Report to

Environment Protection Authority
Government of South Australia

Tradeable Discharge Rights to Reduce Nutrient Pollution in the Port Waterways Catchment

Final Report

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BDA Group
Economics and Environment

econsearch

MELBOURNE
PO Box 6009
Hawthorn West, VIC 3122
Ph 041 268 7712
Fax (03) 9852 8969

CANBERRA
PO Box 4022
Manuka ACT 2603
Ph (02) 6282 1443
Fax (02) 6161 9310

EXECUTIVE SUMMARY

The South Australian Government is seeking to develop a market instrument to better achieve water quality goals in the Port River and Barker Inlet waterways. The South Australian Environment Protection Authority commissioned BDA Group, with assistance from EconSearch, to undertake a study into tradeable nutrient discharge rights for the Port Waterways.

The study was undertaken in three parts. Part 1 was an investigation of the suitability of tradeable nutrient discharge right approaches to the management of nutrient pollution in the Port Waterways catchment. Part 2 involved the investigation and assessment of instrument options, and recommendations for the most suitable instrument. In Part 3 of the study, the policy framework, principles and key design parameters for the recommended instrument were developed.

The most significant contributors to nutrient loads in the Port Waterways are two major point sources: the Penrice soda plant and the Bolivar wastewater treatment plant. A range of diffuse sources make a much smaller contribution. There are also a number of confirmed and possible sources of nutrients for which there is uncertainty around their impact and likely contribution to nutrient loads.

Most pollution trading schemes focus on achieving a reduction in total pollutant load as a proxy for environmental outcomes. In the Port Waterways situation there are multiple environmental outcomes being sought through the reduction of nutrients: addressing mangrove decline, seagrass loss and algal blooms. The impact of different nutrient sources on these outcomes is thought to vary substantially and significant uncertainty exists over relationships between the nutrient sources and individual environmental outcomes. Expert advice suggests that the Bolivar WWTP has the greatest impact per kilogram of nutrient for most environmental issues.

For phosphorus, Bolivar is the only significant point source. The diffuse source contribution in load terms is small, and considering its relative environmental impact is insignificant compared to the point sources. A tradeable rights instrument therefore offers no gains over existing regulatory tools. The study therefore focused on assessing trading options to reduce nitrogen.

The assessment compared the likely outcomes of using different trading approaches to meet a nitrogen reduction target of 50% of current loads by the year 2010/11. The following three options were assessed: a bubble trading scheme (allowing trade between the two major point sources to meet new targets), negotiated licensing offsets (that allow the two major point sources to trade with each other or any other source to meet new targets under the existing licensing system) and a formal offset trading scheme (establishing a total allowable level of nitrogen discharges to the Port Waterways and allocating rights). The criteria used to assess the options included efficiency, compliance flexibility, administrative simplicity and stakeholder acceptance.

Compared to the option of a regulatory approach via mandated nitrogen reductions for each licensee, a trading instrument is likely to provide some cost savings. However, the analysis found

that in certain circumstances the gains from trade may be modest. This suggests a scheme with small set up costs is appropriate. Given the small number of sources likely to be involved in trading, the administrative costs of a formal offset scheme are likely to outweigh the benefits. Negotiated licensing offsets can provide most of the gains of a formal offset scheme without the extra setup costs or ongoing complexity in administration.

Negotiated licensing offsets is considered more suitable than a bubble trading scheme as it provides more compliance flexibility and has the potential to achieve the nutrient target more efficiently. Given there are uncertainties about nutrient loads and the opportunities to reduce nutrients from a range of uncertain sources, it is considered worthwhile providing the extra flexibility offered by negotiated offsets to licensees.

By signalling the potential for offsets beyond the two key point sources, the EPA will foster a cultural change to seeking cost-effective environmental gains wherever they may lie. This will harness the business acumen of both SA Water and Penrice towards investigating innovative low-cost offset opportunities. This may for example, lead to the identification and realisation of a diffuse or uncertain nitrogen reduction source that the EPA alone may find difficult to achieve.

One of the key reasons for pursuing a tradeable discharge rights approach is that the market works out the best way to meet the target. This saves government trying to estimate the cost structures of the key players. While there are significant uncertainties relating to costs, this is a good reason to embrace a trading approach. In terms of compliance costs, there is no downside from introducing a trading approach. However, there can be a downside for the environment, with a potential to undershoot on the environmental outcome. The science underpinning any scheme is therefore very important.

Negotiated licensing offsets would involve setting new individual nutrient reduction targets for Bolivar and Penrice and at the same time establishing a new provision under the licensing scheme to allow any licensee to negotiate offsets at other point or diffuse sources to meet new nutrient reduction targets. The report outlines a policy framework and set of principles recommended for using negotiated licensing offsets to reduce nitrogen in the Port Waterways. It also provides guidance for the development of offset terms and conditions.

The EPA is currently undertaking water quality modelling and developing a Water Quality Improvement Plan for the Port Adelaide's waterways. The overall nutrient reduction target for the Port Waterways will determine the obligations of the major point sources in meeting the objectives of the Plan. Negotiated licensing offsets will ensure that these obligations can be achieved at least cost, providing flexibility to licensees, with relatively small administrative costs for the EPA. The water quality modelling work and community consultation process will improve the EPA's understanding of the environmental impacts of different nutrient sources and the relative importance of the environmental issues in the waterways. This information can be used to refine the settings of the proposed negotiated licensing offsets scheme.

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1 INTRODUCTION

The South Australian Government is seeking to develop a market instrument to better achieve water quality goals in the Port River and Barker Inlet waterways. Market instruments are policy mechanisms that provide monetary incentives to reduce pollution. Under certain circumstances, they may deliver outcomes faster and at lower cost than more prescriptive measures.

The South Australian Environment Protection Authority (EPA) commissioned BDA Group, with assistance from EconSearch, to undertake a study into tradeable nutrient discharge rights for the Port Waterways. The study was undertaken in three parts. Part 1 was an investigation of the suitability of tradeable nutrient discharge right approaches to the management of nutrient pollution from the Port Waterways catchment. Part 2 involved the investigation of instrument design options, assessment of those options and recommendations for the most suitable instrument. In Part 3 of the study, the policy framework, principles and key design parameters for the proposed instrument were developed.

This report combines the findings of all three parts of the study. Section 2 examines the concepts behind tradeable discharge rights and Australian and international experience in using tradeable discharge rights. Section 3 outlines the Port Waterways nutrient problem including the environmental context and contributors to the problem. Section 4 assesses the suitability of tradeable discharge rights for the nutrient problem in the Port Waterways. Section 5 identifies a set of policy options, provides a comparative assessment of those options and recommends negotiated licensing offsets as an appropriate tool to address the problem. Section 6 outlines a policy framework and set of principles for implementing negotiated licensing offsets. Section 7 outlines the proposed process for negotiated licensing offsets. Section 8 provides guidance for developing offset terms and conditions and Section 9 discusses some implementation issues.

Important contributions have been made to the study by the EPA, Eco Management Services who led the development of the draft Water Quality Improvement Plan (WQIP) and a number of stakeholders consulted through the course of the study. The goals of the WQIP may change as the Plan is finalised and over time new information is likely on the relationships between nutrient discharges and environmental issues, as well as the extent and cost of various nutrient reduction initiatives. However, the recommended instrument provides adequate flexibility to accommodate these and continue to promote a cost-effective nutrient management policy tool.

2 CONCEPTS AND EXPERIENCE WITH TRADEABLE DISCHARGE RIGHTS

This section discusses the use of market-based instruments (MBIs) as policy tools, alternative design approaches for tradeable rights schemes, and experience with tradeable rights schemes.

2.1 Market instruments as policy tools

Market instruments are policy tools that encourage behaviour through market signals rather than through explicit directives. In this way, governments do not require detailed information on who is best placed to make changes and how, rather this information can be 'revealed' by the market.

There is growing interest in market instruments as they can often deliver equivalent outcomes to prescriptive regulatory approaches at lower cost by allowing firms the flexibility to decide on whether to change their actions or incur higher costs. In this way, those firms who face the lowest costs will make the environmental improvements. Accordingly:

> *… market instruments are best used when there are a range of agents who can make changes, diversity in the means of achieving the environmental outcome, and importantly, where there is significant cost differences between these ways and agents. In these situations, market instruments through the trade of improvement efforts, can 'open up' low cost abatement options to deliver environmental gains at lower cost.*

Market instruments generally operate as either a price or quantity based instrument, although instruments aimed at improving the operation of existing markets, termed 'market-friction' instruments, are sometimes included as market instruments.

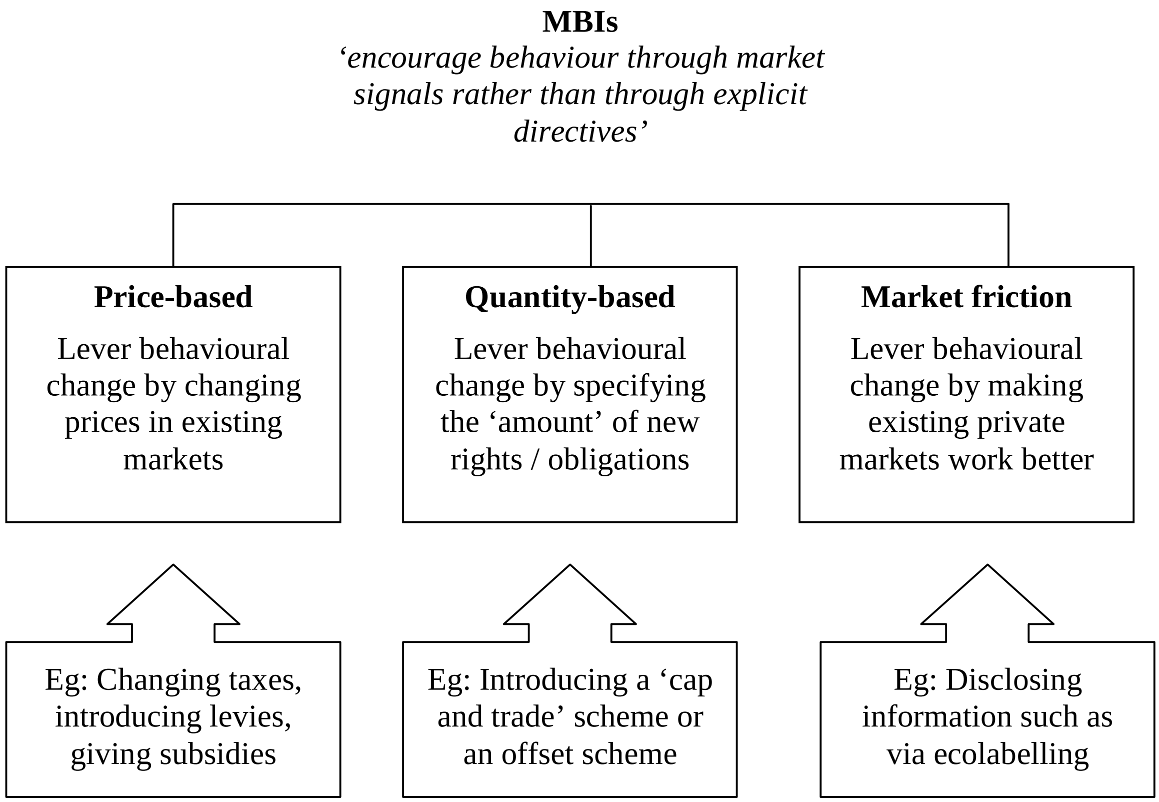
Price based instruments assign a price to environmental impacts within existing markets through the imposition of charges, taxes or subsidies. Firms then respond to the modified market signals and adopt the resource use or management practice that offers them the greatest benefit and, if the policy is effective, leads to a better resource management outcome. While these instruments cannot guarantee the *extent* of changes, they act to cap the *costs* incurred under the instrument.

Quantity based or 'tradeable rights' instruments create a market in the rights to engage in an activity associated with environmental damage, by restricting the total level of activity and allocating rights to participate in that activity. An efficient allocation of rights is then determined through a market mechanism. Quantity based instruments tend to be used when it is important to get a certain environmental outcome - for example, when pollution of a waterway is close to a level that may cause irreversible or unacceptable degradation.

The environmental regulator must determine the total quantity of the good to be expressed in the rights, as well as a range of parameters that define who can own the various rights, the conditions under which trade can take place, how rights will be monitored and enforced, etc. Because of the need to create the regulatory framework necessary for market approaches, their application has predominately been for the management of urban air and water pollution, and for emissions from already regulated and monitored point sources.

'Market friction' instruments try to improve environmental outcomes by making existing private markets work more effectively. They 'oil the wheels' of an existing market. Perhaps the most familiar type of market instrument in this category is eco-labelling, which seeks to make existing markets work better by improving the information disclosed in the market.

Figure 1: Types of Market-based Instruments



Market instruments can be used in conjunction with other policy tools, and as indicated above, have often been built on established regulatory platforms. In addition, more than one market instrument can be used to tackle the same environmental issue. For example, participants in the NSW Hunter River Salinity Trading Scheme are also liable for pollution fees, as are licensed sources participating in the NSW nutrient trading schemes on the Hawkesbury-Nepean River. The setting of 'soft' non-punitive penalties within tradeable rights schemes also provides a hybrid price and quantity approach, as participants will balance meeting quantity targets with price disincentives posed in penalty regimes. This approach is used in the Renewable Energy Certificates Scheme in Australia.

Under the Port Waterways WQIP, a price instrument (fees under load-based licensing) as well as quantity instruments (the focus of this study) are being investigated. It will be important that incentives under these instruments are mutually enforcing. Leveraging improvements through the specific linking of pollution fees and tradeable right instruments can offer an attractive policy mix. This is explored further in section 5.1.

2.2 Range of tradeable rights instruments

With available scientific understanding, and monitoring and enforcement technologies, it is not feasible to establish tradeable rights directly for environmental damages. As a surrogate, rights to a closely related activity can be used to achieve the desired environmental outcome. A successful tradeable rights instrument therefore requires a direct relationship between the activity expressed in the rights and the environmental outcome being sought.

The focus of this study is on tradeable rights instruments suitable for managing nutrients in the Port Waterways. It therefore presupposes that the control of nutrient discharges to the waterway has a direct relationship with subsequent water quality and environmental outcomes. In the Port Waterways context, questions have been raised as to whether all nutrients have the same impact, or whether different nutrients or similar nutrients but at different locations or discharged at different times, have differential impacts. The resolution of these questions is fundamental to defining appropriate rights and trading rules. Section 4 explores this issue further.

Putting aside this issue for the moment and assuming all nutrients have a similar impact, a range of tradeable right instruments can be described to illustrate the range of design approaches. Common approaches include offset schemes, bubble schemes and permit trading schemes.

Offset schemes allow regulated sources to achieve pollution abatement requirements through sponsoring abatement effort from other regulated or unregulated (often non-point) sources. Offset schemes have typically been used in conjunction with development consent processes applicable to new operations, and to constrain growth in pollution loads. Over time, modest reductions in total discharges may be realised where offsets are required to be greater than 1:1 relative to the requirements imposed on the regulated sources. Offset schemes could be used to promote significant reductions if load reduction requirements were imposed on existing sources, such as through pollution reduction programs typically negotiated with licensed activities.

Bubble schemes involve setting an overall pollution limit over one or a small number of regulated point sources, and allowing them to trade abatement effort. Because of the small number of participants, they can enter into their own bilateral arrangements for improvements subject to the agreement of the environmental regulator. In this way, the prior definition of pollution rights and trading arrangements are not required, reducing the administrative cost and complexity for regulators. However where the number of participants increases, administration costs will also increase, while the ability of participants to identify mutually advantageous exchanges will become harder. In these circumstances, more formal trading arrangements offered in permit trading schemes are likely to be superiour.

Permit trading schemes involve placing a cap on the overall load of pollutants discharged from a wider set of participating sources, allocating tradeable permits and only allowing discharges from permit holders. Non point sources may be included in bubble or permit trading directly (by imposing regulatory obligations and requiring them to hold discharge permits) or indirectly through offsets (where non point sources can voluntarily enter into arrangements to sell approved abatement effort to point sources).

Bubble and permit trading schemes have often been employed where a significant reduction in pollution loads is required, as they introduce statutory requirements for improvements from new and existing sources and are not reliant on opportunistic gains associated with new developments or individually negotiated pollution reduction programs with existing licensees.

Hybrid schemes can be used where the major pollution sources are subject to pollution fees, by allowing **fee offsets** for emission reductions achieved off-site. Fee offsets are available for example, under the NSW load-based licensing scheme. Like other offset approaches, improvements are more opportunistic and will be driven as much by the fee levels as well as the relative cost-effectiveness of on-site and off-site improvements.

Within these major categories, numerous variants can be crafted that seek to provide as great a flexibility for abatement effort as possible within the circumstances, and hence drive down the cost of environmental gains. Table 1 illustrates variants of tradeable rights instruments, from simple fee offsets through to more complex trading instruments involving point and diffuse, regulated and unregulated sources of pollution.

The choice of instrument depends on the aims of the scheme, the extent and significance of different sources of pollution, differences in abatement costs and likely gains from trade. The simpler instruments can often be integrated easily into existing regulatory frameworks. The more complex instruments require more development work and administrative effort to run and these are only likely to be pursued if the anticipated gains from trade are large.

Table 1: Tradeable rights instrument

Option	Features
Fee offsets	Pollution fees paid by regulated (licensed) activities can be reduced through funding off-site nutrient reductions
Development offsets	Voluntary method for new development to meet development consent conditions through funding off-site improvements
Licensing offsets	Voluntary method for licensed sources to meet new licence targets – opportunistic, requiring guidelines rather than formal scheme
Bubble scheme	Small number of point sources meet aggregate nutrient discharge target, statutory based and subject to agreed scheme parameters (eg; targets, trading rules, monitoring, etc).
Mandatory offset scheme	New developments required to arrange appropriate offsets or contribute funds to offset scheme to ensure load target eg: NSW green offset scheme suggests a 'no net increase in pollution requirement. Requirements for existing regulated sources to meet new licence targets could be introduced with a mandatory offset scheme.
Point source trading scheme	Point sources allocated permits that limit discharges but are allowed to trade permits among themselves subject to a set of trading rules
Point source trading scheme with offsets	As with point source trading scheme, but point sources can use offsets purchased from voluntary (and often diffuse) sources to meet scheme requirements
Point & diffuse source trading scheme	Point and diffuse sources allocated permits and all sources can trade to meet requirements

increasing complexity, less opportunistic

2.3 Use of trading in other States/countries

Based on experience overseas and in Australia, trading in abatement effort has great potential to assist in achieving better water quality. In Australia, emission trading has been used to reduce water pollution through the South Creek nutrient trading scheme in NSW, the Hunter River salinity trading scheme in NSW, the wastewater treatment plant offsets at Busselton in Western Australia and the South Creek bubble licence scheme in NSW.

In the United States, examples of trading to manage water pollution include the Phosphorus Offset Pilot Programs for protecting New York City water; water emission offsets under the Minnesota

Clean Water Regulations; nutrient trading schemes involving both point and diffuse sources in the Dillon and Cherry Creek Reservoirs in the Denver, Colorado areas and in North Carolina's Tar-Pamlico Basin; and other US nutrient trading schemes in Colorado, Connecticut, Michigan, Minnesota and Wisconsin. In general, water pollution trading schemes have been constrained by the significance of non point source emissions from agriculture, the influence of the farm lobby groups and the lack regulatory force behind some early schemes.

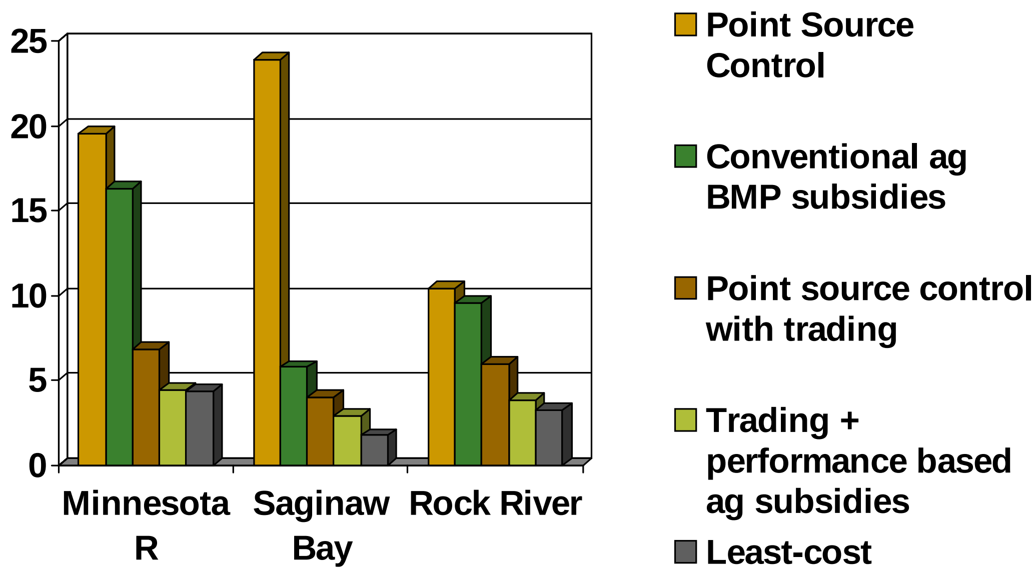
As an example of the benefits of emission trading, a small self-contained bubble scheme was introduced in NSW in 1996 through the South Creek Bubble Licence Scheme. The scheme mandated significant reductions in nutrient discharges from a group of three sewage treatment plants. Trading allowed the least cost abatement strategy to be implemented – focussing predominantly on only one of the sewage treatment plant - saving around $45m compared to a traditional uniform standards regulatory approach. This example shows it is not necessary to introduce a scheme covering numerous sources in order to achieve significant cost savings.

Often reducing pollution from diffuse sources is cheaper than point source reduction on a per unit basis. This is because many diffuse sources can rely on low cost or non-structural measures to reduce pollutants. In addition, regulations have generally focused on point sources for many years and therefore low cost point source controls have already been implemented.

Studies in the US have examined the potential for tradeable rights instruments to reduce the costs of reducing nutrients in US waterways. The World Resource Institute (2000) used case studies of three US watersheds to explore the cost-effectiveness and environmental performance of various strategies to reduce phosphorus loads. The study found that policy approaches utilising nutrient trading are dramatically less expensive than conventional point source requirements. Figure 2 below summarises the results.

Similar findings have also been found in an applied context for nutrients in Australia. In 2001, the University of Western Sydney identified cost-effective abatement measures for reducing nutrients in the Hawkesbury-Nepean river system in NSW. As an example, the cost of reducing phosphorus through run-off detention at a market garden was found to be around $20 per kilogram per year compared to $10,000 per kilogram to upgrade current sewage treatment plants.

Figure 2: Cost-effectiveness of US nutrient trading schemes ($/lb Phosphorus)



Source: World Resources Institute 2001

3 THE PORT WATERWAYS NUTRIENT PROBLEM

This section outlines the environmental impacts in the Port Waterways catchment and the context for improvements under the proposed Water Quality Improvement Plan. It presents the current and future loads of nutrients from different sources in the catchment and explores options for reducing nutrients in the future.

3.1 Environmental Impacts and the Water Quality Improvement Plan

The Port River Estuary and Barker Inlet contain diverse and ecologically important aquatic ecosystems including mangrove stands, salt marshes, tidal flats and sea grass beds. They are an important breeding ground for fish, as well as providing habitat for migratory bird species and dolphins.

Eco Management Services has identified nutrients as a principle factor in ecosystem decline. The two nutrients that are most influential in aquatic systems are nitrogen and phosphorus. Although they are both significant, nitrogen is considered the more important nutrient pollutant in the Port River waterways.

It is not only the quantity of nutrients that is important but also the timing, location and chemical composition of the nutrients. This issue will be considered in more detail in section 3.3 as part of a discussion of the contribution of different sources to the nutrient problem in Port Waterways. Table 2 shows the key problems caused by nutrient discharges and their location.

Table 2 Key nutrient problems and location

Nutrient problem	Location	Segment of waterways
Loss of seagrass meadows	Extensive impact across the northern part of the Port catchments	Northern segment
Mangrove decline	Impact across whole region. Most significant decline found between Gawler Creek and Barker Inlet.	Whole region
Loss of salt marshes	Impact across whole region. Greatest loss in the Barker Inlet-Port Adelaide region.	Whole region
Toxic algal booms	Frequent ‘red tides’ of potentially toxic algae in the Port River.	Central and southern segments

Some of the problems are localised effects which may be short in duration but also frequent, such as red tides. Others are broader and longer term ecosystem effects, such as mangrove and seagrass decline.

Eco Management Services defines three separate segments of the Port Waterways according to the level of protection required. They are:

- Northern segment – north of St Kilda and Torrens Island (high conservation/ecological significance, severely impacted by nutrients)
- Central segment – south of St Kilda in Barker Inlet, Angus Inlet, North Arm, North Arm Creek and the Port River north of North Arm (slightly to moderately disturbed, needs protection for ecosystem recovery)
- Southern segment – the Port River to North Arm (degraded area, important recreational value)

The EPA's ambient water quality monitoring has indicated that nutrient concentrations are elevated across all sites in the Port River and Barker Inlet.

The SA EPA is developing a Water Quality Improvement Plan to protect the environmental values of Port Adelaide's waterways by setting nutrient discharge and environmental flow targets. The EPA will be setting an overall nutrient reduction target for the Port Waterways as part of the Plan. However, at this stage further water quality modelling is being undertaken to determine a suitable target.

This report examines the potential benefits of a trading instrument to achieve a target of a 50% reduction in current total nutrient loads entering the Port Waterways by 2010/11.

3.2 Current and future nutrient loads and sources

There are a number of existing point and diffuse sources of nutrients in the Port Waterways. The most significant point sources are the Bolivar and Port Adelaide wastewater treatment plants, and the Penrice soda plant. The diffuse sources include agricultural runoff, urban stormwater runoff and septic tanks.

There are three major point source discharges of nutrients into the Port Waterways catchments. These point source discharges are controlled through EPA licences. There are a range of diffuse sources of nutrients in the Port Waterways. In the northern sections of the catchment there are a range of agricultural activities such as market gardens, viticulture and broadacre cropping. Residential, commercial and industrial areas are concentrated in the southern sections of the catchment. There are around 130 companies licensed by the EPA in the Port Adelaide, Gillman and West Lakes areas.

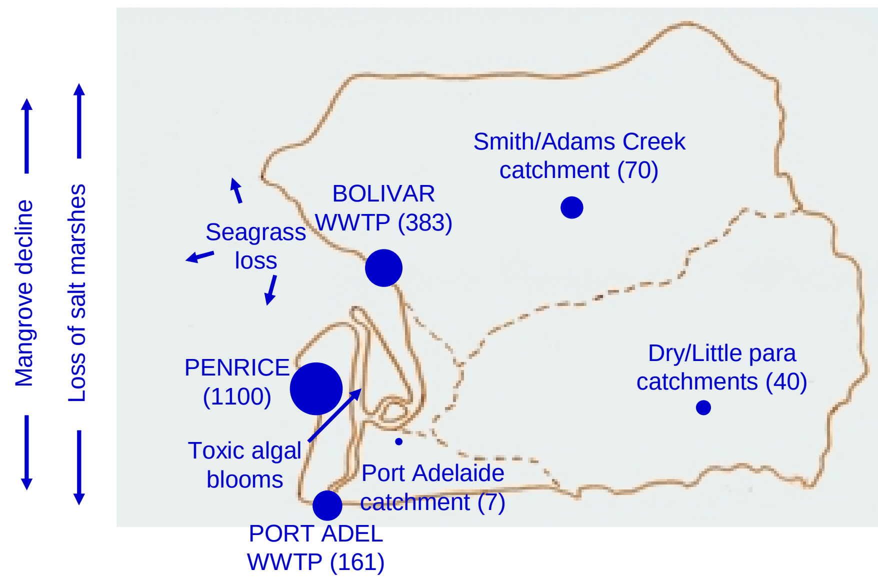
The discharges of nutrients from the major point sources are controlled through EPA licences. Each of the major sources has an Environment Improvement Plans (EIP) under the licensing system relating to the nutrients discharged into the Port Waterways.

The nutrient runoff from diffuse sources is not controlled through regulation by the EPA. However, it is influenced by the activities of the relevant councils and catchment water management boards that undertake a range of activities aimed at improving water quality in the catchment. Recent examples include pollution prevention projects with small business and industry, development of wetlands and programs to address erosion and improve channel stability.

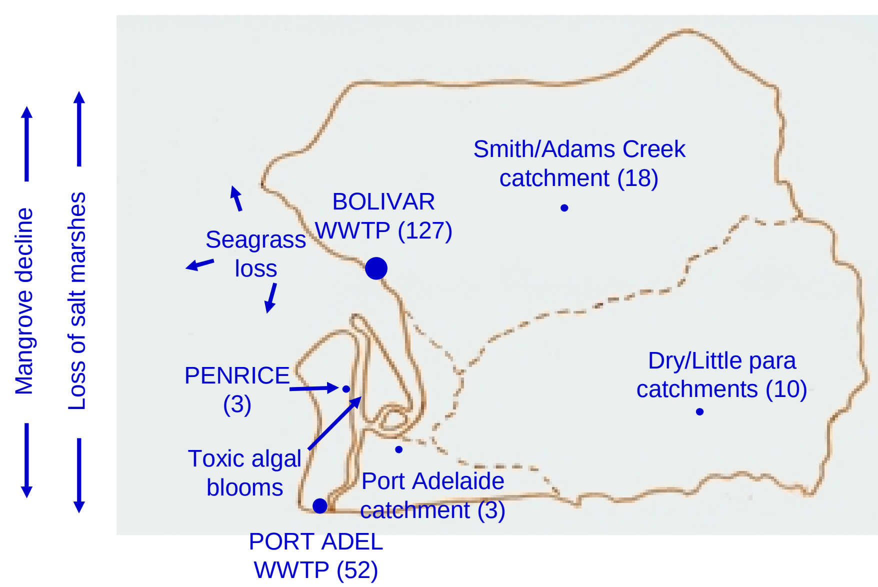
There will be a number of new sources of nutrients into the Port Waterways as a result of the development of the Northern Lefevre Peninsula. Under the proposed development the outer harbour will become a centralised industrial zone and the inner harbour a river front residential and recreational/tourism zone. The most significant possible new source of nutrients would be the Port Front development to house 4,000 people. While the development involves new medium-high density housing on around 50 hectares of land, the existing area is industrial and the development would involve relocation of businesses currently contributing nutrient loads through stormwater, as well as heavy metals and hydrocarbons.

The maps below show the location of current nitrogen and phosphorus loads in the Port Waterways, with the size of symbols reflecting the relative scale of discharges from each source. The maps also show the location of the nutrient problems.

Map 1 Current nitrogen loads



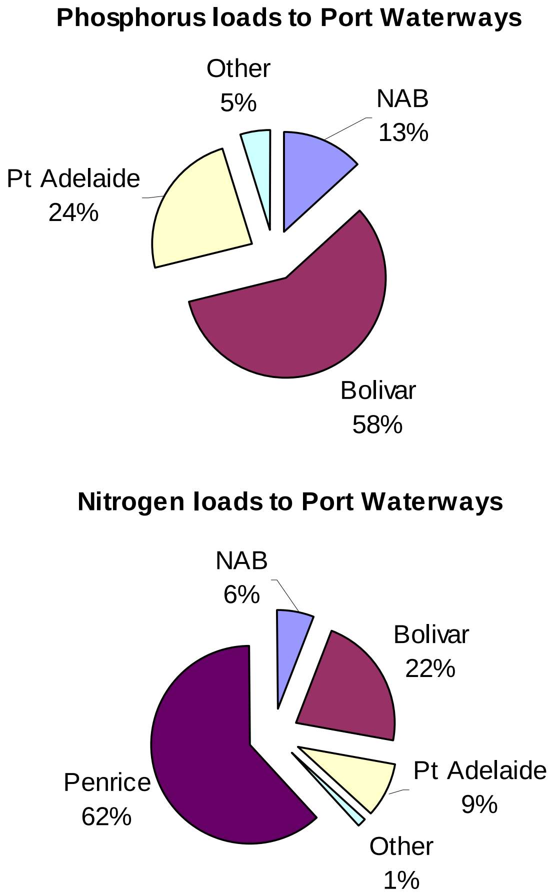
Map 2 Current phosphorus loads



The most significant contributors to nutrient loads in the Port Waterways are highlighted in Figure 3. The Penrice soda plant dominates nitrogen loads, contributing around 62% of current loads. The wastewater treatment plants contribute around 31% and the NAB catchment around 6% of total nitrogen loads.

For phosphorus, the wastewater treatment plants dominate loads, contributing around 82% of current loads. The Northern Adelaide Barossa catchment is estimated to contribute around 13% of phosphorus loads.

Figure 3: Breakdown of point and diffuse source nutrient loads to Port Waterways



Care is needed when comparing the load contributions of different sources as they have different impacts due to the pollutant composition, location, timing of the discharge and the environmental conditions of the receiving waters. The high bioavailability of the discharges of nutrients from Bolivar and Penrice mean that their impact is likely to be greater than the nutrients from diffuse sources that are associated with particulate matter. The timing of the discharges also differs, with

Penrice discharging a constant quantity of nitrogen, whereas both Bolivar's discharges and those from the catchments are lower during the summer months.

The location of the discharge is another key factor in assessing loads. The discharge from Penrice is currently thought to contribute to red tides, however these are expected to be reduced once the Port Adelaide WWTP closes as its freshwater input is a key factor in their development. In the future, the Penrice discharge may be the primary cause of localised impacts such as other types of algal blooms. Much of the runoff from the catchments enters the waterways a long way from the areas of high nutrient impact and the fate of the pollutants is much more difficult to determine.

During low flow, the contribution of the diffuse loads from the NAB catchment would be smaller than is suggested in the pie charts. During and after rainfall however, runoff can be a significant source of excessive nutrients.

There are also a number of confirmed and possible sources of nutrients for which there is uncertainty around their impact and likely contribution to nutrient loads. These include:

- Future nutrient loads from the Port Adelaide catchment - there is some uncertainty about the ability of the Gillman wetlands to continue to reduce nutrient loads from the Port Adelaide catchment. The redirection of stormwater from fertiliser companies into the Magazine Creek wetland has increased discharges to the wetland and may be placing increasing pressure on it.
- The possible contribution of the Gawler river catchment to nutrient loads in the Port Waterways. The EPA expects that its water quality model will confirm that the Gawler River does not have a significant impact on the region. This is because the river only flows in periods of heavy rain and this would have to coincide with a large incoming tide and strong north-westerly wind.
- Loads from the Smith/Adams creek sub-catchment.
- The contribution of septic tanks in the Wingfield industrial area – this has been raised as a significant issue by stakeholders, however it is more of a public health issue than a nutrient problem.
- Thermal pollution from TXU power station – the power station draws seawater from the Port River and returns heated discharge water to the marine environment at Angus Inlet. Where there is an excess of nutrients, the increased temperature can cause algal blooms. However, it is impossible to quantify the contribution of the TXU power station to nutrient pollution of the Port Waterways without in-depth scientific surveys.
- Leachate from Garden Island Landfill – there is considerable uncertainty about the impact of ammonia rich leachate from the Garden Island landfill. The estimated total nitrogen load into

the Angus Inlet and North Arm is less than 5 tonnes per year, however the amount that actually reaches the marine environment is uncertain.

- Atmospheric deposition – The EPA has derived preliminary estimates of the total loads of nutrients from atmospheric deposition from published studies. Annual loads of 25-45 tonnes of nitrogen and 0.9-3.0 tonnes of phosphorus have been estimated. However, the estimate for nitrogen is thought to over-estimate true loads.
- Sediments adjacent to the Port Adelaide WWTP in the upper reaches of the Port Waterway.

There are a number of programs underway to reduce nutrient loads entering the Port Waterways. Table 3 below shows the major loads predicted from major sources in the Port Waterways in 2010/11 under current programs.

Table 3: Predicted loads from major sources by 2010/11

Source	Predicted nitrogen tonnes	Predicted phosphorus tonnes
Bolivar WWTP	318	120
Penrice soda plant	800	3
NAB catchment	102	26
Torrens catchment	7	3
Other	19	4
Total	1246	156

Source: All data from Eco Management Services report on the draft WQIP Improvement Plan apart from NAB catchment estimates (see Appendix A)

The main changes to nutrient loads between 2003/04 and 2010/11 are lower nitrogen (from Penrice cleaner production activities as well as greater effluent reuse from Bolivar through the Virginia pipeline scheme) and lower phosphorus (from better treatment of effluent redirected from Port Adelaide to Bolivar and greater effluent reuse through the Virginia pipeline scheme). It is also assumed that the loads from the NAB would be reduced by around 7.5% as a result of pollution reduction activities undertaken by the catchment management board (assumption used in Eco Management Services report on draft WQIP Improvement Plan).

Based on these load projections, the contribution of the NAB catchment to total nutrient loads is expected to increase from 6% to 8% for nitrogen, and from 13% to 17% for phosphorus, by the year 2010/11.

The nutrient reduction target requires a reduction in both nitrogen and phosphorus loads of 50% by 2010/11. Table 4 below shows the current and predicted future loads and sets out the reductions in nitrogen and phosphorus that would need to be achieved through additional abatement actions.

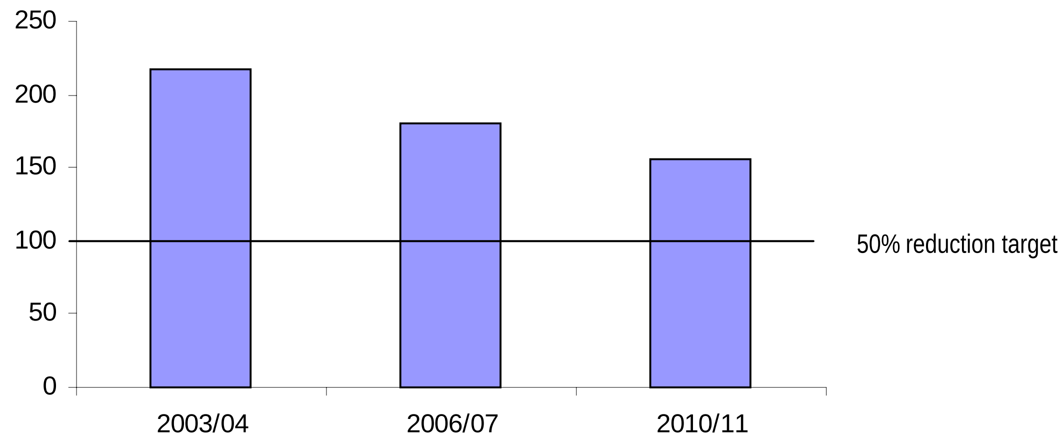
Table 4: Nutrient reductions beyond 'business as usual' required to meet WQIP target

	Nitrogen tonnes	Phosphorus tonnes
Current loads 2003 / 04	1,782	217
Business as usual (BAU) loads 2010 / 11	1,246	156
WQIP target 2010 / 11	891	108
Additional reduction required to meet WQIP target by 2010 / 11	**356**	**48**

Figures 4 and 5 below show, in graphical form, the predicted changes in nitrogen and phosphorus discharges anticipated under current programs, and in comparison to the WQIP nutrient reduction targets.

Figure 4: Predicted 'BAU' nitrogen loads and WQIP target (tonnes per year)

Figure 5: Predicted 'BAU' phosphorus loads and WQIP target (tonnes per year)



3.3 Options for reducing nutrients beyond business as usual

This section examines ways to reduce nutrients beyond existing programs, including point and diffuse source abatement actions and their cost-effectiveness. Note that the cost estimates included in this section are indicative only. The available estimates are used to gain an appreciation of the likely relativity of costs between options as a step towards estimating the potential benefits from trading nutrient abatement effort and the merits of tradeable discharge rights.

3.3.1 Wastewater treatment plants

The EPA and SA Water have established Environment Improvement Plans (EIPs) for both of the WWTPs discharging nutrients into the Port Waterways. Bolivar aimed to reduce the amount of nitrogen discharges by 80% down to 318 tonnes per year by 2003/04. Bolivar installed an activated sludge plant at a cost of $110m and the Virginia pipeline scheme to provide treated effluent to irrigators at a cost of $30m. These measures reduced actual nitrogen discharges down to 380 tonnes per year in 2002/03. The total cost of the reduction in nitrogen to date (1,210 tonnes) was $140m or $115,000 per tonne.

Under the EIP for Port Adelaide, the plant will close in 2004 and effluent will no longer be discharged to the Port Adelaide River. The effluent will be diverted to the Bolivar plant increasing nitrogen loads at Bolivar to around 450 tonnes in 2004/2005. Increased use of the Virginia Pipeline scheme is then expected to reduce loads over time to around 318 tonnes in 2010/11. If effluent reuse does not reach anticipated levels (50% of effluent), Bolivar could undertake additional treatment of effluent at the plant to meet its nitrogen reduction target. The cost of this has been estimated at $30m (or $480,000 per tonne if it was used to reduce nitrogen down from 380 tonnes to 318 tonnes).

There are a number of options for further reducing nutrients loads from Bolivar in the future:

- Treating effluent to A grade and pumping it to the Parklands was considered previously in the context of the Glenelg WWTP. The cost of water treatment was estimated at around $15m. If there was demand for treated effluent of an additional 15,000ML per year (over and above the 30,000 ML per year for the Virginia pipeline scheme), and the costs of supply and distribution were met by users, this type of option could reduce nitrogen discharges from Bolivar by another 65 tonnes per year at a cost of $200,000 per tonne. This estimate should be considered with caution as the cost of treatment was for Glenelg and was calculated for reuse of around 5,000 ML per year. The viability of the option depends on demand for treated effluent and the capacity of users to pay for supply and distribution.
- Aquifer storage and recovery to enable greater expansion of effluent reuse through the Virginia pipeline scheme. There is no information currently available on the likely costs and nutrient reduction that could be achieved through this option.

The future cost to SA Water of reducing nutrients beyond BAU is estimated at around $200,000 per tonne.

3.3.2 Penrice soda plant

Penrice has a current EIP that requires a cleaner production program to be implemented to reduce ammonia loss to the Port River down to 1,000 tonnes per annum by the end of 2004. Penrice has spent around $2.5m on cleaner production activities resulting in a decrease in total nitrogen by 200 tonnes per year. This has also provided a saving of $130,000 worth of ammonia. The costs to date have been around $12,500 per tonne of total nitrogen.

The second stage of the EIP is to investigate options for removing ammonia from the effluent stream. As the soda plant is unique in Australia there is no information available to estimate abatement costs. Penrice has indicated that they will be examining a range of options to further reduce ammonia discharges. These include microbiological solutions or use of a cooling tower for air/vapour exchange. As Penrice are only in the very early stages of considering these options, the costs, likely load reductions and other environmental impacts have not been considered.

The costs of future options are likely to be greater than the costs incurred to date as many of the cheaper options have probably been implemented, for example through simple management changes. The EPA has indicated that the costs of future options are likely to be up to ten times greater than the costs of previous abatement measures. For the purpose of the analysis, the costs are assumed to be between $12,500 per tonne and $125,000 per tonne.

3.3.3 Diffuse sources

Nutrient loads from Port Adelaide catchment runoff are already reduced significantly as discharges enter the Port waterways through the three Gillman Wetlands – the Barker Inlet Wetland, Magazine Creek Wetland and the Range Wetland. The catchment is covered by the Torrens Catchment Water Management Board which undertakes a range of activities with the aim of improving water quality in the catchment. Recent examples include pollution prevention projects with small business and industry, and investigations into additional wetlands and aquifer storage and recovery schemes for stormwater harvesting.

The Northern Adelaide and Barossa Catchment Water Management Board also undertakes activities to improve water quality in the catchment. Programs include industry partnerships to address stormwater, development of wetlands and programs to address erosion and improve channel stability.

There are a range of possible abatement measures to reduce nutrients in the catchments. Some are engineering/structural solutions and others involve improving management strategies. Appendix B shows the most promising abatement measures for diffuse sources.

3.3.4 Speculative options

A number of other possible abatement options are being investigated by the EPA. These include:

- Dredging the upper reaches of the Port River – The cost-effectiveness of dredging 91,000 m3 of sediment and the transport and disposal of sediment is estimated at $1,968 per tonne of nitrogen and $8,346 per tonne of phosphorus. However, these costs relate to a one-off reduction, rather than the cost of achieving an on-going reduction. For comparative purposes, the dredging costs are equivalent to $25,000 and $105,000 per tonne respectively, if achieved each year over 30 years.
- Remediation of ammonia rich groundwater from Garden island landfill – options include pumping out polluted groundwater for treatment/disposal, phytoremediation, on-site treatment or groundwater bioremediation trenches. However no cost data is currently available.
- Reducing thermal discharge from TXU power station – for example, change to cooling towers at a cost of $50m-$300m or divert heated cooling water discharge to another location at a cost of $10m-$50m. As the impact of reducing thermal pollution on the various environmental problems is unknown, it is not possible to estimate costs per tonne of nutrient reduction.

Table 5 sets out broad estimates of the cost-effectiveness of abatement options for point sources and the most promising abatement options identified for diffuse sources. Information on the costs and effectiveness of many of the options is limited. Where local information was not available, estimates drawing on experience with nutrient reduction in NSW were used.

Table 5: Cost-effectiveness of abatement options

Source / option	Cost-effectiveness	Other environmental benefits	Possible nutrient reduction assumed
Bolivar	$200,000 per tonne of phosphorus / nitrogen	-	Reduction of around 100 tonnes pa of N, 50 tonnes pa of P
Penrice	$12,500-$125,000 per tonne of nitrogen	-	Reduction of 50% total load (550 tonnes per year of N)
Wetlands – NAB catchment	$40,000-$80,000 per tonne of N $200,000-$400,000 per tonne of P	Reduces sediment loads, biodiversity and amenity values	Reduce NAB catchment load by 80% of N (88 tonnes pa) and 65% of P (19 tonnes pa)
Riparian restoration – NAB catchment	$30-$1,400 per tonne of N $400-$80,000 per tonne of P	Reduces sediment loads Ecological benefits eg habitat restoration, biodiversity and amenity values	Reduce 22% of nutrient loads from agriculture in NAB catchment (8 tonnes pa of N and 2 tonnes pa of P)
Best Management Practices for market gardens – NAB catchment*	$10 per tonne of N $20 per tonne of P	Reduces sediment loads	Reduce 50% of nutrient loads from 50% of market gardens in NAB catchment (4 tonnes of N and 1 tonne of P)

* In the absence of local information costs have been used from *Ranking nutrient export abatement actions for South Creek*, University of Western Sydney for NSW EPA, Sep 2001

4 THE SUITABILITY OF TRADEABLE DISCHARGE RIGHTS FOR PORT WATERWAYS

This section explores how suitable tradeable discharge rights are for the Port Waterways nutrient problem. It assess the potential for compliance cost savings through tradeable discharge rights compared to other policy approaches and examines the issue of environmental equivalence between sources of nutrients in the catchments. It assesses whether tradeable discharge rights is an appropriate instrument to reduce nitrogen and phosphorus in the Port Waterways.

4.1 Potential for compliance cost savings

This section compares the costs and likely environmental outcomes of a prescriptive approach to achieving the WQIP nutrient reduction target of 50% by 2010/11 and various options for tradeable discharge rights in order to answer the question of whether trading is likely to offer significant cost savings. The options for tradeable discharge rights assume there are no restrictions on trades. Only abatement options shown in table 5 have been included, namely those at Bolivar, Penrice and in the NAB catchment.

This section summarises the results of a preliminary analysis that was carried out in Part 1 of the project to inform later parts of the project.

The options examined were:

- Continue current regulatory approach (ie: Individual licence requirements) - under this option the two major point sources could be required to meet their share of the reductions in nitrogen and phosphorus needed to meet the WQIP target. In the preliminary analysis it is assumed the share for each would reflect their respective proportion of current nutrient loads.
- Bubble trading scheme for major point sources – this option would allow trading between the two major point sources. It would only operate for nitrogen as there is only one major source of phosphorus in the catchment.
- Offset requirement for new development - under this option any new development would be required to offset any additional nutrient loads (after appropriate stormwater management measures have been implemented on-site). Although this approach would prevent new development from increasing nutrients loads into the waterway, by itself it would not meet the target (and so is not included in table 6 or figure 6).
- Tradeable permit scheme - in theory, a tradeable permit scheme involving Bolivar, Penrice and some of the key diffuse sources could be established to meet the desired nutrient reduction targets.

Table 6 and figure 6 summarise the costs and outcomes of the different policy approaches. Note that the purpose of this assessment is not to provide a definitive estimate of the likely magnitude of the costs of meeting the nutrient reduction target. The costs are preliminary and should be interpreted accordingly. The purpose is to examine the *relative* costs and outcomes of different policy approaches to inform instrument selection.

Table 6: Summary of costs and outcomes of different policy approaches

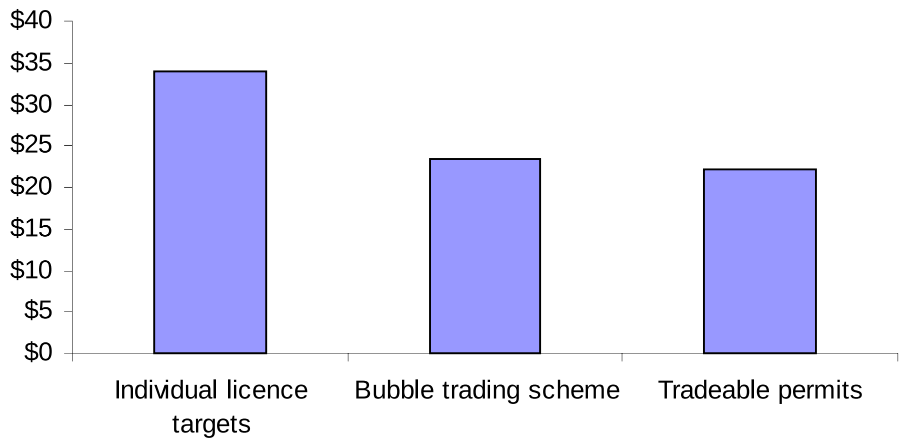
Option	Abatement cost *	Location of nutrient reductions	Likely environmental outcomes
Continue current regulatory approach (ie: Individual licence requirements)	$34m	Reductions at Bolivar and Penrice in northern and central segments.	Possible reduction in mangrove/seagrass decline Possible reduction in red tides
Bubble trading scheme for nitrogen	$23m	Reduction at Penrice in central segment.	Possible reduction in red tides
Tradeable permit scheme	$22m	Significant reduction at Penrice in central segment. Possible reductions of nitrogen in NAB catchment (depending on relative abatement costs). Reduction of phosphorus from Bolivar.	Possible reduction in red tides. Possible reduction in\ mangrove/seagrass decline (depending on relative abatement costs).

* net present value of costs over 7 years at a discount rate of 7% to meet WQIP target by 2010/11

There is very little difference in costs between the trading options because most reductions in nitrogen occur at Penrice and most reductions in phosphorous occur at Bolivar under both options. The minor difference in costs reflects the opportunities for reducing nutrients from diffuse sources in the NAB catchment.

The analysis suggests that a tradeable rights instrument could reduce the costs of meeting the target by around 30% ($10m over seven years). However, there are a number of uncertainties about both the accuracy of the information on loads from different sources and the abatement costs. The costs of meeting the target using different instruments is very dependent on the relative abatement costs for Penrice, Bolivar and the installation of wetlands in the NAB catchment.

Figure 6: Cost of policy instruments to meet WQIP target by 2010/11 ($m)



4.2 Environmental equivalence

While the preliminary analysis suggests there is potential for compliance cost savings through trading, a key issue is whether nutrients are suitable for trading in the Port Waterways context. Part 1 of the project identified the need to explore the relationship between nutrient loads from different sources and specific environmental issues. BDA Group approached the EPA to provide an expert assessment of the likely contribution of different nutrient sources to the key nutrient problems in the Port Waterways. Preliminary quantitative relationships have been developed between different sources for the five major nutrient problems: mangrove decline, seagrass loss, phytoplankton blooms, macroalgal blooms, toxic blooms and mosquito breeding.

The reported relationships take into account the:

- location of discharges
- chemical composition of discharges
- timing of discharges.

Tables 7 and 8 summarise the quantitative relationships for nitrogen and phosphorus respectively. The numbers in the cells refer to the quantity of nutrient discharge (in kilograms) that is equivalent to one kilogram of nutrient discharge from Bolivar. For example, the first row indicates that 1 kilogram of nitrogen from Bolivar is expected to have the same impact on mangrove decline as 5-10 kilograms of nitrogen from Penrice or 10-20 kilograms of nitrogen from diffuse sources. Appendix C provides the detailed tables developed by the expert group.

Table 7: Quantitative relationship between sources of nitrogen in Port Waterways

Environmental Problem	Nutrient Source		
	Bolivar	Penrice	Diffuse
Mangrove decline	1	5-10	10-20
Seagrass loss	1	5-10	very large
Phytoplankton blooms	1	1-5	very large
Macroalgal blooms	1	2-5	very large
Toxic blooms	1	1	very large
Mosquito breeding	1	very large	very large

Table 8: Quantitative relationship between sources of phosphorus in Port Waterways

Environmental Problem	Nutrient Source	
	Bolivar	Diffuse
Mangrove decline	1	10-50
Seagrass loss	1	very large
Phytoplankton blooms	1	Na
Macroalgal blooms	1	very large
Toxic blooms	1	very large
Mosquito breeding	1	very large

The relationships suggest that the Bolivar WWTP has the greatest impact per kilogram of nutrient for most environmental issues. Nitrogen from Penrice is thought to have an impact on all issues (except for mosquito breeding), however its impact per kilogram of discharge is generally lower than that of Bolivar. The only environmental issue where the impact per kilogram of the Bolivar WWTP and Penrice plant are similar is toxic blooms.

The relationships also suggest that nitrogen from diffuse sources is having very little impact when compared to other point sources in the region. While reducing nutrient loads from diffuse sources could have a small impact in addressing mangrove decline in Port Waterways, it would have virtually no impact on any of the other environmental issues. This is primarily because the diffuse discharges enter the estuary primarily during winter when water temperatures and light levels are lower.

For phosphorus, Bolivar is the only significant point source. The diffuse source contribution in load terms is small, and when adjusted for environmental equivalence it is relatively insignificant compared to the point sources.

4.3 Assessment of suitability – nitrogen only

For nitrogen there are two major point sources and a range of diffuse sources having a much smaller impact. A preliminary equivalence relationship has been established between these sources. Given this and the potential for compliance cost savings identified in the previous section, a tradeable discharge rights instrument is likely to provide benefits over other policy approaches.

Bolivar is the dominant source of phosphorus in the Port Waterways. The environmental benefits of reducing phosphorous from sources other than Bolivar provided only a fraction of the benefits from reductions at Bolivar on a tonne for tonne basis. Accordingly, there is little opportunity to meet the phosphorus related environmental goals of the WQIP anywhere but at Bolivar. A tradeable rights instrument therefore offers no gains over existing regulatory tools. Under these circumstances it is appropriate for any phosphorus target in the Water Quality Improvement Plan to be implemented as a licence requirement through Bolivar’s Environment Improvement Plan, rather than through a tradeable rights instrument.

4.4 Implications for choosing a nitrogen reduction target and metric

Following on from the issues raised above, a number of factors need to be considered in finalising a nitrogen reduction target and choosing a trading metric for use with a tradeable rights instrument. They are;

- Adjusting the nitrogen target in lieu of likely nitrogen reductions that would be achieved by Bolivar concurrently with phosphorus reductions as part of a new EIP;
- Choosing a common metric for trading discharge reduction efforts between different sources; and
- Establishing trading ratios that reflect both the environmental equivalence of discharges but also the relative importance of each environmental problem being addressed in the WQIP.

These issues are briefly addressed below.

Any reduction in nitrogen that would be associated with Bolivar meeting its phosphorus target needs to be taken into account in the analysis of options to meet the overall nitrogen target. This has been done by estimating the likely reduction in nitrogen associated with phosphorus management at Bolivar and deducting this from the overall nitrogen target required under the WQIP beyond *Business as Usual' (BAU)*.

Table 4 in section 3.3 estimated the annual nutrient reductions required beyond BAU to meet the WQIP target of 50% of current loads by 2010/11. These were estimated at 356 tonnes for nitrogen and 48 tonnes for phosphorus. The reduction in nitrogen load associated with Bolivar meeting an additional 48 tonne phosphorous reduction has been estimated based on the assumption that SA Water is likely to expand effluent reuse to meet this obligation. The associated reduction in nitrogen load is estimated to be 141 tonnes. The evaluation of options in the next section examines the likely benefits of tradeable rights options to meet a revised WQIP nitrogen target of 215 tonnes per year (being the initial 356 tonnes less the 141 tonnes assumed to be achieved at Bolivar).

Secondly, most pollution trading schemes focus on achieving a reduction in total pollutant load as a proxy for environmental outcomes. Through the work on environmental equivalence, it has become apparent that there are multiple environmental outcomes being sought in the Port Waterways and the impact of different sources on these outcomes is thought to vary substantially - yet significant uncertainty exists as to these relationships.

To minimise the impact of these uncertainties a different metric is needed so that alternative tradeable rights instruments can be compared in terms of there efficiency in delivering the same environmental outcome. For the purpose of the analysis of options, this can be achieved by specifying the nitrogen reduction target in terms of a common source. So for example, 'Bolivar equivalent' nitrogen tonnes could be used as a metric. While the environmental outcome associated with reducing nitrogen at Bolivar may remain uncertain, through the use of equivalence ratios, reductions in nitrogen from any source can be expressed in terms of Bolivar equivalents. If all instrument options are investigated in terms of their efficiency in delivering the same amount of Bolivar equivalent reductions in nitrogen, then their relative effectiveness can be compared.

Unfortunately, setting the target at 215 *Bolivar equivalent* tonnes (or a target of that magnitude in *Penrice equivalent* tonnes) would make the analysis unworkable, as a reduction of this magnitude is unlikely to be possible given known abatement options. Consequently we have chosen to express the WQIP nitrogen target in terms of *Penrice equivalent* tonnes for the purpose of the analysis. That is, it is assumed that the environmental outcome sought under the WQIP would be achieved by reducing 215 tonnes of nitrogen per year at Penrice.

As indicated by the equivalence ratios, a 215 tonne reduction in *Bolivar equivalent* tonnes would generate a better environmental outcome than the same reduction in *Penrice equivalent* tonnes. The ultimate reduction in nitrogen required under the WQIP and its translation into either metric is yet to be determined. A given environmental outcome can easily be set in either metric (the tonne reduction would differ taking into account the environmental equivalence between the two dischargers). It is the overall magnitude of the environmental outcome required that is important. The likely outcome of choosing targets of different sizes (regardless of the metric) is explored in the analysis.

Thirdly, is the issue of the relative importance of each environmental problem. The optimal suite of nitrogen reduction efforts will vary as the importance placed on each problem is varied. This issue can be addressed through adjustments to trading ratios. For this preliminary analysis, the EPA has advised that all environmental issues are considered equally important. Accordingly the analysis presented is based on this assumption. However, alternative scenarios are also presented to illustrate the significance of alternative environmental priorities to the operation of a tradeable rights instrument.

5 EVALUATION OF OPTIONS AND SELECTION OF INSTRUMENT

This section outlines a range of tradeable rights approaches and defines a set of options for assessment. The costs of achieving a reduction of 215 tonnes of nitrogen per year (in Penrice equivalent tonnes) by the year 2010/11 under the various options are presented. The likely level of cost savings from trade are revisited taking into account the environmental equivalence issues (that were not factored into the preliminary analysis in Section 4). The scientific and financial uncertainties are explored as well as the implications of these for the outcomes of the different approaches. The section concludes with a comparative assessment of the options and a recommended instrument.

5.1 Options for assessment

A range of tradeable discharge rights instruments were outlined in Table 1 in Section 2.2 from simple fee offsets through to more complex trading instruments involving point and diffuse, regulated and unregulated sources of pollution.

The choice of instrument depends on the aims of the scheme, the extent and significance of different sources of pollution, differences in abatement costs and likely gains from trade. The simpler instruments can often be integrated easily into existing regulatory frameworks. The more complex instruments require more development work and administrative effort to run and these are only likely to be pursued if the anticipated gains from trade are large.

The dominance of two major point sources in the Port Waterways catchment lends itself to the less complex and more opportunistic options in Table 1, such as the licensing offsets and bubble scheme.

Fee offsets are not explored further, as the major licensees would need to be paying significant incentive fees to drive them to seek offsets. Given that the fees for Bolivar and Penrice are not likely to provide a significant incentive under the proposed load based licensing scheme (and in fact Bolivar's fees are likely to be reduced) fee offsets are not considered sufficient to promote the nutrient reductions being sought.

As new development currently planned for the Port Waterways catchment is not likely to significantly increase nutrient loads, development offsets are unlikely to yield the scale of nitrogen reductions being sought.

Trading schemes require significant developmental and administrative work and are generally pursued where there are a large number of sources with differing abatement costs and the expected gains from trade are large. A trading scheme is not likely to be worthwhile for the Port Waterways catchment given that the nutrient loads are dominated by two large sources.

The following three options have been identified for assessment:

- Option 1 - Bubble trading scheme
- Option 2 - Negotiated licensing offsets
- Option 3 - Formal offset trading scheme

A bubble trading scheme usually involves setting an aggregate pollution reduction target for a small number of sources. Where the sources are owned by the same entity, this can be achieved through a single bubble license. Given that the two major sources are independent entities, a bubble scheme would involve setting new nutrient reduction targets for each licensee and allowing trading arrangements to be negotiated between them.

The option of negotiated licensing offsets would also involve setting new individual nutrient reduction targets for Bolivar and Penrice and allowing either to negotiate offsets between themselves *or* from other point or diffuse sources (subject to a set of offset rules).

A formal offset trading scheme would establish a total allowable level of nitrogen discharges to the Port Waterways equivalent to the WQIP target, and allocate rights for a proportion of this total to each liable party in the scheme. Given identified nitrogen sources, liable parties may be restricted to Bolivar, Penrice, and new development. It is possible that a zero rights allocation could be provided to new development - effectively mandating a 'no net discharge' requirement. These schemes have also been characterised by the scheme manager sponsoring the development of offsets from parties without a formal liability (such as diffuse sources) and on-selling them to liable parties. Alternatively, private brokers or 'Offset banks' may provide this role. These arrangements can be important to provide 'liquidity' in the market, so that for example new developments are provided greater certainty that their liabilities will be able to be met on a timely and cost-effective basis.

However formal offset trading schemes are typically used where there are a large number of trading parties and transactions, and to lower administrative and transaction costs trading is more 'rules-based'. While such a scheme is clearly not suited to the circumstances of the Port Waterways, it is included so as to scope the maximum potential benefits from trade.

Table 9 shows the key features of the three options to be assessed.

Table 9: Key features of options

	Bubble trading scheme	Negotiated licensing offsets	Formal trading scheme
Participants	Bolivar and Penrice	Bolivar, Penrice, other point and diffuse sources eg. market gardens, councils, farmers in NAB catchment	Bolivar, Penrice, other point and diffuse sources eg. market gardens, councils, farmers in NAB catchment
Legal obligations	Individual nutrient reduction targets set in Bolivar and Penrice licences (with trade allowed between them)	Individual nutrient reduction targets set in Bolivar and Penrice licences (with offsets allowed to achieve them)	Individual nutrient reduction targets set in Bolivar and Penrice licences and no net discharge for new developments (with use of offset scheme allowed to achieve them)
Regulatory framework	Under existing licensing system	Amendments to licensing regulation required.	New regulatory framework required. Scheme manager could be SA EPA or third party.
Enforcement	Enforcement under existing licensing system. No changes required.	Enforcement under existing licensing system. Enforcement activities would need to be extended to cover off-site nutrient reduction.	Scheme manager would need to have powers to monitor approved offsets and enforce compliance.

5.2 Criteria for assessing options

All options would be crafted to provide the same environmental outcome. The following criteria have been developed for assessing their performance:

- efficiency – this will be measured by examining the overall cost under each option to achieve the specified nitrogen reduction target (explored in detail in section 5.3).
- compliance flexibility – the greater the flexibility for liable parties to meet nutrient reduction requirements the lower the compliance costs for each liable party (and overall)

- administrative simplicity – this takes into account the information required to establish and administer the instrument and whether the instrument can integrate well into existing regulatory and administrative arrangements or whether there is a need for legislative or regulatory change
- stakeholder acceptance – this considers the likely level of acceptance from relevant stakeholders including licensees and the broader community.

5.3 Costs of options

This section presents the refined analysis of the costs of the three options outlined in section 5.1 as well as the following two regulatory options:

- Penrice required to reduce total target
- Bolivar and Penrice given licensing targets based on current load shares.

The compliance costs under the negotiated licensing offsets and formal offset trading scheme will be the same, and so the analysis reports these under the term 'offsets'. Appendix D provides the cost assumptions for the analysis.

Table 10 below shows the costs of instrument options if all environmental issues are considered equally important. The environmental equivalence between Bolivar and Penrice discharges of 4.5 is based on draft equivalence relationships (as discussed previously) and assumes all environmental issues are considered equally important. The equivalence means that 1 tonne of nitrogen from Bolivar is likely to have the same environmental impact as 4.5 tonnes from Penrice. All instrument options provide the same environmental outcome - equivalent to reducing 215 tonnes per year from Penrice.

Under the 1st regulatory option, Penrice is required to reduce all 215 tonnes per year. Under the 2nd regulatory option with licensing targets based on current load shares, Penrice must reduce 159 tonnes per year and the remainder comes from Bolivar (equivalent to 12 tonnes per year at Bolivar with an environmental equivalence of 4.5).

On a per tonne basis it is cheaper to reduce nitrogen at Penrice rather than Bolivar. However, at an environmental equivalence of 4.5 it becomes cheaper to reduce a certain amount from Bolivar (around 65 tonnes based on estimated cost structures). Beyond this amount, it becomes cheaper to reduce nitrogen at Penrice even after the environmental equivalence is taken into account.

Under a bubble, there would be an incentive to trade, and it would be cheaper for Bolivar to make all the required reductions (around 48 tonnes per year at Bolivar). Under an offset scheme, the reductions at diffuse sources would be cheapest, however they would achieve only a very minimal reduction and the remainder would be cheapest at Bolivar. The outcomes of the bubble and offset approaches are therefore very similar.

Table 10 Analysis results for options – environmental issues equally important

	Bolivar : Penrice trading ratio	Point : Diffuse trading ratio	Cost ($m)
Regulatory (licensing) options			
(i) Penrice to reduce total target	n/a	n/a	$17m
(ii) Bolivar & Penrice share target based on current load shares[1]	n/a	n/a	$13m
Trading instruments			
Bubble	1 : 4.5	n/a	$10m
Offsets	1 : 4.5	1 : 83	$10m

1 Under this option, Bolivar must meet 26% of the target (56 tonnes), but the actual reduction required is only around 12 tonnes taking into account the environmental equivalence of 1:4.5 if all issues are considered equally important.

Trading is estimated to result in cost savings of around $7m compared to an individual target requiring the total load reduction from Penrice. The savings from trade are around $3m compared to the option of licence targets based on current load shares. There is only a minor difference in the costs of meeting the target under a bubble or offset program, due to the small loads from diffuse sources.

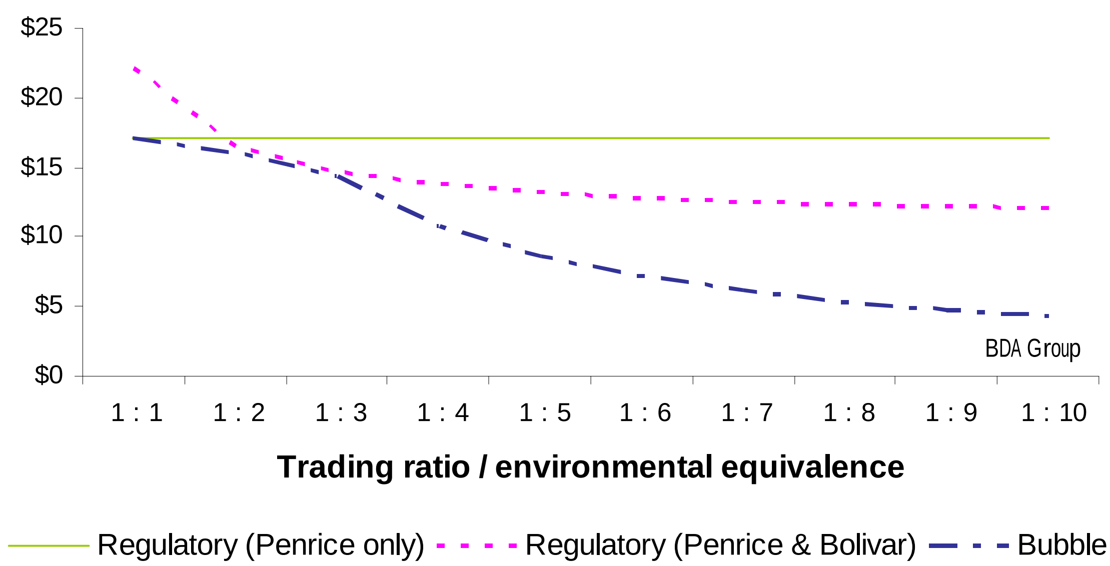
Table 11 below shows the total costs under a bubble trading scheme if different environmental issues are considered more important and trading ratios are adjusted accordingly (based on the weightings outlined in Appendix E).

Table 11 Analysis results for bubble – varying importance of issues

	Trading ratio	Bubble Cost ($m)	Cost saving compared to regulatory approaches ($m)	
			(i) All Penrice	(ii) Bolivar & Penrice
Toxic blooms most important	1 : 2.75	$15	$2	$0.06
Phytoplankton most important	1 : 3.75	$11	$5.5	$2.5
Macroalgal blooms most important	1 : 4	$11	$6.3	$3
Mangroves or seagrass most important	1 : 6	$7	$9.9	$5.6

Figure 7 below explores how the costs of options change as environmental priorities change and as expressed via adjustments to the trading ratios (used for a bubble) and environmental equivalence (used for the regulatory option involving both Penrice and Bolivar).

Figure 7: Costs of options ($m)



In Figure 7, the line representing the cost of the regulatory option with all reductions required from Penrice is horizontal and fixed as it is not dependent on environmental equivalence or a trading ratio. The sloped lines represent options that are dependent on the trading ratio or environmental equivalence. Under the regulatory option involving Penrice and Bolivar, the load reductions required are calculated using the environmental equivalence. Under the bubble trading scheme, the trading ratio (along with cost) determines where it is cheapest to reduce nitrogen loads.

Under a bubble with low trading ratios, it is cheaper for Penrice to reduce nitrogen than Bolivar and the outcomes are similar to requiring Penrice to make all the reductions. The regulatory option involving both Penrice and Bolivar has a higher cost than the other options, because Bolivar is required to make some reductions even though the costs are higher.

At an environmental equivalence and trading ratio of 1:2, the loads reduced under the regulatory option involving Penrice and Bolivar and the bubble trading scheme are similar resulting in similar costs.

As the environmental equivalence increases, the load reduction required from Bolivar for each tonne of the target becomes lower (as the target is set as Penrice equivalent tonnes). This reduces the cost of the regulatory option involving both Penrice and Bolivar by directly reducing Bolivar's costs. Under the bubble trading scheme, the higher trading ratios mean it is cheaper for Bolivar to make the reductions and the load reduction required from Bolivar becomes lower. For both these options, the stepwise reductions in load related to the cost differentials are smoothed as the increasing trading ratio progressively reduces the size of the reduction needed at Bolivar.

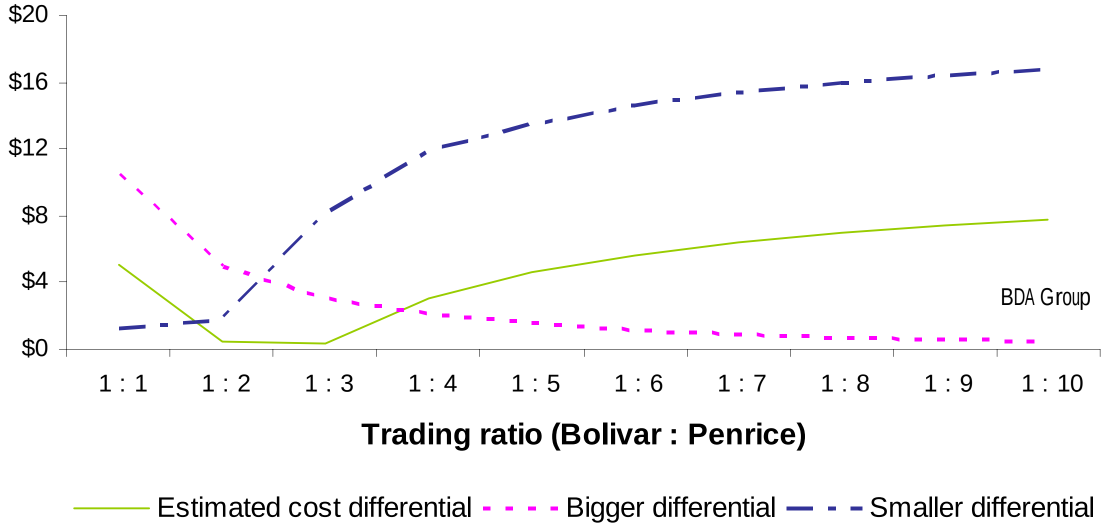
The figure shows that the ability to trade nitrogen abatement effort under a bubble arrangement becomes increasingly important to reducing overall compliance costs as the trading ratio increases. Higher trading ratios would be associated with mangroves and/or seagrass being the most important environmental priorities. However there is a greater risk involved in setting a higher trading ratio and this is explored further in the section below on confidence in the environmental equivalence relationships.

5.4 Sensitivity of estimated cost savings from trade

As shown above, the cost savings from a trading instrument will depend on the trading ratio and the difference between abatement costs for Penrice and Bolivar. Figure 8 below presents the impact of a bigger and smaller cost differential on the likely cost savings from trade. The cost savings have been calculated by comparing the cost of regulatory option involving both Bolivar and Penrice (at varying environmental equivalence) to the cost of a bubble (at varying trading ratios).

The first line in the legend shows the cost savings based on current estimates of costs for Penrice and Bolivar. The line dips down towards zero at the environmental equivalence/trading ratio of 1:2. This is because the loads reduced by Bolivar and Penrice under the regulatory option and bubble trading scheme are similar and therefore the cost savings are minimal.

Figure 8: Cost savings from trade ($m)



The kinks in the lines show a change in the direction of trade. At a trading ratio of 1:1 it is cheaper to reduce nitrogen at Penrice and the entire target reduction is made at Penrice. At higher trading ratios it becomes cheaper to reduce nitrogen at Bolivar and the direction of trade changes. Where there is trade, there are gains compared to a regulatory approach. The nature of the gains is dependent on the size and direction of trade.

The cost savings from trade will also vary depending on the environmental target chosen because a larger target may mean the licensees are on a different part of their abatement cost curve. Table 12 shows the estimated cost savings for different environmental targets based on current cost assumptions and assuming an environmental equivalence between Bolivar and Penrice of 1:4.5.

Table 12 Cost savings for different environmental targets

Nitrogen reduction target	Approximate Cost saving ($m)	Load split under bubble	Explanation
WQIP target of 215 in *Penrice equivalent* tonnes (or 48 Bolivar tonnes)	$3m	Penrice 0% Bolivar 100%	Under a bubble to meet this target, Bolivar would reduce a lot more and Penrice less compared to the regulatory option (involving both Bolivar and Penrice). Bolivar would actually reduce the whole nitrogen target under the bubble. This is because the initial reductions from Bolivar are cheaper with an environmental equivalence of 4.5. Neither Bolivar nor Penrice would need to go into the higher part of the cost curve under either option to meet a target of this size. As a result the cost savings are relatively small.
WQIP target of double the above (430 Penrice or 96 Bolivar equivalent tonnes)	$12m	Penrice 67% Bolivar 33%	Under a bubble to meet this target, similar to above – Bolivar would reduce more and Penrice less compared to the regulatory option. However, Penrice would need to go into the higher part of the cost curve under the regulatory option but could avoid this under a bubble. As a result the cost savings are greater.
WQIP target of 215 in *Bolivar equivalent* tonnes[1] (or 968 Penrice tonnes)	$3m	Penrice 91% Bolivar 9%	Under a bubble to meet this target, the nitrogen reductions would be similar to the regulatory option, with Bolivar making small reductions and Penrice providing the rest of the reductions. As a result the cost savings are relatively small.

1 Note that it is uncertain whether Penrice could make the reductions assumed in the analysis under this option in the timeframe. It would require a nitrogen reduction of around 80% of current levels under either the regulatory option or bubble.

Another consideration is the level of confidence in the environmental equivalence relationships and the consequences of getting them wrong. Table 13 below shows the percentage of the environmental outcome that would be achieved under a bubble trading scheme if the trading ratio did not reflect the true environmental equivalence. The environmental outcome is calculated as Penrice equivalent tonnes of nitrogen reduced. The percentage of environmental outcome achieved is the “real” outcome of the bubble (based on the true environmental equivalence) as a proportion of the “target” outcome (based on the trading ratio).

Table 13 Uncertainty and Environmental Outcomes

Bolivar : Penrice					Environmental equivalence					
Trading equivalence	1 : 1	1 : 2	1 : 3	1 : 4	1 : 5	1 : 6	1 : 7	1 : 8	1 : 9	1 : 10
1 : 1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1 : 2	91%	100%	109%	119%	128%	137%	147%	156%	165%	174%
1 : 3	40%	70%	100%	130%	160%	191%	221%	251%	281%	312%
1 : 4	25%	50%	75%	100%	125%	150%	175%	200%	225%	250%
1 : 5	20%	40%	60%	80%	100%	120%	140%	160%	180%	200%
1 : 6	17%	33%	50%	67%	83%	100%	117%	133%	150%	167%
1 : 7	14%	29%	43%	57%	71%	86%	100%	114%	129%	143%
1 : 8	13%	25%	38%	50%	63%	75%	88%	100%	113%	125%
1 : 9	11%	22%	33%	44%	56%	67%	78%	89%	100%	111%
1 : 10	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%

As an example of the results, if a trading ratio of 1:4 is chosen, this would allow a 0.25 tonne reduction at Bolivar to meet a 1 tonne reduction requirement at Penrice. However if the true environmental equivalence was 1:2, then a 0.5 tonne reduction at Bolivar is really needed to provide an equivalent environmental outcome as a 1 tonne reduction at Penrice. Therefore for each tonne traded only 50% of the desired environmental outcome will be achieved. Under the assumed environmental target and cost functions, a bubble scheme with a trading ratio of 1:4 would see Bolivar undertake all nitrogen reductions and so the overall environmental outcome will also be 50% of the target.

Alternatively, if a trading ratio of 1:2 was chosen, when the real environmental equivalence was double (1:4), then trading would provide twice the intended environmental outcome on a tonne for tonne basis. Under the assumed cost functions, a bubble scheme with a trading ratio of 1:2 would see Bolivar undertake only some of the nitrogen reductions, with the overall environmental outcome estimated to be 119% of the target.

The shaded diagonal line in Table 13 shows that where the trading ratio matches the environmental equivalence the trading scheme achieves the target outcome. Below this line, the trading equivalence is higher than the environmental equivalence and there is a gradual reduction in the proportion of the target outcome achieved in each column. The greater the difference between the trading equivalence and environmental equivalence the worse is the outcome.

Above the shaded line, the trading equivalence is lower than the environmental equivalence. The outcome peaks at a trading ratio of 1:3 then reduces down to 100% in each column. This is because the trading ratio of 1:3 results in the greatest physical tonnage reduction from Bolivar (of 65 tonnes per year). At trading ratios lower than 1:3 Penrice does some of the work and at trading ratios higher than 1:3 the reduction required from Bolivar to meet the target is progressively lower.

Table 13 shows that if the target is set as Penrice equivalent tonnes then a conservative trading ratio provides more confidence that the intended environmental outcome will be achieved, but increases the likelihood (and associated costs) of over-compliance relative to nitrogen reductions that may be needed to meet environmental targets. If the target is set as Bolivar equivalent tonnes, then a higher trading ratio provides more confidence, but also increases the likelihood of over-compliance.

5.5 Comparative assessment of options

This section provides an assessment of the three main options against the criteria outlined in section 5.2. The options are compared to the option of prescriptive individual targets for Bolivar and Penrice (50% each). The assessment draws on the results of section 5.3 relating to the costs of options. The information is based on the scenario assuming all nutrient issues are of equal importance in the Port Waterways catchment.

5.5.1 Bubble trading scheme

A bubble trading scheme is an efficient instrument for achieving the nutrient reduction target. Compared to setting individual targets it is likely to reduce compliance costs. A bubble scheme offers compliance flexibility by allowing the two major point sources to trade to achieve their nutrient reduction targets. A bubble scheme would offer administrative simplicity as it would integrate well into the current licensing framework (particularly with the current move towards load based licensing). The level of work involved in establishing the initial targets in licences and administering the licences would be similar to the option of setting prescriptive targets. There would be some additional work involved in determining rules for trading and including these in licences.

The issue of acceptance by the SA community has been raised in the context of a trading instrument that may result in a publicly owned entity (SA Water re Bolivar) paying industry (Penrice) to reduce nutrients. It can be shown that a bubble has the potential to reduce the costs of Bolivar meeting its regulatory requirements. However, it is clear that this issue would need to be addressed through community consultation before a bubble could be introduced.

5.5.2 Negotiated licensing offsets

Negotiated licensing offsets are expected to be marginally more efficient than a bubble trading scheme. Negotiated licensing offsets offer greater compliance flexibility than a bubble trading scheme by allowing the two major point sources additional opportunities to trade (either with other point or diffuse sources). Negotiated licensing offsets would also integrate well with the current licensing framework. The initial level of work involved in establishing targets in licences would be similar to that for a bubble trading scheme. There would be some additional work in determining appropriate offset rules (to cover a wider range of sources as required) and in approving offsets and monitoring compliance with any offset arrangements. The resources would be greater for any offset arrangements involving unlicensed activities.

Similar to the bubble trading scheme, there would be an issue of acceptance by the SA community if Bolivar provided funding to Penrice to reduce nutrients and this issue would need to be addressed through community consultation prior to the introduction of negotiated licensing offsets.

5.5.3 Formal offset trading scheme

A formal offset trading scheme would also provide some efficiencies in achieving the nutrient reduction target. It would provide similar outcomes to negotiated licensing offsets in terms of reducing costs. A formal offset trading scheme would offer compliance flexibility by allowing participants to arrange approved offsets or purchase offsets from a scheme manager. The administrative complexity of a formal offset scheme would be greater than other options. It is also likely to require regulatory changes, for example, to establish a scheme manager and set out common trading, monitoring and enforcement rules. The level of work involved in establishing and running the scheme would be substantially greater than for a bubble or negotiated licensing offsets.

Similar to the other trading instruments, there would be an issue of acceptance by the SA community if Bolivar were to pay Penrice to reduce nutrients and this issue would need to be addressed through community consultation prior to the introduction of a formal offset scheme.

5.5.4 Comparative assessment

Table 14 summarises the assessment of options against the criteria set out in section 5.2. All three options involving trade are likely to be a more efficient way of reaching the nutrient reduction target compared to prescriptive targets. The options involving offsets are likely to be slightly more efficient than a bubble as a greater number of sources could be involved. However, in the short term the number of sources participating is expected to be small.

Prescriptive targets do not provide any flexibility for the major point sources. Negotiated licensing offsets and the formal offset trading scheme offer the greatest flexibility, allowing the major point sources to take up any lower cost opportunities for reducing nutrients from both point and diffuse sources in the future.

The administrative costs of the formal offset trading scheme would be much greater than for the other options that can all be implemented through the existing licensing framework. Individual targets would be the simplest approach. However, the additional administrative costs of implementing a bubble or negotiated offsets are not likely to be large.

For all trading options the issue of acceptance by the SA community has been identified as a potential concern and would need to be addressed through community consultation prior to the introduction of any trading instrument.

Table 14: Comparative assessment of options

	Individual targets (50%)	Bubble trading scheme	Negotiated licensing offsets	Formal offset scheme
Efficiency in meeting target	n/a	✓	✓✓	✓✓
Compliance flexibility	n/a	✓	✓✓	✓✓
Administrative simplicity	✓✓✓✓	✓✓✓	✓✓	✓
Stakeholder acceptance	✓✓	✓	✓	✓

Notes: The ticks in the table represent the extent to which each option meets the criteria compared to the other options.

If the costs of abating nitrogen were known then the EPA could set individual targets for Bolivar and Penrice at a point which maximises environmental outcome and minimises costs. However, costs are not known and there is the potential that this approach would lead to much greater compliance costs to meet the target. It would not provide any flexibility to the major licensees, and would not be able to adapt to changing circumstances.

Compared to the option of a regulatory approach via mandated nitrogen reductions for each licensee, a trading instrument is likely to provide some cost savings. It will also provide more flexibility to licensees as well as more certainty for the EPA that the lowest cost solution will be pursued. The estimated savings with a bubble trading scheme, seeking a 215 tonne reduction in *Penrice equivalent* nitrogen and under the assumed cost and trading ratios is only $3m. This saving could be greater if a larger tonnage of nitrogen had to be reduced overall. For example, if the target reduction was doubled to 430 tonnes per year in *Penrice equivalent* nitrogen, then the saving is estimated at around $12m.

The analysis has highlighted a trade-off between uncertainty over compliance costs and scientific uncertainty on nitrogen reductions needed to achieve environmental goals and in relation to the environmental equivalence of different nitrogen sources. The problem is compounded if consideration of the more uncertain sources (such as dredging, thermal pollution, etc) were to be included.

One of the key reasons for pursuing a tradeable discharge rights approach is that the market works out the best way to meet the target. This saves government trying to estimate the cost structures of the key players. While there are significant uncertainties relating to costs, this is a good reason to embrace a trading approach. Scoping the context of the scheme (as has been done is this project) is necessary to provide guidance on what sort of scheme is appropriate, rather than to predict exactly who would do what.

In terms of compliance costs, there is no downside from introducing a trading approach. However, there can be a downside for the environment, with a potential to undershoot on the environmental outcome. The science underpinning any scheme is therefore very important. Once the Water Quality Improvement Plan and modelling work has been developed, the EPA will be better able to assess the likely magnitude of the nutrient reduction required and the environmental equivalence relationships.

The analysis suggests that in certain circumstances the gains from trade may be modest. This suggests a scheme with small set up costs is appropriate. Given the small number of sources likely to be involved in trading, the administrative costs of a formal offset scheme are likely to outweigh the benefits. Negotiated licensing offsets can provide all the gains of a formal offset scheme without the extra setup costs or ongoing complexity in administration.

The two most promising options are a bubble trading scheme and negotiated licensing offsets. Negotiated licensing offsets provide more compliance flexibility and have the potential to achieve the nutrient target more efficiently. Based on currently available information there is only a small load contribution from diffuse sources and limited abatement potential, meaning that the cost of these two options is expected to be similar. The administrative costs of negotiated licensing offsets would be slightly higher if offsets outside of Bolivar or Penrice were sought – however this is only likely where significant reductions in compliance costs is anticipated. Hence the additional benefits are likely to outweigh the additional costs. Given there are uncertainties about nutrient loads and the opportunities to reduce nutrients from a range of uncertain sources, it may be worthwhile providing the extra flexibility offered by negotiated offsets to licensees.

Moreover, through signalling the potential for offsets beyond the two key point sources, the EPA will foster a cultural change to seeking cost-effective environmental gains wherever they may lie. This will harness the business acumen of both SA Water and Penrice towards investigating innovative low-cost offset opportunities. This may for example, lead to the identification and realisation of a diffuse or uncertain nitrogen reduction source that the EPA alone may find difficult to achieve.

5.6 Recommended instrument – negotiated licensing offsets

Negotiated licensing offsets will involve setting new individual nutrient reduction targets for Bolivar and Penrice and at the same time establishing a new provision under the licensing scheme to allow any licensee to negotiate offsets at other point or diffuse sources to meet new nutrient reduction targets.

The policy framework to support negotiated licensing offsets will be much more straight-forward than that required for a formal offset scheme. In the case of the latter, rules would need to be crafted in relation to offset credit metrics, credit duration, ownership and trading the potential for advance crediting, credit banking and borrowing, financial assurances, penalty regimes, and so. In the case of negotiated offsets, these issues can be assessed on a case by case basis and tailored to the specific circumstances. This flexibility is perhaps the greatest advantage of this approach.

Nevertheless, broad principles to be followed and guidance in crafting offset terms and conditions will be needed. These are discussed in the following sections.

6 POLICY FRAMEWORK AND PRINCIPLES FOR NEGOTIATED LICENSING OFFSETS

This section outlines the proposed policy framework for negotiated licensing offsets, including the legislative basis, nitrogen reduction target, the liable parties and their obligations under the proposed scheme. It also covers the proposed principles for implementing negotiated licensing offsets.

6.1 Legislative basis

The legislative basis for using negotiated licensing offsets to achieve the nitrogen reduction target could be established in the Environment Protection (General) Regulation 1994 or in the Environment Protection (Water Quality) Policy 2003 (both operate under the Environment Protection Act 1993). Administrative implementation could occur through the current licensing system.

Load reduction requirements for nitrogen loads would need to be established for the liable parties. These could be established as new licence conditions or as new discharge limits in Schedule 3 of the Environment Protection (Water Quality) Policy 2003. There are currently no discharge limits in Schedule 3, however, it is intended to be used in the future to set load allocations. Setting new licence conditions would be simpler, however, given the significance of the reductions required a formal amendment to the policy would be more transparent and may be considered more appropriate.

A regulatory provision would also be needed to allow "offset credits" issued by the EPA to contribute towards meeting load limits (either established in Schedule 3 or in any licence). Either the Environment Protection (General) Regulation 1994 or Environment Protection (Water Quality) Policy 2003 could be amended to include this. The provision would also state that an offset credit could be earned by reducing nitrogen off-site, from another source within the Port Waterways catchments. The amendment would set out the circumstances under which the EPA could issue an offset credit to a licensee.

It may also be necessary to amend Regulation 11 of the Environment Protection (Fees and Levy) Regulations 1994 to allow any future load based licence fees to be based on the "net" nitrogen load (the on-site nitrogen load less the amount of any offset credits earned).

6.2 Nitrogen reduction target

As discussed earlier, the nutrient targets for Port Waterways have not been set yet. An illustrative target is used for describing the policy framework. The target is a 50% reduction in nitrogen on current loads from all sources by 2010/11, yielding a residual load of 891 tonnes per year. This will require a reduction of 215 tonnes per year of nitrogen from the liable parties (being the 356 tonne reduction required from business as usual loads less the 141 tonnes assumed to be achieved at Bolivar to meet the equivalent phosphorus target).

As discussed earlier, to ensure the environmental outcomes of meeting the target are fixed, the target must be set in terms of either Bolivar or Penrice *equivalent* tonnes of nitrogen. For illustrative purposes the target is defined as 215 *Penrice equivalent* tonnes of nitrogen.

It may be considered appropriate to phase in the new requirements by setting interim targets. However, current EIPs already do this to some extent.

6.3 Liable parties and obligations

The liable parties would be the two major contributors to nitrogen loads in the Port Waterways catchment: SA Water's Bolivar sewage treatment plant and the Penrice soda plant.

Their obligation could be based on sharing the reduction in nitrogen load proportionate with their current contribution to nitrogen loads. The current loads are 544 tonnes per year from Bolivar (383 tonnes per year + the 161 tonnes per year diverted from the Port Adelaide WWTP) and 1,100 tonnes per year from Penrice (see Map 1). The current shares are therefore 33% from Bolivar and 67% from Penrice.

Bolivar would be required to reduce the nitrogen load by an additional 71 *Penrice equivalent* tonnes per year by the year 2010/11 (beyond current programs). Penrice would be required to reduce its nitrogen load by an additional 144 *Penrice equivalent* tonnes per year by 2010/11 (beyond current programs).

Table 15 below summarises the obligations for liable parties. The bottom row shows the load limit that would be included as a licence condition.

Table 15: Obligations for liable parties

	Bolivar	Penrice
Current loads 2003 / 04	544	1,100
Estimated reduction from current programs by 2010 / 11	65	300
Additional reduction required to meet share of target	24[1]	144 Penrice equivalent
Load limit for 2010 / 11	**455**	**656**

Source: Eco Management Services report on the draft WQIP Improvement Plan and licensee industry monitoring report cards

Notes: 1 This is equivalent to 71 *Penrice equivalent* tonnes based on the proposed trading ratio of 1:3 for trades between Bolivar and Penrice (outlined in section 7.4 below)

6.4 Scheme principles

A recent set of trading principles were established for the Pollution Reduction Trading Scheme for South Creek in NSW. The scheme includes a provision for licensing offsets to meet current or future load limits (similar to the proposal for Port Waterways). The relevant principles are:

- All standard regulatory requirements must still be met.
- The scheme must not reward poor environmental performance.
- The scheme will complement other government programs.
- The scheme aims to achieve a net environmental improvement.

The USEPA Water Quality Trading Policy Statement identifies a number of common elements of credible trading programs which are also relevant for the Port Waterways situation. These are:

- Clear legal authority and mechanisms for trade
- Clearly defined units of trade
- Corresponding creation and duration of credits
- Ensuring uncertainty is managed, for example, through monitoring, trading ratios, conservation assumptions regarding effectiveness of measures, using site-specific discount factors or retiring a proportion credits.
- Compliance and enforcement provisions using a combination of record keeping, monitoring, reporting and inspections
- Public participation and access to information
- Program evaluations

Some of the principles outlined above are not relevant in the Port Waterways context as they are intended to manage the impacts of new development, rather than achieve reductions in pollution from licensed sources.

Key principles recommended for negotiated licensing offsets for the Port Waterways are:

I. Offsets must result in an equivalent water quality outcome to the liable party meeting its nitrogen reduction target. To ensure an equivalent outcome, offsets must be based on ratios that account for environmental equivalence, risk and uncertainty.

II. All standard regulatory requirements must still be met.

III. Minimum standards for offset providers will be used to ensure the scheme does not reward poor environmental performance.

IV. All parties will be kept accountable to make sure offsets achieve their objectives.

V. Offsets should not be approved if they may lead to another negative environmental outcome.

7 PROCESS FOR NEGOTIATED LICENSING OFFSETS

This section provides the proposed process for negotiated licensing offsets from creation through to enforcement. It outlines the overall process, responsibilities of key players, trading arrangements and monitoring, verification and enforcement activities.

7.1 Overall process

The process for offset creation and enforcement is outlined in the following five steps:

Step 1 The licensee approaches offset providers to determine how much nitrogen could be reduced by the provider and the likely cost and timeframe. If a suitable opportunity arises, the licensee prepares a *draft offset proposal* and submits it to the EPA. The draft offset proposal must include the name and location of the offset provider, the nitrogen abatement technique, the estimated magnitude and timing of nitrogen load reductions, the basis for estimating nitrogen reductions, proposed monitoring methods and a reporting schedule.

Step 2 The EPA evaluates the *draft offset proposal* and provides feedback or preliminary approval. In some circumstances, the EPA may undertake a site inspection of the proposed offset provider to assess the suitability of the proposal (for example, where the provider is not a licensed premise). If preliminary approval is given the EPA indicates what trading ratio would be applicable, taking into account the nature and location of the sources of nitrogen and the uncertainties involved.

Step 3 The licensee prepares an *offset plan* that includes the name and location of the offset provider, the nitrogen abatement technique and associated maintenance activities, the estimated magnitude and timing of nitrogen load reductions, the approved trading ratio, proposed monitoring methods, a reporting schedule and a contingency plan. The contingency plan must outline what actions would be undertaken to ensure licence limits are met. The licensee establishes a *contractual agreement* with the offset provider. The licensee provides the EPA with the *offset plan* and a copy of the *contractual agreement* (omitting confidential commercial components if necessary).

Step 4 The EPA formally approves the offset plan under the licensing system as an attachment to the licence. The licensee has sole responsibility for ensuring the plan is implemented, including ensuring that monitoring is carried out, and reporting to the EPA on outcomes under the offset plan. If the monitoring shows that nitrogen abatement is lower than originally estimated, the licensee is responsible for arranging alternative actions to meet its licence conditions.

Step 5 The EPA reviews reporting from the licensee on the offset plan as part of its review of the annual licensing return, including review of monitoring results. The EPA may also verify the loads reduced by the provider through an annual inspection. If necessary, the EPA may seek independent review of quality assurance to verify the magnitude of the reduction in nitrogen. The EPA takes into account the loads reduced under the offset plan in assessing compliance with licence conditions (including meeting pollution reduction targets).

The box below summarises the responsibilities of the key players throughout the process.

Summary of responsibilities for negotiated licensing offsets

A *licensee* is responsible for ensuring the performance of offsets, negotiating non-performance arrangements with offset providers (such as financial assurances) and ensuring compliance with licence conditions.

An *offset provider* is responsible for meeting the terms of the contractual agreement with the licensee including carrying out abatement actions to reduce nitrogen as well as meeting any monitoring and reporting requirements under the contract.

The *EPA* is responsible for considering, providing feedback and, where appropriate, approving offset plans and taking into account the loads reduced under an approved offset plan in assessing compliance with licence conditions

7.2 Trading arrangements

Trading is to be undertaken on a bilateral basis under commercial arrangements between liable parties and offset providers.

Notwithstanding the EPA's role in approving offsets, liable parties are solely responsible for ensuring the performance of offsets and negotiating non-performance arrangements with offset providers.

Where an offset fails to provide anticipated nutrient reductions, only realised reductions will be credited to the liable party holding the offset. The liable party will be responsible for ensuring alternative arrangements for compliance with licence conditions.

7.3 Monitoring, verification and enforcement

Some early offset schemes, including the wetland offsets in the US, focused primarily on offset initiation without adequate follow-up monitoring and offset failure was common. Monitoring and enforcement may be undertaken using a combination of record keeping, estimation, verification, monitoring, reporting and inspections.

Proposed estimation or monitoring techniques for offset measures need to be reviewed by the EPA before an offset is approved to ensure they are reliable and robust. If necessary, independent verification could be sought by an external expert.

Once the offset is approved, regular reporting should be required through the licensing system. Rigorous assessments of compliance with licence conditions will be needed where offset measures are contributing to compliance. This will include review of estimation/monitoring results, inspections at critical points and where necessary, independent verification of outcomes achieved.

Failure of a liable party to meet licence limits for the discharge of nitrogen, through either on-site management action or offsets, will lead to a breach in licence conditions and the licensee will be subject to existing penalty provisions.

8 GUIDANCE FOR DEVELOPING OFFSET TERMS AND CONDITIONS

This section sets out guidance for developing offset terms and conditions in the context of the Port Waterways catchment. It covers who can provide offsets, the basis for approving them, minimum standards for offset providers, and proposed trading ratios.

8.1 Offset credit providers

Offset credits may be sourced from other licensed or unlicensed sources, subject to EPA approval. Unlicensed sources may include unlicensed commercial & industrial premises, urban development (such as in relation to stormwater management), diffuse agricultural sources or other sources. Discharges from offset credit providers must currently be into the Port Waterways, as defined by the Port Waterways Improvement Plan.

8.2 Approval of offsets

To be approved by the EPA, offset measures must meet certain criteria. The South Creek pilot pollution reduction trading scheme provides an example of a set of requirements for offset measures. Under this scheme, offsets must be enduring, quantifiable, targeted, located appropriately and supplementary. Each of the characteristics is discussed below.

The requirement for offsets to be *enduring* is to ensure that the duration of the benefits from the offset matches the impact of the development or licensee purchasing the offset. If a developer with a new long term impact were allowed to purchase a short term offset then the scheme would not provide an equal environmental outcome. In the context of the Port Waterways catchment, it is important that the duration and timing of the offset measure is such that the offset provides at least an equal environmental outcome compared with on-site abatement by the licensee purchasing the offset. While the timing of discharges has been taken into account in determining environmental equivalence, it is important that the EPA is satisfied for each case that an equivalent outcome will be provided. Credits may be issued in perpetuity or may have a specified expiry date in accordance with the timing of the reduction from the nitrogen source. Banking and borrowing is common under some trading schemes, however it is not appropriate in the Port Waterways context as compliance with the total nutrient target is necessary each year.

In most schemes there is a requirement that the outcomes of offsets are *quantifiable*. It is essential to be able to verify that the use of an offset by a licensee to meet a target provides an equivalent environmental outcome. In the context of the Port Waterways catchment this means the nitrogen reduction must be able to be reliably estimated. Where the cost of actually measuring nitrogen pollution is prohibitive (for example for some diffuse sources), there must be acceptable estimation techniques, such as robust models or generation factors available, as well as satisfactory verification techniques.

The requirement in the South Creek pilot scheme that offset measures are *targeted* refers to a requirement that the offset measure must address the same pollutant as the original impact. The Port Waterways scheme is proposed to include only one pollutant (nitrogen).

All schemes have some sort of boundary within which offset measures can be *located*. For example, in the US Wetlands Banking Scheme, offsets must be within defined service areas of similar climate and ecosystem type. In the Port Waterways situation, environmental equivalence relationships have been established for key sources of nitrogen across the catchment area as a whole. While the impact of different sources on particular environmental issues differs, the major sources have an impact on all problems and it is not considered necessary to restrict trading within geographical parts of the Port Waterways area.

The requirement for offsets to be *supplementary* is essential to ensure any scheme does not reward poor environmental performance. The Sydney Drinking Water Catchment Offset scheme requires that '*an offset proposal cannot include pollution abatement measures if they are already required under federal, state or council legislation, or any other requirements, or if Government funds them. This includes measures required by an environment protection licence condition (including pollution reduction programs). Credit will not be given for work that would have happened anyway (eg. decommissioning a plant that was already scheduled for closure)*'. In the context of the Port Waterways catchment, offset measures must be beyond current regulatory requirements, including any licence conditions, environment improvement programs or provisions of the Environment Protection Water Quality Policy 2003. In addition, they should not already be credited or funded under another scheme.

The box below summarises the characteristics of offsets required for approval in the Port Waterways context.

Nitrogen offsets in Port Waterways must be:

Equivalent in duration/timing – the duration/timing of the nitrogen reduction from the offset must be equivalent to that of the licensed source.

Quantifiable – the nitrogen reduction from the offset must be able to be reliably estimated.

Located appropriately – the measures must reduce a source of nitrogen located within the Port Waterways catchment area.

Supplementary – beyond current regulatory requirements and not credited or funded under another scheme

8.3 Duty of care or minimum standard

Most trading or offset schemes set out a duty of care or minimum standard that offset providers must meet before they can participate in an offset or trading scheme. The Duty of Care may reflect a performance level better than required under legislation or government requirements, but reflects community expectations for environmental stewardship. By setting a Duty of Care, offset credits will not be issued for nitrogen reduction activities that the community believes should already have been realised. The EPA could require a minimum level of nutrient management by offset providers in the Port Waterways, from which additional abatement may be approved for offset purposes.

The USEPA has set baselines for pollution reduction credits in its 2003 Water Quality Trading Policy Statement. It recommends that the baseline for point sources is established by the applicable water quality based effluent limitation, a quantified performance standard or a management practice derived from water quality standards. The baseline for non-point sources is recommended as the level of pollutants associated with existing land uses and management practices that comply with applicable regulations.

The Sydney Drinking Water Catchments offset scheme envisages a ‘duty of care’ criterion for participating landholders. Landholders will be expected to demonstrate that they are meeting their statutory obligations and achieving at least minimum environmental standards before additional offsets can be located on their properties. Initially, the existence of an appropriate farm management plan may be taken as evidence that the landholder is meeting minimum environmental expectations.

In the Port Waterways context, any licensed point source generating offset credits should be complying with current licence conditions. There may also be a case for requiring a licensed point source to reach a satisfactory level of environmental performance before providing offsets, if this is not currently reflected in licence conditions. For example, where an environment improvement program is in place to improve performance this may need to be completed before offsets can be provided.

If the point source is not licensed, this could be based on the provisions in Part 4 of the Environment Protection (Water Quality) Policy 2003 covering the management and control of point source pollution. In the case of diffuse sources this could be based on the provisions in Part 5 of the same policy covering the management and control of diffuse sources of pollution. Diffuse sources could also be required to comply with any new measures included in proposed amendments to the Environment Protection (General) Regulation 1994.

Alternatively, separate minimum or benchmark levels of performance for particular activities could be established as a pre-requisite for creating offsets. However, a balance would be required because setting a high benchmark may actually discourage participation and reduce the opportunities to achieve improvements under the scheme. For example, reducing nitrogen runoff from market gardens was identified as a possible opportunity for offsets. Market gardeners could be required to meet certain best practice requirements or simply to demonstrate a commitment to the environment.

8.4 Trading ratios

Trading ratios between liable parties and offset sources will be used to ensure that any trading provides an equivalent environmental outcome. Trading ratios should account for three main issues:

- Environmental equivalence – different impacts from different sources taking into account their location, chemical form and timing of discharge
- Uncertainty in estimating current loads of nitrogen, and load reductions from measures to reduce nitrogen discharges
- The risk that an offset measure underperforms

Key ratios, such as between Bolivar and Penrice, need to be established from the outset and are explored further below. Trading ratios for other trades would be determined on a case-by-case basis to reflect differences in environmental equivalence, uncertainty with measurement and risks associated with offsets.

Most offset or trading schemes have a single ratio for all point source to point source trades. For example the Proposal for the South Creek scheme in NSW proposed a ratio of 1:1.5 for nutrient trading between point sources (an increase of 1 kilogram of nutrients at a point source has to be offset with a reduction of 1.5 kilogram at the point source providing the offset). The long term impact of nutrient discharges from any two point sources on the South Creek ecosystem was considered similar, suggesting a 1:1 ratio. However, the ratio was increased by 0.5 to account for the uncertainties and risks involved.

The Port Waterways situation is more complex as there is a more complex set of environmental issues to be addressed. There is also a substantial difference in the impact of different point sources depending on their location, chemical form and timing. The information on environmental equivalence (from section 4.2) can be used to represent the difference in impacts. There are also the measurement uncertainties and risks associated with offset measures, and the ratio should take these into account as well.

The proposed trading ratio for Penrice and Bolivar is based on the preliminary information on environmental equivalence using a weighted average of the results for all environmental issues. The equivalence between Bolivar and Penrice is estimated at 1:4.5. As the target is stated in Penrice equivalent terms, for Bolivar to achieve a 1 kilogram reduction in nitrogen (in Penrice equivalent tonnes) it only needs to reduce its discharge by 0.22 kilograms. It is suggested that this requirement is increased by half to account for the measurement uncertainties and risks associated with offsets. The trading ratio between Bolivar and Penrice would therefore be 1:3 (or 1:0.33 stated in Penrice : Bolivar terms). This assumes that all environmental issues are of equal importance to the community.

Proposed trading ratios for Port Waterways:

Trades between Bolivar and Penrice at 1:3 – 1 kilogram nitrogen abatement at Bolivar earns 3 kilograms of *Penrice equivalent* nitrogen

All other trades – determine on a case by case basis taking into account environmental equivalence, risk and uncertainty

During the development of the water quality improvement plan, it may become clear that environmental issues are not of equal importance. The EPA has indicated that of all issues, seagrass is the most likely to be of greater importance. If this was the case, the trading ratio between Penrice and Bolivar would need revision. Based on the priority weightings examined in this study where seagrass was allocated a higher weight, the environmental equivalence between Bolivar and Penrice would be 1:6. Taking into account measurement uncertainty and risk, the trading ratio between Bolivar and Penrice could be set at 1:4.

The proposed trading ratio between Bolivar and Penrice may also need to be adjusted if there are significant risks perceived to be associated with any proposed nitrogen abatement techniques.

Other trading ratios should be developed on a case by case basis taking into account environmental equivalence, uncertainties in estimation and risks associated with abatement techniques.

9 IMPLEMENTATION ISSUES

This section discusses implementation issues including consultation and recovery of administrative costs.

9.1 Consultation with stakeholders

Consultation with stakeholders will be essential prior to the introduction of negotiated licensing offsets. In NSW a series of discussion papers were prepared for community consultation on the use of economic instruments for environment protection, prior to the development of proposals for specific schemes.

Consultation with stakeholders and the community on negotiated licensing offsets needs to link into the consultation on the Water Quality Improvement Plan. Following development of the environmental targets under the plan and community acceptance of these, stakeholders need to be shown the likely merits of this approach compared to other policy alternatives to meet the targets.

At a minimum, the following parties need to be consulted on any proposal for negotiated licensing offsets:

- SA Water
- Penrice
- SA Industry Associations
- Environment groups
- Community groups

Consultation could occur through the preparation of a proposal for consultation or through the establishment of a reference group to provide input to the development of the mechanism. Alternatively, there may already be a suitable reference group established that could provide input (eg. a group established for input to the WQIP or LBL).

Given the perception that trading may result in a public authority paying industry for pollution improvements, consultation with community representatives is essential. Suitable forums would need to be sought to demonstrate the likely benefits of the approach in meeting the overall targets of the WQIP.

There has been some stakeholder resistance to the use of offset schemes in the past. Three key issues that would need to be addressed by the scheme are:

- Rewarding poor environmental performers – stakeholders would be concerned with any scheme that may allow poor environmental performers to be paid (through offsets) to bring their operations to a level already expected by the community. Clear minimum standards via an explicit Duty of Care and transparent processes can address this concern.

- Poor monitoring and enforcement by offset managers – some early offset schemes, including the wetland offsets in the US, focused primarily on offset initiation without adequate follow-up monitoring and offset failure was common. Clear monitoring and reporting requirements, backed up by penalties under the existing licensing system, and adequate resources for enforcement are essential for the proposed scheme.
- Potential for hot spots – hot spots occur where trading results in localised areas with high levels of pollution (around sources where abatement is more expensive). This is a concern with any scheme that allows an increase in pollution load (for example from a new development or expansion of a licensed activity) to be offset by measures elsewhere in a catchment.

There are a number of ways to ensure localised impacts do not arise – limiting offsets to regional areas, requiring more credits at greater distances between the trading sources and individual regulatory review of offset proposals (Morrison 2002). In the Port Waterways situation, there are already two very large sources of nitrogen and the local impacts of these sources are currently controlled through licence conditions. As the primary role of the offset provision is to provide flexibility to these two sources to meet new nitrogen reduction targets, the hot spot issue is not as relevant. If negotiated licensing offsets were used in the future to allow a licensed source to stay within its load limit while expanding capacity and discharges, then potential localised impacts would need to be considered in the offset approval process.

9.2 Administrative costs

There will be some setup costs to make the regulatory and administrative changes required to implement the negotiated licensing offsets under the current system. It is likely to require a dedicated project manager for six months to develop the regulatory amendments and undertake consultation.

The ongoing costs of administering the scheme include the costs of reviewing and approving offset proposals and plans and auditing and enforcement functions. The costs could be recovered by increasing the administrative licence fee for licensees with offset plans. This would require an amendment to the Environment Protection (Fees and Levy) Regulation 1994. There could be two fee levels set – one for offset plans involving other point sources and one for offset plans involving unlicensed sources. The costs would be lower for the former as some of the administrative work could be combined with other licensing activities.

The actual level of ongoing costs would depend on the opportunities for offsets. From the information gathered in this report it is most likely that only a small number of offset arrangements would be made in the medium term. For example, one offset arrangement between Bolivar and Penrice may be established to facilitate meeting their targets by 2010/11. This is may only require a similar level of resources to negotiating and enforcing a new environment improvement program for a large activity.

APPENDIX A: ESTIMATION OF NUTRIENT LOADS FROM NAB CATCHMENT

There are no data available on the loads of nutrients from the Smith and Adams Creek sub-catchment of the Northern Adelaide Barossa catchment. Smith and Adams Creek is the largest of the three sub-catchments (around 1.5 times the land area of the other two sub-catchments). The greatest area of intensive agricultural activity occurs in the Smith and Adams Creek catchment. Of the 140,000 km^2 used for agriculture, around 40,000 km^2 is used for market gardens and 20,000 km^2 used for other horticulture.

It is difficult to estimate loads accurately as the hydrology of the river systems is highly variable. Generally, creeks are dry over summer and only flow during winter. Although the Smith and Adams creek catchment contains more intensive agriculture, much of this is part of the Virginia horticultural area which is well controlled due to the use of reclaimed water from the Bolivar WWTP. The estimates of 18 tonnes of phosphorus and 70 tonnes of nitrogen for the Smith/Adams Creek catchment are preliminary estimates based on implied runoff rates for other NAB sub-catchments (by allocating total load estimates from the Eco management services report and using the relationships between standard run-off rates). Table A.1 below shows preliminary estimates of loads from different activities in the NAB creek catchment.

Table A.1: Preliminary estimates of current nutrient loads by activity in the NAB catchment

Activity	Total nitrogen load tonnes per year	Total phosphorus load tonnes per year
Market gardens	15	4
Horticulture	9	2
Other agriculture	11	1
Residential	41	9
Commercial	2	1
Industrial	2	1
Institutions	7	1
Other	24	9
Total	110	28

APPENDIX B: ABATEMENT MEASURES FOR DIFFUSE SOURCES

There are a range of possible abatement measures to reduce nutrients in the catchments. Some are engineering/structural solutions and others involve improving management strategies. Tables B.1 and B.2 summarise some of the available options.

Table B.1 Engineering options for diffuse source nutrient abatement

Abatement option	**Effectiveness of nutrient removal**	**Costs** [a]	**Applicability**	**Likely cost-effectiveness**
Wetlands [b]	High – provided that macrophytes are harvested to maintain efficiency. Wetlands may also be installed to remove other pollutants (e.g. sediment loads) or for other purposes (e.g. flood mitigation and irrigation water supplies). They can also provide other benefits such as biodiversity, visual amenity and recreational values. Existing wetlands in the TCWMB area have been estimated to remove between 3 and 24 per cent of N and P loads [c]. As a rule of thumb, wetlands are designed to remove approximately 80 per cent of nitrogen loads and 60 to 70 per cent of phosphorus loads in stormwater (Paul Manning, Eco Management Services, pers. comm.). Cheltenham Racecourse proposal has the potential to remove 10 per cent of the pollutant loads to West Lakes (i.e. approximately 0.7 t/annum N and 0.1 t/annum P) [c].	High - difficult to attribute costs to the nutrient removal component of their function. Existing wetlands in the TCWMB area are estimated to have cost between $0.5m and $2.5m to construct [c]. Cheltenham Racecourse proposal: $2m for wetland, $0.5m for ASR and $2m for diversion - largely for flood mitigation and irrigation purposes [c].	Opportunities for wetland construction in the Port Adelaide catchment (TCWMB area) are limited by lack of open space and the fact that the catchment is already extensively served by wetlands. Significant opportunities exist for wetland construction in the Dry Creek, Little Para and Smith and Adams Creek catchments (NABCWMB area) [d].	Low [e] $40,000-$80,000/t/an of nitrogen $200,000-$400,000/t/an of phosphorus
Gross pollutant traps	Low/Medium - an indirect form of abatement. Nutrient removal is not the main objective of installing this type of infrastructure but is a by-product of its operation.	Medium - difficult to attribute costs to the nutrient removal component of their function. Cost of establishment ranges from $1,000 to $2,000 for side entry pit catch GPTs (low efficiency, very high maintenance costs) to $50,000 to $500,000 for in-stream booms (high efficiency for floating materials, medium-high maintenance costs) [c].	The TCWMB has undertaken an extensive GPT installation program in the Port Adelaide catchment but there is scope for expansion. Further opportunities also exist for GPT installation in the Dry Creek, Little Para and Smith and Adams Creek catchments.	Low

Abatement option	Effectiveness of nutrient removal	Costs [a]	Applicability	Likely cost-effectiveness
Grassed swale versus concrete drains	Medium/High – for example, concentrations of nutrients, heavy metals etc. in North Arm East Drain are lower than other concrete drains in the Port Adelaide catchment [c].	High – may require the purchase of a wider easement.	Opportunities exist for converting concrete drains to grassed swales in all catchments in the study area For example, the Helps Road Drain and lower sections of the Dry Creek system have minimal or no capacity to absorb pollutant loads	Low
Buffer strips, revegetation and/or fencing of riparian zones	High – but these types of engineering solutions are generally installed to remove a range of pollutants (e.g. nutrients, sediment loads etc.). They can also provide other benefits such as improved biodiversity and visual amenity. Modelling undertaken for the TCWMB indicates that buffer zone establishment for all third, second and first order rural watercourses in the Torrens catchment could reduce pollutant loads (including suspended solids, N, P and heavy metals) by 10, 15 and 30 per cent respectively [c].	Medium - difficult to attribute costs to the nutrient removal component of their function. Initial establishment cost: $5,000/km (fencing of buffer strips) to $14,000/km (full revegetation) and up to $25,000/km where erosion control works are required. Maintenance costs up to $1,500/km/annum for at least 5 years [g].	The Port Adelaide catchment is highly industrialised and urbanised and has very limited opportunities for these options. Opportunities exist for these options in the Dry Creek, Little Para and Smith and Adams Creek catchments.	Medium $30-$1,400/t/an of nitrogen $400-$80,000/t/an of phosphorus [h]

a Initial costs of construction, installation or establishment and ongoing operational, management and maintenance costs.

b With or without an associated Aquifer Storage and Recovery scheme.

c Torrens Catchment Water Management Board (2002) *Catchment Water Management Plan 2002-2007.*

d See Kellogg, Brown and Root (2003) *Northern Adelaide Regional Water Resources Plan* and Australian Groundwater Technologies (2001) *Review of the Potential of Aquifer Storage and Recovery in the Tea Tree Gully Council Area.*

e See Attachment B for details.

f Northern Adelaide Barossa Catchment Water Management Board (2001) *Northern Adelaide Barossa Catchment Water Management Plan*.

g Estimates obtained from Tom Carrangis (NABCWMB, pers. comm.) and TCWMB (2002). The administration and management of these activities could add another 10 to 30 per cent to the overall cost.

h Imputed from information in TCWMB (2002). Based on the construction of buffer strips on watercourses in the TCWMB watershed (see Attachment B for details).

GPT Gross pollutant trap

NABCWMB Northern Adelaide Barossa Catchment Water Management Board

TCWMB Torrens Catchment Water Management Board

Table B.2 Options for improved management practices of diffuse source

Abatement option	Effectiveness of nutrient removal	Costs	Applicability	Likely cost-effectiveness
Reduced urban and industrial pollution through education and extension programs (e.g. Pollution Prevention Officers in the NABCWMB area)	Medium/High – very difficult to measure. These types of programs are generally introduced to minimise a range of pollutants, in addition to nutrients (e.g. heavy metals). It has been estimated that past community education programs (residential, commercial, industrial and rural) have reduced pollutant loads in the TCWMB area by approximately 10 per cent [a].	Medium - difficult to attribute costs to the nutrient removal component of their function.	Programs have largely been established but require ongoing funding. May be difficult to include as an offset action if it is difficult to measure outcomes.	Medium
Reduced rural pollution through the adoption of 'best management practices' (e.g. through the preparation and implementation of Property Management Plans)	Medium/High - difficult to measure. Management changes of this type are likely to be introduced to remove other pollutants (e.g. sediment loads) as well as nutrients.	Medium - difficult to attribute costs to the nutrient removal component of their function.	The Port Adelaide catchment is highly industrialised and urbanised and has very limited opportunities for these options. Opportunities exist for these options in the Dry Creek, Little Para and Smith and Adams Creek catchments. May be difficult to include as an offset action if it is difficult to measure outcomes.	Medium

[a] Torrens Catchment Water Management Board (2002) *Catchment Water Management Plan 2002-2007.*

NABCWMB Northern Adelaide Barossa Catchment Water Management Board

TCWMB Torrens Catchment Water Management Board

APPENDIX C: ENVIRONMENTAL EQUIVALENCE RELATIONSHIPS

These figures have been provided by the EPA and have been generated with consultation with experts within the EPA, other government departments, consultants and industry (SA Water). They are based on the best estimates of the relative impacts of nutrients discharged from point and diffuse sources (excluding internal sources) in the Port Waterways and assessed on a region wide scale. The numbers provided are not attempting to draw cause and effect relationships between sources. There is a significant amount of uncertainty in the fate and effects of nutrients discharged in the Port Waterways. These figures may change in the near future on completion of the Port waterways Water Quality Improvement Plan (WQIP).

Table A.1 Impact - Seagrass loss – NITROGEN

Source	Relative Equivalence	Explanation
Bolivar	1kg	Nitrogen input into the Port Waterways is causing seagrass loss in the Port Waterways.
Penrice	5-10	The EPA's ambient monitoring indicates that NH_3 and NOx concentrations are low at close to the northern region, however concentrations are elevated in other regions of the Port River and Barker Inlet. It is uncertain whether this is causing seagrass loss. Evidence suggests that on an outgoing tide ammonia is taken quite quickly through the shipping channel out to sea [MFP, 1995].
Helps Rd Drain	very large	The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower. The load and timing of nitrogen from diffuse sources is having very little impact when compared to other point sources in the region.
Dry/Little Para	very large	
Port Adelaide	very large	

Table A.2 Impact - Seagrass loss - PHOSPHORUS

Source	Relative Equivalence	Explanation
Bolivar	1kg	Uncertainty exists over the role of phosphorus and whether at any stage it is the limiting nutrient due to the excess nitrogen and silica present.
Penrice	na	Penrice has no significant phosphorus discharge
Helps Rd Drain	very large	The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower. Phosphorus may be present in these discharges in particulate form, which is not readily bioavailable. Available information suggests that the seagrass around the river discharges are healthy and relatively unaffected by nutrients discharged from the rivers.
Dry/Little Para	very large	
Port Adelaide	very large	

Table A.3 Impact - Phytoplankton Blooms - NITROGEN

Source	Relative Equivalence	Explanation
Bolivar	1kg	There is evidence that significant phytoplankton blooms are occurring around the northern regions of the waterway during the warmer months. These have been noted to be separate events to algal blooms in the Port River. It is likely that Bolivar is significantly contributing to these blooms.
Penrice	1-5	Uncertainty exists over the likelihood of ongoing phytoplankton blooms after the closure of Pt Adelaide WWTP. However large volumes of bioavailable nitrogen are entering the central region from Penrice, which may contribute to blooms during warmer months.
Helps Rd Drain	very large	The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower. Evidence suggests that there are very few marine phytoplankton blooms in the vicinity of the riverine discharges.
Dry/Little Para	very large	
Port Adelaide	very large	

Table A.4 Impact - Phytoplankton Blooms - PHOSPHORUS

<table>
<tr><th>Source</th><th>Relative Equivalence</th><th>Explanation</th></tr>
<tr><td>Bolivar</td><td>1kg</td><td>There is evidence that significant phytoplankton blooms are occurring during the warmer months around the northern regions. These have been noted to be separate events to algal blooms in the Port River.
Uncertainty exists over the role of phosphorus and whether at any stage it is the limiting nutrient due to the excess nitrogen and silica present.</td></tr>
<tr><td>Penrice</td><td>na</td><td>Penrice has no significant phosphorus discharge</td></tr>
<tr><td>Helps Rd Drain</td><td>na</td><td rowspan="3">The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower.
Phosphorus may not be in a bioavailable form.
Evidence suggests that there are very few marine phytoplankton blooms in the vicinity of the riverine discharges.</td></tr>
<tr><td>Dry/Little Para</td><td>na</td></tr>
<tr><td>Port Adelaide</td><td>na</td></tr>
</table>

Table A.5 Impact - Macroalgal Blooms - NITROGEN

<table>
<tr><th>Source</th><th>Relative Equivalence</th><th>Explanation</th></tr>
<tr><td>Bolivar</td><td>1kg</td><td>The macroalgal blooms in the northern regions of the waterway. These have been thought to contribute to mangrove decline and reduction in aesthetic values.</td></tr>
<tr><td>Penrice</td><td>2-5</td><td>Large volumes of bioavailable nitrogen are entering the central region of the waterway from Penrice, which may contribute to blooms in this region during the warmer months.
However there is consistently little macroalgae in the vicinity of the Penrice discharge. This may be due to the higher velocities in the shipping channel.</td></tr>
<tr><td>Helps Rd Drain</td><td>very large</td><td rowspan="3">The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower.
Evidence suggests that there are very few marine macroalgal blooms in the vicinity of the riverine discharges.
However there is the possibility of cumulative effects of nutrients building up in the sediment which may flux out.</td></tr>
<tr><td>Dry/Little Para</td><td>very large</td></tr>
<tr><td>Port Adelaide</td><td>very large</td></tr>
</table>

Table A.6 Impact - Macroalgal Blooms - PHOSPHORUS

Source	Relative Equivalence	Explanation
Bolivar	1kg	There are significant macroalgal blooms occurring during the warmer months around the northern Barker Inlet and the Bolivar WWTP outfall. However the role of phosphorus in macroalgal growth is uncertain in this particular situation.
Penrice	na	Penrice has no significant phosphorus discharge
Helps Rd Drain	very large	Evidence suggests that there are very few macroalgal blooms in the vicinity of the riverine discharges. The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower. Phosphorus may not be in a bioavailable form. However there is the possibility of cumulative effects of nutrients building up in the sediment which may flux out.
Dry/Little Para	very large	
Port Adelaide	very large	

Table A.7 Impact - Mangrove decline - NITROGEN

Source	Relative Equivalence	Explanation
Bolivar	1kg	Mangrove decline has largely been attributed to the proliferation of *Ulva* and its smothering of juvenile mangroves. Mangrove decline may be more attributed to changes in hydrology
Penrice	5-10	The mangroves opposite Penrice are in relatively good condition and there is very little macroalgal growth in this region. However there is macroalgal growth in Angus inlet but this cannot be solely attributed to Penrice.
Helps Rd Drain	10-20	The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower. Evidence suggests that the mangroves in the central region are relatively healthy and are encroaching further seawards. However there is the possibility of cumulative effects of nutrients building up in the sediment which may flux out.
Dry/Little Para	10-20	
Port Adelaide	10-20	

Table A.8 Impact - Mangrove decline - PHOSPHORUS

Source	Relative Equivalence	Explanation
Bolivar	1kg	Mangrove decline has largely been attributed to the proliferation of *Ulva* and its smothering of juvenile mangroves. Mangrove decline may be more attributed to changes in hydrology. It is unclear of the role of phosphorus in these processes.
Penrice	na	Penrice has no significant phosphorus discharge
Helps Rd Drain	10-50	Evidence suggests that there are very few macroalgal blooms in the vicinity of the riverine discharges and the mangroves in this region are relatively healthy and are encroaching further seawards. The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower. Phosphorus may not be in a bioavailable form. However there is the possibility of cumulative effects of nutrients building up in the sediment which may flux out.
Dry/Little Para	10-50	
Port Adelaide	10-50	

Table A.9 Impact - Harvesting shellfish (toxic blooms) – NITROGEN

Source	Relative Equivalence	Explanation
Bolivar	1kg	Nitrogen rich water from Bolivar can promote blooms of toxic dinoflagellates, which can cause paralytic shellfish poisoning (PSP, DSP etc).
Penrice	1	Penrice may have an effect on the central regions where recreational fishing of shellfish may occur. Recreational harvesting may be difficult to regulate.
Helps Rd Drain	very large	The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower.
Dry/Little Para	very large	
Port Adelaide	very large	

Table A.10 Impact - Harvesting shellfish (toxic blooms) - PHOSPHORUS

Source	Relative Equivalence	Explanation
Bolivar	1kg	Uncertainty exists over the role of phosphorus and whether at any stage it is the limiting nutrient due to the excess nitrogen and silica present in dinoflagellate growth.
Penrice	na	Penrice has no significant phosphorus discharge
Helps Rd Drain	very large	The riverine discharges enter the estuary primarily during winter when water temperatures and light levels are lower. Phosphorus may not be in a bioavailable form.
Dry/Little Para	very large	
Port Adelaide	very large	

Table A.11 Impact - Mosquito breeding - NITROGEN

Source	Relative Equivalence	Explanation
Bolivar	1kg	Increased nitrogen in supratidal pools can cause an increased abundance of mosquito larvae as nutrients are no longer limiting growth. Growth may also be facilitated by large areas of Ulva being used as a food source.
Penrice	very large	Penrice's effluent is discharged into a deep shipping channel with high tidal velocities which can transport it out to sea and away from mosquito breeding areas.
Helps Rd Drain	very large	The riverine discharges enter the estuary primarily during winter when water temperatures are lower, light conditions are lower.
Dry/Little Para	very large	
Port Adelaide	very large	

Table A.12 Impact - Mosquito breeding - PHOSPHORUS

Source	Relative Equivalence	Explanation
Bolivar	1kg	Increased nutrients in supratidal pools can cause an increased abundance of mosquito larvae as nutrients are no longer limiting growth. Growth may also be facilitated by large areas of Ulva being used as a food source.
Penrice	na	Penrice has no significant phosphorus discharge
Helps Rd Drain	very large	The riverine discharges enter the estuary primarily during winter when water temperatures are lower, light conditions are lower. Phosphorus may not be in a bioavailable form. There are limited shellfish regions in the vicinity of the riverine discharges.
Dry/Little Para	very large	
Port Adelaide	very large	

APPENDIX D: ASSUMPTIONS RELATING TO ABATEMENT COSTS

This attachment provides the cost assumptions for the scenarios in sections 5.3 and 5.4 of the report.

Table E.1: Abatement costs for point sources

Bolivar		Penrice	
Load reduction possible (tonnes per year of nitrogen)	Abatement cost (per tonne of nitrogen reduced)	Load reduction possible (tonnes per year of nitrogen)	Abatement cost (per tonne of nitrogen reduced)
65	$200,000[1]	175	$68,750[3]
100	$600,000[2]	500	$125,000[4]

Notes:

1. From BDA Group/Econsearch Part 1 report
2. Assumed to be three times costs of initial reductions
3. Average of current cleaner production costs ($12,500) and upper estimate of ($125,000) provided by SA EPA
4. Upper estimate of $125,000 provided by SA EPA

Table E.2: Abatement costs for diffuse sources

Abatement measure	Possible load reduction (tonnes of nitrogen per year)	Cost (per tonne of nitrogen)
Wetlands	88	$60,000
Market garden best practice	4	$10
Riparian works	8	$715

Source: BDA Group/Econsearch Part 1 report

APPENDIX E: RELATIVE IMPORTANCE OF ENVIRONMENTAL ISSUES

Table E.1 shows the weights that have been assigned to the relative importance of different environmental issues for the purpose of generating a range of scenarios. In the table five points are allocated across the nutrient issues. The issue of mosquito breeding has been omitted from the analysis as it is likely to be impacted by only one source and therefore a trading instrument would not be an appropriate tool for addressing it.

Table E.1: Weights for relative importance of nutrient issues

Scenario	Mangroves	Seagrass	Phytoplankton blooms	Macroagal blooms	Toxic blooms
Equal weighting	1	1	1	1	1
Mangroves most important	3	0.5	0.5	0.5	0.5
Seagrass most important	0.5	3	0.5	0.5	0.5
Phytoplankton blooms most important	0.5	0.5	3	0.5	0.5
Macroalgal blooms most important	0.5	0.5	0.5	3	0.5
Toxic blooms most important	0.5	0.5	0.5	0.5	3