various models produced by ACWS to ensure they remain both relevant and accessible. Consideration should also be given for the establishment of a research/monitoring coordination body. A primary function of this body would be to prioritise ongoing and future research activities, and to seek and allocate funding according to those priorities.
Monitoring	8	Implement a long-term monitoring program to assess seagrass quality (or health) at sites adjacent to land-based discharges and at suitable reference sites.
Monitoring	9	Implement a long-term monitoring program of the outer depth margin of *Posidonia* meadows in Holdfast Bay.
Monitoring	10	Implement a long-term monitoring program of seagrass meadow fragmentation at a range of sites in Holdfast Bay.
Monitoring	11	Undertake detailed mapping of the distribution of *Amphibolis* across the Adelaide metropolitan area, determine the lower depth limit of seagrasses in Holdfast Bay, and map seagrasses in the southern metropolitan area between Seacliff and Sellicks Beach.
Monitoring	12	Undertake a spatially intensive nitrogen stable isotope survey to determine the offshore and northern extents of nitrogen influence from WWTP and industrial outfalls along the Adelaide metropolitan coastline, and also characterise nitrogen stable isotope signatures of potential nitrogen sources.
Integrated management	13	Undertake an audit of key environmental assets in the southern metropolitan coastal region; identify risks to those assets and develop an integrated management plan to mitigate the risks. The applicability of management actions developed in response to the findings of this study to halt and reverse ecosystem degradation in the northern regions should be investigated with a view to adopting it (possibly with modification) in the southern region.
Integrated management	14	Adelaide's coastal marine environment must be managed as a component of a system that integrates catchment management, urban and rural land use, demographics, urban and industrial development, climate change/climate variability, and water reuse.

Table 4 Summary of environmental values (EVs) and water quality objectives (WQOs) for Adelaide's coastal waters

Water quality issue	Relevant environmental values (EVs)	Outcomes—quotes from the ACWQIP Stage 1 Executive Summary	Water quality objectives (WQOs) and performance indicators	Long-term water quality targets (20+ years)	Shorter-term targets/outcomes (1–5 years)
Sediments/ suspended solids	• primary recreation • aesthetic • cultural	• 'go swimming and see my feet in afternoon sea waters' • 'observe the sea floor' • 'ability to see the blue line closer to shore' • 'healthy reefs'	• suspended solids <3 mg/L (90th percentile) • ecological/aesthetic/cultural • turbidity <1 NTU (90th percentile) >200 m offshore • recreational • <25 NTU (90th percentile): – reduction in light penetration affecting photosynthesis – ambient water quality objectives achieved.	**ACWS** Recommendation 3— a 50% load reduction (from 2003 levels) would be sufficient to maintain adequate light levels above seagrass beds for most of the time. The reduced sediment load would contribute to improved water quality and aesthetic. **AMLR NRM Regional Plan targets:** T1, T2, T8, T9, T10, T11 & T12 **Water for Good** Action 16 – aims to provide 60GL/annum of recycled stormwater in Greater Adelaide by 2050	**AMLR NRM Regional Plan** **MAT24—Sediment migration from urban watercourses to the coast reduced by 5% from 2008 levels.** **Adelaide Living Beaches Strategy**—reduced impact of dredging to suspended solids in ACWS.

Water quality issue	Relevant environmental values (EVs)	Outcomes—quotes from the ACWQIP Stage 1 Executive Summary	Water quality objectives (WQOs) and performance indicators	Long-term water quality targets (20+ years)	Shorter-term targets/outcomes (1–5 years)
Nutrients–Nitrogen	• ecological • commercial	• 'coastal waters being free of stormwater discharge and nutrient rich outflows in the future' • 'no species loss due to water quality issues' • 'ability to see the blue line closer to shore'	• nitrogen • total N <200 ug/L (90th percentile) • ammonia <10 ug/L (90th percentile) • commercial • nitrate and Nitrite N 10 ug/L • ammonia 10 ug/L: – reduced frequency, extent and duration of algal blooms – ammonia concentrations largely reduced below 200 ug/L in the Port River channel – minimal or no odours from decaying algae – reduction in the amount of epiphytic algae on seagrass – no further seagrass loss – healthy mangrove recruitment.	**ACWS** Recommendation 2— the total load of nitrogen discharged to the marine environment should be reduced to around 600 tonnes per annum (representing a 75% reduction from the 2003 value of 2,400 tonnes). **AMLR NRM Board Plan target:** T1—75% of stormwater reused, 100% of wastewater reused. **Penrice** Reduce nitrogen discharge to less than 250 tonnes by 2015. **Water for Good** Action 16 – aims to provide 60GL/annum of recycled stormwater in Greater Adelaide by 2050	**SA Water** • Bolivar WWTP 2008—less than 493 tonnes (2003 load 1464 tonnes) (including the Port Adelaide WWTP discharge – moved to Bolivar in 2004) • Glenelg WWTP 2008—less than 213 tonnes (2003 load 471 tonnes) • Christie Beach WWTP 2008—less than 115 tonnes (2003 load 178 tonnes) • Upgrade under construction and reuse to meet ACWS targets. **Penrice** Reduce nitrogen loads were reduced to less than 575 tonnes by 2010 (2003 load 1000 tonnes).

Water quality issue	Relevant environmental values (EVs)	Outcomes—quotes from the ACWQIP Stage 1 Executive Summary	Water quality objectives (WQOs) and performance indicators	Long-term water quality targets (20+ years)	Shorter-term targets/outcomes (1–5 years)
Coloured dissolved organic matter (CDOM)	• recreational • aesthetic • cultural • commercial	• 'go swimming and see my feet in afternoon sea waters' • 'observe the sea floor' • 'ability to see the blue line closer to shore' • 'healthy reefs'.	• colour—<15 Hazen Units (90th percentile) • reduction in light penetration affecting photosynthesis	**ACWS** Recommendation 4—to assist in the improvement of the optical qualities of Adelaide's coastal waters, steps should be taken to reduce the amount of CDOM (coloured dissolved organic matter) in waters discharged by rivers, creeks and stormwater drains. **AMLR NRM Regional Plan targets:** T1, T2, T8, T9, T10, T11 & T12 **Water for Good** Action 16 – aims to provide 60GL/annum of recycled stormwater in Greater Adelaide by 2050	**AMLR NRM Regional Plan** **MAT24—**sediment migration from urban watercourses to the coast reduced by 5% from 2008 levels. **MAT30**—watercourse rehabilitation for water quality improvement being undertaken along an additional 40 km above 2008 commitments.

Water quality issue	Relevant environmental values (EVs)	Outcomes—quotes from the ACWQIP Stage 1 Executive Summary	Water quality objectives (WQOs) and performance indicators	Long-term water quality targets (20+ years)	Shorter-term targets/outcomes (1–5 years)
Pathogens	• recreational • aesthetic • cultural • commercial	• 'creative solutions to capture, clean and reuse stormwater' • 'recreational activities including swimming, boating, walking and fishing to be enjoyed anywhere along the coastline' • 'coliform levels be consistent with natural levels and cycles'	Enterococci—<200 orgs/100 ml EPA have defined these waters as low risk and this risk level has been taken from *Guidelines for Managing Risks in Recreational Water* (National Health and Medical Research Council 2006): • ambient water quality objectives achieved • there is no contamination of human food species.	**ACWS** Recommendation 14—Adelaide's coastal marine environment must be managed as a component of a system that integrates catchment management, urban and rural land use, demographics, urban and industrial development, climate change/climate variability and water reuse. **AMLR NRM Board Plan targets:** T1,T2, T10, & T12	**AMLR NRM Regional Plan** **MAT24—**Sediment migration from urban watercourses to the coast reduced by 5% from 2008 levels. **MAT17**—Water quality parameters (objectives) set for watershed, groundwater and coastal water resources in the region.
Salinity	• commercial • ecological	'no species loss due to water quality reduction'	• low salinity not a major stressor to healthy seagrass • impacts of high salinity can be site specific and should be addressed for individual sites	Saline discharges need to be undertaken in a manner that does not cause environmental harm. **AMLR NRM Regional Plan target:** T2	Achieve long-term target

4.4 Current water quality status

The general water quality status for the Port waterways and southern estuaries, based on ambient water quality monitoring is summarised in Map 2. For the defined EVs (ecosystem protection, harvesting of food for human consumption and recreation), defined by the EPA (EPA 2000, 2004), the key parameters examined included: nutrients, metals, turbidity, Chlorophyll 'a' and microbiological indicators. However, in stakeholder consultation for the development of the ACWQIP the parameters of metals and Chlorophyll 'a' were not seen as being so relevant for reducing inputs of sediments and nutrients to Adelaide's coastal waters.

Historically, the EPA classified water quality based on a monthly ambient water chemistry monitoring program where results were categorised as good, moderate or poor. In 2008, the EPA commenced a review of its water quality monitoring programs. This review has led to the alteration of its Coastal Water Quality Monitoring Program to include a significant amount of biological data and a more statistically robust sampling strategy.

The EPA commenced the revised program in 2009 and has assessed 62 sites along the Adelaide metropolitan coast in both 2009 and 2010. At the time of the development of the ACWQIP there were few data points in the Port waterways zone (defined as a sub-region in the monitoring program). Therefore, only the information recorded under the previous monitoring program is presented here for the Port waterways.

Water quality for the Port waterways is defined under the previous EPA classification system as good, moderate or poor (Map 2) while for water quality for Adelaide's coastal waters a written description is provided based on recent water quality monitoring results from monitoring undertaken by the EPA.

4.4.1 Port waterways

In the Port waterways, as shown on Map 2, ambient monitoring of concentrations of metals, nutrients, turbidity and Chlorophyll 'a' has led to the water quality being classified as moderate to poor in most locations. This is to be expected with the extent of industrial, commercial, urban and port activities, Bolivar WWTP industrial discharges and stormwater runoff. The waterways also receive heated cooling water from the power stations.

The southern Barker Inlet, North Arm and North Arm Creek often have oxygen concentrations well below recommended levels. During dodge tide conditions, very low oxygen conditions occur in some areas for 1–2 days. Apart from the direct adverse impact this can have on aquatic fauna, it also produces conditions conducive to the remobilisation of contaminants (eg metals and nutrients) from sediments. This situation is largely due to the shallow sheltered nature of the area.

Periodic toxic dinoflagellate blooms (red tides) occur in the Port waterways, which are also a very important factor in determining water quality status, both with respect to recreational use and the protection of aquatic ecosystems.

4.4.2 Adelaide coastal waters

Recent water quality monitoring results for Adelaide's coastal waters show nutrients (nitrogen) and Chlorophyll 'a', an indicator of plant biomass in aquatic ecosystems, to be generally elevated. The most significant difference in water quality between sites and those in other parts of Gulf St Vincent is elevated turbidity and suspended solids.

Along the metropolitan coast, water quality is usually highly variable, depending on storm activity and inputs from rivers, stormwater outlets and whether coastal dredging is being undertaken. In summer a daily cycle is common where turbidity is low during calm conditions in the morning, then increases during the day particularly when weather conditions allow the development of a sea breeze. Most outflows occur in the winter months when approximately 80% of the annual flows discharge.

Occasional large catchment storm events can deliver large pollutant loads and result in turbid waters along the coast, extending for up to one km offshore, which may last for 1–2 weeks. This is partly due to water movement patterns along

the coast. Modelling of salinity gradients undertaken as part of the ACWS showed that freshwater discharges dispersed along the coast, predominantly in a northerly direction, rather than out to sea (Map 3).

Metals measured in translocated mussels (Gaylard *et al* in prep) were variable but showed patterns linked to industrial and urban stormwater sources. While these results are likely to be largely due to anthropogenic sources, there are also natural sources of metals that enter the coastal environment from time to time.

With respect to recreational use, turbidity is an important issue, affecting both amenity and safety due to reduced visibility during contact recreation. While turbidity is derived from storm events and outflows as described earlier, there is frequently an opaqueness, which occurs due to wave action re-suspending material. This has increased with the loss of inshore seagrass meadows. Studies (Corbin and Gaylard 2005) have shown that micro-biologically (faecal micro-organisms), Adelaide's coastal waters are generally safe for swimming three days after heavy rainfall events. Invariably discharges after heavy rainfall are highly coloured. The DOH recommends the public avoids swimming in the vicinity of discoloured water.

4.4.3 Water quality in estuaries

Water bodies defined as estuaries would include those of the Gawler River, Port River–Barker Inlet system, River Torrens outlet, West Lakes system, Patawalonga Basin, Field River, Onkaparinga estuary, Christies Creek, Maslin Creek, Willunga Creek, Sellicks Creek and the Washpool as identified in the Draft State Estuaries Policy and Action Plan (DEH 2007a) and discussed in AMLR NRM Regional Plan (2008a).

The Patawalonga Basin, Torrens River outlet and West Lakes were described as being highly modified, artificial estuarine environments. Their current biodiversity values are considered to be limited, although they are regionally important for some marine species (AMLR NRM Board 2008a).

In the PWWQIP, it was considered more appropriate to consider the majority of Port River–Barker Inlet system as a bay rather than an estuary (EPA 2008a). It is important to note that four of the wetlands are listed in the *Directory of Important Wetlands in Australia* (DEH 2007b), being Gawler River estuary (Port Gawler and Buckland Park Lake), Port River–Barker Inlet (Barker Inlet and St Kilda), Onkaparinga estuary and the Washpool lagoon. This importance derives partly from the function of these estuarine areas for the use of migratory birds, subject to a range of international agreements.

Except for the large Port River–Barker Inlet system, where direct discharges of significant loads of nitrogen occur, specific water quality objectives have not been defined for estuaries along the Adelaide metropolitan coast. It is expected work to define EVs for these estuaries will be undertaken and will lead to the option of developing WQOs specific to each. In the meantime the reduction in catchment-sourced pollutant loads to assist in achieving the WQOs discussed below, will improve water quality in the estuaries.

All of the estuaries are either highly modified and/or have agricultural/urban catchments. Consequently, they are impacted by a range of pollutants, notably nutrients, turbidity/suspended solids, toxicants (metals) and faecal micro-organisms. This is reflected in the ambient water quality monitoring data available for some of the smaller southern estuaries presented in Map 2.

Similar to marine waters, occasional episodic events occur in the estuarine reaches, resulting in high suspended solid concentrations, and frequently relatively high concentrations of pollutants associated with particulate matter, such as metals. Much of this material can end up in the estuarine sediments.

The water quality of estuaries is defined under the previous EPA classification system as good, moderate or poor as indicated in Map 2.

4.4.4 Sediment quality

The location of sediment sampling sites along the coast and in the Port waterways are shown on Maps 4 and 5. The sediments have been classified as good, slightly impacted, moderately impacted or severely impacted in relation to the *Interim Sediment Quality Guidelines* or ISQG (ANZECC 2000) which are also discussed in the *Handbook for sediment*

quality assessment (Simpson *et al* 2005). The ISQG are presented as trigger levels and are not intended to definitively indicate a problem exists. Nevertheless, the higher the concentrations the greater the potential for ecological impact, particularly of manufactured chemicals.

Examining Maps 4 and 5, it can be seen that the majority of sediment sampling has focused on the Port River and North Arm areas of the Port waterways in high-risk locations associated with stormwater drains and other expected sources of toxicants.

These sites were typically contaminated with a range of toxicants, including metals, organic materials (eg polychlorinated biphenyl or PCBs, organochlorine pesticides) and antifouling agents (eg tributyline-tin or TBT). It could be expected with the scale of existing activities, sheltered waters, fine-grained sediments/mangrove muds and history of activities, there would be some areas of contamination. It is also important to note that many of the sites which were classified as poor or moderate, investigated by EPA in the *Special survey of the Port River, for heavy metals and PCBs in dolphins, sediment and fish* (EPA 2000a) were targeted sites, being the most likely locations for contamination. The existing record of samples should not be considered representative of the wider Port waterways region.

Other estuarine environments examined include the Onkaparinga estuary and Patawalonga Basin. Sediment analysis has been undertaken for copper (Cu), lead (Pb) and zinc (Zn) at over 60 locations throughout the Onkaparinga estuary. Virtually all concentrations were less than the ISQG low-level trigger values. Some analysis has also been undertaken for organics with none detected.

It is well documented that the Patawalonga Basin previously acted as a detention basin for upstream catchment flows, resulting in pollutant retention (metals and nutrients). As part of the project to divert stormwater from Patawalonga Basin direct to the Adelaide coast via the constructed Barcoo Outlet in the late 1990s, the lake was dredged to remove accumulated silt. This diversion of flows up to the 1–in–2 year Average Recurrence Interval (ARI) events has returned the lake to a condition allowing for the recreational use for which it was intended, as well as establishing a healthier aquatic ecosystem. The implementation of the Patawalonga Catchment Water Management Plan to date has resulted in a pollutant load reduction in the lake through the regular removal of accumulated silt from upstream structures.

Along the coastline, analysis of sediment for metals has been undertaken at the SA Yacht Club basin, Outer Harbor channel, North Haven Marina, Largs Bay and Port Stanvac. At the 10 ACWS monitoring sites, which included locations on the River Torrens and Barcoo Outlets, analysis included metals, organochlorine and organophosphate pesticides, triazine herbicides, glyphosphate, polycyclic aromatic hydrocarbon (PAHs) and total petroleum hydrocarbons (TPHs). The organic compounds in the ACWS were all below detectable limits and all metals were below ISQG low trigger levels. Consequently sediments are classified as good.

For sediment reduction work, any investment in catchment remediation and engineering structures needs to be properly targeted to know what fraction of the sediment load is being addressed and which methods will have the greatest beneficial impact on Adelaide's coastal waters. To date the AMLR NRM Board has designed sediment basins to remove 50% of the total sediment load, but it is uncertain if the right sediment fraction has been targeted. Research has not yet been undertaken. Understanding this is vital to ensure funds are appropriately targeted to directly manage the problem.

4.5 Condition of marine and estuarine habitats

The recent *State of the Region Report 2008 (AMLR NRM Board 2008a)*, prepared by the AMLR NRM Board, broadly describes the marine and estuarine habitats and the services which provide direct benefits to the community. These include the provision of food (recreational and commercial fisheries), cultural and recreational benefits, nutrient cycling, coastal protection, etc. The habitats include:

- pelagic (open, deeper waters offshore) habitat
- submerged or subtidal habitats:
  - subtidal reefs
  - seagrass meadows

  - soft and sandy bottoms.
- intertidal habitats:
  - mangrove forests
  - salt marshes
  - intertidal rocky reefs
  - sandy and muddy beaches
- estuaries.

These habitats, their ecosystems, fauna and flora are impacted to varying degrees by over exploitation, visitor pressure, development and the loss of habitat and water pollution. The habitats are broadly indicated in Map 6 (based on Bryars 2003).

While these habitats are directly affected by water quality impairment, those that provide indicators of the overall health of the marine ecosystem are seagrass, mangroves and reefs. The impacts on these habitats of reduced water quality include the large-scale loss of offshore seagrass meadows, seagrass loss, mangrove death, extent of *Ulva* (cabbage weed) in the Port River–Barker Inlet system, and the poor condition of some subtidal reefs.

4.5.1 Loss of seagrass

In the ACWS, as summarised by Fox *et al* (2007), many years of near-continuous inputs of nutrient-rich, turbid and coloured water and wastewater have long been implicated in the loss of over 5,000 hectares of seagrasses. The ultimate source of these discharges have been the development of the Adelaide metropolitan area and associated stormwater, wastewater and industrial discharges (Westphalen *et al* 2004). Note that Westphalen et al (2004) includes a map of historic seagrass loss along the Adelaide coastline that clearly shows the impact of the wastewater treatment plant sludge outfalls on seagrass loss alongside and near to the sludge pipelines. These sludge discharges no longer occur along the Adelaide coastline. The ACWS, which had three focus points (water quality, seagrasses and sediments), has indicated that all the evidence points to a key role of nitrogen loads in seagrass decline. Increased turbidity levels, resulting in reduced light penetration have also been a factor for seagrass loss in what is now called the inshore zone. The extent of recent change to seagrass populations is shown in Map 7. This recent DENR seagrass map shows the blue line of seagrass being approximately 1 km offshore and that in some areas regrowth of seagrass is occurring in areas where water quality has improved.

Sediment movement inside the current line of seagrass offshore may be sufficient to prevent regrowth of seagrasses in many locations even if excess nutrients were not an overriding problem. More research is needed to determine the most likely locations where sediment conditions and water quality improvement would allow the recovery of seagrass towards shore.

A seed bank is available to support future recovery, if conditions were conducive to recruitment and subsequent growth. Fox *et al* (2007) describes timeframes for the regrowth of seagrass in other parts of the world as 20 years or more once suitable conditions were re-established, with a return to a seagrass dominated system of local species potentially taking over 100 years.

There is some hope that intervention in key areas with re-establishment of seedlings may potentially assist this process. This recovery can only commence when substantial reductions in nutrient and sediment discharges are achieved and light conditions for seagrass are improved with lower turbidity nearshore.

DENR has been working with research organisations and other government agencies to undertake work that will help prepare seagrass ready maps to identify locations best suited to the assisted recovery of seagrass. This work needs further support to continue for a long enough period to inform and then monitor seagrass recovery efforts.

4.5.2 Ecosystem decline in the Port waterways

The Port River–Barker Inlet system shows clear signs of serious environmental stress and ecosystem decline (EPA 2008a). There are a range of water quality issues and contaminants, and nitrogen is the most significant problem. Nutrient enrichment and the proliferation of undesirable algal growth especially *Ulva* sp, is a principal factor in the large-scale loss of intertidal and subtidal seagrass meadows and the decline in mangroves (Map 8) with effects on associated fauna, biodiversity and fisheries. The extensive occurrence of *Ulva* also results in conditions which are unsightly, and produces offensive odours when the vegetation is decaying.

An ample nutrient supply supports algal blooms (Map 9), including occasional toxic algal blooms (red tides), the largest stretching some 30 km northward from the inlet. They are of major concern because of the health risk and the ecological impacts, including fish kills (Cannon 1991). Algal blooms can also result in aesthetic problems through unsightly discolouration of the water and unpleasant odours.

4.5.3 Health of subtidal reefs

The health of subtidal reefs along Adelaide's coastline has been assessed on several occasions in recent years using the Reef Health Survey approach (Turner *et al* 2007), an analysis of Reef Watch data (Westphalen 2009 and Westphalen 2010) community based reef monitoring programs currently underway including Reef Watch and the Reef Life Survey.

How does Reef Watch describe the health of Adelaide's subtidal reefs?

Reef Watch is an environmental monitoring program managed by the Conservation Council of South Australia and funded mainly by the AMLR NRM Board. The Reef Watch training program provides recreational scuba divers and snorklers with the necessary skills to gather valuable information about the marine environment. The data will contribute to a growing body of information enabling better management.

With the aid of many of South Australia's top marine scientists and educators, Reef Watch has developed survey methods that are easy to use, providing useful data that is comparable with those collected by scientists. With the help of hundreds of volunteers, Reef Watch is able to gather, collate and disseminate quality information on the status of our marine environment. This information is made available to the general community, schools, government bodies and research institutions.

In order to establish a ranking for each site, all survey information is averaged to produce a single composite score, ranging between zero and 100. This score provides a relative measure of health. Reef health is set at three break points:

- poor condition (0–34)
- caution recommended (35–65)
- good condition (66–100)

The 'caution recommended' classification highlights reefs that may be in a state of flux, but should not necessarily be allocated to the 'poor condition' category. Instead such reefs should be the focus of further monitoring and research.

The current health of metropolitan subtidal reefs is summarised in Map 10 from information presented in Westphalen (2009) and (2010), and Turner *et al* (200)7 based on several reef health surveys undertaken from 2005 to 2010. The reef health ratings presented in Map 10 refer to the most recent assessments available for specific sites. Some sites have not had repeat surveys to update their ratings since the information was presented in Turner *et al* (2007). Note that there has been some variability in ratings between seasons as indicated by Westpahlen (2009 and 2010) and the most recent reef health survey work has found that the Hallett Cove reef that was previously considered to be in 'good' condition now has a 'caution' rating and has been overtaken by a rapid expansion of mussels as reported by Westphalen (2010).

However, there is a distinct south to north trend, with the southern reefs considered to be healthier, being dominated by the large brown (Phaeophycean) macroalgae and the northern reefs composed of the smaller foliaceous and turfing red (Rhodophycean) algae. The healthier reefs had macroalgal community structures similar to those found on the Fleurieu and Yorke Peninsulas. However, many of the southern reefs that appeared healthy when considering macroalgal composition still received a low rating because of low fish numbers, sedimentation levels and/or bare substrate.

It is notable that Horseshoe Reef has declined substantially in health since an earlier survey in 1999, with a change from a mussel/robust brown community to a reef comprising 60% bare substrate. Horseshoe Reef was subsequently rated as the poorest site in the 2005 survey. This reef is relatively close to the dredging site offshore Port Stanvac (Map 10) and Christies Creek, which has been identified as a sediment source as a result of erosion (AMLR NRM Board 2006a).

The causal mechanisms for reef degradation are difficult to pinpoint, as reef health is likely to be the product of a range of both direct and indirect influences similar to those posing threats to local seagrass systems (Westphalen *et al* 2004). However, nutrients and turbidity are known to be implicated in the loss of large canopy brown algae, with increases in turf-forming species. Turf-forming algae pose a serious threat to the biodiversity of coastal ecosystems, due to their ability to inhibit the recruitment of the larger canopy forming algae. A study conducted within South Australian waters has found turf-forming algae create more extensive habitat on subtidal rock adjacent to urban areas than in non-urban coastal areas (Gorgula and Connell 2004)**.**

Our understanding of subtidal reefs is currently insufficient to establish sustainable nitrogen, suspended solids or coloured dissolved organic matter loads. It is therefore important to monitor subtidal reefs while pollutant loads are reduced to ensure these reductions are sufficient to protect these ecosystems and allow for recovery**.**

To avoid the current trend of seagrass loss and declines in reef health condition, WSUD approaches as detailed in the *WSUD Technical Manual for Greater Adelaide* (DPLG 2009) need to be applied in a comprehensive manner to all new and infill development through the planning system as well as in the design and operation of other urban areas, such as streetscapes and open spaces.

5 Estuarine environmental flows

As a result of agricultural and urban developments in the coastal catchments, natural flow patterns have been considerably altered, impacting on estuarine aquatic ecosystems. Although environmental flows would normally not be regarded as an issue in the offshore marine environment for Gulf St Vincent, this can be an issue in some of the estuaries, particularly for areas where there were more regular winter freshwater inputs, such as the Onkaparinga estuary.

Some work has been done for the Onkaparinga and Gawler Rivers. A study has been undertaken of the environmental water requirements (EWRs) for catchments such as Gawler River (NABCWMB 2000), the Onkaparinga River (Sinclair-Knight Merz 2003) and the AMLR NRM region. The program is called Environmental Water Trials for the Western Mount Lofty Ranges (AMLR NRM Board 2006b). After the surface watercourses and underground waters of the western Mount Lofty Ranges were prescribed in 2005, a water allocation plan was prepared under the provision of the *Natural Resources Management Act 2004*. Environmental flows were allocated to estuaries as part of water allocation plan development.

The need to provide water for the environment has been recognised by state and federal governments, and under the Council of Australian Governments agreement (COAG 1994) the environment is recognised as a legitimate water user. Previous studies and trials have not addressed the estuaries. It is important to be generally aware of the issue so that strategies adopted to minimise pollution do not inadvertently impact on natural estuarine flow regimes. Environmental flows are briefly discussed below for each of the key estuary systems. In general, changes in the flow regimes of urban catchment that move flow patterns toward those that were in place prior to European management are likely to enhance receiving environments.

5.1 Port waterways

The Port waterways are a marine estuarine system dominated by tidal flows. Prior to European settlement, freshwater inflows from the south, including the River Torrens system, were intercepted by extensive freshwater/brackish wetlands, which dampened the effect of major storm flows. These wetlands no longer exist and the area is now urbanised. The River Torrens, which was the major stream formerly discharging into the Port waterways and wetlands, was diverted directly into Gulf St Vincent via a channel cut through the dune system at West Beach.

To the north, on the eastern side, are Dry Creek, Little Para River and Smith Creek. These were formerly ephemeral in nature, largely flowing to the coast only during major flood events, and in particular for Smith Creek and Dry Creek, spreading out into the former extensive saltmarsh areas. The lower part of Dry Creek is now an artificial drain, allowing the rapid passage of floodwaters from its urbanised catchment.

As described in the PWWQIP (EPA 2008a), large areas of the Port waterways and virtually all of the natural freshwater wetlands have been lost to development. Given its estuarine nature and the characteristics of catchment drainage to the waterways, environmental flows are considered below in relation to:

- interruptions to, or improvements in, tidal flows and the effects of sea level change due to greenhouse impacts
- the development of constructed freshwater wetlands and fish passage opportunities
- flows in the Dry Creek, Little Para and Smith Creek catchments.

5.1.1 Interruptions in tidal flows

Tidal flows have been interrupted by:

- urban and industrial development which has prevented inland tidal flows resulting in the loss of saltmarsh and mangrove habitats
- the construction of levee banks, further alienating areas that had been previously inundated by high tides
- the construction of easements (transmission line easement across to Torrens Island Power Station)

- the modification of flow patterns in Angas Inlet, as a result of cooling water needs for the power station.

Significant actions taken have improved flows or had some compensatory benefits. The transmission line easement across southern Barker Inlet formerly interrupted flows, resulting in the loss of large mangrove areas. A culvert has since been constructed on the tidal channel resulting in mangrove recolonisation. Imperial Chemical Industries (ICI), who developed the Penrice saltfields, removed a seawall in 1954 when the saltfields were constructed, resulting in the large-scale re-establishment of mangroves (EPA 2008a). The construction of the 170-ha Barker Inlet Wetland includes a marine intertidal wetland area of approximately 50 hectares for saltmarsh/mangrove colonisation. A management plan has been prepared for the Mutton Cove Conservation Park. This aims to improve tidal exchange within the cove by modifying the inlet structure (Coleman and Cook 2003). These modifications to flow are intended to benefit the biological communities of the cove and the removal of the tide gates at the mouth of Dry Creek could have some benefits for fish passage.

The need for saltmarsh and mangrove regrowth areas in the event of sea level rise should be seen as a general planning issue for the region. For example, if land is available behind the levee banks on the eastern side (saltfields, Bolivar WWTP lagoon area), environmental needs should be considered rather than seeing this area as land only for new development. With sea level rises, there may be impacts on mangroves and saltmarsh but the extent of the impacts will depend upon the rate of change. Saltmarsh and mangroves trap sediments and will adjust to the changes, but if flows are restricted and changes occur too quickly for species to adapt and move landward then mangrove areas will be at risk along with remaining saltmarsh areas.

5.1.2 Constructed wetlands and fish passage opportunities

Within the vicinity of the Port waterways a number of large freshwater wetland systems have been developed, which include:

- Greenfields Wetlands, Stages I, II and III
- Barker Inlet Wetland
- Magazine Creek Wetland
- Range Wetland.

Collectively, these represent a substantial area, which goes part of the way to replacing some of what has been lost. The wetlands were developed with the following broad objectives:

- to improve stormwater quality and protect downstream ecosystems (Port waterways)
- to improve landscape amenity and provide passive recreational opportunities
- to provide improved habitat for fauna and flora
- to provide opportunities for the harvesting and reuse of stormwater, and in some instances, flood control.

A small detention basin was also developed on the Lefevre Peninsula at Snowdens Beach, but was never completed to be a functioning wetland system.

Greenfields, Barker Inlet, Magazine Creek and Range Wetlands have achieved their objectives, and the Barker Inlet and Greenfields Wetlands are now part of the Metropolitan Open Space System (MOSS). Although only developed in the early 1990s, the Barker Inlet Wetland has developed significant conservation value and has been listed as a wetland of national importance. Due to the proximity of these wetlands to the Port waterways, fish movement from the estuary into the wetlands is a significant opportunity.

5.1.3 Flows in Smith Creek, Dry Creek and Little Para River

Although Smith and Dry Creeks may be seen as artificial drains, there are opportunities for fish passage, linking with the upstream constructed wetlands, including Greenfields. These opportunities should be considered in:

- future wetland design, and even revisiting existing wetland outlet structures

- future design and landscaping of the drains.

Little Para River is a developing catchment with a water supply reservoir in its headwaters. Consequently it has a modified flow regime, but still remains an ephemeral system that flows in the winter and spring and is often dry through summer and autumn, except for some small pools of water. However, the current environmental flows for most of Little Para River are largely similar to pre-European conditions. This may change in the future with further development of the catchment.

5.2 Gawler River estuary

Gawler River forms a significant, long, narrow estuary with delta creeks at Port Gawler. The estuary is classified as a tide dominated creek in a Northern Adelaide and Barossa Catchment Water Management Board study (NABCWMB 2000). The extensive tidal flats consist of shelly silts, clays and sands supporting significant low mangrove woodland. Small areas of samphire shrubland sit at the mouth of the Gawler River. Of the 65 coastal bird species recorded in the region, 16 species at Buckland Park and 12 species at Port Gawler are listed under treaties. As indicated earlier, the Gawler estuary including Port Gawler and Buckland Park Lake are listed in the Directory of Important Wetlands. The Port Gawler Conservation Park also conserves one of the larger areas of mangrove and samphire in the state and is listed in the *Register of the National Estate–A list of natural, Indigenous and historic heritage places throughout Australia administered by the Australian Government* under the *Environment Protection and Biodiversity Conservation Act 1999*.

Even though the estuary still retains considerable ecological value, Gawler River is a highly modified system, with approximately 56% of the natural flow diverted for consumption purposes. Total volumes, durations, frequencies and seasonality of flows have all been affected. Flow is heavily regulated due to dams, weirs and diversion from Gawler River tributaries.

The NABCWMB (2000) study defined the specific requirements of the section between the coast (at Buckland Park) and the town of Gawler. The numerical flow requirements of this section referred to as the meandering zone, are summarised in Table 5. A reach of the Gawler River system, Barossa Diversion Weir to Gawler (South Para), is included in the AMLR NRM Board environmental trials, as discussed below.

Table 5 Environmental water requirements of the lower Gawler River (coast to town of Gawler)

Flow band	Peak flow (m^3/s)	Daily flow (ML)	Average frequency	Duration (Time)	Importance	Seasonality
Pool connection	6–10	420–700	Once every 3 years as a minimum, but every year is far more beneficial	Minimum 2–3 months	Water quality for pools. Riffle habitat available. Recharge habitat for aquifers. *Paratya* (freshwater shrimp) migration. Fish reproduction and migration flows.	Autumn and spring for fish migration

Flow band	Peak flow (m^3/s)	Daily flow (ML)	Average frequency	Duration (Time)	Importance	Seasonality
Mid-flow	10	350	Yearly	Minimum 2–3 months	Connection and recharge to Buckland Park (BP). BP would require water flowing into the lake for 2–3 months per year. Sediment transport.	Winter to spring
Bank-full	<300	20,300	Once every 10–20 years	Hours	Sediment and organic matter transport. Channel maintenance.	N/A
Over-bank	300+	20,300+	Once every 10–20 years	Hours	Floodplain maintenance and organic inputs to channel.	N/A

Source: Northern Adelaide and Barossa Catchment Water Management Board 2000

5.3 River Torrens

Average annual pre-European or natural flows in the lower River Torrens have decreased by approximately 34% (Eco Management Services 2000). The use of River Torrens (and other catchments) for public water supply purposes by the construction of reservoirs, the diversion of Murray River water and use of part of the river as an aqueduct, has progressively modified the flows to the lower urban reaches which now receive urban stormwater runoff. In general terms, the natural pattern of low or no flow in summer–autumn with flows in winter–spring has now been replaced in the lower reaches with a flow after any rainfall event of significance and winter–spring flows reduced by reservoir storages.

The current Breakout Creek channel and outlet weir were completed in 1939. Prior to this there was no major freshwater inflow to the gulf at this location. This in itself has been a major alteration in natural flows. The lower river, below the city weir to the coast at Henley Beach has become a major community asset. It is part of the Torrens Linear Park with significant recreational and amenity value as well as valuable biodiversity values. Due to the weir at the constructed mouth of the River Torrens it is described as an artificial estuary. The weir prevents saltwater intrusion upstream as would occur in a natural estuarine system. However, marine species do migrate into it and this has recently been assisted by the AMLR NRM Board with the construction of a fish ladder.

Draft EVs developed for Adelaide's coastal waters and associated water quality objectives for primary and secondary recreation and aesthetics could be achieved with mainly surplus winter and spring flows in the River Torrens, and summer flows being retained as much as possible for reuse or natural infiltration into groundwater. For future water allocation planning for streams that discharge to Adelaide's coastal waters, planners should accept this as a preferred option and clearly state economic, social and ecosystem values where this condition cannot be achieved. For example in areas where concrete drains are the only option due to the nature of historical urban development that has taken place limiting opportunities to retain, filter and reuse water.

The AMLR NRM Board (2006b) has developed environmental flow trials for four priority reaches (including two in the River Torrens):

- Barossa Diversion Weir to Gawler (South Para)
- Gumeracha Weir to Kangaroo Creek Reservoir (River Torrens)
- Gorge Weir to Torrens Lake (River Torrens)
- Clarendon Weir to estuary (Onkaparinga estuary).

The trials were put on hold for sometime because of the long drought conditions, but have continued as planned following good rainfall in the winter of 2010. Water for environmental flows was released in spring 2010. These trials are intended to last three years, with the aim of testing the benefits of returning environmental flows, providing information that can be applied elsewhere as well as improving ecosystem function to these high priority reaches.

A detailed monitoring program has also been developed to assist with evaluating the results of the trial. The monitoring program comprises ecological surveys linked to flow monitoring in order that ecological responses to the environment water requirements (EWRs) can be evaluated. The program is being implemented by a consortium comprising scientists from the Australian Water Quality Centre and the University of Adelaide.

A consultation program for the environmental flow trials is included as part of the Western Mount Lofty Ranges Water Allocation Plan.

5.4 Onkaparinga River estuary

Similar to River Torrens, the use of Onkaparinga River for public water supply has changed flows. Since European settlement, it is estimated that approximately 75% of flow has been extracted prior to entering the Onkaparinga estuary. Only the largest flows (ie flood events) in Onkaparinga River move downstream to the estuary, and at most times there is no flow directly below Clarendon Weir (OCWMB 2000). Water is held in the Mount Bold Reservoir before reaching Clarendon Weir. From the weir, water is diverted to Happy Valley Reservoir.

During the wetter winter months with inflow from the upstream catchment, the estuary is generally freshwater down to approximately Salt Fleet Bridge. During the dry summer months, with little or no flow from the catchment, it is saline (seawater salinity) up to Old Noarlunga.

The EWRs of Onkaparinga River have been determined by the former Onkaparinga Catchment Water Management Board (OCWMB), through a study commissioned in 2000 (Sinclair Knight Merz, 2003). This report identified EWRs for the Onkaparinga River at Old Noarlunga. This is the most downstream reference point provided along the river, and specifies the requirements of part of the upper estuary. The three-year environmental flow trial for the Onkaparinga River below Clarendon Weir is based on the EWRs developed in 2003. Although this flow was intended to deliver environmental benefit to the river within the lower reaches and gorge area, there might be some ecological benefit to the lower estuary from the trial, although this was not part of the trial objectives.

As indicated in the information for River Torrens, the environmental flow trials were put on hold for sometime because of the drought conditions have continued as planned following good rainfall in the winters of 2009 and 2010. Water for environmental flows was released in spring 2009 and spring 2010 from the Clarendon Weir. As discussed in the AMLR NRM Board document (2006b), these trials are intended to last three years, with the aim of testing the benefits of returning environmental flows, providing information that can be applied elsewhere as well as improving ecosystem function to these high priority reaches.

The EWR environmental releases at Clarendon Weir to downstream are included in Table 6, and the volumes required in Table 7.

However, it is important to note for the Onkaparinga River system sedimentation from the mouth is rare, based on ongoing monitoring undertaken by the AMLR NRM Board (reported in Cook and Coleman 2010a) resulting from a lack of flow in the lower Onkaparinga system. There has only been one large turbidity slug in last three years and small flows in a more natural pattern are more important for maintaining the lower Onkaparinga River and estuary in a more natural condition. Cook and Coleman (2010b) have also reported on the recent occurrence of mangroves in the Onkaparinga estuary as a result of the completely unnatural flows that the river system has experienced in recent decades.

Table 6 Environmental water requirements below Clarendon Weir

Season	Magnitude	Frequency	Duration
Low flow (Jan–May)	>10 ML/day	Low flow period	Entire period
	>20 ML/day	2 annually	10 days
High flow (Jul–Nov)	>30 ML/day	High flow period	Entire period
	>100 ML/day	2 annually	5 days
	>650 ML/day	2 annually	2 days

Source: Sinclair Knight Merz 2003

Table 7 Summary of trial environmental water provisions for Onkaparinga River

System	Low flows (ML/yr)	Fresh flows (ML)	Flush flows (ML)	Total volume (ML/yr)	Comment on timing of flows
Onkaparinga River–Clarendon Weir to estuary	4,260	1,080	3,900	9,240	• Low flows (Jan–Oct) • Fresh flows (Mar, May, Jul and Sep) • Flush flows (Jun, Aug and Oct).

Source: Sinclair Knight Merz 2003

Within each of the flow bands, the intent is as follows:

- *Summer low flows*: maintain shallow water habitat for macro-invertebrates and improve water quality in pools.
- *Summer freshes*: flush pools to improve water quality and increase habitat value.
- *Winter low flows*: create surface water flow sufficient to fill low flow channels and provide migration opportunities for fish and macroinvertebrates. These flows will not significantly impact the depth of pools.
- *Winter freshes*: provide longitudinal connection between pools and allow migration for fish and macro-invertebrates. These will not be sufficient to scour biofilms or sediment.
- *Large winter pulses*: reset habitat and ecosystem processes by scouring sediments and biofilms. These will also aid in controlling vegetation.

The overall ecological objectives are summarised as follows:

- the provision of longitudinal connection for fish and macro-invertebrate migration
- to maintain and improve water quality
- the maintenance of self-sustaining fish populations
- the maintenance and restoration of habitat diversity for macro-invertebrates
- to control terrestrial vegetation encroachment of the river
- to reset aquatic habitat.

The need for improved flushing of the lower section of the Onkaparinga estuary is important in terms of benefits to aquatic ecosystems, movement of in-stream silt and reducing community concerns regarding stagnant water and

aesthetic issues. However, the changed water regime since European settlement together with upstream landuse activities have increased sedimentation in the upper estuary, particularly with the reduced frequency of larger flows and velocities reducing the transport of sediment downstream. However, with large flow events, sedimentation on the nearby Onkaparinga reef is also an issue of concern where changes in flow patterns result in increased sediment loads, particularly during the period of recruitment of reef species (July–December).

5.5 Other small estuaries

Although small, the southern coastal estuaries, including Christies, Willunga, Maslins, Field and Pedler Creeks are still regionally important for recreation as well as their ecological habitats and function. There is little information to quantify changes, but similarly to the major catchments, as a result of agricultural development and increasing urban developments, flow patterns have changed. It is important that the environmental water requirements for these estuaries are recognised as the water allocation plan is developed.

6 Water quality improvement targets, current management strategies and actions, and the way forward

6.1 Background

The key forward planning feature of the ACWQIP is establishing long-term targets for nutrients and suspended solids, based on the EVs and WQOs agreed through community and stakeholder input (refer to Table 4 in Chapter 4). The ACWS has also established nitrogen and sediment inputs as the main contributors to issues impacting on Adelaide's coastal waters and seagrass health. Through the development of the ACWQIP they have also been confirmed as the main issues impacting on the EVs.

Targets for nutrients and suspended solids reductions to achieve water quality improvement and the WQOs established in Chapter 4 have been derived from three main sources—the ACWS, PWWQIP, and the community and stakeholder consultation work undertaken through the EPA in 2007 and 2008 (refer to the supporting technical reports on the EPA website).

The major sources of nutrient and suspended solid inputs, including discharges from WWTPs, industry and stormwater (catchments) are shown in Map 11, which indicated the reduction of the 2003 loads of metals (copper, lead, zinc), suspended solids and nitrogen from the period 1975–85. There have been major reductions in these loads in the northern and central regions of Adelaide's coastal waters, in contrast with the southern region where there was some increase.

The northern and central reductions have been due to considerable work undertaken by SA Water, Penrice Soda Holdings, the former catchment water management boards (now incorporated into the AMLR NRM Board), councils, EPA and general community. The rise in the southern region is due to population growth which has increased the volume of wastewater and loads of suspended solids and coloured dissolved organic matter (CDOM) in the stormwater produced by this area.

Most of the damage to offshore seagrasses occurred in the northern and central areas when discharges were greater than they are now (Fox *et al* 2007) and concentrated mainly in the Port River (EPA 2008a). While seagrass loss is continuing, and further load reductions are required, it is important to recognise the considerable effort and progress to date that has been made by SA Water, Penrice Soda Holdings and the AMLR NRM Board. This also highlights the need to manage the southern area of Adelaide's coastal waters in a way that minimises the potential for considerable losses to seagrass, reef habitat and amenity.

This chapter includes details on the future water quality improvement targets required for nutrients and sediments, and current action by SA Water, Penrice and various other agencies to achieve improvements in water quality and seagrass health for Adelaide's coastal waters. Eight strategies are outlined for a long-term improvement and to create the conditions conducive for the return of seagrass in areas where it has been lost in Adelaide metropolitan coastline.

6.2 Load reduction targets

In the ACWS Final Report (Fox *et al* 2007), 14 recommendations were listed (Table 3) and five of these focused on obtaining reductions in the volumes of stormwater, wastewater, nutrient loads, sediment loads, CDOM and toxicants. These recommendations aimed not only at arresting further decline, but assisting in system recovery.

Recommendation 2 is that the total load of nitrogen should be reduced to approximately 600 tonnes, which is a 75% reduction of the estimated 2003 load of 2,400 tonnes. Nitrogen is the key nutrient that needs to be reduced in marine environments as the phosphorus levels are generally relatively low. An exception to this proviso exists in the southern Barker Inlet where the nitrogen concentrations are sufficiently high due to the inputs from Penrice Soda Holdings and wind-driven phosphorus from the Bolivar WWTP to cause algal blooms from time to time that allows this area to be a source of nuisance macro-algae (*Ulva lactuca*) and marine pest organisms (*Caulerpa taxifolia*).

Recommendation 3 is that a general 50% reduction target of suspended solids should occur. Meeting this target would result in a major reduction in other pollutants usually associated with particulate matter such as metals and improve amenity and recreational safety.

Adelaide's coastal waters cover a large area and include about 70 kilometres of coastline. The recommendations of the ACWS with respect to the loads of key pollutants—nitrogen, suspended solids and coloured dissolved organic matter (CDOM) inevitably carry a degree of scientific uncertainty. It should be noted that the ACWS wording of 'around' is used with care by the report authors, indicating that there are a number of uncertainties involved in the calculation of the appropriate nitrogen load, and uncertainty is also implicit in the recommended load for suspended solids. There was sufficient uncertainty in the required load for CDOM that the authors did not feel justified in nominating an acceptable load. The required nitrogen and suspended solids loads may be somewhat smaller or larger, and the loads for the different parts of Adelaide's coastal waters are not specified.

The approach to these areas of uncertainty in other water quality improvement plans is often to derive quanta for the level of uncertainty in the recommended long-term loads and apply this as a margin of safety—typically 5 to 10 % and reduce the target loads accordingly. While this approach has not been undertaken in this WQIP, managers of discharges such as Penrice Soda Holdings and SA Water recognise that long-term targets for the nitrogen content of their discharges will be based on local effects as well as the more diffuse effects of their discharges over a large area. The quality of the monitoring of these discharges will be very important in confirming long-term targets for each discharge.

There will be costs associated with the reduction of pollutant loads. These are not well defined at present, and the ACWQIP has not developed early estimates as they may be misleading. While these are not high on a per capita basis —particularly when implemented over time, the community may choose not to pay and accept that the way that we manage our coastal discharges into the future will cause harm. The consultation undertaken as part of the development of the ACWQIP has shown a firm resolve on the part of the community to achieve the return of seagrass and have the Adelaide coast as a high value recreation area into the future, However, as costs are attached to improvement in the coming years, the community will have opportunity to re-think this through successive reviews of the ACWQIP at five-yearly intervals. These will provide be opportunity to set different long-term targets for the community derived WQOs, particularly those that relate to aesthetics and recreational water quality. This would require a consensus that they are not achievable in the future at a reasonable cost (Report 2). This may be the case in specific locations adjacent to major stormwater drains at times of discharge, eg the Torrens River outfall. However, at the time of stakeholder and community input, views about the required water quality of Adelaide's coast and the return of seagrass emerged as a consistent theme in consultations (Report 1).

Currently, many options are available for the improved management and reuse of both wastewater and stormwater. In order for Adelaide's community to settle for a lower water quality in the long term, there would need to be a general understanding that all available improvements in wastewater and stormwater quantity and quality had been implemented.

6.3 Reducing nitrogen loads

The major sources of nitrogen discharges to Adelaide's coastal waters (94%) are derived from single sources of industrial or wastewater treatment activities (Table 8), all of which are subject to licences under the Environment Protection Act 1993.

Licensing of discharges to the marine environment began in 1990, focusing considerable attention on SA Water WWTPs and industrial sites (eg Penrice Soda Holdings). As a result of the regulation of major dischargers, there have been significant reductions in both the number of discharges and the loads discharged to the waterways. Relevant examples include:

- The significant reduction of suspended solids (about 100,000 tonnes per year) discharge from Penrice Soda Holdings at Osborne into the Port River.
- The Glenelg to Adelaide Parklands Recycled Water Project which has the capacity to produce 5.5 GL of high-quality recycled water annually. The project provides up to 1.3 billion litres each year to irrigate the Adelaide Park Lands and presents opportunities for the development of additional recycled water initiatives.

- The upgrade to the Christies Beach WWTP which will effectively achieve the ACWS recommended target of 75% reduction in nitrogen through a cost-effective combination of capital works and improved reuse in the Willunga Basin (reducing drawdown issues in the Willunga Basin).
- The investment of over $200 million by the SA Government through SA Water to relocate the Port Adelaide WWTP to Bolivar, and the associated redevelopment of the Bolivar WWTP. This has reduced SA Water's contribution to the nutrient load to the Port waterways by over 1,200 tonnes of nitrogen (70% of total nitrogen contribution to Port waterways) and 60 tonnes of phosphorus (17% of total phosphorus contribution to Port waterways).

Table 8 shows the targets for nitrogen discharges to Adelaide's coastal waters. These include the change from 2003 loads and factor in population growth across the Adelaide metropolitan area from 1.14 to 1.85 million by 2036 (DPLG 2010). This information includes the expected results of all projects to reduce nitrogen loads with a high degree of certainty, ie projects or targets agreed to and/or very likely to be funded and completed.

Table 8 Adelaide Coastal Water Quality Improvement Plan targets for nitrogen reduction (tonnes/year)

Source	1975–85 loads	2003 (ACWS)	2008	*Forecast 2028 including pop growth*	ACWQIP target	Notes
Penrice	1,300	1,000	604	*300*	250	2011 Penrice Environment Improvement Program (approved February 2011) shows commitment to reductions of 15 tonnes of ammonia per year for next 5 years
Wastewater treatment plants (WWTPs)	2,279	1,136	821	*761*	300	
Potential reuse options				*−60*		Nitrogen reduction from flow reduction of 7.4 GL from WWTP by 2025 from reuse. About 30% of this saving (80 tonnes) is assumed by 2012.
Stormwater	639	153 (2)	153	*50*	50	(2) No significant change assumed 2003 to 2008
Totals	4,218	2,289	1,578	*1,051*	600	

Notes: Forecasts for 2028 include current population growth estimates and assume achievement of ACWS recommendations for load discharges.

6.3.1 Penrice Soda Holdings

Penrice has made the following commitment to working towards achieving improvements in water quality for Adelaide's coastal waters:

> Penrice Soda Holdings is committed to reducing its ammonia load to the Port River, consistent with the intent of the Adelaide Coastal Water Quality Improvement Plan (ACWQIP).
>
> Penrice endorses the ACWQIP and its targeted reduction of a 75% nitrogen reduction against 2003 levels for all polluters and the findings of the Port Waterways Water Quality Improvement Plan (PWWQIP). The PWWQIP identified that Penrice should ultimately reduce its nitrogen load to 250 tonnes and Penrice will use all reasonable and practicable means to achieve this target.

The ammonia reduction achieved over the previous five years has been substantial; a 42% nitrogen reduction against 2003 levels was achieved through the ongoing implementation of identified best practice methodologies. Penrice Soda Holdings successfully achieved the 2005–2010 Environment Improvement Programme (EIP) commitment to reduce the nitrogen load to 575 tonnes by 2010. The current Penrice EIP (approved by the EPA February 2011) commits to a further reduction of 15 tonnes of ammonia per year over five years

Penrice has accepted the ACWQIP target for 2030, the achievement of this target requires investigations into technological solutions that will achieve a significant step change in performance. Substantial ammonia reduction solutions are capital intensive and land intensive. For Penrice to achieve this target, it is anticipated that a level of co-investment and cooperation will be needed from key stakeholders.

6.3.2 SA Water

SA Water has made the following statement in relation to findings of the ACWS and the ACWQIP:

SA Water has been keen to ensure that any environmental impacts caused by its wastewater treatment plants (WWTPs) are identified and strategies developed to address these. With this in mind, SA Water provided financial and material support for the Adelaide Coastal Waters Study (ACWS).

The ACWS establishes targets for reducing the pollutant loads to Adelaide's coast. SA Water accepts these targets and has already delivered significant reductions in the loads from its discharges. This includes an 85% reduction in ammonia loads from coastal WWTPs since 2003. The achievement of these targets is subject to the availability of finance, the feasibility of further large-scale reuse schemes, and agreement on timing. It will also take into account the results of current and future research and the availability of emerging technology.

Consistent with the commitments in the Water for Good initiative which targets 50 GL of reuse, SA Water is seeking to further reduce loads from its wastewater discharges in a sustainable manner that optimises the value to the SA community. Individual strategies for its metropolitan WWTPs will be further developed over the next 12 months and will include innovative approaches to reuse, underpinned by SA Water's significant commitment in research and development.

The recommended targets in the ACWS cover the whole of Adelaide's coast. While a proportional approach has been adopted in the major division of discharges by Penrice Soda Holdings and, SA Water, long-term discharge targets for each of SA Water's wastewater discharges have not been derived as part of the development of this WQIP. Long-term discharges from each wastewater discharge will need to be agreed with the EPA as the licensing authority. These will need to take into account the effect that each discharge might have on the adjacent receiving waters, along with the more widespread effect of each discharge as it is transported along the coast. Through an adaptive management strategy, SA Water will use ongoing monitoring and localised studies to assess the impact of previous load reductions and to develop these load targets for individual WWTPs. The studies include support for research into restoration of seagrasses. This research aims to provide direct evidence of the extent of the impact of the WWTP discharges.

SA Water will seek support from the SA Government to enable any required WWTP modifications in the future.

The data in Table 8 shows that even with the inclusion of projects yet to be implemented, population growth indicates that the current outlook is that long-term nitrogen discharges of about 1,000 tonnes will still be approaching twice the sustainable limit of 600 tonnes for Adelaide's coast.

Discussion about the management strategies and specific actions of different organisations aimed at reducing nitrogen loads are detailed in Table 9, with further information provided in to Report 3 of the supporting technical reports on the EPA website.

Table 9 Summary of management strategies and actions aimed at nutrient load reduction for key stakeholders

Agency	Management strategies and/ or action
Penrice Soda Holdings	Penrice Soda Holdings successfully achieved the 2005–10 EIP commitment to reduce the nitrogen load to 575 tonnes by 2010. The current Penrice EIP (Approved by the EPA in February 2011) commits to a further reduction of 15 tonnes of ammonia per year over five years. Although Penrice face uncertainties with respect to technology, cost and land availability in achieving their target of 250 tonnes target by 2030, this proposed improvement is assumed to be in place for the purposes of this ACWQIP. It is expected that further agreements between the EPA and Penrice about load reduction actions will result in future EIP targets being met with a high degree of certainty and that this process will continue until Penrice's discharge load allows for ACWS load targets and agreed EVs for the Port River to be achieved.
SA Water—Bolivar WWTP	Following the re-development of the Bolivar WWTP and the incorporation of flows from the former Port Adelaide WWTP in 2004, significant reuse of the resultant wastewater has occurred. Currently over 30% of the wastewater from the Bolivar WWTP is reused during the warmer months. At the time of the Bolivar upgrade, SA Water recognised that further treatment might be required from the upgraded site if at least 50% reuse of effluent was not achieved. With the findings of the ACWS now available, SA Water is developing practical and cost-effective strategies. An example of this is where a major expansions of wastewater reuse are being investigated that incorporate the development of managed aquifer recharge (MAR) of presently under-utilised winter wastewater to provide source water for horticultural expansion. An inter-agency framework to allow these options to be explored is provided by SA Water's commitments to Actions 16 and 19 in the Water for Good Plan.
SA Water—Glenelg to Parklands reuse scheme	The diversion of up to 5.5 GL of wastewater for reuse has been included in the outlook for nutrient reductions. Modelling used to develop the ACWS showed that the Glenelg WWTP discharge impacts on seagrass in southern Holdfast Bay. Further reduction in this discharge will be required to avoid further losses in this area undergoing seagrass loss.
SA Water—Christies Beach WWTP	SA Water are constructing an upgraded WWTP at Christies Beach. The aim of this plant will be to treat the increasing volumes of wastewater generated by the expansion of the southern suburbs to a high level and to also support an increase in the reuse of this wastewater. This combined approach is cost effective and provides a high certainty of meeting the ACWS recommended reductions from this source in the long term.
SA Water and Department for Water	The current range of projects described above are under Water for Good. Their combined result will be a flow reduction of 7.4 GL from metropolitan WWTPs, corresponding to a nitrogen load reduction of about 270 tonnes with present treatment methods. This is a significant contribution to the ACWQIP target reductions that SA Water is supporting. Actions 16 and 19 in the Water for Good Plan are particularly relevant to achieving the ACWQIP targets.

Agency	Management strategies and/ or action
AMLR NRM Board regional targets for stormwater	The current AMLR NRM Regional Plan has identified a 20-year target of 75% of stormwater to be reused. The Board are currently developing a range of projects with local government and other stakeholders that aim to capture stormwater, focusing on rainfall events up to the 1 in 5–10 ARI storm events. Stormwater accounted for 6% of nitrogen but is the main source of suspended solids and coloured dissolved organic matter that reached Adelaide's coastal waters in 2003. As these projects also focus on the reuse of stormwater, or directing water to well-planned wetlands, this reuse target for stormwater will effectively reduce nutrients in stormwater. The adoption of water sensitive urban design (WSUD) features (DPLG 2009) into land development offers the opportunity to minimise the entry of further pollutants including nitrogen and sediment into Adelaide's coastal waters if adopted for all new land developments and will support pollution load reductions if retro-fitted during urban consolidation. Action 68 in Water for Good includes the introduction of targets for WSUD and if based on ACWS targets could greatly assist in reducing nutrient and sediment loads to Adelaide's coastal waters. An aspirational target of 75% reduction of stormwater has been adopted by the AMLR NRM Board which is consistent with the ACWS recommendations. Given that there are currently no targets for 2012, it is assumed that there will be no measurable change to loads by this time. Note that determining meaningful loads for nitrogen (and suspended solids) has been difficult during drought conditions.

Why simply apportion the available nitrogen load?

For the purposes of this ACWQIP, the nutrient reduction targets to avoid environmental harm have been derived from a simple apportionment of the available final nitrogen load of 600 tonnes per year from the Adelaide Coastal Waters Study (ACWS).

However, following a simple proportional reduction from each individual discharge location, as tabled in this paper, it is likely to lead to only partial solutions. Because of the different characteristics of the marine area (eg depth, current velocities, benthos) along Adelaide's coast, there will be cases where some discharges may remain above a sustainable level for one receiving environment, and others where they are reduced to levels well below those needed to provide for the protection of the associated receiving environment. As current discharge loads approach these proportional targets, location-specific investigations may lead to more appropriate target loads being derived for individual discharges. This has already occurred for the Port waterways where the independently derived targets for the Port Waterways Water Quality Improvement Plan (PWWQIP) are very consistent with the outcome of a 75% reduction called for by the ACWS. Other local studies may lead to a different apportionment of the nutrient loads of Glenelg and Christies Beach WWTPs.

Given the time needed to fully implement the considerable discharge reductions required, the current levels of uncertainties about localised effects is no impediment to adopting a proportional approach to the total targets in 2010. Consequently, the ACWS recommended targets have been adopted as the targets for 2030. However, this could be revised as part of implementing an adaptive management approach for the ACWQIP.

Hence, there can be a high degree of certainty the total targets provided by the ACWQIP, informed by the ACWS, are acceptable targets upon which to plan pollution reduction strategies and to continue their implementation at this early stage. Adjustment of individual targets within the 600-tonne maximum can be expected in the longer term based on location-specific studies.

6.4 Reducing stormwater flows, suspended solids and coloured dissolved organic matter

Table 11 summarises the outlook for reductions in suspended solids over the period of the ACWQIP. It is assumed that flow and loads of suspended solids and coloured dissolved organic matter (CDOM) are closely related (eg a drop in flows will result in a corresponding drop in suspended solids and CDOM). Discussion about the management strategies and specific actions, of different organisations are detailed in Table 10, with further information in Report 3.

Stormwater is now being recognised as an important additional source of water for South Australia. In the 2008 State of the Environment Report one of the key findings was that there was still only a small percentage of stormwater being captured for reuse. Recommendation for Action 2.3 of the SOE was to "Double the capture and re-use of stormwater and waste water by 2012" (EPA 2008b). The harvest, treatment where necessary, and reuse of stormwater will increase over the next few years under Water for Good Actions to 35 GL per year by 2025 and 60 GL per year by 2050 (Office for Water Security 2009). The projects to achieve these targets have received some preliminary assessment through the Urban Stormwater Harvesting Options Study undertaken by the Stormwater Management Authority in 2009. Further development and prioritisation of projects will be carried out through the development of a stormwater and wastewater master plan, successive AMLR NRM Board business plans and also on a case-by-case basis as funding and market opportunities arise.

For the purposes of the ACWQIP, it has been assumed that key targets agreed by the community in formulating the AMLR NRM Board Plan (AMLR NRM Board 2008a) will eventually be substantially achieved. While the reuse of stormwater to meet the water needs of the Adelaide community is a current focus, the management of stormwater to reduce the current environmental harm that it causes to our coast is likely to include a wide range of initiatives—many of which will improve the quality of stormwater prior to discharge to the coast. Within this wider context, the development of the Water for Good Stormwater Master Plan will be needed to ensure that the AMLR NRM Board and other organisations such as local government are able to coordinate the delivery of a stormwater discharge regime to Adelaide's coast that can meet the environmental, social and economic needs of the community.

It is important to understand that the intent of particulate matter reduction is to achieve a particular water quality status as defined in the ambient WQOs in Report 2. From an ecological perspective, the intent is to create a light climate which facilitates the health of existing seagrass meadows and allows recovery in denuded areas. In the relevant ACWS recommendation, the intent is to maintain adequate light levels for most of the time.

It is understood that there is a limit to what can be achieved in particulate matter reduction and this will vary from catchment to catchment, particularly following large storm events. The ambient WQOs along Adelaide's coast for turbidity 200 metres from shore is for the 90th percentile value to be <1 NTU. This allows for low levels for 90% of the time, but higher levels for 10% of the time as a result of offshore storm activity and large catchment storm events. Monitoring should focus on the ecological indicators and the achievement of satisfactory water quality as defined in the ambient WQOs, rather than on a load reduction target as an end in itself.

6.4.1 Adelaide coastal waters

Turbidity discharges following storm events from catchments (rivers, creeks and storm drains) are an aesthetic problem as well as a potential health problem. Acknowledging the practical limits of what can be achieved, the intent is to reduce the frequency, extent and duration of turbid condition and coloured water to a level that is acceptable to the community. This can be done by effectively reducing the total amount and regular input of fine sediment into nearshore waters following light rainfall events by reusing this flow in an appropriate mixture of both large and local sized schemes. This is also reflected in the current ambient WQOs, for a 90th percentile value of <25 NTU for turbidity in the swimming area adjacent to the shore, which would again mean that this value could be exceeded for 10% of the time and that good conditions would occur for 90% of the time. Outside of this, from 200 metres from the shore, a low-level 90th percentile value of <1 NTU for turbidity should be maintained to protect and encourage seagrass meadows.

6.4.2 Port waterways

The 50% target is also adopted as an interim target for the Port waterways. Sources of metals and other pollutants are from stormwater runoff, riverine flows (Dry Creek, North Para River, etc) and remobilisation from sediments. However, as discussed in the PWWQIP Stage 1 Technical Report (EPA 2005), most metals entering the waterways now are in stormwater runoff. While a 50% total reduction is defined, there should be an 80% reduction in stormwater sources. This localised target is based on the practical ability of stormwater treatment initiatives such as Gillman and Greenfields wetlands to achieve this level of suspended solids reduction in the discharges to the Port waterways if these systems are appropriately managed and maintained. It recognises the strength of commitment by local government and the AMLR NRM Board to treat and reuse this resource. Longer-term monitoring will provide feedback to ensure that these measures remain effective. The load reductions targets for suspended solids are given in Table 10.

6.4.3 Southern Adelaide coast

The situation in the southern part of the metropolitan area calls for a slightly different approach. Some southern reef communities, such as Horseshoe Reef, have been severely impacted by suspended solids and many others are under threat so there is a need to improve the quality of stormwater as soon as possible. In response to this, projects undertaken by the local councils and the AMLR NRM Board in Christies Creek and other southern catchments seek to manage suspended solids and reuse stormwater through systems that provide water for irrigation and (potentially) industrial uses. While southern metropolitan urban development is also intensifying, current technology also provides opportunities to deal with water quality pressures by incorporating WSUD approaches.

A strong focus on adherence to WSUD targets at the land division, planning approval and building stages of development needs to be integrated with the development of stormwater retention and harvesting infrastructure. Failure to implement these targets is likely to result in long-term damage to the southern area's prime attraction—its coastal environment.

The part that key contributing organisations have in implementing the ACWQIP and in achieving the pollutant load reduction targets and WQOs to protect EVs is nominated in their own forward planning. Information from these plans particularly relevant to water quality is summarised below.

Table 10 Adelaide Coastal Water Quality Improvement Plan targets for suspended solid reductions (tonnes/year)

Source	1975-85 loads	2003 (ACWS)	2008	*Forecast 2028 including pop growth*	ACWQIP target	Notes
Penrice	**100,000**	**1,780**	**810**	***810***	**890**	
Wastewater treatment plants (WWTPs)						
Bolivar WWTP	2,430	1,270	840	*565*	635	Based on flow reduction expectations
Glenelg WWTP	130	225	170	*90*	85	Based on flow reduction expectations
Christies WWTP	35	85	50	*20*	40	Based on flow reduction expectations
Sewage sludge to sea	4,410	0	0	*0*	0	Sludge discharges ceased 1993
SA Water subtotal	**7,005**	**1,580**	**1,060**	***675***	**760**	

Source	1975-85 loads	2003 (ACWS)	2008	*Forecast 2028 including pop growth*	ACWQIP target	Notes
Stormwater from Adelaide's catchment						
Northern region						
Gawler River	2,690	2,330	2,040	*585*	1,165	
Barker Inlet	2,790	1,460	1,460	*365*	730	
Central region	2,690	1,920	1,680	*480*	960	Includes Torrens, Patawalonga and stormwater system
Southern region	990	1,150	1,000	*290*	575	Comprises Field River, Onkaparinga River, Christies Creek and Southern catchments
Subtotal	9,160	**6,860**	**6,180**	***1,720***	**3,430**	
Total sediment	**116,165**	**10,220**	**8050**	***3,205***	**5,080**	

Notes: Forecasts for 2028 include current population growth estimates and assume achievement of ACWS recommendations for load discharges.

Table 11 Summary of management strategies and actions aimed at reducing stormwater flows, suspended solids and coloured dissolved organic matter

Agency	Management strategies and/or action
Penrice Soda Holdings	A large reduction in the loads of suspended solids travelling to Adelaide's coast occurred when Penrice Soda Holdings developed ponds in 2002 to remove this prior to discharge. Much of this remained in the Port River where it was discharged (eventually impeding the passage of shipping). Some of it, particularly the finer fractions travelled to Adelaide's coast. Historically, Penrice used to dredge this material every few years and discharge it directly into Adelaide's coastal waters near Outer Harbor. This practice has ceased with the last sea dumping of this material in 1993. Penrice is likely to maintain the same level of suspended solids discharge over the foreseeable future; however, their current discharge load achieves the ACWS recommended outcome when compared with their 2003 load.
SA Water—Bolivar WWTP	Increased reuse of wastewater that is processed by the Bolivar WWTP will also remove further sediment from the marine outfall. There is a high likelihood that reuse projects will achieve the ACWS recommended outcome compared with their 2003 loads; however the 2028 loads are only estimates and are dependent on numerous variables such as population growth projections, water use and uptake of recycling.
SA Water—Glenelg WWTP	Increased reuse of wastewater diverted by reuse from the Glenelg to Parklands reuse scheme will remove further sediment from the marine outfall. There is a high likelihood that reuse projects will achieve the ACWS recommended outcome compared with their 2003 loads; however the 2028 loads are only estimates and are dependent on numerous variables such as population growth projections, water use and uptake of recycling.

Agency	Management strategies and/or action
SA Water—Christies Beach WWTP	Increased reuse of wastewater for horticultural production and for domestic 'third pipe' systems in developing suburbs will remove further sediment from the marine outfall. Additionally, the former sewage sludge lagoons that received sediment are being rehabilitated and used as a wetland to minimise suspended solids and other pollutants from urban stormwater presently discharged to the Onkaparinga estuary. There is a high likelihood that reuse projects will achieve the ACWS recommended outcome compared with their 2003 loads; however the 2028 loads are only estimates and are dependent on numerous variables such as population growth projections, water use and uptake of recycling.
SA Water and Department for Water	The current range of projects including the Glenelg to Parklands scheme, the Blakeview housing development and the Southern Urban recycling project under Water for Good will result in a flow reduction of up to 7.4 GL from WWTPs. Also Water for Good Actions 16 and 19 will contribute to further water quality improvement for Adelaide's coastal waters in reducing sediment discharges from WWTPs and stormwater.
Local government/ Stormwater Management Authority and Department for Water	Actions 16 and 68 in Water for Good are particularly relevant to developing options for greater reuse of stormwater and use of WSUD. Report 3 in the EPA website lists the range of actions currently being undertaken by organisations that will result in suspended solid and CDOM load reductions to Adelaide's coast. The major contributions of both coastal and inland councils to these load reductions will be of increasing importance in future years. However, given that there are currently no interim targets for 2012, it is assumed that there will be no change to loads at this early stage of the implementation of the strategy.
AMLR NRM Board targets for stormwater	The current AMLR NRM Regional Plan has identified a 20-year target of 75% of stormwater to be reused. The Board are currently developing a range of projects with local government and other stakeholders that aim to capture stormwater, focusing on rainfall events up to the 1 in 5–10 ARI storm events. Stormwater is the main source of suspended solids and coloured dissolved organic matter that reached Adelaide's coastal waters in 2003. The adoption of water sensitive urban design (WSUD) features (DPLG 2009) into land development offers the opportunity to minimise the entry of further pollutants including nitrogen and sediment into Adelaide's coastal waters if adopted for all new land developments and will support pollution load reductions if retro-fitted during urban consolidation. Action 68 in Water for Good includes the introduction of targets for WSUD and if based on ACWS targets could greatly assist in reducing nutrient and sediment loads to Adelaide's coastal waters. An aspirational target of 75% reduction of stormwater has been adopted by the AMLR NRM Board which is consistent with the ACWS recommendations. Given that there are currently no targets for 2012, it is assumed that there will be no measurable change to loads by this time. Note that determining meaningful loads for nitrogen (and suspended solids) is difficult during drought conditions, but over a three to five year period including a range of drier to wetter years an estimation of annual loads could be more meaningfully established. Determining if reductions have been achieved that meet the recommendations of the ACWS will require ongoing monitoring and review of stormwater discharges from watercourses and stormwater drains . Given the increased understanding of the potential for the reuse of stormwater, it is expected that the 75% reuse target will be achieved over time for low to medium flows.

Stormwater—what is the problem?

Coast and marine ecosystems and recreational amenity are the two main aspects of coastal water quality that are impacted by pollutants in Adelaide's stormwater. Specific Adelaide coastal waters environmental values (EVs) that are affected by stormwater include aesthetic, cultural and spiritual, ecological and recreational values. In the development of the ACWQIP, the Adelaide coastal community has expressed its desire for action to be undertaken to reduce the volume and improve the quality of stormwater inputs to Adelaide's coastal waters.

Loads of suspended solids and coloured dissolved organic matter (CDOM) in stormwater and catchment flows are generally consistent with amounts of rainfall. For example, low stormwater flows carry lower loads (although these can be disproportionately high for CDOM at different times of the year), and the high flows from the occasional very high rainfall events scour stream banks and mobilise sediments that are retained in weir structures adding disproportionately to the loads carried by these very high flows.

While most of the suspended solids and CDOM generated across the Adelaide region enters coastal waters and eventually impact on seagrass, ACWS modelling has shown that it is retained for long periods close to shore, mostly inside the seagrass line. In this location along the coast, it causes little direct ecosystem harm at present, but has consistently contributed and will contribute in the future to the poor water quality that has characterised Adelaide beaches over the past few decades. The high flow/load events that occur every few years exclude light from seagrass, particularly nearer to shore. Healthy seagrass is better able to cope with this effect if it only lasts for up to a week or so and does not add to an existing pattern of generalised low light (as is often now the case).

While further work is required to effectively understand the way that suspended solids and CDOM disperse along the coast, our current understanding of the dynamics of Gulf St Vincent leads us to expect that this material travels north over time and contributes to the general filling of the gulf. The only effective way to improve swimming water quality along Adelaide's beaches is to remove the regular discharges of fine sediment and organic matter from stormwater sources.

High flow and low flow—different parts of the problem

For the Adelaide coast, there is a large difference in effect between the regular low to medium flows that discharge to and remain along our swimming areas, and the occasional episodes of high flow that discharge over the remains of our seagrass meadows.

High flow episodes are such that they currently (and will most likely always) overwhelm any engineering system designed to capture stormwater. There are usually some years between these events and at these times it is important that we maintain a stormwater network that continues to minimise the risk of property damage from flooding. Existing and proposed stormwater harvesting schemes will have little measurable effect on these flows. A recent example of this was the stormwater flows noted in the ACWS in October 2005. In this rare event water spilled from Kangaroo Creek reservoir and travelled at a high velocity from the dam, picking up large loads of sediment as it eroded stream banks. SA Water aims to minimise these episodes of overflow as they represent a loss of valuable water supply at these times. The flow characteristics of water from the proposed desalination plant may offer further flexibility to keep the reservoir water level lower and so retain a larger proportion of these events.

These episodes are consistent with the pattern of flow to the Adelaide coast in pre-European times and there is growing evidence that these flows were of little harm to otherwise healthy seagrass meadows. It is also likely that they were an important source of nutrients and a trigger to the breeding and life cycles of fish and other elements of the local marine ecosystem. Low flows to the coast (except for the Onkaparinga River system – refer to section 5.4) on the other hand, are unlikely to have been a feature of Adelaide's coast in pre-European times as the coastal dune system probably held and absorbed most of them. With the development of a stormwater system to protect properties from flooding and the low rainfall events that characterise Adelaide's climate these low flows no longer reach the dune system. This has also resulted in flows and associated pollutants impacting our seagrass and impairing the quality of our swimming beaches.

Current and future stormwater harvesting approaches focus on what is reasonably achievable in terms of flow volumes, ie the low to medium flows. This approach is likely to be consistent with improving beach amenity and supporting a slow shoreward progression of seagrass meadows, particularly in the context of the ecosystem improvements that will occur as we move toward sustainable nutrient loads to the Adelaide coast in the coming years.

At a local level, the inclusion of WSUD features into all new greenfields developments and particularly in redevelopment of existing urban areas will assist these processes over time. WSUD techniques can include the retention of more of these flows on site and allow the progressive release of filtered, higher quality stormwater over the following days and weeks. While this will take time and diligent application of these measures, the results should include pleasant, green urban landscapes in the face of water supply shortages, increased amounts of high quality stormwater able to be harvested for reuse, less requirement to upgrade the capacity of urban stormwater systems, improved beach amenity and protection, and contribution towards the re-establishment of seagrass off Adelaide's metropolitan coastline.

Note that although Water For Good proposes mandating WSUD by 2013, WSUD will not be achieved solely through the planning system. What is required is extensive support for WSUD implementation from residents, local government, investors, developers and state government agencies for all new development and re-development as well as retrofitting existing urban areas.

6.5 EPA activities

The EPA has a key role in the reduction of pollution loads to Adelaide's coast. In undertaking this role, the EPA administers the Environment Protection (Water Quality) Policy 2003 (EPA 2003). The EPA licenses and sets limits for major discharges and the development of individual environmental improvement plans (EIPs). It has led the development of the PWWQIP, and coordinated the ACWS and the preparation of the ACWQIP. The EPA's major activities are summarised in Report 3 of the supporting technical reports on the EPA website (Table 1).

SA Water and Penrice Soda Holdings hold licences under the Environment Protection Act 1993 to discharge to Adelaide's coastal waters. The provisions of the Act require the EPA to ensure environmental harm is minimised by these licensees using all reasonable and practicable measures.

The ACWQIP uses the ACWS as an authoritative source of information that has now defined the discharge loads of nitrogen required to ensure environmental harm is reduced to a more sustainable level. When finalised and endorsed, the ACWQIP will provide guidance to the EPA about whether measures proposed by licensees to minimise nitrogen in their discharges are acceptable and under what conditions licences will be issued.

This provides a mechanism that ensures the relevant licensees can undertake their activities with a high degree of confidence provided that they can prove that their nitrogen discharges are being reduced as quickly as is practically possible.

The other outcome of the findings of the ACWS is that it is now clear that current loads of nitrogen, suspended solids and CDOM are causing environmental harm to Adelaide's coast. The EPA is therefore likely to oppose proposals for development that involve loads of these materials reaching Adelaide's coast or waterways.

6.6 AMLR NRM Board activities

The AMLR NRM Board has developed a regional plan based on a long-term vision for the future of the region, which is *Thriving communities caring for our hills, plains and seas* (AMLR NRM Board 2008a). It also outlines what the stakeholders in the region, namely local, state and federal government, industry groups, non-government organisations and the community) are aiming to achieve in the next 20 years.

Regional targets have been developed describing the desired condition of natural resources in 20 years for various 'themes', which include seascapes, urban watercourses and water for life (water resources). These targets need to be achieved for the longer-term regional vision to be met in 50 years. In this sense, 20-year regional targets will assist with

evaluating the region's collective performance towards achieving the shared vision over the long term. The regional targets have been developed in consideration of the targets set out in South Australia's Strategic Plan 2007 and the State Natural Resources Management Plan (DWLBC 2006). For the themes, the Board has developed a range of strategies and actions that it believes are an important part of achieving the 20-year regional targets. To measure its success in undertaking those actions, a series of shorter-term management action targets (MATs) are also defined.

For all themes in the plan, there is a diverse and complex program of strategies and actions, which will collectively achieve the Board's vision for the region, including the coastal waters. Although many aspects of the plan are relevant to the ACWQIP to some degree, the longer-term targets/strategies and short-term MATs are of more direct relevance to achieving the particular ACWQIP objectives as summarised in Report 3 of the supporting technical reports on the EPA website (Table 2). For the three themes, the strategy objectives are defined as follows:

- *Seascape Strategy Objectives*—These strategies will work towards protecting reefs, seagrasses and estuaries from land-based pollution impacts, managing coastal habitats across the region, protecting habitats for migratory shore birds and marine species, encouraging sustainable use of marine resources and increasing the knowledge and awareness of the community about the coast and marine environment. Technical advice, research and financial support to protect and improve the coast and marine environment are key components of achieving the targets identified in the plan.
- *Urban Watercourses Strategy Objectives*—These strategies aim to protect against further degradation of waterways and marine water quality from urban land uses, and to retain, and where possible return, indigenous biodiversity values. As part of improving water quality and managing flood risk, strategies aim to better manage stormwater runoff through WSUD, and to be better prepared for potentially damaging flooding events.
- *Water for Life Strategy Objectives*—Strategies aim to develop and implement plans to sustainably manage both surface water and groundwater, and to develop opportunities for reuse of treated wastewater discharged by treatment plants, as well as stormwater which runs off urban areas in volumes in excess of natural rates. Importantly, it also aims to protect marine, fresh and groundwater from potentially contaminating practices in urban and rural areas.

  Continued investigations, technical advice and financial support will contribute towards achieving the targets identified in the plan. This program is critical to protecting water resources through the allocation of water to productive and environmental uses and to minimise the impact of stormwater and wastewater on the degradation of urban, coast and marine environments.

6.7 SA Water activities

The SA Water projects are summarised in Report 3 of the supporting technical reports on the EPA website (Table 3).

The SA community invests in the provision of safe and reliable water supplies and the disposal of wastewater in a safe and environmentally sustainable manner through SA Water. Following many years of the development of the sewerage reticulation system where treated wastewater and sewage sludge were discharged to the Adelaide coast, loss of seagrass and other environmental problems were noted. Through the implementation of the environment improvement programmes (EIPs) for its WWTPs, partly funded through the environmental levy, SA Water has already made considerable progress in reducing nutrient loads to the Port River–Barker Inlet system and the metropolitan coastal waters. Since the 1975–85 period, when most damage was done to the aquatic ecosystems, the load of nitrogen discharged from the WWTPs has reduced by approximately 48%. This has involved considerable planning and investment, and included the cessation of discharges such as the Port Adelaide and Glenelg sludge outfalls, the relocation of the Port Adelaide WWTP discharge to Bolivar, the upgrade of the WWTPs resulting in reduced loads in discharges and improved quality for reuse, and reuse of reclaimed water, particularly at the Virginia horticultural area.

Now that the ACWS has provided some clear ecosystem nitrogen load targets, SA Water is seeking to further reduce loads from its wastewater discharges in a sustainable manner that optimises the value to the SA community. Individual strategies for its metropolitan WWTPs will be developed by early 2011 and will include innovative approaches to reuse, underpinned by SA Water's significant commitment in research and development.

The work of SA Water in developing and implementing improvements to its WWTPs is also informed by 'Actions' in the Water for Good plan. This work is taking place in partnership with others, particularly the AMLR NRM Board, Department for Water, Commissioner for Water Security and the EPA.

6.8 Water for Good, The 30-Year Plan for Greater Adelaide and other activities

Pressures on South Australia's water supply from severe drought, climate change, future population growth and national concerns about the balance between the water needs of the environment and consumptive uses, were the main drivers for developing Water for Good. While many of the actions planned under Water for Good, particularly in relation to greater reuse of wastewater and stormwater, will result in reduced discharges to Adelaide's coastal waters, it should be recognised that it is primarily focused on addressing water security and improving coastal waters is a secondary outcome. Other initiatives to improve the quality of coastal water such as improvement of WWTPs and Penrice discharges will still need to occur if community expectations for the coast are to be met.

However, a number of the actions listed in Water for Good (refer to section 2.5) will have multiple benefits other than securing Adelaide's water supply for the future. Included in the benefits are improved water quality in Adelaide's water supply catchments, and healthier rivers, waterways, catchments and marine environments through the provision of environmental flows, and reduced effluent and stormwater discharges, provided that these are sufficient to allow improvement.

Earlier work completed under Water Proofing Adelaide (WPA), now incorporated into Water for Good implementation, projected annual savings by 2025 from the current projects and strategies. The projected savings from reduced effluent flows are linked to information summarised in Table 11 and their effect is shown in Table 12. With a potential reduction of about 270 tonnes of nitrogen load to Adelaide's coast, there are significant benefits if the strategies of the original WPA actions are achieved. The nitrogen and sediment reduction benefits are likely to continue as Actions 16 and 19 in Water for Good are implemented.

As part of Action 68 in Water for Good and implementation of the 30-Year Plan for Greater Adelaide other coastal water quality improvements should result from large scale use of WSUD across the Adelaide region. Also the national Cities as Water Supply Catchments project has a role in land use planning for water supply and stormwater management and will have benefits for improved water quality. The project is a research program that aims to harness the potential of stormwater to overcome water shortages, reduce urban temperatures, and improve the landscape and liveability of Australian cities. The project is to be undertaken by Monash University and is supported and partly funded by the National Water Commission and a number of state governments, including South Australia through the DPLG (lead agency), Department for Water (DfW), SA Water, Land Management Corporation (LMC), and the SA Murray–Darling Basin and Adelaide Mount Lofty Ranges NRM Boards.

The Department for Water is playing a key facilitating role in promoting projects that address greater reuse of wastewater and stormwater. The *Urban Stormwater Harvesting Options Study*, (Stormwater Management Authority 2009), has provided a framework for the numerous agencies involved (eg local government, SMA, AMLR NRM Board and many others) in investigating and developing stormwater harvesting projects with a guide to suitable areas across metropolitan Adelaide for such activities. If many of these projects are developed then they could result in multiple benefits for improvement of water quality for Adelaide's coastal waters and greater security of water for different purposes across metropolitan Adelaide.

The extent to which stormwater harvesting and wastewater reuse initiatives in Water for Good contribute towards the nutrient and sediment targets set by the ACWS will become clearer as reuse projects are developed. Since November 2009, a number of new stormwater harvesting and reuse projects in the Adelaide region have been announced that will help to reduce stormwater pollutant loads entering receiving waters in addition to providing treated stormwater fit for purpose use. The Glenelg to Adelaide Park Lands Recycled Water Project and a number of other initiatives also assist in reducing wastewater-related pollutant loads. The ACWS provides a specific focus for stormwater and wastewater re-use projects in terms of reducing sediment and nutrient loads to Adelaide's coastal waters. However, further work is likely to be needed in the area of reducing sediment and nutrient loads to Adelaide's coastal waters beyond the current stormwater and wastewater reuse projects underway and actions indicated in Water for Good to sufficiently improve

water quality to create the overall conditions suitable for the recovery of seagrass along the Adelaide metropolitan coastline.

Stormwater harvesting and use projects, rainwater tanks, the incorporation of WSUD in new developments and the use of recycled water have the potential to reduce outflows to Adelaide's coast by up to 12.5 GL/year. Current stormwater sources contain about 67% or 6,849 tonnes of the total 10,337 tonnes of total suspended solids to Adelaide's coast per year. Potentially suspended solids reduction of about 10% (685 tonnes) are likely from current or committed stormwater projects. Current discharges from WWTPs include about 15% (1,579 tonnes) of the total suspended solids to the Adelaide coast. WPA identified reductions in water use that will potentially reduce discharges from WWTPs by 7.4 GL, which would further reduce suspended solids by about 200 tonnes.

While stormwater is a major source of suspended solids and coloured dissolved organic matter, the WWTPs contribute about 49% (1,204 tonnes) of total 2453 tonnes total nitrogen per year to Adelaide's coast. The use of the 7.4 GL recycled water could potentially also result in a reduction of 130 tonnes of nitrogen per year. Stormwater contributes only about 6% of the nitrogen to Adelaide's coast and the reduced stormwater is correspondingly low at about 15 tonnes per year.

The reuse of water has the potential to provide sustainable reductions in nitrogen loads to Adelaide's coast from WWTPs which can be a cheaper option than upgrading of infrastructure and processes. However, the proposed actions in Water for Good would not be enough alone to provide the necessary scale of reductions in nitrogen loads as identified in the ACWS Final Report.

Completion of Actions 16 and 19 in Water for Good of integrated strategies for greater use of stormwater and wastewater have the potential to maximise the economic, social and environmental return to the community from reuse of water and will be of benefit to ensure that the water needs can be met at the same time as achieving environmental benefits sought by the community for Adelaide's coastal waters.

6.9 Department of Environment and Natural Resources activities

The Living Coast Strategy (DEH 2004) sets out the state government's environmental policy commitments for coastal, estuarine and marine environments. It encompasses a range of environmental initiatives and programs, and sets out the policy direction that the state government will be taking up to 2010 to help protect and manage South Australia's coastal areas, estuaries and marine ecosystems for their conservation and sustainable use. It defines the principles considered necessary for their sustainable use.

The Living Coast Strategy also identifies and addresses six key objectives for our coastal, estuarine and marine environments.

A number of actions for state government and lead agencies are also identified. The objectives and actions are set out in Report 3 of the supporting technical reports on the EPA website (Table 4).

The Coast Protection Board (CPB) operates under the Coast Protection Act 1972, but also implements some of the recommendations of the Living Coast Strategy. The CPB is also tasked with the management of sand along Adelaide's beaches, including beach protection measures and the maintenance of navigable channels along the coast. This work often involves dredging or the pumping of sand which includes a small portion of fine materials derived from stormwater flows and beach transport. When this is being undertaken, there is a degradation of water quality for amenity purposes over an area that varies with wind and tide. There is considerable scope to minimise this effect by dredging at times that the community avoids beach use (eg night time, winter).

Starting in 2000, DENR on behalf of the CPB, initiated a review of the management of Adelaide's metropolitan beaches. Based on examination of the benefits and costs of a range of strategies, along with the results of a series of modelling and feasibility studies and input from the community, the department has developed an innovative strategy for managing Adelaide's beaches called Adelaide's Living Beaches: A Strategy for 2005–2025 (DEH 2005). The strategy consists of five main components and supports a number of aims. The Adelaide metropolitan coast was effectively be divided into seven management cells, with some interconnectivity between them. The components and aims are listed in Report 3 of the supporting technical reports on the EPA website (Table 4).

There is some potential for the pipelines used in the Living Beaches Strategy to be used to transport stormwater to a central coastal location for reuse.

Other coast and marine work that supports the achievement of improved water quality for Adelaide's coastal waters includes work on conservation and management of estuaries and marine planning. Some of this work is progressing with the involvement of the AMLR NRM Board for the coastal waters. However, much of this work has been on hold due to the current priority of establishing 19 Marine Parks across the state. None of the proposed Marine Parks will include Adelaide's coastal waters, but there are proposed Marine Parks that will cover the northern and southern ends of Gulf St Vincent.

6.10 Local government activities

Local government is very active in natural resource management. The main local coastal council areas adjacent to Adelaide's coastal waters include the City of Onkaparinga, City of Marion, City of Holdfast Bay, City of West Torrens, City of Charles Sturt, City of Port Adelaide–Enfield, City of Salisbury, City of Playford and District Council of Mallala. Across these council areas there are some key activities being undertaken that will result in improvements to water quality for Adelaide's coastal waters.

The City of Salisbury is a recognised leader in the area of water conservation and management. It aims for ecologically sustainable development, as outlined in its *Salisbury, Sustaining Our Environment—An Environmental and Climate Change Strategy 2007*. The protection of the coastal environment and marine water quality are key environmental objectives of the council.

The City of Salisbury is looking to implement Australia's first totally integrated water management plan to efficiently harvest and manage systems for rainwater, stormwater, ground water, recycled wastewater and potable water. This plan is an integral part of the Waterproofing Northern Adelaide project which received significant funding from the Australian Government in 2006. The project also has a sustained focus on broadening community awareness and action about conserving water and innovative ways to use this natural resource.

Some of the activities which will contribute directly or indirectly are listed in Report 3 of the supporting technical reports on the EPA website (Table 5). The other councils with extensive programs are City of Charles Sturt (Table 6), City of Port Adelaide–Enfield (Table 7) and City of Onkaparinga (Table 8).

The City of Mitcham was chosen as a representative upstream council to identify the range of activities undertaken by local government, which will have a major role in the implementation of the ACWQIP.

Its *2008–2012 Strategic Plan* outlines the medium-term strategic directions for achieving the long-term vision for the area. The strategic plan establishes four broad goal areas (Objectives) with an emphasis on contributing to long-term sustainability. The strategies (Actions) guide the council's Annual Business Plan and Budget as well as guiding the its long-term Financial Plan. With regard to the ACWQIP, the environmental sustainability goal is relevant and is outlined in Report 3 of the supporting technical reports on the EPA website (Table 9).

The council's Public and Environmental Health Management Plan (PEHMP) was produced in 1997 and identified several strategies to sustain the health of catchments within the Mitcham Council area. The specific WQOs outlined in the PEHMP are also listed Table 9.

The council's *Water Management Plan 2004–2009* outlines strategic direction and an implementation schedule for water-related actions. The plan has been prepared using the International Council for Local Environmental Initiatives (ICLEI) Water Campaign™ Framework. ICLEI is an international not-for-profit non-government membership organisation of local governments and their associations. The objectives, strategies and actions are listed in Table 9.

6.11 Stormwater Management Authority activities

In May 2005, the *Urban Stormwater Management Policy for South Australia* was released aimed at improving the way stormwater was managed. This policy was adopted following negotiation between the state government and the Local Government Association (LGA).

In February 2006 the state government and LGA entered into a Stormwater Management Agreement that provided an improved framework for stormwater management on a catchment-wide basis throughout the state. The Stormwater Management Authority (SMA) was established under the Local Government Act 1999 (Stormwater Management Amendment 2007) which came into effect on 1 July 2007. The Authority, which is responsible for implementation of the Stormwater Management Agreement, provides funding towards the cost of floodplain mapping, preparation of stormwater management plans and priority stormwater infrastructure works.

Stormwater projects must demonstrate a significant flood mitigation component as well as addressing, wherever practicable, value adding opportunities such as stormwater reuse and water quality enhancements to be eligible for funding from the Stormwater Management Fund.

The Urban Stormwater Management Policy identifies the following goals for collaborative and forward looking stormwater management:

- Apply a risk management framework for hazards/flooding based on catchment characteristics and rigorous data collection.
- Facilitate more productive use of stormwater.
- Manage the environmental impacts of stormwater as a conveyer of pollution.
- Manage stormwater as part of the urban water cycle recognising natural watercourses and ecosystems where feasible.
- Achieve responsible stormwater management locally by making better use of the statutory development planning system.
- Gain innovative stormwater policy outcomes through the most effective funding and procurement arrangements.

Stormwater management plans are required to set catchment-specific objectives, identifying clearly how the above goals can be achieved and measured.

Since September 2006, 46 projects have been approved. Some major projects include:

- Gawler River Flood Mitigation Scheme
- Port Road Catchment Stormwater Management Plan
- Brownhill and Keswick Creeks Catchment Stormwater Management Plan
- Norwood Payneham and St Peters First Creek flood mitigation works.

In the future stormwater management plans will contribute to achieving important water quality outcomes necessary for delivering the ACWIP stormwater targets. The ACWS has informed the development of both short- (three-year MATs) and long-term targets by the AMLR NRM Board who reviews stormwater management plans. With the incorporation of the AMLR NRM Board Plan into the ACWQIP, those preparing the stormwater management plans will now have a consistent set of long-term targets to provide context and focus. Water quality improvement plans for other watercourses as proposed in the current AMLR NRM Board Plan will similarly also provide in-stream targets to assist in defining plan goals.

7 Implementation, monitoring and evaluation

As outlined in Chapter 6, there are a wide range of programs and activities being undertaken by a number of agencies, which will reduce loads and improve water quality. While the outcomes of the programs being implemented to reduce nutrients from the major point sources can be clearly determined in terms of pollutant load reduction, this is not the case for the pollutants from diffuse sources. At present, it is somewhat uncertain what the effects of diverse catchment programs would be on loads of suspended solids, turbidity, metals, nutrients and faecal micro-organisms with the full implementation of current works. What is required is an integrated monitoring approach that will provide timely information to inform managers whether the various water quality objectives, targets and longer-term goals are being achieved.

Data from monitoring of both water quality and the condition of ecosystems are necessary to inform the ongoing investment in the programs so that they are efficient, effective and adaptive to change. This information should be reported to the South Australian community in a clear and easily understandable manner. Currently, the AMLR NRM Board and EPA are reviewing and developing revised monitoring approaches. These approaches are discussed briefly below, following an outline of the comprehensive range of strategies for water quality improvement.

7.1 Strategies for implementation, adaptive management and review

7.1.1 Strategies for implementation

Findings and recommendations from the ACWS, and community and stakeholder input into the development of the ACWQIP have together shaped the development of eight strategies (Table 13) for implementation in the following ways:

- The ACWS has formed a key foundation of scientific knowledge for the development of the ACWQIP, and
- Community and stakeholder consultation undertaken as part of the development of environmental values and water quality objectives for the ACWQIP have reinforced the relevance of the findings and recommendations of the ACWS.

The details of the strategies (Table 13a) have been designed to meet the water quality improvement targets established in the ACWS and achieve the community vision for the ACWQIP to see the return of the 'blue-line of seagrass closer to shore'. These strategies have been developed through discussions with stakeholders after revision of draft versions of the ACWQIP by the Adelaide Coastal Waters Steering Committee in 2008 and 2009. Table 13 b indicates the relevant agencies for lead on the different strategies.

Strategies for implementation included in the ACWQIP are cross referenced against the 14 recommendations of the ACWS in Table 14.

Figure 2 outlines the components of the adaptive management approach being used in the implementation and review of the ACWQIP. Many of the recommendations from the ACWS and strategies for implementation relate to undertaking further investigative work and testing of different approaches to address water quality issues and seagrass health. It is critical that an adaptive management approach is used where monitoring, review and assessment are undertaken of any actions and a review process assesses the relevant costs and benefits of continuing such actions on a longer-term basis as part of the ongoing implementation of the ACWQIP. The process and timing of review of the ACWQIP also strongly links to the adaptive management approach in informing success of actions.

Note that use of the adaptive management approach does not mean doing nothing now and waiting to see what happens in the future; instead it is about implementing actions based on our current knowledge of the situation. As new information and knowledge becomes available and monitoring results are known, management approaches can be reviewed and adapted accordingly.

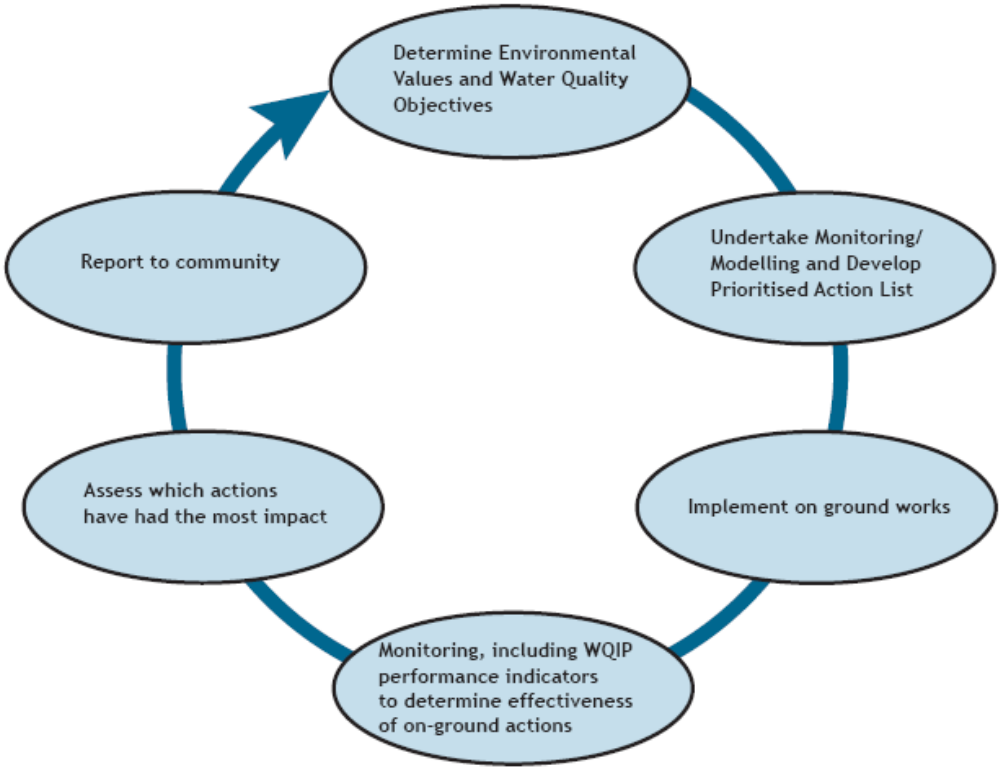

Figure 2 Adaptive management framework as it applies to implementation of the Adelaide Coastal Water Quality Improvement Plan

7.1.2 Adaptive management and review

Since many of the initial strategies for implementation of the ACWQIP are projects involving investigative work and feasibility assessment for commitment to longer-term actions, a regular reporting and review process is essential to the long-term success of the ACWQIP. Reviews will be undertaken within an adaptive management framework (Figure 2) to allow for review of proposed actions after initial investigative work has been completed. It is also appropriate that the review process is synchronised with that of other agencies, particularly the AMLR NRM Board and the SA State of Environment (SoE) reporting process.

This proposed reporting framework for the ACWQIP is outlined as follows:

- **Annually** (2010 to 2030) following the review of the monitoring needs of the ACWQIP and progress on implementation of strategies, annual monitoring reporting will continue, with data being regularly reviewed against environmental values, pollutant reduction targets and water quality objectives.
- **Five-yearly review** (starting in 2012 to link to SoE reporting in 2013) the ACWQIP will be reviewed every five years and undertaken in a timeframe that will allow integration with SoE reporting. Reporting will include progress towards achieving the longer-term ecological goals, long-term reduction pollutant targets, ambient water quality objectives and resource allocation.

In addition to the annual and five-yearly reporting, reports will be provided to the EPA Board regarding progress on implementation of the ACWQIP, including reference to relevant EPA authorisations and any inter-agency issues that may impact on the implementation of specific strategies.

Meetings of representatives from relevant stakeholder groups will be convened from time to time through focused forums and workshops. The EPA will seek to present and discuss at these meetings, the results of monitoring, assessments and possible trends in the management of water quality.

The development and implementation of the ACWQIP will be guided by an adaptive management framework that aims to:

- achieve continuous improvement in the health of the Adelaide coastal waters
- identify key gaps in understanding of the system
- improve understanding of the ecosystem responses, thresholds and dynamics in order to adapt practices to fit changing social and economic values, and ecological conditions
- gain reliable feedback about the effectiveness of alternative policies/practices
- encourage innovation and learning
- pass on information and knowledge gained through experience
- foster a management culture that emphasises learning and responsiveness.

Table 13a Adelaide Coastal Water Quality Improvement Plan strategies for implementation over the next 2–5 years (subject to funding)

Strategy no.	ACWQIP strategies (improve seagrass and water quality)	Details of specific actions required	Current actions	Who is involved or will be involved?
1	Reduce nutrient, sediment and coloured dissolved organic matter discharges	1.1 EPA continue to work with SA Water and Penrice Soda Holdings to reduce nutrient and sediment loads 1.2 Encourage practical action for sediment reductions 1.3 Encourage uptake and implementation of Water Sensitive Urban Design (WSUD) across Adelaide region	• EPA licenses SA Water and Penrice for discharge of wastewater • AMLR NRM Board work towards 75% reduction in stormwater discharge • Local government stormwater management and reuse, street sweeping • Increase in WSUD implementation according to Water for Good Plan and The 30−Year Plan for Greater Adelaide	• Nutrients – EPA, SA Water, Penrice Soda Holdings • Sediments – Department for Water, EPA, SA Water, Penrice Soda Holdings, AMLR NRM Board, local government and Stormwater Management Authority • WSUD–promotion by SA Government agencies involved in planning and metropolitan local governments

Strategy no.	ACWQIP strategies (improve seagrass and water quality)	Details of specific actions required	Current actions	Who is involved or will be involved?
2	Promote integrated use of wastewater and stormwater	2.1 Undertake further investigative work regarding options to facilitate greater integrated reuse of stormwater and wastewater (links to Actions 16 and 19 in Water for Good) 2.2 Develop pilot or regional area projects for integrated use of stormwater and wastewater	• Many localised projects are underway as part of Water Proofing the South and Waterproofing North Adelaide. Local government has played a major role in facilitating such projects especially the City of Salisbury and the City of Onkaparinga. More work is proposed under Water for Good • *Urban Stormwater Harvesting Options Study* (2009) identifies potential to harvest up to 60 GL of stormwater by 2050, through large-scale schemes at specific sites across metropolitan Adelaide • *Water for Good Plan* (2009) has targets of harvesting 60 GL of stormwater by 2050 and 50 GL of wastewater in SA	• Department for Water (DfW), SA Water, EPA, Local Government, Stormwater Management Authority, AMLR NRM Board and many others including land owners, developers and building and construction industry
3	Further investigate sources and volumes of sediment and coloured dissolved organic matter (CDOM)	3.1 Further investigate sources of CDOM and sediments for catchment modelling 3.2 Identify practical and prioritised action that can be taken for reductions in CDOM and sediments from catchments	• SARDI have previously sought funding for some work to be done, but further work is required to fill in gaps on sediment sources from different catchments • Sediment and CDOM generation, transport and management all require further work	• AMLR NRM Board, DFW, local government, Stormwater Management Authority, SA Water and EPA

Strategy no.	ACWQIP strategies (improve seagrass and water quality)	Details of specific actions required	Current actions	Who is involved or will be involved?
4	Integrate monitoring for cumulative impact assessment across Adelaide region	4.1 Facilitate integrated monitoring of cumulative impacts and emerging issues across agencies for Adelaide's coastal waters 4.2 Investigate and coordinate gap and operational funding for monitoring that needs to be done to meet recommendations of ACWS 4.3 Support ongoing monitoring of reef and seagrass condition to integrate with other monitoring activities.	• The EPA has undertaken a recent review of the ambient monitoring program for marine waters and produced a Gulf St Vincent (GSV) risk assessment that will guide the development of future monitoring for meeting ACWS recommendations	• Nutrients—EPA, SA Water, Penrice Soda Holdings • Desalination—SA Water & contractors • Sediments—AMLR NRM Board, EPA, local government, DFW and Stormwater Management Authority • Seagrass—DENR, SARDI and universities • Reefs—EPA, Conservation Council of SA, DENR, SARDI
5	Model and evaluate the impacts of climate change, human impacts and population growth implications for Adelaide's coastal waters	5.1 Information from CDOM and sediment investigations and integrated monitoring activities to be fed into future modelling work 5.2 Model projection of wastewater treatment plant (WWTP) inputs and outflows as a result of population change	• May link to other work that comes under Water for Good Plan and The 30-Year Greater Adelaide Plan.	• EPA, AMLR NRM Board, DFW, local government, Stormwater Management Authority, and SA Water
6	Establish planning and funding priorities for water initiatives for Adelaide's coastal waters	6.1 Identify priority funding areas for projects with multiple benefits (incorporate triple bottom line accounting into project planning)	• Research into the storage of winter wastewater discharges could be an example of such a project that has multiple benefits, including agricultural development	• AMLR NRM Board, DFW, local government, Stormwater Management Authority, SA Water, PIRSA and EPA

Strategy no.	ACWQIP strategies (improve seagrass and water quality)	Details of specific actions required	Current actions	Who is involved or will be involved?
		6.2 Trial investigations for storage and use of water normally discharged to coast in winter months	• Needs link to other work that comes under Water for Good Plan Actions and The 30–Year Greater Adelaide Plan, including the focus on greater reuse of stormwater and wastewater and the implementation of WSUD	
7	Undertake seagrass mapping and rehabilitation work	7.1 Develop and update 'seagrass ready' maps that integrate water quality and sediment information 7.2 Further support for seagrass rehabilitation work	• Department for Environment and Natural Resources (DENR), SARDI and Flinders University have an agreement for some work to be done, but more follow-up work is required for strategies 7.1 and 7.2 and work needs to link to impacts of discharges from WWTPs and Penrice Soda Holdings	• DENR, SARDI and universities • Possible role for SA Water, Penrice Soda Holdings and EPA
8	Build community capacity to take action to improve coastal water quality	8.1 Use Healthy Waters networks and local government contacts to get messages across to community regarding how it can take action for water quality improvement 8.2 Further develop linkages with Kaurna and Ramindjeri people regarding community water quality messages	• Links to Water for Good, AMLR NRM Plan and current Conservation Council of SA actions and projects • Planning for WSUD capacity building work to facilitating uptake of WSUD across Adelaide region is currently taking place	• EPA, local government and AMLR NRM Board, DFW, Kaurna and Ramindjeri Nations and Conservation Council of SA

Table 13b Timing for implementation of strategies and actions for the Adelaide Coastal Water Quality Improvement Plan over the next 2–5 years (subject to funding).

Proposed timing from 2011–12 to 2015–16		2011–12	2012–13	2013–14	2014–15
Strategy no.	**Agency to coordinate activities**	**Work to be undertaken on relevant strategies**			
1.1	EPA	1.1	1.1	1.1	1.1
1.2	EPA/DPLG/ DFW	1.2	1.2	1.2	
2	EPA/ /SA Water/DFW	2.1 & 2.2	2.1 & 2.2	2.1 & 2.2	
3	EPA	3.1 & 3.2	3.1 & 3.2		
4	EPA	4.1 & 4.2	4.1 & 4.2	4.1 & 4.2	4.1 & 4.2
5	EPA/DPLG/DFW		5.1	5.1	5.1
6.1	AMLR NRM Board	6.1	6.1	6.1	6.1
6.2	SA Water/PIRSA	6.2	6.2		
7	DENR	7.1 & 7.2	7.1 & 7.2		
8	AMLR NRM Board	8.1 & 8.2	8.1 & 8.2	8.1 & 8.2	8.1 & 8.2

Table 14 Adelaide Coastal Water Quality Improvement Plan strategies for implementation cross referenced against the 14 recommendations of the Adelaide Coastal Waters Study

Summary of 14 ACWS recommendations for quick reference

1	Reduce wastewater, stormwater and industrial inputs to marine environment
2	Reduce annual nitrogen discharged to marine environment to around 600 tonnes
3	Reduce loads of particulate matter discharged to marine environment by approximately 50% from 2003 levels
4	Reduce the amount of CDOM discharged by rivers, creeks and stormwater drains
5	Continue to reduce and monitor toxicant levels discharged to marine environment
6	Develop and implement a comprehensive and integrated environmental monitoring program
7	Maintain and develop the comprehensive database of historical inputs generated by this study
8	Implement a long-term monitoring program to assess seagrass quality
9	Implement a long-term monitoring program of the outer depth margin of Posidonia meadows in Holdfast Bay
10	Implement a long-term monitoring program of seagrass meadow fragmentation in Holdfast Bay
11	Undertake detailed mapping of the distribution of Amphibolis across the Adelaide metropolitan area
12	Undertake a spatially intensive nitrogen stable isotope survey
13	Undertake an audit of key environmental assets in the southern metropolitan coastal region
14	Manage Adelaide's coastal marine environment as a component of an integrated system

ACWQIP Strategy	Links with numbered ACWS recommendations *													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Reduce nutrient, sediment and CDOM discharge	♦	♦	♦	♦										
2 Integrate reuse of wastewater and stormwater	♦													♦
3 Further investigate sources and volumes of sediment and coloured dissolved organic matter			♦	♦		♦								
4 Integrate monitoring for cumulative impact assessment					♦	♦	♦	♦	♦	♦	♦	♦	♦	
5 Model the impacts of climate change, new human impacts and population growth implications	♦	♦	♦	♦		♦								
6 Establish planning and funding priorities for water initiatives	♦	♦	♦	♦										♦
7 Undertake seagrass mapping and rehabilitation work						♦	♦	♦	♦	♦	♦	♦	♦	
8 Build community capacity to take action	♦	♦	♦	♦	♦									♦

7.2 AMLR NRM Board monitoring evaluation and reporting framework

The AMLR NRM Board monitoring evaluation and reporting framework (MERF)- (AMLR NRM Board 2008b), prepared for the regional NRM Plan, has been developed to focus the related regional activity by addressing the following three questions:

- To what extent has the region succeeded in implementing the NRM Plan (and supporting plans)?
- To what extent has the region progressed towards achieving the goals described in the Plan?
- Is the condition of the natural resources within the region getting better or worse?

This information will inform decisions regarding natural resource management, such that the management effort is efficient, effective and adaptive to change.

The AMLR NRM Board MERF provides the mechanism for determining the effectiveness of various programs in achieving the regional targets. It proposes a transition from the current approach of project-based monitoring at local scales towards investment in long-term monitoring of key environmental indicators at the regional scale that are directly related to the regional targets identified in the Plan.

Significant progress towards these regional targets is not likely to be detectable for very long time periods. Management action targets (refer Attachment 3 Table 2 for those applicable to the ACWQIP) provide short- to medium-term targets that are more directly attributable to the implementation of the AMLR NRM Regional Plan.

Core environmental indicators have been identified. These are indicators of change in the environment, including environmental pressures, the condition (or state) of the environment and the consequent impacts. They were selected on the basis of being relevant, simple, measurable, accessible, and timely. Those particularly relevant to the ACWQIP are listed in Table 15. Management indicators have also been selected and social and economic impacts are also recognised.

Incorporating long-term ambient environmental monitoring into current MERF activity is a key challenge for the region, as is the development of a standard approach to program and project-based monitoring. Sustained investment in monitoring, evaluation and reporting is critical for the board to be able to effectively track performance of the plan and change in the state of the region's natural resource base.

Community involvement in the monitoring is seen as necessary for the successful implementation of NRM programs. Existing programs include WaterWatch, Frog Census and ReefWatch.

Reporting on progress for the environmental indicators should be based on a five-yearly cycle, although there will be annual reporting on program implementation and resource allocation (management indicators)

The MERF will be followed by a Monitoring, Evaluation, Reporting and Improvement (MERI) Program. The program will include technical documents, monitoring protocols for each indicator, evaluation and reporting tools and provide guidance on how to include adaptation for improvement. The documents will require regular review and revision.

For effective achievement of the long-term targets, there should be an integration of monitoring undertaken by the AMLR NRM Board and that of other agencies, including the major point sources monitored by the EPA. This could well be achieved through the coastal waters report card reporting structure currently being developed by the EPA in consultation AMLR NRM Board.

7.3 ACWQIP catchment model and monitoring plan

The EPA has also developed a hydrological model of the whole of the metropolitan coastal catchments which can be used to assist in the implementation of both the AMLR NRM Board Plan and ACWQIP. Modelling has the potential to be used interactively to guide the development of appropriate monitoring and to provide guidance about the types and/or

intensity of management actions. For this reason, modelling has been considered along with monitoring, rather than as a separate task for the implementation of the ACWQIP.

7.3.1 Catchment model

The catchment model developed for the ACWQIP (refer to Report 4 of the supporting technical reports on the EPA website) is aimed at providing sufficient information about proposed management strategies for Adelaide's coastal catchments to assist with the development of the ACWQIP. It enables the relative effects of different management strategies to be understood, eg use of WSUD.

There are many other models that have been used to provide information about flows and discharges from different parts of Adelaide's metropolitan catchments, but rather than replacing these, the Adelaide Catchment Model uses the flows and other information derived from these models. It enables integration of existing information across a much broader area than any of the other models produced so far. Where other models provide better information about specific areas, eg the modelling undertaken for the Torrens Catchment Water Management Plan, the information has been incorporated.

The EPA will initially use the model to understand the relative effects of different strategies on reducing or managing runoff to decrease nitrogen and suspended solids loads and CDOM levels. This level of sensitivity is sufficient for the present, as it enables the relative effect of different options to be understood and how climate and population change may affect the discharges to Adelaide's coast.

The EPA supports the use of the model to assist other organisations and agencies to gain insights into changes in the discharge of pollutants as a result of proposed management changes.

The use of the model in a more quantitative manner is currently limited by a lack of monitoring data. Of primary importance is sufficient time series of relevant data for the major streams and stormwater systems across Adelaide. The AMLR NRM Board has put a monitoring strategy in place that includes 14 samplers at creeks and stormwater drains that discharge to Adelaide’s coast. The AMLR NRM Board may also include project-focused monitoring to assess the effectiveness of stormwater management projects across Adelaide. This monitoring data is likely to provide important information for initial modelling, and enable subsequent monitoring and modelling within catchments to be undertaken effectively.

While the Adelaide Catchment Model will provide additional information about the effects of different water quality management strategies across Adelaide, there is a need to understand how these discharges affect the adjacent coastal water quality, particularly with respect to suspended solids and CDOM. A generalised inputs model was proposed during the development of the ACWS. However, the focus provided by the final recommendations of the ACWS, particularly with respect to suspended solids and CDOM, means that a far more effective solution would be to link inputs with the existing hydrodynamic model for Adelaide's coastal waters developed as part of the ACWS. This would provide a valuable tool for the AMLR NRM Board as they develop their long-term investment strategy.

Table 15 Adelaide and Mount Lofty Ranges Natural Resource Management Board—monitoring, reporting and evaluation framework targets and environmental indicators

Target	Information required	Environmental Indicator(s)
Water		
T1 Stormwater and wastewater	Stormwater quantity	Volume of stormwater generated
		Volume of stormwater discharge to coast or marine systems
		Volume of stormwater reused
	Stormwater quality	Stormwater pollutant load

Target	Information required	Environmental Indicator(s)
Water		
T1 Stormwater and wastewater	Wastewater quantity	Volume of wastewater generated
		Volume of wastewater discharge to coast or marine systems
		Volume of wastewater reused
	Wastewater quality	Wastewater quality
T2 Surface and ground water quality	Surface water quality	Exceedences of pH water quality triggers (surface water)
		Exceedences of salinity water quality triggers (surface water)
T3 Sustainable management of water resources	Surface water use	Surface water used for agriculture/irrigation
		Surface water used by industry
		Surface water used for urban/domestic
		Total surface water required for the environment compared to that provided
Biodiversity		
T8 Extent of functional ecosystems (coastal, estuarine, terrestrial, riparian)		Area of native vegetation
Marine		
T10 Land-based impacts on coastal, estuarine and marine processes	Catchment condition	Catchment sediment load
	Stormwater quality	Stormwater pollutant load
	Stormwater quantity	Volume of stormwater discharge to coast or marine systems
	Wastewater quantity	Volume of wastewater discharge to coast or marine systems
T11 Seagrass, reef and other coast, estuarine and marine habitats	Coast, estuarine and marine ecosystems	Distribution and abundance of seagrass
		Condition of reefs
		Condition of estuaries
		Distribution and abundance of mangroves

Target	Information required	Environmental Indicator(s)
Marine		
T12 Coast, estuarine and marine water quality	Coast, estuarine and marine water quality	Exceedences of heavy metals triggers (coastal, marine and estuarine waters)
		Exceedences of marine Chlorophyll concentrations
		Exceedences of marine nutrient concentrations
		Exceedences of marine turbidity
		Sea surface temperature

Source: AMLR NRM Board Monitoring, Evaluation and Reporting Framework 2008 (AMLR NRM Board 2008b)

7.3.2 ACWQIP monitoring and assessment framework

The EPA commissioned an assessment on ACWQIP monitoring requirements and the report is included as Report 5 of the supporting technical reports on the EPA website. The ACWQIP sets long-term targets for the improvement of water quality (specifically total nitrogen, total suspended solids and CDOM) for the Adelaide metropolitan coast. To assess progress towards these targets, developing a monitoring and assessment framework is a necessary step to ensure management interventions are leading to outcomes that are in line with the goals of the ACWQIP.

Some monitoring already occurs to assess the quality of Adelaide's coastal waters, its ecosystem and sediments. While this work is undertaken by different agencies in response to their different needs, it is certainly the case that most agencies undertaking monitoring need to understand key information and much of this information is the same as that required to assess the effectiveness of the ACWQIP. It is not surprising that these monitoring programs have generally developed from individual needs and could provide much of the information needed to assess the effectiveness of the implementation of the ACWQIP.

The approach to developing the monitoring and modelling plan for the ACWQIP has included assessment of the need to implement the ACWQIP and ensure that the recommendations of the ACWS are implemented; review of the ACWS Technical Report 19 covering the background of what would be needed for an integrated monitoring program for Adelaide's coastal waters; and preparation of a list of current monitoring undertaken. The approach has also aimed to ensure good communication across all agencies responsible for monitoring and getting feedback on priorities, capabilities and methodologies.

Use will be made of existing monitoring efforts undertaken by the EPA and others. Where further monitoring is needed, the aim will be to ensure that the work is undertaken by the agency best placed to undertake the monitoring in the most efficient manner.

It should be understood that monitoring can be expensive and monitoring programs can use a significant proportion of available resources. However, by using monitoring and modelling effectively to better focus management actions, a well-integrated monitoring program will save money. As part of an adaptive management approach to the implementation of the ACWQIP the long-term targets and monitoring will be regularly reviewed and reassessed in terms of outcomes being achieved and value for money from management actions. Monitoring actions can then be modified as water quality improvement management strategies are successfully implemented.

As part of the assessment of monitoring requirements, a stakeholder consultation workshop (refer to Report 5 of the supporting technical reports on the EPA website) was held to confirm the nature (indicators, frequency, and spatial distribution) of current and proposed sampling in the region. The comparison of current and proposed monitoring revealed several significant gaps in the sampling programs with regards to their capacity to fully inform the progress of the ACWQIP.

In terms of the indicators considered as critical to inform the progress towards the targets of the ACWQIP, the condensed list is simply:

- input water quality to the coast including stormwater, wastewater, industrial, groundwater and atmospheric inputs
- coastal water quality
- sediment stability
- ecosystem health
- physical processes (tides, wind, currents).

The monitoring and assessment framework report (refer to Report 5 of the supporting technical reports on the EPA website) recommends that the EPA take responsibility for coordinating and reporting on coastal water quality monitoring for the initial period of the implementation of the ACWQIP.

The EPA licenses the significant wastewater treatment and industrial discharges being delivered to the Adelaide coastal waters and monitoring of these discharges is covered under EPA licence conditions for SA Water and Penrice Soda Holdings. However, it is recommended that simple changes are made to these licence arrangements, so that 'end-of-pipe' monitoring reports pollutant loads, rather than concentrations. SA Water currently undertakes some receiving waters monitoring near its discharges. It keeps these monitoring plans under regular review and is likely to change their monitoring approach in future in line with the findings of the ACWS. Future monitoring of the effects of their discharges on receiving waters may inform progress towards the targets of the ACWQIP. A recommended replacement for receiving waters sampling is a monitoring program designed to determine and track changes to the 'sphere of influence' of wastewater using stable nitrogen isotope signatures in seagrass meadows.

The ACWQIP monitoring and assessment framework also recommends the following:

- Given that groundwater discharge to coastal systems is considered to be low, there is arguably little need for targeted monitoring with respect to the ACWQIP. Groundwater input monitoring undertaken by the AMLR NRM MERF and licensing of aquifer recharge projects should provide a suitable level of information for informing the ACWQIP.
- Atmospheric inputs (especially particulate matter dry fall) need to be estimated based on a modified sampling program already undertaken by the EPA.

The EPA has taken account of the ACWQIP monitoring and assessment framework in a comprehensive review of its ambient marine and coastal monitoring program. The program, which has received formal scientific review enables the EPA to better evaluate water quality from an ecosystem-based approach.

For monitoring by the Coast Protection Branch, there are only minor recommended changes to the existing sediment stability and sediment profiling sampling with the suggestion of having a number of additional indicators to ensure that the existing program can better inform the ACWQIP.

Historically, ecosystem health condition parameters have not been quantified in a way that can reasonably inform progress on the ACWQIP targets. The measures that need to be developed include many of those previously identified during the ACWS. These revised sampling programs need to be implemented so as to provide relevant information to the monitoring of the progress against the ACWS recommendations and ACWQIP targets, especially with reference to seagrass and reef condition throughout the region. These could be based on some existing programs (with modifications) such as Reef Health.

- The workshop attendees generally agreed that further expensive ongoing monitoring of physical processes in the region could be discontinued in the context of a properly focused monitoring plan being implemented. Establishing monitoring governance with relevant scientific experience was identified as a way of ensuring integration of monitoring effort and developing a multi-agency funding bid for further monitoring and modelling for Adelaide's coastal waters.
- There is a need to develop a seagrass health assessment framework that integrates the range of sampling tools identified by Henderson *et al* (2006) within a mutually supportive arrangement for spatial and temporal monitoring.

The targeting of observations to areas of particular concern needs to be established, which may include proximity to inputs as well as results of stable nitrogen isotope studies.

The ACWQIP monitoring and assessment framework highlights that the mechanism for sampling the health of reef systems needs to be identified in a similar fashion to that established for seagrass health. Sampling should follow the methodology and locations employed in earlier reef health assessments (Turner *et al* 2007). However, the indices used to assess reef status need to be confirmed. While some existing indices are going to remain relevant, other indices along the lines of those identified in Turner *et al* (2007) should be considered. Both seagrass and reef health assessments also need to be referenced against appropriate control locations. This suggestion is being taken into account in the review of EPA marine monitoring which is more focused on monitoring of ecosystem condition.

The workshop also highlighted the need to determine an appropriate proxy measurement for CDOM and determine what should constitute environmental flows from rivers, creek and streams in the Adelaide region.

Sediment stability investigations are recommended for sediment grain size, cliff stability and high-risk areas. The latter could potentially link to coastal water quality sampling, in particular event-based observations as well as telemetry. However, whilst it would assist in filling in gaps around issues that relate to integrating catchment and coastal system modelling, substantial funding would be required for this work to be undertaken.

The validity of employing commercial and recreational fisheries stock assessment data as another mechanism for ecosystem health assessment should also be investigated.

The availability of data and outputs from various mass balance water flow models for the Adelaide metropolitan coast as well as the Port waterways, particularly for projections relative to changes in management activity, should be examined with a view to determining their use in supporting ACWQIP objectives.

The principle outcome from the ACWQIP monitoring and assessment framework work is that a set of monitoring indices have been clearly identified and agreed to by relevant stakeholders and the responsibility for the monitoring of specific indicators has now been documented. The ACWQIP monitoring and assessment framework also fits well with the MERF implemented by AMLR NRM Board.

7.4 Climate change and population growth impacts on coastal water quality

The EPA commissioned a review of the implications of future population growth and climate change to give an insight into how they may impact upon water quality within the Adelaide coastal waters. The aim of the work was not to consider how climate change may alter physical drivers of coastal processes such as sea level, patterns of storms and rainfall events. The full report for this investigation is included as Report 6 of the supporting technical reports on the EPA website.

While it is not possible to explicitly predict the nature and impact of either population or climate change, a broad understanding of potential changes and achieving the targets of the ACWQIP can be developed. Such understanding is important to allow flexibility in planning and policy development to ensure that management objectives are realistic and achievable.

Likely scenarios for both climate change and population growth in the Adelaide region were derived from the DPLG forecasts that have originated from CSIRO published studies and Australian Bureau of Statistics (ABS) data. This information is used to develop a simple matrix of potential interactions for climate change and population growth based on several sets of scenarios: for low and high climate change, and low, medium and high population growth by the year 2030. This time step was chosen as it is a point at which there are reasonable predictions available for both population and climate change and it is within a timeframe relevant to the development and management of policies to protect and enhance environmental values, such as the ACWQIP.

While population growth has been included in ACWQIP targets for nitrogen reduction (Table 8), the information available, and the level of understanding of the likely effects of climate change were not sufficient to provide useful information with respect to other key pollutants. This, along with an understanding of the physical processes likely to ensue from climate change are the aim of proposed Strategy 5 of the ACWQIP.

7.5 Other threats to coastal and marine ecosystems

Awareness and management of other threats to coastal, estuarine and marine ecosystems apart from water quality decline are managed through a number of other government agencies and groups including DENR, DPLG, PIRSA, AMRL NRM Board, DTEI and Conservation Council of SA. However, much of the recent research, awareness and work on the threats to coastal, estuarine and marine ecosystems have been undertaken primarily through the AMLR NRM Board and DENR coast and marine programs covering marine parks, marine planning and the promotion of the conservation and management of estuaries. Examples of the range of coastal, estuarine and marine threats applicable to Adelaide's coastal waters and Gulf St Vincent include:

- issues relating to the management of competing uses and activities
- the impacts of climate change and sea-level rise on coastal, estuarine and marine habitats
- ongoing management of the impacts of historic and current development along the coastline
- management of coastal and marine pest plants and animals.
- emergency spill management.

8 Investigating market based instruments for stormwater

In the development of the ACWQIP the EPA engaged BDA Group and Econsearch to investigate potential market based instruments (MBIs) to minimise the effect of stormwater on Adelaide's coastal water quality). While the primary purpose of this work was considered to be improved water quality, the interactions between water quality and quantity were also considered. The report was provided to the EPA as a consultancy report from the BDA Group in early 2009.

Methods for improving the quality or reducing volumes of stormwater discharged were considered, along with information on the costs and effectiveness of those measures. Methods include common structural controls such as stormwater retention and use, infiltration systems, conveyance systems, detention and pollution control. The report also briefly discussed key issues relevant to retrofitting existing urban areas.

MBIs used within and outside Australia to improve water quality were reviewed, as well as market based approaches used for other objectives that may have relevance for stormwater management. Applications designed specifically to address stormwater runoff and pollution were also highlighted.

The objectives of a stormwater MBI for Adelaide's coastal waters were stated and the suitability of MBIs to the stormwater pollution problem assessed. The relative merits of different types of MBIs that could be used to manage stormwater in the context of Adelaide's coastal waters were discussed.

This preliminary assessment suggested that the following types of MBIs would be most suited to improving stormwater quality and reducing impacts on Adelaide's coastal waters:

- stormwater quality charges
- subsidy program by competitive tender
- stormwater offset contribution scheme.

A review of conceptual framework and key design features for each of the shortlisted MBIs was outlined, along with the current legislative and institutional arrangements and policy settings relevant to the management of stormwater in SA.

However, despite further work with stakeholders indicating that there is interest in the concept of MBIs for improving water quality for Adelaide's coastal waters, further feasibility work is required to provide detail of how each of the potential systems may work for the Adelaide region. Further work in this area would also need to consider the context of considerable current work being undertaken to capture and use stormwater using systems at a scale driven by local government. So in summary, more investigations on the practicality and suitability of MBIs for the Adelaide context is required and, at this stage, there is no intention in the immediate future to implement MBIs across the Adelaide region for the purpose of improving coastal water quality.

9 Capacity to implement the ACWQIP

The statutory capacity of relevant agencies to implement the ACWQIP has been considered (Report 7 in the EPA website), including the legislative framework for managing activities that can affect the water quality of the Adelaide coast.

Legislation covers many aspects of businesses and individuals who interact with Adelaide's coast. Most of this has little or no direct bearing on Adelaide's water quality or related management and an exhaustive list is not provided. All South Australian legislation can be accessed at <www.legislation.sa.gov.au/index.aspx>.

The following legislation has aims consistent with the outcomes sought for Adelaide's coastal waters:

- Environment Protection Act 1993
- Development Act 1993
- Natural Resources Management Act 2004
- Adelaide Dolphin Sanctuary Act 2005
- Local Government Act 1999
- Coast Protection Act
- Stormwater Management Act.
- Protection of Marine Waters (Prevention of Pollution from Ships) Act 1987

These acts are listed with their full titles, objects and a summary of their statutory capacities with respect to the ACWQIP in Report 7 of the supporting technical reports on the EPA website.

The effective management of activities to enable the recommendations of the ACWS to be achieved is within the scope of existing legislation. Changes to relevant Schedules and Tables of the Environment (Water Quality) Policy 2003 where the EVs and WQOs developed for the ACWQIP are used to provide more focused targets will enhance the effectiveness of the Environment Protection Act 1993.

10 Reasonable Assurance Statement for the ACWQIP

The Reasonable Assurance Statement (RAS), referred to in Report 8 on the EPA website, seeks to provide stakeholders with a high degree of confidence that, if the ACWQIP is implemented, aiming for the ACWS nutrient and sediment load reduction targets, the water quality of Adelaide's coastal waters will improve and the likelihood of seagrass loss being halted and future seagrass return will be greater. This information is important to ensure that those investing resources in the implementation of the ACWQIP (such as state and Australian governments and businesses) can be confident of outcomes.

The RAS considers how certain we are about:

- our knowledge of the response of the system to pollutant loads
- the effectiveness of proposed interventions to achieve load reductions
- the adoption of proposed interventions, in terms of timing and extent. To account for uncertainty in the spirit of the precautionary principle this may require high levels of adoption of key interventions.

All key stakeholders accept that they need to manage Adelaide's coastal water quality in line with the recommendations of the ACWS and this provides a good level of confidence that the effective interventions will be developed and adopted to provide the necessary level of water quality improvement.

There is a high degree of confidence in the ability of the major dischargers—Penrice Soda Products and SA Water to reduce nitrogen loads in the medium to longer term, and that these reductions will allow for water quality conditions where seagrass can be protected and recover.

The outlook for suspended solids and other stormwater sourced inputs is less clear, mainly because there are multiple drivers for change in place, and it is more difficult to measure progress. While improvements in these may take longer, initial work is likely to lead to improved amenity of Adelaide's coastal waters. The energetics of the nearshore, likely to inhibit regrowth of seagrass, means that recovery of seagrass in this area will be long-term—consistent with the long-term nature of likely improvements in total suspended solids and coloured dissolved organic matter loads.

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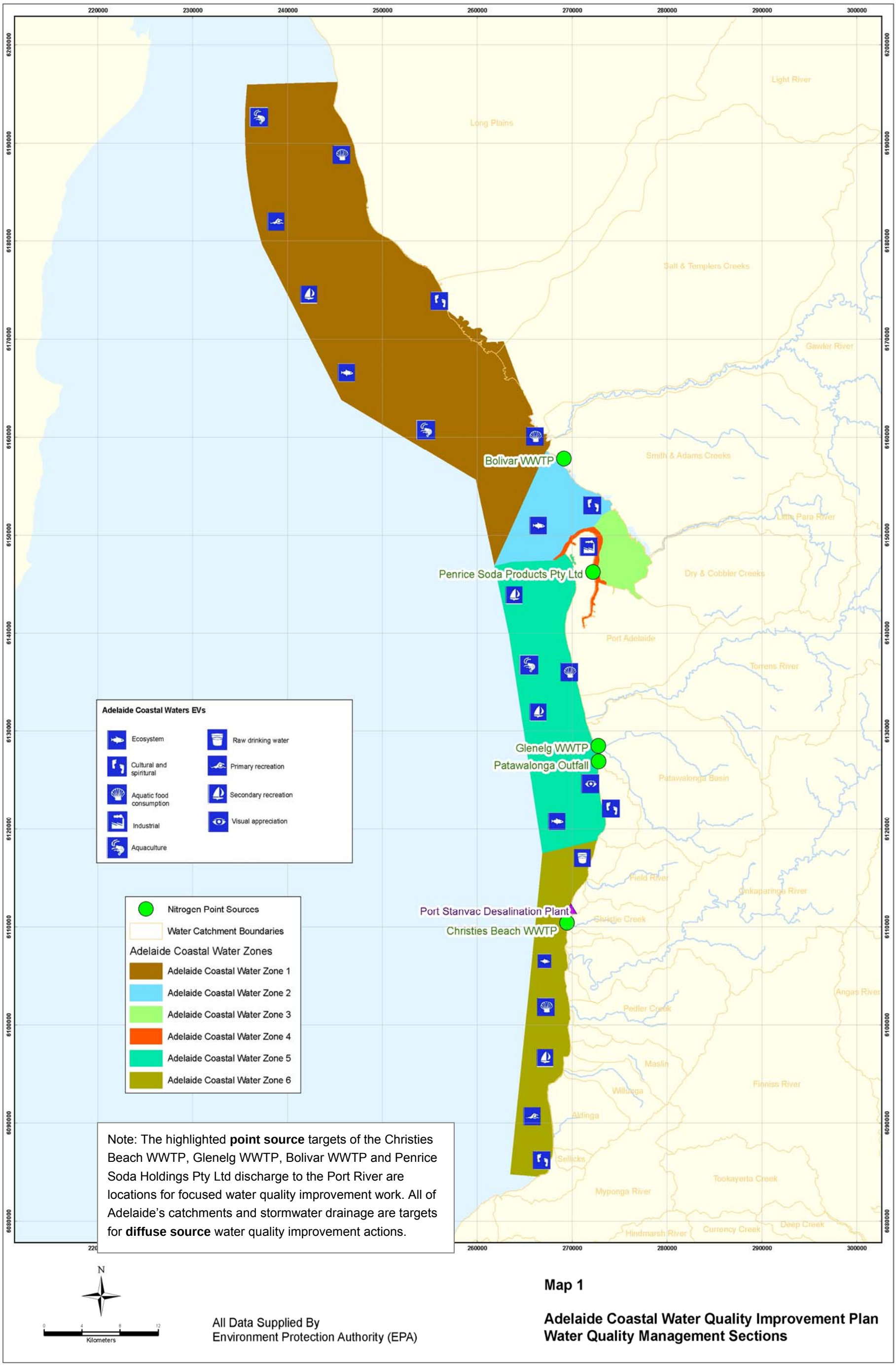
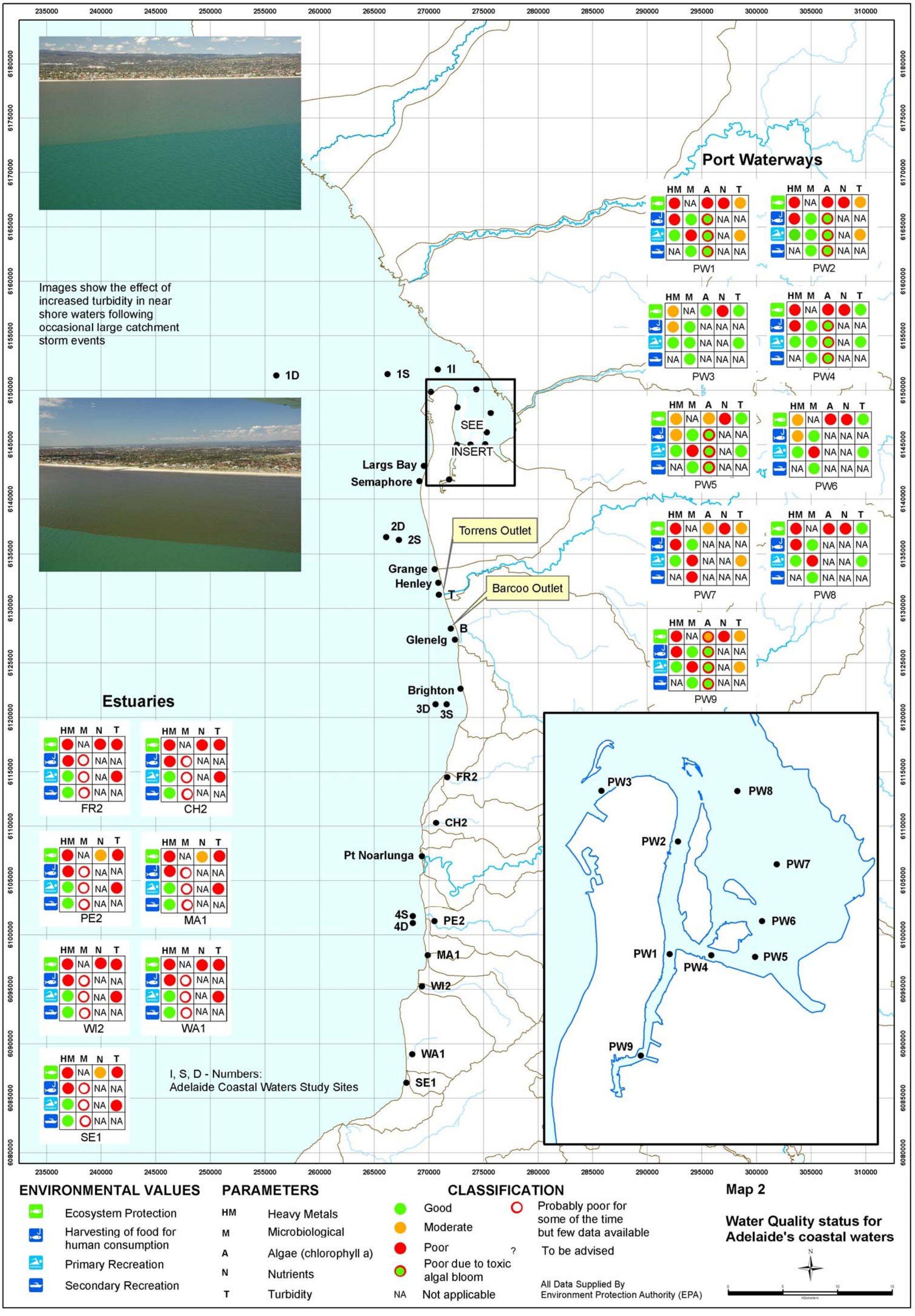
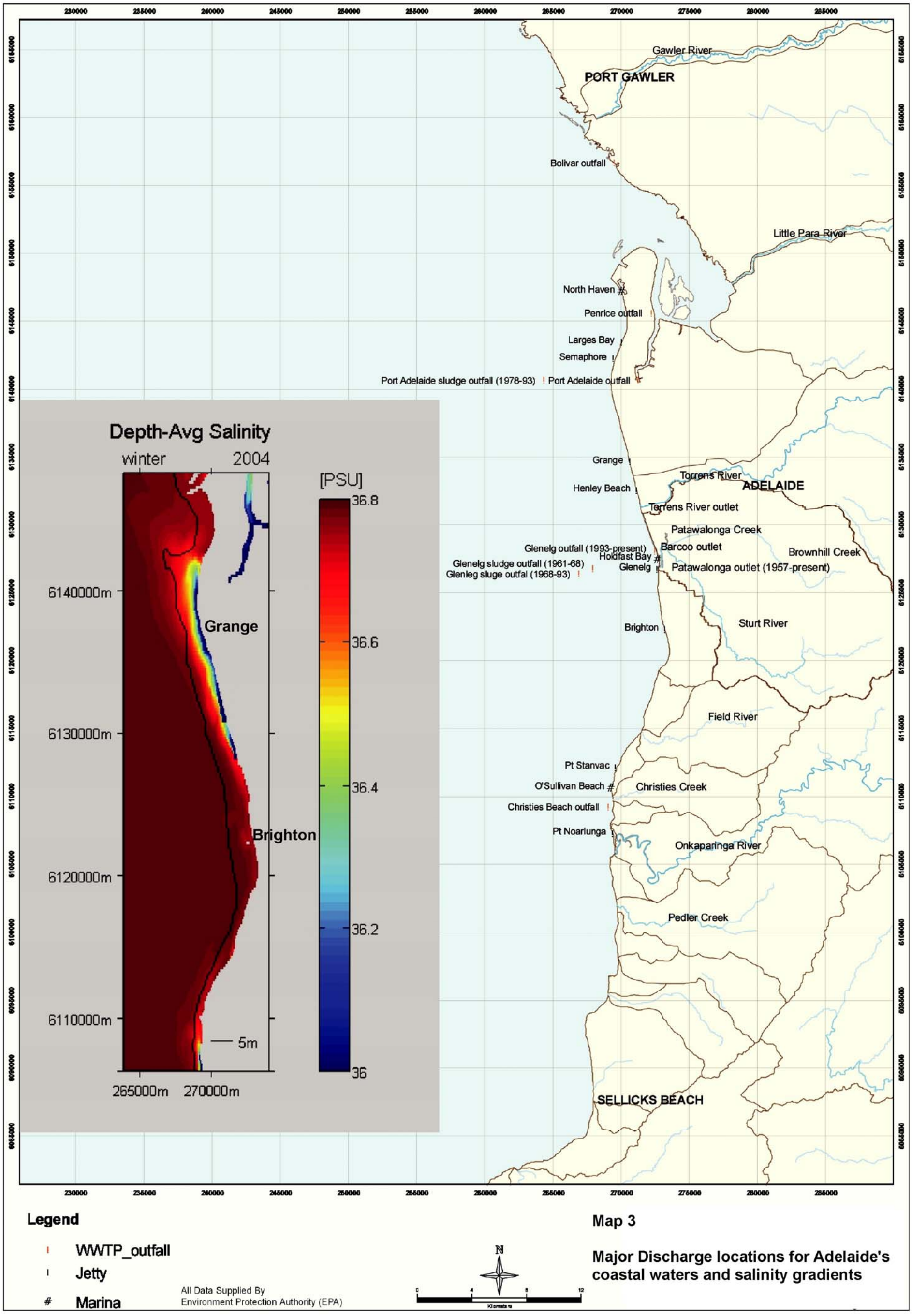


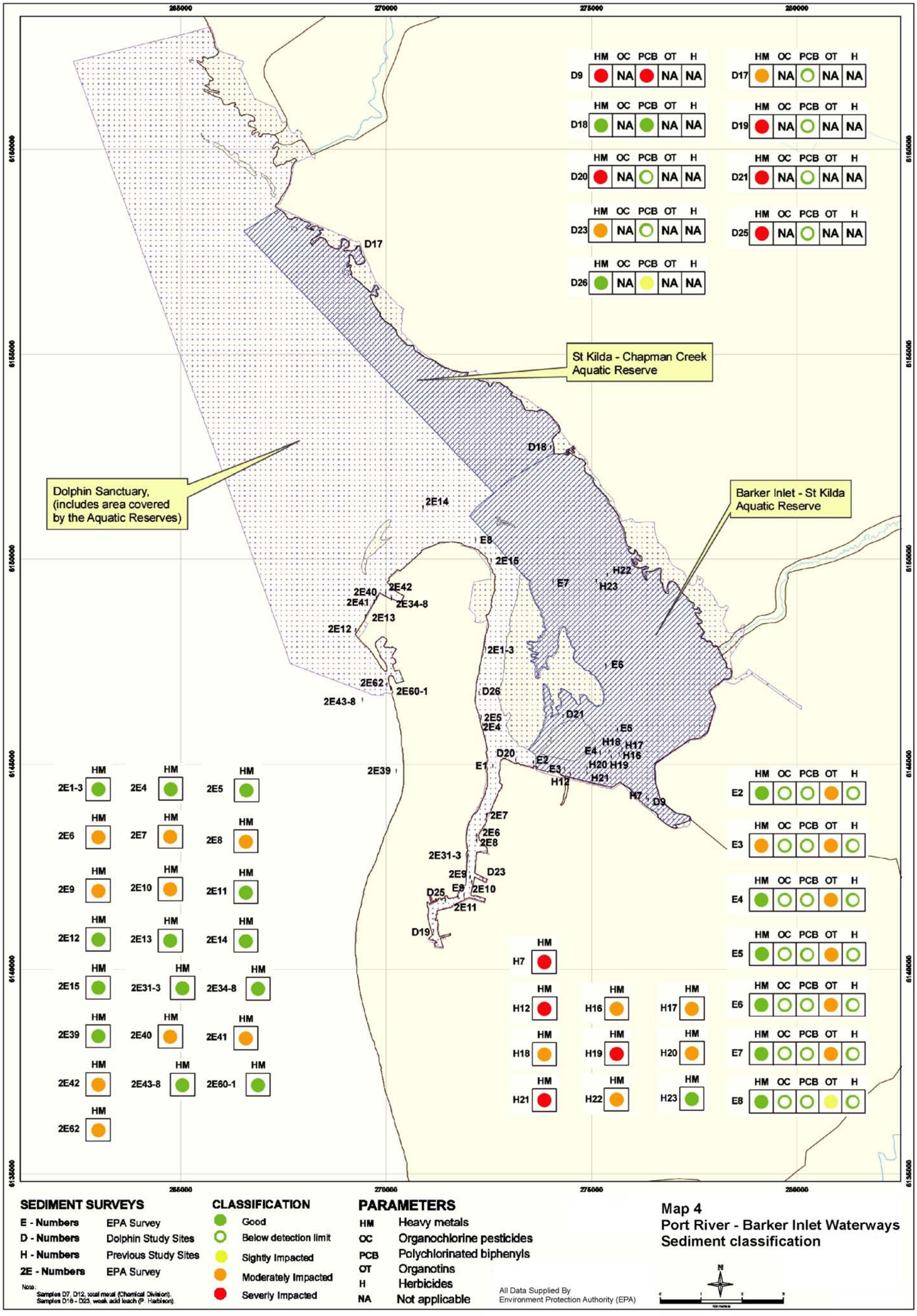
Map 1 Adelaide Coastal Water Quality Improvement Plan water quality management sections



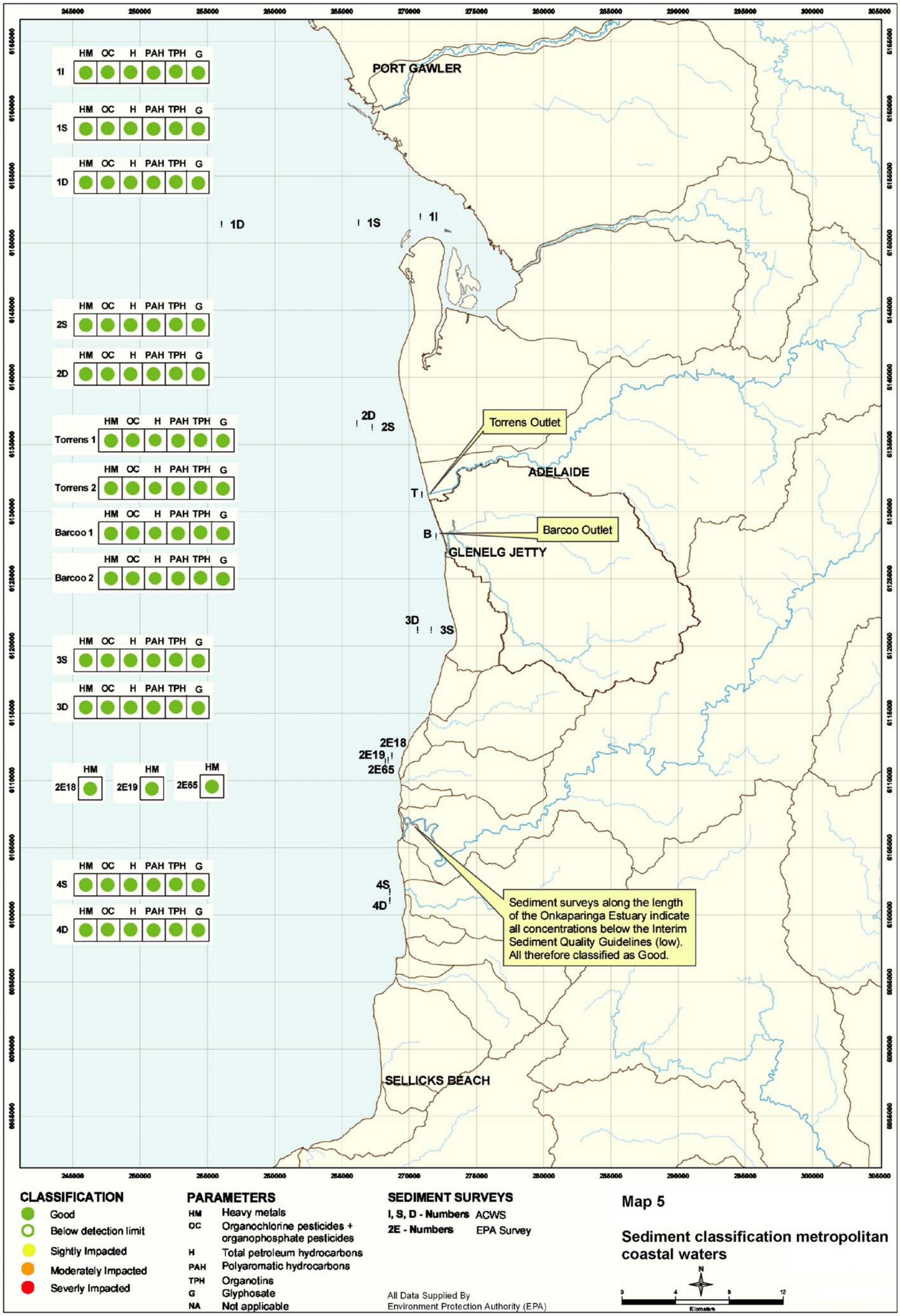
Map 2 Water quality status for Adelaide's coastal waters



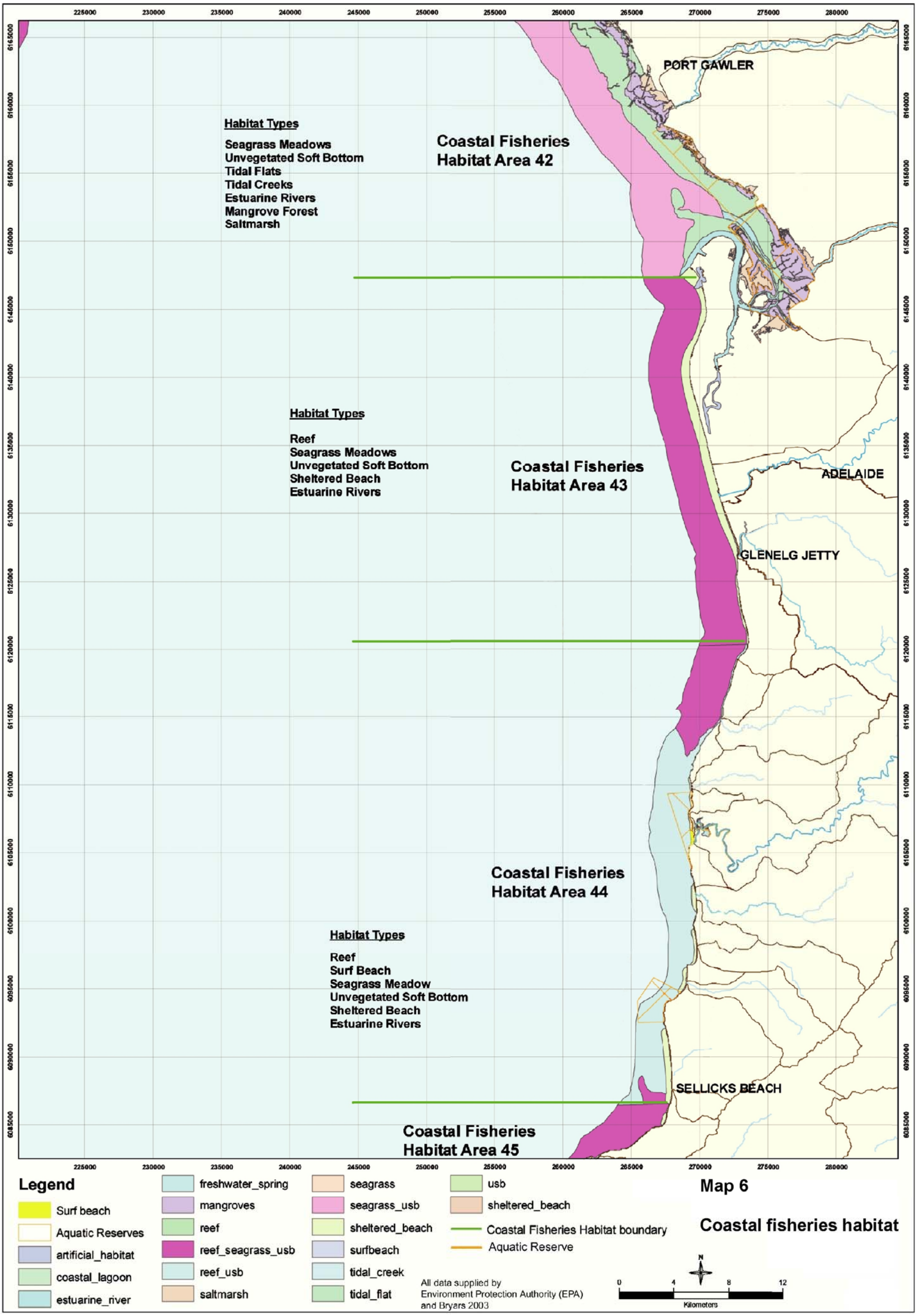
Map 3 Major discharge locations for Adelaide's coastal waters and salinity gradients



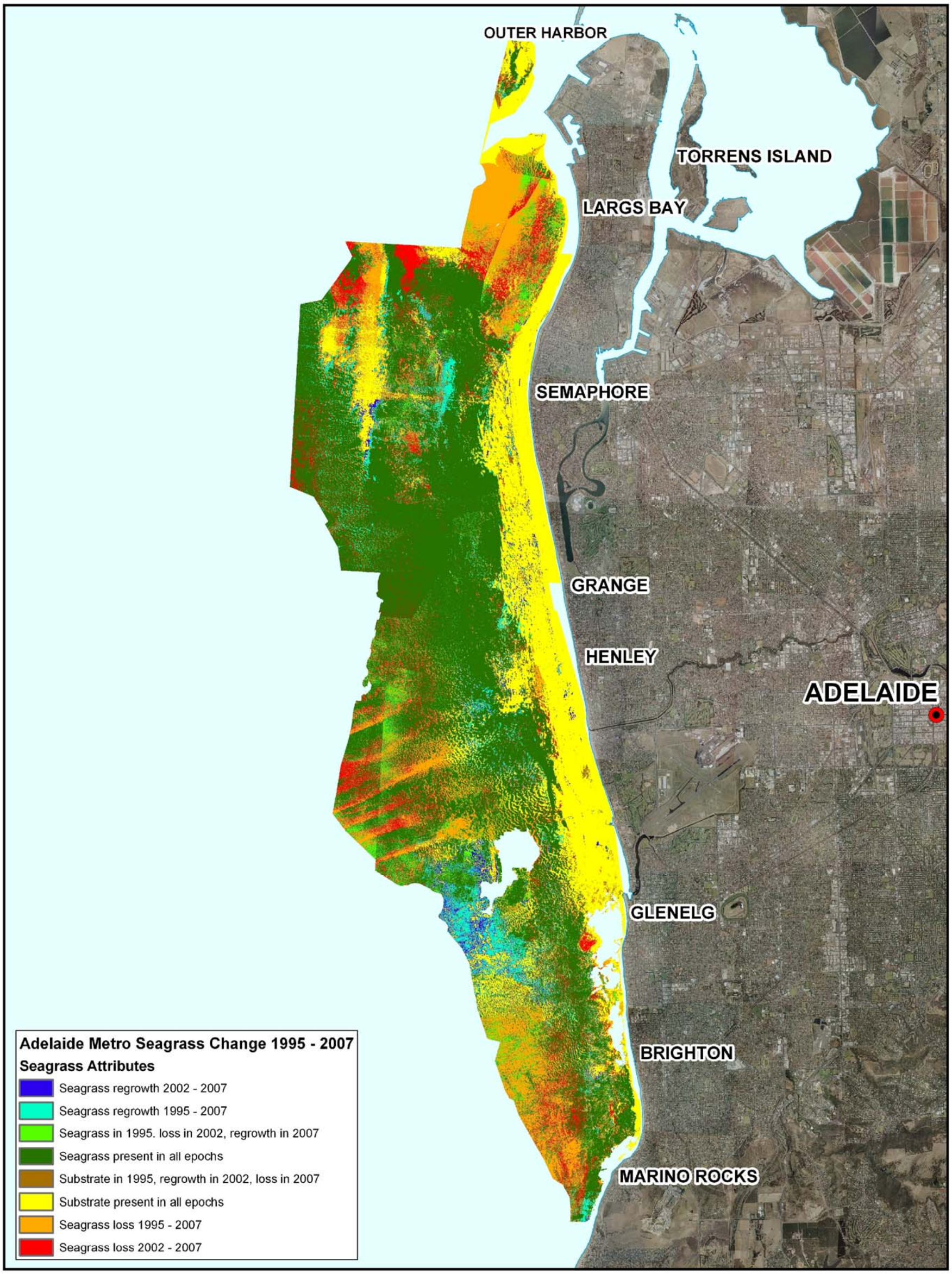
Map 4 Port River–Barker Inlet waterways sediment classification



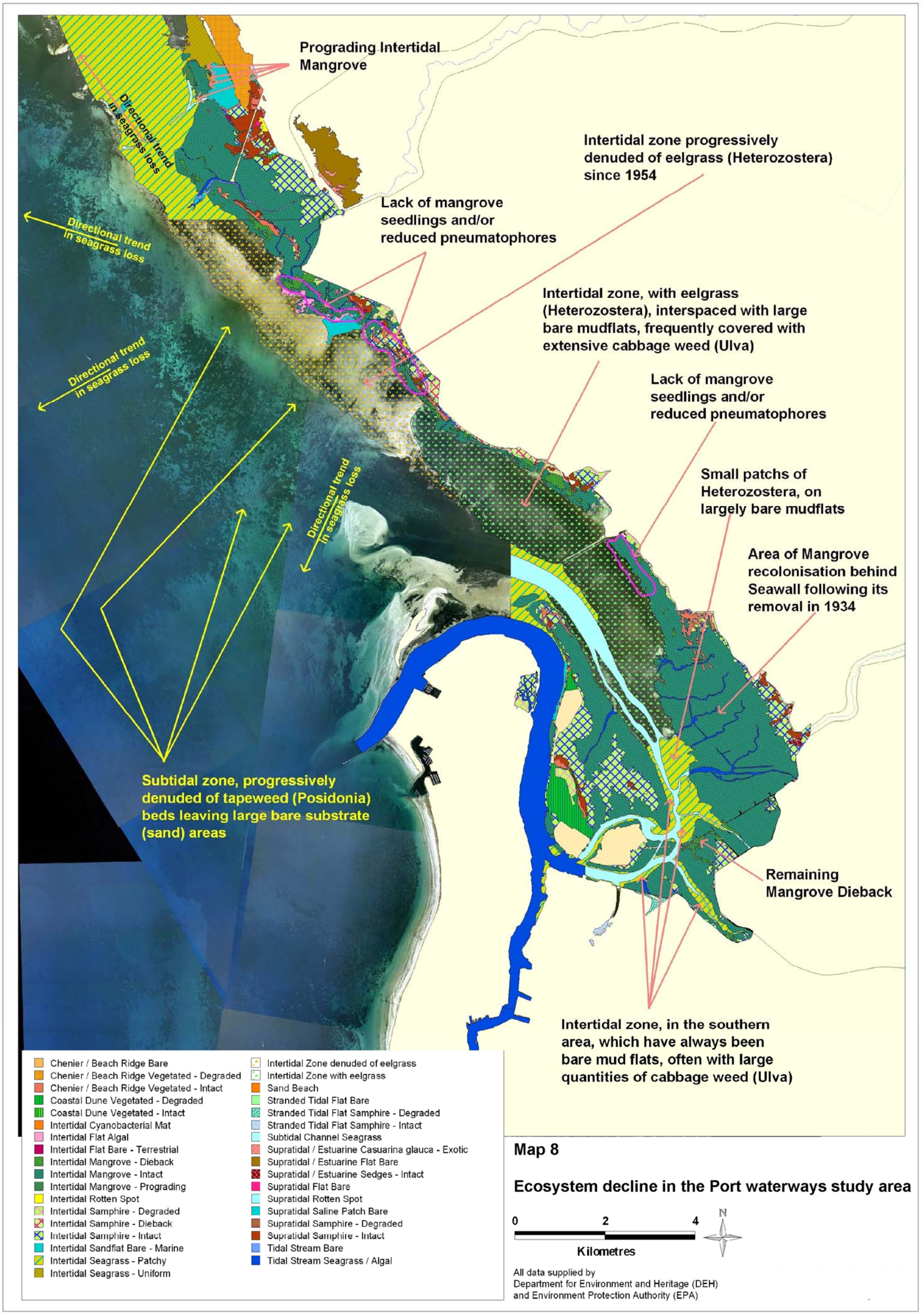
Map 5 Sediment classification metropolitan coastal waters



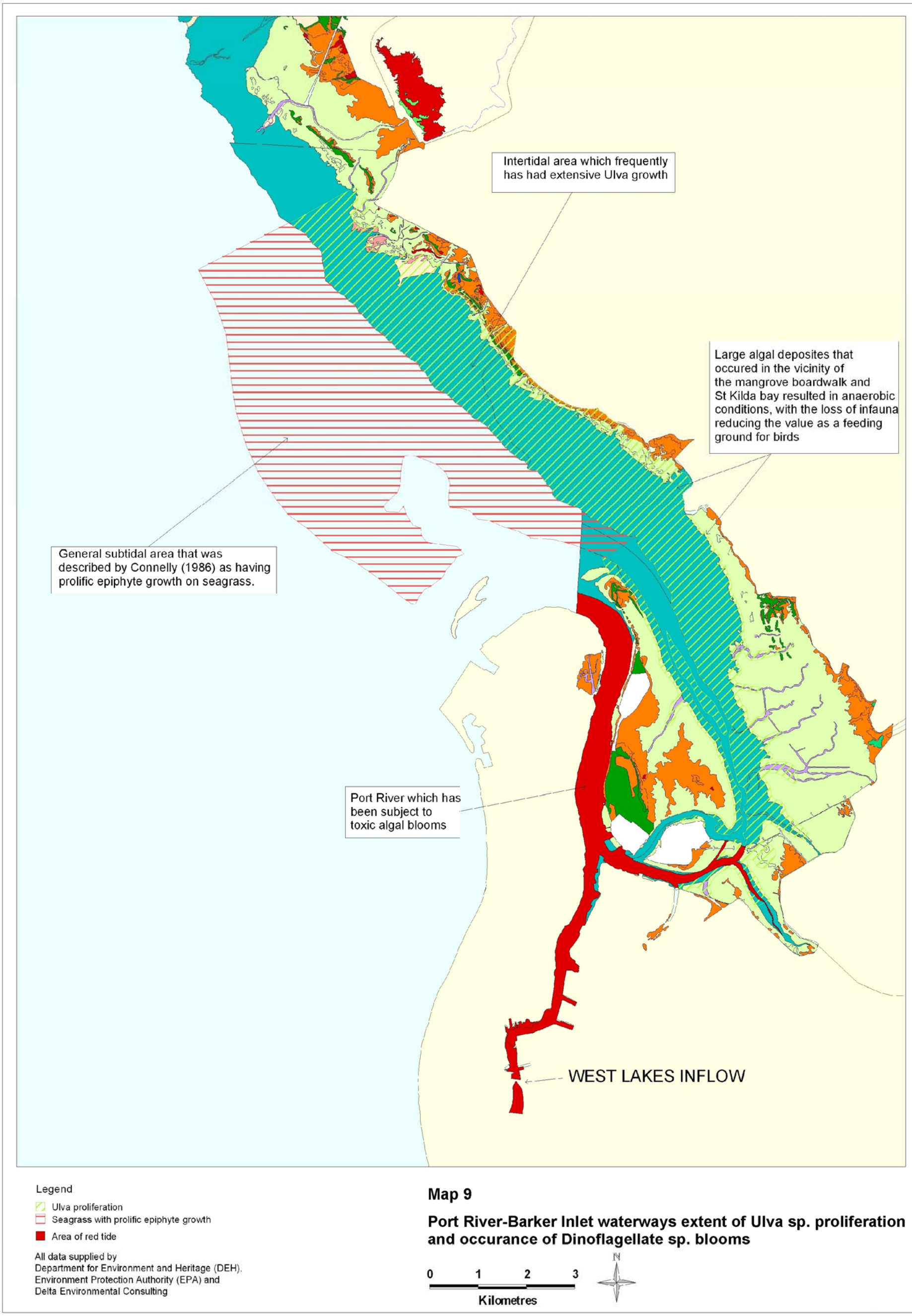
Map 6 Coastal fisheries habitats



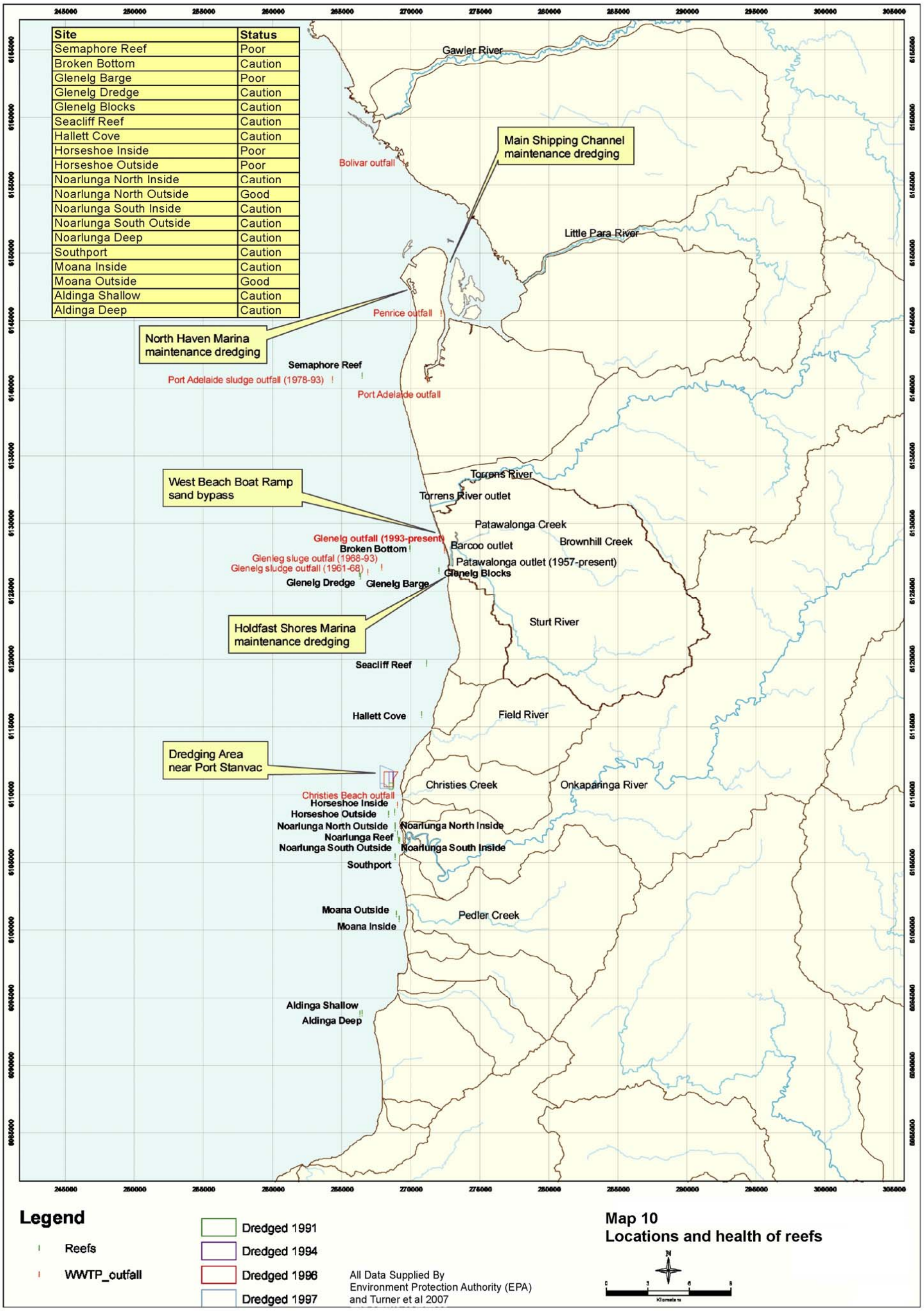
Map 7 Map of Adelaide showing seagrass change 1995–2007



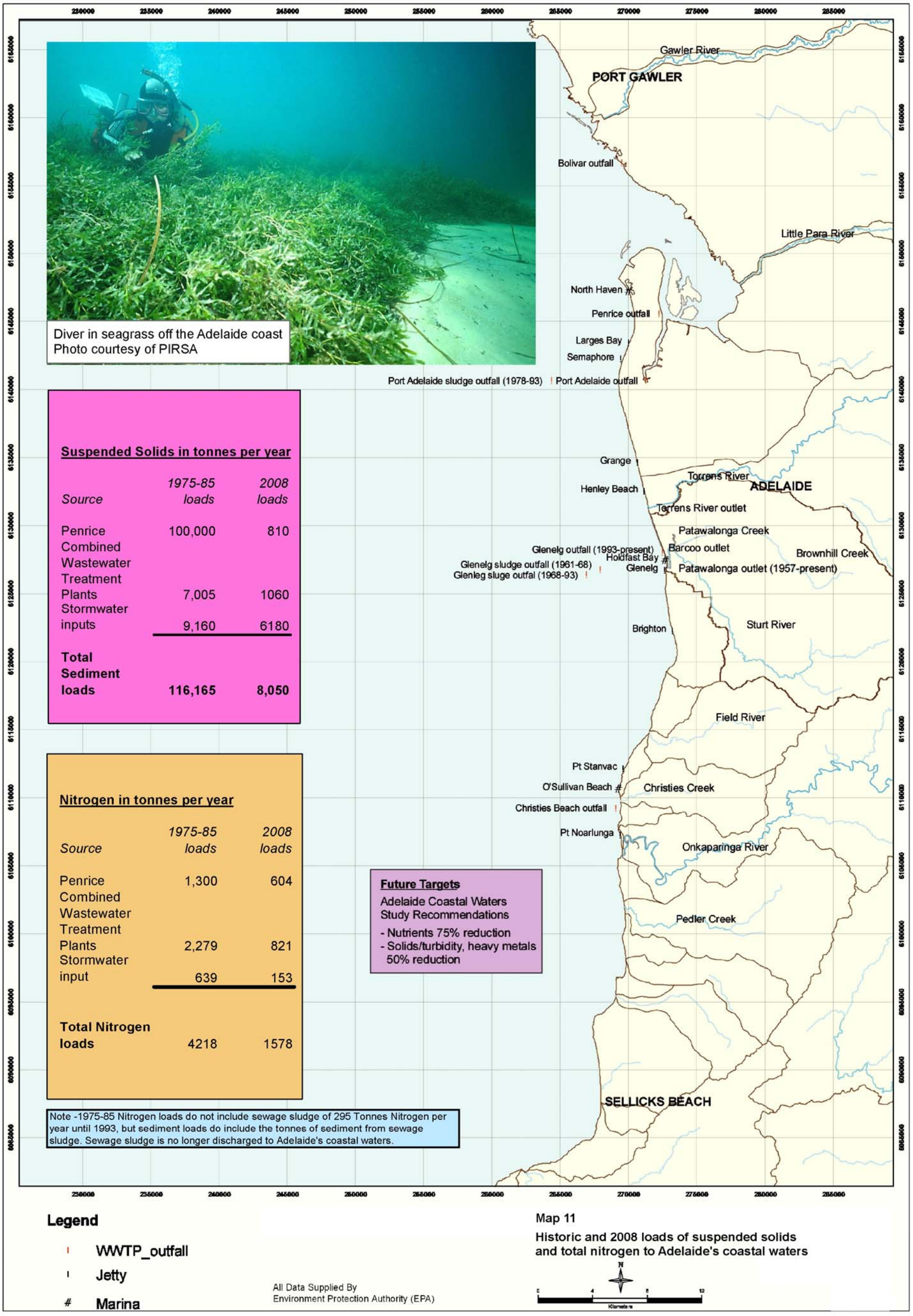
Map 8 Ecosystem decline in the Port waterways study area



Map 9 **Port River–Barker Inlet waterways extent of *Ulva* sp. proliferation and occurrence of *Dinoflagellate* sp. blooms**



Map 10 Locations and health of reefs



Map 11 **Annual loads for suspended solids, total nitrogen and metal**