Prepared by

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in association with

Water Technology and Capital Strategies for

WMC Resources
taken over by
BHP Billiton
during 2005

A Water Supply for Regional South Australia: Reducing Reliance on the River Murray

Feasibility Assessment Report
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APPENDICES
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Coastal Desalination
Sea Water Reverse Osmosis (SWRO) Request For Information (RFI) Report
Appendix B
Spencer Gulf Desalination
Brine Dispersion Feasibility Study Report
Submission Reference 85045
Description Final delivered

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Date 6/03/2006 8/03/2006 8/03/2006
Executive Summary

In April 2005 WMC Resources, in association with the South Australian Government, was granted funding under the Murray-Darling Basin Commission’s (MDBC) Development of Infrastructure Projects Program. WMC Resources was subsequently taken over by BHP Billiton.

The aim of the funding was to assess the feasibility of creating a regional water supply solution for South Australia based on seawater desalination, that:

- Addressed the additional water needs of the Olympic Dam expansion proposal.
- Provided an alternative to River Murray water to supply South Australia’s Upper Spencer Gulf and Eyre Peninsula regions, and the towns of Pimba and Woomera.
- Provided the opportunity for future demand for water on the Eyre Peninsula to be satisfied without reliance on the River Murray.

Arup was appointed by WMC Resources in consultation with SA Water and MDBC to lead the assessment.

The agreed high level technical concept was based on a 100ML/d seawater reverse osmosis (SWRO) desalination plant located in the vicinity of Point Lowly/Port Bonython supplying a new pipeline and pumping system to deliver a uniform 70ML/d to Olympic Dam and other agreed demands en route. The new pipeline would also be linked into the existing Morgan-Whyalla Pipeline and thereby supply water to Whyalla, Port Augusta and parts of Eyre Peninsula.

If the concept proceeds, its likely commissioning date would be 2012. At this time, it is predicted that about 17GL/a of demand that otherwise would be supplied from the River Murray via the Morgan-Whyalla Pipeline, could be supplied from the desalination plant. This provides the opportunity for significant River Murray water savings, but given the timeframe envisaged, it is a potential opportunity subsequent to the present Living Murray initiative. The present capital value of this water saving is $23.8m based on the current, typical market rate for permanent River Murray water entitlements in South Australia of $1,400/ML. The transactional details of putting in place such a recovery of water are yet to be resolved.

From a high level, sustainability perspective two issues needed evaluation at an early stage. These were SWRO plant concentrate (brine) discharge and ‘greenhouse’ impacts and mitigation strategies. Preliminary brine dispersion modelling has not identified any major concerns with the Port Bonython site. The ‘greenhouse’ impacts relative to pumping water from the River Murray are capable of being mitigated by a variety of means and the cost of doing so is not material.

The proposal is considered technically feasible and this was further validated by the Government of South Australia and WMC Resources jointly engaging the marketplace in a Request for Information (RFI) process. The market was also asked to provide preliminary commercial information including water pricing, based on a standard set of assumptions. The indicative commercial selling price of water from such a plant ranged between $0.80/kL and $1.25/kL.

The commerciality of the SWRO proposal depends on how the project is assessed against the status quo.

The SA Water position is based on a marginal cost assessment of water delivered to the Upper Spencer Gulf, which is in the range of $0.20/kL-$0.30/kL. The quantum is not in dispute. From SA Water’s perspective the project would add $0.50/kL-$1.05/kL to its cost of water supply.

The consulting team’s position is based on the true cost of water delivered to the Upper Spencer Gulf from the River Murray, including an independent and conservative estimate of the Community Service Obligation (CSO) component. Using this method of evaluation the true cost of River Murray water is considered to be at least $1.83/kL. This compares to the estimated true cost of desalinated water,
which is $1.02-$1.56/kL including the costs of purchasing the water, linking to the existing system and 'greenhouse' mitigation.

Both the SA Water point of view and the consulting team's position are valid. In the short term there will be an additional cost to SA Water in using desalinated water rather than the existing supply. In the long term, when significant replacement of the Morgan Whyalla pipeline becomes necessary, then desalination becomes financially attractive.

It is SA Water’s view that no significant asset replacement will be required for many years, and therefore the business case for investment in desalination in the short term should be based on the broader benefits to the State rather than the water supply system.

The Government of South Australia and BHP Billiton have agreed to a further economic study to quantify the broader benefits associated with the regional desalination proposal and assess the merit of further investigating a regional facility.

In the meantime, BHP Billiton is continuing with its water supply strategy investigations and 'whole of project' EIS, including additional investigations into SWRO and the sustainability of brine concentrate disposal to Spencer Gulf.

This report has been accepted by the Steering Committee as concluded. It is recommended that this report be referred to the South Australian Department of Water, Land and Biodiversity Conservation for consideration and determination of future actions.
1 Introduction

In April 2005 WMC Resources, in association with the South Australian Government, was granted funding under the Murray-Darling Basin Commission’s (MDBC) Development of Infrastructure Projects Program. WMC Resources was subsequently taken over by BHP Billiton.

The aim of the funding was to assess the feasibility of creating a regional water supply solution for South Australia based on seawater desalination, that:

- Addressed the water needs of an expanded Olympic Dam, and the towns of Roxby Downs and Andamooka.
- Provided an alternative to River Murray water to supply South Australia’s Upper Spencer Gulf region and the towns of Pimba and Woomera.
- Provided the opportunity for future demand for water on the Eyre Peninsula to be satisfied without reliance on the River Murray.

The concept is to develop a significant seawater desalination plant in the Upper Spencer Gulf region that could transfer water into existing regional water supply infrastructure and the recently committed Iron Knob – Kimba pipeline, linking the Morgan - Whyalla Pipeline to the Eyre Peninsula water distribution system. The desalination plant would also be the major source of new water for an expanded Olympic Dam mine, Roxby Downs township, Andamooka and Pimba and Woomera. A new pipeline would transport the desalinated seawater to the mine and the above mentioned communities.

The opportunity is considered both visionary and strategic in terms of:

- Providing a significant source of new water to South Australia’s far North and West.
- Reduced potential constraints on future development opportunities.
- Eliminating any future reliance for growth in South Australia’s Upper Spencer Gulf and Eyre Peninsula regions on the abstraction of more water from the River Murray.
- Demonstrating national leadership and action in reversing the over-exploitation of the Murray-Darling rivers system.
- Replacing the existing use of River Murray water in locations that are hundreds of kilometres from the river.

This report presents the findings of the feasibility assessment.

The assessment has been completed as the first stage in the process of addressing over-allocation in the Murray Darling Basin (MDB) as set out in the inter-governmental agreement (MDB-IGA).
2 Background and Alternative Water Supply Concept

A master plan for water supply to the Eyre Peninsula was prepared for SA Water in 2002/03, and provides some background to issues and supply options in the region.

Consideration of the expansion of Olympic Dam had not been announced at the time. The scope of the master plan did not include Port Augusta and Whyalla and consequently any additional demand that might be created in Upper Spencer Gulf as a result of the expansion was not considered. The proposed expansion of BHP Billiton's Olympic Dam mine will depend on many factors, one of which is adequate water supply. A pre-feasibility study into the expansion is presently underway and an assessment of water supply options and the development of a preferred water supply strategy is part of that study.

2.1 Olympic Dam – Brief History

Olympic Dam presently comprises an underground, hard rock mining operation as well as hydrometallurgical, smelting and refining operations. The original operation was commissioned in 1988 at a production rate of 45,000 tonnes per annum (tpa) copper, plus gold, silver and uranium oxide. Four expansions have since occurred and current capacity is 235,000tpa copper and increased tonnages of other products. At present copper prices, Olympic Dam generates annual revenues in excess of $1.2billion, mostly in export income. This is of the same order as the entire South Australian wine industry. A recent photograph of Olympic Dam operations is shown below at Fig 2.1.

2.2 Olympic Dam – Potential Expansion

Based on present proved and probable ore reserves, and an expanded capacity of 500,000tpa copper and other products, Olympic Dam has a minimum life of 70 years. This puts it in both the world class and very long life categories. Under this scenario, Olympic Dam Operations (ODO) would generate annual revenues in excess of $2.5billion. The very long mine life also aligns infrastructure investment considerations for ODO with those for public infrastructure, which creates a rare opportunity for regional South Australia and BHP Billiton to create infrastructure of mutual benefit.
2.3 Additional Water Supply

Investigations into seawater desalination were commenced as one alternative to securing a long term, sustainable water supply for the expansion of Olympic Dam's operations and the needs of the nearby town of Roxby Downs. Other water supply possibilities are increased abstractions from the Great Artesian Basin (GAB) and a private pipeline from the River Murray or possibly from Port Augusta, subject to negotiating with SA Water a major capacity upgrade and access to the existing Morgan – Whyalla Pipeline.

Subject to an assessment of the options as part of the Olympic Dam pre-feasibility study, BHP Billiton is attracted to seawater desalination as it:

- Provides a new source of water for a mine located in a water deficient desert ecosystem.
- Contributes to a 'Water Smart Australia'.
- Provides the Government of South Australia with the opportunity to reduce reliance on the River Murray to supply the cities of the Upper Spencer Gulf region and other communities across Eyre Peninsula.
- Could liberate about 17GL/a of River Murray water to be returned for environmental purposes.
- Could provide a major opportunity for public – private sector co-operation that can bring benefits to each of the sectors and the community at large.
- Is an expandable water supply solution, which in a drying climate, provides a better long term investment solution for Olympic Dam and other potential projects within the general vicinity of the proposed plant and pipeline.
- Could play a significant role in helping South Australia meet its COAG obligations on the River Murray.

2.4 Initial Concept

2.4.1 Overview

A seawater reverse osmosis (SWRO) plant near the top of the Spencer Gulf could provide a highly secure and sustainable supply to regional South Australia, including an expanded Olympic Dam mine.

Water produced from the plant could be transferred into the Morgan-Whyalla Pipeline to meet the residential, commercial and industrial demands of Whyalla and Port Augusta. Pt Pirie demand has not been included based on advice from SA Water regarding the technical difficulties and additional costs of so doing. These difficulties relate to the effects of mixing different quality waters and to the configuration of existing infrastructure.

With the addition of a new pipeline between Iron Knob and Kimba, a desalination plant could also supply existing and new demand on Eyre Peninsula. Water from the plant could also be transported to Roxby Downs, Andamooka and Olympic Dam via a new pipeline system that could also replace the existing service to Pimba and Woomera.

To meet BHP Billiton’s intended development program for the Olympic Dam expansion, an operational desalination plant would need to be progressively commissioned within the period 2011 – 2013.

The following demands could be supplied from such a plant at commencement:

- **Olympic Dam, Roxby Downs, Andamooka, Woomera, Pimba**: 25GL/a (based on 70ML/d initial assumption from the pre-feasibility study being conducted for BHP Billiton) to satisfy the present proposed mine expansion and associated residential and community needs.
Expansion of the plant and inter-connection with SA Water’s other regional infrastructure could be timed to either progress Government policy with respect to Living Murray water savings or to optimise SA Water’s utilisation of its existing pipeline assets from the River Murray. Additional demand that could be serviced at that time includes:

- **Upper Spencer Gulf**: up to 14.5GL/a to meet demand in Whyalla and Pt Augusta; and,
- **Eyre Peninsula**: up to 2.3GL/a to supply the demand deficit in the Eyre Peninsula, which is consistent with the design capacity of the proposed pipeline from Iron Knob to Kimba.

Supply to these regions would be a highly reliable and expandable source of new water. If as above, full replacement of River Murray water were achieved, approximately 17GL/a (about half of South Australia’s target) would be saved. Future growth of the Upper Spencer Gulf and Eyre Peninsula regions could be managed so as not to place greater demands on the River Murray. This aligns with the Government’s desire to reduce River Murray abstractions.

SWRO plants also have the advantage that they lend themselves to modular construction and can be expanded to meet increased demand in the future.

The nature of the demand for water in Whyalla and Port Augusta is quite variable and typically in January can be double that in July. For this initial concept, and to provide clarity for the business case, total replacement of this demand has been assumed. The desalination plant and associated balancing storages have been sized to enable the peak demands to be accommodated.

To that background and in order to enable other elements of this feasibility assessment to proceed in parallel, the order of magnitude of plant production capacity initially assumed was 100ML/day.

A relatively constant year around flow assumed for this assessment at 70ML/d, would be directed via a 330km pipeline system to the water demands of Pimba, Woomera, Roxby Downs, Andamooka and Olympic Dam. Olympic Dam operations will comprise about 90% of demand utilised in minerals processing and metallurgical operations. This demand is relatively constant year around. For operational security, significant storage is also intended and this will attenuate short term fluctuations. Consequently, this assessment has assumed a constant daily output of 70ML/d to satisfy the Olympic Dam and associated demands.

The balance of the desalination plant’s design capacity could be used to partly replace the River Murray water supplied to approximately 75,000 people living and working throughout the Upper Spencer Gulf and Eyre Peninsula regions of South Australia. A plan showing the indicative regional water distribution system is shown at Figure 2.2.

### 2.4.2 Sustainability

A valid and acceptable concept that is socially, environmentally and economically sustainable is critical to the development of a successful project. The headline issues relevant to this desalination proposal are:

- Social acceptance and support
- Environmental acceptability
- Demand for the project and its output at acceptable cost of supply
- Acceptable risk profile and ability to be funded

Whilst market research has not yet been conducted, anecdotal evidence indicates that the community has no objection to seawater desalination as a means of generating new sources of fresh water, as long as the issues of power consumption as related to greenhouse emissions, and any ecological impacts of concentrate disposal can be managed.
The primary objective of this feasibility assessment is to determine whether there is a business case for a SWRO plant to supply the water needs of the Olympic Dam expansion as well as those of parts of regional South Australia, thereby enabling replacement of water sourced from the River Murray.

Consequently the headline sustainability issues have been given more prominence and focus in this assessment than the details of the technical solution.

With the environmental and demand issues appropriately considered and successfully concluded for this level of study, the main remaining issue was that of cost.

SA Water has advised that the barrier to SWRO as a business opportunity and as a cost competitive alternative to regional water supply is that the marginal cost of water supply from the River Murray to Whyalla and Port Augusta using existing infrastructure is $0.25/kL compared to a purchase price of $0.80/kL to $1.25/kL from a new, private sector built, owned and operated desalination plant.

SA Water's view that the business case be based on the additional cost of purchasing desalinated water, less the avoidable costs in ceasing to use the existing pipeline infrastructure, is not considered appropriate for use in determining the most cost effective regional water solution. Given the age of the SA Water pipeline assets, and the strong likelihood that these assets will need to be either significantly upgraded or replaced in the coming 20-30 years, it is considered more appropriate to assess the options using the full long term costs, rather than the marginal cost analysis proposed by SA Water. A full long term cost methodology seems a more appropriate methodology for the government to assess its strategic options and infrastructure asset plans.

The basic commercial premise for the comparison is that the benchmark cost is that of delivery to Whyalla and Port Augusta. The cost of delivery of water beyond those locations such as to Eyre Peninsula will be nominally the same, regardless of the source.

As for risks, no issues considered unmanageable have been identified in relation to the SWRO plant, however, reliability and storage, as much for Olympic Dam operations as for the regional community, need particular consideration. As such, the technical concept allows for significant storage as part of this proposal. Significant storage is also provided for at Olympic Dam, but not at a cost to this project.

In assessing SA Water's relevant assets it is noted that the undersea section of the No.2 pipeline to Whyalla is about 45 years old. Given the harsh exposure conditions, this steel pipe could be assumed to have a useful life of 50 years, or until 2010, before the risk of a significant failure becomes progressively more likely. Whilst SA Water has its No.1 pipeline that is totally on land, this asset is 60 years old, in the back half of its useful life and capacity constrained. Therefore, SA Water and consequently the Government of South Australia are considered to be at risk of failure to be able to supply water to the Whyalla region. Such a failure would have major economic and financial consequences. A regional SWRO, if completed and commissioned by 2012 would be a major contribution to risk reduction and management.

SA Water advises that both pipelines are managed according to their age and location and that it recognises the risks and manages them accordingly. It advises that the undersea crossing was specially designed and more stringent quality controls were applied to the construction to cope with the harsh environment:

- Thicker pipe was used and it was protected externally with a thicker than standard coating of coal tar epoxy.
- All shop and field welds were X-rayed to ensure the integrity of the welds.
- The pipe is encased in concrete of a minimum thickness of 50mm, reinforced with steel mesh, for both protection and weight.
- The pipe crossing is protected by an impressed current cathodic protection system.
- The pipe is laid in a trench which has been backfilled to provide physical protection.
SA Water further advises that while this section of the pipeline is laid in a harsh environment, current condition assessments give no indication of any deterioration of the pipe:

- The electrical current levels for maintaining the cathodic protection have increased only marginally over the past 38 years indicating no drastic deterioration of the pipe external coating.
- Internal inspections of various sections of the Morgan Whyalla No 2 Pipeline have shown that the internal lining is in excellent condition with expectations that the underwater section of main is in similar condition.

However the age of these assets, and issues concerned with the appropriateness and adequacy of maintenance budgets for infrastructure over the long run, versus eventual replacement cannot be ignored.

### 2.4.3 Technical Concept

The technical concept needs to be of sufficient detail to have confidence in its workability. The concept also needs to enable cost estimates to be made to a level of accuracy within which the actual costs will be and that are sufficient to assist in differentiating options.

This proposal is to locate near Port Bonython a SWRO desalination plant with sufficient capacity and storage to reliably deliver water to the demands indicated earlier. It was agreed with SA Water that to keep the initial concept simple, replacement of year around demand to Whyalla, Port Augusta and to the proposed Eyre Peninsula and Olympic Dam pipelines would be adopted. This eliminated any technical and commercial complications to do with hybrid supply concepts.

It was also agreed with SA Water and BHP Billiton that this study would focus on the desalination plant and that the pipeline to Olympic Dam would not be considered, except to the extent necessary to provide off-takes for Iron Knob and Port Augusta. The pipeline route to Olympic Dam as shown on Figure 2.2 is indicative only and may change subject to these and other considerations.

The total demand from a SWRO has been assumed as 42GL/a. This indicates an annual average flow of 115ML/d. Olympic Dam demand is assumed relatively constant on a seasonal basis so the 25GL/a equates to a relatively constant daily flow of 70ML/d. This is a reasonable assumption based on demand data and BHP Billiton’s intention to hold a week’s demand in storage on site.

Allowing for the monthly variability advised by SA Water for the Upper Spencer Gulf and reported herein, and factoring for weekly variability on the basis of large storages to sustain Whyalla and Port Augusta indicates a daily flow range to satisfy regional demand ranging from 35ML/d to 65ML/d.

Combining both demands indicates a SWRO design range of 105ML/d to 135ML/d.

As part of this study, information on costs, pricing and other issues were sought from the private sector in relation to SWRO plants at 50ML/d and 100ML/d capacities. This information is summarised in Section 5. As explained below, the likely rated capacity for a plant to replace the agreed regional demands is greater than 100ML/d. This is not considered an impediment to this level of study as costs can be extrapolated if necessary, but more relevant is the fact that the comparative cost analysis in Section 6 is based on volumetric selling prices not the capital cost of a specific capacity plant. Therefore benchmarking these prices from a 100ML/d capacity plant is conservative because the relative cost of production per kilolitre generally reduces as capacity increases, as long as the percentage utilisation stays similar.

One of the private sector respondents referred to in Section 5 indicated in its submission that its plants were rated at winter temperatures and that by a combination of favourable factors, i.e. highest demand in hot weather co-incident with warmer water of lower viscosity, plus normally inbuilt redundancy, a 100ML/d rated SWRO plant should be capable of running at up to 125ML/d for limited periods. This is an interesting claim and whilst it would be unwise to base concepts on these claims at such an early
stage, it indicates that with innovation and risk management, there will be opportunities to optimise SWRO capacity and storage to manage both capital investment and operating costs. The same respondent suggested a minimum of eight days storage would be prudent to allow for both planned and unplanned maintenance events and other potential supply interruptions, reinforcing the need to further consider the capacity versus storage issue at an appropriate point in design development.

SA Water has advised that based on the estimated demand ranges and capacities indicated above, a 100ML/d SWRO plant may be consistently required to run at an average 15% in excess of rated design capacity. SA Water does not believe this would provide it the required level of reliability and that more capacity should be built in to accommodate this. Because SA Water has a more variable daily demand than Olympic Dam, the contention is that if it participated, SA Water would need to fund more capacity and this would increase the cost per kilolitre of water to it.

The alternate view is that the technical merits of capacity utilisation and cost apportionment can be negotiated a number of ways and it is too early to assume capacity utilisation as the sole metric for a project of this nature. This issue is noted but should be dealt with as more information comes to hand. One reason this matter is premature is because the project could attract Commonwealth funding, but it is clear that such funding would only be forthcoming for the public benefit component of such a project. How this might affect the overall cost apportionment negotiation is not clear at this early stage.

### 2.4.4 Other Considerations

A technically and commercially robust desalination plant proposal will require a commitment from BHP Billiton and the Government of South Australia to develop the concept, undertake the ownership, financial, engineering, environmental and contractual evaluations, decide on the best course of action and implement project delivery.

The SWRO concept also requires an initial evaluation of environmental and site factors as an indicator of viability. The initially indicated production capacity of 100ML/d provided an understanding of the order of magnitude of raw water flows, concentrate discharge flows, energy needs and footprint. An initial scan of suitable locations in Upper Spencer Gulf identified Port Augusta, Port Pirie and Point Lowly as possibilities. Port Augusta is attractive as clearly the closest location to Olympic Dam, but initial engineering judgement flagged risks associated with higher seawater salinity and the long term sustainability of concentrate discharge. Point Lowly is marginally closer to Olympic Dam than Port Pirie. Point Lowly also has much deeper water relatively close to shore and has suitable land and tenure to accommodate a plant of this size. Conceptually, a SWRO plant at Point Lowly is likely to avoid sensitive marine environments, and be well positioned to link into existing SA Water pipeline infrastructure. Power supply infrastructure of sufficient capacity is also in close proximity to this site and preliminary advice from ETSA Utilities indicates that a transformer upgrade is all that is likely to be required to accommodate the project.

For the purpose of developing a conceptual cost estimate, selection of the Whyalla Resource Development Estate at Point Lowly as a plant location provides a robust starting point. A map illustrating the site and environs is at Figure 2.3. If future studies indicate that other sites further up Spencer Gulf and closer to Olympic Dam are more suitable, then this may result in reduced costs and other project benefits.
Figure 2.2: Plan of Regional Water Distribution System
Figure 2.3: Whyalla Resource Development Estate, Port Bonython, Point Lowly and Environs
3 Current Situation – Demands and Supply System

3.1 Olympic Dam

3.1.1 Existing Supply Arrangements
Water supply to Olympic Dam and Roxby Downs is currently supplied from the Great Artesian Basin (GAB) typically at an average rate of 34ML/d representing an annual water demand of 12GL/a. The water is harvested from two existing Borefields designated A and B.

3.1.2 Water Quality
The GAB supply has an average chloride concentration of 496mg/L and salinity (TDS) of 1,000 mg/L, but this varies depending on the blend from the source borefields. Chloride concentrations typically vary between 380mg/L from Borefield B, which is farther and deeper into the GAB, to 1100mg/L from Borefield A, which is closer to the edge of the basin. There is an existing Reverse Osmosis (RO) desalination plant on the mine site with a capacity of 15ML/d that typically processes GAB sourced water to produce 8.5ML/d for potable use including Roxby Downs, and 2.5ML/d for high quality process use.

3.1.3 Stability of Demand
The Olympic Dam operation has an average daily demand of 34ML/d supplied from about one week’s local storage. At present 5-6ML/d is recycled from various sources within the mine and process area. The mine and process area potable demands are quite stable as operations are continuous. An average 2.5ML/d or about 6% of the water sourced from the GAB and treated at the RO plant is taken by the town of Roxby Downs for potable use. This is supplied from a 10ML storage.

The constant, 24/7 nature of production at Olympic Dam and the low proportion of residential demand result in a low seasonal variation in demand. As a result, an expanded Olympic Dam and associated water demand can be assumed to remain constant throughout the year.

3.2 Upper Spencer Gulf

3.2.1 Existing Supply Arrangements
Water supply to the Upper Spencer Gulf major centres of Whyalla and Port Augusta is via the Morgan-Whyalla pipeline (MWP). Water is drawn from the River Murray at Morgan and treated at the Morgan Water Filtration plant prior to pumping and distribution via the pipeline (see Figure 3.1 below).

Some elements of the system reach capacity over the peak summer season. Given its present configuration, SA Water advise that the system’s capacity is limited by the size of the section of pipeline between Hanson Storages and Guhlare Tanks, a length of about 65 kilometres.

In response to inquiries related to the proposed expansion of Olympic Dam, SA Water has advised that the Morgan-Whyalla system is presently capable of supplying 18ML/d on an annual average basis at Port Augusta, subject to investment in a significant storage and infrastructure upgrade that would be required to ensure acceptable probability of supplying 18ML/d on every day of the year. Even more significant investment in infrastructure would be required to upgrade the Morgan-Whyalla system to accommodate the indicative 70ML/d of additional water required for the expansion.
Figure 3.1: SA Water Morgan-Whyalla Network (pipe diameters colour coded)
3.2.2 Water Quality

Salinity and chloride concentrations in River Murray water at Morgan are currently well within the accepted guidelines for drinking water.

Whilst there have been various predictions about the long term trends for salinity and chloride concentrations, the MDBC has a salinity management programme in place to manage this issue. In addition, the Living Murray initiative should also assist in river water quality management by enabling more salt to be discharged from the system as more water is returned for environmental purposes.

3.2.3 Existing Demand

Whyalla and Port Augusta use approximately 12.7GL/a of water, which based on SA Water estimates are broken down as follows:

- Whyalla – 6.8 GL/a
- Port Augusta – 5.9 GL/a

A proportion of this demand comes from industrial water users, predominately in the areas of steel making and oil and gas processing. However, the majority of demand variation is most likely the result of seasonal variations in residential demand.

SA Water has supplied multiplication factors to be used with average annual demands to determine monthly average demands. These factors are shown in Figure 3.2 below.

![Figure 3.2: Estimated Monthly Averaging Factors relative to Annual Annual Demand](Source: SA Water)
3.3 Eyre Peninsula

3.3.1 Existing Supply Arrangements
The Eyre Peninsula is supplied predominately from a variety of groundwater resources. In the past there has been surface water augmentation from the Tod Reservoir, but SA Water advises it no longer uses this source.

3.3.2 Water Quality
Salinity concentrations generally greater than 500mg/L are a feature of most of the ground water resources used for potable supply on Eyre Peninsula.

3.3.3 Existing Demand
Figures contained with the Eyre Peninsula Water Supply Master Plan (EP WSMP) have suggested demand in the Eyre Peninsula has ranged from 9.4 GL/a to 10 GL/a in the last five years with no apparent long-term trend of increased demand.

Water demand in the Eyre Peninsula is also subject to seasonal peaks.
4 Future Projections - Demands and Supply Options

4.1 Introduction

Planning SA has not predicted any material population increase in the regions under consideration. This prediction may be conservative given the massive investment being contemplated by BHP Billiton in Olympic Dam and given the industrial base, potential labour force and general supporting infrastructure that exists in the Upper Spencer Gulf. Industry expansion is likely to put greater demand on the existing water supply to the region.

SA Water demand estimates for the region appear to reflect the Planning SA predictions as only a minor increase in water demand of less than 10% to 2013 is allowed for. Consequently, these demands may be understated if the Olympic Dam expansion proceeds.

The following section details predicted future demands in the various regions and potential water supply options in these regions to meet any increases in demand.

4.2 Olympic Dam

4.2.1 Future Demands

Future expansion of the Olympic Dam mine is currently undergoing pre-feasibility assessment by BHP Billiton. The presently assumed new demand from the expanded mine operations is 70ML/d or 25GL/a. It is anticipated that the mine will still have a highly reliable steady demand for water because of the constant and relatively steady state nature of its operations.

4.2.2 Limitations of Existing System

Construction of the expansion could begin to ramp up from 2008 and be practically complete by 2013. Current supply to Olympic Dam and Roxby Downs of about 12GL/a is from the GAB via two separate pipelines from each of Borefield A and B. The project’s current groundwater abstraction licences are related primarily to pressure draw down rather than volume. That said, volume is a factor and in theory, the existing system and approvals status have a volumetric upper limit of 15GL/a. This indicates that a modest buffer exists to accommodate the early additional water needs of the proposed expansion, until the preferred additional water supply option is constructed.

4.2.3 Future Supply Options

The Infrastructure and Environmental component of the Olympic Dam Development Pre-Feasibility Study (ODD PFS - 2005) produced for BHP Billiton by Arup investigates three main supply options for an expanded Olympic Dam operation. These are:

- The River Murray via either a private pipeline direct to Olympic Dam, or via a substantially upgraded Morgan – Port Augusta segment of the Morgan – Whyalla Pipeline and a new pipeline from Port Augusta to Olympic Dam.
- The GAB via one or more new borefields and a new associated pipeline to Olympic Dam.
- A SWRO plant in Upper Spencer Gulf, nominally at Port Bonython and a new pipeline from there to Olympic Dam.
4.3 Upper Spencer Gulf

4.3.1 Future Demands
The demand for water, based on SA Water estimates, is anticipated to increase in Whyalla and Port Augusta by approximately 1.8GL/a to 14.5GL/a of water by 2013, distributed as follows:
- Whyalla – 8.4 GL/a
- Port Augusta – 6.1 GL/a

This represents an increase in demand of more than 13%.

Planning SA projections suggest minor population growth in the region of around 0.1%. However, a large proportion of demand in this area comes from industrial water users, predominately in the areas of steel refining and smelting, mining, mineral processing, oil and gas processing. Consequently water demands from these sectors may be expected to increase with global demand for these products. The potential increase in population and industry as a consequence of the Olympic Dam expansion has not been factored into these population and water demand forecasts.

4.3.2 Limitations of Existing System
SA Water estimate the spare capacity in the existing Morgan – Whyalla Pipeline at Port Augusta is limited in February to approximately 4ML/d on an average day. Based on the above growth rates, which could be conservative, it is predicted that water demand growth in Port Augusta and Whyalla will exceed 4ML/d in February by 2013. SA Water has advised that this constraint can be relatively easily overcome because it is caused by a localised bottle-neck in the system rather than large scale capacity limitations.

4.3.3 Future Supply Options
Currently no information on future supply options for the region is available. SA Water is monitoring demand in the region and if significant development increases water demands above the predictions, capacity could be increased by system augmentation, with the additional water sourced from the River Murray.

The regional SWRO proposal provides an alternative source of water that could augment the River Murray supply and limit further abstraction whilst not constraining growth in the region. Furthermore, the proposal provides the Government of South Australia with the flexibility to adjust its water supply policy should it so choose.

4.4 Eyre Peninsula

4.4.1 Future Demands
The demand over the past five years has ranged between 9.4 GL/a and 10 GL/a. It is almost certain that this demand is artificially low due to mandatory restrictions, with available supply limiting development and economic growth.

Planning projections for South Australia suggest minor population decline in the Eyre Peninsula region of around 0.5%. The EP WSMP identifies a series of potential economic developments proposed for the Eyre Peninsula. These include various mining operations, aquaculture, tourism and vineyards.

Water supply constraints to the region may be among other infrastructure issues, a contributing factor to restricting economic development in the region (EconSearch 2002). Therefore increased water supply may lead to some increase in development and therefore water demand, although the extent of this is unclear.
Following further analysis the EP WSMP estimated future water demand in the Eyre Peninsula as 10.25GL/a by 2012.

4.4.2 Limitations of Existing System

The existing system is supply limited and SA Water proposes to overcome this by constructing a pipeline extension from the Morgan-Whyalla pipeline (MWP) system at Iron Knob to the Eyre Peninsula water distribution system at Kimba. SA Water has advised that the design capacity of this extension caters for the predicted future demand. More details on the background to this are reported below.

4.4.3 Future Supply Options

The following four main supply augmentation options were investigated as part of the EP WSMP:

- Desalination Plant located at the Tod Reservoir treating brackish water;
- Desalination plant at Louth Bay treating either brackish water from the Tod Reservoir or seawater;
- Connection to the MWP system via a pipeline between Iron Knob and Kimba; and
- Desalination plant located at Port Lincoln treating seawater.

Following economic analysis of capital and operating costs the desalination plan located at the Tod Reservoir was recommended. However, significant issues and cost increases arose out of subsequent negotiations with the EPA in relation to disposal of concentrate containing chemicals derived from the agricultural catchment. Ultimately, SA Water recommended to the government the option of connecting the Eyre Peninsula system to the Morgan – Whyalla Pipeline system. The proposed capacity of this connection is 2.3GL/a.

4.5 Summary of Future Demands and New Supply Opportunities

The predicted future demands and supply opportunities in the regions under consideration are summarised in the table below:

<table>
<thead>
<tr>
<th>Region</th>
<th>Demand GL/a (Year)</th>
<th>Supply Opportunity GL/a (Year)</th>
<th>Supply Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olympic Dam (Expanded Operations), Roxby Downs, Andamooka, Woomera, Pimba</td>
<td>37 (2013)</td>
<td>25 (2013)</td>
<td>SWRO, River Murray or GAB</td>
</tr>
<tr>
<td>Upper Spencer Gulf comprising Whyalla and Port Augusta</td>
<td>14.5 (2013)</td>
<td>14.5 (2013)</td>
<td>River Murray (MWP) or SWRO</td>
</tr>
<tr>
<td>Eyre Peninsula Pipeline</td>
<td>10.25 (2012)</td>
<td>2.3 (2012)</td>
<td>SWRO or River Murray (MWP)</td>
</tr>
</tbody>
</table>

A SWRO plant capacity of 42GL/a is indicated if a new demand of 25GL/a for Olympic Dam is to be supplied, along with total replacement of water otherwise supplied from the River Murray to Whyalla, Port Augusta and the connection to Eyre Peninsula.
The following demands to be satisfied from a SWRO are used to develop the business case:

- **Olympic Dam**: 25GL/a (based on 70ML/d initial assumption from the pre-feasibility study being conducted for BHP Billiton) to satisfy the proposed mine expansion;

- **Upper Spencer Gulf**: up to 14.5GL/a supplied to the Morgan-Whyalla Pipeline to meet demand in Whyalla and Pt Augusta; and,

- **Eyre Peninsula**: up to 2.3GL/a to supply the demand deficit in the Eyre Peninsula.

Speculative demands from other potential resource projects in the general region have not been considered at this stage of investigations because there are no private parties of substance that are likely to underwrite additional capacity and it is assumed that the Government of South Australia would not wish to do so.

The proportionate annual supply under the above scenario is presently assumed as 60% Olympic Dam related demand and 40% regional consumer demand.

However, if the residential and community demand of Roxby Downs, Andamooka, Woomera and Pimba, that in 2013 is predicted to amount to 3GL/a is subtracted from the Olympic Dam demand and classed as regional consumer demand, the relative proportions approach 55% Olympic Dam and 45% regional consumer demands.
5 Desalination - Private Sector Interest and Costs

In April 2005, the then WMC Resources, in association with the South Australian Government, went out to the market with a Request For Information (RFI) to assess the private sector’s interest in and capacity to build one of Australia’s biggest coastal desalination plants.

This section provides an overview of the submissions received from the RFI. More detail on the individual submissions is contained in the summary report that is enclosed at Appendix A.

5.1 Summary of the Request for Information (RFI) Process

Out of approximately 80 requests for the RFI document, Arup received submissions from 17 respondents. The respondents’ experience and capabilities were reviewed and a list of companies with suitable experience and capabilities that met the RFI requirements has been compiled. Table 5.1 illustrates the rating of responses.

5.2 Estimated Costs and Water Price

Table 5.2 outlines the estimated capital and operating expenditures and water selling prices for a 100 ML/day plant capacity as provided by the summary list of respondents.

BHP Billiton emphasises to readers of this document that the summarising of respondents is not part of a procurement selection process, but a means of presenting the range of completed information. The summary is of those companies that submitted clear and concise replies to all the questions of the RFI. Five questions were regarded as particularly significant and these are shown in Table 5.1. If the desalination proposal progresses further, a separate procurement process will be commenced.

The six respondents summarised were:

1. CH2M Hill;
2. GE;
3. International Power;
4. Multiplex;
5. United Utilities; and

A brief overview of these companies is below:

CH2M Hill is a global, employee-owned consulting and project delivery firm. In 2004 it posted revenues exceeding US$4 billion. CH2M Hill has extensive experience in developing seawater desalination solutions and has had roles in delivering plants with capacities up to 137 ML/day.

GE Infrastructure Water and Process Technologies has 200 employees based in Australia. GE has a turnover of approximately AU$2.7 billion per annum. GE is already engaged with BHP Billiton as a provider of chemicals and services to, amongst others, the Olympic Dam site. GE has delivered large capacity seawater reverse osmosis plants with capacities up to 375 ML/day in Trinidad, Tobago, Algeria and Kuwait.

International Power is a wholly owned subsidiary of International Power plc. International Power plc is one of the world’s largest independent electricity generating companies and has assets located in 15 countries. International Power (Australia) was established in 1996 and employs in excess of 700 staff across Australia. International Power currently owns four desalination plants, has two under construction and is developing two reverse osmosis plants both with capacities greater than 200 ML/day.
Multiplex posted revenue of AU$3.3 billion in 2004 and has 1,300 employees. Multiplex has, together with Degrémont, been awarded the contract to design and construct the 130 ML/day Perth Seawater Desalination Plant. Degrémont has undertaken desalination projects with capacities up to 170 ML/day.

United Utilities Australia has a strong presence in South Australia and is headquartered in Adelaide. Globally, United Utilities had a turnover of AU$5 billion. United Utilities has partnered with Hydranautics, a reverse osmosis membrane supplier and plant designer which recently completed a 95 ML/day plant in Tampa Bay, Florida.

Veolia Water is a global company with more than 77,000 staff across 65 countries. Veolia has installed reverse osmosis plants with capacities up to 267 ML/day.

### Table 5.1 - Responses Supplied

<table>
<thead>
<tr>
<th></th>
<th>Capital Expenditure</th>
<th>Operational Expenditure</th>
<th>RO Water Selling Price</th>
<th>Large Scale Experience</th>
<th>Renewable Energy</th>
<th>Environmental Consideration</th>
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<td>✓</td>
<td>✓</td>
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<td>x</td>
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<tr>
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<td>x</td>
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<tr>
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<tr>
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<td>✓</td>
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<td>x</td>
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<tr>
<td>Multiplex</td>
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<td>✓</td>
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<td>✓</td>
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<td>✓</td>
</tr>
<tr>
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<td>✓</td>
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<td>The City of Whyalla</td>
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<td>United Utilities</td>
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<tr>
<td>Veolia Water</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Weir Techna</td>
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<td>x</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
5.3 Estimated Costs and Water Price

Table 5.2 below presents the expected capital and operating cost and water selling price estimates of the six respondents whose submissions were complete.

Table 5.2 - Expenditure and Selling Price Estimates (100 ML/day plant)

<table>
<thead>
<tr>
<th></th>
<th>Capital Expenditure ($ Million)</th>
<th>Operating Expenditure ($ Million per Annum)</th>
<th>Water Selling Price ($ per kilolitre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH2M Hill</td>
<td>200</td>
<td>20</td>
<td>0.80 – 1.20</td>
</tr>
<tr>
<td>GE</td>
<td>198.7</td>
<td>23.2</td>
<td>1.00 – 1.05</td>
</tr>
<tr>
<td>International Power</td>
<td>145 – 162</td>
<td>20.1</td>
<td>1.05 – 1.25</td>
</tr>
<tr>
<td>Multiplex</td>
<td>250</td>
<td>19.7</td>
<td>1.20</td>
</tr>
<tr>
<td>United Utilities</td>
<td>217.4</td>
<td>16.7</td>
<td>0.95 – 1.02</td>
</tr>
<tr>
<td>Veolia</td>
<td>214.5</td>
<td>18.9</td>
<td>1.16</td>
</tr>
</tbody>
</table>

Figures 5.1 to 5.3 overleaf display the expected capital expenditure, operating expenditure and water selling prices for a 100 ML/day plant.

The respondents were asked to provide suggestions for renewable energy sources to power the proposed desalination plant. Photovoltaic cells and wind turbines were the two common suggestions. GE proposed the idea of generating electricity from geothermal power plants, and is currently undertaking a feasibility study of generating geothermal energy near Olympic Dam. Potential greenhouse mitigation strategies are discussed in Section 6.3.

It was also requested that respondents provide comments on the possibility of designing a chemical free desalination process. The general response was that it is possible to design the plant so that it does not require coagulant chemicals in the pre-treatment or anti-scalant chemicals in the reverse-osmosis stage. This would, however, reduce recovery and increase both capital and operating expenditure. If the process were to be completely chemical free, including no cleaning-solutions, membrane replacement would be too frequent to be cost effective. Design and management techniques were suggested that could minimise discharge of water treatment chemicals to the marine environment.

It was also evident from the responses that in the absence of suitable quantities and grade of waste heat, reverse osmosis (RO) was the preferred desalination technology.

Delivery times for the project including environmental and development approvals and pilot plant work were estimated by respondents at between 2 and 5 years. For a project of this scale and current status, Arup considers a 4 year delivery time as the most aggressive minimum that should be adopted for present planning purposes.
Figure 5.1: Estimated Capital Expenditure

Figure 5.2: Estimated Annual Operational Expenditure
5.4 Conclusion

For the purposes of this study it is proposed to use the range of selling price nominated, i.e. $0.80 to $1.25/kL plus the capital and operating cost allowances to integrate this supply into the regional infrastructure that is explained in Section 7.3, as the benchmark price range against which to compare SA Water’s present cost of supply to the region.

As the prices were proposed by private sector operators, they include commercial returns on private equity, private sector rates of interest on borrowings, operating profit margin, depreciation and tax. No offsets, contributions or grants have been assumed in arriving at these prices.
6 Desalination - Environmental Issues, Risks and Mitigation

From a community perception perspective as well as in reality, the two main environmental issues of SWRO desalination proposals are:

- Concentrate disposal
- Power consumption and greenhouse emissions and mitigation

These two issues have been specifically investigated as part of this proposal. They are addressed and reported on below.

6.1 Concentrate Disposal

6.1.1 Locations Investigated

Arup commissioned coastal and environmental consultants, Water Technology to carry out an investigation into the dispersion of a concentrate (brine) stream from a proposed SWRO plant in the vicinity of either Point Lowly, Port Augusta or Port Pirie, all in Spencer Gulf. Water Technology's full report is enclosed at Appendix B.

For the purposes of the initial study, it was assumed the brine would come from a desalination plant with a capacity of up to 100ML/day. A product water recovery rate of 35% was assumed and is considered within +/-5% of the likely recovery, meaning that typically 285ML/d would need to be processed with 185ML/d being returned to the sea as concentrate. The investigations were to determine the feasibility of constructing an outfall that would achieve the nominal EPA target of being within 10% of the ambient water quality at the edge of a 100m mixing zone. This initial study was aimed at determining the feasibility of the proposed outfall.

At Point Lowly the study focused upon two possible outfall sites. With relatively strong tidal currents and ready access to deep water, these locations were considered to have the greatest potential for brine dispersion.

Due to the closer proximity of Port Augusta to Olympic Dam than Point Lowly, with consequent savings in pipeline and pumping costs, the feasibility of locating the SWRO and brine outfall in the cooling water outlet channel of the Port Augusta Power Station was also assessed.

A magnesium smelting complex had once been proposed for a site north of Port Pirie. An EIS was prepared for this proposal, which included a cooling water discharge to Spencer Gulf. Due to its shallow bathymetry, eastern Upper Spencer Gulf was not considered as being as suitable for a SWRO as the other sites. However, a qualitative assessment of the general area in terms of the proposed brine outfall was sought.

6.1.2 Preliminary Conclusions

From the results of this investigation, it is concluded that it is feasible to construct a brine outfall for the proposed desalination plant that will meet the EPA's water quality requirements. The outfall could be located at either of the two main sites considered. That is, at the Port Bonython Jetty or the area to the northeast of Point Lowly. This is because the receiving water at both these sites is relatively deep, is well-mixed, and has relatively strong tidal currents. All these factors will help contribute to good near-field dilution.

At either site, adequate initial "near-field" dilution could be achieved by terminating the outfall pipe with an appropriately designed, relatively simple sub-surface diffuser of the multi-port, side discharge type.
At Port Bonython it may be possible to attach the outfall pipe and diffuser to the existing jetty that is understood to be owned by the Government of South Australia. This would likely give this site a significant cost advantage over the site to the northeast of Point Lowly, where a new structure would be required. It would also avoid the creation of another marine structure with attendant construction and marine navigation hazard risks.

The near-field model results indicated that commonly occurring ambient current speeds can result in initial dilution rates well in excess of that required to break up the interface between the diluted discharge and the surrounding sea water. Consequently, the nominal EPA target of being within 10% of ambient water quality at the edge of a 100m mixing zone can be easily achieved. The relatively strong tidal currents will also provide significant potential for further “far-field” dilution, thereby minimizing the risk of long-term accumulation of salinity in the area. Further work will be required to quantify this. This is proposed to be undertaken as part of the Olympic Dam Expansion EIS investigations.

With respect to the Port Augusta Power Station site, it may be feasible to locate the brine outfall in the cooling water outlet canal. Further investigations will be required to assess the risk of cooling water recirculation, and to determine whether the brine discharge may lead to a long-term accumulation of salinity in the area.

At Port Pirie, the weaker tidal currents, and much shallower water depths will result in reduced mixing and a much greater risk of long-term accumulation of salinity in the area, relative to that at Port Bonython or Point Lowly.

Given the preliminary nature of these investigations, the Port Bonython site presently indicates the least environmental risks with respect to concentrate disposal and at the same time offers advantages with respect to existing infrastructure. The water depth and current characteristics at this site also indicate that the concentrate discharge from a SWRO plant of greater capacity than 100ML/d could be accommodated.

6.2 Power Consumption

6.2.1 Relative Power Consumption

Based on Arup’s knowledge of the systems pump and motor inventory and assumptions it considers reasonable, the power consumed per kilolitre of water pumped from Morgan to Whyalla has been calculated. It is estimated to vary between about 2.2 kilowatt-hours (kWhr) and 3.5 kWhr, depending on the demand, the rate of high lift pumping and boosting, and the loss rate en-route due to leakages, overflows and evaporation out of uncovered storages.

The power consumption is higher during periods of high demand due to greater flows and therefore friction loss. The losses will therefore be higher in hot weather periods. This biases the average power consumption per kilolitre toward the higher end and on average over a year, it is expected to be in the range of 2.5kWhr/kL to 3.0kWhr/kL delivered to Whyalla.

SA Water purchases grid power, which is largely produced from brown coal fired generation facilities with some gas supplementation.

Because power consumption is a significant cost of desalination, a great deal of effort has been and continues to be directed at an industry level toward energy efficiency, lower energy use membranes, and energy recovery. In addition, specific projects also have the opportunity to seek out ways to optimise the process and reduce the energy consumption per unit of desalinated water produced.

Based on information gained from the RFI process discussed in the previous section of this report, as well as our own experience with a range of RO projects internationally, Arup considers that with
current technology, average power consumption per kilolitre for water delivered to Whyalla from a SWRO plant is expected to be no more than 4.0kWhr/kL. There is a reasonable expectation that technological developments in membrane technology could drive this power consumption down toward 3.0kWhr/kL over the next 10-20 years.

The cost of the estimated power to transport water from the SWRO plant to Whyalla of 0.3kWhr/kL, as advised by SA Water has been allowed for in the cost analysis described in Section 7.3.

To power the SWRO plant, BHP Billiton is keen to follow sustainable development principles and to play a role in promoting the implementation of appropriate greenhouse mitigation strategies.

### 6.3 Potential Greenhouse Gas Emissions and Mitigation

*Arup acknowledge the assistance and contribution of Hydro Tasmania to this section.*

#### 6.3.1 Potential Greenhouse Gas Emissions

In Australia electricity generation was responsible for about 35% of the total greenhouse gas emissions in 2003. Climate change due to greenhouse gas emissions could result in a long-term decline of water availability in South Australia. When considering augmentation of water supplies by methods that emit relatively large amounts of greenhouse gases, it is important to consider greenhouse mitigation options as a key aspect of the sustainability of the project.

If greenhouse emissions contributed by the operation of such projects are managed, it is possible to deliver additional water supplies with a neutral or even advantageous greenhouse effect.

The greenhouse emissions arising from SWRO are explained as follows:

A power consumption for SWRO of 4.0kWhr/kL as discussed in the above section, is equivalent to 4.0GWhr/GL. Therefore production of 42GL/a of desalinated seawater will consume 168 GWhr of power per annum. Using grid electricity, that in South Australia creates an estimated 0.96 tonnes of CO$_2$ equivalent (CO$_2$e) per MWhr$^1$ means the SWRO plant would be responsible for about 161,000 tonnes of CO$_2$e/annum.

#### 6.3.2 Lower Greenhouse Forms of Electricity Generation

Several forms of electricity generation can provide base-load power including Open Cycle Gas Turbines, Combined Cycle Gas Turbines, and Gas-Wind Hybrid systems.

Open Cycle Gas Turbines utilise natural gas as a fuel, and waste heat from the generation is emitted to the atmosphere. Combined Cycle Gas Turbines utilise natural gas as a fuel, and capture the waste heat of combustion in a waste heat recovery steam generator to drive a steam turbine, making them more efficient, but more capital intensive. Gas-Wind systems are an emerging concept where Open Cycle Gas Turbines and Wind Farms are connected to the same electrical connection point. The gas turbine(s) and wind farm work in concert to deliver base load power.

#### 6.3.3 Green Power and Renewable Energy Certificates (RECs)

Green Power is a nationally accredited electricity product whereby a retailer undertakes to purchase power from renewable sources for the end user. The volume of electricity purchased must be greater than that consumed by the end user, who pays a premium for the service. A variation on this theme is that of a dedicated “offset” wind farm, which is relatively novel in Australia. A wind farm, or other renewable energy power generation system, could be built to supply the equivalent of the power

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$^1$Greenhouse Emissions arising from use of electricity from the South Australian electricity grid are dependent upon the generation mix including coal, gas, wind, and imported electricity from Victoria. The average greenhouse emissions factor for electricity use in South Australia is sourced from AGO Factors and Methodologies Workbook, and is 0.960 Tonnes CO$_2$e/MWh.
consumed by the desalination plant. The issue of whether the power plant provides electricity directly to the desalination plant, whether the output of the power plant is contracted to the wind farm directly, and whether or not the desalination plant operator pays the full cost of the power, would need further exploration with an electricity retailer.

Eligible renewable energy generators in Australia can create Renewable Electricity Certificates (RECs) for every MWhr generated. It is the financial premium from the sale of these that makes most renewable energy projects viable.

6.3.4 Verified Greenhouse Offsets

Another option is the purchase of verified greenhouse “offsets” from the local or international market. One example of these is the BP’s Global Choice program. An Australian market in these offsets is emerging in response to demand and greenhouse emission offsets can be accredited through Australia’s Greenhouse Friendly Verification program and then sold on. Other international markets for trading offsets also exist.

6.3.5 Greenhouse Mitigation or Reduction Options

Opportunities for reducing the greenhouse intensity of industrial activities generally include efficient energy design and operation, energy substitution, and/or carbon sequestration. For this project, mitigation could be achieved in one or more of the following ways:

- Rigorously investigate energy efficiency opportunities including matching the pipe-pump selection to flows, considering variable speed pump drives if variable flows are required, ensure pipe cleaning components are included in system design (e.g. pig entry/exit points), diligently selecting and maintaining motor and pump efficiencies, implementing energy efficient treatment processes, limiting salt reduction in treatment to the maximum salt level and minimum volumes possible, and ensuring that the electricity prices used in the cost-benefit analysis take into account a carbon-constrained future.

- Operating on-site gas-fired or hybrid gas-wind electricity generation at the SWRO plant. Cogeneration and combined cycle arrangements should also be evaluated. Electricity generated in this way would be consumed directly by the desalination plant.

- Purchasing renewable energy for all or part of energy supplies via Green Power schemes. This requires an electricity retailer to source renewable energy from elsewhere in the National Electricity Market and for the user to pay a premium over and above the standard price.

- Building or incorporating a dedicated renewable energy facility e.g. wind farm with equivalent power production to that used by the SWRO. This is an offset type approach.

- Vegetative sequestration by planting large areas of appropriate trees or vegetation to offset remaining emissions through CO2 take-up in the biomass.

- Purchase of verified greenhouse “offsets” from the local or international market.

These options are not mutually exclusive and the optimal solution is likely to be a combination of the above. For instance, pursuit of energy efficiency will reduce the total emissions and, therefore, the volume of offsets required. All of these options are currently available, although technological improvements and market mechanisms can be expected to increase their viability before the expected commissioning of the desalination plant. A summary of strategies and their indicative costs are presented in Table 6.1 below.

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6.3.6 Solar Energy

Presently available solar technology for this application and scale is of itself not viable. Two recent examples of applications of photovoltaic cells in commercial environments are a grid connection at the CSIRO Energy Centre in Newcastle, NSW\(^4\) and a similar type project at Queen Victoria Markets in Melbourne, Victoria.\(^5\) The CSIRO project generates 122MWhr/a and was completed in March 2003 at a cost of $1.35m. The Markets project generates 260MWhr/a, was also completed in March 2003 and cost $1.79m. Based on these costs and assuming a linear scale-up, the 168GWhr/a required to fully power the SWRO plant contemplated here would require a capital investment of about $1.5billion. Minor offsetting opportunities are potentially available, linked to government initiatives such as Solar Cities\(^6\) but the opportunities for material off-sets using photovoltaic technology are presently not viable.

However, other solar technologies are being explored and a company named Wizard Power is attempting to develop a project in Whyalla using Australian National University’s (ANU’s) solar dish technology. Other participants include United Utilities Australia (UUA) whose role is proposed to be the delivery of a SWRO plant utilising this energy source, and the City of Whyalla, which has been a long term promoter of solar energy use in the region.

Table 6.1 Indicative greenhouse emissions, mitigation strategies and costs based on 168GWh/a power consumption and 42GL/a water production

**Worked Examples:**
Annual greenhouse emissions = Annual power consumption x emission intensity
Additional cost for emission reductions = Annual power consumption x extra cost of power
Cost of emission reductions = Additional cost for emission reductions / greenhouse reduction potential
Additional cost of mitigation = Additional cost for emission reductions / 42GL/a

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid Electricity Supply</td>
<td>0.960</td>
<td>45</td>
<td>161,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>7.56</td>
<td>0</td>
</tr>
<tr>
<td>Gas Turbine (Open Cycle)</td>
<td>0.707</td>
<td>55</td>
<td>119,000</td>
<td>42,000</td>
<td>40</td>
<td>1.68</td>
<td>9.24</td>
<td>0.04</td>
</tr>
<tr>
<td>Gas Turbine (Combined Cycle)</td>
<td>0.570</td>
<td>Variable</td>
<td>96,000</td>
<td>65,000</td>
<td>Variable</td>
<td>Uncertain</td>
<td>Variable</td>
<td>Uncertain</td>
</tr>
<tr>
<td>Gas-Wind hybrid (assuming no RECs)</td>
<td>0.474</td>
<td>64</td>
<td>80,000</td>
<td>81,000</td>
<td>39</td>
<td>3.2</td>
<td>10.76</td>
<td>0.08</td>
</tr>
<tr>
<td>Solar PV</td>
<td>0.000</td>
<td>1000</td>
<td>0</td>
<td>161,000</td>
<td>1000</td>
<td>160</td>
<td>168</td>
<td>160</td>
</tr>
<tr>
<td>Solar Dish</td>
<td>0.000</td>
<td>?</td>
<td>0</td>
<td>161,000</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>GreenPower Offset wind farm (no RECs)</td>
<td>0.000</td>
<td>80</td>
<td>0</td>
<td>161,000</td>
<td>36</td>
<td>5.88</td>
<td>13.44</td>
<td>0.14</td>
</tr>
<tr>
<td>Offsets purchased from market</td>
<td>0.000</td>
<td>45 (assume grid supply)</td>
<td>0</td>
<td>161,000</td>
<td>10 as a possible example</td>
<td>1.68</td>
<td>9.24</td>
<td>0.04</td>
</tr>
</tbody>
</table>

7 As advised by Hydro Tasmania as being typical base load prices for comparative estimating purposes.
8 Insufficient applied information is available to draw any useful conclusions at this time, but mention is warranted as it is a present area of research.
9 As above.
6.3.7 Preliminary Conclusions

The above analysis, whilst preliminary, indicates there are several methods of reducing or even eliminating greenhouse emissions from the proposed desalination plant. Preliminary conclusions are:

- Projected electricity prices are critical to future analysis and decision making. It is recommended that future carbon constraints are incorporated into the projected electricity pricing before undertaking cost-benefit analyses of energy efficiency and low-greenhouse generation and offset options.

- The lowest cost option that also has the potential to achieve a net zero greenhouse position for the project could be “offsets” purchased from the market, such as BP’s Global Choice program.

- The next lowest cost option is gas-wind power generation where no RECs are sold to retailers in the National Electricity Market. The notional RECs are applied to the SWRO project. This option only achieves a 50% cut in the greenhouse intensity of the project.

- The next lowest cost option that also has the potential to achieve a net zero greenhouse position for the project is a GreenPower project designed to fully off-set the project’s greenhouse gas generation, eg a wind farm matched to the SWRO plant’s load.

- To better assess the options and their relative merit more accuracy is required in the assumptions including gas generation pricing, gas price forecasting, energy efficiency opportunity cost, electricity price forecasting, and wind resource monitoring. New technologies may also be more viable in five years time, including large scale solar thermal or solar concentrated PV.

- The foregoing analysis indicates the cost to achieve greenhouse neutral status for the SWRO plant could be in the range of $1.7m to $5.9m per annum.

- The cost range is $0.7m to $2.4m per annum if only that proportion to achieve greenhouse neutrality attributable to Whyalla, Port Augusta and Eyre demand is considered. This adds between $0.04 and $0.14 per kilolitre to the cost of water.

- If the cost range to achieve equivalent greenhouse status to water supplied from Morgan is calculated, this is estimated to only add between $0.025 and $0.09 per kilolitre to the cost.

- Solar energy in the form of photovoltaic technology is presently not a viable option as a material greenhouse offsetting energy supply. However, other alternative conversion technologies are emerging and the situation should be reviewed again prior to any off-set strategy being finalised.
7 Methodology and Assessment of the Business Case for Desalination (SWRO) as a Regional Solution

This section of the report provides an overview of the key commercial feasibility issues which require consideration in assessing a SWRO plant as a regional water solution. The key issues addressed in this section are:

- Volume requirement
- Cost competitiveness
- Barriers to implementation
- Timetable
- Other issues

7.1 Volume requirement

Section 4.5 of this report indicates that regional demand of 17GL/a could be supplied from a regional desalination plant, in addition to the 25GL/a presently assumed as required for the Olympic Dam expansion.

The potential of a significant base load, relatively constant, long term, secure demand such as the 25GL/a required at Olympic Dam, provides a level of demand sufficient to justify consideration of investment in a large SWRO plant, which should ensure a relatively low average unit cost is achieved.

This then creates an opportunity to take advantage of economies of scale to replace the demand of Whyalla and Port Augusta, as well as Pimba and Woomera presently supplied from the River Murray, as well as the demands of Roxby Downs and Andamooka presently supplied from the Great Artesian basin.

7.2 Cost Competitiveness – BHP Billiton Perspective

BHP Billiton is currently conducting preliminary pre feasibility studies into the expansion of the Olympic Dam mine in the far North of South Australia. In addition to resource, mining and processing related issues, the preliminary pre feasibility study is reviewing infrastructure issues associated with mine expansion. Securing a long term, reliable water resource for both mine and town use at an affordable cost is critical to the future of the development. The selected water resource option will need to satisfy the following key conditions:

- Sustainability and reliability of the resource
- Acceptable cost
- Acceptable future cost stability
7.2.1 Desalination as an Option

Assuming this option comprises a SWRO plant potentially at Port Bonython, and a new 350km pipeline from there to Olympic Dam.

- Greenhouse emissions are an issue but can be effectively managed. There are no long term resource concerns. Further work is required to confirm preliminary indications that ecological issues with respect to concentrate disposal are manageable over the long term. Assuming greenhouse and concentrate disposal can be managed, the community is likely to be supportive.

- Under present assumptions, cost is at the high end of acceptability.

- The sustainability issues are manageable for this option. Power costs and greenhouse neutrality will drive cost sensitivity but off-setting this is the potential for technology advances in the alternate energy and greenhouse mitigation fields and in the drive for lower energy/lower cost SWRO membranes. Future cost sensitivity is considered moderate.

7.2.2 Conclusions

The work done by BHP Billiton to date with respect to its future water supply strategy for an expanded Olympic Dam is not complete.

However, the very long mine life, the likely sustainable nature of SWRO at the location selected, the likelihood that greenhouse impacts can be effectively managed, the less constraining nature of SWRO to future mine expansions and the technology enhancement/cost reduction potential of SWRO are all favourable considerations for this option.

7.3 Cost Competitiveness – other users’ perspective

Up to 2.3GL/a on Eyre Peninsula and the predicted 14.5GL/a by 2013 in Whyalla and Port Augusta is currently supplied or is intended to be supplied by SA Water from the River Murray.

The majority of water users in this region pay the State-wide price for water. This is not sufficient to meet the costs of delivery by SA Water. Under existing arrangements with the State Government, SA Water is compensated for this shortfall through various Community Service Obligation (“CSO”) payments.

Set out in Table 7.1 below is an indicative calculation of the likely cost to SA Water, as calculated using the principles in its annual report and as required under the National Competition Policy framework.

These conservative estimates indicate that the true cost of water supplied to Whyalla is $1.83/kL or more. It is a similar cost for Port Augusta and is likely to be significantly higher for Eyre Peninsula.

The fundamental assumptions are:

- Total Asset Value - Optimal Deprival Value (ODV) is estimated at about $1.2bn.

- Except for pump stations where 25% has been used, 35% of ODV is attributable to supplying about 10GL/a to ‘nearer’ River Murray customers, eg Morgan, Robertstown, Burra, Bundaleer, Clare, Beetaloo, Peterborough, Crystal Brook.

- Of the estimated 30GL/a pumped from Morgan, 20GL/a is the volume against which 65% of the ODV has been attributed.
Based on the above assumptions, the annual CSO assumed paid by the Government of South Australia to SA Water to deliver 20GL/a of water to Upper Spencer Gulf is that volume multiplied by the difference between $1.828m/GL ($1.828/kL) and the State Wide Price $1.03m/GL, which equals about $16m.

This compares to SA Water's Annual Report that advised the total CSO receipts from government as $100.2m in 2004\textsuperscript{10}.

As the Morgan-Whyalla system is SA Water's largest single country asset, the assumptions made herein seem conservative.

Table 7.1 Indicative CSO calculation for water delivered to Whyalla from the River Murray

<table>
<thead>
<tr>
<th>Asset</th>
<th>Distance (km)</th>
<th>Approx current replacement cost ($m/km)</th>
<th>Approx current replacement cost ($m)</th>
<th>Less % attri to nearer Murray regions</th>
<th>Net current replacement cost ($m)</th>
<th>Est of useful life (years)</th>
<th>Annual asset charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipeline 1 - Land : Morgan – Baroota</td>
<td>231</td>
<td>1.2</td>
<td>277.2</td>
<td>35%</td>
<td>180.2</td>
<td>100</td>
<td>$1.8m</td>
</tr>
<tr>
<td>Pipeline 1 - Land : Baroota – Whyalla</td>
<td>125</td>
<td>1.2</td>
<td>150.0</td>
<td>150.0</td>
<td></td>
<td>100</td>
<td>$1.5m</td>
</tr>
<tr>
<td>Pipeline 2 - Land : Morgan – Baroota</td>
<td>231</td>
<td>1.5</td>
<td>346.5</td>
<td>35%</td>
<td>225.2</td>
<td>100</td>
<td>$2.3m</td>
</tr>
<tr>
<td>Pipeline 2 - Sea : Baroota – Whyalla</td>
<td>50</td>
<td>4.0</td>
<td>200.0</td>
<td>200.0</td>
<td></td>
<td>50</td>
<td>$4.0m</td>
</tr>
<tr>
<td>Morgan Filtration</td>
<td>1</td>
<td>75.0</td>
<td>75.0</td>
<td>35%</td>
<td>48.8</td>
<td>50</td>
<td>$1.0m</td>
</tr>
<tr>
<td>Pump Stations</td>
<td>4</td>
<td>10.0</td>
<td>40.0</td>
<td>25%</td>
<td>30.0</td>
<td>25</td>
<td>$1.2m</td>
</tr>
<tr>
<td>Storages</td>
<td>3</td>
<td>35.0</td>
<td>105.0</td>
<td>105.0</td>
<td></td>
<td>100</td>
<td>$1.1m</td>
</tr>
<tr>
<td>Total Asset Value – Optimal Deprival Value (ODV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1,193.7</td>
</tr>
<tr>
<td>Estimated Asset Charge (depreciation equiv.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated “Return” Charge - say 2% on ODV (equivalent to 6% on written down value (WDV))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Asset Charges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimated Annual Volume (excluding near Murray regions)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20,000 ML</td>
</tr>
<tr>
<td>Estimated Annual Asset Charge (Vol/Total Asset Charge above)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1.578 / kl</td>
</tr>
<tr>
<td>Add Volumetric Costs - Filtration at Morgan - Pumping to Whyalla</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0.075 / kl $0.175 / kl</td>
</tr>
<tr>
<td>Estimated comparable cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$1.828 / kl</td>
</tr>
</tbody>
</table>

The excess of this cost estimate over the State Wide Price would be reimbursed to SA Water under the CSO arrangements.

A sensitivity analysis on the "estimated return charge" included above is set out below.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Cost per KL</th>
<th>Return Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>4% on WDV / 1.3% on ODV</td>
<td>Est comparable cost $1.51/kl</td>
<td>Est &quot;Return&quot; Charge $12.4m</td>
</tr>
<tr>
<td>8% on WDV / 2.7% on ODV</td>
<td>Est comparable cost $2.15/kl</td>
<td>Est &quot;Return&quot; Charge $23.2m</td>
</tr>
</tbody>
</table>

The appropriate charge can only be calculated via a detailed review of SA Water asset registers and depreciation policies. This is not practicable within the scope of this brief.
The above calculations based on what are believed to be conservative assumptions, indicate that the true cost of water delivered to Whyalla and similarly to Port Augusta by way of the existing SA Water assets, is at least $1.83/kL.

In Section 5 of this report, private sector providers have indicated that water should be able to be sold from the SWRO plant in the range of $0.80-$1.25 per kilolitre. Some respondents suggested innovations to reduce intake and outlet costs, which can be significant, and if realised could drive costs to the lower end of the range. However at this stage of the study, it is recommended that prices in the top half of the range be considered more likely.

In line with the initial concept outlined in Section 2.4, the additional assets and the capital conservatively identified to make for a workable concept are:

- A 500ML lined and covered storage complex adjacent the SWRO plant, estimated to cost $12m.
- Works to link the pumping main to Olympic Dam with SA Water’s infrastructure and a conservatively sized 1000L/s pumping station to supply Whyalla, estimated to cost $3m.
- A 500ML lined and covered storage complex North of Port Augusta and interconnecting pipework capable of providing reliable supply to Port Augusta, estimated to cost $14m.

A total of 1500ML of storage is proposed, accounting for the above and the minimum proposed storage at Olympic Dam, which is costed separately and not part of this project. At 120ML/d output, this is 12.5 days storage, a very high level of security. With design development this volume and the associated costs may be reduced.

It is noted that there are a number of conceptual possibilities to integrating the existing customer base with the proposed desalination plant and new pipeline to Olympic Dam, but for the sake of simplicity and to establish a straightforward prima facie business case, the capital expenditure required for system integration has been assumed to be in line with the above allowances that amount to $29m.

Based on estimated lives for these assets and a ‘return’ charge of 6% of written down value, this capital expenditure would need to recover an estimated $2.4m annually. Dividing this by the 17GL/a of water distributed through these additional assets adds about $0.14/kL to the cost of water.

Additional operating costs will also be required and these are estimated to total between $0.045/kL and $0.11/kL comprising the following:

- Proportionate greenhouse mitigation costing between $0.025/kL and $0.09/kL.
- Additional pumping allowance to supply the regional demand from the SWRO bulk storage estimated to cost no more than $0.02/kL.

### 7.3.1 Conclusions

The selling price for desalinated seawater from a 100 ML/d plant at Port Bonython has been advised by potential private sector providers at $0.80/kL to $1.25/kL. A larger capacity plant to satisfy a proportionally larger demand is likely to result in lower selling prices.

An additional volumetric charge to fund the capital works involved in supplying water from the SWRO plant to agreed points of transfer into SA Water’s infrastructure to enable supply to Whyalla, Port Augusta and Eyre Peninsula, and to accommodate the seasonal variability in demand has been estimated at $0.14/kL.

Additional operating costs to fund greenhouse mitigation are estimated at between $0.025/kL and $0.09/kL with the cost of localised pumping in addition to that required by the present system estimated at about $0.02/kL.
Therefore the sum of the selling price and volumetric charges ranges from $0.985/kL to $1.50/kL.

Both the upper and lower ranges of cost are considerably less than the conservatively estimated $1.83/kL full cost of water presently supplied to Whyalla and Port Augusta.

Based on these assumptions, there is an economic business case for a regional seawater desalination plant to supply water to Whyalla, Port Augusta and the proposed Eyre Peninsula pipeline.

The above financial calculations have not allowed for payment to the Government of South Australia of an estimated $26m in return for replacing 17GL/a of demand from the River Murray, nor any other capital funding that may be available as part of the $2bn Australian Government Water Fund. Receipt of such funds would further reinforce the economic business case.

7.3.2 SA Water Response

SA Water has responded to a series of drafts of this report that have led to this final version. Technical matters have been resolved appropriately. It has been agreed that at this early stage of discussion and project definition, there are a range of technical matters of detail that will need further work if this proposal is to be advanced. It has also been agreed that the technical information reported herein is a high level perspective appropriate to this stage of the concept.

The material differences in perspective between SA Water and the consulting team relate to the issues of short versus long term comparative cost analysis and CSO funding, both of which affect the business case from a commercial perspective.

It is SA Water’s view that no significant asset replacement will be required for many years, and therefore the business case for investment in desalination in the short term should be based on the broader benefits to the State rather than the water supply system.
8 Implementation Issues, Risks and Mitigation

The following section provides a summary of the issues to be considered in preparing an initial project implementation plan.

8.1 Ownership/Funding Options

The SWRO plant could be owned by any of BHP Billiton, SA Water or a specialised infrastructure provider. A critical consideration for BHP Billiton will be the ability of other potential owners to align with the water supply requirements of the Olympic Dam expansion timetable. The relative merits of ownership of by each of these parties are further discussed below:

8.1.1 BHP Billiton

In the event the SWRO plant was solely supplying BHP Billiton, there would be a strong argument for the ownership of this asset by BHP Billiton.

Given that the proposed plant will be located in a region where connection into the network supplying regional potable water supplies is available, then the most appropriate economic use of this asset will, at some time, involve integration with this network. For this reason the proposal takes on the nature of a business in its own right, rather than a project providing a resource to a single user. In such circumstances, BHP Billiton may elect to contract with a party experienced in running businesses of this nature.

8.1.2 SA Water

Given the potential for connection into the regional water supply and to retain their pre-eminent position as both supplier and distributor of water to regional consumers, it is appropriate that SA Water consider its future ownership (and operation) of this infrastructure.

8.1.3 Specialised infrastructure provider

Assuming a strong baseline contract can be negotiated with BHP Billiton, this asset would be considered relatively attractive to specialist providers of infrastructure of this nature, such as many of the respondents to the RFI as reported on in Section 5. Such providers have indicated a strong willingness to contemplate a ‘merchant desalination plant’ given the credit worthiness of the base customer and the exceptionally long mine life.

Such a provider would also give careful consideration to access regime agreements available under current competition laws, whereby these parties should be able to access SA Water’s infrastructure and provide an alternate water supply to the Upper Spencer Gulf, Eyre Peninsula and adjacent regions.

8.2 Procurement Options

As set out above, the SWRO plant could be owned by any of BHP Billiton, SA Water or a specialised infrastructure provider. The final method of procurement would be selected by the owner, but would likely be a matter of significant interest to BHP Billiton, in particular the timing, cost and reliability issues.

If initial government ownership risked the meeting of the Olympic Dam expansion timetable, there is the opportunity to negotiate a future ‘buy in’ arrangement to suit the requirements of all parties.

The main options and the strengths and weaknesses of each general method of procurement are summarised below. These options are general only and there are various hybrid and variant forms of
procurement developed for specific projects. One of the key drivers to selecting the most appropriate form of procurement is risk management. The procurement method should only be chosen following a comprehensive assessment of the risks and the identification of those parties best suited to assume the various risks. Such an approach will aid in delivering a successful project:

8.2.1 Traditional Ownership, Design, Tender, Construct
In this case the owner determines what is required and justified as an investment, depending on its drivers, i.e. private and public sector owners will have differing justifications. Through a series of iterations and progressive studies a preliminary design and cost estimates are determined and commitments to funding the project are obtained.

The owner then appoints a designer to design and document the works. The level of design detail should be driven by the relative uniqueness of the project. With this project there will be some unique elements, e.g. site layout, seawater intake and concentrate outlet concepts, but many potentially pre-designed elements, e.g. pumps, RO modules, filters, chemical storages. Under these circumstances a value designer will only design what can not be satisfactorily purchased as a manufactured element. The design will integrate the unique elements with those that can be purchased. The designer will then produce drawings and documentation sufficient to tender the work and lead to a construction contract.

Often with the designer’s help, the owner will seek tenders for the work either from the open market or from selected, pre-qualified contractors. The tenderers then price the job on the basis of the documentation and submit their offers. The owner, assisted by the designer, assesses the offers and selects a tenderer to become the contractor to deliver the work.

Once completed and commissioned, the contractor hands the works over to the owner. The owner than steps into the operator’s role or, in parallel with construction, the owner may have negotiated with a third party to step in as the operator.

The main strengths of his approach are that the design is completed and a final estimate of both capital and operating costs is done before committing to construction. If sufficient resources are committed to the design phase, many uncertainties can be dealt with and risks managed. The owner can influence the design, revise it if costs are excessive or circumstances change and therefore more greatly influence the final outcome.

The main weakness is the sequential nature of the whole process, which means it takes longer than some of the more contemporary processes. Depending on contractual arrangements, this method can result in more risk residing with the owner in return for more control.

8.2.2 Traditional Ownership, Design and Construct (D&C)
The main difference in this case is the owner moves from the preliminary design stage direct to a tender process to select a D&C contractor to both design and build the project. The owner with the help of the preliminary designer selects a contractor to deliver the work. The contractor will have a designer as part of the project team. The design and construction phase are combined and controlled by the contractor.

The main strengths of this approach are the potential for parallel activity and time savings, the potential for the designer and contractor to work together and innovate in design, constructability and delivery methods, and generally the transfer of more risk (and possibly reward) to the contractor.

The main weaknesses are the owner loses some control of the design, which may or may not be an issue and whilst risk is transferred, if savings are made, these will usually reside with the contractor.
8.2.3 Traditional Ownership, Design, Build, Operate (DBO)
This method is the same as the former except the contractor is also required to commit to a generally significant period of operation, and this cost plus a margin is priced into the original tender.

The advantages of this approach over and above the former are that the owner is able to obtain a contracted price for operation. This approach also tends to force designers and contractors to concern themselves with operating costs, reliability and longevity. Depending on the length of the operating period, this approach gives the owner an indication of full life cycle costs of owning and operating the asset.

From the owner’s perspective, if the designer and contractor innovate, they may capture the savings in capital and operating expenditure for themselves. However, as long as the asset is built to the quality required and assuming the operations phase eventually transitions to the owner, the benefits of innovation should flow through.

8.2.4 Traditional Ownership, Managing Contractor, Front End Engineering Design (FEED)
This approach is common in the resources sector. It is similar to the D&C approach, except the owner appoints a managing contractor to take the majority of responsibility for delivering an outcome. In the case of resources projects, the owner’s expertise lies in the operations not the design and construction. Consequently, the owner outsources to the managing contractor the delivery of a commissioned asset, that the owner can then step into and operate.

The advantages are that some risks are transferred to a party better able to deal with them and the owner can concentrate on core business.

The disadvantages are that a fee is paid to manage the risks, and the owner loses some control including over matters that may affect operational performance, cost and reliability.

8.2.5 Traditional Ownership, Alliance Contract
Under this arrangement, a group of parties with the critical skills, resources and attributes to deliver a successful project, join together as an alliance and undertake to ‘share the pain and the gain’. The parties would generally include the owner, designer(s), constructor(s), operators and possibly the financier(s). The intent is to work together collaboratively in a no blame, solutions and innovations oriented culture to deliver a sound project and be rewarded accordingly.

If properly set up, the advantages are that the risks are identified and apportioned fairly and appropriately, all parties are involved in adding value, value and losses that are created are shared, problems that arise affect all parties and the owner has influence over the holistic outcome.

The disadvantages are the set up time and costs of an alliance are significant and choosing the right alliance partners and individuals are paramount to success as one of the fundamentals of alliance partnering is having and maintaining sound relationships, especially in adversity.

8.2.6 Build, Own, Operate, Transfer (BOOT)
The key aspect of a BOOT arrangement is to do with initial ownership and financing of the asset, with a hand-over to an agreed owner at some future time, typically twenty years or so.

In simple terms, BOOT transactions can be thought of in terms of a lease arrangement, i.e. a party wishes to access the outcomes of owning an asset but does not want the responsibilities of ownership including the need to provide or borrow the capital. Consequently that party contracts with another, the BOOT proprietor, who is prepared to own and operate the asset for the nominated period and deliver the specified outcomes. In return, the recipient of the outcomes agrees to specified periodic payments to the BOOT proprietor. At the end of the BOOT period, the asset usually transfers to the recipient, often for one dollar.
The design, construction and operation of the asset can be procured by the BOOT proprietor in whichever way thought appropriate, and should be driven by what results in the most profitable overall outcome to the BOOT proprietor.

The advantages of BOOT transactions are usually related to financial and taxation issues. The disadvantages are usually related to inappropriate use of BOOT transactions resulting in end users risk and payment profile being less favourable than if an alternate method had been used.

8.3 Operator Options

Operation of the SWRO plant will most likely be a choice determined by the owner of the plant. It could therefore be any of BHP Billiton, SA Water or a specialist plant operator of the nature of the parties that responded to the RFI. As the major user of the output of the plant, this would likely be a decision in which BHP Billiton would seek to determine in consultation with the South Australian Government.

8.4 Delivery Risks

This section assesses the major delivery risks associated with the SWRO option, specifically:-

- Approval Risk – Likelihood of the project being approved for development.
- Timing Risk – Alignment to Olympic Dam expansion timetable
- Technical Risk – Risk associated with the technology used in the project.
- Capital Risk – Will capital be provided for the project.
- Operational Risk – Are sufficiently skilled parties available to operate the project element.

8.4.1 Approvals

If selected, the SWRO project will form part of the EIS being prepared for the Olympic Dam expansion project. With respect to the concept outlined herein, nothing has been discovered prior or during this investigation that indicates any high risk issues or impediments to the approval process.

8.4.2 Timing

The approvals, negotiations, transactions and procurement are capable of being delivered within the present timetable for the expansion of Olympic Dam. However, the risk of delays and barriers increases with the number of parties involved in the transaction. Decisions and commitments on ownership and procurement strategy will need to be made early to manage this risk.

8.4.3 Technical

Projects of this nature currently operate around the world and, therefore, the likelihood of emergence of significant technical risk is considered low. The significant response to the RFI reinforces this opinion.

8.4.4 Availability of capital and operational capability

The RFI process conducted in April 2005, by WMC Resources in association with the South Australian Government, undertook an assessment of the capacity to build and operate a large coastal desalination plant. The responses to this process provide sufficient comfort with respect to the availability of capital for this project and the availability of capable operators for this project.
8.5 Timetable

The following table summarises the key elements of the Olympic Dam expansion timeline, and parallels a potential timeline for the water infrastructure issues:

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Olympic Dam Expansion Milestones</th>
<th>Water Supply Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Government negotiations</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>EIS lodged</td>
<td>Decision on preferred option and implementation plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Commence procurement process</td>
</tr>
<tr>
<td>Mid 2008</td>
<td>EIS approval target</td>
<td>Conditional commitments to proceed</td>
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<tr>
<td>Mid 2008</td>
<td>BHP Billiton Board decision to proceed</td>
<td>Relevant parties commit unconditionally to proceed</td>
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<tr>
<td>April 2008 – December 2008</td>
<td>Mobilisation of preferred procurement option and finalisation of contract arrangements</td>
<td>Final contract negotiations and works preliminaries</td>
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<tr>
<td>January 2009 – December 2011 (3 Years)</td>
<td>Mine, process and infrastructure development including pipeline</td>
<td>Construction of SWRO plant (and pipeline)</td>
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<tr>
<td>January 2012</td>
<td>12 month commissioning commences</td>
<td>SWRO/pipeline operational</td>
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Based on this timetable, it does not appear that inclusion of an SWRO plant in BHP Billiton’s plans is time critical. However, the timelines indicated above would need constant monitoring to ensure this did not become an issue in the future. It should be recognised that BHP Billiton is currently in a pre-feasibility study stage and the timeframes above are subject to change.

8.6 Key Issues To Be Addressed For Project To Proceed

The following key issues have been identified as requiring resolution prior to project commitment:

8.6.1 BHP Billiton’s Timeline For Expanding Olympic Dam

BHP Billiton recently completed its takeover of WMC Resources. To ensure the maximum commitment to the regional SWRO project from other stakeholders, it is necessary for BHP Billiton to confirm its undertakings and timeline with respect to the project. The water strategy for the expansion is expected to be confirmed in the first half of 2006.

8.6.2 SA Water’s Potential Involvement

A preliminary review of the project indicates that the SWRO element of the project should be attractive to SA Water, in that:

- It meets SA Water’s historic charter, in that it requires the delivery of water resources to expanding industry regions and populations. The expansion of Roxby Downs and Olympic Dam in the early part of the 21st century is no different to Whyalla in the 1950’s when the second Morgan/Whyalla pipeline was constructed to support state development.
- The underlying tariffs will most likely meet or exceed SA Water’s target return requirements.
- The creditworthiness of the major customer is prime.
• It provides SA Water with the capacity to offer an alternate (and possibly cheaper) water source for the Eyre Peninsula and surrounding regions.
• It would be expected to generate for it additional annual revenue of $32m, including an underlying return on funds invested in the order of $12.0m per annum.

8.6.3 Water Recovery Framework
The potential volume of water saved from the River Murray within the context of the proposal discussed herein is 17GL/a. This quantum of water has a capital value of $23.8m based on the current, typical market rate for permanent River Murray water entitlements in South Australia of $1,400/ML. One option is that the water saving be sold back to the MDBC at the prevailing market price. Other options and the transactional details of putting in place such a recovery of water are yet to be explored and resolved.


9 Summary and Conclusions

On the information available and on the basis of the assumptions made herein, there is a sustainable business case for a SWRO desalination plant to satisfy the following demands:

- **Olympic Dam**: 25GL/a (based on 70ML/d initial assumption from the pre-feasibility study being conducted for BHP Billiton) to satisfy the proposed mine expansion;

- **Upper Spencer Gulf**: up to 14.5GL/a supplied to the Morgan-Whyalla Pipeline to meet demand in Whyalla and Pt Augusta; and,

- **Eyre Peninsula**: up to 2.3GL/a to supply the demand deficit in the Eyre Peninsula.

SA Water has expressed the strong view that no major asset replacement will be required for many years, and therefore there will be significant additional costs in using desalinated water rather than the current supply for that period. It acknowledges that there are broader benefits to the State that may justify involvement in the project for other than the reasons considered in this report.

Speculative demands from other potential resource projects in the general region have not been considered at this stage of investigations because there are no private parties of substance that are likely to underwrite additional capacity and it is assumed that the Government of South Australia would not wish to do so.

The proportionate annual supply under the above scenario is presently assumed as 60% Olympic Dam related demand and 40% regional consumer demand. However, if the residential and community demand of Roxby Downs, Andamooka, Woomera and Pimba, that in 2013 is predicted to amount to 3GL/a is subtracted from the Olympic Dam demand and classed as regional consumer demand, the relative proportions approach 55% Olympic Dam and 45% regional consumer demands.

The results of preliminary brine disposal investigations indicate it is feasible to construct a brine outfall for the proposed desalination plant that will meet the EPA’s water quality requirements. The outfall could be located at either of the two main sites considered. That is, at the Port Bonython Jetty or the area to the northeast of Point Lowly. This is because the receiving water at both these sites is relatively deep, is well-mixed, and has relatively strong tidal currents, all of which will help contribute to good near-field dilution.

There are several methods of reducing or even eliminating net greenhouse emissions from the proposed desalination plant. If the cost range to achieve equivalent greenhouse status to water supplied from Morgan is calculated, this is estimated to only add between $0.025 and $0.09 per kilolitre to the cost.

The selling price for desalinated seawater from a 100 ML/d plant at Port Bonython has been advised by potential private sector providers at $0.80/kL to $1.25/kL. A larger capacity plant to satisfy a proportionally larger demand is likely to result in lower selling prices.

An additional volumetric charge to fund the capital works involved in supplying water from the SWRO plant to agreed points of transfer into SA Water’s infrastructure to enable supply to Whyalla, Port Augusta and Eyre Peninsula, and to accommodate the seasonal variability in demand has been estimated at $0.14/kL. Additional operating costs to fund localised pumping in addition to that required by the present system are estimated at $0.02/kL.

Combining the indicated selling price with the allowances for additional capital works and operating charges indicate a water cost to SA Water in the range $0.985/kL to $1.50/kL.

The consulting team believes this cost should be compared with $1.83/kL, the full cost of water presently supplied to Whyalla and Port Augusta. SA Water believes it should be compared to $0.20/kL - $0.30/kL which is the short term marginal cost of supplying water to the region. This issue remains unresolved.
The Government of South Australia and BHP Billiton have agreed to a further economic study to quantify the broader benefits associated with the regional desalination proposal.

The financial calculations made to arrive at this conclusion have not allowed for payment to the Government of South Australia from the Living Murray initiative or from the $2bn Australian Government Water Fund. Based on the current, typical market rate for a permanent River Murray water entitlement in South Australia of $1,400/ML, a once off payment of $23.8m in return for replacing 17GL/a of demand from the River Murray is considered indicative. Receipt of such funds would further reinforce the economic business case.

The regional SWRO proposal presents an opportunity to the Government of South Australia to deliver in one project, significant water savings to the River Murray.

The regional SWRO project would also deal with the additional water supply required by BHP Billiton for the expansion of Olympic Dam, thereby resolving one of the key barriers to the expansion.

Servicing this new demand would provide an estimated return on investment of $12m annually to SA Water.

The project would provide a clear transitional strategy to deal with the existing, ageing public water supply assets in the region.

10 Recommendations

This report has been accepted by the Steering Committee as concluded. Additional work to quantify the broader economic benefits that might flow from the project has already been commenced.

It is recommended that this report be referred to the South Australian Department of Water, Land and Biodiversity Conservation for consideration and determination of future actions.
Appendix A
Coastal Desalination
Sea Water Reverse Osmosis (SWRO)
Request For Information (RFI)
Report
Private sector interest in, indicative cost and associated data relating to the possibility of constructing a 50-100ML/d seawater desalination plant adjacent the Upper Spencer Gulf in South Australia.

Request for Information Document

Information Requested By:
12noon Australian CST Tuesday 17th May 2005

(Note: Date changed from advertisement due to 16th May 2005 being a public holiday in South Australia.)

Contact Person: Borvin Kracman
Arup Water
Level 2, 431-439 King William Street
ADELAIDE SA 5000

Telephone: (08) 8212 5580
Mobile: 0408 824 362
Facsimile: (08) 8212 5590
Email: borvin.kracman@arup.com.au
Private sector interest in, indicative cost and associated data relating to the possibility of constructing a 50-100ML/d seawater desalination plant adjacent the Upper Spencer Gulf in South Australia.

Request for Information Document

April 2005
Private sector interest in, indicative cost and associated data relating to the possibility of constructing a 50-100ML/d seawater desalination plant adjacent the Upper Spencer Gulf in South Australia.

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This report takes into account the particular instructions and requirements of our Client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.
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1. THE REQUEST

This Request for Information (RFI) is directed at suitably experienced and capable organisations with a successful history of delivering major water and marine infrastructure projects exceeding $100m in capital value. The organisation must include or be able to integrate with a seawater desalination plant provider capable of delivering a 50-100ML/d seawater desalination plant in South Australia’s Upper Spencer Gulf.

The information is being sought as part of the pre-feasibility study (PFS) into the expansion of WMC’s Olympic Dam mining and processing operations.

This RFI is led by WMC in collaboration with the Government of South Australia. The Government of South Australia and its agencies have made no undertakings whatsoever in terms of being potential purchasers of water from such a plant should one be built, but it is recognised that such an initiative would provide an opportunity as a new source of water for future development additional to that at Olympic Dam. The location of Olympic Dam is shown on the map below.

The expansion of Olympic Dam and investigation of desalination options provides an opportunity for the South Australian Government to also consider desalination options that meet the broader needs of the region or the State. At this early stage of investigations the Government of South Australia has made no commitment to becoming a purchaser of water from any desalination project. That said, proponents are encouraged to consider commercial solutions that address the water requirements for the region/State both for existing and future demand requirements while also meeting the specific needs of WMC.

Map showing location of Olympic Dam in South Australia.
2. PRESENT SITUATION

WMC’s Olympic Dam copper/uranium/gold/silver mine is a world class operation. The deposit is the fourth largest remaining copper resource, the fourth largest remaining gold resource and the largest uranium resource in the world. WMC is currently the 17th largest copper producer and 3rd largest uranium producer globally. The mine is the largest underground mine in Australia and employs approximately 1,670 staff (including contractors). Projected production for the 2004 financial year is approximately 224,000 tonnes of copper and 4,400 tonnes of U$_3$O$_8$, based on the mining and treatment of approximately 8.8 million tonnes of ore. Given a current proved and probable measured reserve of 730 million tonnes, and a total resource base of more than 3.8 billion tonnes, Olympic Dam has the potential to support a very long life mining operation at production rates substantially greater than current rates.

The Olympic Dam operations consist of an underground mine, mineral processing plant, smelter, and refinery, associated infrastructure and the mine town of Roxby Downs, approximately 16 km south of the mine. Located approximately 570 km north-west of Adelaide in South Australia, the Olympic Dam deposit was discovered by WMC in 1975 following drilling near a small stock water dam known as “Olympic Dam”.

Water is supplied from two borefields, respectively 106km and 200km north of the mine, situated in the Great Artesian Basin. Olympic Dam’s special water licence provides for up to 42 megalitres per day (ML/d) of water consumption. Current consumption is approximately 32ML/day. Of this, 15ML/d of the better quality Borefield B is water desalinated at about 75% recovery to provide 8.5ML/d of potable water and 2.3ML/d of high quality process water of about 10mg/L chloride.

The 8.5ML/d of potable water reports as follows:

- Roxby Downs township 2.2 ML/day
- Mine 0.7 ML/day
- Process 5.6 ML/day

The reject is blended with Borefield A and other recycle streams to provide lower quality process water.

Within the present water circuit, the extent of recycle is limited by chloride build up. The concentration at which chloride materially affects metals recovery is 3000mg/L, as chloride.

Energy is a major cost for Olympic Dam, with approximately $60 million per annum spent on electricity, LPG, distillate and fuel oil. Power for Olympic Dam is supplied via a 275kV power line owned by WMC and connected to the grid in the vicinity of Pt Augusta. Power is currently supplied under power supply and transmission contracts until July 2006.

3. THE REGION

The town of Roxby Downs currently supports a population of approximately 4,000. Under the proposed Olympic Dam expansion the population has potential to grow to around 7,000 residents.

As detailed above, the area’s water supply is via a local desalination plant which has operated successfully for the past 15 years.

The Upper Spencer Gulf region and neighbouring Eyre Peninsula has a population of around 100,000. Key centres in the Upper Spencer Gulf include the cities of Whyalla, Pt Augusta
and Pt Pirie, with water supplied by SAWater from the River Murray via the Morgan to Whyalla pipeline.

Pt Lincoln and the Eyre Peninsula are supplied from a series of underground basins, topped up by the Tod Reservoir system through a local SAWater network.

4. PROPOSED EXPANSION

In May 2004, WMC announced it intended to spend a further $48 million over two years in a PFS of the expansion of Olympic Dam to incorporate the resources located in the southern area of the deposit. A combined WMC/contractor team has been appointed to undertake the study, which is due to be completed in early 2006. It is expected by WMC, on the basis of work carried out to date, that an expansion of copper production to around 500,000 tonnes per annum (tpa) is achievable. This would be based upon production from open pit mining of the southern area (combined with existing underground operation in the north). The study will identify a whole of life mine plan for the entire Olympic Dam resource.

The PFS includes more than 72 kilometres of surface drilling, an assessment of mining and processing methods, environmental investigation and baseline studies, and an evaluation of likely infrastructure including water and energy requirements.

Other critical issues to be addressed during the PFS include the availability of sufficient power, water, road/rail infrastructure and town development to support an expanded mine operation.

Power consumption under the expansion case is expected to increase from a current average load of approximately 100MW to in the order of 370MW, and natural gas is considered by WMC to be a viable option to help meet these increased energy requirements (WMC has an option for 12-30 PJ per annum from the PNG Gas Project, which announced the commencement of front end engineering design in October 2004). Gas could be used to generate electricity at Olympic Dam to meet the anticipated power requirements. It is possible that power surplus to local requirements could be exported using the existing WMC owned 275 kV power line. Proposals have been received from potential energy providers.

Water requirements are expected to increase by an additional 70 ML/d for the expanded operations. Work to refine the quantity and quality requirements to support the expansion, identifying sustainable primary source options and water management strategies is presently in progress as part of the PFS.

5. THE WATER SUPPLY OPTIONS

To determine the optimum sustainable water solution for the proposed development, effort is being focussed on reduction, re-use and recycling on site as well as investigating additional water supply alternatives.

The main alternative sources of additional water presently being investigated are the Great Artesian Basin (GAB) and desalination of seawater from a location in the Upper Spencer Gulf. The distances from Olympic Dam to a potential new borefield in the GAB to the north, or to a potential coastal desalination site to the south are both similar and about 300 kilometres. A new pipeline system will be required for either option. The topography and other pipeline considerations result in similar costs to transport water from either source.

The selection of the most appropriate water source is a critical decision for the long term future of the mine. The life-of-mine at expanded production is presently estimated at 70+ years.
The cost and life of a pumping main of the length, capacity and reliability necessary to support the expansion is such that choosing one source will exclude the other, ie the decision is intended to determine the life-of-mine water supply.

Subject to ongoing metallurgical and logistics investigations, it is presently assumed that out of the 50-100ML/d of additional water, about 20ML/d will need to be of a quality suitable for potable and process use. This requirement presently leads to the conclusion that if additional water is sourced from the GAB then an additional 20ML/d will need to be desalinated at Olympic Dam, whereas if additional water is sourced from a coastal desalination plant and this water is potable quality, then only an additional 5ML/d will need to be desalinated at Olympic Dam. (5ML/d is the estimated additional high quality process water requirement).

Despite the peripheral desalination requirement, from a present day economic perspective there is a significant cost premium associated with a seawater desalination option compared to the GAB option. However, considerations including sustainability over life-of-mine, risk issues, technology improvement potential, social benefits, regional development opportunity and the scale of the potential expansion have led WMC, its advisors and the Government of South Australia to conclude that the desalination option is worthy of further investigation.

By working collaboratively with governments and industry and by taking a long term view, WMC believe this project can provide the platform for regional development prosperity that is sensitive to the ecological needs of the arid host environment. An expandable regional desalination plant may contribute to development opportunities on South Australia’s Eyre Peninsula and the highly prospective Gawler Craton geological region. With the very real prospect for Australia of a long term drying climate, the sea provides the lowest risk source for a sustainable water supply. That said, the three key public concerns regarding seawater desalination that have been noted by WMC to date are energy consumption and consequent greenhouse issues, concentrate disposal and consequent ecological effects, and cost.

6. OBJECTIVES OF THE RFI

Recognising that seawater desalination projects at this scale are not common, the objectives of this RFI are:

- To assess the interest and the critical considerations of the private sector in participating in such a project.
- To provide a cross check of first order cost estimates based on experience with projects of this nature and scale.

The information is being sought for project evaluation purposes only.

7. BASE INFORMATION AND ASSUMPTIONS

7.1 Base Information

Background information regarding WMC can be found at http://www.wmc.com/

A profile of Olympic Dam can be found at http://www.wmc.com/acrobat/xstrata/targetstatgrantpartb.pdf

Information about South Australia can be found at http://www.southaustralia.biz/home_page.htm

Information about Whyalla can be found at http://www.whyalla.com/site/page.cfm?u=8

A map outlining a possible desalination plant site is at http://www.whyalla.com/webdata/resources/files/industry_land_map1.jpg

7.2 Base Assumptions

For the purposes of comparison against information and cost estimates that have already been gathered it would be appreciated if the following assumptions were made when responding to this RFI. The assumptions advised below are considered reasonable on the basis of current knowledge and information. Note that monetary currency in this RFI is in AUS$ and all responses are requested to be in AUS$.

- For the purpose of this RFI the desalination plant will be located in the Whyalla Resource Development Estate, adjacent to Pt Bonython. The site is located close to major power and water infrastructure, on land that is appropriately zoned. It is adjacent to some of the deepest water relatively close to the shore of the gulf and that experiences good tidal currents. Point Lowly is the land extremity southeast of the nearby Santos facility. Seaward and east of Point Lowly is assumed to be a suitable location for concentrate disposal. The seabed gradient is steep. Depths of greater than 20 m are reached within 500 m of Point Lowly, and below 10 m there is minimal seagrass growing. The deep water forms a channel running north-south that has tide-induced currents reaching 1.0 metre per second. Preliminary indications are that a dilution factor of over 100 can be expected within the initial mixing zone of the discharge point with a value of 0.5 metres per second assumed for lateral currents.

(Selection of a site for a desalination plant is not yet confirmed and will be the subject of considerable further investigations. An EIS and consultation process is to be assumed.)

- The plant in its entirety, up to a discharge interface at an adjacent balancing tank and pump station will be owned and operated by a private party with WMC being a long term purchaser of either 50ML/d (18,250 ML/year) or 100ML/d (36,500 ML/year) of bulk product water on a take or pay basis. The balancing tank, pump station and pipeline system to Olympic Dam will be owned by WMC. (WMC understand this assumption may change if the desalination option develops).

- That upstream and downstream balancing storage will amount to no more than a few days consumption by WMC resulting in the need for a high degree of water production and delivery security on a continuous basis.

- The plant owner/operator will be free to sell additional water to the market but no undertakings have been given by the Government of South Australia or its agencies with respect to their participation.

- Power available at a site price of $50/MWhr in 2005 dollars.

- Power to the site is via a 132kV line with capacity for desalination operations but requiring a transformer that is to be costed into the desalination plant.

- Raw seawater has a TDS range of 40,000 to 45,000 mg/L and a maximum temperature range of 12 to 24°C.

- Product water is to be potable as defined by the Australian Drinking Water Quality Guidelines and have a Langelier Saturation Index in the range minus 0.5 to minus 1.7.

- Cost of capital is 7%

- Operator’s margin is 5%

- USDollar:AuDollar exchange rate is 0.70

- Area of land for the plant is 5 hectares and cost of land is $1m.
• Chemicals used in the process to be in accordance with established good practice and sustainable practice.
• Intake main to be 1km marine and 1km on land.
• Discharge main to be 1km marine and 1 km on land.

8. INFORMATION REQUESTED

The information being sought is intended to be brief, at a high level, indicative only and of a nature that participants are prepared to disclose to disclose bearing in mind the objectives of this RFI. Short responses to each item, bullet pointed phrases and indicative numbers are preferred.

• Principal respondent, organisational structure and identity of key parties.
• A brief summary of previous experience in seawater desalination plants of this scale, including location and key data.
• Level of interest in participating in a project of the type described herein.
• Comments if any on the base information and assumptions.
• Comments if any on major and critical issues facing a project and suggestions as to how such a project might be best progressed, should WMC wish to do so.
• Comments on any other headline commercial issues e.g. term of offtake agreement, pricing options, debt and equity arrangements and opportunities to expedite a project.
• Comment on strategies for renewable energy and greenhouse gas reduction that might be able to be cost effectively incorporated into a project.
• Comments on likely preferred pre-treatment and desalination technology type and reasons for the preference.
• Comment on the likely rated plant capacities that would be initially contemplated, given the supply rate and security required by WMC.
• Comment on the relative ease of upgrading plant output in response to other demands and comment on the supply factors that will create a ceiling on the other demands that may be able to be satisfied.
• Indicative capital cost estimates, expected percentage accuracy (+/-30% preferred) and other key assumptions for each of a 50ML/d and 100ML/d continuous supply capacity desalination plant, divided into:
  • Intake works including marine component
  • Pre-treatment
  • Desalination
  • Post-treatment
  • Outfall works including marine component
  • Site infrastructure (e.g. site preparation, buildings, roads, security, power supply, telecommunications, etc)
  • Preliminary investigations costs (surveys, pilot plant, EIS and approvals)
  • Project delivery costs (e.g. design, documentation, procurement, project management, legals, commissioning, training)
  • Other costs (e.g. site establishment/disestablishment, contractor profit, etc)
• Indicative operating cost estimates per annum, expected percentage accuracy (+/-30% preferred) and other key assumptions for each of a 50ML/d and 100ML/d continuous supply capacity desalination plant, divided into:
  • Power
  • Chemicals
  • Membranes or other specialist items, depending on technology proposed
  • Consumables
  • Maintenance
  • Personnel
  • Overheads

• Key process design assumptions appropriate to the technology proposed (e.g. filter loading, recoveries, membrane flux, chemical dose rates, membrane element size, membrane life, power consumption)

• Comments in relation to the effect on costs, recovery and flux if a chemical free process was mandated.

• Approximate range of selling price of product water to WMC as $/ML in 2005 dollars for a 50ML/d demand and a 100ML/d demand, stating key assumptions.

• Anticipated range of timeframes suggested for the following activity groupings, stating key assumptions and ability for parallel activities:
  • Preliminary investigations
  • Pilot plant trials
  • EIS and approvals
  • Design, documentation and procurement
  • Construction including marine works
  • Commissioning

9. PREFERRED FORM OF RESPONSE

RFI Responses are requested to be typed in the English language and address each of the elements requested, in sequence. As a guide, no more than fifteen pages of original typed material plus appropriate and relevant supporting material are suggested.

RFI Responses are requested to be lodged as a pdf attachment to an email addressed to borvin.kracman@arup.com.au and with the subject title of RFI – WMC Desalination Plant.

Lodgement of RFI Responses is requested by 12 noon, Australian central standard time on Tuesday 17th of May 2005.

There is no requirement for the submission to comprise hard copy documentation.

10. CONDITIONS OF LODGEMENT

Upon submission of the RFI Response document, ownership of it transfers to WMC.

In seeking this information, WMC advises it has no intention to use it to create commercial relations with respect to the procurement of a seawater desalination plant to service Olympic Dam.

WMC shall not be held liable for any costs incurred in the preparation of the RFI Response.

Submission of an RFI Response deems acceptance of these conditions.
11. AKNOWLEDGEMENT

WMC thanks respondents in advance for their provision of the information sought.
BHP Billiton

Olympic Dam Development Pre-Feasibility Study

Coastal Desalination

Sea Water Reverse Osmosis (SWRO) Request For Information (RFI) Report
ArupWater

BHP Billiton

Olympic Dam Development Pre-Feasibility Study

Coastal Desalination

Seawater Reverse Osmosis Request for Information Report

August 2005
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APPENDICES

APPENDIX A
RFI Terms of Reference
1 Executive Summary

The proposed expansion of BHP Billiton's giant Olympic Dam mine will depend on many factors, one of which is water.

In April 2005 WMC Resources, in association with the South Australian Government, went out to the market with a Request For Information (RFI) to assess the capacity to build one of Australia's biggest coastal desalination plants. WMC Resources was subsequently taken over by BHP Billiton.

The aim of investigating seawater desalination is to secure a long term, sustainable water supply for Olympic Dam's operations and the domestic needs of nearby Roxby Downs and provide additional capacity to supply the cities of the Upper Spencer Gulf region along with Pt Lincoln and other communities across Eyre Peninsula.

The plant will supply an estimated 100ML/day of high grade potable water via a pipeline more than 300kms to BHP Billiton's operations at Olympic Dam as well as to approximately 100,000 people living and working throughout the Upper Spencer Gulf and Eyre Peninsula regions of South Australia.

This report summarises the submissions received from the RFI.

Out of approximately 80 requests for the RFI document, Arup received submissions from 17 respondents. The respondents’ experience and capabilities were reviewed and a list of companies with suitable experience and capabilities that met the RFI requirements has been compiled. Table 1 overleaf illustrates the rating of responses.

Table 2 outlines the estimated capital and operating expenditures and water selling prices for a 100 ML/day plant capacity as provided by the summary list of respondents.

BHP Billiton emphasizes to readers of this document that the summarising of respondents is not part of a procurement selection process, but a means of presenting the range of completed information. The summary is of those companies that submitted clear and concise replies to all the questions of the RFI. Five questions were regarded as particularly significant and these are shown in Table 1. If the desalination proposal progresses further, a separate procurement process will be commenced.

The six respondents summarised were:

1. CH2M Hill;
2. GE;
3. International Power;
4. Multiplex;
5. United Utilities; and

A brief overview of these companies is below:

CH2M Hill is a global, employee-owned consulting and project delivery firm. In 2004 it posted revenues exceeding US$4 billion. CH2M Hill has extensive experience in developing seawater desalination solutions and has had roles in delivering plants with capacities up to 137 ML/day.

GE Infrastructure Water and Process Technologies has 200 employees based in Australia. GE has a turnover of approximately AUS$2.7 billion per annum. GE is already engaged with BHP Billiton as a provider of chemicals and services to, amongst others, the Olympic Dam site. GE has delivered large capacity seawater reverse osmosis plants with capacities up to 375 ML/day in Trinidad, Tobago, Algeria and Kuwait.
International Power is a wholly owned subsidiary of International Power plc. International Power plc is one of the world’s largest independent electricity generating companies and has assets located in 15 countries. International Power (Australia) was established in 1996 and employs in excess of 700 staff across Australia. International Power currently owns four desalination plants, has two under construction and is developing two reverse osmosis plants both with capacities greater than 200 ML/day.

Multiplex posted revenue of AU$3.3 billion in 2004 and has 1,300 employees. Multiplex has, together with Degrémont, been awarded the contract to design and construct the 130 ML/day Perth Seawater Desalination Plant. Degrémont has undertaken desalination projects with capacities up to 170 ML/day.

United Utilities Australia has a strong presence in South Australia and is headquartered in Adelaide. Globally, United Utilities had a turnover of AU$5 billion. United Utilities has partnered with Hydranautics, a reverse osmosis membrane supplier and plant designer which recently completed a 95 ML/day plant in Tampa Bay, Florida.

Veolia Water is a global company with more than 77,000 staff across 65 countries. Veolia has installed reverse osmosis plants with capacities up to 267 ML/day.
Table 1 - Responses Supplied

<table>
<thead>
<tr>
<th></th>
<th>Capital Expenditure</th>
<th>Operational Expenditure</th>
<th>RO Water Selling Price</th>
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* While it was requested that respondents submitted suggestions for “zero material harm”, none did. Many did, however, consider environmental effects.

Table 2 - Expenditure and Selling Price Estimates (100 ML/day plant)

<table>
<thead>
<tr>
<th></th>
<th>Capital Expenditure ($ Million)</th>
<th>Operating Expenditure ($ Million per Annum)</th>
<th>Water Selling Price ($ per kilolitre)</th>
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<td>GE</td>
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<td>23.2</td>
<td>1.00 – 1.05</td>
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<td>20.1</td>
<td>1.05 – 1.25</td>
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<td>250</td>
<td>19.7</td>
<td>1.20</td>
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<td>United Utilities</td>
<td>217.4</td>
<td>16.7</td>
<td>0.95 – 1.02</td>
</tr>
<tr>
<td>Veolia Water</td>
<td>214.5</td>
<td>18.9</td>
<td>1.16</td>
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</table>
Figures 1 to 3 display the expected capital expenditure, operating expenditure and water selling prices for a 100 ML/day plant.

The respondents were asked to provide suggestions for renewable energy sources to power the proposed desalination plant. Photovoltaic cells and wind turbines were the two common suggestions. GE proposed the idea of generating electricity from geothermal power plants, and is currently undertaking a feasibility study of generating geothermal energy near Olympic Dam.

It was also requested that respondents provide comments on the possibility of designing a chemical free desalination process. The general response was that it is possible to design the plant so that it does not require coagulant chemicals in the pre-treatment or anti-scalant chemicals in the reverse-osmosis stage. This would, however, reduce recovery and increase both capital and operating expenditure. If the process were to be completely chemical free, including no cleaning-solutions, membrane replacement would be too frequent to be cost effective. Design and management techniques were suggested that could minimise discharge of water treatment chemicals to the marine environment.

It was also evident from the responses that in the absence of suitable quantities and grade of waste heat, reverse osmosis (RO) was the preferred desalination technology.

Delivery times for the project including environmental and development approvals and pilot plant work were estimated by respondents at between 2 and 5 years. For a project of this scale and current status, Arup considers a 4 year delivery time as the most aggressive minimum that should be adopted for present planning purposes.
Figure 1 - Estimated Capital Expenditure
Figure 2 - Estimated Annual Operational Expenditure

![Diagram showing estimated annual operational expenditure for different companies. The expenditures are as follows: CH2M Hill: $20 million per annum, GE: $23.2 million per annum, International Power (RO): $20.1 million per annum, Multiplex: $19.7 million per annum, United Utilities: $16.7 million per annum, Veolia Water: $18.9 million per annum, Arup: $24 million per annum.]
Figure 3 - Estimated Water Selling Price

- CH2M Hill: $0.80 - 1.20
- GE: $1.00 - 1.06
- International Power (RO): $1.05 - 1.25
- Multiplex: $1.20
- United Utilities: $0.85 - 1.02
- Veolia Water: $1.16
- Arup: $1.20

Estimated RO Water Selling Price (100ML/day plant)
2 Introduction

Arup has been engaged by BHP Billiton as infrastructure and environmental advisers for the proposed Olympic Dam mine expansion pre-feasibility study (PFS). There are a variety of strategies being considered to meet the increased water demand, which is expected to be up to an additional 70ML per day.

As part of the PFS process, the commercial desalination project domain was approached to confirm the market participants’ opinions as to appropriate desalination technologies, to provide indicative cost information and determine the level of interest in undertaking a desalination project of this scale in South Australia.

A request for information (RFI) process was carried out with the placement of an advertisement in the printed media, namely The Australian, The Advertiser and The Financial Review. In response to this, approximately 80 parties requested the full RFI document, which contained background information to the proposed expansion and also specific points to be addressed in the RFI response.

Out of the 80 parties responding to the advertisement, 17 submitted contributions. This report presents a summary of the reviews that were undertaken of these 17 responses.

3 Description of the RFI Process

The RFI process is outlined in Table 3:

<table>
<thead>
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<td>RFI submissions close</td>
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The RFI advertisement taken out in news media is shown in Figure 4.
REQUEST FOR INFORMATION

Seawater Desalination Plant in South Australia

WMC Resources Limited, in association with the South Australian Government, is calling for private sector interest in the possible construction of a large-scale seawater desalination plant in the Upper Spencer Gulf region of South Australia.

Key considerations:
- Plant capacity of 50-100 ML/d seawater desalination
- Renewable energy, in part or in whole, to be considered
- Zero material effect of brine discharge into marine environment
- Companies must have a successful track record in delivering major water and marine infrastructure projects valued in excess of $100m
- Companies must include, or be able to integrate with, a seawater desalination plant-provider

Objectives: Recognising that seawater desalination projects at this scale are not common, the objectives of this RFI are:
- To assess the interest and the critical considerations of the private sector in participating in such a project.
- To provide a cross check of first order cost estimates based on experience with projects of this nature and scale.

Background: This Request for Information (RFI) will form part of an existing pre-feasibility study (commenced June 2004) into the expansion of WMC’s mining and processing operations at Olympic Dam. Whilst there is a strong focus on reduction, re-use and recycling, it is likely that the expansion will require additional water to be brought to site. Two primary sources of new water are being investigated, the Great Artesian Basin and seawater desalination. Either solution will require water to be delivered to Olympic Dam by a new 200 km northern or southern pipeline. Only one pipeline option will be chosen. (The pipeline is not part of this RFI).

The Government of South Australia recognises that such an initiative would provide significant opportunity as a new source of water for future development across the region. Consequently the Government is a joint participant in this RFI.

The RFI is for evaluation purposes only. There is no intention to use it to create commercial relationships. A separate process will follow if it is decided to take the seawater desalination option further.

Contact: WMC has appointed Arup to provide advice on infrastructure issues related to the Olympic Dam expansion proposal. An electronic copy of the RFI Document can be requested by interested parties telephoning Arup’s Adelaide office on +61 8 8212 5580 during normal business hours.

Information Requested By Date: Monday 16th May 2005.

Figure 4 - RFI Advertisement
4 **RFI Submissions Received**

Out of the 80 responses to the advertisement, 18 submissions were made. They were from:

1. Abigroup;
2. Agility Management;
3. Black & Veatch;
4. CH2M Hill Australia;
5. GE;
6. Hydro Tasmania;
7. International Power;
8. ITT Industries;
9. Multiplex;
10. Pacific Pure Water, Inc.;
11. Packaged Food International;
12. Soil Water Solutions;
13. The City of Whyalla;
14. Transfield Services;
15. United Utilities;
16. Veolia Water; and
17. Weir Techna.

5 **Summaries of received RFI submissions**

Below are summaries of the submissions that were received:
5.1 Abigroup

Principal respondent, organisational structure and identity of key parties

- Consortium Members:
  - Acquasol Pty. Ltd, as Project Developers;
  - Abigroup Ltd, as D&C Engineers, Project Management, Civil Engineers, Structural Engineers and Marine Engineers. Abigroup has a large presence in Australia and New Zealand with approximately 1,500 employees; and
  - Cheetham Salt Ltd, for brine utilisation and salt harvesting. Cheetham Salt Ltd. is Australia’s largest producer of salt and is wholly owned by Ridley Corporation Limited.
  - Bongiorno Consulting Pty. Ltd for project finance.

- Subcontractors:
  - Sumitomo Co. Ltd (Engineering, coordinators for Sasakura and Hitachi);
  - Sasakura Ltd. (Desalination, reverse osmosis and multi-effect distillation equipment suppliers);
  - Pex Industries Pty. Ltd. (Reverse osmosis and multi-effect distillation equipment suppliers and contract operators);
  - Hitachi Ltd. (Power Generation and Gas turbines); and
  - Boeing Company (Solar power generation and thermal storage).

Summary of Experience

Several smaller RO plants are listed and one 330 ML/day plant in Israel.

Level of Interest

Acquasol has had dialogue with BHP Billiton personnel regarding the Olympic Dam expansion and has previously indicated its interest.

Comments on the base information and assumptions

Alternative site suggested:
- Point Paterson, south of Port Augusta.
- Recommended due to ability to be co-located with a salt manufacturing plant.

Comment on any headline commercial issues

- Long term take-off agreement required to privately finance the project.
- The consortium members are prepared to be equity investors.

Renewable Energy Strategies

- The use of a Boeing Company solar thermal power plant will reduce greenhouse gases.

Comment on preferred pre-treatment and desalination technology type

- Membrane filtration will be preferred pre-treatment, along with dosing of anti-scalant, acid and sodium bisulphate.
- The proposed desalination technology is reverse osmosis.
Comment on the initial plant capacity

- 25% overcapacity for the RO membranes and the pre-treatment.
- Critical pumping and dosing equipment will have either 50% or 100% standby capacity.

Comment on the upgradeability of the plant in response to demands

- Due to modular nature of reverse osmosis technology and membrane filtration, upgrading the plant capacity is easy.
- Pumps, dosing equipment, intakes and discharges should be designed to allow for maximum upgradeability.

Indicative capital cost estimates

For Port Bonython:
- 50 ML/day plant: $108,900,000;
- 100 ML/day plant: $148,100,000.

For Point Paterson:
- 50 ML/day plant: $257,383,431;
- 100 ML/day plant: $281,096,492.

It is not clearly stated, but it is understood that there is also a multi-effect distillation plant included in the capital and operating cost for Point Paterson, which explains the doubling of cost.

Indicative operating cost estimates

For Port Bonython:
- 50 ML/day plant: $6,350,000 per annum;
- 100 ML/day plant: $12,150,000 per annum.

For Point Paterson:
- 50 ML/day plant: $15,932,788 per annum;
- 100 ML/day plant: $18,989,000 per annum.

Key process design assumptions

Two-pass system.

Pricing

- $1.00 to $1.30 per kilolitre.

Programme

60 months
5.2  Agility Management

*Principal respondent, organisational structure and identity of key parties*

Agility Management is a wholly owned subsidiary of AGL and was established in 2000. Agility Management currently has approximately 1,100 employees who manage water, gas and electricity infrastructure.

*Summary of Experience*

Agility Management has no experience with desalination, but has extensive experience in the provision of infrastructure solutions in gas, electricity and water industries. Recent experience includes:

- **Water Industry:**
  - Construction of 7 km pipeline and pumping station upgrade.
  - Replacement of 70 km of water mains.
  - Construction of 5 km of pipeline.

- **Gas Industry:**
  - Construction of 840 km gas pipeline.
  - Ongoing rehabilitation of 5,700 km gas pipeline.

- **Electricity Industry:**
  - Hallett Power Station
    - Construction of 180 MW generators.
    - Construction of 11 frame gas turbines.
    - O&M services.
  - D&C of 4.2 km 66 kV power lines and associated equipment.

*Level of Interest*

Agility Management has no interest in the desalination plant, but is interested in constructing and operating surrounding infrastructure, such as electrical infrastructure, water transmissions mains and power supply solutions.
5.3 Black & Veatch

Principal respondent, organisational structure and identity of key parties

Black and Veatch is the principal respondent. Black and Veatch was founded in 1915 and in 1999 became a global, employee-owned corporation. Black and Veatch has 6,800 employees working in more than 90 offices around the world. Black and Veatch, Singapore submitted the RFI response.

Summary of Experience

Black and Veatch has executed projects totalling 1,900 ML/day. The largest plant is currently under construction and is to have a capacity of 136 ML/day. Black and Veatch produced the design.

Black and Veatch also has an interest in the energy generating market, and has designed power plants with a combined capacity of over 120,000 MW.

Comment on preferred pre-treatment and desalination technology type

The preferred pre-treatment is membrane filtration. The desalination technology implemented is proposed to be Reverse Osmosis.

Indicative capital cost estimates

- Installed cost of approximately $1,500,000 per megalitre.
  - 50 ML/day plant: $75,000,000.
  - 100 ML/day plant: $150,000,000.

Pricing

- $0.60 to $1.10 per kilolitre.

Programme

- 39 to 48 months
5.4 CH2M Hill

Principal respondent, organisational structure and identity of key parties

CH2M Hill is the principal respondent. CH2M Hill is an employee-owned project delivery firm with in-house capability of total project development from planning through to commissioning. The firm posted revenues exceeding US$4 billion in 2004.

CH2M Hill has partnered with OSMOFLO in developing the RFI Submission. OSMOFLO is a producer of membrane separation systems.

Summary of Experience

CH2M Hill has extensive experience with seawater desalination, and has been researching, pilot testing and installing desalination systems for more than 25 years, including plants with capacities up to 137 ML/day.

Level of Interest

CH2M Hill routinely participates in projects of this type.

Comments on the base information and assumptions

- CH2M Hill believes the feed TDS has been over-estimated and the minimum temperature has been underestimated.
- Operator’s Margin of 5% seems low, and is generally set to 10%.

Comments on major and critical issues

- The agreed capacity of the plant must be decided to provide certainty of the initial sizing of the infrastructure.
- Secure sufficient off-take agreements as to cover financing costs and recover equity.
- CH2M Hill suggests getting two detailed designs by two members of a competitive alliance to ensure minimum capital and operational expenditure is found.

Comment on any headline commercial issues

- Establishing an agreed demand ceiling.
- Variable charges could be structured to reflect the reduced marginal cost of water above certain daily consumption levels.

Renewable Energy Strategies

- Both wind and solar power need to be considered for economic viability.

Comment on preferred pre-treatment and desalination technology type

Preferred Pre-treatment:

- Ultra-filtration or Micro-filtration.
  - Both will produce consistent feed water quality for the RO with a low silt density index.

Preferred desalination technology:

- Reverse osmosis.
  - Best return on investment, especially with a lack of waste-heat to use.
Comment on the initial plant capacity

- Plant capacities:
  - For 50 ML/day plant, 97% availability is used, so required plant capacity is 51.5 ML/day.
  - For 100 ML/day plant, the rated plant capacity will be 103.1 ML/day.
- During membrane cleaning, the production will drop by 6.25% for the duration of the cleaning for the 50 ML/day plant and 3.15% for the 100 ML/day plant.

Comment on the upgradeability of the plant in response to demands

- Due to the modular nature of reverse osmosis technology, it would be feasible to upgrade the plant to a selected future capacity provided that there is sufficient space for the RO skids, switchgear, pumps and chemical storage.
- The inlet and outlet pipe work should be sized to allow for the future plant capacity.

Indicative capital cost estimates

- 50 ML/day plant: $110,000,000
- 100 ML/day plant: $200,000,000

Indicative operating cost estimates

- 50 ML/day plant: $10,600,000 per annum
- 100 ML/day plant: $20,000,000

Implications of a chemical free process

CH2M Hill suggests it is not possible to have a chemical free RO process, but it is feasible to reduce the amounts of chemicals used.

Pricing

- 50 ML/day plant: $0.85 to $1.40 per kilolitre
- 100 ML/day plant: $0.80 to $1.20 per kilolitre

Programme

Overall plant delivery: 51 months.
5.5 GE

Principal respondent, organisational structure and identity of key parties

The principal respondent is a team comprising GE Infrastructure Water and Process Technologies and UnitedKG. UnitedKG will take a lead role as EPC contractor and GE will undertake the design and supply of desalination technology and equipment.

GE Infrastructure Water and Process Technologies has 200 employees based in Australia and a turnover of approximately AU$2.7 billion per annum.

United KG employs approximately 2,700 people around the world and posts revenues greater than AU$1.2 billion per year.

Summary of Experience

- 136 ML/day SWRO, Trinidad and Tobago
- 25 ML/day SWRO, Spain
- 200 ML/day SWRO, Algeria
- 375 ML/day BWRO, Kuwait (expandable to 600 ML/day)

Comments on the base information and assumptions

- If only a small quantity of potable water is required at Olympic Dam and the majority of water required can be less than potable standard, then it may be possible to produce water to the required level for the majority of the water and then have a smaller brackish water RO plant at Olympic Dam to extract the potable water.

Comments on major and critical issues

- The possibility of a negative effect on the cuttlefish and the aquaculture.
- The salinity of the seawater in the Northern Spencer Gulf is similar to the Middle East, but the increased salinity is not offset by increased temperatures.
- The following waste streams are generated:
  - Brine
  - Media filter backwash
  - RO Membrane cleaning solutions and rinsing waters.
  - Tank and piping disinfection during commissioning.
- The proposed coagulant will contain iron. If the EPA nominates a maximum allowable iron concentration in waste water it may be necessary to remove iron sludge from the waste water and dispose of it.

Comment on any headline commercial issues

- Off-take agreement types

Renewable Energy Strategies

The possibilities are:

- Wind
- Geothermal
  - There are currently plans for test-wells to be drilled near the Olympic Dam site to establish whether a geothermal energy source exists.
Comment on preferred pre-treatment and desalination technology type

Pre-treatment:
- Media-filtration
  - Gravity or pressure, depending on the SWRO capacity.

Desalination:
- Reverse Osmosis
  - Evaporation technologies could be used if there is a substantial and sustained supply of waste steam.

Comment on the initial plant capacity

The plant capacity will be n+1, where n is the number of trains.

Indicative capital cost estimates
- 50 ML/day plant: $106,500,000
- 100 ML/day plant: $198,700,000

Indicative operating cost estimates
- 50 ML/day plant: $12,900,000 per annum.
- 100 ML/day plant: $23,200,000 per annum.

Pricing
- 50 ML/day plant: $1.05 to $1.10 per kilolitre.
- 100 ML/day plant: $1.00 to $1.05 per kilolitre.

Programme

47 months
5.6 Hydro Tasmania

Principal respondent, organisational structure and identity of key parties

Hydro Tasmania is the principal respondent.

Summary of Experience

Hydro Tasmania’s area of expertise lies in renewable energy using wind turbines.

Level of Interest

Hydro Tasmania are interested in partnering with the desalination plant owner to provide renewable energy for the desalination process.

Renewable Energy Strategies

Hydro Tasmania has extensive experience with using wind turbines for renewable energy. Projects with capacities up to 140 MW are planned.

Hydro Tasmania has development tools to aid in the design and placement of the wind turbines to minimise the energy cost taking into consideration the prevailing wind speeds, the topography of the proposed area, the existing transmission lines, vegetation and environmental factors as well as roads.

Hydro Tasmania believe that it is potentially possible to supply power to the desalination plant with a greenhouse intensity between 0.1 and 0.3 kg CO₂e/kWh, which is 10-30% of the national grid average.
5.7 International Power

Principal respondent, organisational structure and identity of key parties

International Power (Australia) Pty. Ltd. is the principal respondent and has not joined with other parties in producing the RFI submission. They will integrate with a desalination technology provider. International Power is the largest independent power producer in Australia and employs 700 staff.

International Power is interested in assuming the role as lead developer, owner and operator of the plant.

Summary of Experience

Two large (approximately 450 ML/day and 700 ML/day) multistage flash desalination plants are operational in United Arab Emirates.

Two seawater reverse osmosis plants are currently in development, both in excess of 200 ML/day.

International Power is currently developing a number of desalination options to be co-located with the Pelican Point power station.

Comment on any headline commercial issues

"The plant operator should consider attracting an off-taker for the brine by-product to help the economics and related environmental issues for such a project."

Renewable Energy Strategies

- Establish a long-term agreement with a wind farm.
- Explore smaller renewable energy sources, like solar panels, for non-essential loads.

Comment on preferred pre-treatment and desalination technology type

- Both RO and Multistage Flash Distillation (MSF) have been considered.
  - RO was found to provide the required flexibility of supply.

Comment on the upgradeability of the plant in response to demands

Due to modular nature of Reverse Osmosis, it can easily be upgraded, unlike MSF.

Indicative capital cost estimates

Reverse Osmosis:

- 50 ML/day plant: $76,000,000 to $88,000,000
- 100 ML/day plant: $145,000,000 to $162,000,000

Multistage Flash Distillation:

- 50 ML/day plant: $92,000,000 to $105,000,000
- 100 ML/day plant: $174,000,000 to $188,000,000
Indicative operating cost estimates

Reverse Osmosis:
- 50 ML/day plant: $10,100,000 per annum to $11,900,000 per annum
- 100 ML/day plant: $18,250,000 per annum to $21,900,000 per annum

MSF:
- 50 ML/day plant: $14,600,000 per annum to $16,430,000 per annum
- 100 ML/day plant: $27,380,000 per annum to $31,030,000 per annum

Implications of a chemical free process

If a chemical free process is required, MSF may be the desired technology, due to the minimal chemical requirement.

Descalent, oxidiser and pH adjuster seen as essential chemicals for water treatments.

Pricing

Reverse Osmosis:
- 50 ML/day plant: $1.10 per kilolitre to $1.30 per kilolitre
- 100 ML/day plant: $1.05 per kilolitre to $1.25 per kilolitre

MSF:
- 50 ML/day plant: $1.15 per kilolitre to $1.35 per kilolitre
- 100 ML/day plant: $1.10 per kilolitre to $1.30 per kilolitre

Programme

Including development, 24 to 30 months
5.8 ITT Industries

Principal respondent, organisational structure and identity of key parties

ITT Industries, Aquivous and Water Equipment Technologies are membrane technology specialists. They will partner with ITT Flygt to deliver membrane separation solutions. ITT Flygt is a pump specialist.

Summary of Experience

ITT Industries has completed small seawater reverse osmosis treatment plants, sizes ranging from 0.5 ML/day to 4 ML/day. Larger brackish water desalination plants have been constructed. ITT Industries is currently working on a 113.5 ML/day reverse osmosis plant in the Middle East, to be completed February 2006.

Level of Interest

“ITT Industries would welcome the challenge of this project and working with the planners, designers and communities of South Australia”

Comments on the base information and assumptions

- Concerns about concentrate disposal
- Energy is “relatively inexpensive”.

Renewable Energy Strategies

35% Energy saving by use of energy recovery device.

Comment on preferred pre-treatment and desalination technology type

No pre-treatment comments provided.

Reverse Osmosis chosen as preferred desalination technology due to lower capital cost and reasonable operating cost, smaller footprint, less energy and is a cleaner process.

Comment on the initial plant capacity

9 train layout, with the possibility of adding additional trains.

Indicative capital cost estimates

Cost for design, documentation, project management, equipment, commissioning and training (no civil works):

- 50 ML/day plant: $27,900,000
- 100 ML/day plant: $67,600,000

Indicative operating cost estimates

Not including power:

- Based on 100 ML/day plant: $458.86 per megalitre ($16,750,000 per annum)

Implications of a chemical free process

Increased maintenance frequency

Programme

45 months
5.9 Multiplex

Principal respondent, organisational structure and identity of key parties

The principal respondent is Multiplex.

The key parties are:

- Multiplex (Diversified Property Business);
- Degrémont (Treatment Plant Specialists); and
- Australian Water Services (Part of Degrémont).

Degrémont is a world leading provider of seawater desalination plants, and is part of the Suez group.

Multiplex is the largest Australian owner developer and contractor of major commercial and resource infrastructure. Multiplex posted a revenue of $3.3 billion in 2004 and has 1,300 employees.

Australian Water Services operate several water and wastewater plants around Australia.

Summary of Experience

Multiplex and Degrémont were awarded with the contract to design and construct the 130 ML/day Perth Seawater Desalination Plant.

Degrémont is currently constructing a desalination plant in Northern Chile, with a capacity of 45 ML/day.

Other projects are two seawater desalination plants with capacities of 120 ML/day and 170 ML/day and two brackish water desalination plants with capacities of 68 ML/day and 165 ML/day.

Comments on major and critical issues

- To ensure that the plant will operate at the rated capacity, a pilot plant is suggested.
- Water quality required by different off-takers must be defined early.

Comment on any headline commercial issues

- A long-term (25-30 year) off-take agreement would be appropriate.

Renewable Energy Strategies

- To reduce the required energy input, three energy recovery devices are available, being:
  - Pelton wheel,
  - DWEER System (Dual Work Exchange Energy Recovery)
  - Pressure exchange device
- Renewable energy can come from a range of sources, including:
  - Solar
  - Wind
  - Geothermal
  - Wave
  - Biomass
Comment on preferred pre-treatment and desalination technology type

- Depending on feed water, the desalination could comprise of:
  - Coarse and fine screening
  - Oxidisation
  - Clarification or flotation
  - Filtration
- Desalination type:
  - As there is no waste heat available at Port Bonython, the most energy efficient process is Reverse Osmosis.
  - A single pass configuration should provide sufficiently low salinity.
  - If low boron or bromide is important, then a multi-pass system can be adopted.

Comment on the initial plant capacity

As the actual demand is not known, it is not possible to comment on the initial plant capacity.

Comment on the upgradeability of the plant in response to demands

Due to the modular nature of RO, the plant capacity can easily be increased with demand.

Indicative capital cost estimates

- 50 ML/day plant: $145,000,000
- 100 ML/day plant: $250,000,000

Indicative operating cost estimates

- 50 ML/day plant: $13,750,000 per annum
- 100 ML/day plant: $19,700,000 per annum

Key process design assumptions

- 30-40% recovery

Implications of a chemical free process

To allow chemical free operation, it will be required to perform detailed pilot testing to determine the recovery, flow rates, fouling etc.

Pricing

- 50 ML/day plant: $1.45 per kilolitre
- 100 ML/day plant: $1.20 per kilolitre

Programme

- 42 to 56 months.
5.10 Pacific Pure Water, Inc.

Principal respondent, organisational structure and identity of key parties

- Pacific Pure Water (Water technology company)
- Whittaker Controls Inc. (Desalination technology producer and support and management of desalination technologies)

Summary of Experience

Insufficient to confidently deliver the project.

Comment on preferred pre-treatment and desalination technology type

The preferred desalination technology for Pacific Pure Water is nano-filtration.

Programme

70 months
5.11 Packaged Food International

Principal respondent, organisational structure and identity of key parties

Packaged Food International Pty. Ltd. is the principal respondent.

The key parties are:
- Packaged Food International;
- Desalination and Energy Systems; and
- Ace Water Treatment Company.

Summary of Experience

The projects listed as reference projects are small, ranging from 0.88 ML/day to 9.6 ML/day.

Level of Interest

Packaged Food International is interested in participating as Engineering, Procurement and Construction contractors.

Renewable Energy Strategies

- Wind energy is proposed for the desalination plant.
  - Part of the wind energy will be used to generate hydrogen from desalinated water to run a fuel-cell for co-generation.

Comment on preferred pre-treatment and desalination technology type

Microfiltration or Ultrafiltration is the preferred pre-treatment methods.

Two-stage reverse osmosis is the preferred desalination technology.

Indicative capital cost estimates

- 50 ML/day plant: $163,000,000
- 100 ML/day plant: $271,000,000

Indicative operating cost estimates

- 50 ML/day plant: $22,810,000 per annum
- 100 ML/day plant: $41,020,000 per annum

Pricing

- 50 ML/day plant: $1.30 per kilolitre
- 100 ML/day plant: $1.20 per kilolitre

Programme

60 months
5.12 Soil Water Solutions

No large scale experience, and are incapable of delivering a project.

5.13 The City of Whyalla

The response submitted by The City of Whyalla did not cover any of the questions stated in the RFI document. However, The City of Whyalla is willing to support the development of a seawater desalination plant in Whyalla and commends the proposed utilisation of renewable energy.

The City of Whyalla feels that its current reliance on the Murray River for water is unsustainable and sees seawater desalination as a sustainable water source.

5.14 Transfield Services

Principal respondent, organisational structure and identity of key parties

Transfield Services is the principal respondent and will work together with Weir Techna and Downer Energy Systems. Much of the Transfield RFI submission is identical to Weir Techna’s submission.

Weir Techna is a specialist engineering and systems integration division of Weir Group.

Downer Energy Systems design, construct and commission power plants.

Comment on preferred pre-treatment and desalination technology type

The preferred desalination technology proposed by Transfield is Multiple Effect Distillation, with the supporting argument that it is beginning to challenge large capacity – up to 25 ML/day – plants. A two or four trained layout is proposed for the 50 ML/day and 100 ML/day plants.

Pricing

- 50 ML/day plant: $0.70 per kilolitre
- 100 ML/day plant: $0.60 per kilolitre
5.15 United Utilities

Principal respondent, organisational structure and identity of key parties

The key parties are:

- United Utilities (Private Water Company);
- WorleyParsons Ltd. (Engineering firm with seawater reverse osmosis experience); and
- Hydranautics (Membrane supplier and seawater reverse osmosis designer).

United Utilities operates around the world and in 2004 had a turnover of AU$5 billion. WorleyParsons Ltd. has over 9,500 personnel in 29 countries. Hydranautics has been manufacturing reverse osmosis membranes since 1970 and has delivered membranes producing a total of 2,700 ML/day around the world.

Summary of Experience

In 2002, Hydranautics completed a 95 ML/day seawater desalination plant in Tampa Bay, Florida, USA. Other large scale projects involving United Utilities or WorleyParsons are yet to be completed. The uncompleted projects are: Perth Seawater Desalination Plant (100 ML/day), Goldfields Desalination Project (60-90 ML/day) and a 280 ML/day thermal desalination plant in Karratha, Western Australia.

Level of Interest

"Extremely High"

Comments on the base information and assumptions

"No specific concerns"

Comments on major and critical issues

- Due to the high energy consumption of a desalination process, there is a possibility that a renewable energy source must be used.
- Demand certainty must be established to ensure that cost effective finance is obtained.
- Using seawater instead of Great Artesian Basin will preserve the GAB for future generations.
- Establishing the exact water quality required by Olympic Dam and also for each off-take customer, as these will vary.
- As there are two significant stakeholders, it is important that skilled stakeholder management is undertaken.

Comment on any headline commercial issues

- United Utilities is currently undertaking a similar project and is constructing a “merchant plant” that is funded by long-term off-take agreements with customers.
- Debt to Equity ratio is expected to be 4:3, but possibly better.
- An off-take agreement should be longer than the debt financing of the project. 20-25 years is acceptable, but the mine-life would be preferred.
- Due to advancements in technology, price reviews would be undertaken at regular intervals.
- Security of supply is essential, and should UU/WorleyParsons undergo commercial failure, buy-out and step-in rights would be applied.
Renewable Energy Strategies

- Together with The City of Whyalla and ANU, United Utilities has been developing the Whyalla Solar Oasis Project, which, if it goes ahead, would generate 24MW of power using a 200 solar dish array.
- Wind farming is a possibility
- Growing of native species (including saltbush) as CO₂-sinks.

Comment on preferred pre-treatment and desalination technology type

- Proposed Pretreatment
  - Membrane based micro-filtration (fine hollow fibre)
    - Robust operation with variable feed water quality, to deliver high quality water to the reverse osmosis membranes.
  - Ferric Chloride dosing to coagulate fine particles (if required)
  - Ultraviolet Disinfection
- Proposed Desalination Technology
  - Single stage Hydranautics SWC5 low energy seawater membrane to reduce energy consumption and maintain rejection rates.

Comment on the initial plant capacity

- 55 ML/day, for winter temperatures. This will allow up to 61 ML/day at summer temperatures.
- 400 ML storage to ensure complete security of supply

Comment on the upgradeability of the plant in response to demands

- Single intake pipeline for 50 ML/day plant, duplicate for 100 ML/day plant
- Wet well caisson and pumps designed for 100 ML/day plant.
- Single outfall and diffuser pipeline for 50 ML/day plant, duplicate for 100 ML/day plant.
- Footprint of plant remains nearly unchanged for 100 ML/day plant upgrade.

Indicative capital cost estimates

- 50 ML/day plant $120,320,000
- 100 ML/day plant $217,396,000

Indicative operating cost estimates

- 50 ML/day plant $9,655,000 per annum (including 5% operator’s margin)
- 100 ML/day plant $16,704,000 per annum (including 5% operator’s margin)

Key process design assumptions

- Seawater Quality: 40 – 44 g/L
- Seawater Temperature: 12 – 24 °C
- RO System Recovery: 45%
- RO Membrane Life: 5 years
Implications of a chemical free process

There is a possibility of a process that does not return any introduced chemicals into the brine stream. Any chemicals used in the pre-treatment or during the cleaning stages would be diverted to an evaporation lagoon.

Pricing

- 50 ML/day plant: $1.08 - $1.19 per kL
- 100 ML/day plant: $0.95 - $1.02 per kL

Programme

49 months
5.16 Veolia Water

Principal respondent, organisational structure and identity of key parties

Veolia Water is the only sole respondent. Veolia Water is the world’s largest water services company, employing more than 77,000 staff across 65 countries.

Summary of Experience

- 267 ML/day, Saudi Arabia
- 100 ML/day, Abu Shabi
- 40 ML/day, Spain
- 40 ML/day, Libya

Currently involved with world’s largest RO plant, 320 ML/day in Israel.

Comments on the base information and assumptions

- Sufficient to generate RFI response.

Comments on major and critical issues

- Undertake environmental studies.
- Establish a suitable energy source.
- Resolve community issues, if they arise.
  - Environmental issues
  - Public perception of alternative sources of water.
  - Community impact during construction and operation.

Comment on any headline commercial issues

- Establish off-take agreements

Renewable Energy Strategies

Renewable energy from wind is between 50% and 80% more expensive than the current price of non-renewable energy. Solar energy is more expensive again.

Comment on preferred pre-treatment and desalination technology type

The preferred pre-treatment depends on the raw water quality. The options include:

- Coagulation and filtration;
- Coagulation, sedimentation and filtration;
- Coagulation, dissolved air flotation and filtration;
- Cartridge filtration; and
- Micro filtration and ultra filtration.

The proposed desalination technology is reverse osmosis.

Comment on the initial plant capacity

Due to the modular nature of reverse osmosis, the capacity of the plant is scalable.
Indicative capital cost estimates
- 50 ML/day plant: $134,500,000
- 100 ML/day plant: $215,500,000

Indicative operating cost estimates
- 50 ML/day plant: $11,300,000 per annum
- 100 ML/day plant: $18,900,000 per annum

Implications of a chemical free process
Chemical free processes have been used and have caused problems. If a chemical free process is to be used, extensive pilot testing is recommended.

Pricing
- 50 ML/day plant: $1.36 per kilolitre
- 100 ML/day plant: $1.16 per kilolitre

Programme
60 months
5.17   Weir Techna

Principal respondent, organisational structure and identity of key parties

The principal respondent is Weir Techna.

The Weir Techna company responsible for delivering the technology package will be Weir Westgarth Ltd. The Weir Group, of which Weir Techna is a part, posted a profit of £61.2 million (AU$145 million) in 2004.

Summary of Experience

Weir Techna has completed at least 6 seawater reverse osmosis plants ranging in capacity from 6 ML/day to 45.4 ML/day and 3 Multi-stage Flash distillation plants with capacities from 32 ML/day to 273 ML/day.

Level of Interest

“Extremely”

Comments on the base information and assumptions

Weir has assumed land-cost to be $0.

Renewable Energy Strategies

None mentioned, but has considered the possibility of partnering with an Independent Power Producer, who may consider renewable energy.

Energy recovery devices are suggested to reduce the energy consumption of the plant.

Comment on preferred pre-treatment and desalination technology type

Preferred filtration system is: dual media filters combined with cartridge filters as it is tried and tested with SWRO technology.

Membrane filtration is also a possibility. The product stream quality is less dependent on the feed water stream in membrane filtration than in the dual media filters/cartridge filters method.

Comment on the upgradeability of the plant in response to demands

- Modular nature of RO allows addition of process train to increase plant capacity.
- Max capacity dependent on available space, capacity of existing storage and power availability.

Indicative capital cost estimates

- 50 ML/day plant: $49,825,000
- 100 ML/day plant: $86,370,000

This is much lower than the average capital cost for the plants as generated by the other respondents. The outlined components does not seem to be lacking anything.

Implications of a chemical free process

Weir Techna believe that it will not be economically viable to operate the plant as chemical free, due to the requirement of cleaning solutions and also the pre-treatment. Should a chemical free process be mandatory, then it would be possible by replacing fouled membranes instead of cleaning them.

Programme

- 35 months
6 Summary

In Table 4 is a summary of the capital cost, operational cost and selling price provided by the respondents. Figure 5 and Figure 6 show capital and operating costs as estimated by the RFI respondents. In the instances where a price range was given for the capital expenditure or operational expenditure the average expenditure has been shown in Table 4, Figure 5 and Figure 6.

### Table 4 - Cost Summary

<table>
<thead>
<tr>
<th>Principal Respondent</th>
<th>Capital Expenditure ($ Million)</th>
<th>Operational Expenditure ($ Million per Annum)</th>
<th>Water Selling Price ($ per kL)</th>
<th>Timeframe (months)</th>
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<td>134.5</td>
<td>11.3</td>
<td>1.36</td>
<td>60</td>
</tr>
<tr>
<td>Weir Techna</td>
<td>49.83</td>
<td>-</td>
<td>-</td>
<td>35</td>
</tr>
</tbody>
</table>
Figure 5 - Capital Expenditure
Figure 6 - Operating Expenditure
7 Conclusions

With the exception of Section 7.1, the conclusions will focus on the six respondents that clearly answered all of the questions of the RFI and also displayed sufficient experience to undertake a large project of this nature. BHP Billiton again emphasizes that this RFI process was not intended to create commercial relations nor was it part of a procurement process. If the desalination proposal progresses further, a separate procurement process will be commenced.

7.1 Summary of Experience

The experience of the respondents varied greatly. Out of the 17 respondents, six succinctly and clearly answered all of the questions asked in the RFI and also displayed sufficient experience to undertake the project with minimum risk of failure. They were:

- CH2M Hill;
- GE;
- International Power;
- Multiplex;
- United Utilities; and
- Veolia Water.

Other respondents displayed sufficient experience and expertise but their responses were incomplete. They were:

- Black & Veatch;
- ITT Industries;
- Transfield Services; and
- Weir Techna.

Abigroup, Pacific Pure Water, Packaged Food International and Soil Water Solutions did not display sufficient understanding of the scope of the project and/or needs of the end user. BHP Billiton will continue to require a secure water supply, and as such, it is not in a position to adopt commercially un-proven technology. Organisations promoting commercially unproven technologies at the required scale should consider their options for developing the credibility necessary to be seriously considered as participants in a possible future project.

Agility Management and Hydro Tasmania submitted documents to display an interest in the project but have no experience in desalination technology.

The City of Whyalla submitted a letter of support.

7.2 Level of Interest

When addressed in the RFI submission, the level of interest in undertaking the project was generally very high.

7.3 Comments on the base information and assumptions

Only minor comments regarding the base information and assumptions were reported. CH2M Hill believed that the salinity of the water in the Northern Spencer Gulf had been overestimated and the temperature underestimated.
Should the water quality required for the ore extraction be less than potable, GE offered the suggestion of treating the water to the required level for the extraction process at the Spencer Gulf and later producing the required potable quantities at Olympic Dam using a smaller desalination plant.

7.4 Comments on major and critical issues

GE raised the issue of reduced performance of the reverse osmosis membranes in highly saline Northern Spencer Gulf.

GE also suggested that the concentration of iron in the waste stream of the pre-treatment might become a concern for the EPA which may nominate a maximum allowable concentration. If this was to occur, alternative disposal methods must be developed.

Waste streams from the reverse osmosis and related processes generate waste streams. The increased salinity of the brine stream may have a negative impact on the marine life of the Northern Spencer Gulf.

Veolia Water raised a concern for the issues that may arise from the community.

United Utilities suggested that it was vital to establish the off-takes of water other than Olympic Dam and also the specific water qualities required by each off-taker.

7.5 Comment on any headline commercial issues

The commercial issues that ran through most of the reports was that it is very important to establish which type of off-take agreement should be implemented and also the duration of the agreements to ensure the plant is economically viable and will recover equity.

7.6 Renewable Energy Strategies

The renewable energy strategies suggested in the reports were photovoltaic cells, wind turbines and geothermal energy.

7.7 Comment on preferred pre-treatment and desalination technology type

The majority of respondents, and all six of the selected respondents, suggested using reverse osmosis for the desalination. International Power also included multi-stage flash distillation in their submission.

Micro-filtration or ultra-filtration and media filters were suggested for the pre-treatment.

7.8 Comment on the initial plant capacity

The initial plant capacity was not considered in detail by the six main respondents. To ensure security of supply to Olympic Dam and any off-takers, redundancy of vital components must be designed for.

7.9 Comment of the upgradeability of the plant in response to demands

There was a consensus that due to the modular nature of reverse osmosis technology, with appropriate design considerations, future upgrades of capacity will be possible.

7.10 Indicative capital cost estimates

Figure 1 on page 5 shows the estimated capital expenditure for the six respondents and Arup.
7.11 Indicative operating cost estimates

Figure 2 on page 6 shows the estimated capital expenditure for the six respondents and Arup.

7.12 Predicted Reverse Osmosis Water Selling Price

Figure 3 on page 7 shows the selling price for the reverse osmosis water as predicted by the six respondents and Arup.

7.13 Key process design assumptions

The key design assumptions that were mentioned rarely went beyond the scope of what was offered in the RFI document, or beyond the standard design parameters of reverse osmosis membranes.

7.14 Implications of a chemical free process

The interpretation of “chemical free process” varied greatly between the responses. Most submissions interpreted it to mean that no coagulant or anti-scalant was to be used in the filtration and desalination process. These respondents indicated that it would be possible, but that recovery rates would decrease significantly and costs would increase. Any chemicals used for cleaning would be diverted from the main brine stream into an evaporation pond, preventing cleaning chemicals and anti-scalant from entering the Northern Spencer Gulf.

Other respondents interpreted it as a completely chemical free process, including cleaning chemicals. These respondents believed that it would not be possible to have a completely chemical free process due to the inhibiting cost of replacing reverse osmosis membranes instead of cleaning them.

7.15 Pricing

The proposed selling prices of the water ranged from $1.05 to $1.45 per kilolitre for the 50 ML/day plant and from $0.95 to $1.25 per kilolitre for the 100 ML/day plant.

7.16 Programme

The expected time frame to undertake the project is 2 to 5 years. This time frame does include time to generate environmental impact statements and to be granted all approvals form relevant parties. Arup believes 2 years is very ambitious.
Arup, BHP Billiton and the MDBC Living Murray Initiative

Spencer Gulf Desalination
Brine Dispersion – Feasibility Study

Report No. J185/R01

August 2005
Arup, BHP Billiton and the
MDBC Living Murray Initiative

Spencer Gulf Desalination
Brine Dispersion – Feasibility Study

Report No. J185/R01
August 2005
It is the responsibility of the reader to verify the currency of revision of this report.
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Cover Image: Aerial photograph from Google Earth. Image Copyright 2005 EarthSat and DigitalGlobe
1 INTRODUCTION

Arup has commissioned Water Technology to carry out an investigation into the possible dispersion of brine at Point Lowly on Spencer Gulf. The brine will come from a proposed sea water reverse osmosis (SWRO) desalination plant with a capacity of 50 to 100 ML/day. The investigations are to determine the feasibility of constructing an outfall that will be able to achieve the nominal EPA target of being within 10% of the ambient water quality at the edge of a 100m mixing zone. The investigations are also to consider the feasibility of effective brine dispersion at other locations within Spencer Gulf, namely Port Augusta and Port Pirie.

This initial study has been aimed at determining the feasibility of the proposed outfall. Subsequent investigations will be required to assess in detail the effects of the proposal.

As part of a preliminary assessment by Arup, the study has focussed upon two possible outfall sites located in the Point Lowly region. With relatively strong tidal currents and ready access to deep water, these locations were considered to have the greatest potential for brine dispersion.

1.1 Scope of Work

The work carried out as part of this initial study has included:

1. **Inception Meeting and Site Inspection:** to obtain copies of data, clarify any issues related to the scope of work, and to obtain first hand experience of the conditions at the proposed outfall site.

2. **Data Collation and Review:** to determine what tide, current, sea temperature and salinity data is available for the area, and obtain copies of wind, rainfall and temperature data for the region from the Bureau of Meteorology.

3. **Preliminary Assessment of Currents:** including the use of Water Technology’s “Spencer Gulf Model” to provide a preliminary assessment of currents in the area.

4. **Near Field Mixing:** to investigate the likely mixing that can be achieved within the EPA’s 100m mixing zone.

5. **Outfall Design:** to develop a preferred outfall concept.

6. **Reporting:** describing the investigations, summarising the main findings, and describing what additional studies may be required.

Due to the much closer proximity of Port Augusta to Olympic Dam than Point Lowly, Arup was also interested in determining the feasibility of locating the SWRO and brine outfall in the outlet channel of the Port Augusta Power Station. The feasibility of an outfall at this location is considered separately in Section 8 of this report.

A magnesium smelting complex had once been proposed for a site north of Port Pirie, in the Upper Spencer Gulf. An EIS was prepared for this proposal, which included a cooling water discharge to Spencer Gulf. This site was not initially considered by Arup as being as suitable for a SWRO as the other sites. For a variety of reasons, however, a qualitative assessment of the general area in terms of the proposed brine outfall was requested. This assessment is provided in Section 9 of this report.
2 THE STUDY AREA

The study area is centred on the Port Bonython – Point Lowly area, which is approximately
15 km north east of Whyalla in the northern part of Spencer Gulf. The general Spencer Gulf
area is shown in Figure 2.1.

![Figure 2.1 Locality Plan for Spencer Gulf and Whyalla](Source: Royal Australian Navy)

Figure 2.2 shows more detail of the area around Whyalla and Point Lowly. It can be seen that
Point Lowly and Ward Spit on the opposite (eastern) side of the Gulf provide a constriction to
flows in this area. There is a relatively deep channel between Point Lowly and Ward Spit
with water depths in excess of 20m. This channel provides access to the northern part of the
Gulf and, ultimately, to Port Augusta, approximately 60 km to the north.

More details of the Point Lowly – Port Bonython area are presented in Figure 2.3. This figure
shows:

- The channel between Point Lowly and Ward Spit, which has depths of up to 20m close in
to Point Lowly, and locally of up to 24m elsewhere.
- The Port Bonython Jetty that extends approximately 2.4 km southwards into water with a
depth of about 20m.
- The Point Lowly Shoal, which is approximately 1 km northeast of Point Lowly. There
are water depths in excess of 10m in the channel between the shoal and the mainland, and
in excess of 20m in the main channel to the east of the shoal.

The two main outfall locations under consideration at the Port Bonython Jetty and at a
location to the northeast of Point Lowly. These are shown as positions A and B in Figure 2.3.
Figure 2.2 Locality Plan for Whyalla and Point Lowly
(Source: Royal Australian Navy)

Figure 2.3 Locality Plan for Port Bonython and Point Lowly showing Possible Outfall Sites at; A Port Bonython Jetty, and B Northeast of Point Lowly
(Source: Royal Australian Navy)
3 THE INCEPTION MEETING AND SITE INSPECTION

The Inception Meeting and Site Inspection was carried out on 21 July 2005. Arup had arranged for a hire car and charter boat that made it possible to inspect the area around Port Bonython and Point Lowly from both the land and the sea.

Predicted tide conditions for the day were as follows:

<table>
<thead>
<tr>
<th></th>
<th>Time</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Water</td>
<td>02:15</td>
<td>0.09m CD</td>
</tr>
<tr>
<td>High Water</td>
<td>08:54</td>
<td>1.79m CD</td>
</tr>
<tr>
<td>Low Water</td>
<td>12:09</td>
<td>1.56m CD</td>
</tr>
<tr>
<td>High Water</td>
<td>18:32</td>
<td>2.96m CD</td>
</tr>
</tbody>
</table>

(where the levels are given in metres relative to chart datum (CD), which is approximately 1.50m below mean sea level.)

The weather was clear and sunny and there was a moderate to fresh north-westerly wind.

The boat left the Whyalla boat harbour at approximately 12.10 pm. This was just after the predicted time for low water. That is, just after the start of the flood tide current.

The boat stopped at two locations just outside the 400m exclusion zone at the Port Bonython Jetty, and at 3 locations in the vicinity of Point Lowly. Figure 3.1 shows a photograph of the seaward end of the Port Bonython Jetty, as viewed from the first measurement location. Figure 3.2 shows more detail of the structure of the jetty close to the jetty head. Figure 3.3 shows a view of the Point Lowly lighthouse, with the Port Bonython Jetty in the background.

Figure 3.1  The Seaward End of the Port Bonython Jetty
At each location, a Yeokal multi-probe water sampler was used to obtain measurements of a range of water quality parameters. These included salinity, temperature, conductivity, dissolved oxygen content and turbidity. On the return trip, additional sets of measurements were taken at the second Port Bonython measurement site, and at locations midway back to Whyalla, and offshore from the Whyalla boat harbour.
At all locations, the dissolved oxygen of the seawater was close to 100% saturation. The water was relatively clear at all sites. This was confirmed by a turbidity reading of 1.5 NTU (nephelometric turbidity units) that was obtained at the first site. There was little variation in parameters with depth over the top 4m of the water column. The temperature and salinity measurements at each location have been summarised in Table 3.1.

**Table 3.1 Temperature and Salinity Measurements – 21 July 2005**

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Temp (°C)</th>
<th>Salinity (PSU) at approximate depth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1m</td>
<td>2.5m</td>
</tr>
<tr>
<td>12.40</td>
<td>400m west of Port Bonython Jetty</td>
<td>12.8</td>
<td>42.9</td>
</tr>
<tr>
<td>12.55</td>
<td>400m south of jetty head</td>
<td>12.8</td>
<td>42.6</td>
</tr>
<tr>
<td>13.10</td>
<td>300m south of Point Lowly</td>
<td>12.8</td>
<td>42.3</td>
</tr>
<tr>
<td>13.20</td>
<td>300m east of Point Lowly</td>
<td>12.8</td>
<td>42.3</td>
</tr>
<tr>
<td>13.25</td>
<td>1,200m east of Point Lowly</td>
<td>12.9</td>
<td>42.6</td>
</tr>
<tr>
<td>13.40</td>
<td>400m south of jetty head</td>
<td>12.9</td>
<td>42.3</td>
</tr>
<tr>
<td>13.55</td>
<td>Midway back to Whyalla</td>
<td>12.9</td>
<td>41.7</td>
</tr>
<tr>
<td>14.10</td>
<td>Offshore from Whyalla</td>
<td>13.1</td>
<td>41.5</td>
</tr>
</tbody>
</table>

The salinity readings show little variation with depth over the top 4m of water. They do, however, show a general increase in salinity from around 41.5 PSU (practical salinity units)* near Whyalla to 42.6 in the area offshore from Point Lowly. It is also interesting to note that the salinity off the head of the Port Bonython Jetty decreased from 42.6 PSU to 42.3 PSU over 45 minutes from 12.55 to 13.40. This is consistent with lower salinity water being advected northwards with the incoming tide.

After inspecting the possible outfall sites from the sea, we drove to Point Lowly to view the area from the land. Figure 3.4 shows a view of the Port Bonython Jetty from the west side of Point Lowly. Figure 3.5 shows a view of the Point Lowly Lighthouse.

Figure 3.6 shows a view looking westward across a rocky outcrop just to the north of Point Lowly. This last photograph looks out across Spencer Gulf over the Point Lowly Shoal. At the time of the photographs, the tide was still coming in, and there was a strong north-going current flowing past Point Lowly. By comparison, there was a weak south-going current in the shallower nearshore area to the north of Point Lowly. It was not clear as to whether this weak return flow was due to an eddy being shed from Point Lowly, or whether it was due to the effects of the wind.

Overall, the site inspection provided valuable insight into the prevailing conditions in the vicinity of the proposed outfall sites. Of particular interest was the spatial gradient in salinity, with salinity increasing with distance north from Whyalla, and decreasing with time on the incoming tide as lower salinity water was advected northwards.

* Where practical salinity units (PSU) are the formal scientific unit for salinity. They are numerically equivalent to the more commonly used engineering units of gm/L, or ppt (parts per thousand).
Figure 3.4 The Port Bonython Jetty seen from the West Coast of Point Lowly

Figure 3.5 The Point Lowly Lighthouse
Figure 3.6. Looking Westward from Point Lowly across Spencer Gulf
4 DATA COLLATION AND REVIEW

4.1 Meteorological Data

The Bureau of Meteorology maintains a weather station at Whyalla. This station has more than 40 years of wind and temperature data, and more than 90 years of rainfall data.

Mean temperatures at 9.00 am range from 10.3 °C in July to 22.5 °C in January, while mean temperatures at 3.00 pm range from 15.8 °C in July to 27.6 °C in January.

The area is dry, with a mean annual rainfall of only 278 mm. Nevertheless, what rainfall there is, is relatively evenly distributed throughout the year, with a minimum of 17.5 mm in March and a maximum of 27.1 mm in June.

Regional evaporation measurements, based on class A pan evaporimeters, show an average potential evaporation in the area of just under 2,000 mm per year. In high temperature regions, however, it has been found that pan evaporation rates tend to over-estimate the actual evaporation. Following Hounam (1961), Nunes and Lennon (1986) found that a pan factor of 0.8 gave reasonable results in their simple salt balance model. This would provide an average annual evaporation of just under 1,600 mm. That is, the average evaporation in the area is more than 5 times higher than the average rainfall.

Average wind speeds range from 10.5 km/h at 9.00 am to 15.0 km/h at 3.00 pm. Winds come predominantly from the south and southeast during summer. This is caused by the sea breeze effect. During winter, the wind comes predominantly from the north and the northwest in the morning. In the afternoon, however, there is also a significant component of the wind that comes from the south. This demonstrates that sea breezes also have an effect on the wind during winter.

4.2 Tidal Data

Some of the main features of the tide in Spencer Gulf include:

- The tide is predominantly diurnal. That is, there is generally only one main tide per day.
- The tidal range increases from typically about 1.0m at the entrance to Spencer Gulf to more than 3.0m at Port Augusta.
- The increase in tidal range is due partly to a steady increase in the diurnal (i.e., daily) tidal constituents along the length of the gulf, and a more rapid increase in the semi-diurnal (i.e., twice-daily) tidal constituents in the northern half of the gulf.

The tide in the vicinity of Point Lowly is predominantly diurnal, with a tidal range varying from about 1.0m during neap tides (sometimes referred to as “dodge” tides) to more than 2.5m during spring tides.

Figure 4.1 shows a plot of tidal variations at Point Lowly over a month (that is, over a full neap-spring-neap-spring-neap tidal period). These tidal elevations have been computed using Water Technology’s Spencer Gulf Model. This model has been calibrated against predicted tides at a number of locations around Spencer Gulf, including Whyalla. The tidal variations in Figure 4.1 demonstrate the predominantly diurnal (once daily) nature of the tide in the area. They also show that there is a weaker semi-diurnal (twice daily) component to the tide. This
The semi-diurnal component becomes most pronounced just before neap tides. During neap tides, however, the reduced tidal movement becomes almost entirely diurnal.

![Figure 4.1 Computed Tides in the Vicinity of Point Lowly](image1)

### 4.3 Current Data

No current data for the area was discovered from enquiries to Adelaide University, Flinders University and the National Tidal Facility. As a result, Water Technology’s Spencer Gulf Model has been used to provide a preliminary assessment of currents in the area. Figure 4.2 shows a vector plot of modelled currents in the area during peak spring tide flood flow. Figure 4.3 shows a corresponding plot of peak spring tide ebb flow. (Note that current vectors are only displayed at every second computational grid point.)

![Figure 4.2 Computed Peak Spring Tide Flood Flows in the Vicinity of Point Lowly](image2)
Figure 4.3 Computed Peak Spring Tide Ebb Flows in the Vicinity of Point Lowly

These figures show clearly the way Point Lowly in the west and Ward Spit in the east constrict the flows in the area. Peak current velocities off the tip of Point Lowly are in the order of 1.0 m/s. Currents in the vicinity of the Port Bonython Jetty would be expected to be aligned roughly east-northeast (flood flow) – west-southwest (ebb flow), and have peak speeds of about 0.7 m/s. Currents in deeper water to the east of Point Lowly would be expected to be aligned north-northeast (flood flow) – south-southwest (ebb flow) and have similar peak speeds of about 0.7 m/s.

Figure 4.4 shows a plot of tidal current speeds in the vicinity of the head of the Port Bonython Jetty over the same month of computations as for the tidal water levels presented in Figure 4.1. On this figure the current speeds have been resolved relative to the main alignment of the channel in the area, with flood flow positive and ebb flow negative. The figure shows that peak tidal current speeds in the area could be expected to vary from about 0.2 m/s during neap tides, to in excess of 0.6 m/s during spring tides.

Figure 4.4 also shows that, although the tidal elevations in the area are predominantly diurnal (once daily), the tidal currents are predominantly semi-diurnal (twice daily). It is only during neap tides that the currents become predominantly diurnal. This is when the main solar and lunar semi-diurnal tidal constituents cancel each other out. Further analysis of tidal currents at Port Bonython and Point Lowly showed that the current speeds at both possible outfall locations are very rarely below 0.05 m/s.

More work will be required in the next stage of investigations to provide a more detailed description of the currents in the area. This may include current measurements and/or more detailed current modelling.
4.4 Temperature and Salinity Data

As reported in Nunes and Lennon (1986), Nunes (1985) carried out a detailed study of temperature and salinity variations in Spencer Gulf. Further work was carried out by Bye and Harbison (1987 and 1989), however, their work seems to have been focussed mainly on the far north of the Gulf and the Pirie Torrens Plains.

Nunes and Lennon (1986) classify Spencer Gulf as an “inverse estuary”. This is because there is no significant freshwater inflow to the Gulf and, because the evaporation in the area by far exceeds the rainfall. These factors result in the salinity increasing with distance from the mouth of the Gulf.

Nunes and Lennon (1986) found that the northern part of Spencer Gulf was generally well-mixed in the vertical. They concluded that:

“Excluding periods of coincident dodge (neap) tides and light winds, tidal and wind mixing normally generate sufficient turbulence to maintain conditions uniform in the vertical. At these times, the depth average picture is a good approximation to the overall structure.”

Transfer of salt from the northern part of the Gulf to the southern part was found to take place “relatively steadily through the year”. By comparison, it was thought that “the southern basin acts as a reservoir for the high-density outflow from the northern gulf for most of the year, only flushing its accumulated load to the shelf during winter.” Mixing processes between the southern part of the gulf and the continental shelf were investigated in more detail by Lennon et al (1987).

Figure 4.5 shows the variation in depth-averaged salinity in central and northern Spencer Gulf, as observed in March 1984. This figure has been taken from Nunes and Lennon (1986). It shows the salinity varying from about 38.5 PSU at Wallaroo in the south to about 48 PSU at Port Augusta in the north. At the same time, the salinity at Whyalla was just below 40 PSU, while the salinity at Point Lowly was about 41.5 PSU.
Figure 4.5 also shows a west to east increase in salinity in the area south of Whyalla. Nunes and Lennon (1986) attribute this to “the presence of a cyclonic (clockwise from above) gyre in this area.”
Nunes and Lennon (1986) also studied the variation in Temperature and Salinity over time. For the area adjacent to Port Bonython, it was found that the sea temperature varied typically from about 12°C in winter to about 24°C in summer. Salinities in the area were found to vary typically from about 40.5 PSU in winter/spring to 42.0 PSU in summer/autumn. As a result of the variations in both temperature and salinity, the density of sea water in the area was found to vary from about 1,028.5 kg/m³ in summer to about 1,031.5 kg/m³ in winter.

With measured salinities in the area of up to 42.9 PSU during the site inspection, it would appear that some variation in salinity could be expected from one year to another.

Further work will be required in future to provide a more comprehensive description of the salinity and temperature variations in the area. This would include monitoring of the vertical profiles of salinity and temperature in the immediate vicinity of the proposed outfall.
5 NEAR-FIELD MODELLING

5.1 Discharge Characteristics

The aim of the proposed desalination plant will be to provide from between 50 to 100 ML of freshwater per day. With a conservative 35% recovery rate and a residual salinity of 500 mg/L (0.5 PSU) for the produced fresh water, this will require an intake flow ranging from 143 to 285 ML/day (2.31 to 3.30 m$^3$/s), with corresponding outfall discharges ranging from 93 to 185 ML/day (1.50 to 2.14 m$^3$/s).

Using the seasonal data of Nunes and Lennon (1986) it was estimated that the discharge would have a salinity ranging from about 62 PSU in winter/spring to 64.5 PSU in summer/autumn (an increase of about 22 PSU above background levels), with densities ranging from 1,045 kg/m$^3$ in summer to 1,049 kg/m$^3$ in winter. This will result in a difference in density between the intake and outfall flows of about 17 kg/m$^3$ (ranging from 16.7 to 17.3 kg/m$^3$).

With the increase in density, the discharge will be negatively buoyant. That is, it will tend to flow towards the sea bed. As the discharge flows toward the sea bed, it will entrain ambient sea water through turbulent mixing. This process is commonly termed “near-field” mixing. The rate of subsequent “far-field” mixing of the resulting diluted discharge will depend upon its stability. This in turn will depend upon the local difference in density between the discharge and the receiving water. In this respect it is noted that Abraham and Brolsma (1965) have suggested a density of 0.5 kg/m$^3$ as a critical value below which ambient turbulence will be sufficient to break up the interface between the diluted discharge and the surrounding sea water.

5.2 Near-Field Modelling

With initial density differences of about 17 kg/m$^3$, a near-field dilution rate of about 35 to 1 will be required to obtain a residual density difference of 0.5 kg/m$^3$ or less between the discharge and the receiving water.

For this part of the investigation, the approach of Wood, Bell and Wilkinson (1993) has been used to obtain a first estimate of the discharge configuration that may be required to achieve this initial dilution. The approach involves the use of Cederwall’s empirical relationships (Cederwall, 1968) to determine the size and number of discharge ports required to achieve the required initial dilution. Cederwall’s relationships assume no flow in the receiving water. This is effectively a worst case scenario. Further, the model calculations were carried out assuming the maximum discharge rate of 2.14 m$^3$/s, and an initial density difference of 17.0 kg/m$^3$.

Two initial water depths were considered: 20m (the depth at the end of the Port Bonyngham Jetty) and the depth readily available to the east of Point Lowly Shoal), and 14m (the depth readily available along an extensive length of the Port Bonyngham Jetty). The discharge point was assumed to be at 1.0m below Chart Datum and, following Wood et al (1993), the effective depth available for mixing was assumed to be 85% of the depth below the point of discharge. That is, the depths available for mixing at the 20m and 14m depth locations were assumed to be 16m and 11m, respectively.
5.2.1 Single Pipe Discharge

The simplest outfall configuration is to discharge the brine directly from the end of the outfall pipe. With this approach, the end of a pipe would be located just below the low tide sea surface level. The brine will be denser than the surrounding receiving water, and will flow downwards toward the sea bed. As it does, it will become diluted as it entrains surrounding sea water, as shown in Figure 5.1.

![Figure 5.1 Schematic of the Operation of a Single Point Discharge](image)

Assuming a pipe diameter of about 1,200 mm, the maximum initial dilution that could be obtained with a single outlet was about 9 to 1. This is well below the required 35 to 1. As a result, it was concluded that it will be necessary to use a multi-port diffuser to achieve the required initial dilution.

5.2.2 Multi-Port Diffuser

Multi-port diffusers are used to provide greater initial dilution than can be achieved with a single pipe. They involve the use of multiple smaller diameter ports along the length of the outfall pipe, with alternate ports typically discharging in opposite directions. A schematic of the operation of a multi-port diffuser is shown in Figure 5.2. Multi-port diffusers achieve their higher dilution rates by increasing the relative depth (i.e., the ratio of the water depth to the discharge port diameter) of the discharge, and by spreading the discharge over a much greater area.

Using the approach of Wood et al (1993) it was found that initial dilutions of 35 to 1 could be achieved by diffusers having the following configurations.

- **Initial water depth 14m:** 40 ports with a diameter of 150 mm and a spacing of 2.0m
- **Initial water depth 20m:** 16 ports with a diameter of 225 mm and a spacing of 3.0m

These initial configurations provide a basis from which to develop the design and incorporate the effects of cross current mixing as reported on in the following section.
In both cases it is assumed that:

- the ports would discharge horizontally at a point 1.0m below Chart datum
- the discharge will be perpendicular to the line of the diffuser
- alternate ports would discharge in opposite directions

![Diagram of multi-port diffuser operation]

Figure 5.2 Schematic of the Operation of a Multi-Port Diffuser;
(a) End-on Elevation, (b) Plan View
5.3 Construction Issues

To obtain maximum initial dilution, it will be necessary for the diffuser ports to be located just below the sea surface. This can be achieved by:

- Attaching the outfall pipe and diffuser to an existing structure, such as the Port Bonython Jetty.
- Constructing a new jetty specifically for the outfall pipe and diffuser.
- Locating the outfall pipe and diffuser on the sea bed, and using “risers” to bring the discharge ports up to just below the sea surface

For the last case, it will be necessary to attach the risers to some form of structure to ensure their stability, and to prevent them becoming a navigational hazard and being damaged by boats. This could be achieved by attaching the risers to:

- An existing structure, such as the Port Bonython Jetty.
- A new offshore structure at the location of the diffuser
- Individual piles driven at the location of each riser
6 OUTFALL DESIGN

6.1 Discharge Characteristics

As discussed above, the approach of Wood et al (1993) assumes that there is no flow in the receiving water. This approach may be overly conservative, as ambient currents in the area of the outfall locations being considered would be expected to below 0.05 m/s only rarely, and could be in excess of 0.6 m/s during spring tides.

To provide a more reliable estimate of mixing under a range of likely current conditions, and to investigate the possible effects of interaction between discharges from individual ports, more detailed near-field simulations have been carried out using the CORMIX near-field mixing zone model.

6.2 The CORMIX Near-Field Model

As described by the CORMIX web-site (www.cormix.info):

“CORMIX is a USEPA-supported mixing zone model and decision support system for environmental impact assessment of regulatory mixing zones resulting from continuous point source discharges. The system emphasizes the role of boundary interaction to predict steady-state mixing behaviour and plume geometry. The CORMIX methodology contains systems to model submerged single-port and multi-port diffuser discharges as well as surface discharge sources. Effluents considered may be conservative, non-conservative, heated, or contain suspended sediments.”

CORMIX software is licensed and distributed by MixZon Inc.

6.3 CORMIX Near-Field Modelling

The CORMIX modelling was carried out assuming a minimum current speed of 0.05 m/s. It was also assumed that this current would be perpendicular to the line of the diffuser.

Using range of diffuser configurations, it was found that, with a cross current of 0.05 m/s, initial dilutions of 35 to 1 or more could be achieved by diffusers having the following configurations.

- **Initial water depth 14m:** 20 ports with a diameter of 200 mm and a spacing of 2.5m
- **Initial water depth 20m:** 12 ports with a diameter of 250 mm and a spacing of 4.0m

As before, it was assumed that:

- the ports would discharge horizontally at a point 1.0m below Chart datum
- the discharge will be perpendicular to the line of the diffuser
- alternate ports would discharge in opposite directions

It can be seen that a relatively small cross-current of 0.05 m/s can result in significantly greater mixing than for stagnant ambient conditions.
To give a better indication of the effects of cross currents, the model simulations were repeated for current speeds of 0.20 m/s and 0.50 m/s. The resulting near-field dilutions rates have been summarized in Table 6.1.

<table>
<thead>
<tr>
<th>Water Depth</th>
<th>Configuration</th>
<th>Near-Field Dilution Rate for Given Current Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.05 m/s</td>
</tr>
<tr>
<td>14m CD</td>
<td>20 x 200 mm @ 2.5m</td>
<td>35 : 1</td>
</tr>
<tr>
<td>20m CD</td>
<td>12 x 250 mm @ 4.0m</td>
<td>42 : 1</td>
</tr>
</tbody>
</table>

In the 0.05 m/s and 0.20 m/s current cases, the listed dilution rates were achieved when the discharge reached 85% of the water depth below the discharge ports. With the relatively low current speeds of these cases, this dilution was obtained well within the 100m mixing zone. For the stronger 0.50 m/s current cases the discharge was advected 100m down-current before it could reach 85% of the water depth. For these cases, the listed dilution rates were computed for a location at the edge of the 100m mixing zone.

The results show that ambient current speeds of 0.20 m/s or more would result in initial dilution rates well in excess of the 35 to 1 required to break up the interface between the diluted discharge and the surrounding sea water. With additional current and temperature and salinity data for the area, there may be scope to further optimize the outfall configuration during the Stage 2 Investigations.

### 6.4 Far-Field Accumulation

The surface area of the Gulf to the north of Point Lowly is approximately 500 km². With a mean diurnal tidal range in excess of 2.0m, this means that approximately 1,000,000 ML of seawater is exchanged with the northern section of the Gulf (to the north of Point Lowly) each day. With a peak flow rate of 185 ML/day, the discharge from the desalination plant will contribute to less than 0.02% of this exchange. As such, it is expected that there will significant potential for further “far-field” dilution of the discharge as it is advected away from the outfall site by tidal currents.

Additionally, if the peak freshwater production rate of 100 ML/day was maintained over a full year, this would be equivalent to an additional net evaporation from a surface area of approximately 28 km². To put this in perspective, it is noted that the surface area of the Gulf to the north of Wallaroo is approximately 3,500 km². As such, the desalination plant would be expected to contribute to less than 1.0% of the effective net evaporation in the area. This is unlikely to have a significant effect on the overall salinity in the region. Nevertheless, it is considered that additional modeling work will be required to quantify the far-field dilution effects, and to determine whether the brine discharge may lead to a long-term accumulation of salinity in the area.

### 6.5 Site Considerations

From the preceding sections, it is clear that with suitable diffuser design either of the two locations being considered (i.e., either the Port Bonython Jetty, or the area northeast of Point Lowly)
Lowly) would be suitable for the proposed brine outfall. This is because the receiving water at both sites is relatively deep, is well-mixed, and has relatively strong tidal currents. All these factors will help contribute to good near-field dilution. The relatively strong tidal currents will also provide significant potential for further “far-field” dilution, thereby minimizing the risk of long-term accumulation of salinity in the area.

To obtain the necessary near-field dilution rates, the discharge from the diffuser will need to be from just below the sea surface. As discussed in Section 5.3, it may be possible to attach the outfall diffuser to the existing Port Bonython Jetty. This would give this site a significant advantage over the site to the northeast of Point Lowly where a new structure would be required.
7 ADDITIONAL INVESTIGATIONS

Additional investigations that would be required to carry out a more comprehensive assessment of the outfall, and further optimise its performance would include:

- Detailed hydrographic survey of the proposed outfall area(s)
- Current measurements at a location representative of the proposed outfall site, taken over a period of at least 30 days.
- Monitoring of the vertical profiles of salinity and temperature, taken over a period of at least 30 days, and preferably longer.
- Further near-field optimisation of the proposed outfall, based on the results of the current, salinity and temperature measurements.
- Far-field modelling using a fine grid model of the area (nested within the Spencer Gulf Model) to investigate mixing processes away from the immediate vicinity of the outfall, and to investigate the possibility of long-term accumulation of salinity in the area.
8 PORT AUGUSTA – INITIAL ASSESSMENT

Due to the much closer proximity of Port Augusta to Olympic Dam than Point Lowly, Arup was also interested in determining the feasibility of locating the brine outfall in the outlet channel of the Port Augusta Power Station.

8.1 Site Location and Characteristics

The Port Augusta Power Station is on the east coast of Flinders Channel in the far north of Spencer Gulf. It is located approximately 6 km south of the centre of Port Augusta, mid-way between Orchard Point and Snapper Point., as shown in Figure 8.1.

![Figure 8.1 Locality Plan for the Port Augusta Power Station](Source: Royal Australian Navy)
More details of the Channel in the vicinity of the power station are presented in Figure 8.2. This figure shows typical depths within the channel of 7m to 8m below Chart Datum. Depths in the area immediately offshore from the power station are locally up to 11.3m below Chart Datum.

![Figure 8.2 Details of the Channel in the Vicinity of the Power Station](Source: Royal Australian Navy)

Figure 8.3 shows an aerial view of the Port Augusta Power Station. The cooling water intake and outlet channels can be seen in the top left corner of the photograph. The intake channel is the one that is closer to the power station. To prevent recirculation of warmer less dense water from the outlet channel, there is a surface barrier across the mouth of the intake channel, and cooling water is drawn in from the bottom 1m of the channel in this area.

The intake channel is approximately 700m long by 90m wide. The outlet channel is approximately 900m long, and increases in width from about 90m near the power station, to 140m at its mouth.

The power station has two units and the cooling water flows range from 950 ML/day (11.0 m$^3$/s) with one unit in operation, to 1,900 ML/day (22.0 m$^3$/s) with both units in operation. The cooling water temperature at the outlet to the channel is 1.5 to 2.0 °C above background levels.
8.2 Local Conditions

8.2.1 Meteorological Data

The Bureau of Meteorology maintained a weather station at the Port Augusta Power Station, which has more than 30 years of wind, temperature data and rainfall data.

Temperatures are generally slightly warmer than in Whyalla. Mean temperatures at 9.00 am range from 9.8 °C in July to 23.5 °C in January, while mean temperatures at 3.00 pm range from 16.1 °C in July to 30.2 °C in January.

The area is slightly drier than Whyalla, with a mean annual rainfall of only 257 mm, and the evaporation slightly higher, with an average annual evaporation rate of about 1,600 mm.

Average wind speeds are somewhat higher than at Whyalla, and range from 13.1 km/h at 9.00 am to 18.6 km/h at 3.00 pm. The wind comes predominantly from the south during summer. During winter, the wind comes predominantly from the north and the northwest in the morning, and in the afternoon, there is also a significant component of the wind that comes from the south.

8.2.2 Tidal Data

As for the Point Lowly region, the tide at Port Augusta is predominantly diurnal with a weaker semi-diurnal component. Figure 8.4 shows a plot of predicted tidal elevations at Port Augusta. These tidal elevations have been predicted using tidal constituents from the Australian National Tide Tables (Department of Defence, 2004). Relative to Point Lowly (Figure 4.1), the tidal range at Port Augusta is increased slightly; varying from about 1.0m during neap tides to more than 3.0m during spring tides.
8.2.3 Tidal Currents

The surface area of the Gulf to the north of the power station is approximately 20 km$^2$. For each metre of tidal range, this will require 20 x 10$^6$ m$^3$ to flow into and out of this region each day. With an approximate channel width of 600m and depth of 7 to 8m, peak tidal current speeds are estimated to range from about 0.2 m/s during neap tides, to about 0.7 m/s during spring tides.

8.2.4 Temperature and Salinity Data

For the Port Augusta area, Nunes and Lennon (1986) found that the sea temperature varied typically from about 12 °C in winter to about 25 °C in summer. Salinities in the vicinity of the Power Station were found to vary typically from about 43 PSU in winter/spring to 48 PSU in summer/autumn. It is noted that the summer/spring salinity values are up to 6 PSU higher than the corresponding values for the Point Lowly area. It is considered that this is due to the combination of higher evaporation that would be expected in summer, and reduced dispersion of salt due to the more confined nature of the northern part of the Gulf.

As a result of the variations in both temperature and salinity, the density of sea water in the area was found to vary from about 1,035 kg/m$^3$ in summer to about 1,033 kg/m$^3$ in winter.

8.3 Near-Field Considerations

Assuming the same conservative 35% recovery rate, as before, and a residual salinity of 500 mg/L (0.5 PSU) for the produced fresh water, the desalination plant requires an intake flow ranging from 143 to 285 ML/day (2.31 to 3.30 m$^3$/s), with corresponding outfall discharges ranging from 93 to 185 ML/day (1.50 to 2.14 m$^3$/s).

Using the seasonal data of Nunes and Lennon (1986) it was estimated that the discharge would have a salinity ranging from about 65.9 PSU in winter/spring to 73.6 PSU in summer/autumn (an increase ranging from about 23 to 26 PSU above background levels), with densities ranging from 1,053 kg/m$^3$ in summer to 1,051 kg/m$^3$ in winter. This will result in
in a difference in density between the intake and outfall flows of about 18 kg/m$^3$. With this increase in density, a near-field dilution rate of about 36 to 1 will be required to obtain the residual density difference of 0.5 kg/m$^3$ required to ensure that ambient turbulence will be sufficient to break up the interface between the diluted discharge and the surrounding sea water.

As described in Section 8.1, the cooling water discharges from the Power Station range from 11 to 22 m$^3$/s, depending upon whether one or two generation units are in operation. If the outfall for the desalination plant is to be located in the cooling water outlet canal, this will give a maximum initial dilution rate ranging from about 6:1 to 11:1. Using the approach of Wood et al (1993) it was found that these initial dilutions could be achieved by a diffuser having 40 ports with a diameter of 150 mm. The diffuser would need to be located at, or near the water surface, and would need to extend across the full width of the canal.

With more detailed calculations using CORMIX, it was found that, in open water, the 40 port diffuser would be capable of achieving much higher initial dilutions in the water depth available. However, the limiting factor on initial dilution was the amount of cooling water flowing along the canal that would be available for dilution purposes. With maximum initial dilution rates of between 6:1 and 11:1, the residual density difference between the cooling water/brine and the ambient seawater would still be of the order of 1.6 to 3.0 kg/m$^3$. This would be sufficient to maintain a relatively stable warmer but denser outflow along the bed of the outlet canal. This is shown schematically in Figure 8.5.

![Figure 8.5 Schematic of Diffuser Operation in the Outlet Canal](image)

The warmer denser cooling water/brine mix would be expected to form a relatively stable layer flowing along the bed of the canal. This denser bottom layer would flow out from the mouth of the outlet canal, where it will mix with the tidal currents flowing across the canal mouth. This could create a potential problem for cooling water recirculation on the in-coming tide. Under these conditions, there is the possibility that the warmer denser outlet flow could be drawn directly into the submerged cooling water intake. This in turn could affect the efficiency of the power station.

Further more detailed investigations would be required to determine whether possible recirculation would be an issue for the power station. One way to avoid possible recirculation problems would be to construct a submerged weir across the outlet canal at some distance...
downstream of the brine diffuser. The cooling water/brine mix would build up behind this weir and additional mixing with ambient sea water would occur as the mix flowed over the weir, or through ports in the top of the weir as shown in Figure 8.6. In this way, the additional 3:1 to 6:1 dilution required to reduce the residual density difference to 0.5 kg/m³ or less could readily be achieved.

![Schematic of Submerged Weir Operation in the Outlet Canal](image)

**Figure 8.6  Schematic of Submerged Weir Operation in the Outlet Canal**

### 8.4 Far-Field Accumulation

As discussed in Section 8.2.3, the surface area of the Gulf to the north of the Power Station is about 20 km². With a mean diurnal tidal range in excess of 2.0m, this means that approximately 40,000 ML of seawater is exchanged with the area to the north of the Power Station each day. With a peak flow rate of 185 ML/day, the discharge from the desalination plant will contribute to approximately 0.25% of this exchange. As such, it is expected that there will significant potential for further “far-field” dilution of the discharge as it is advected away from the outfall site by tidal currents.

As discussed in Section 6.4, a continuous freshwater production rate of 100 ML/day would be equivalent to the net evaporation from an additional sea surface area of approximately 28 km². Given the more confined nature of the northern part of Spencer Gulf, and the conservative nature of salinity, there is some concern that the brine discharge may lead to a long-term accumulation of salt within the area. In this respect, it is noted that the northern section of the Gulf north of a line between Mangrove Point and Redcliff Point (see Figure 8.1), is approximately 150 km². As such, the brine discharge would be equivalent to an increase in evaporation in this northern part of the Gulf of up to about 20%.

As shown in Figure 4.5, Nunes and Lennon (1986) measured an increase in salinity in early autumn from 43.5 PSU at Mangrove Point to 48 PSU at Port Augusta. Assuming a linear relationship between the effects of evaporation and salinity increase, an effective increase in evaporation of 20% in this northern section of the Gulf could possibly result in an increase in salinity in the Port Augusta region of up to about 1 PSU.
8.5 Discussion

Overall, it is considered that it may be feasible to locate the brine outfall in the outlet channel of the Port Augusta Power Station. However, further investigations would be required to assess the risk of cooling water recirculation, to quantify the far-field dilution effects, and to determine whether the brine discharge may lead to a long-term accumulation of salinity in the area.
9 PORT PIRIE – INITIAL ASSESSMENT

A magnesium smelting complex had once been proposed for a site north of Port Pirie, in the Upper Spencer Gulf. As an EIS had been prepared for this proposal, which also included a cooling water discharge, Arup requested a high level, qualitative assessment of the Port Pirie region as a possible location of the SWRO desalination plant. Arup has advised that the distances from Olympic Dam to Point Lowly and Port Pirie are similar and that they are not aware of any other features that clearly favour either locality at this preliminary stage, except for proximity to existing infrastructure accessing nearby deep seawater.

Port Pirie is located on the east coast of Spencer Gulf approximately 30 km southeast of Point Lowly, as shown in Figure 9.1.

![Figure 9.1 Locality Plan for Port Pirie](Source: Royal Australian Navy)

Port Pirie is connected to the Gulf via a channel that has been dredged across Germein Bay, and has its entrance approximately 5 km southwest of Port Germein, as shown in Figure 9.2. The channel is relatively narrow, and the area of Germein Bay it passes through is relatively shallow (typically 4 to 5 m), and is bordered by extensive inter-tidal flats and mangroves.
Figure 9.2 Details of Germein Bay and the Port Pirie Channel
(Source: Royal Australian Navy)

The meteorological conditions (temperature, wind, rainfall and evaporation) for Port Pirie would be expected to be similar to those for Whyalla and Point Lowly, described in Section 3.

The tides at Port Pirie would also be expected to be similar to those at Point Lowly, as shown in Figure 4.1.

The tidal currents in the area would, however, be expected to be significantly weaker than those at Point Lowly, as shown in Figures 4.2 and 4.3.
With the weaker tidal currents, and much shallower water in Germein Bay (4 to 5m relative to 14 to 20m), the capacity for near-field mixing associated with a brine discharge in the Port Pirie region will be reduced significantly relative to that at Point Lowly.

Further, the weaker tidal currents and reduced mixing will result in a reduced exchange of water with the rest of the Gulf. This would be expected to reduce the far-field dilution effects, and increase the risk of long-term accumulation of salinity in the area. This is supported by the data of Nunes and Lennon (1986), which suggests that the salinity at Port Pirie may be 1 PSU, or more, higher than at Point Lowly. (See Figure 4.4.)
10 CONCLUSIONS

From the results of this investigation, it is concluded that it will be feasible to construct a brine outfall for the proposed desalination plant that will meet the EPA’s water quality requirements. The outfall could be located at either of the two main sites considered. That is, at the Port Bonython Jetty, or the area to the northeast of Point Lowly. This is because the receiving water at both these sites is relatively deep, is well-mixed, and has relatively strong tidal currents. All these factors will help contribute to good near-field dilution.

At either site, adequate initial “near-field” dilution could be achieved by a sub-surface diffuser having the following configurations.

**Initial water depth 14m:** 20 ports with a diameter of 200 mm and a spacing of 2.5m

**Initial water depth 20m:** 12 ports with a diameter of 250 mm and a spacing of 4.0m

At Port Bonython it may be possible to attach the outfall pipe and diffuser to the existing jetty. This would give this site a significant advantage over the site to the northeast of Point Lowly, where a new structure would be required.

The near-field model results show that commonly occurring ambient current speeds can result in initial dilution rates well in excess of the 35 to 1 required to break up the interface between the diluted discharge and the surrounding sea water. Consequently, the nominal EPA target of being within 10% of ambient water quality at the edge of a 100m mixing zone can be easily achieved. It is therefore considered that with additional current, temperature and salinity data for the area, there may be scope to further optimize the outfall configuration.

The relatively strong tidal currents will also provide significant potential for further “far-field” dilution, thereby minimizing the risk of long-term accumulation of salinity in the area. Further work will, however, be required to quantify these effects.

With respect to the Port Augusta Power Station proposal, it is considered that it may be feasible to locate the brine outfall in the cooling outlet canal. However, further investigations would be required to assess the risk of cooling water recirculation, and to determine whether the brine discharge may lead to a long-term accumulation of salinity in the area.

At Port Pirie, the weaker tidal currents, and much shallower water depths will result in reduced mixing and a much greater risk of long-term accumulation of salinity in the area, relative to that at Port Bonython or Point Lowly. As such, an outfall in the Point Lowly region is considered to be more favourable from a brine dispersion point of view.
11 REFERENCES


