Melbourne Augmentation Program

Seawater Desalination

Feasibility Study

June 2007

Prepared by
Melbourne Water
GHD

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A Victorian Government Initiative

Victoria
The Place To Be

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Seawater Desalination Feasibility Study

June 2007

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Executive Summary

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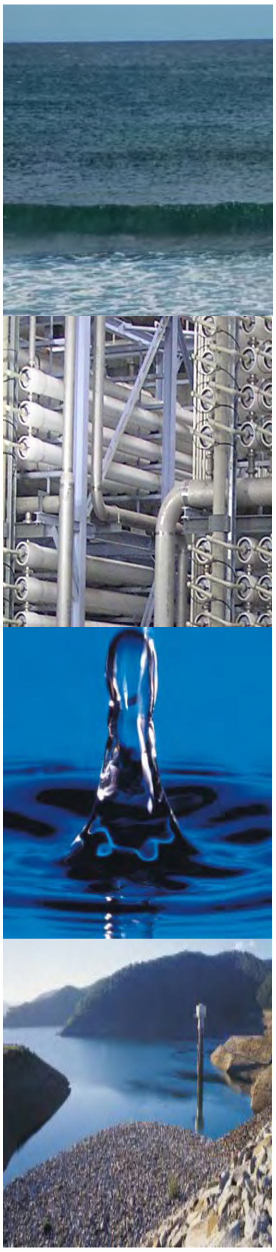


Executive Summary

Context and Scope

As part of planning to address shortfalls in water supply for Melbourne, several parallel investigations have been under way.

This report summarises a study undertaken to investigate the feasibility of seawater desalination as one of the options to provide a major augmentation for Melbourne's water supply.

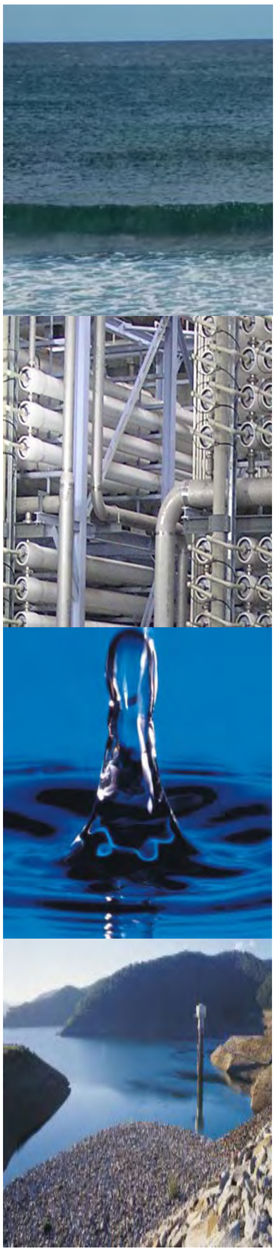
The seawater desalination feasibility study examined a range of possible scheme sizes, plant locations and project timing. Preliminary results from the desalination feasibility study were provided to the team preparing the wider strategic plan. As a result, this report covers a range of different seawater desalination scheme sizes and plant locations up to a maximum capacity of 200 GL/yr.

Background

Seawater is desalinated to provide drinking water at many locations throughout the world. Recent advances in technology have reduced the costs and energy use of desalination. These technical advances and increasing shortages of freshwater have led to increasing numbers of large plants being constructed around the world. This trend is most evident in Australia, with the plant recently commissioned in Perth, a plant under construction on the Gold Coast and proposed new plants in Perth and in Sydney.

Experience from these Australian examples, and from elsewhere in the world, has been referred to in this study. However, the costs and environmental and social impacts vary based on specific local features and geography. The key decision that influences these factors is the selection of a site. Therefore this study has included a comparison of possible sites over a wide extent of the Victorian coastline.

The concept design for the plant includes tunnels under the coast to connect the ocean to the plant, a treatment process based on reverse osmosis membranes and a new pipeline to connect the plant to the existing water supply network for the metropolitan and adjacent areas.



Possible Plant Locations

An initial screening study of Victorian coastal locations identified nine possible "long listed" sites. Four general locations were subsequently investigated in more detail and included in the final feasibility study: the Surf Coast, Eastern Shore of Port Phillip Bay, Western Shore of Western Port and the Bass Coast (See Table 1). Key constraints, cost estimates and examination of social and environmental impacts were developed for each of these locations.

The study concluded that it is feasible to treat water from any of the above general locations, but that more extensive pre-treatment of the water would be required if water is drawn from the two bay sites. This increased cost for more treatment is offset to some degree by the shorter pipelines from the two bay sites to the existing water pipe network. Both Port Phillip Bay and Western Port have environmental and social values, which suggest that the return of the concentrated seawater to the bays would need careful consideration. Understanding wider area effects would need further study, although preliminary modelling results indicate some small increases in salinity in Port Phillip Bay, but much lower increases in Western Port.

Desalination plants at the Surf Coast and Bass Coast locations would draw water from Bass Strait and return the concentrated seawater to Bass Strait. Open ocean water is less likely to contain sediments or other contaminants and therefore less pre-treatment will be required. The higher wave energy and wider dispersion in Bass Strait suggests that salinity increases from concentrate disposal are unlikely to occur. However, these coastal locations are further from the existing water supply network connection points and therefore the capital cost of connecting pipelines from these locations will be higher.

The coastal locations have a benefit for local communities near the plant sites and near the pipeline corridor: in that additional water could be provided to those communities from the plant. There are currently water shortages both on the Surf Coast and on the Bass Coast.

Various potential sites were considered at each location. Each location has some particular environmental and social constraints, which are outlined in the report. Some sites are either more industrial or are currently owned by water authorities. Others are currently open farmland, and the construction of a plant will introduce a change in the local landscape. In some cases acquisition of private property will be required.

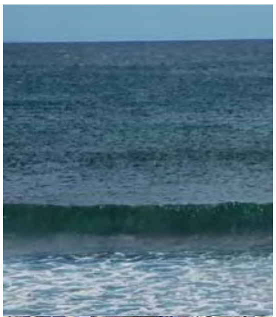
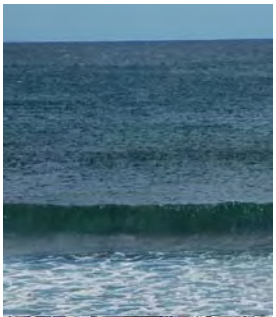



Table 1 Summary of the Review of "Long Listed" Locations

Location	Status	Reasoning for Status on Long List
Surf Coast	Included on the short list	Access to open ocean water. Ability to put water to the west of the city. Water authority land available in the area.
North Bellarine	Exclude	May be suitable for a smaller plant. Restricted access to seawater due to aquaculture. Transfer pipeline costs similar to Surf Coast therefore there are no distinct advantages over Surf Coast option. May be difficulties with concentrate disposal compared to open ocean.
Port Phillip Bay West (West of the Bay)	Exclude	Southwest end of bay has RAMSAR site and Western Treatment Plant. Northern end has less of these constraints and has lower piping costs. Evaluation shows similar in costs and concerns to Top of Bay. Lower circulation in this part of the Bay.
Port Phillip Bay North (Top of the Bay)	Exclude	Industrial zoned land, but availability and ownership needs further investigation. Close to the city so reduces transfer costs, but higher water quality risks due to proximity to industrial areas, rivers and port, etc. Lower circulation in this part of the Bay.
East of Port Phillip Bay	Included on the short list	Sites appear restricted, but existing Eastern Treatment Plant site is a possibility. Better circulation and geotechnical conditions than North and West of the Bay. Closer to Cardinia and Silvan reservoirs.
Mornington Peninsula	Exclude	Similar or higher cost than other ocean options (eg Surf Coast or Bass Coast). Limited sites. Boags Rocks outfall constrains locations. Difficult pipe corridor for transfer up the Mornington Peninsula.
Western Port	Crib Point included on the short list	Closer to Cardinia and Silvan Reservoirs than open ocean options. High turn-over of water in deep channel section. Multiple sites are available. Risks such as RAMSAR classified waters, mangroves, shipping, and feed water quality. Possible site near Crib Point.
Bass Coast	Included on the short list	Lowest cost open ocean site which delivers water to east of city. Sites appear to be available. Deep water closer to shore than many other locations. Long pipeline to existing water supply system, but in semi-rural rather than suburban areas.
Ninety Mile Beach	Exclude	Would deliver water to Thomson Reservoir. Significantly higher energy use due to lift up to dam. Long transfer pipelines, with some difficult sections. Does not provide the risk protection that a separate supply would in case of bush fire or other incident.




Constraints on Plant Capacity

There are some practical engineering constraints that affect the evaluation of different sites. Sites to the east of the city can connect the water into the Cardinia and Silvan Reservoir system. This would allow more than 200 GL/yr of water to be introduced into the existing system.

In contrast, the water supply network to the west of the city is constrained such that only around 100 GL/yr of water could be introduced into the system without significant expenditure to allow water to be pumped back toward the east of the city. This means that if other water supply augmentation options that supply water to the west or the north of the city are also in consideration, the combined augmentation options are constrained to a combined total of less than 100 GL/yr.

Comparison of Locations

The locations of the “short listed” sites are shown in Figure 1. The short-listed sites have different advantages and disadvantages. The study concluded that the key difference between the sites is how they fit into the strategic context of water supply augmentation planning for Melbourne.

Other parallel studies have been considering the capacities and timing required for augmentations to Melbourne’s water supply. Under the assumption that:

1. The location for seawater desalination ought to be able to accommodate a plant that can produce up to 150 GL per year potentially expandable to 200 GL/year in the long term, and;
2. The water should be provided as soon as practical;

the location for the desalination plant should be to the east of the city, to allow supply of up to 150 GL per year, and that the location with greatest certainty and the least risk to timely delivery should be adopted as the preferred location.

On this basis, the Bass Coast location is preferred, as the sites on Port Phillip Bay and Western Port have risks that could lead to significant delays because of complex environmental and planning concerns. A summary of each site in relation to key evaluation criteria is presented in Table 2.

The Bass Coast location is therefore preferred, subject to:

1. Due diligence including a range of technical and environmental studies on the various Bass Coast sites that are available;
2. Community consultation; and
3. Resolution of approvals and planning matters.

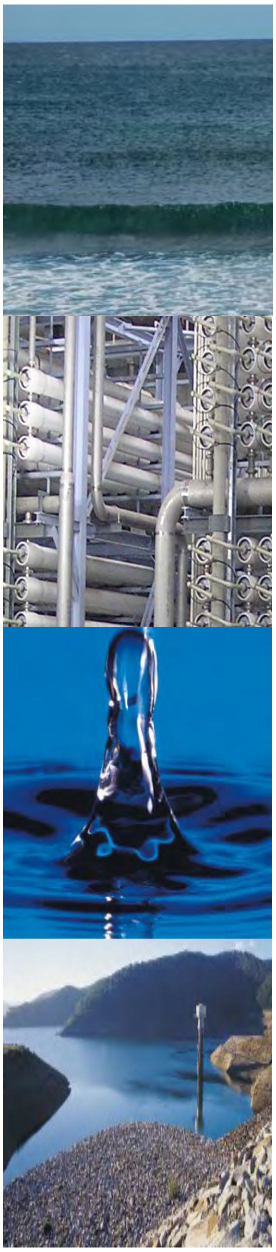
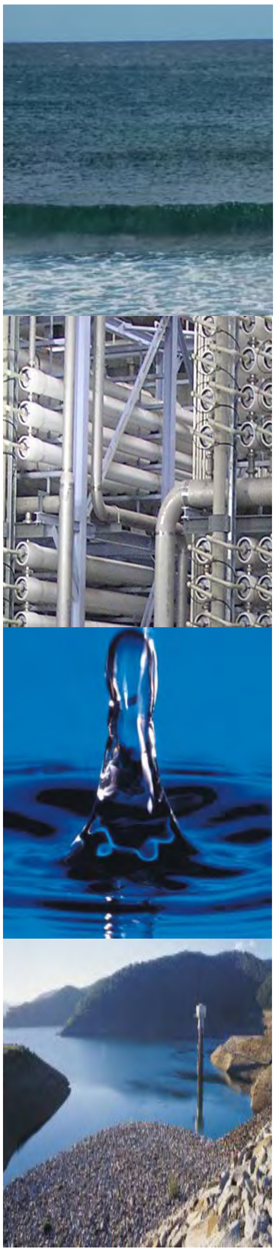


Table 2 Summary of Significant Differences in Evaluation Criteria Between Locations

Criterion	Surf Coast	East of Port Phillip Bay	West of Western Port	Bass Coast
Ability to provide up to 200 GL/yr in the long term.	Constrained to 100 GL/yr.	Likely to be constrained by risks related to concentrate disposal.	Likely to be constrained by risks related to concentrate disposal.	Feasible.
Risk to Delivery Timeframe	Moderate.	Higher.	Higher.	Least.
Risk of Impact on Marine Ecology	Lower than bays.	Higher than ocean.	Higher than ocean.	Lower than bays.
Visual Impact on Landscape	Currently open and relatively undeveloped landscape.	Already developed.	Already developed.	Similar to Surf Coast.
Source Water Quality	Black Rock outfall nearby.	Natural variation in quality in the bay, Patterson River nearby.	Natural variation plus risk due to proximity of shipping channel.	Wonthaggi outfall, Powlett River nearby. Lowest Risk Location.
Other Significant Factors	Opportunity to use existing wastewater treatment plant site at Black Rock.	Risks regarding the use of the South Eastern Outfall for concentrate discharge.	RAMSAR Area Potentially contaminated site.	History of coal mining.



The Project

To meet the need for a seawater desalination plant to supply 150 billion litres of water per annum to the Melbourne water supply system in the earliest practical time, and with the potential to expand the plant to a capacity of 200 billion litres per year, the following is proposed:

a. The plant be located in the Wonthaggi region on the Bass Coast (see Figs 4 and 5 of report).

b. The plant will supply water to the Melbourne water supply system via a new 85 km pipeline to the Cardinia Reservoir and then Silvan Reservoir.

c. The cost of the plant is estimated to be $3.1 billion – this includes the cost of building the seawater inlet and outlet tunnels and the pipe connecting to the Melbourne system at a size that will cater for an ultimate upgrade of the plant to 200 billion litres per year.

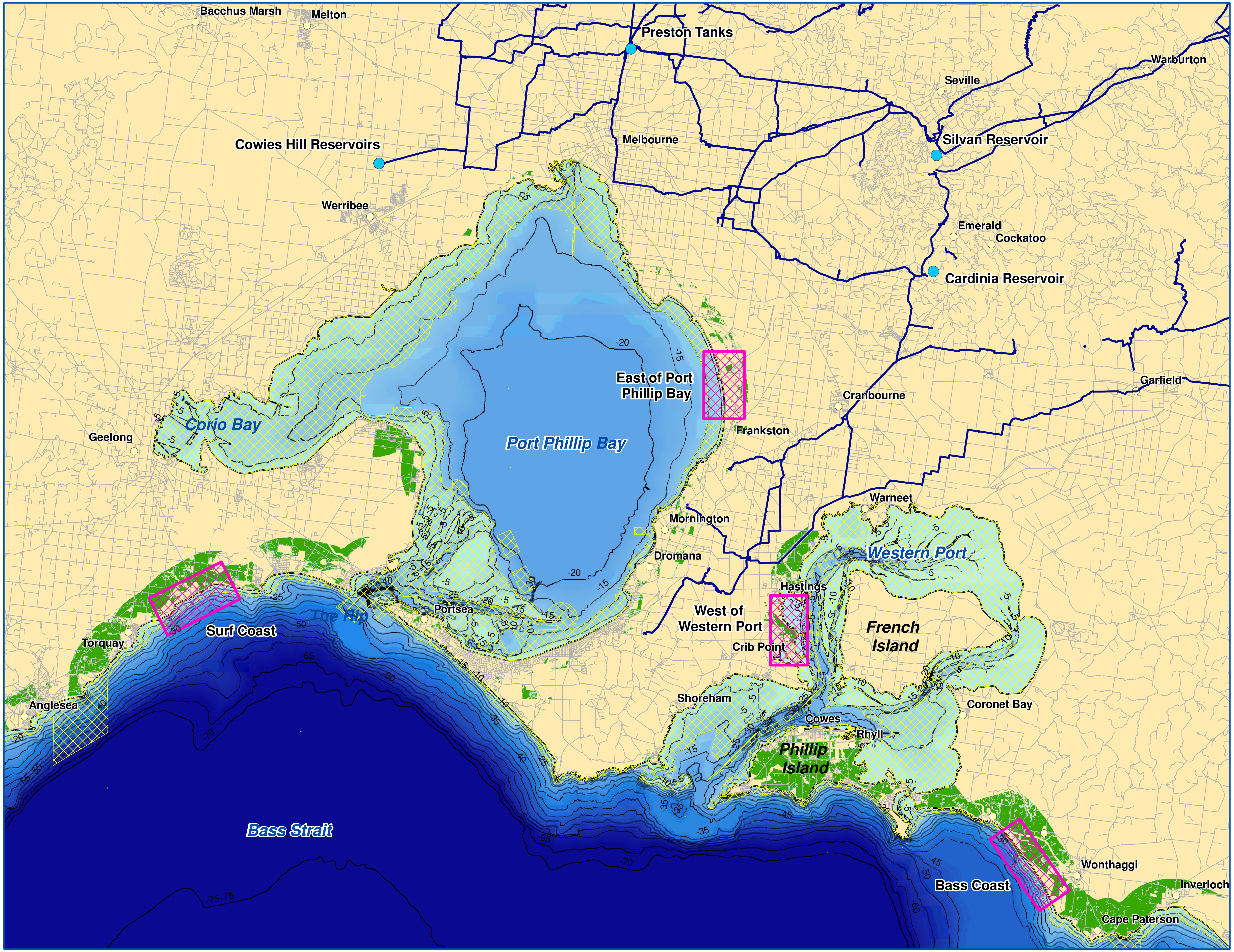
d. The plant will be powered by renewable energy – the extra cost associated with this is included in the estimated operating cost of $130 million per annum.

e. Towns on Phillip Island (supplied by Western Port Water) and nearby towns including Wonthaggi (supplied by South Gippsland Water) will be able to be provided with water from the plant.

f. The plant will be able to provide water to the Melbourne system to allow Geelong to be serviced via a new pipeline from Melbourne to Geelong

g. Of the three locations that were capable of providing for 150 GL per annum or more, the Wonthaggi location has the least potential impact on the marine ecology and the purest source of sea water.

h. Because the preferred location has the least environmental and planning concerns it is the location that has the most certainty in terms of delivery time. It is feasible to complete the construction of a plant by the end of 2011.



LEGEND

- Water Storage
- Large Water Main
- Short Listed Locations
- Not Feasible for Intake / Outfall

Plant Siting Model (Land & Water)

- Possible Region for Plant Site
- Not Feasible for Plant Site
- Depth Contours (5m Intervals)

Water Depth (m)

High : 0

Low : -90

INCA GIS MODEL CRITERIA

LAND

Aboriginal Sites
Biosites
Distance to Coastline
EVC
Electrical Easements
Oil & Gas Facilities
Flood Overlay
Heritage Overlay
Parcel Sizes
Parks and Reserves
Planning Zones
Plant Elevation
Power Proximity
RAMSAR
Reserves
Surface Slope
Threatened Flora
Threatened Fauna
Utilities
Water Areas
Waterways
Wetlands

WATER

Bathymetry
Flushing Times
Industry Outfalls
Stormwater Outfalls
Marine Parks
Aquaculture Zones
RAMSAR
Boating Facilities
STP Outfalls
Seagrasses
Shipping Channels
Threatened Fauna

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Figure 1 - Short Listed Locations

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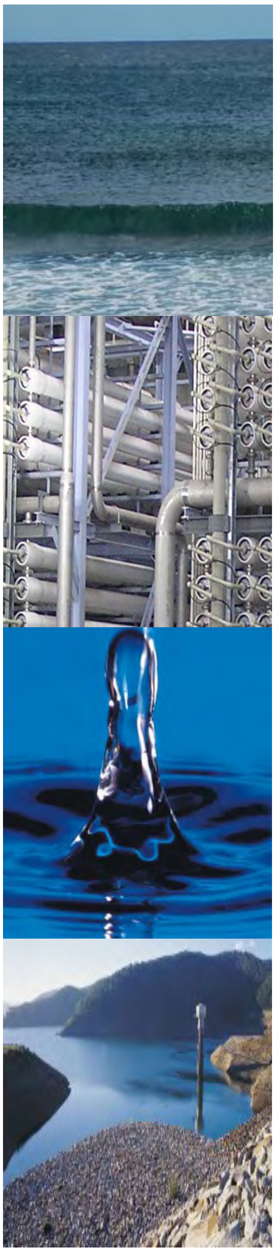


Summary of the Cost Comparison of Different Locations

The relative capital costs including breakdown is shown in Figure 2. The main differential between locations is the transfer pipeline and site-specific costs, which include managing likely location-specific risks.

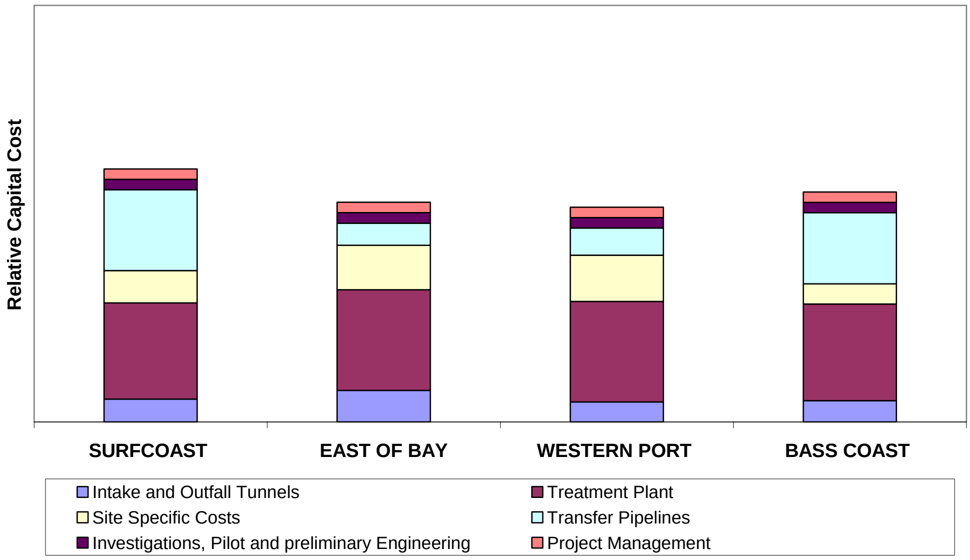


Figure 2 – Capital Cost Breakdown for short-listed locations

Power consumption is the predominant component of the operating costs. The breakdown of operating costs is shown in Figure 3.

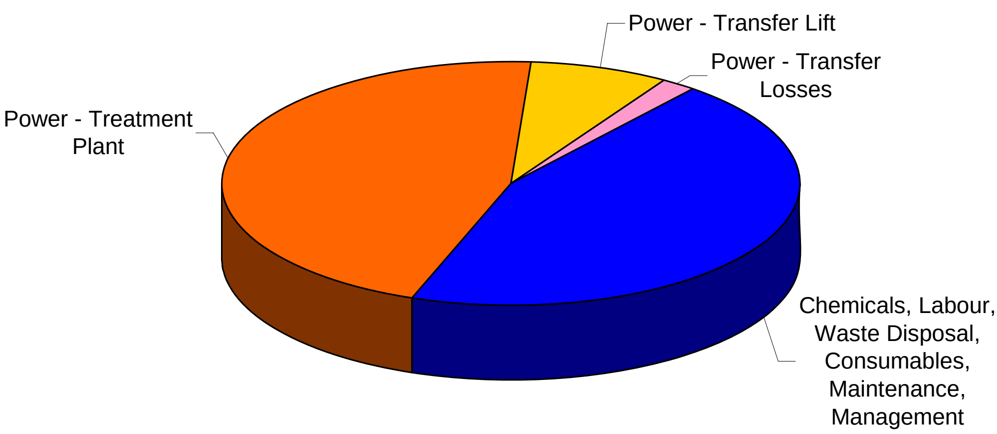
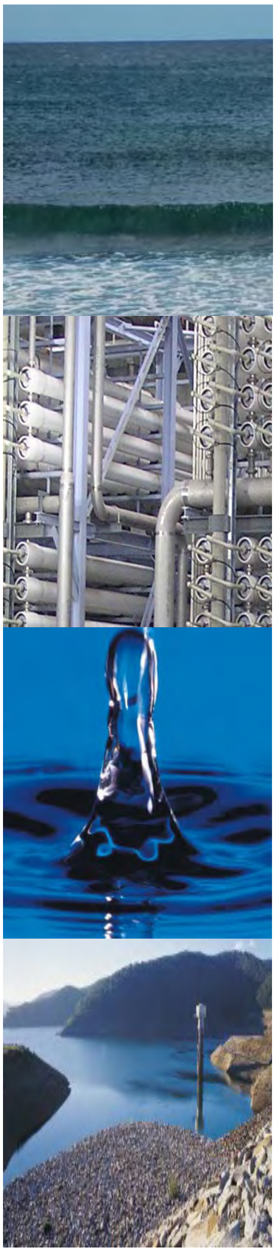


Figure 3 –Operating cost breakdown



Costs and Energy Supply

The overall costs of the project vary depending on the size of the plant, and the location chosen. Because there is no theoretical constraint on the use of seawater as a resource, several different plant sizes were explored. For a plant sized at 450 ML/day at the Bass Coast, which would provide around 150 GL/y of new water, capital costs are approximately $3.1 billion and operating costs are approximately $130 million per year (in 2007 dollars).

Operating costs include labour, replacement of membranes, chemicals costs and energy. A plant of 150 GL/y will require 90 MW of power. The operating cost estimate in this report is based on the use of renewable energy. The study included an examination of the opportunities to provide enough renewable energy to supply the demand for a plant of this size. The conclusion of this review is that there is a range of viable options to provide this amount of renewable energy.

The plant would be connected to and powered from the electricity grid. The new renewable energy source to offset the energy demand of the plant could be at the most appropriate location close to the existing grid, not necessarily close to the plant itself.

Plant Concept for Bass Coast

The Bass Coast area is shown in relation to the existing Melbourne water supply system in Figure 4. A conceptual configuration of a plant on a notional site is shown in Figure 5. There are also other locations in the Bass Coast area that may be suitable.

Note that not all land within the broad location shown is suitable as a site for a seawater desalination plant, due to engineering, environmental or social constraints.

The next steps in determining a preferred site on the Bass Coast include due diligence and community consultation.

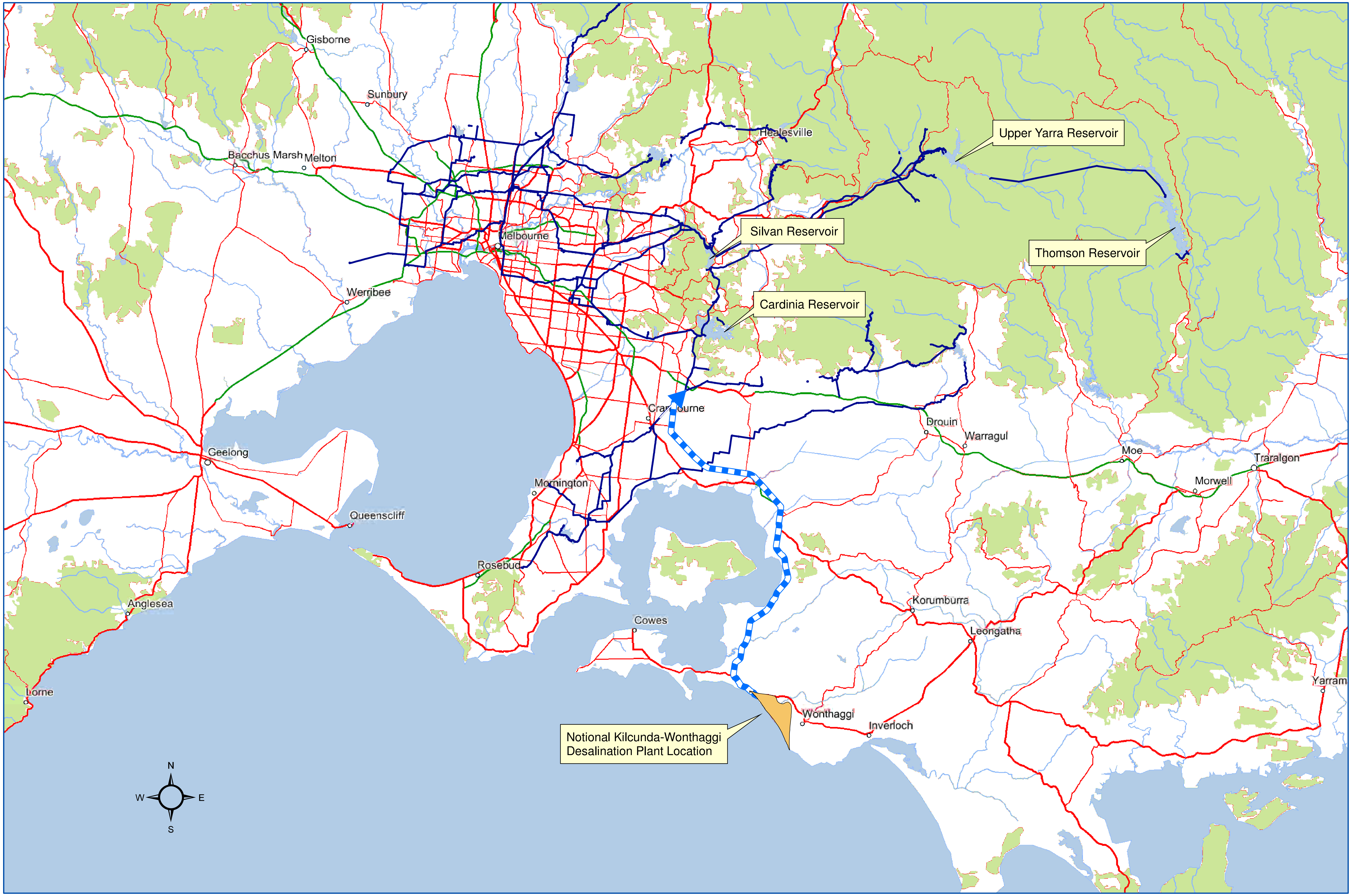


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Figure 4 - Conceptual Pipe Route for Bass Coast Option

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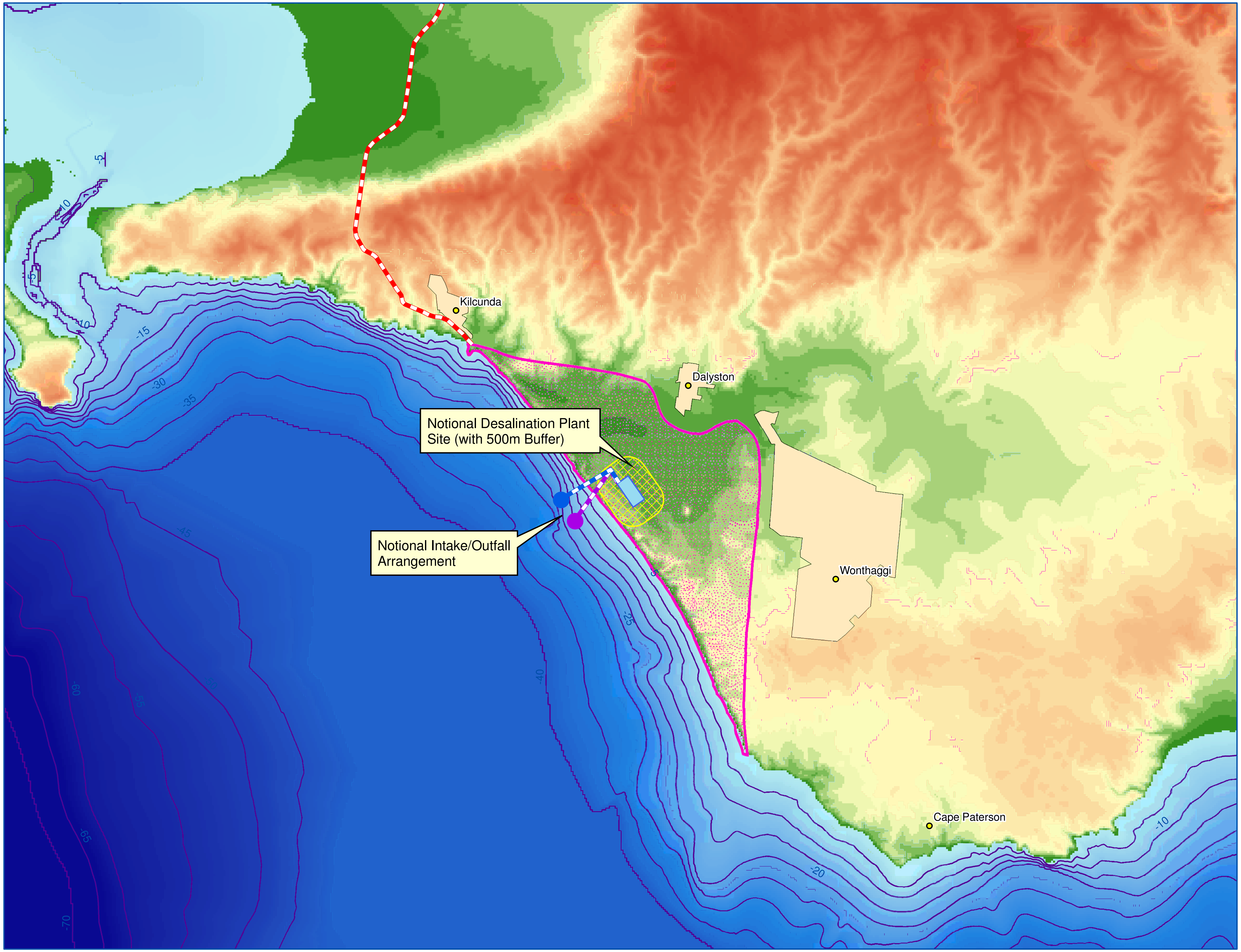

Legend

- Notional Kilcunda-Wonthaggi Desalination Plant Location
- Notional Pipeline Corridor
- Township Regions
- 5m Depth Contours

*** Note: Not all land within the highlighted area is suitable for a seawater desalination plant.**

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Figure 5 - Locality Plan (Bass Coast)

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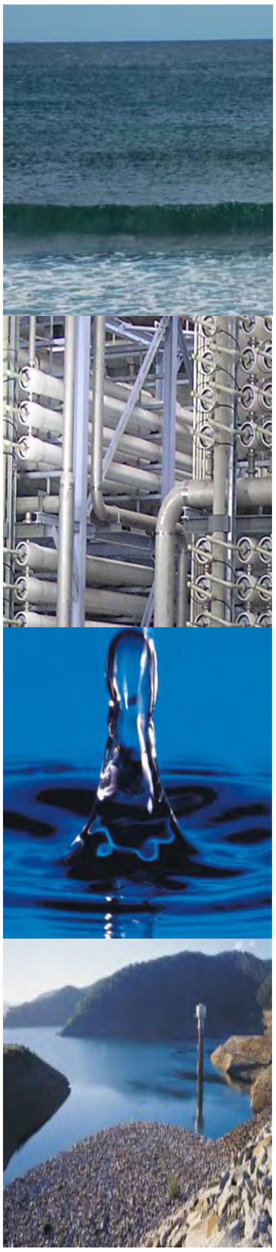


Some Questions Answered

Is it feasible?

Numerous large seawater desalination plants are in operation around the world. Provided the plant is designed to account for seawater quality in Victoria, it is feasible to desalinate seawater to create a new water supply for Melbourne. Although Melbourne is located close to Port Phillip Bay, there is significant development along the local bay coastline at the points that are closest to the city. This constrains the choice of sites near to the city. There are also environmental concerns related to return of concentrate to Port Phillip Bay, and to Western Port, which is also close to the city. Sites that draw from the open ocean (i.e. Bass Strait) are located 80 km or more from the city. Bass Strait has high wave energy so concentrated seawater should disperse readily.

The adopted concept design basis includes tunnels under the coastal strip and beaches to access the ocean. Taken in combination, these factors mean that a seawater desalination project for Melbourne may include both long seawater inlet and outlet tunnels and a long supply pipeline back to the city. This increases overall project costs relative to cities where the physical and environmental situation is different.

How big could the plant be?

A range of different sizes of seawater desalination plants can be constructed together with provisions to allow them to be upgraded or reduced in size in the future. This study has evaluated seawater desalination at 100 GL per year, 150 GL per year and 200 GL per year to provide information on different sizes and inform further decision-making. All of these sizes are feasible, with costs increasing for the larger plants.

As a quick reference, the recently commissioned Perth plant, and the plant under construction on the Gold Coast are sized at 45 GL per year (Figure 6). The proposed Sydney plant could start at approximately 45 GL per year and be expanded to 180 GL per year. The second proposed Perth plant will start at 50 GL/year, expandable to 100 GL/year.

What technology to use?

There are two technologies that are considered sufficiently mature to be used at this scale. These are ‘reverse osmosis’, which is based on pumping the sea water through membrane filters to produce fresh water, and ‘thermal’ which uses heat to evaporate off fresh water and then cools and distils the water.

All the recent Australian plants have used reverse osmosis, as it is more energy efficient, less visually intrusive and more cost effective in our circumstances. Analysis for Melbourne has led to the same conclusion, and therefore the reverse osmosis approach had been adopted in this study.

An overview of the reverse osmosis process is shown in Figure 7.

Figure 6 - Perth Desalination Plant 45 GL/year (Permission: WA Water Corp)

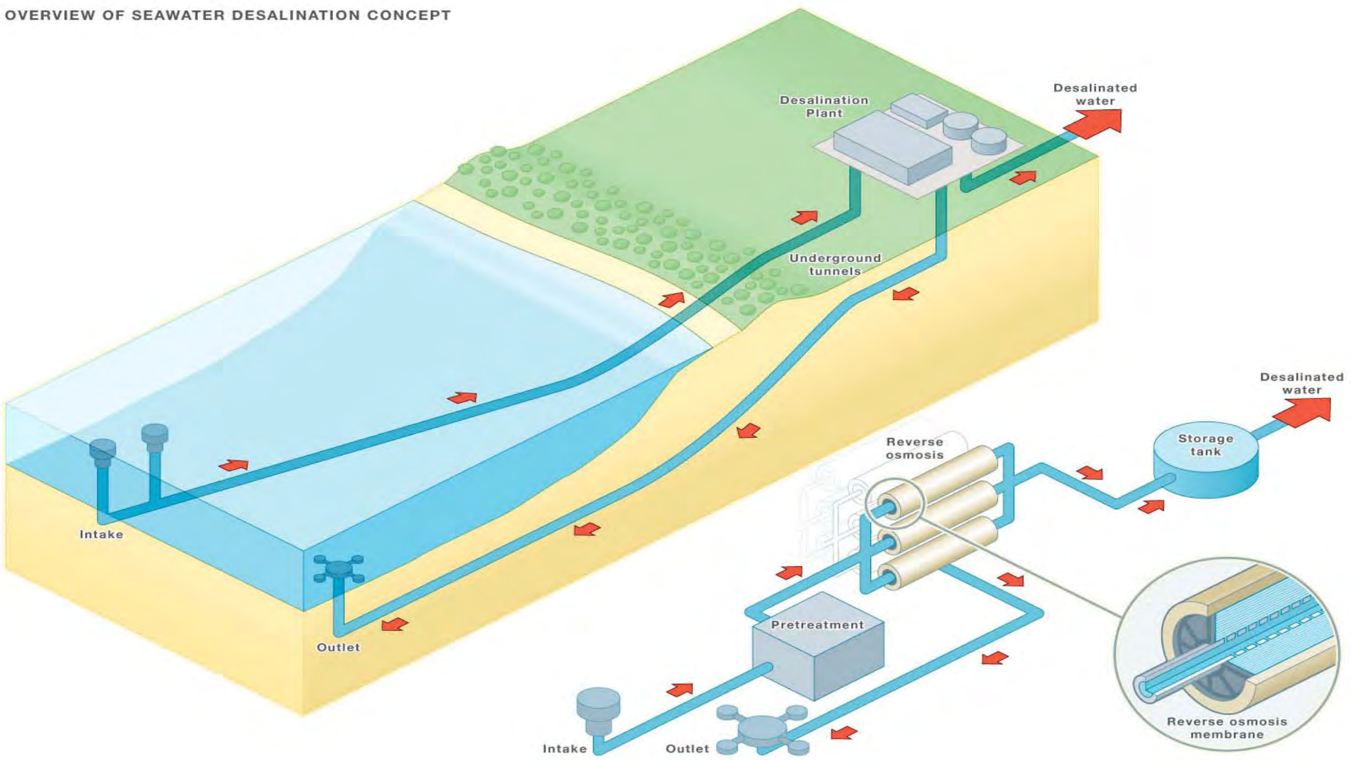
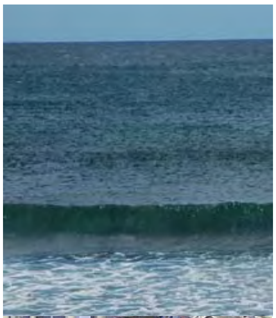


Figure 7 – Overview of seawater reverse osmosis desalination




How will the plant be powered and what can be done about greenhouse gas impact?

A 150 GL per year plant will draw approximately 90 MW of power. The annual CO_2^{-e} emissions from a 150 GL/year plant would amount to around 1 million tonnes per year (based on AGO 2006 emission factors for Victoria).

The energy use can be greenhouse neutral and thus avoid these impacts. This can be achieved by the purchase of renewable energy.

This study has determined that there are sufficient future planned renewable energy sources to provide an incremental amount to match the plant's annual use. For example, approximately 270 MW of wind power would be required to provide an annual energy amount equivalent to that used by a 150 GL/year desalination plant. There are currently more than 1300 MW of proposed wind farms in Victoria with planning approval.

In practice, the plant will be connected to the existing electricity network, which means the renewable energy plants can be located almost anywhere in Victoria. It also means there is backup power available so that the plant can operate continuously and reliably.

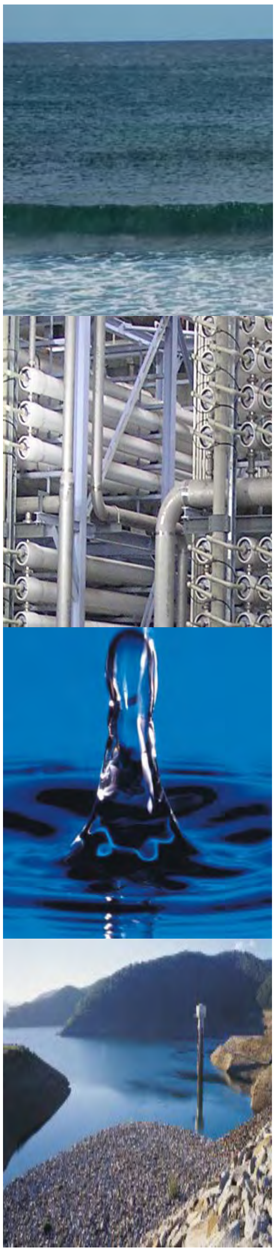
The use of renewable energy is included in the operating cost estimates.

Are there other environmental impacts?

Desalination of seawater with reverse osmosis leads to a concentrate stream, which has about twice the salt levels of seawater. For a 150 GL per year plant, there will be around 200 GL per year of concentrate. This would be returned to the ocean. It is possible to design diffuser nozzles so that this stream will mix back into the ocean within a short distance from the concentrate pipeline. Provided there are not wider hydrodynamic effects that allow salts to build up over time, this effect should be localised and have minimal if any impact. This risk is lowest for the open ocean locations. The desalination pre-treatment process produces a solid waste that will be sent to landfill or treated and recycled.

Construction of the plant, tunnels and connecting pipelines are engineering works similar to other projects in both the water industry and in wider industry. Provided the sites and pipeline routes are chosen to avoid damage to unique high value environments, these construction-related impacts appear to be manageable.

On this basis, provided greenhouse effects are minimised, it appears that seawater desalination can provide a relatively small environmental footprint. However, site selection and appropriate design are critical in achieving this goal.



How long will it take to build?

There is some variation in the predicted construction times for the different locations, and the times are also dependent on the approach to contract delivery. In broad terms, and based on Australian experience, the project - at the preferred location - might be expected to have two phases.

First there would be a period of around 1½ to 2 years studying seawater quality, evaluating geology, undertaking a range of investigations and environmental assessments, community consultation, pilot testing, and developing design concepts further. This phase would also include engagement with the contracting community, developing contract documentation and tendering. Then there would typically be a further 2½ to 3-year period of detailed design, construction and commissioning before water is available. There will be some overlap between these phases.

How much will it cost to build and run?

The estimated costs for the construction of the inlet and outlet tunnels, the plant and the connecting pipeline are set out in the report. It is possible to have staged schemes where larger tunnels and pipelines are constructed initially, and the plant is increased in size over time. This is the approach under consideration in Sydney.

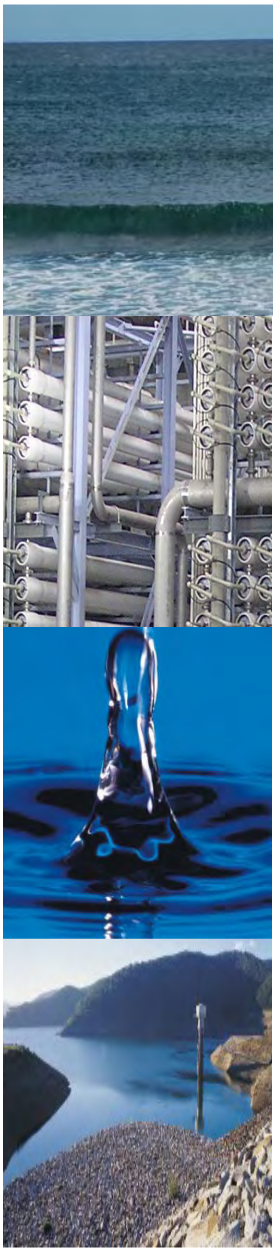
The cost estimates for the Bass Coast location at different sizes are provided in Table 3 to allow comparison with other schemes and to provide a sense of the additional costs associated with constructing larger schemes to allow staging in future.

The operating costs reported above reflect a cost of electricity of 10c/kWh, which reflects the current assessment of the costs for a renewable energy supply for a demand of this size.

Table 3 Costs for Bass Coast Option

Scheme			Capital Cost $ Billion	Operating Cost (per year) $ Million
Inlet/Outlet capacity (GL/y)	Plant capacity (GL/y)	Transfer to supply (GL/y)		
150	150	150	2.9	130
200	150	200	3.1	130

Could Water be Supplied to Local Communities?



Many of the towns in the local regions are also experiencing water shortages. It is possible to supply additional water to towns near the plant itself, and to towns near the transfer pipeline.

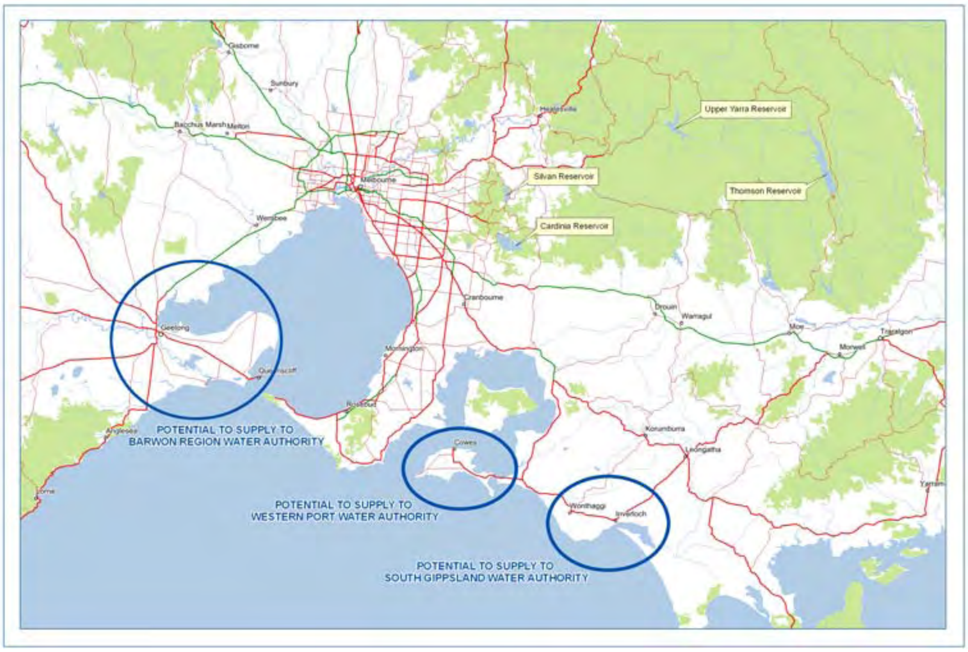
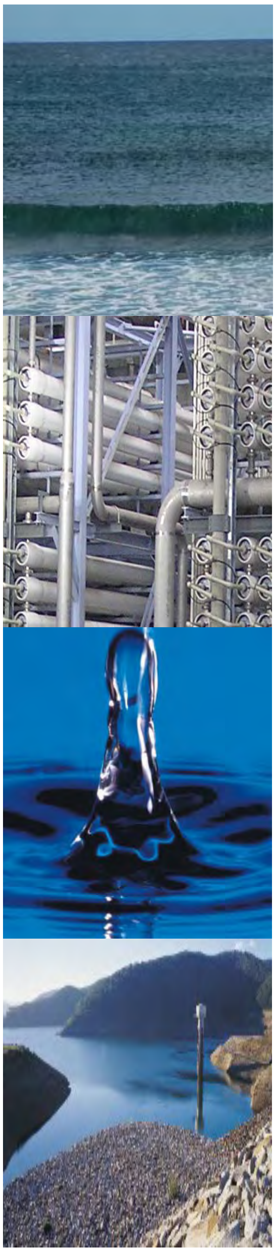


Figure 8 – Potential to supply water to local communities

The Bass Coast location offers the possibility to supply additional water to Phillip Island and surrounding towns by connection downstream of the Candowie Reservoir, which is near the proposed transfer pipeline corridor. The towns of Wonthaggi, Inverloch and Cape Paterson could all be supplied with additional water via a pipeline from the desalination plant itself to connect downstream of Lance Creek Reservoir. It would also be conceptually possible to construct a longer pipeline and send water towards the towns of Korumburra and Leongatha. There is also an opportunity to provide additional water to Geelong through a new pipeline connection to Melbourne.

The additional costs for these connections are not included in the cost estimates.



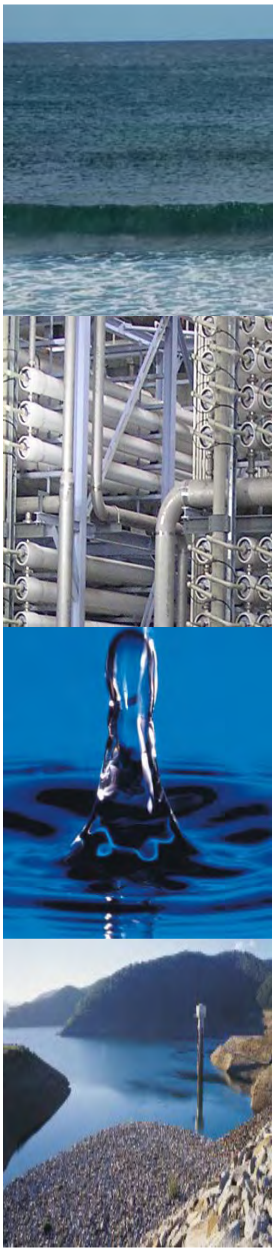
What next?

There is a range of activities that needs to occur to take a seawater desalination project forward from feasibility study into implementation. These are summarised in the report, and include due diligence site reviews, seawater sampling, pilot testing, environmental studies, hydrodynamic modelling, approvals and land acquisition, design development, community consultation, contract development and others.

Community Consultation

Considerable community consultation and engagement is now required to translate a proposal to construct a desalination plant in the Wonthaggi area (see Fig 4) to a detailed planning and construction phase.

The process for finalising the planning, land acquisition, siting details and construction and operating guidelines will be developed with all stakeholders and landowners in the area.



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Key Terms

Term	Definition
Alkalinity	Capacity of water to resist pH change by its content of bicarbonates, carbonates, or hydroxides. Measured in mg/L as $CaCO_3$.
Brine	See Concentrate
Buffer zone	Area around a plant to provide a barrier to minimise disturbance to neighbouring areas (e.g. noise, odour etc)
Co-location	Siting of a desalination plant with an industrial facility such as a power station to utilise waste heat and existing infrastructure.
Concentrate	Saline waste stream produced as a by-product of the desalination process.
Concentrate Outlet	Structure used to discharge concentrate back into the marine environment with diffuser structures attached.
Desalination	Process of producing fresh water from saline water.
Diffuser	Structure fitted to the outlet to facilitate rapid mixing and dilution of concentrate back into the marine environment.
Greenhouse Gas	A number of gases, which contribute to global warming, measured as a mass of equivalent carbon dioxide.
INCA	Geographical information system (GIS) model used to evaluate locations against a wide range of criteria.
Long Listed Locations	Initial set of potential locations considered as part of this study.
Osmotic Pressure	Pressure gradient across a semi-permeable membrane created by the difference in concentration of a solute.
Post-treatment	See potablisation.
Potabilisation	Treatment of desalinated water to add alkalinity and make suitable for drinking.
Pre-treatment	Treatment to remove suspended solids and other matter from influent seawater prior to desalination
Potable Water	Water suitable for human consumption and compliant with the Australian Drinking Water Guidelines and the Victorian Safe Drinking Water Act.
Reverse Osmosis	A water treatment process whereby dissolved salts may be separated from water by forcing the water through a semi-permeable membrane under high pressure.
Seawater Intake	Structure (either tunnel or pipeline) used for drawing seawater to be desalinated.
Short-circuiting	Risk of water from another source (e.g. concentrate outlet, drain etc) being drawn into the intake structure and into the treatment plant.

Term	Definition
Short Listed Locations	Set of potential locations refined from the long listed set.
Sludge	Waste by-product of the pre-treatment process containing solids and organic matter removed from incoming seawater.
South Eastern Outfall (SEO)	Pipeline used to transfer treated effluent from the Eastern Treatment Plant at Bangholme for discharge into Bass Strait at Boags Rocks
Suspended Solids	Solids present in seawater that are removed by the pre- treatment process.
Thermal Desalination	Desalination process utilising heat by evaporating “pure” water, leaving the salt behind.
Transfer Pipeline	Pipeline used to carry desalinated water to supply network.
Recovery	Proportion of influent seawater converted to fresh water, expressed as a percentage.
Total Dissolved Solids	Measure of the dissolved constituents in water (e.g. salt)
Water Quality	Term used to describe water based on its chemical constituents and characteristics.

1. Introduction

The Victorian Government has been investigating options to provide a major augmentation for Melbourne's water supply. A range of possible augmentation options was identified in the Central Region Sustainable Water Strategy (2006). Seawater desalination was one of the options identified for further investigation.

GHD was engaged by Melbourne Water to undertake a feasibility study to evaluate seawater desalination as a water supply augmentation option for Melbourne. The key elements of this work included selection of a short list of locations, development of a concept for each location and then a preliminary assessment of costs, time to implement and various risks and issues for the locations. This report also outlines some fundamentals for the evaluation of a seawater desalination plant and how this relates to Melbourne's water supply and geography.

Modelling undertaken in parallel with this study has identified the requirement for a rainfall-independent 150 GL/yr augmentation by the end of 2011 in addition to other augmentation options. The augmentations are to provide recovery of the system following extended draw on the reservoirs, particularly Thomson, and to provide for an ongoing reliable supply on the basis of the shift in the hydrological conditions observed since 1997. If the augmentation is provided by seawater desalination, the plant should be expandable to 200 GL/yr to allow for possible longer term scenarios where more water is required.

1.1 Objectives and Scope of the Feasibility Study

The objectives of the feasibility study include:

- To identify a technically feasible option to desalinate seawater as a significant augmentation to Melbourne's drinking water supply.
- To determine the life cycle costs of the preferred option for desalination together with an assessment of consequential environmental and social impacts of the project.
- To specify matters that should be investigated further if the project is to be developed further.

The scope of this study was to evaluate the feasibility of seawater desalination as a water supply augmentation for Melbourne by undertaking the following:

- An evaluation of suitable locations.
- Develop a scheme for desalination at a short list of locations.
- Develop a concept design for the desalination plant and associated infrastructure including transfer of water into the existing water system for each of the schemes developed.
- Evaluate environmental, social and planning aspects associated with the schemes developed for each short listed location.
- Develop a cost estimate for comparison of the schemes developed for the short listed locations.
- This study is to be conducted confidentially and as such will be largely at a desktop level.

1.2 Disclaimer

GHD and Melbourne Water have prepared this feasibility report to meet the scope outlined above and the concepts have been developed to a preliminary level, based mostly on desktop study.

Cost estimates, technical concepts, impact assessments and evaluation of risks and opportunities set out in this report are considered to be preliminary and further development will be required before the project's business case is finalised.

2. Seawater Desalination: Some Background Information

Seawater desalination is new to Melbourne, although it is presently being implemented in other cities around Australia. It has, however, been used to supply water suitable for drinking since Greek and Roman times. Australia's first desalination plants were wood-fired facilities treating saline groundwater in the gold fields of Western Australia at Kalgoorlie, which operated through the 1890s until the completion of the Goldfields Water Supply Scheme in 1903.

A number of aspects of seawater desalination are common to most plants and locations, and this chapter is intended to provide some background information on such common aspects.

The schemes investigated for Melbourne in this report are of capacities in the range 100 to 200 GL/ year, which equates to a plant providing around 300 to 600 ML/d of drinking water.

By way of comparison, Melbourne's water consumption in the calendar year 2006 was approximately 450 GL.

Melbourne's current water supply has a dissolved solids (salt) content of around 40 to 100 mg/L. This is low, and is partly why Melbourne is considered to have a high quality water supply.

2.1 Removing Salt from Water

Desalination removes dissolved salts from water. The primary difference between seawater and drinking water is its high salt content. It is possible to use the technologies described in this report to produce the ultra pure water that is used in computer manufacture and the production of pharmaceuticals.

The processes described in this report can be used for seawater, groundwater, estuary water or even recycled water to reduce salt levels. Seawater has a dissolved solids concentration of around 35 000 mg/L. This varies however. Areas with low inflows from rivers and high evaporation have higher salinity levels, with the Middle East a typical example. In contrast, many areas that have river inflows nearby have lower salinity. When rain falls it is essentially pure water, so rivers have low salinity unless the water has spent time in contact with salty rocks or soils.

Technology advancements of today mean that desalination can readily achieve a water quality that meets the Australian Drinking Water Guidelines.

2.2 Broad Context

There has been a downward trend in the costs and energy use of desalinated water over the last 20 years, due to technological advances enabling better performance. Note that there has been some speculation that these downward trends may be flattening out, particularly for plant cost, partly due to competition in the market. Also, some notably low cost projects (e.g. Tampa Bay in the USA) have had difficulties requiring some reconstruction; therefore the real cost of water is higher than first reported. Figure 1 demonstrates the cost decrease and performance improvement in seawater reverse osmosis over the past several decades. Table 1 below outlines the current status of the major seawater desalination projects in Australia.

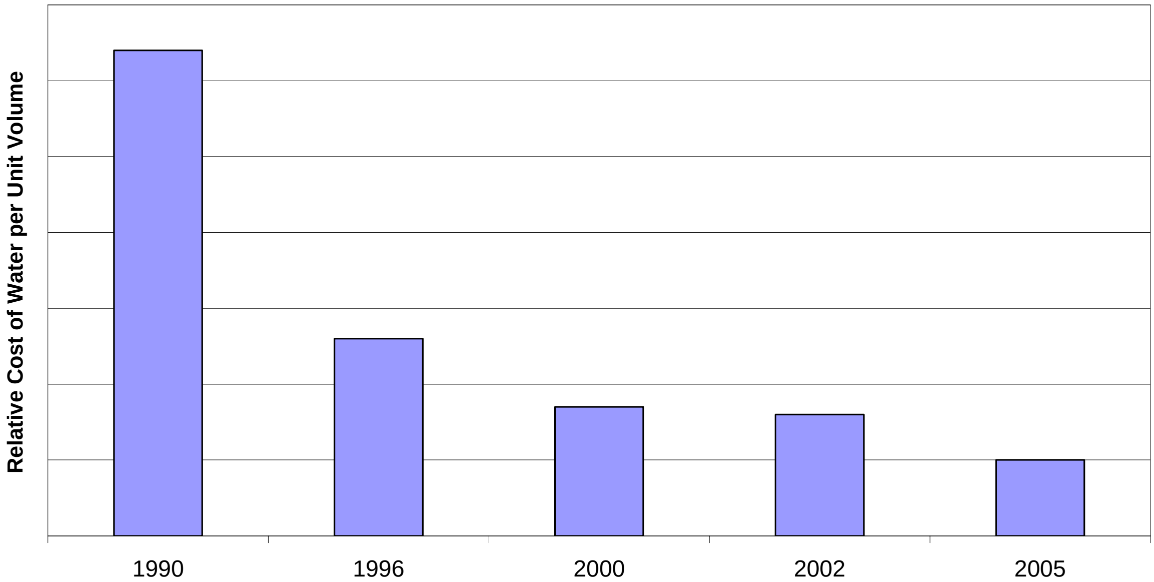


Figure 1 – Historical Cost of Desalinated Water From Large SWRO Plants (Adapted from: Membrane Desalination Technology, Wilf M, 2007)

Table 1 Seawater Desalination Status in Australia

City	Size (ML/d) (GL/yr)	Status	Technology	Energy Source
Perth (1)	125 (45)	Commissioned in 2006	RO	Wind Farm (via grid)
Perth (2)	125 – 250 (50 – 100)	Planning	RO	Not announced To be Confirmed
Sydney	120-500 (45 – 180)	Tendering for Construction	RO	Not announced To be Confirmed
Gold Coast	125 (45)	In Construction	RO	Not announced To be Confirmed
Adelaide (BHP, Olympic dam)	120 or greater (40)	Detailed Design	RO	Not announced To be Confirmed

Figure 2 – Perth Desalination Plant 45 GL/y (Permission: WA Water Corp)

Figure 3 – Ashkelon Desalination Plant, Israel (110 GL/y, co-located with power plant)

2.3 Some Technical Fundamentals of Seawater Desalination

The following points summarise some key technical fundamentals of seawater desalination, which have informed this study.

1. The desalination process operates at around 40% recovery. This means that more than twice the flow of product water must be pumped from the ocean, and slightly more than the product flow must be returned. As a result the piping and pumping costs for the inlet pipeline and concentrate return pipeline are higher per km than for the delivery pipeline for final desalinated water. This means that it is more economic to site the plant as close as possible to the ocean source.
2. The cost of piping water is significant. Therefore it is preferable to site the plant at a point where the ocean is relatively close to the point where the water can be introduced into the system. Further, the height to which the water must be lifted to get it into the system also affects the costs and energy use. So sites that are close to points with lower lifts, are also preferred.
3. Drawing from seawater in deeper open ocean water which is unaffected by inflows from the land leads to more consistent salinity and lower suspended solids. This reduces the extent of pre-treatment required, and thus reduces plant costs and operational risks. So sites that can draw from 'clean' open ocean water are preferred. However, it is possible to engineer plants to use variable estuarine feed water. The consequence is increased costs and increased time to understand and manage the feed water quality variations. Thus drawing water from less pristine sources is possible, but this needs to be weighed up against other factors when selecting a site.
4. To maintain reasonable inlet water quality, it is preferable to have the inlet located in deeper water. This avoids sediments that are stirred up by wind and wave action in more shallow waters. It is also preferred to keep the inlet deep enough to avoid any interaction with boats and shipping. Further, constructing the connecting pipes or tunnels to the inlet is often costly, and minimising this length is therefore beneficial. This means that sites where deeper water is relatively close to shore are preferred.
5. The concentrate can be dispersed effectively using diffusers on the outlet pipeline. However, this requires a minimum depth of water. Significant local currents also assist, and reduce the need for extensive diffuser approaches. Again this means sites near deeper water are preferred.
6. A site of around 20 hectares is required for a plant of 100 GL per year. Larger plants require more land. Sites where this area of cleared land is available are preferred.

Note that all of the points noted above can be addressed with various design approaches. Moving away from the 'preferred' position will impact either cost or time to implement.

A review of these considerations shows that the 'ideal' site is vacant land, next to deep open ocean water and relatively close to key water supply assets that can accept the water. This concept provides useful background when considering the sections of this report that discuss the site selection process.

2.4 Plant Sizing

This study considers a detailed comparison of the capital costs of plants at four short listed locations. Given that the ultimate useful capacity of a plant at Surf Coast is constrained to a maximum of 100 GL/y (see Section 7.2), the "base case" for cost comparison was taken to be a plant size of 100 GL/y – to provide an "apples with apples" comparison.

Desalination plants require significant capital investment and therefore are typically operated at a steady rate to provide a base load supply so that the amount of water from the plant is maximised to minimise the effective cost of water from the plant. There is some planned downtime in operation, and also the need to allow for some margin for risk in operation. Therefore, for a plant size of 100 GL/y, and allowing for approximately 10% downtime, the plant would operate at 300 ML/d. The study also considered plants of other sizes (at locations where this is practical), and used the same downtime allowance. Thus: a 150 GL/y plant would operate at 450 ML/d and 200 GL/y at 600 ML/d.

2.5 Desalination Technology

Desalination is the process of removing dissolved salts from a saline water source such as seawater, brackish water or wastewater. The salt content of a saline water source is commonly expressed as total dissolved salts (TDS). Although various methods can be used to desalinate seawater, thermal (evaporative) and reverse osmosis (membrane based) methods are the two mature desalination technologies. Figure 4 illustrates the layout of a desalination plant.

Both thermal and RO desalination methods separate seawater into two streams:

1. The desalinated product water that is low in salts relative to the source seawater; and
2. The concentrate (brine) that is high in salts relative to the source seawater.

The unit production capacities of thermal and reverse osmosis processes differ along with both their energy demand and also their source water pre-treatment requirements which are in turn intended to protect desalination equipment.

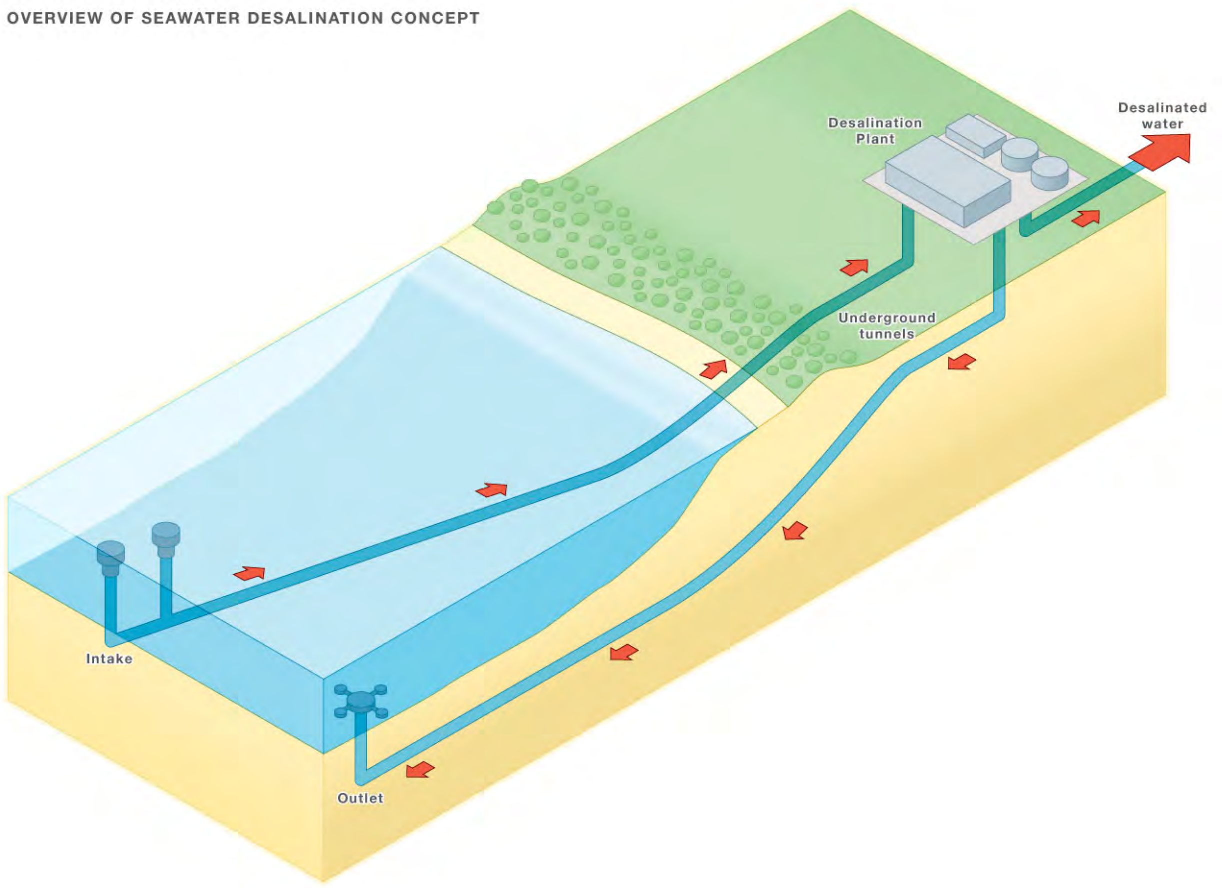


Figure 4 – A Typical Desalination Process

The following brief sections summarise some key aspects of seawater desalination.

2.5.1 Reverse Osmosis Desalination

The reverse osmosis (RO) membrane based technology was originally developed to desalinate brackish water in the early 1970s. RO does not rely on a phase change to effect separation and therefore, the energy requirements are lower. Instead, electrical energy is transformed by pumps into mechanical energy, to pressurise the seawater above the osmotic pressure of the salts in the seawater. This pressure gradient then drives the diffusion of water through the semi permeable RO membrane while the salts and other impurities are rejected by the membrane and discharged in the concentrate[1]. The RO process is illustrated schematically in Figure 5. Note that as the RO process does not rely on heat and the temperature increase in the concentrate is minimal (< 2°C).

1 "Concentrate" the more correct term for the concentrated waste stream in RO membrane processes is used in this report. "Brine" is often used for RO, as it is the term applied in thermal desalination processes.

Ions in seawater are rejected by RO membranes at different rates, depending upon their valency and atomic weight. On average, this rejection rate is in excess of 99% for seawater RO (SWRO) membranes and >97% for brackish water membranes (BWRO). In addition to the removal of salts in solution, RO removes other contaminants such as organic molecules and microorganisms.

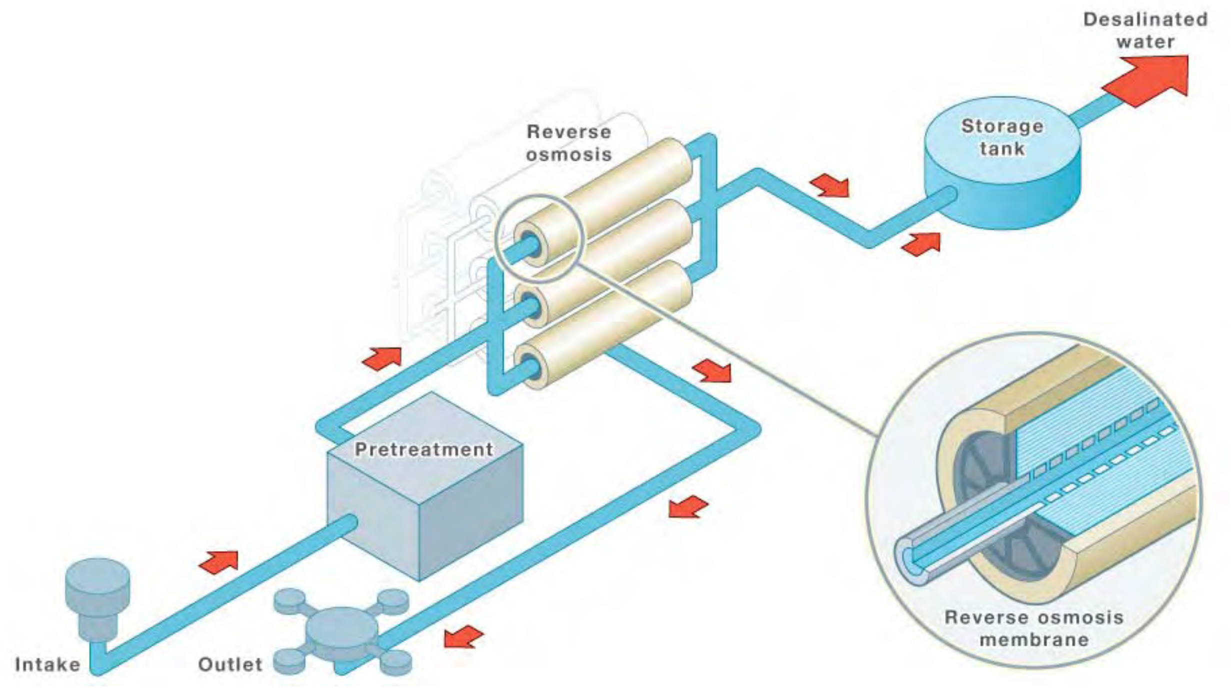


Figure 5 – Reverse osmosis (RO) system

Unlike thermal processes, the pressure and hence energy requirements and operational costs of RO systems vary with salinity. SWRO systems typically require pressures of 55 to 70 bar to desalinate seawater. Using modern energy recovery devices, this equates to a power demand ranging from less than 4.0 to 5.0 kWh/m^3. Energy savings are possible when using estuarine water of a lower salinity. However, this must be balanced by any additional pre-treatment requirements due to fluctuations in either water quality or suspended solids loads or organics in the water due to freshwater inflow.

Salinity will also influence capital costs through the system recovery and hence intake and concentrate plant flows, pumps etc. For seawater, the recovery achieved by the RO system is limited by the pressure ratings of SWRO membranes and recoveries are typically limited to 40 – 60%.

Feedwater salinity will also influence RO product water quality. For seawater desalination, the TDS of the permeate of a single pass RO system is typically < 500 mg/L. If a product water with a lower salt content is required, the desalinated water produced from the SWRO is polished by a second pass through another set of membranes. This is known as a ‘two pass’ system.

The reverse osmosis membranes are sensitive to the feed water quality they receive. If this water is contaminated, the membranes can ‘foul’ and as a result produce significantly less water. Hence the seawater is treated with various filtration systems prior to the membranes. This 'pre-treatment' process is now understood to be one of the critical aspects of reverse osmosis.

With appropriate pre-treatment, membranes are now expected to have a life of five years or more.

2.5.2 Thermal Desalination

Thermal (evaporative) methods remove salt by causing the source water to go through a phase change. The water is evaporated, under normal atmospheric or reduced pressure conditions, leaving the salts behind in a concentrate stream. The evaporated water is then condensed to give almost pure water. This approach to desalination has been used for thousands of years. It has been the technique used for the major plants in the Middle East until recently. If there is a readily available and low cost source fuel it can appear attractive.

Thermal processes are inherently energy intensive as the principal component of their energy requirement is related to the (latent) heat required to evaporate seawater. This energy requirement is not greatly influenced by salinity. Hence, salinity levels in the feedwater do not influence capital or operating costs. An advantage of thermal systems is that they are generally robust and relatively forgiving of feedwater quality and variations. High quality filtration for pre-treatment is generally not required. This means there is less need for operator attention during operation.

Thermal processes have lower recovery, and therefore the intake flow and concentrate flow are higher than for a reverse osmosis plant producing the same volume of water. This means the size and therefore cost of the inlet and outlet infrastructure are higher.

The concentrate produced has an elevated temperature. This can have adverse environmental impacts, and therefore the concentrate disposal from thermal plants can be more challenging than for reverse osmosis plants. The plants are larger and more 'industrial' in appearance than reverse osmosis plants, leading to a greater visual impact if sited in an area with landscape value.

2.5.3 Energy Use and Recovery

A typical requirement for total power use at an RO desalination plant is around 4 kWh/kL of water produced, which reflects energy recovery within the process. Plants with lower salinity feed water, and using only a single pass, can have lower energy use. It is important to understand which aspects of the plant and system have been included in the calculation when comparing the energy use at different plants.

Energy recovery is now a key component of RO desalination processes. Energy consumption is one of the major cost components of the overall water production cost of RO systems, especially for seawater. As the RO concentrate remains pressurised downstream of the separation it holds a part of the energy supplied to the feedwater by the high-pressure pumps. Consequently, recovery of this energy will reduce the overall energy demand of the RO and is one of the optimisation decisions during the design of an RO desalination plant.

Different energy recovery technologies are available on the market. Most of the technologies apply the same basic concept of exchanging energy between the concentrate stream and the feedwater stream. Recent advances in this area, together with ongoing improvements in the membranes, have led to the recent reductions in energy use.

The need to pump the water back to the city and up to the required elevation to the water storages leads to a significant input of energy. For example, if water is pumped long distances and up 500 m (say) of lift, then the energy use for this pumping could be more than half that required to desalinate the seawater itself. This point has been considered when comparing water supply schemes.

Energy use data quoted later in this report incorporates the pumping energy to extract seawater from the ocean, the energy required to desalinate and treat the seawater, and the energy required to pump the water to the city.

2.5.4 Co-location

Some desalination plants located overseas are co-located with power stations (or other industrial facilities). Advantages of co-location include being able to piggyback on existing infrastructure and utilise waste heat to either drive or improve the desalination process.

The infrastructure that is most commonly shared is seawater intakes and outlets. This is only an option where the power station uses seawater for cooling purposes. This study is considering a desalination plant capable of producing 100 GL/year or more. For co-location with an existing power station to be an option, a facility drawing well in excess of 700 ML/d of seawater for cooling and operating continuously would be required.

Waste heat from thermal power generation (coal or gas fired generation) falls into two broad categories. High temperature waste heat (as from the exhaust of a gas turbine) can be used to directly drive a thermal desalination process. Low temperature waste heat from a combined cycle or cooling water stream can be used to preheat the feed water to a reverse osmosis process. Higher temperatures will increase the possible flux, reducing the pumping required. Conversely, higher temperatures increase the salt passage, producing a lower quality water.

In Victoria a new gas-fired power station has recently been built in the Laverton North area to meet peak loads. Another gas-fired power station has been proposed for Mortlake in the south west of the state. Neither of these plants is near to the coast, so will not utilise seawater cooling. Modern power station design tends to favour air-cooling to reduce the use of fresh water and minimise the environmental impact associated with seawater cooling. Given that there are no suitable continuously operating existing/proposed power stations near the supply system in Melbourne, it is unlikely that co-location will be a viable option.

2.5.5 Alternative technologies

For the purposes of this feasibility study, only the mature and widely utilised technologies of RO and thermal desalination have been investigated. Other desalination technologies do exist however are generally limited by constraints on their size and level of development.

There is a range of promising new desalination technologies, which are in development around the world. These include the Long Beach 'Dual Nanofiltration' approach, membrane distillation, solar approaches and a range of other possibilities. Further, there are new approaches proposed to reduce the costs of reverse osmosis, including the use of larger diameter modules, and the use of other membrane processes for pre-treatment.

All of these possible improvements are being pursued to lead to lower costs, reduced energy use or other operational benefits. In some cases the potential reductions in cost and energy use are substantial. This means that in the future, a desalination plant could possibly be retrofitted to provide improved performance.

2.6 Seawater Quality in Victoria

This study has considered locations that would draw water from and return concentrate to Port Phillip Bay, Western Port and Bass Strait.

Seawater quality is influenced by the general geography of the bodies of water involved. The following sections provide some background information on these bodies of water. Figure 6 shows the key bodies of water including some broad scale idea of water depths.

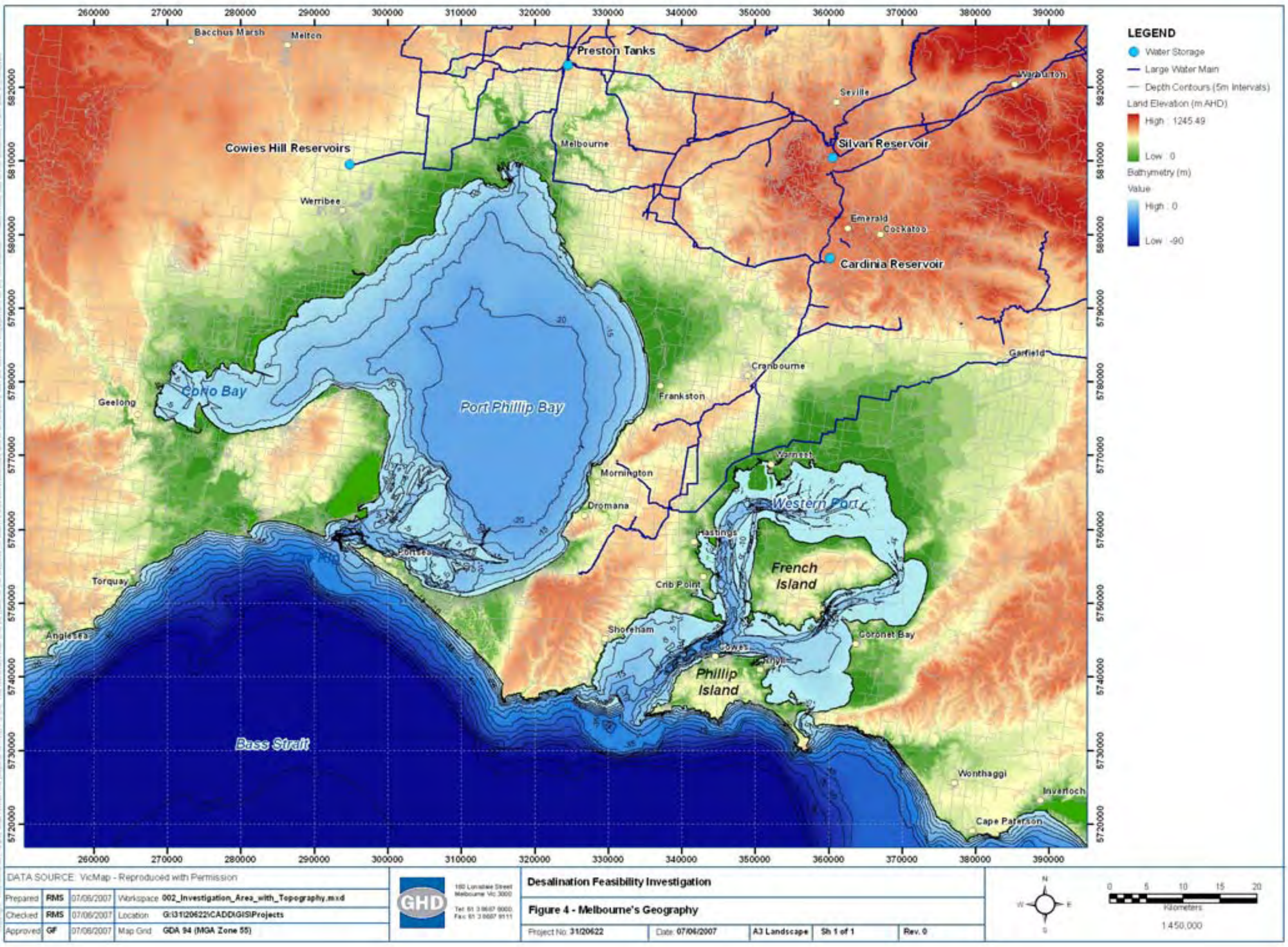


Figure 6 – Melbourne's Geography

2.6.1 Port Phillip Bay (*From Port Phillip Bay Environmental Study, CSIRO, 1997)*

Port Phillip Bay (Port Phillip Bay) is a large shallow bay covering some 1950 km^2. Nearly half the bay is less than 8 m deep with a water depth of 24 m at its deepest point. As a result of the narrow entrance (The Rip) there is limited mixing with Bass Strait and the flushing time of the Bay is estimated to be around 200 days on average. The Bay water is normally well mixed within the water column at any one place due to the shallow depth of the Bay. Port Phillip Bay typically receives inputs of fresh water from the Yarra River and Maribyrnong River in wet years, however Port Phillip Bay is essentially a marine system with water of a similar salinity to that of Bass Strait due to the high ratio of salt water to freshwater input (40 times). Flushing times near The Rip (say near the Portsea-Sorrento area) are quite short, whereas flushing times toward Geelong and Corio Bay are greater than a year.

Port Phillip Bay has been studied extensively in the past. The following plates show some data on the bay drawn from the Port Phillip Bay Environmental Study 1997.

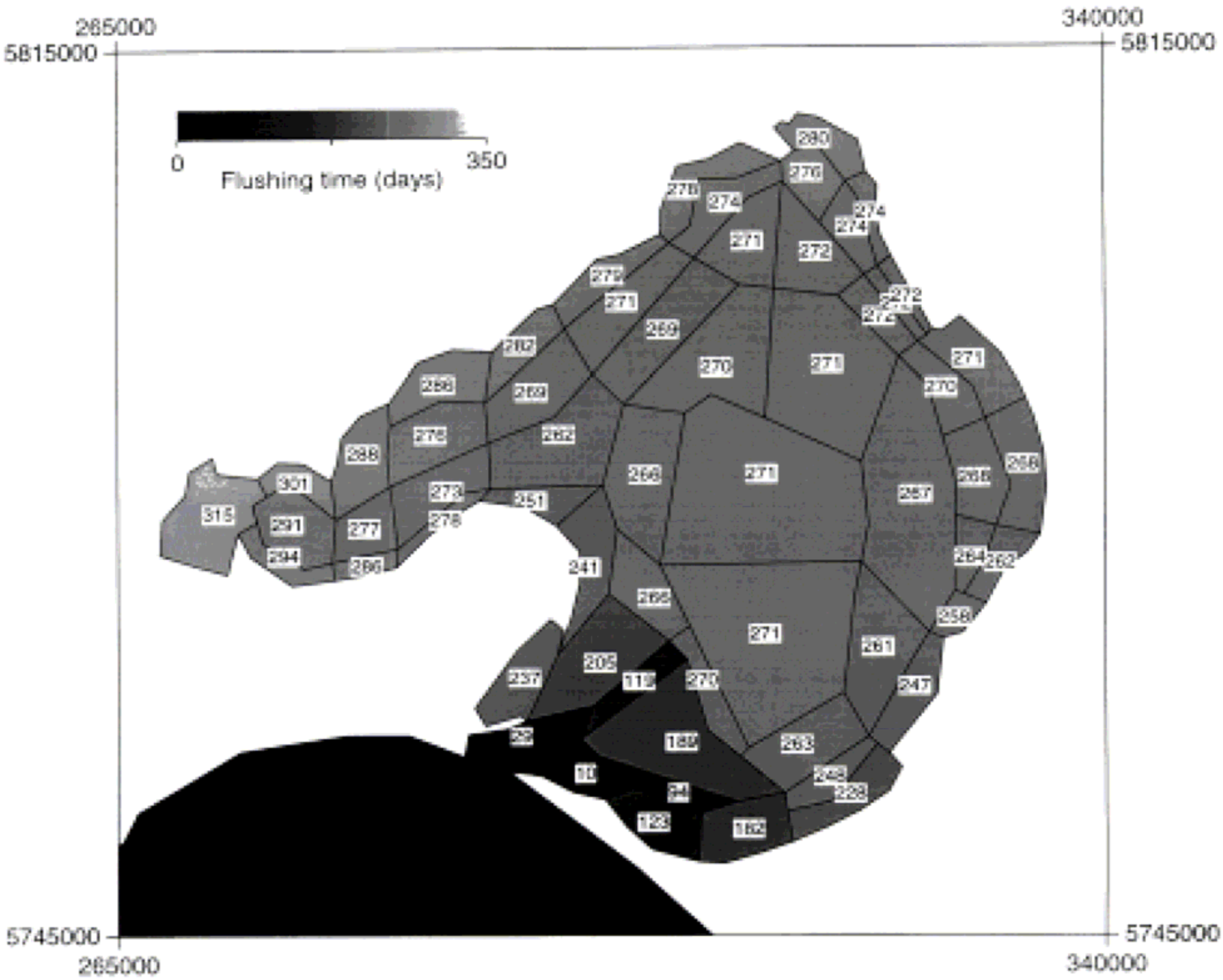


Figure 7 – Flushing Times in Days in Port Phillip Bay (Source: Port Phillip Bay Environmental Study 1997)

2.6.2 Western Port

Western Port contains two major islands and two entrances to Bass Strait. The two major islands are French Island, that lies in the centre of Western Port, and Phillip Island that lies at its entrance (Figure 8). The net water flow is in a clockwise direction around French Island. Water exchange with Bass Strait through the Western Entrance is high, primarily due to the wide entrance (approx. 10 km) and the predominant ocean swell from Bass Strait towards the Western Entrance. The Lower North Arm at the Eastern Entrance experiences a large tidal range, being flood dominated rather than ebb dominated in this region. There is generally good vertical mixing in the water column but lateral mixing may be stronger due to the strong tides in the basin. Water depth varies significantly throughout Western Port with 40% exposed as mud flats at low tide. Hastings is a commercial port with naturally deep water; the shipping channel is around 14 m deep.

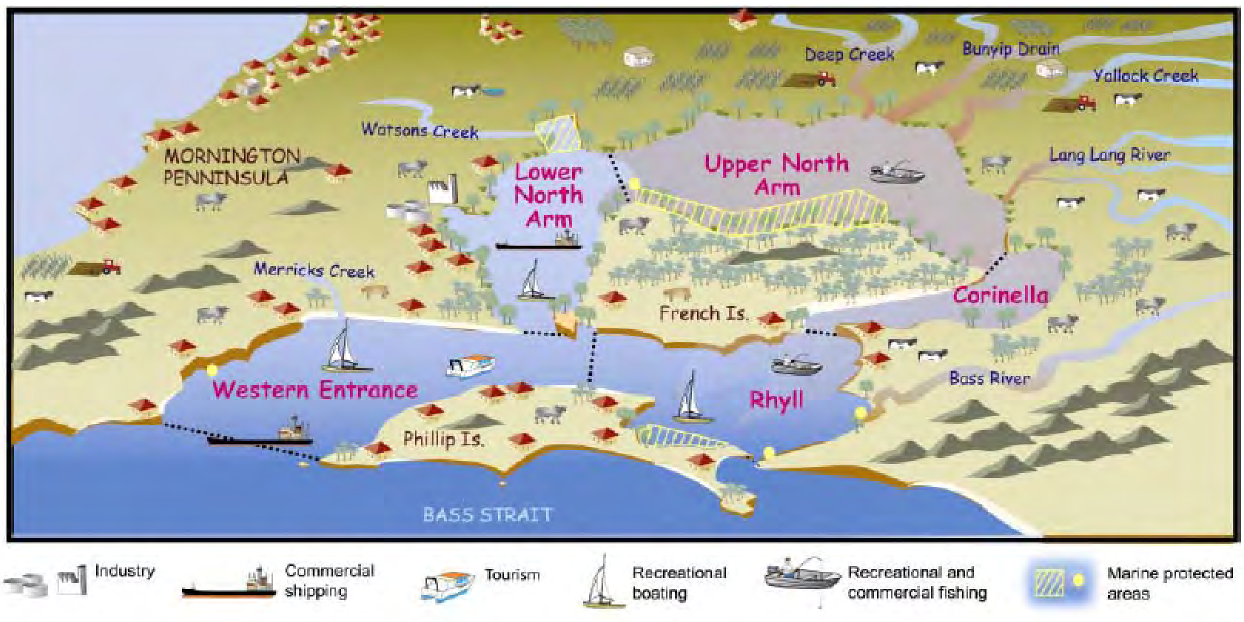


Figure 8 – Western Port marine environment [Source: Western Port Research Co-ordination Stage 1, 2003]

2.6.3 Bass Strait

Bass Strait is the body of water south of Victoria, between the Australian mainland and Tasmania. This marine environment is highly energetic with significant swells influenced by the predominant west to east weather patterns of the Southern Ocean. The oceanic coastline in the areas considered as part of this study are characterised by sandy beaches with outcropped reefs and significant surf conditions. Water mixing in Bass Strait is generally very good, and is likely to present reliable and consistent marine water quality. Fresh water influence from rivers and other discharges tends to be local in nature.

2.6.4 Seawater Quality Considerations for Pre-treatment

In general, estuarine and bay-located SWRO desalination plants require more robust pre-treatment than open ocean-located SWRO desalination plants due to fluctuations in salinity (diurnal/seasonal) associated with freshwater inflow which is often accompanied by an increase in suspended solids, nutrient and organics. In contrast open ocean SWRO plants generally have limited salinity fluctuations and a lower nutrient and turbidity content, making such plants easier to operate. The overall quality of the seawater will be dependent on coastal land use, discharges and marine activities.

2.6.5 Water Quality Data

Temperature and salinity vary seasonally and spatially in Port Phillip Bay. In general, water in Port Phillip Bay is warmer than Bass Strait in summer and cooler in winter. Data on temperature for Port Phillip Bay shows a seasonal influence with rises from 9°C in winter to a maximum of 25°C. There are likely to be local areas with greater ranges in some years.

The temperature range in Western Port is similar to Port Phillip Bay with the seasonal range varying between 8 to 24°C. The temperature is marginally cooler or warmer at Barrallier Island and Corinella in Western Port due to the circulation around the islands as described above.

The water temperature in Victoria is lower than Perth, the Gold Coast and Sydney. This means that the flux rates through the membranes will be lower, the energy use will be higher and salt rejection will be better in Victoria. Plants which operate on lower temperature water need slightly more energy and more membranes, but, as a benefit, produce better quality product water. These differences have been considered in the concept design development.

Salinity data was examined to investigate fluctuations in the Bay. For the Port Phillip Bay Environmental Study (CSIRO, 1996), salinity was measured monthly over two years (1994 - 1995). The salinity measured spatially and seasonally during this time period ranged from <33 to >35 g/L (i.e. 33,000 to 35,000 mg/L), which is typical for marine water. However, this is just a snapshot. Salinity variation over time for close to 20 years, encompassing both earlier wet years and more recent drought conditions, was available from the EPA monitoring sites in Port Phillip Bay and this shows salinity fluctuations are much greater. The data shows that salinity can fluctuate between 27 and 39.5 g/L.

Salinity variation for the three sites available in Western Port shows that salinity fluctuations have decreased over time due to lower freshwater inflow during the recent drought conditions. Salinity variations follow the circulation pattern of Western Port whereby salinity fluctuations increase as the water is transported clockwise around the islands. Lower salinity fluctuations are found at Hastings as the seawater influx from the Bass Strait dominates and freshwater inflow is limited. At Corinella there is more freshwater inflow and salinity varies more. The average salinity at the three sites is similar, at 35 ± 1 g/L. This is slightly more saline than the average salinity in Port Phillip Bay.

Water quality in Bass Strait has not been sampled to the same extent as in Port Phillip Bay and Western Port. However, source data is available which shows that – (as expected for an open ocean environment) – the salinity is more consistent and the suspended solids and nutrient levels are lower than in Port Phillip Bay or Western Port. Water drawn from some locations along the Bass Strait Coastline may be influenced by discharges from rivers or outfalls.

This study included a broad scale source water quality risk assessment to help identify such influences. This risk assessment has been taken into account in the evaluation of different locations.

2.6.6 Comparison of Victorian Seawater with Sources used at Other Desalination Plants

Large Australian desalination plants draw water from open ocean sources. Open ocean sources have the advantage of generally providing more consistent feed water quality free from estuarine conditions and other land-based discharges. These consistent water quality conditions enable greater certainty with the design of the desalination plant and allow simpler process control and plant operation.

Table 1 Source Water for Other Australian Desalination Projects

Plant	Water Body
Perth	Cockburn Sound / Indian Ocean
Gold Coast	Pacific Ocean
Sydney	Tasman Sea / Pacific Ocean

2.6.7 Seawater Sampling

The next stage of development of a seawater desalination plant requires site-specific seawater quality monitoring to be undertaken to confirm the composition and variability of the seawater at particular sites. Such monitoring is required for process design and to properly understand and quantify seawater quality risks. If limited time is available, then the sampling program may not cover periods of water quality variation, such as significant inflows due to major rain events. Typically, sampling periods of 12 months or more would be seen as desirable for a source with variability such as an estuarine source.

The parameters tested would allow the basis for design of the pre-treatment and RO. Parameters would need to be tested in the vicinity of any proposed intake, i.e. some distance from shore in deeper water. Sampling is required both from the surface and from depth to properly understand the expected feed water quality. Seawater quality monitoring would be required to continue once a SWRO plant was in operation to ensure the feed water quality is of a standard the process can treat. Additional monitoring may also be required to confirm the assessment of impact of the concentrate discharge on the receiving environment.

2.7 Seawater Desalination Infrastructure

The following sections describe the main infrastructure items required for a seawater desalination plant.

2.7.1 Seawater Intake and Concentrate Outlet

A seawater desalination plant requires a reliable source of water of consistent quality and typically the same water body is used for concentrate disposal. Therefore location and design of the seawater intake and concentrate outlet are key aspects to consider in the design of a desalination plant.

Seawater is transferred to the SWRO plant via an intake structure located offshore in water generally of a minimum depth of 10 – 15 m. The intake structure is designed to control the local velocity of the intake water to avoid entrainment of debris or marine life. Design considerations for the seawater intake are illustrated in Figure 9.

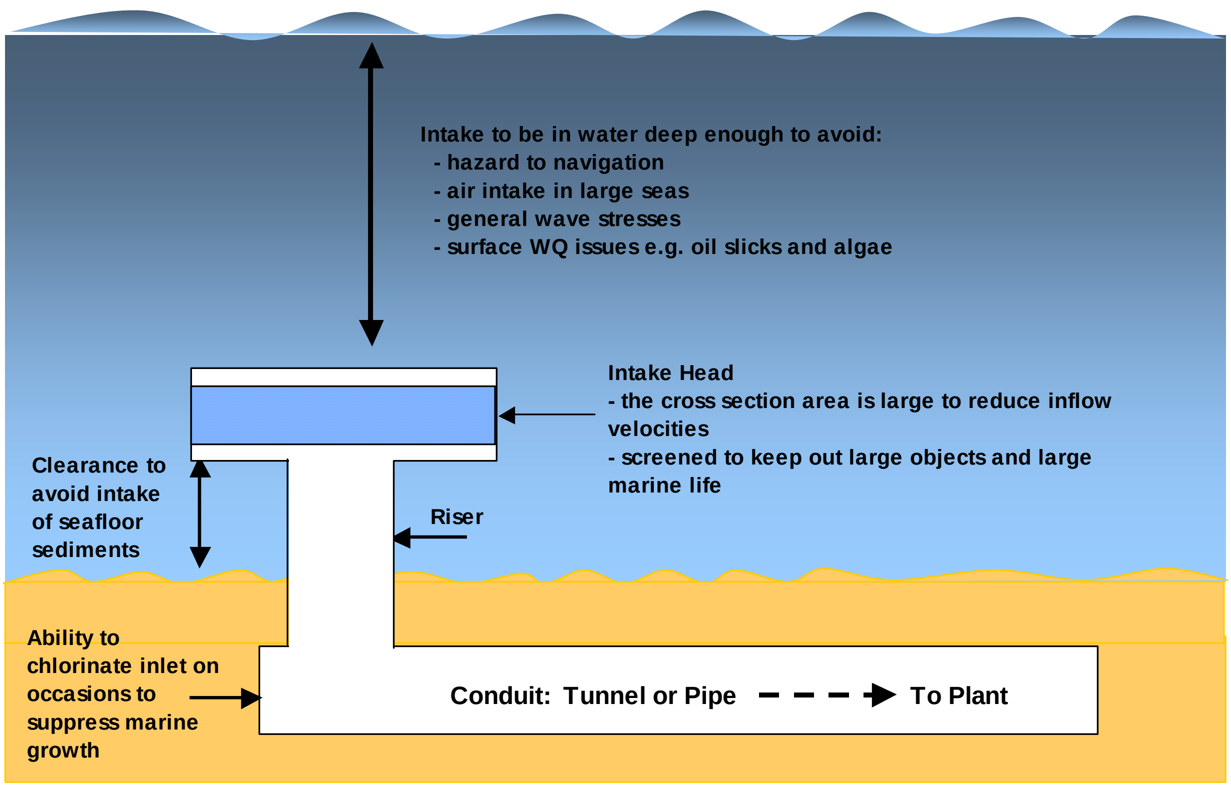


Figure 9 – Intake Design Considerations

Water is transferred via an underground tunnel or pipeline from the seawater intake to the desalination plant site near the shoreline. The seawater is then screened to remove matter that may be drawn in by the intake. The seawater is then pumped up from below sea level to the plant site for pre-treatment.

This intake structure is dark, relatively free of predators and has a constant flow of seawater. It is therefore an ideal environment for the growth of various attached organisms like mussels, bryzoans and others. Intermittent chlorination known as “shock chlorination” is generally employed to control marine growth in the seawater intake, screens and pump station.

The seawater intake should be located in water of sufficient depth to avoid sediment from the bottom from being entrained by wind and waves. It also needs to be in water deep enough to provide clearance for navigation. Likewise the intake should be located at a sufficient distance from the concentrate outlet to prevent short-circuiting. Design considerations for the intake head and for the location of the intake and outlet are shown in Figure 10.

The intake design also needs to allow for ongoing maintenance in the future.

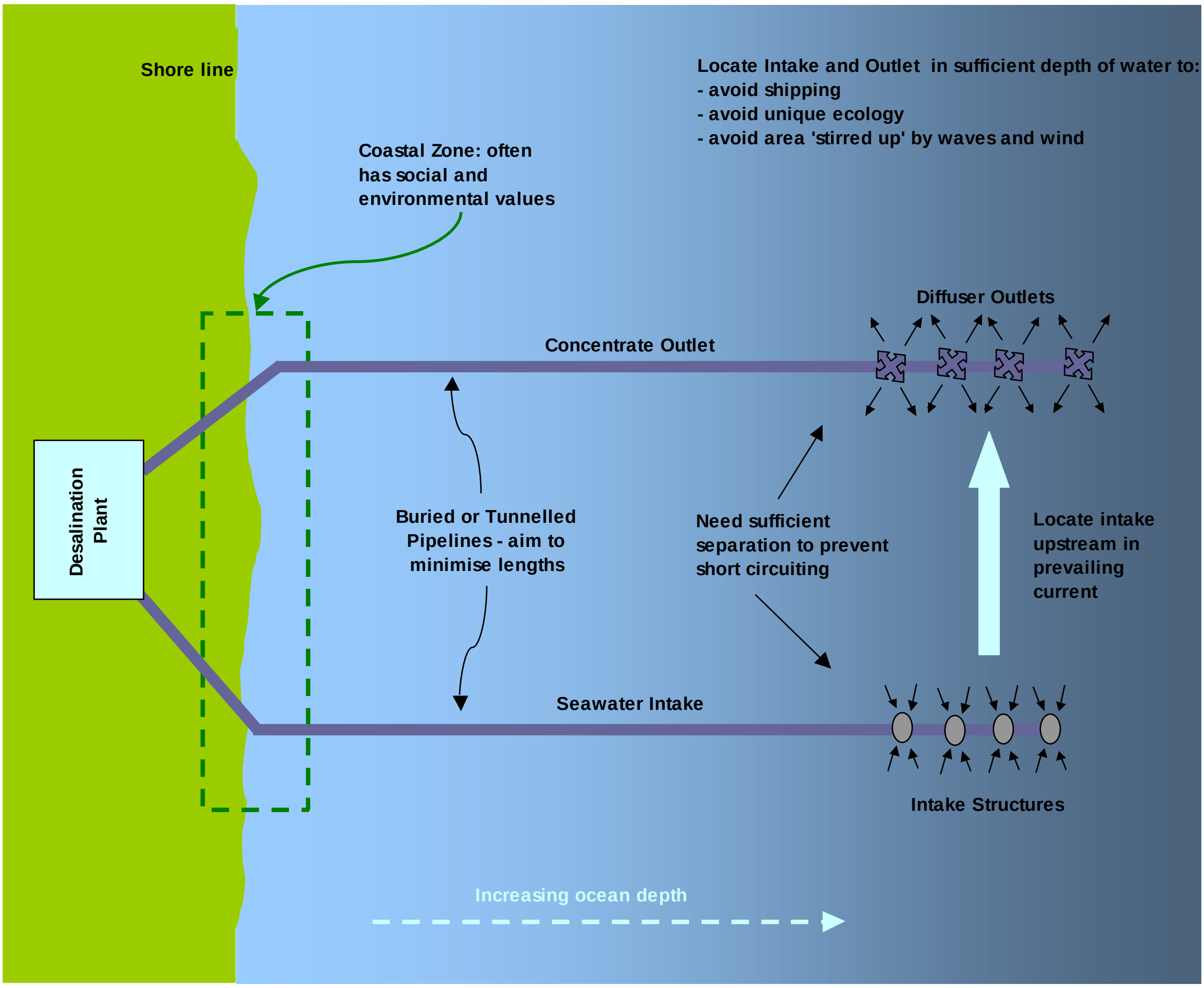


Figure 10 – Design Considerations for Location of the Intake and Outlet

Concentrate from the RO membranes contains elevated concentrations of the salts naturally found in seawater. The concentrate will also contain trace amounts of the chemicals added to the process, which react or break down to form constituents already found in the ocean.

The concentrate is discharged via a pipeline similar to the intake pipeline. A diffuser arrangement is included which maximises the concentrate dilution and dispersion into the wider water column. A typical diffuser head structure is shown in Figure 11 and dilution of concentrate from the diffuser is illustrated in Figure 12. This diffusion and the location of the outfall with respect to the intake means that the salinity of the feed water to the plant is not significantly affected by the concentrate discharged.

Figure 12 also illustrates that, for this particular diffuser design, the (mixed discharge) salinity is within 1 ppt of the background level within 15 to 20 m from the diffuser. This could be reduced even further by means of alternative designs or ambient currents.

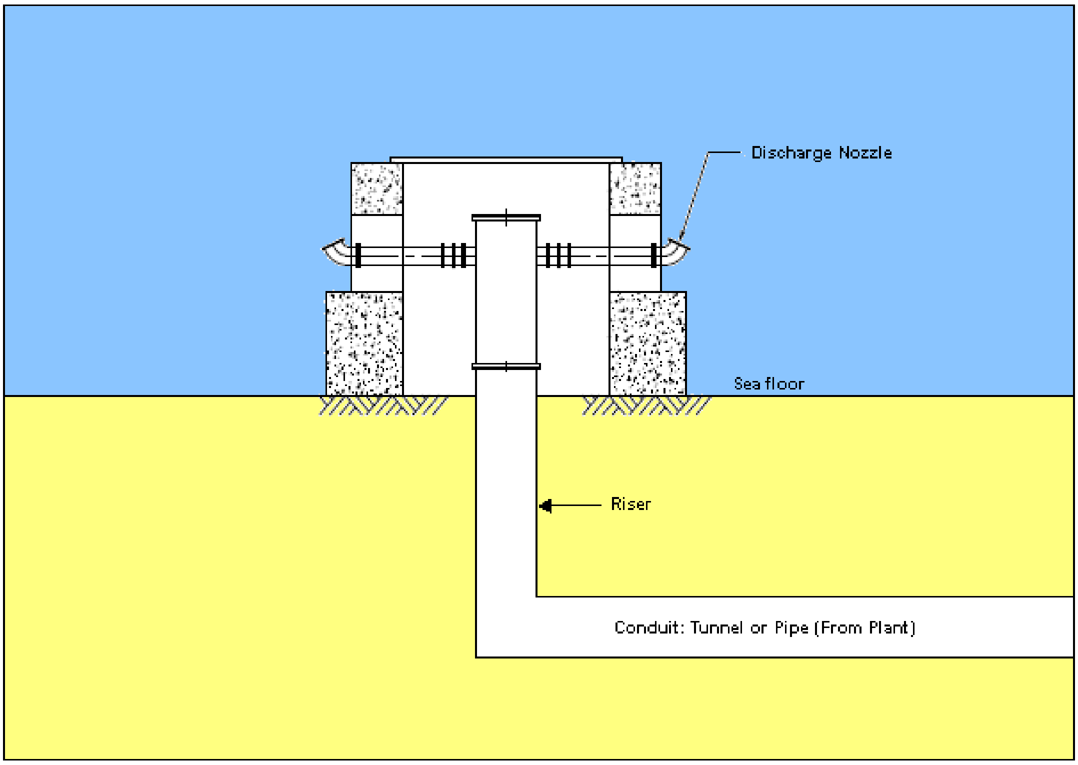


Figure 11 – Concentrate Outlet Diffuser Head Structure

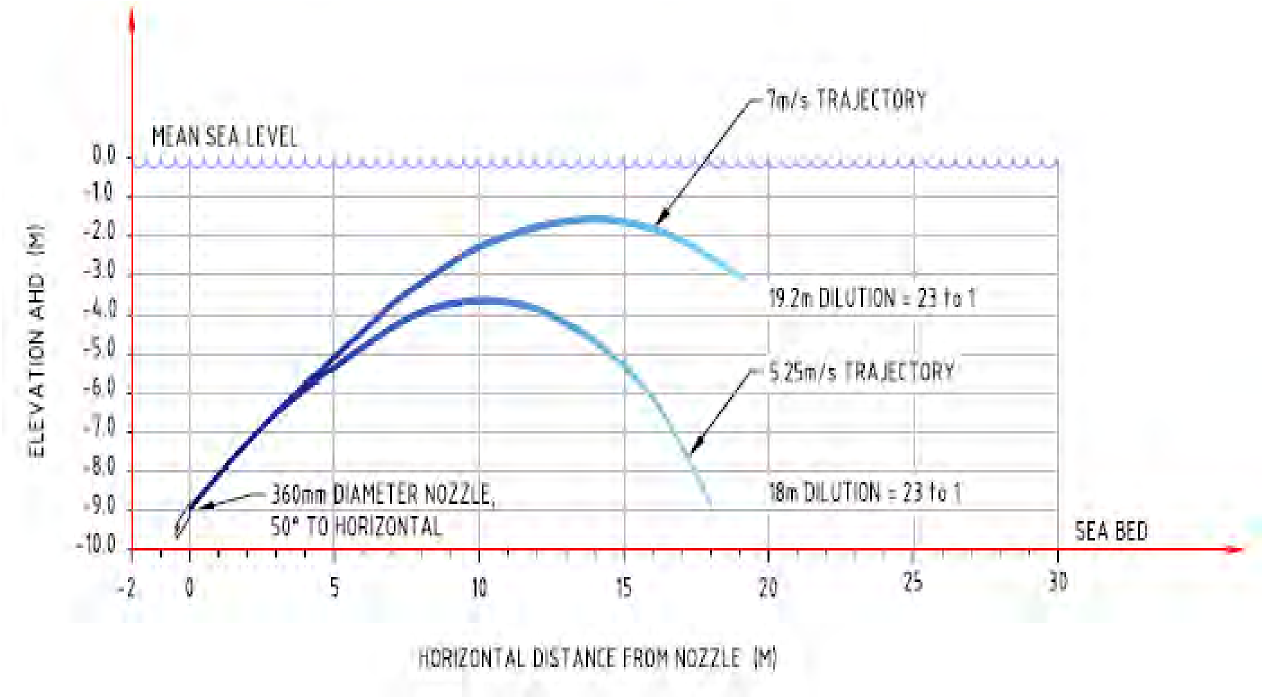


Figure 12 – Dilution of Concentrate

2.7.2 Design Compromise: Open Ocean versus Calm Waters

Review of the discussion above shows that it is desirable to locate intakes and outlets in deep and energetic open ocean water, as this provides the best intake water quality and outlet mixing. However, the open ocean environment in Victoria has many days with large waves which therefore presents construction difficulties.

As a result construction of inlets and outlets in Bass Strait is likely to be more expensive and time consuming than construction in either of the Bays. This means there is a compromise between the more desirable water conditions for diffusion, and the additional difficulty in construction.

2.7.3 Pre-treatment

Seawater must be conditioned to ensure it is of a suitably high quality for use in the RO plant. Reverse osmosis membranes are expensive, and susceptible to fouling due to contaminants in their feedwater. As a result, appropriate feedwater treatment is vital in maintaining ongoing performance and avoiding significant problems. Some major desalination projects have experienced problems that have been at least partly related to pre-treatment failures.

The key objectives of the pre-treatment are to:

- Remove turbidity and suspended solids, making the water suitable for use in the RO plant.
- Manage risks from human activities such as oil leaks from shipping
- Manage risks from naturally occurring events such as algal blooms.

Pre-treatment generally resembles the processes used for treatment of fresh water. Different processes can be employed, depending on the quality of the seawater, site location, and other constraints. In all processes some form of filtration is performed.

Prior to filtration the seawater is chemically conditioned to adjust pH and to flocculate the suspended matter, prior to the multi-media filters. Chemicals added include sulphuric acid, ferric chloride (or ferric sulphate) and a polymer flocculant. The flocculation process occurs in slow mix tanks at the front end of the filtration plant.

For less pristine feed waters, another process is often added. Examples include settling in a clarifier, and also the dissolved air filtration process (DAF). These processes remove the bulk of the material, leaving the filters to remove the residual material. These dual stage processes represent the more robust pre-treatment typically used on estuarine waters.

Provision is made for backwashing the filters to remove accumulated particulate matter. Filtered seawater is used as the backwash water. Air is also used during the backwash to assist in scouring particulate matter from the filter media. Dirty backwash water is treated to remove the solids, which are thickened and dewatered. The treated backwash water is returned to the seawater intake at the head of the plant. The dewatered solids are disposed of offsite to landfill or treated and recycled.

There has been some progress toward pre-treatment with Micro-filtration (MF) or Ultra-filtration (UF) membrane treatment. This approach has not been proven for plants of this size.

2.7.4 Desalination Plant

A reverse osmosis desalination plant is described in this section as it is the concept being adopted for this feasibility study. The reverse osmosis (RO) plant performs the main function of separating the salt from the seawater. The separation is achieved by pushing the water through membranes, with high pressure being used to drive the process.

The water is separated into two streams; the permeate, which has passed through the membrane and has had most of the dissolved constituents removed, and the concentrate which contains the dissolved solids. For seawater, the recovery rate (proportion of permeate in relation to feed) is approximately 40 – 45%. The seawater concentrate is returned to the ocean and the permeate is sometimes treated in a second pass.

A second pass of RO can be employed to achieve lower total salt concentrations and to achieve the required removal of particular parameters. Second pass concentrate is usually returned to the filtered seawater basin and blended with the incoming filtered seawater from the pre-treatment plant. This waste stream has a lower concentration of dissolved constituents than the incoming seawater and has already been conditioned by pre-treatment to be suitable for RO. The RO desalination process is presented schematically in Figure 13.

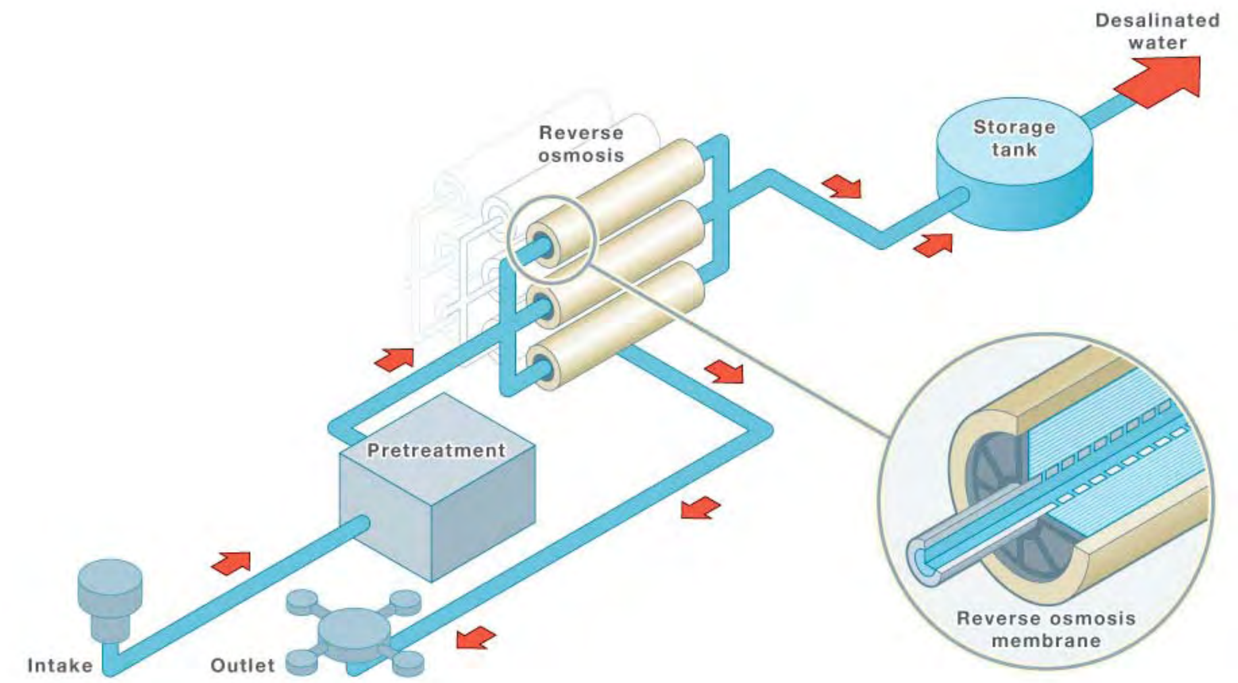


Figure 13 – Schematic of the Reverse Osmosis Desalination Process

The RO plant is configured as a number of independent trains. Each train consists of a series of pressure vessels, a high-pressure pump, an isobaric energy recovery device, three booster pumps, and two cartridge filters. The energy recovery device transfers pressure from the concentrate stream to the incoming feed stream, reducing the required pumping energy.

The RO membranes are periodically cleaned with a mixture of degradable acids and bases to remove any scale build up and restore performance. The used cleaning chemicals are neutralised before disposal.

2.7.5 Potabilisation

'Potable' is a term used to describe water which is appropriate for drinking. The 'potabilisation' process involves adding various constituents back into the desalinated water to provide appropriate final product water prior to distribution. Product water from the RO plant is discharged initially to the permeate water tank. This water is used for flushing and other operations within the desalination plant that need high quality water. This final water is very low in salts, particularly in a two pass plant. As a result the water can actually be 'aggressive' to some pipes and fittings, as it 'tries' to extract ions from the pipes and fittings. The water is therefore typically stabilised before distribution.

Downstream of the permeate tank the water undergoes stabilisation and disinfection before entering the product water storage tanks. Stabilisation typically involves the addition of lime and carbon dioxide which in combination make the water less aggressive to pipes, valves and other fittings. In many cases the water is then distributed directly to consumers, so a trace level of chlorine is added. The details of the various 'potabilisation' processes depend on where the water is introduced into the system, and the degree to which it blends with other water sources. If desalinated water is to be supplied from the plant directly to consumers, fluoride will be added during the potabilisation process.

Water is typically stored in tanks on site known as the clear water storage (CWS) prior to pumping into the distribution system.

2.7.6 Transfer to Melbourne's Water Supply System

Once desalinated water has been produced and put through the stabilisation process, it is possible to produce water that meets all required standards and is close in composition to the water currently supplied in Melbourne. This fact has been used in other cities to lead to the conclusion that the water can be introduced at some closer point in the pipelines than sending the water all the way back to the source reservoirs. This decision can save money and energy.

The consequence of this approach is that consumers who are near the point where desalinated water is introduced will receive 100%, or near to 100%, desalinated water at some times of the year. This is the approach that has been adopted in Perth, the Gold Coast and Sydney. The actual infrastructure required varies depending on the location of the plant, and this is covered in later sections of this report.

2.7.7 Power Supply Infrastructure

The power demand for a desalination scheme of 100 GL per year is around 60 MW. Larger plants will use more power, with a plant of 200 GL per year requiring 120 MW. If the plant is to produce water year round, then it needs a reliable constant source of power at this level. Directly connecting any power plant to the desalination plant (whether a renewable plant or a fossil fuel plant) would tie the reliability of water supply to the reliability of the power plant.

To avoid the potential constraints which this creates, RO plants are typically powered from the wider electricity distribution system (the 'grid'). This provides a more reliable power supply. This approach does not preclude the use of renewable energy. Renewable energy with an annual average equivalent amount can be added to the grid at some point distant from the plant with the same long-term outcome. This is the approach used in Perth, where a large wind farm contributes an annual amount of power equivalent to that used by the Perth desalination plant. This wind farm is around 200 km away, and the plant sources its power directly from the grid.

To provide a sense of this amount of power, the following table is provided which compares some different energy use figures in Victoria.

Table 2 Comparison of Energy Consumption with Other Activities

Activity	Energy Consumption
150 GL per year Desalination Plant	800 GWh/y
Renewable Energy Sales in Victoria, 2006	260 GWh/y#
Victoria's total Annual Electricity Use	58 354 GWh/y *

*Abare website (04-05) # Based on quarterly reports from Green Power for total sales in Victoria during 2006

3. Desalination Concepts Adopted for This Feasibility Study

The following concepts have been adopted to evaluate the feasibility of seawater desalination for Melbourne and were used to develop schemes for the locations that have been evaluated.

3.1 Desalination Plant and Pre-treatment

The water quality required to be supplied by the plant has an influence on the overall design concepts. Various drinking water guidelines and other factors were considered and a risk assessment was performed. Preliminary water quality targets have been set to enable development of a conceptual design. The key parameters that drive the design are set out in the following table. These parameters are similar to those adopted in other Australian cities where desalination is under consideration. These targets would be refined further if seawater desalination is adopted for Melbourne.

Table 3 Key Water Quality Targets

Water Quality Parameter	Preliminary Target Value Adopted
TDS (mg/L)	Minimum possible while managing corrosivity. Likely to be in the range of 30 – 100 mg/L
Boron	(<0.5 mg/L)
Bromide	(<0.2 mg/L)
General water quality	To 'match' that currently supplied *(see later notes on potabilisation)*
Other parameters	Meet the Australian Drinking Water Guidelines and Victorian Safe Drinking Water Act

Note: Boron and bromide are included here as they are parameters that are not generally a problem in surface water supplies, but are more difficult to manage in seawater desalination.

Reverse Osmosis (RO) has been adopted for the design basis. A two pass RO system would be used to achieve the target water quality which is driven by the targets for TDS, boron and bromide.

Plant operational regime and reliability defined at 300 ML/day with ~ 90% reliability, which would lead to annual production of 100 GL/yr. Larger plant sizes lead to larger annual water production. Operation is typically possible down to 25% of capacity.

The bays have higher turbidity and more variable water quality therefore requiring different levels of pre-treatment. For the bays, dissolved air flotation (DAF) followed by filtration. This has been selected on balance to allow for the elevated suspended solids sometimes encountered as well as potential oils and algal blooms. For the open ocean locations on Bass Strait, media filtration has been selected.

3.2 Plant Buildings

A site of 20 – 40 ha would be required for the plant and to provide an operational buffer area. Additional area may be needed to provide space needed during construction. At the upper end of this range of site sizes, it would be possible to accommodate a plant providing up to 200 GL per year.

For some kinds of adjoining land use, there may be a need to provide a buffer area. This means that the effective site size could be much larger in some cases.

The treatment plant, including all pumps and plant components will be housed in a range of buildings to reduce noise levels at the plant boundary. There are therefore opportunities to utilise different architectural approaches to provide a facility that takes into account the visual features of the local landscape.

3.3 Seawater Intake and Concentrate Outlet

The seawater intake and concentrate outlet could both be constructed using tunnel boring machines and then lining the tunnel with concrete segments. A tunnelling approach has been adopted at this stage to reduce any impacts on the coastal area crossed by the intake and outlet alignment. Alternative arrangements such as trenching and laying pipes have been used elsewhere for seawater intakes (for example in Perth), and in Victoria for other intakes and outfalls. The following figure and picture (Figure 14) provide some understanding of the tunnelling approach.

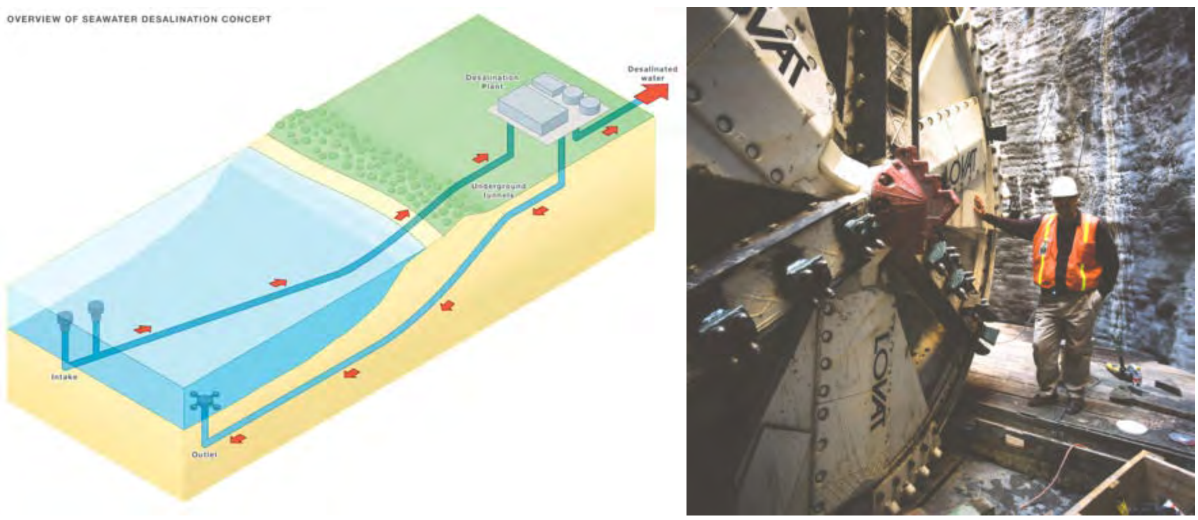


Figure 14 – Schematic of Intake and Outlet Tunnels and Example of Tunnel Boring Machine

As an initial design basis, it is proposed that the intake would be located in a minimum of 10m water in the bays and 15m in the ocean. This approach was then modified for specific locations where unique local factors needed to be accommodated.

The intake head will typically be designed to achieve a maximum intake velocity of 0.1 m/s. This velocity is comparable to background currents in the ocean and should reduce the potential for entrainment. This can be altered to match particular local circumstances.

Diffuser head design can achieve a maximum of a 1 part per thousand (ppt) increase in salinity from background levels outside the mixing zone above the ocean floor, and even better diffuser designs are possible (note that background salinity is around 35 ppt). This is in line with the Victorian SEPP. Specific local hydrodynamic modelling and environmental assessment is required to determine actual design details for the concentrate outlet.

A minimum diameter of the intake tunnel to provide enough seawater for production of 100 GL/yr desalinated seawater is 2.5 m based on hydraulic constraints alone. However there are practical constraints on tunnel construction at such diameters. As a consequence, the likely internal tunnel diameter is approximately 3 m. A plant of 200 GL/yr would need a tunnel with an internal diameter of approximately 4 m.

A minimum distance of 500 m between the intake and outlet has been adopted to avoid short-circuiting between the two. This is based on hydrodynamic modelling for a generalised case. In situations with higher ambient currents, the two might be closer together with more detailed design development.

Intermittent or ‘shock’ chlorine dosing will be used to manage marine growth in the inlet.

Shafts will be sunk to provide access for tunnel boring machines. These shafts will then form part of the seawater pump station and provide a volume to allow surge. These are expected to be around 6 – 9 m in diameter and up to 40 m deep depending on the location.

Downstream of the inlet pump station, either drum or travelling band wire screens would achieve fine screening of the seawater. Screenings will be collected and sent to landfill. These are typically stored in an enclosure designed to minimise odour impacts.

3.4 Potabilisation

The final water is expected to be treated with the following processes before it is sent to the system. The actual design doses of chemicals and controls approach will vary depending on the site selected and the consequent approach to introducing the water to the supply system.

Desalinated water from a two-pass reverse osmosis process will have very low concentrations of dissolved constituents. The water is aggressive and needs to be further treated before it is suitable for transfer into the supply network. Carbon dioxide and lime are added to increase the residual alkalinity and hardness of the water.

Dose rates considered as part of the conceptual design work been aimed at producing a final water quality similar to Melbourne. The TDS, pH and calcium carbonate precipitation potential have all been considered.

It is anticipated that the final water quality will be in the range of 30 – 100 mg/L TDS, comparable to Melbourne's existing supply. The desalinated water is likely to be lower in dissolved sodium but higher in dissolved calcium than Melbourne's water. Further development is required.

Table 4 Potabilisation Process Description

Process	Comment
pH control and Stabilisation by dosing with Lime and CO_2.	The level of calcium and alkalinity added can be varied. Setting targets involves a compromise between protection of pipeline assets and keeping levels low, which might provide benefits to some customers (e.g. industrial customers). Further study including customer consultation is required.
Disinfection with chlorine by dosing with sodium hypochlorite.	Water from the desalination plant is unlikely to have any microbial contamination after two passes of membrane filtration. However, it will then pass through tanks and pipelines where some recontamination could occur. In addition slimes could build over time. So a small dose of chlorine is normally added, which will be similar to the dose currently applied to Melbourne's existing supply.
Fluoridation	Melbourne's water supply is currently fluoridated. If the water from the desalination plant forms 100% or the majority of the supply to an area of consumers, then fluoride addition may be required.

3.5 Transfer Pipeline

A transfer pipeline corridor has been identified to deliver water into storages on the same side of the city as the locations selected. On the west, the pipeline corridors will delivers water to Preston Tanks and Cowies Hill Tank. On the east, water will be delivered to Cardinia and potentially Silvan Reservoir via the Cardinia – Pearcedale pipeline. The system connection to the west is limited to 100 GL per year whereas on the east 200 GL per year or more can be delivered to the system.

The transfer pipeline corridors have been selected to follow routes which provide the least amount of disturbance to residential areas, existing services and vegetation. Where possible, existing easements and road and railway reserves have been selected. The pipe diameter has been determined to achieve the required velocity with consideration of the pump head required. Pipe diameters range from 1.7 to 2.5 m for different locations and plant sizes.

Construction of a 2 m diameter pipeline requires a corridor of around 15 - 20 m in width to allow trenching, spoil management and access for pipe-laying (Figure 15).

It is expected that a construction width of 15 - 20 m will not be a problem for construction through rural areas. However for urban areas, significant traffic management and partial or full road closures will be required to achieve a 15 – 20 m construction width, and a narrower width may have to be considered, noting that a slower rate of progress would then result.

Figure 15 – Construction of a 1700 mm water main in rural and suburban areas

3.6 Concept Design Features

The following tables (Table 5 to Table 7) describe some of the concept design features adopted for this study. Note that the sizes and various details for plant capacities other than those listed can be interpolated from the data provided. Figure 16 illustrates the inside of a typical seawater reverse osmosis desalination plant based on a similar concept to that which has been adopted for this feasibility study.

Table 5 Adopted Design Basis for the Seawater Intake and Concentrate Outlet

Aspect of Design	Description	Adopted Design Basis (100 GL/y)	Adopted Design Basis (200 GL/y)
Design of intake structure.	Multiple mushrooms above the seafloor with local bar screens at approximately 250 mm spacing.	Expect four of around 10 m diameter for the 100 GL/y plant.	Expect eight of around 10 m diameter for the 200 GL/y plant.
Design of outlet diffuser structure.	Multiple examples of multi port diffusers to achieve local velocity of greater than 7 m/s.	Expect four structures each with four diffusers of 360 diameter for the 100 GL/y plant.	Expect eight structures each with eight diffusers of 360 diameter for the 200 GL/y plant.
Depth of intake and outlet.	Intakes in 10 m of water in less active areas, and 15 m in high wave climate. Outlets in 10 m of water. Other local factors may also influence depth for particular sites.		
Construction methods and geotechnical considerations.	Shaft down to approximately 20 to 30 m under AHD. Tunnel out under ocean. Drill through seabed from jack-up barge to make connections to tunnels. Slurry and or pressure tunnel approach if geotechnical studies suggest is possible. If not need to go deeper to get to more suitable rock.		
Length and Diameter of tunnels.	Diameter of 4.0 m for 200 GL/y. Lengths vary from 500 m to more than 4 km for each tunnel depending on sites chosen.		

Table 6 Adopted Design Basis for the Desalination Plant

Aspect of Design	Adopted Design Basis (100 GL/y)	Adopted Design Basis (200 GL/y)
Pre-treatment.	Media filtration operating at 8 m/h on Bass Strait. Addition of DAF on the bays. Based on currently available water quality data. Could change with more data or pilot testing results.	
First Pass of RO.	13 trains (+1 Standby) each producing 26 ML/d.	26 trains (+1 standby) each producing 26 ML/d.
Second Pass of RO.	9 trains (+1 standby) each producing 33 ML/d.	19 trains (+1 standby) each producing 33 ML/d.
Total number of membrane modules in both passes.	38,850	77,700
Recovery through entire plant	42.5%	42.5%

Figure 16 –Reverse osmosis racks inside a large seawater desalination plant (under construction)

Table 7 Adopted Design Basis for the Transfer Pipeline

Aspect of Design	Adopted Design Basis
Diameter	From 1.7 – 2.5m depending on size of scheme and location of plant
Length	From 20 to 90 km depending on location of plant
Material of construction	Welded mild steel pipes with concrete and bituminous lining.
Pump Head	A maximum pump head of 200-220 metres, including multiple pump stations and surge management where required.

4. Environmental Considerations

4.1 Greenhouse Gas and Mitigation Strategies

The lifecycle greenhouse impact of the project has been estimated including direct emissions from equipment used during the construction and operational phases of the project, and indirect emissions associated with the electricity used during construction and operation and emissions embedded in the materials of construction and chemicals used in the process. The assessment covers the intake and outlet tunnels, the desalination plant itself and the transfer pipelines.

This analysis shows that the electricity use dominates the overall impacts of the project: approximately 95 % of the total greenhouse impact after 25 years. Therefore the greenhouse gas mitigation approach adopted has been to seek greenhouse neutrality for this electricity use. Figure 17 shows the cumulative greenhouse impact of a Victorian desalination project over a 25 year period.

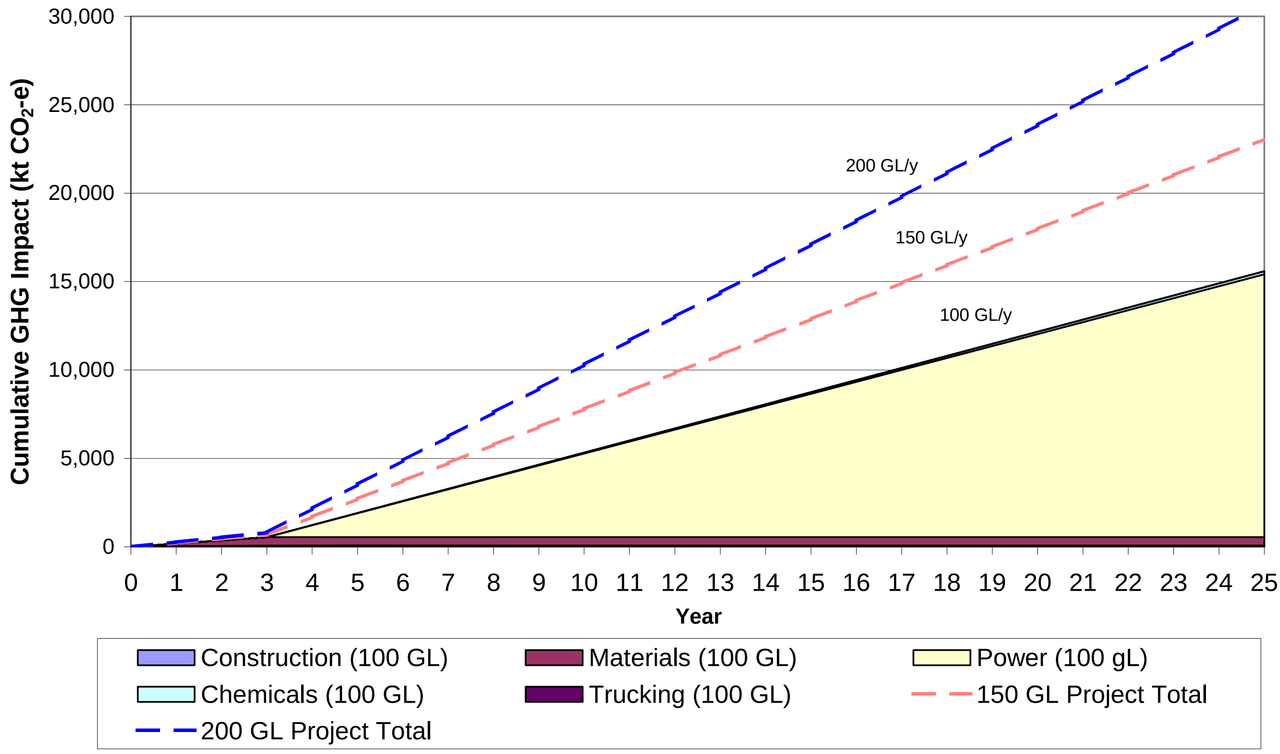


Figure 17 – Cumulative Greenhouse Impact

An investigation of available options for an energy supply, resulting in no net greenhouse gas emissions from power supply, has examined 17 energy supply options. A ranking system has been used which has three main ranking criteria: economic, environmental and operational.

Renewable generation options include: wind, hydroelectric (mini hydro), bioenergy and the emerging technologies of tidal, wave and solar. Non-renewable options with emissions below the grid baseline combined with offset purchases include gas fired generation, cogeneration and large combined cycle gas turbine.

The highest ranked renewable option is wind-generated power. The consumption of a 150 GL/yr desalination is approximately 800 GWh/yr including transfer of the water. A typical load (capacity) factor of a wind farm in Victoria is reported to be approximately 35% due to the intermittency of the wind. A wind farm of approximately 270 MW capacity would be required to provide the annual generation to match the desalination plant's consumption.

There are reported to be 1300 MW of new wind farms proposed for Victoria that have received planning approval, made up of nine major projects ranging from 30 MW rated power to 329 MW. There are currently an additional 340 MW of wind farms seeking development approval. Wind farms to provide 270 MW capacity would require around 100 wind turbines and would take approximately 18 months to construct once design and approvals were completed. The wind farms could be located anywhere in Victoria with connection to the electricity grid.

The current cost of wind generated power under wholesale Power Purchase Agreement is reported to be approximately $80/MWh. A power price of $100/MWh (10 cents/KWh) has been adopted in determining the operating costs of the desalination plant to provide some contingency for changes in cost.

4.2 Management of other Key Potential Environmental Impacts from a Seawater Desalination Plant and Associated Infrastructure

In the previous section, the key potential environmental impact of energy use and its consequential greenhouse gas production are discussed. The following section summarises some of the other potential environmental impacts a seawater desalination plant and its associated infrastructure could have, and sets out how those impacts are managed in the current concept.

Note that this discussion is general in the sense that it broadly applies to most possible locations for a plant. More specific discussion regarding the difference in impacts for different locations is provided later in the report.

4.2.1 Construction of the Desalination Plant and Connecting Pipeline: Impacts on Land

Possible Impacts

The desalination plant is a set of buildings over a site of approximately 20 Ha depending on the size of the plant. Once constructed the pipeline will be underground. During construction, a corridor of around 20 to 30m wide will be disturbed. Construction of the plant and pipeline on land could have impacts on the following environmental values: Flora, Fauna and Habitat, Ground and Surface Waters, Visual Amenity, Noise, Waste and Air (Dust). These could occur in both construction and ongoing operation.

The plant itself is mechanical equipment housed in a building with attendant operation, chemical storage etc. It is similar to a more conventional water treatment plants. So the well understood approaches currently used to design and manage site selection to minimise local impacts are relevant. The pipeline corridors can be researched and investigated on-ground during ongoing design and construction to manage specific local impacts.

Management Approach

It is proposed to use typical approaches for site selection to avoid high-risk ecologically sensitive areas. Design and construction management approaches for noise can be used, for example avoiding truck movements out of working hours, and by incorporating noise reduction in the plant appropriate for the local background noise level. If there is any clearing of native vegetation, a net gain approach is typical. Fundamentally, the approach is to consider and minimise impacts in design.

To consider and minimise impacts in pipeline design and construction, for example it is possible to alter the route, only build in appropriate seasons or use tunnelling and boring in particular areas. These additional details arise as part of detailed design development and once more detail about specific on-ground ecological risks is understood.

More detailed discussion on these approaches is provided later in the report for specific locations where the local risks are higher.

4.2.2 Marine impacts from intake of seawater

Possible Impacts

There is a need to drill through the seafloor to connect the tunnels to the ocean. This penetration of the sea floor is several mushrooms (say four to eight) say around 10 m in diameter. These will be in 10 to 15 m of water. This impact is unlikely to be significant provided there is sufficient investigation into the local conditions and ecology on the seafloor.

There is separate risk of entraining marine life into the intake. This risk is managed through appropriate design. Note that regardless of the design approach, some organisms will choose to enter the intake, and may in fact colonise it if not managed effectively. Many intakes have been compromised by mussel growth for example. This is a separate risk that is managed by an operational approach.

Management Approach

The risk of entrainment is managed by designing the intakes with low velocity to minimise chance of ‘sucking in’ marine life (eg 0.1 m/s or less). This is less than typical sea current velocity, so organisms are adapted to coping with such water movement. In addition, it is typical to use local screening of approximately 250 mm to prevent larger marine life swimming in. Most importantly, the risks are managed by choosing a location with relatively low conservation significance.

Note that designers and operators want to avoid marine life as much as possible as it causes operational difficulties for the plant, so these two objectives are complementary.

4.2.3 Marine Impact from concentrate return to ocean:

Possible Impacts

See previous point on intakes related to construction. Concentrate outlets will employ similar design features.

The plant removes fresh water from the seawater, leaving behind a concentrate stream, which contains around twice seawater concentration of the various ions that were in the seawater originally. There are also some trace levels of antiscalant and other chemicals added prior to the RO plant. The concentrate is clear and odourless.

(Note that some desalination plants in the Middle East and elsewhere discharge the iron rich backwash from pre-treatment along with the concentrate. This approach is not proposed, and instead the iron rich sludge will be sent to landfill or recycled. This discharge is covered elsewhere below.)

Management Approach

The risks related to concentrate return are managed by the design of the concentrate diffusers to achieve significant initial dilution. If a target of no more than 1 ppt increase is adopted, then this is expected to be achieved within several metres of the diffuser heads. If the disposal happens within sufficient depth of water, then this dilution is achieved above the seabed. In other words, if we define a plume as having a boundary of no more than 1 ppt increase, then this plume does not reach the bottom.

The risks are also managed in the first instance by locating concentrate dispersal outlets in areas with low conservation significance. It is also typical to perform hydrodynamic modelling to determine whether there is a risk of accumulation.

4.2.4 Solid (Sludge) waste from the pre-treatment backwash:

Possible Impacts

The pre-treatment process includes media filters which have a backwash system, this is rich in iron due to the typical use of an iron-based coagulant. It will be settled and centrifuged to minimise the volume of water. The extracted water is returned to the head of the plant. The water in the sludge is seawater, and thus the waste stream is salty.

Management Approach

The current approach for other Australian plants is trucking to a suitable landfill. This waste can also be washed and recycled, which is a new and developing approach. This may be more energy intensive than landfill. One risk that needs long term management is determining whether there are long term landfills available.

5. Environmental Approvals

This section provides a brief discussion of some key approvals that could be required for the project.

5.1 Environment Protection and Biodiversity Conservation Act (EPBC Act) (Commonwealth)

Administered through the Commonwealth Department of Environment and Water Resources (DEW) the EPBC Act provides that certain actions that are likely to have a significant impact on a matter of National Environmental Significance are subject to an assessment and approval process. There are a number of matters of National Environmental Significance identified in the Act as triggers for the assessment and approval regime. The triggers that are likely to be encountered by the project are:

- RAMSAR Wetlands;
- Nationally threatened species and ecological communities;
- Migratory species, and;
- National Heritage Places.

History of EPBC Act referrals of Desalination Plants

The referrals made under the EPBC Act for both the Gold Coast and Sydney desalination plants have both been considered to be "Not a Controlled Action" which means that no further assessment apart from the referral itself was required. There were some conditions placed on the decision in respect of the Gold Coast desalination plant, however these conditions referred to the avoidance of terrestrial flora that may be impacted by the pipelines connecting the plant to the water supply system.

5.2 Environment Effects Act 1978 (Victoria)

Under sections 4 and 8 of the Environment Effects Act, individuals or organisations (proponents) putting up a proposal for a development can be asked to prepare a document called an Environment Effects Statement (EES) by the Minister of Planning. This statement summarises the proposal, any feasible alternatives to it and any expected environmental effects. It is expected that, in accordance with the guidelines for the assessment of EES's, a referral will need to be submitted to determine if an EES is required.

5.3 Planning and Environment Act 1987 (Victoria)

The Planning and Environment Act 1987 establishes a framework for land use planning in Victoria.

The planning permit requirements for the project are generally site-specific, triggered by the zones and overlays, and other relevant Clauses of the planning scheme. The relevant Council generally administers the Scheme and associated planning approvals unless otherwise requested by the applicant.

Natural and built environmental, cultural and amenity values are protected under the planning scheme. The following activities normally require planning approval:

- Building and works, in particular, any structure that may need to be located on the foreshore for construction and or operation;

- Shoreline and river crossing;
- Removal of native vegetation;
- Undertaking building and works on or adjacent to historical sites;
- Construction adjacent to a Highway or main road; and
- Earthworks.

The project may be located within one or more Council areas. Each Council would assess the section of the project located within their municipality for planning approval, and in doing so:

- Must take into consideration State Planning Policies, and the relevant planning scheme;
- Must consider the decision of a formal referral authority, i.e. if a formal referral authority refuses the permit application, Council must also refuse approval of the permit;
- May also take into consideration the advice of an informal referral authority;
- Must follow internal policy and procedures and will sometimes take political considerations into account; and
- Must follow the statutory processes and timeframes defined in the Planning and Environment Act 1987.

Given the significance of the project to the State of Victoria, the Planning and Environment Act includes provisions for streamlining such approval processes.

5.4 Native Title Act 1993 (Commonwealth)

Under the Commonwealth Native Title Act 1993 indigenous people can claim native title on Crown Lands and waters in their traditional lands. There is a Native Title Claim currently over the Port Phillip Bay area lodged by representatives of the Bunurong people, although not over Western Port or the open ocean areas. Additional specialist advice is required here.

5.5 Aboriginal Heritage Act 2006 (Victoria)

This Act came into force on the 28th of May 2007 and an activity that may damage any aspect of Aboriginal cultural heritage will only be permitted to occur if there is in place a cultural heritage permit or approved cultural heritage management plan, which is likely to be required for this project.

5.6 Heritage Act 1995 (Victoria)

The Heritage Act administered by Heritage Victoria provides for the protection and conservation of places and objects of cultural heritage significance. Consultation with Heritage Victoria should be therefore undertaken in regard to the requirements for works affecting listed sites, and in regard to other cultural heritage places and objects. It is unlikely that this Act would have a significant impact on project approvals.

5.7 Land Acquisition and Compensation Act 1986 (Victoria)

The creation of easements or acquisition of land for a site associated with a project across individual land titles would typically be undertaken under a separate process after the required approvals are received. The land acquisition process will be subject to the provisions of the Land Acquisition and Compensation Act 1986 and other associated Acts such as the Crown Land Act and Land Act 1958.

The Land Acquisition and Compensation Act 1986 outlines the authorities which are able to compulsorily acquire land, or easements, and outlines the procedure for which land is to be acquired and compensation paid, of which Melbourne Water is such an authority. Generally, unless the project is designated of state significance, land must be reserved for a public purpose under a planning instrument (e.g. a Public Acquisition Overlay) prior to being acquired. However, under Section 6(a)(i) of the Land Acquisition and Compensation Act Regulations, if the area to be acquired is less than 10% of the total landholding and less than 10% of the value of the landholding, reservation under a planning instrument is exempt. The compulsory acquisition of an easement is strictly regulated and defined in this Act.

Experience on other major projects indicates that access to land can often be achieved by cooperative discussion with landowners.

5.8 Coastal Management Act 1995 (Victoria)

Under the Coastal Management Act written consent from the Minister for Planning must be obtained before coastal Crown Land can be used or developed. Under the definition of Coastal Crown Land provided in the Act, being 'the seabed of any sea within the limits of Victoria', it is apparent that the Minister's consent could be required for any development.

The Costal Management Act 1995 provides for the development of a Victorian Coastal Strategy and Strategic Planning for the management of the Victorian coast. This Act establishes the Victorian Coastal and Bay Management Council and the Regional Coastal Boards. The regional coastal board which is relevant is the Victorian Coastal Council, Central Coastal Board.

The Coastal Management Act requires the Central Coastal Board to report to the Coastal Council on the state of coastal planning and implementation of the Victorian Coastal Strategy, coastal action plans and approved coastal guidelines.

5.9 Environment Protection (Schedules Premises and Exemptions) Regulations 1996 (Victoria)

The Environment Protection (Schedules Premises and Exemptions) Regulations 1996 designate certain industrial or commercial activities (scheduled categories) as belonging to one or more of six types as defined in the Environment Protection Act 1970.

These schedules include Schedule 2 that covers waste discharged or likely to be discharged onto any land or into any waters. Schedule 2 premises require an EPA Works Approval before they are built and an EPA licence to operate, unless specifically exempted from these requirements in the regulations, or unless an EPA apporoval has been obtained for research, development or demonstration purposes.

It is likely that a Works Approval will be required. The guidance for the EPA on potential environmental impacts will be given through the SEPPs (see below).

5.10 State Environment Protection Policy (Waters of Victoria)

Any potential impacts on the marine environment will be regulated by the EPA under the SEPP (Waters of Victoria) and its schedules. There are schedules to the SEPP, which apply to specific parts of the marine environment. The SEPP seeks to protect defined beneficial uses of the environment. A mixing zone for a licensed waste discharge may be approved by the EPA where it is not practicable to avoid, reuse, recycle or otherwise manage wastewater. Within the mixing zone, designated environmental quality objectives do not need to be met. It needs to be shown that there will be no environmental harm beyond the mixing zone.

Port Phillip Bay

Port Phillip Bay is covered by SEPP (Waters of Victoria) Schedule F6 Waters of Port Phillip Bay.

Within the Schedule, the Bay is divided into segments. In this case the segments of interest are called General Segment (largely the main area of the Bay) and the Inshore Segment (that area whin 600 metres of the high water mark and outside other segments such as Werribee and Corio). The SEPP provides some objectives for water quality indicators. In the inshore and general segments these provide for a variation in salinity of ± 5% (for a salinity of 35 ppt this is a variation of 1.75 ppt). The beneficial uses of the Bay include impacts on natural ecosystems and recreational and commercial fishing as well as contact recreation. It will be necessary to demonstrate that these uses are not compromised.

Western Port

Western Port is covered by SEPP (Waters of Victoria) Schedule F8 Waters of Westernport and catchment. The areas of potential impact are in the Segment known as Entrances and North Arm. Environmental quality objectives are required to be attained to protect the defined beneficial uses. The environmental water quality indicators and objectives for the Entrance and North Arm Segment (as well as for the East Arm Segment) are ± 1 ppt. As well as the same beneficial uses as Port Phillip Bay, Westernport also has the protection of largely unmodified aquatic ecosystems. It will be necessary to demonstrate that these uses are not compromised.

Bass Strait Waters

Other waters within the Victorian area of jurisdiction are covered by the SEPP Waters of Victoria. These would occur within the segment, Open Coasts. The beneficial uses here are largely the same as for Westernport. It will be necessary to demonstrate that these uses are not compromised.

5.11 Fisheries Act 1995 (Victoria)

This Act provides for the Regulation, Management and Conservation of Victorian fisheries and aquatic habitats. The Aquaculture zones within Port Phillip Bay are established under this Act. It will be necessary to demonstrate that there are no adverse impacts on any fisheries as part of the approvals process for the project.

5.12 Flora and Fauna Guarantee Act 1988 (Victoria)

This Act provides for the conservation of Victoria's native flora and fauna. There are listed species, communities and threatening processes identified under this Act. Consideration will need to be given to any impact on such listed species in the assessment of environmental impacts of the project.

6. The Importance of Site Selection

The influence of site selection on the costs, environmental and social impacts of seawater desalination has been covered under various sections above. The following points are provided as a summary before moving on to the next section of the report, which covers the review undertaken of a range of possible locations in Victoria.

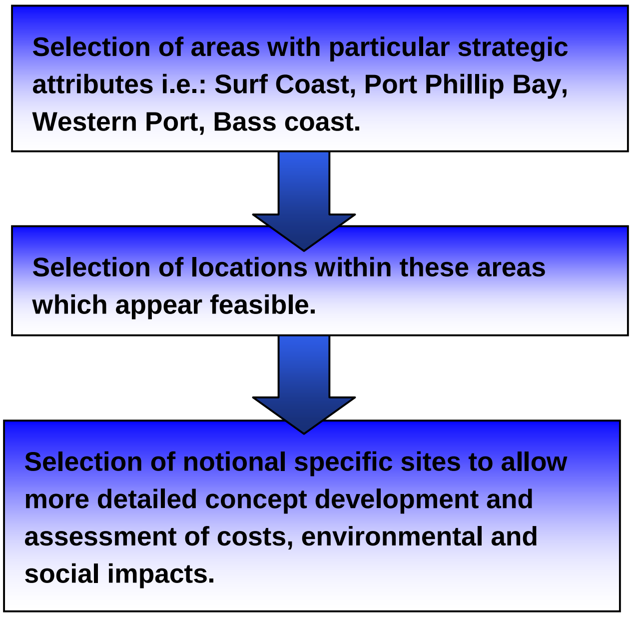
Table 8 The Importance of Site Selection

Area of Influence	Description
Influences On Cost	Sites that are near to the connection points in the city will reduce the cost of the interconnecting pipeline, and the costs of pumping water to the city. Sites that are close to deep water will have lower costs for the intake and outlet tunnels. Sites that are close to open ocean water will have lower costs for pre-treatment prior to the reverse osmosis membranes. Sites with ample open 'Greenfield' land will have lower construction costs (compared to constrained already developed 'Brownfield' sites). Sites closer to major grid assets will have reduced electricity connection costs.
Influences on Environmental and Social Impacts	Sites on 'industrial' land will have less impact on visual amenity. Sites close to bodies of water, which have high turnover and energetic mixing, are less likely to have environmental and social concerns regarding build up of salts. Sites where construction can occur with minimal impact on valued flora and fauna will have less overall impact. Sites with "clear runs" of suitable terrain and ecology to provide pipe corridors can allow the construction of the connecting pipeline to reduce impacts on flora and fauna, as well as minimising social impacts. Sites where ongoing water quality drivers do not constrain other activities (eg constraining shipping to avoid adverse water quality impacts) will have less overall social impact.

7. Possible Locations

To evaluate the feasibility of seawater desalination as a water supply option for Melbourne required the selection of possible suitable locations. The site selection process involved considering locations over a wide region then narrowing this down to a shorter list of possible locations.

The approach applied to identify possible sites is summarised in the following hierarchy of site development.



7.1 Selection Process

To define the extent of the area to be considered, a series of conceptual regional locations were developed. A Geographical Information System (GIS) model called INCA was then used to evaluate environmental, social, planning, and physical site features of both the land and ocean to determine a long list of locations.

Further work was undertaken to evaluate the long list locations and develop a short list of locations. This work involved technical investigations, assessment of risks and opportunities, environmental and social assessments. A short list of locations was then selected and a broad conceptual design was developed for each location.

7.2 Melbourne's Existing Water Supply System

The location of a seawater desalination plant to supplement Melbourne's water supply requires consideration of the existing water supply system. The following points provide some key background information. Also, refer to Figure 18.

- A majority of Melbourne's water comes from protected catchments to the east of the city. Some water comes from the Yarra to the north of the city.
- Major water supply assets transfer water from Thomson to Upper Yarra then to Silvan Reservoir. Silvan water is transferred to Cardinia Reservoir. In combination Silvan and Cardinia supply about 85% of Melbourne, primarily by supplying areas in the east. Some water is transferred to Preston Tanks to the west.
- On the north and west, water from the Yarra is treated at Winneke Treatment Plant and distributed to the west via Preston Tanks and Cowies Hill Reservoir. Water from Silvan is also supplied to this area.
- There are other supplies such as Yan Yean, Sugarloaf and the anticipated Tarago supply.
- These proportions of supply from the different sources vary in different seasons and in different years.

Analysis of annual demand, peak and winter demands and the capacity of existing pipelines was undertaken. This work guided the selection of the two key connection points shown in Figure 18.

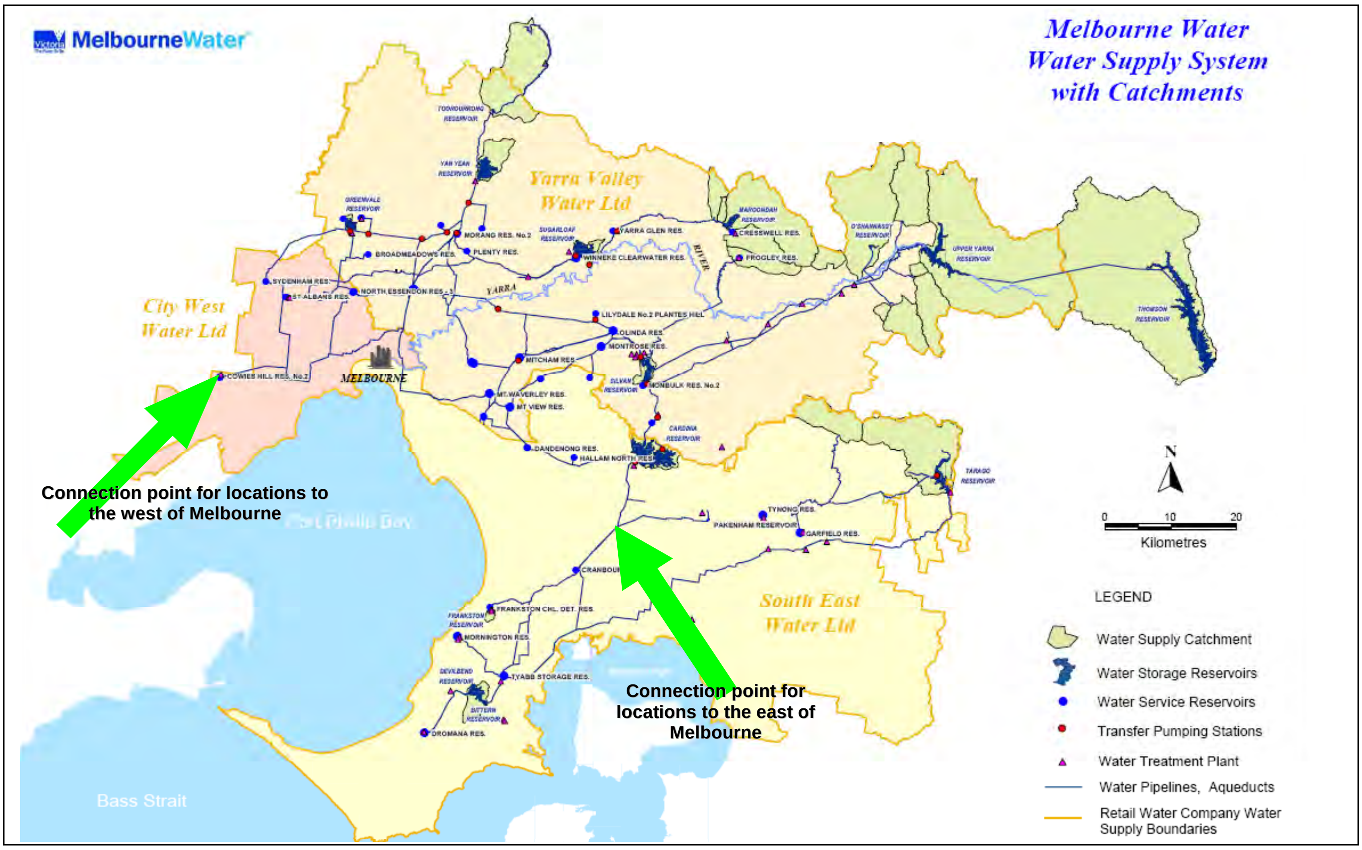


Figure 18 – Melbourne's Existing Water Supply System

7.2.1 Connection Points: Where can Desalinated Water be added to Melbourne's System?

The quantity of water considered in this study (i.e. 100 – 200 GL/year) is more than 20% of Melbourne's annual consumption. Therefore the ability to deliver such a quantity of water into the water supply system is limited to a few strategic points.

Supply from the East: Connection to Cardinia and Possibly Silvan Reservoir

On the eastern side of Melbourne, the Cardinia – Pearcedale pipelines are major assets that transfer water from Cardinia Reservoir to suburbs on the Mornington Peninsula and surrounding areas. A concept was developed for this feasibility study where a desalination plant on the eastern side of Melbourne could connect to the existing Cardinia – Pearcedale pipelines to allow water to be transferred back up to Cardinia Reservoir.

This concept involves some reconfiguration so that water flows "backwards" up the existing mains. This saves many kilometres of new mains.

Around 130 GL/y is currently supplied to areas in the south of Melbourne from Cardinia Reservoir. With a 150 GL/y plant on the eastern side of Melbourne, system reconfiguration and additional piping would be required to send the balance of the desalinated water further north and west via the Silvan Reservoir system.

Supply from the West: Connection to Cowies Hill and Preston Tanks

On the western side of Melbourne water is supplied via Preston Tanks and other local reservoirs. A concept was developed for this study where a desalination plant on the western side of Melbourne could supply water to near Cowies Hill Reservoir and existing mains could be used to transfer water to Preston Tanks. In this scenario, areas in the west of the city would receive mostly desalinated water.

This western system has less scope to accept larger volumes of water due to the lower overall demands and trunk main capacities. With reconfiguration of various parts of the system, it may be possible to deliver up to 100 GL/y from the west, but this is likely to be at the upper limit of volumes that could be practically delivered. Even at 100 GL/y, system changes are necessary to allow water from the Sugarloaf system to still be used in the city. This is important, as adding additional water to the system from a desalination plant, and as a consequence constraining use from existing sources would be counter-productive.

Summary of Possible Connection Points and Constraints on Demand for Desalinated Water

In summary: locations to the west of the city have a single connection point near Cowies Hill Reservoir and are limited to around 100 GL/y. Sites to the east of the city have a single connection point near Cranbourne and can accept 200 GL/y or more if piped back to Silvan.

In both cases there would be areas of the city that receive either 100% or close to 100% desalinated water.

7.3 Developing a List of Locations

Nine conceptual locations were developed covering the length of Victorian coastline from the Surf Coast to Ninety Mile Beach. This included the coastline within and on each side of the two bays. These conceptual locations were broad areas, which had different high-level strategic attributes. Some of the conceptual locations were eliminated in an early screening process on the basis of impracticality, higher costs or higher impacts. These conceptual locations are described below and illustrated in Figure 19.

Table 9 Conceptual Regional Locations

Regional Location	Description
Surf Coast	Locating a desalination plant on the Surf Coast south of Geelong extracting water from Bass Strait. Water could also be supplied to the Surf Coast, Geelong and nearby areas.
North Bellarine	Locating a desalination plant on the Bellarine Peninsula extracting water from near the centre of Port Philip Bay.
Port Phillip Bay West (West of the Bay)	Locating a desalination plant on the western side of Port Philip Bay.
Port Phillip Bay North (Top of the Bay)	Locating a desalination plant at to the northern end of Port Philip Bay close to the city.
East of Port Phillip Bay	Locating a desalination plant on the eastern side of Port Philip Bay.
Mornington Peninsula	Locating a desalination plant on the southern side of the Mornington Peninsula drawing water from Bass Strait.
Western Port	Locating a desalination plant around the west of Western Port – Crib Point to Hastings area.
Bass Coast	Locating a desalination plant near Kilcunda and Wonthaggi drawing water from Bass Strait. Water could also be supplied to Phillip Island, Wonthaggi, and other communities in the area.
Ninety Mile Beach	Locating a desalination plant either at Ninety Mile Beach or on the coast of South Gippsland drawing water from Bass Strait. Desalinated water would be supplied directly to Thomson Reservoir.

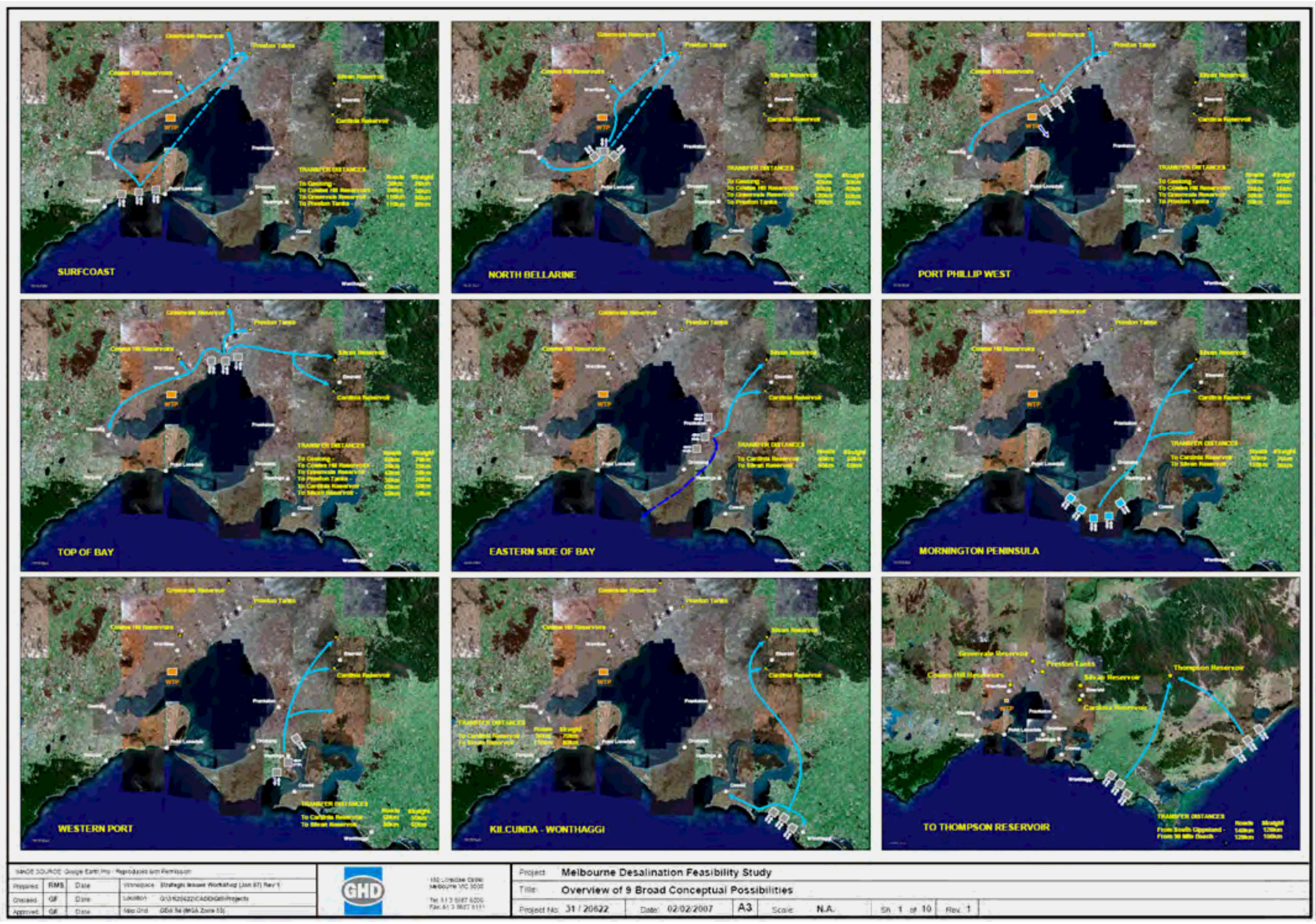


Figure 19 – Conceptual Regional Locations

A GIS model was used to assist in the evaluation of these conceptual locations and to develop a list of locations to evaluate in further detail. The GIS multi-criteria model, called INCA, used a series of GIS layers that spatially represented features of the land and ocean that allowed rapid recognition of key constraints within the conceptual locations. This GIS approach has been used in other desalination studies around Australia and is illustrated in Figure 20.

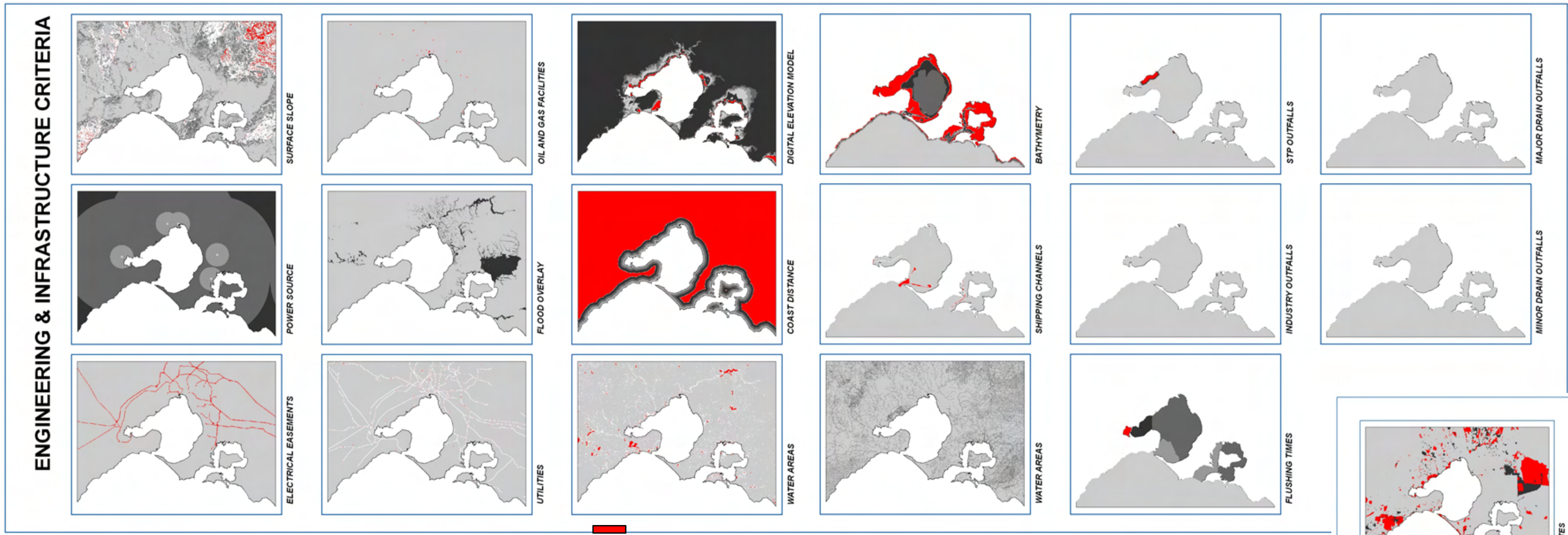
This GIS model identified areas where suitable sites might be available and thus provided a starting point for determining a shorter list of locations. The following table outlines the key elements of the GIS model and the results are shown in colour on the following map (Figure 21). Areas near the coast shown in green or grey are more suitable for siting a desalination plant. Note that this analysis integrates both land and marine information. In practice, more than thirty GIS layers of information were used in the INCA model and these are listed in Table 10.

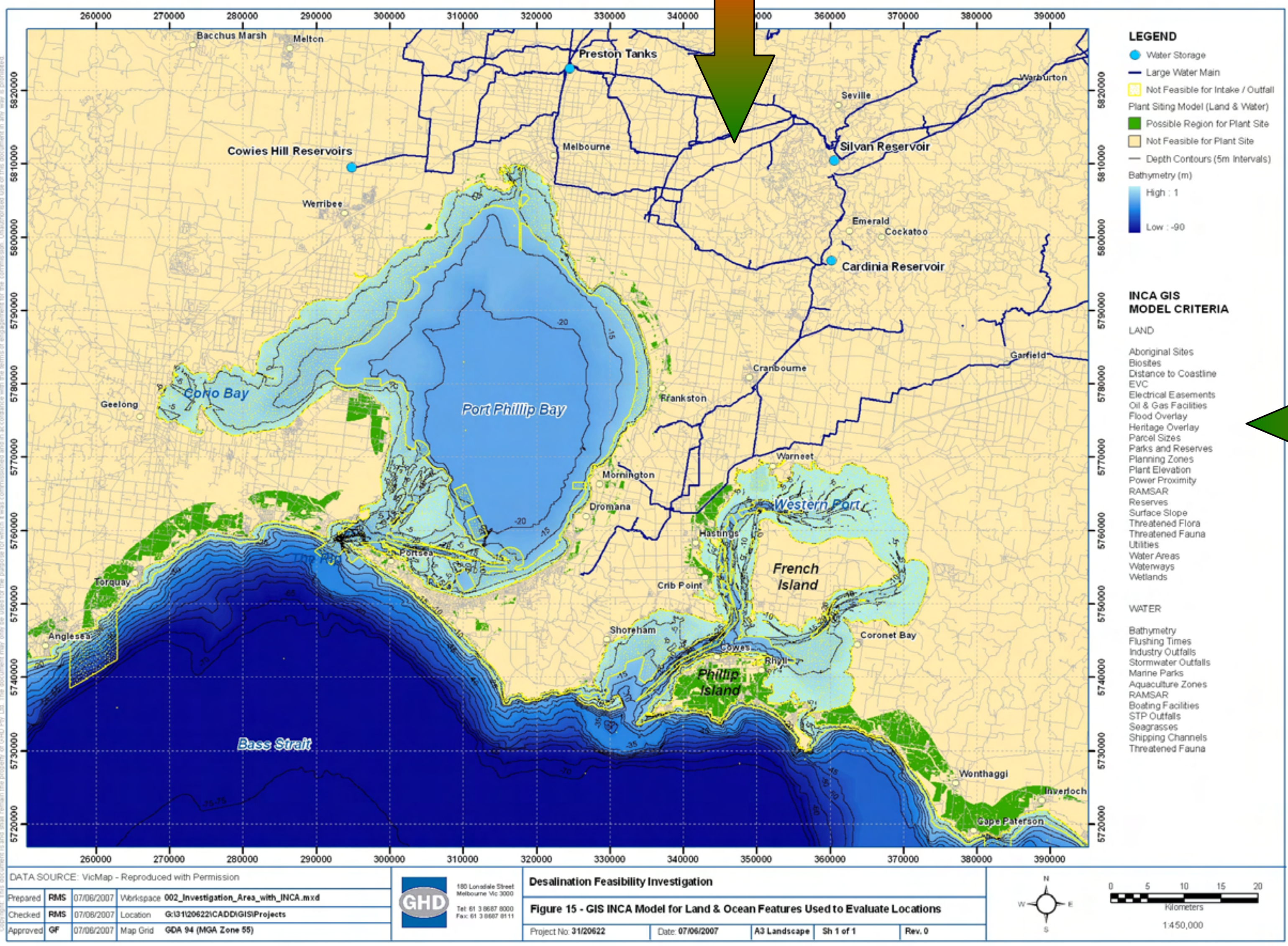
Figure 20 illustrates the INCA process. The smaller maps represent the individual layers of data, which were fed in combination into the model. The model outcome is then represented in the larger map. Figure 21 shows the model output at a larger scale.

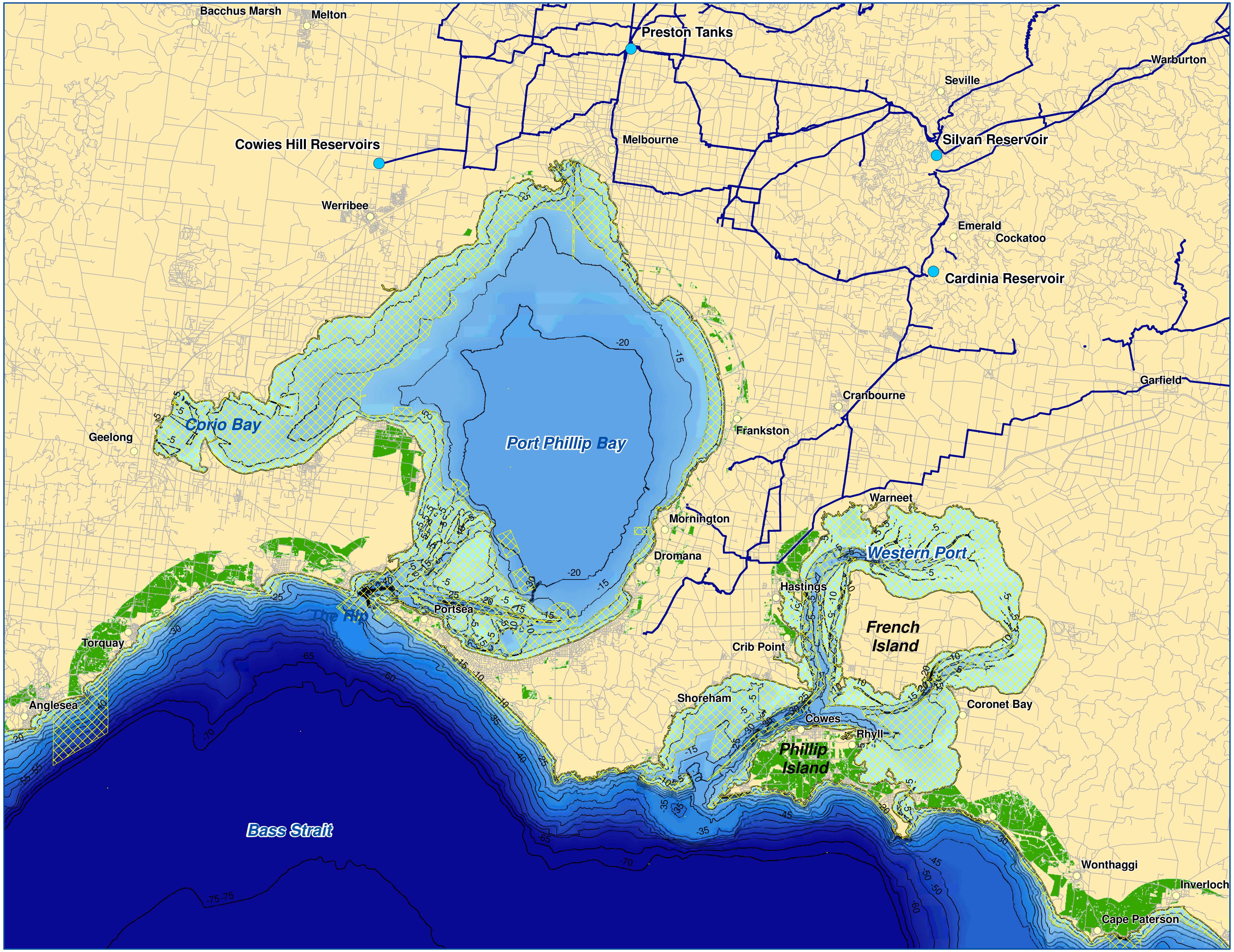
Table 10 - GIS Elements Used to Identify Possible Areas

Land model – Possible Areas	Ocean Model	Land Model – Pipeline
Biosites	Marine National Parks	Parks and Reserves
Parks and Reserves	Threatened fauna	Planning Zones
Reserves	Seagrass Beds	Waterways
Ecological Vegetation Classes	Aquiculture and Special Use Zones	Water Areas
Wetlands	RAMSAR Areas	Wetlands
RAMSAR areas	STP Outfalls	Road Corridors
Threatened flora	Industry Outfalls	Residential Road Areas
Threatened fauna	Outfalls – Major	
Surface Slope	Outfalls – Minor	
Power Source	Boating Facilities	
Electrical Easements	Shipping Channels	
Oils and Gas Facilities	Bathymetry	
Flood Overlay	Flushing Times	
Utilities		
Digital Elevation Model		
Coast Distance		
Planning Zones		
Parcel Size		
Heritage Overlay		
Waterways		
Water Areas		
Aboriginal Cultural Heritage Places		

Figure 20 – Illustration of GIS INCA Model







LEGEND

- Water Storage
- Large Water Main
- Not Feasible for Intake / Outfall

Plant Siting Model (Land & Water)

- Possible Region for Plant Site
- Not Feasible for Plant Site
- Depth Contours (5m Intervals)

Water Depth (m)

High : 0

Low : -90

INCA GIS MODEL CRITERIA

LAND

Aboriginal Sites
Biosites
Distance to Coastline
EVC
Electrical Easements
Oil & Gas Facilities
Flood Overlay
Heritage Overlay
Parcel Sizes
Parks and Reserves
Planning Zones
Plant Elevation
Power Proximity
RAMSAR
Reserves
Surface Slope
Threatened Flora
Threatened Fauna
Utilities
Water Areas
Waterways
Wetlands

WATER

Bathymetry
Flushing Times
Industry Outfalls
Stormwater Outfalls
Marine Parks
Aquaculture Zones
RAMSAR
Boating Facilities
STP Outfalls
Seagrasses
Shipping Channels
Threatened Fauna

DATA SOURCE: VicMap - Reproduced with Permission

Prepared	RMS	07/06/2007	Workspace	002_Investigation_Area_with_INCA.mxd
Checked	RMS	07/06/2007	Location	G:\31\20622\CADD\GIS\Projects
Approved	GF	07/06/2007	Map Grid	GDA 94 (MGA Zone 55)

GHD
180 Lonsdale Street
Melbourne Vic 3000
Tel: 61 3 8687 8000
Fax: 61 3 8687 8111

Desalination Feasibility Investigation

Figure 21 - GIS INCA Model for Land & Ocean Features Used to Evaluate Locations

Project No: 31/20622	Date: 07/06/2007	A4 Landscape	Sh 1 of 1	Rev. 0

N
W E
S

0 5 10 15 20
Kilometers

Initial estimates of costs and evaluation of key risks and advantages were also used to evaluate the potential locations. A flyover air inspection and site visits were conducted, noting the limitation of not contacting owners or agencies due to confidentiality. Reviews of potential environmental and social impacts and risks were undertaken.

The outcomes of these evaluations were then presented to stakeholder workshop groups who provided comments. Outcomes of the review of the conceptual regional locations are described in Table 11.

Table 11 Summary of the Review of "Long Listed" Locations

Location	Status	Reasoning for Status on Long List
Surf Coast	Included on the short list	Access to open ocean water. Ability to put water to the west of the city. Water authority land available in the area.
North Bellarine	Exclude	May be suitable for a smaller plant. Restricted access to seawater due to aquaculture. Transfer pipeline costs similar to Surf Coast therefore there are no distinct advantages over Surf Coast option. May be difficulties with concentrate disposal compared to open ocean.
Port Phillip Bay West (West of the Bay)	Exclude	Southwest end of bay has RAMSAR site and Western Treatment Plant. Northern end has less of these constraints and has lower piping costs. Evaluation shows similar in costs and concerns to Top of Bay. Lower circulation in this part of the Bay.
Port Phillip Bay North (Top of the Bay)	Exclude	Industrial zoned land, but availability and ownership needs further investigation. Close to the city so reduces transfer costs, but higher water quality risks due to proximity to industrial areas, rivers and port, etc. Lower circulation in this part of the Bay.
East of Port Phillip Bay	Included on the short list	Sites appear restricted, but existing Eastern Treatment Plant site is a possibility. Better circulation and geotechnical conditions than North and West of the Bay. Closer to Cardinia and Silvan reservoirs.
Mornington Peninsula	Exclude	Similar or higher cost than other ocean options (eg Surf Coast or Bass Coast). Limited sites. Boags Rocks outfall constrains locations. Difficult pipe corridor for transfer up the Mornington Peninsula.
Western Port (Crib Point)	Included on the short list	Closer to Cardinia and Silvan Reservoirs than open ocean options. High turn-over of water in deep channel section. Multiple sites are available. Risks such as RAMSAR classified waters, mangroves, shipping, and feed water quality. A possible site exists near Crib Point. Hastings was excluded because of higher risks to water quality.
Bass Coast	Included on the short list	Lowest cost open ocean site which delivers water to east of city. Sites appear to be available. Deep water closer to shore than many other locations. Long pipeline, but in semi-rural rather than suburban areas.
Ninety Mile Beach	Exclude	Would deliver water to Thomson Reservoir. Significantly higher energy use due to lift up to dam. Long transfer pipelines, with some difficult sections. Does not provide the risk protection that a separate supply would in case of bush fire or other incident.

The conclusions outlined in this table were checked throughout the project as new information became available to test if the assumptions used to reach the conclusions outlined here remained valid.

This longer list of locations was then examined in more detail, with the aim of generating a shorter list, and also to identify possible sites within each location. A wide range of technical, geographic, environmental and social factors was evaluated using GIS mapping, multi-criteria analysis and some preliminary site visits including some aerial photography. Workshops were conducted with a range of stakeholders where preliminary conclusions were reviewed and tested against the project's strategic objectives.

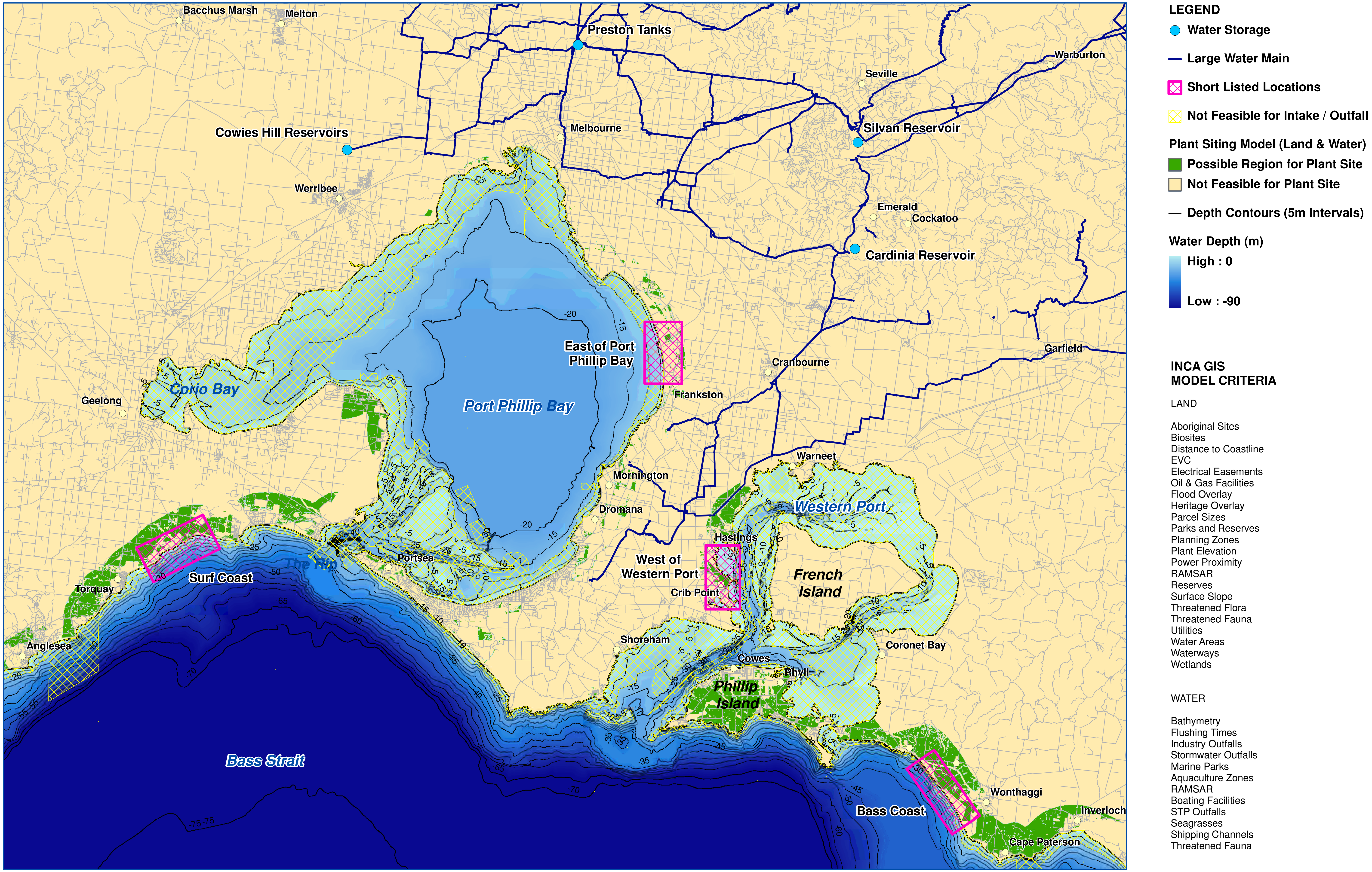
The preliminary conclusions were that the following sites should be carried forward for more detailed investigation as the short list:

- Surf Coast – Torquay to Barwon Heads.
- East of Port Phillip Bay – Carrum area.
- West of Western Port – Hastings to Crib Point.
- Bass Coast – Kilcunda to Wonthaggi.

The northern Port Phillip Bay location was excluded due to a range of risks related to construction cost and water quality. Key reasons for excluding the North Port Phillip Bay location from further consideration include:

- The water quality in this area is subject to fluctuations due to the rivers nearby, and subject to risks such as possibly toxic sediments, dredging, shipping and inflows from industrial areas.
- The geo-technical conditions are risky for the long tunnels required, due to the possible presence of 'fingers' of volcanic rock.
- The land available is in an area with a history of industrial development, and therefore there are risks that there will be contaminated land present.

The following figure (Figure 22) shows the GIS model outputs for the land and ocean evaluation.



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Prepared	RMS	07/06/2007	Workspace	002_Investigation_Area_with_INCA.mxd
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Approved	GF	07/06/2007	Map Grid	GDA 94 (MGA Zone 55)

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Desalination Feasibility Investigation

Figure 22 - Short Listed Locations

Project No: 31/20622	Date: 07/06/2007	A4 Landscape	Sh 1 of 1	Rev. 0

8. Development of Short Listed Schemes

This section covers the development of desalination scheme concept designs at the short-listed locations. These schemes include inlet and outlet tunnels, desalination plants and transfer pipelines.

Costs, environmental and social impacts, risks and opportunities at the locations have also been assessed.

To evaluate the feasibility of a seawater desalination plant, a concept was developed for each short-listed location. This involved the selection of notional specific sites at each location for which to develop the concept. Further due diligence would be required to confirm whether or not they are the most suitable sites in each of the short-listed locations.

The concept development has involved the following aspects for each location:

- Area required for the desalination plant buildings
- Seawater intake and concentrate outlet arrangements
- Pipeline corridors to transfer desalinated water into the existing water supply system.

8.1 Potential Plant Locations

The following table links the wider areas under consideration to particular locations where there are possible sites.

Table 12 Areas under consideration and the potential locations at each

Area	Locations	Type of Land
Surf Coast	In the vicinity of the Surf Coast there appears to be potentially suitable land between Torquay and Barwon Heads including in the vicinity of Black Rock WWTP.	Rural and/or owned by water authority.
Port Phillip Bay	East of Port Phillip Bay is more confined in terms of available suitable land although the vicinity of ETP does provide a possible location.	Industrial and agricultural, owned by water authority.
Western Port	West of Western Port presents some possible locations in the vicinity of the industrial area near Hastings and Crib Point.	Industrial, privately owned.
Bass Coast	In the vicinity of Bass Coast there are potentially suitable sites between Kilcunda and Wonthaggi.	Rural, privately owned.

In summary: sites are available at all the locations but they have different zoning, owners and existing land use.

The following sections outline the key features of the locations considered in the feasibility study.

8.2 Seawater Inlet and Concentrate Outlet

The same concepts for the seawater intake and concetrate outlet were adopted at each location, therefore the key differences between the locations are the length of tunnels and depth of shafts for the pumps. There are also differences in the geology between the locations that could affect the intake and outlet, which are also addressed later under risk assessment. These differences between the locations are reflected in the cost estimates.

The differences in ecological impact related to marine aspects, however, were not fully accounted for in the cost estimate. These differences include the open ocean versus the bays, and the marine ecological values. The marine aspects are discussed in the following section.

8.3 Risk and Management of Possible Environmental Impacts Related to the Seawater Intake and Concentrate Outlet

The intake and the outlet have the potential to impact upon the marine environment in both the construction and operational phases of the project. If site selection and design development does not consider these risks, there could be potential impacts to the marine environment from direct physical disturbance during construction, and during operation, increases in salinity, decreases in dissolved oxygen and the discharges of metals and antiscalants.

Construction impacts could result in minor direct physical disturbance of the benthic environment and potentially cause sediments to be resuspended into the water column in a localised area where the drilling occurs. In the open ocean sites (Surf Coast and Bass Coast) these impacts are likely to be short-lived because these are high energy coastlines which experience significant natural disturbance. Within Port Phillip Bay and Westernport there are greater risks that resuspended sediments may persist for some time.

The intakes have the potential to entrain larvae and small organisms, drawing them into the pipeline and on up into the plant. The velocity of the water in the seawater intakes will be designed to be slow to reduce the potential for entraining organisms. In general, the impacts of entrainment have been considered to be low, as generally the number of organisms entrained is considered low compared to the overall stock of pelagic biota.

The discharges of concentrate have the potential to increase salinity, deplete oxygen levels and discharge metals to the environment. The adopted designs for diffusers at the end of the outlet pipeline are likely to result in local salinities being within 1 ppt of background within approximately 20 m of the outlet pipeline, and before the plume hits the ocean floor. The risks of any ecological impacts outside a small and localised area from this initial discharge are likely to be low.

There is a second and different reason why elevated salinities could occur. In a largely enclosed water body such as Port Phillip Bay there is the potential that the continued removal of the fresh component from the water taken into the plant may cause an overall increase in the salinity of the Bay. Preliminary modelling suggests that this increase may be less than 1% of the background concentration in the long term (further modelling is required). In itself the impact of such an increase may not be significant. However Port Phillip Bay is undergoing a general rise in salinity due to the decreases in freshwater inflow as a result of the drought and other measures such as the reduction in flows from the Western Treatment Plant outfalls. An additional increase in salinity from a desalination plant may be significant in these circumstances, however the exact impact remains unclear. As such the discharge of higher salinity water into the Bay may be a risk.

The discharges of concentrate at the other locations will not lead to the same possible increase in salinity over the relevant water body. In Western Port there is more flow through of water during each tidal period and preliminary modelled increases in salinity are less than the level indicated for Port Phillip Bay. Further modelling and ecological research is required to reach a conclusion. For the open ocean locations there is minimal risk of a general increase in salinity as the water body from which the fresh water is extracted is very large.

The risks of environmental damage due to decreased dissolved oxygen levels can be mitigated through the design of the diffuser head. Decreased dissolved oxygen levels can result from interactions of more concentrated brine with the water layer near the ocean floor. Appropriate diffusers should manage this risk.

There will be some discharge of chemicals with the concentrate. Both metals and antiscalants are likely to be present in low concentrations. Research has shown that in the concentration likely to be discharged from the desalination plant, the potential impacts on the marine environment are likely to be low. These chemicals can be selected in design such that they break down over time in the ocean.

In Summary: The environmental impacts of the construction of the intake and outlets are not likely to cause significant environmental damage. There is a greater risk in Port Phillip Bay that there could be contamination risks from the mobilisation of sediments during the construction phase. As Port Phillip Bay has less natural water movement there is also a greater likelihood than for the other sites that there could be long-term consequences from the extraction of freshwater.

8.4 Desalination Plant and Transfer Pipeline

The same concept for the desalination plant treatment system has been adopted at each location with the exception of pre-treatment. For the bay locations a different pre-treatment system (DAF) has been adopted that can accommodate greater variations in source water quality.

The transfer pipelines have been developed to deliver water to system connections points on the east and west sides of Melbourne. The key differences between the locations is the length of proposed pipeline corridors.

These differences in the treatment systems and lengths of the transfer pipelines have been accounted for in the cost estimates.

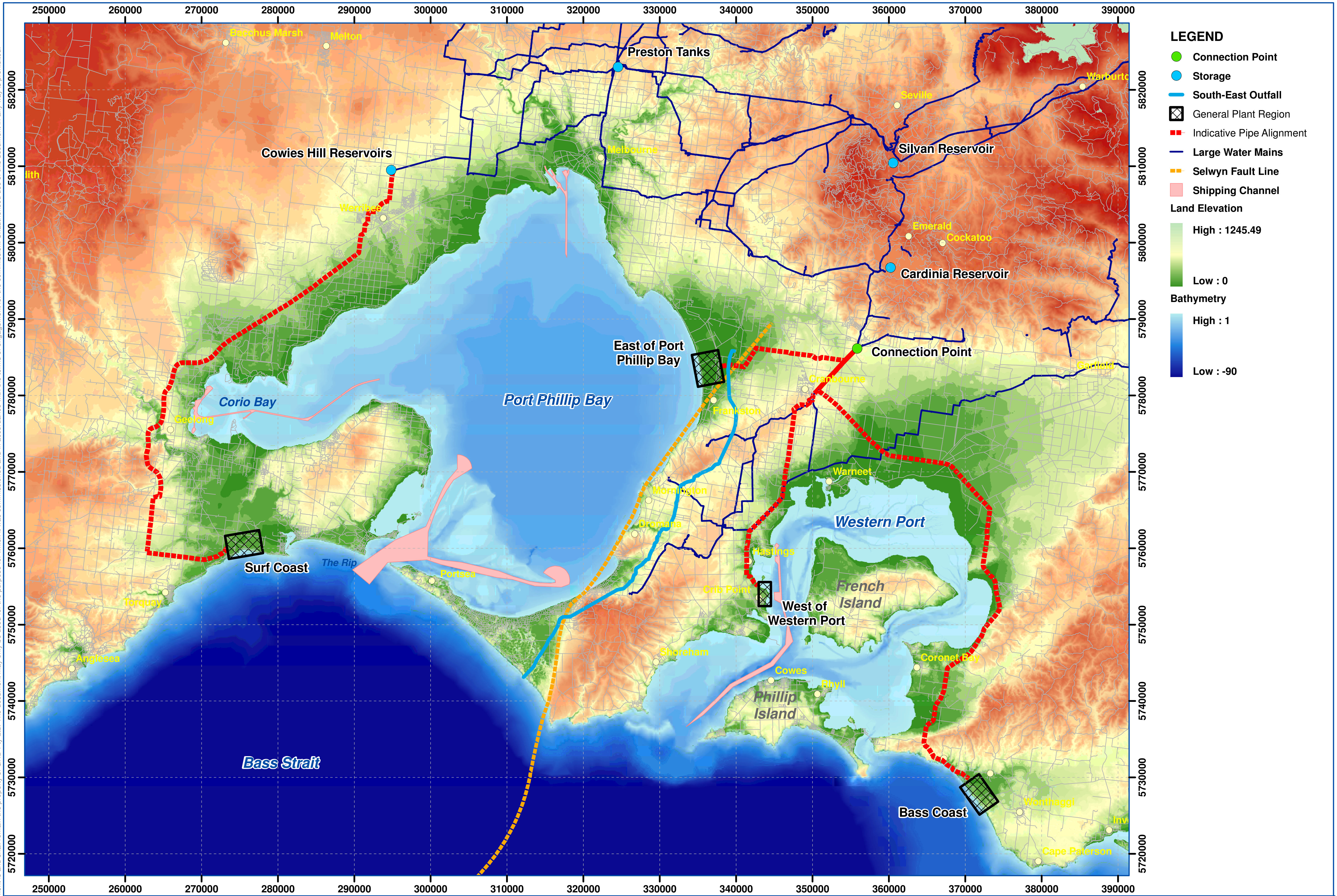
One key area of difference between the locations and pipeline corridors however, is the environmental and social aspect, which is discussed in detail the following sections.

8.4.1 Pipeline Corridors

Pipeline and pumping system concepts were developed for each of the short-listed locations to connect the potential areas where sites are available to the points in the system which can accept the water. The pipeline corridors from East of Port Phillip Bay, West of Western Port and the Bass Coast were developed to deliver water to Cardinia Reservoir via a connection point to the Cardinia – Pearcedale Pipeline at Berwick (Figure 23). The pipeline corridor on the west from the Surf Coast was developed to deliver water to Preston Tanks and Cowies Hill Reservoir. The system connection in the west is limited to 100 GL per year. In the east 200 GL per year or more could be delivered to the system.

The pipeline delivery corridors are summarised as follows:

Surf Coast	80 km long, generally following major roads but also crossing roads and watercourses (Figure 24)
East of Port Phillip Bay	25 km long, generally following roads and crossing two major highways (Figure 25).
West of Western Port	40 km long, generally following roads, power lines and rail easements and crossing roads (Figure 26).
Bass Coast	85 km long, generally following highways and crossing watercourses (Figure 27).



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Approved	GF	07/06/2007	Map Grid	GDA 94 (MGA Zone 55)

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Desalination Feasibility Investigation

Overview of Transfer Pipeline Corridors and System Connection Points

Project No: 31/20622 | Date: 07/06/2007 | A3 Landscape | Sh 1 of 1 | Rev. 0

N W E S

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Kilometers
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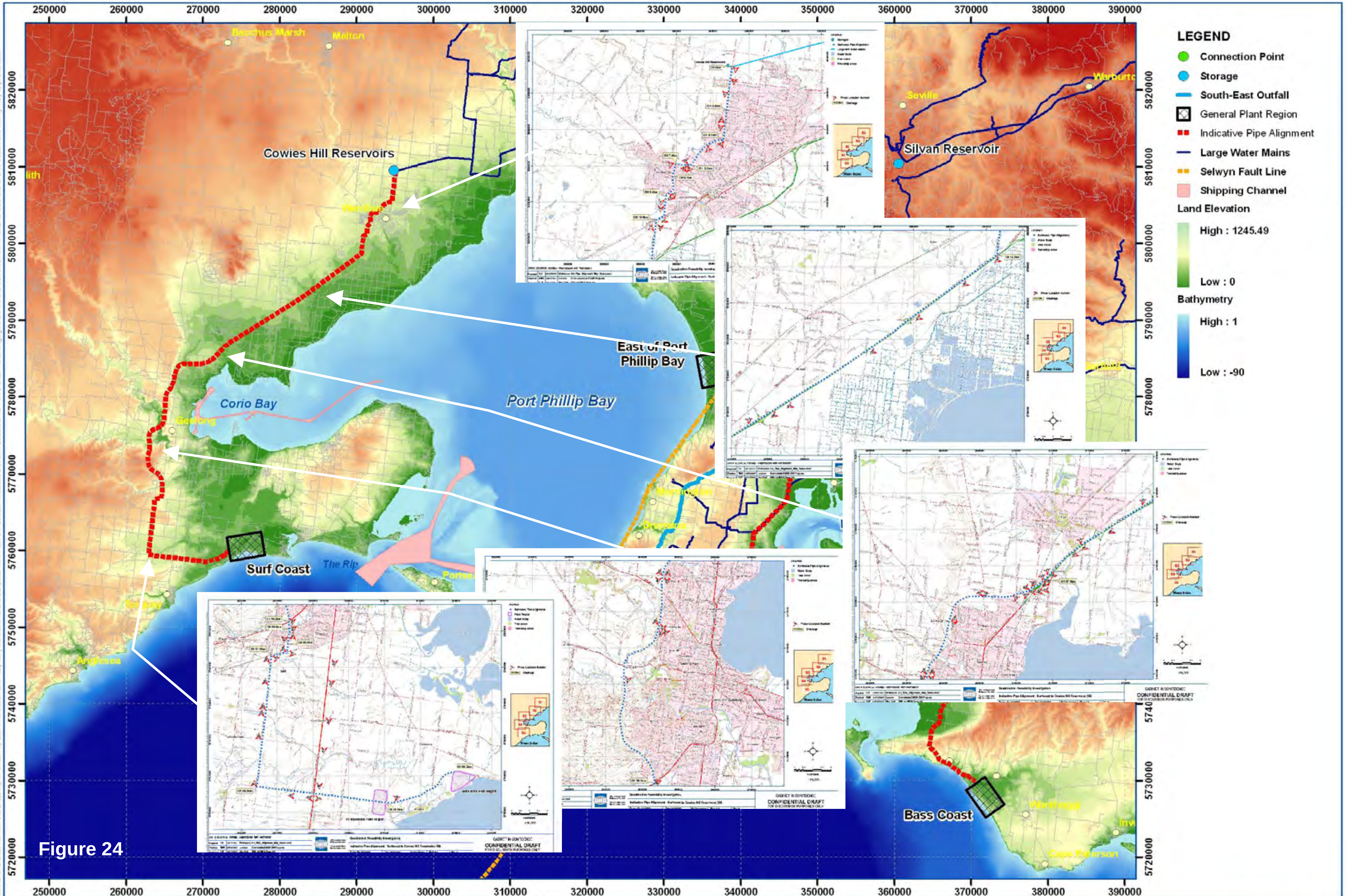

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Desalination Feasibility Investigation

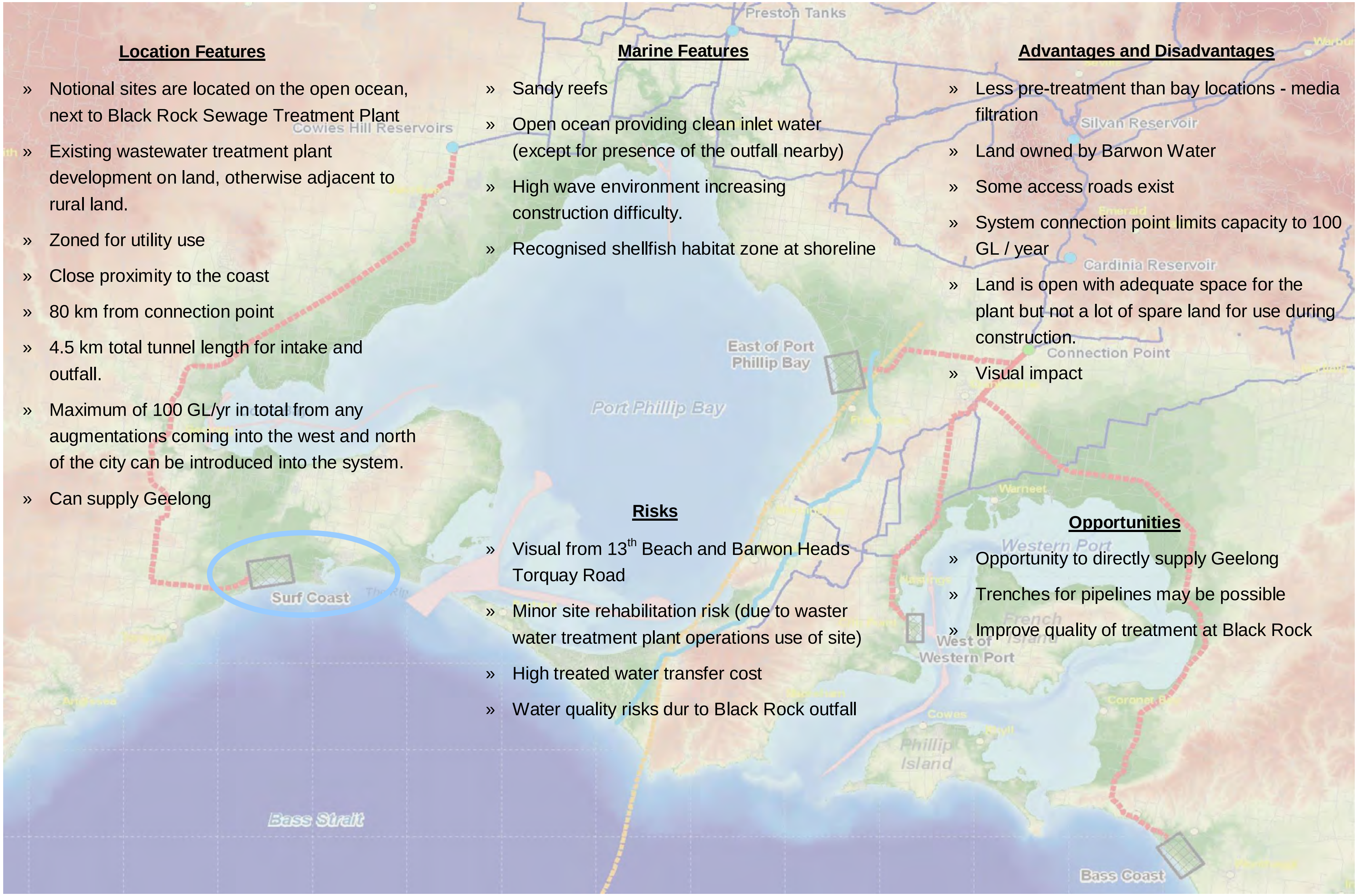
Overview of Transfer Pipeline Corridors and System Connection Points

Project No: 31/20622 | Date: 07/06/2007 | Sh 1 of 1 | Rev. 0

N W E S

0 5 10 15 20
Kilometers

Potential Location to the West: Surf Coast



Location Features

- Notional sites are located on the open ocean, next to Black Rock Sewage Treatment Plant
- Existing wastewater treatment plant development on land, otherwise adjacent to rural land.
- Zoned for utility use
- Close proximity to the coast
- 80 km from connection point
- 4.5 km total tunnel length for intake and outfall.
- Maximum of 100 GL/yr in total from any augmentations coming into the west and north of the city can be introduced into the system.
- Can supply Geelong

Marine Features

- Sandy reefs
- Open ocean providing clean inlet water (except for presence of the outfall nearby)
- High wave environment increasing construction difficulty.
- Recognised shellfish habitat zone at shoreline

Risks

- Visual from 13th Beach and Barwon Heads Torquay Road
- Minor site rehabilitation risk (due to waster water treatment plant operations use of site)
- High treated water transfer cost
- Water quality risks dur to Black Rock outfall

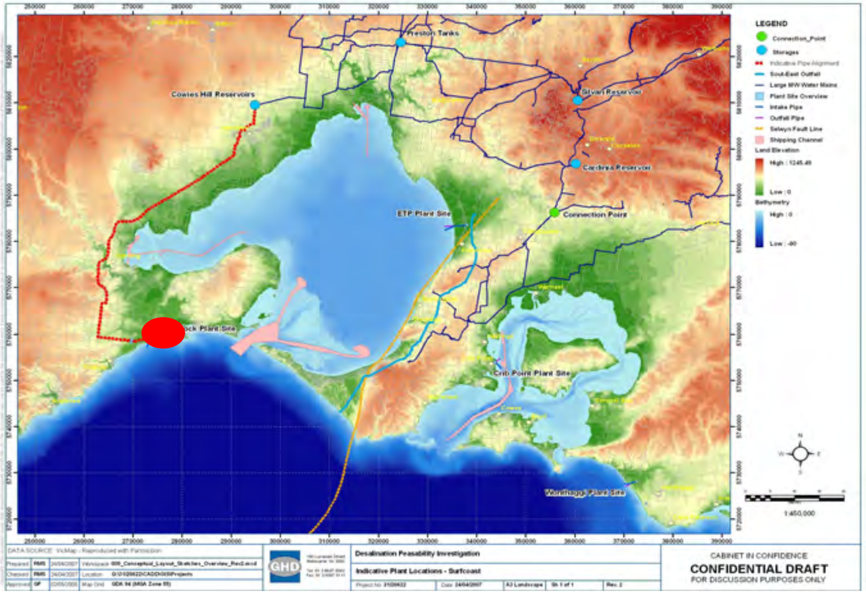
Advantages and Disadvantages

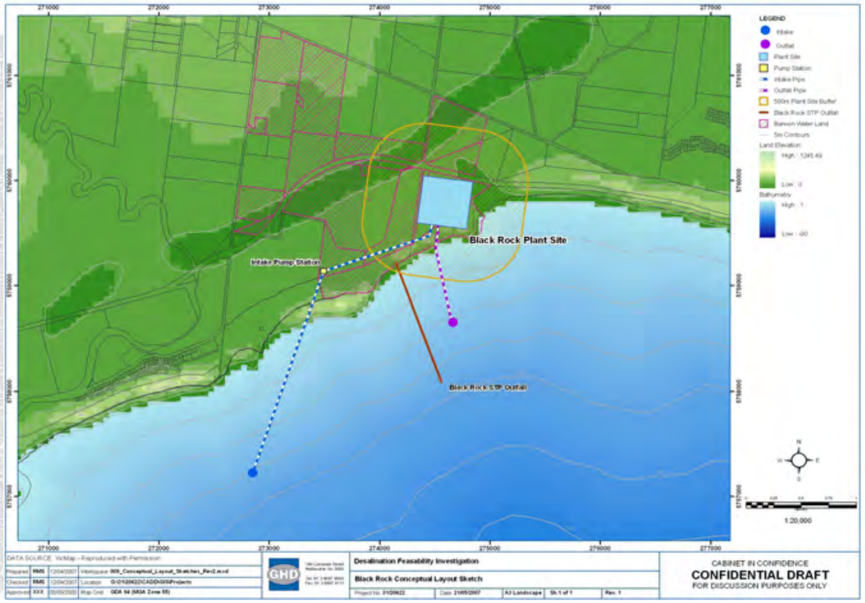
- Less pre-treatment than bay locations - media filtration
- Land owned by Barwon Water
- Some access roads exist
- System connection point limits capacity to 100 GL / year
- Land is open with adequate space for the plant but not a lot of spare land for use during construction.
- Visual impact

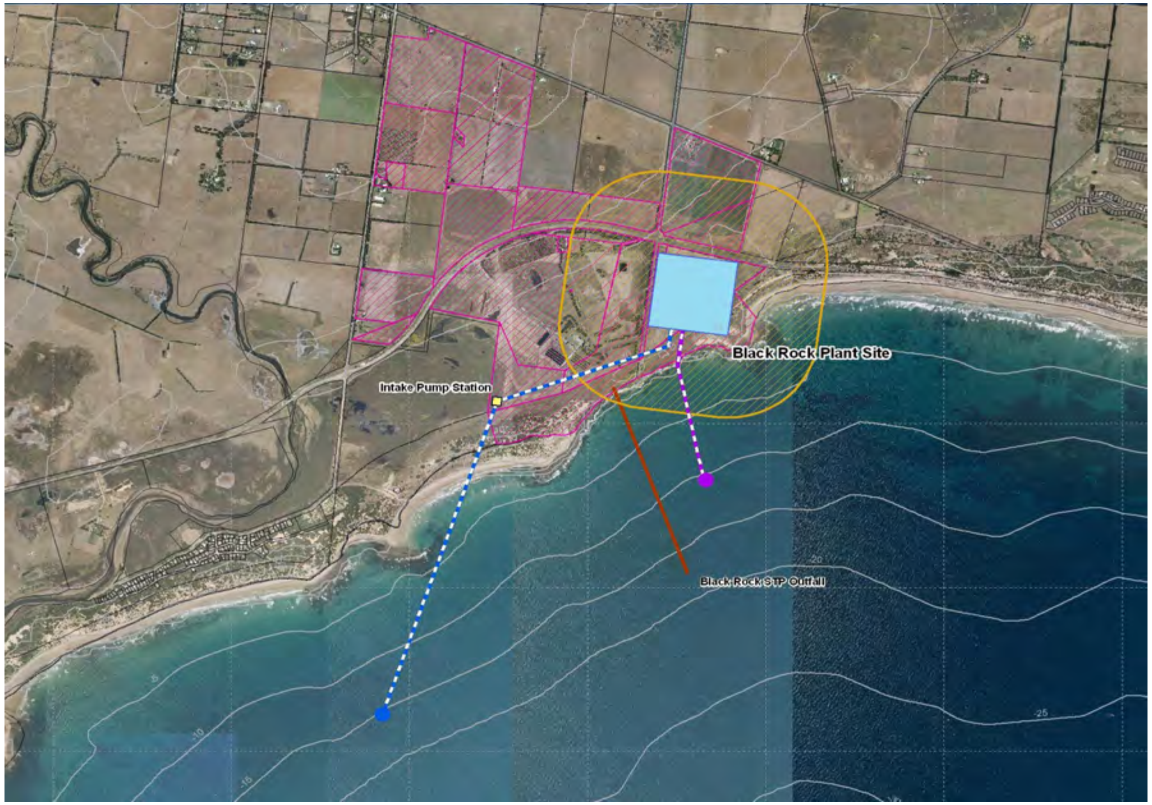
Opportunities

- Opportunity to directly supply Geelong
- Trenches for pipelines may be possible
- Improve quality of treatment at Black Rock

Potential Location to the West: Surf Coast

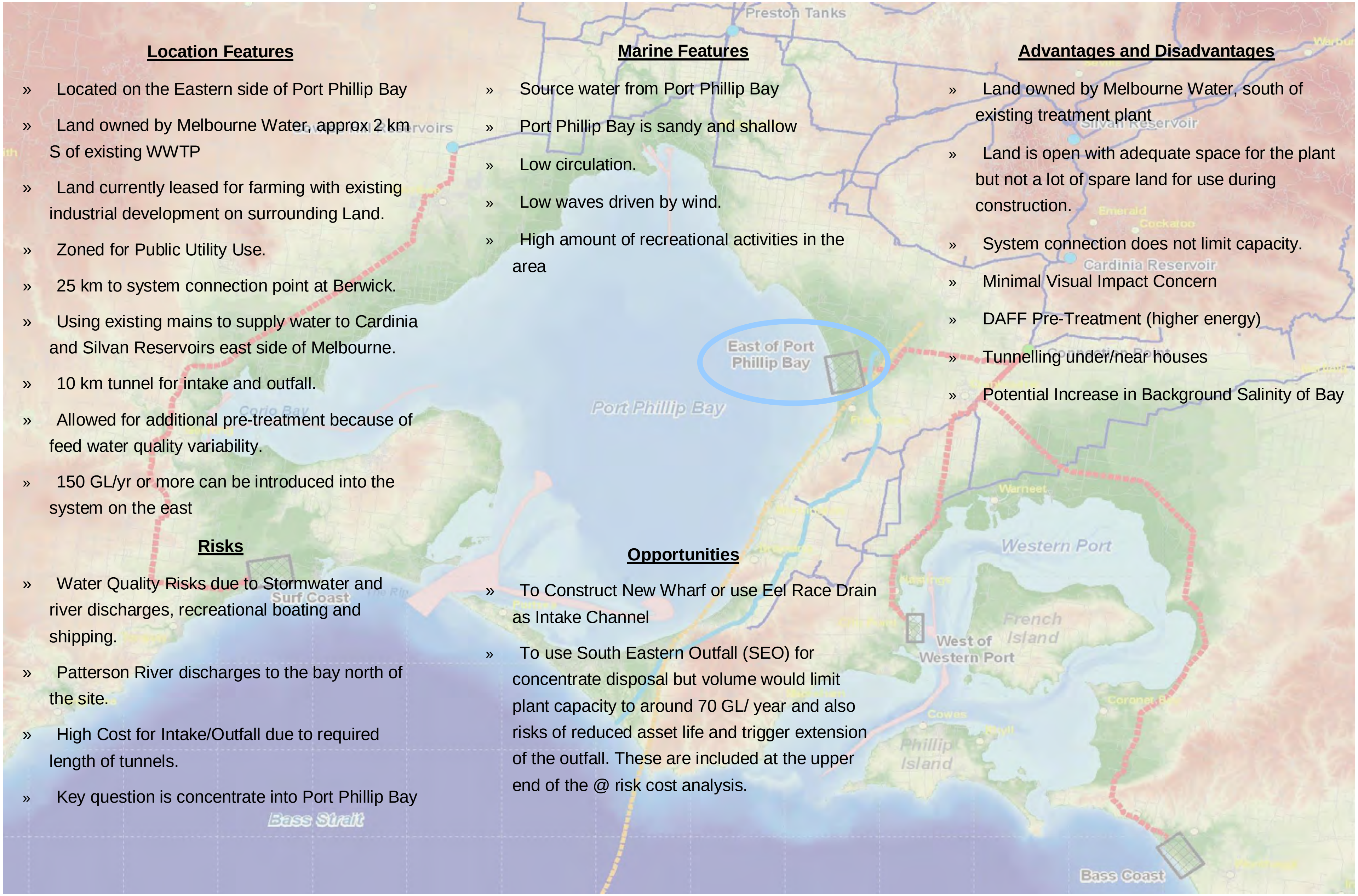






GHD Melbourne Water

Potential Port Phillip Bay Location: East of Port Phillip Bay



Location Features

» Located on the Eastern side of Port Phillip Bay

» Land owned by Melbourne Water, approx 2 km S of existing WWTP

» Land currently leased for farming with existing industrial development on surrounding Land.

» Zoned for Public Utility Use.

» 25 km to system connection point at Berwick.

» Using existing mains to supply water to Cardinia and Silvan Reservoirs east side of Melbourne.

» 10 km tunnel for intake and outfall.

» Allowed for additional pre-treatment because of feed water quality variability.

» 150 GL/yr or more can be introduced into the system on the east

Risks

» Water Quality Risks due to Stormwater and river discharges, recreational boating and shipping.

» Patterson River discharges to the bay north of the site.

» High Cost for Intake/Outfall due to required length of tunnels.

» Key question is concentrate into Port Phillip Bay

Marine Features

» Source water from Port Phillip Bay

» Port Phillip Bay is sandy and shallow

» Low circulation.

» Low waves driven by wind.

» High amount of recreational activities in the area

Opportunities

» To Construct New Wharf or use Eel Race Drain as Intake Channel

» To use South Eastern Outfall (SEO) for concentrate disposal but volume would limit plant capacity to around 70 GL/ year and also risks of reduced asset life and trigger extension of the outfall. These are included at the upper end of the @ risk cost analysis.

Advantages and Disadvantages

» Land owned by Melbourne Water, south of existing treatment plant

» Land is open with adequate space for the plant but not a lot of spare land for use during construction.

» System connection does not limit capacity.

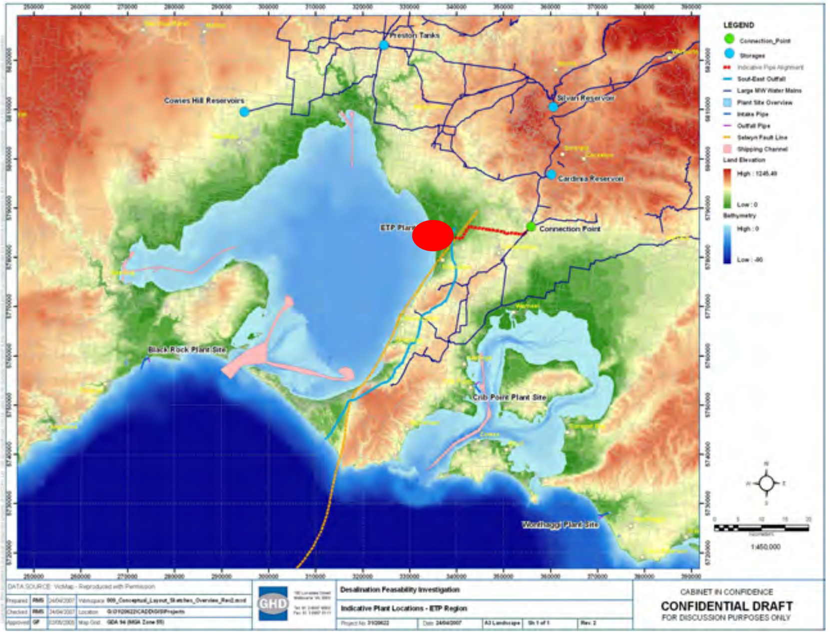
» Minimal Visual Impact Concern

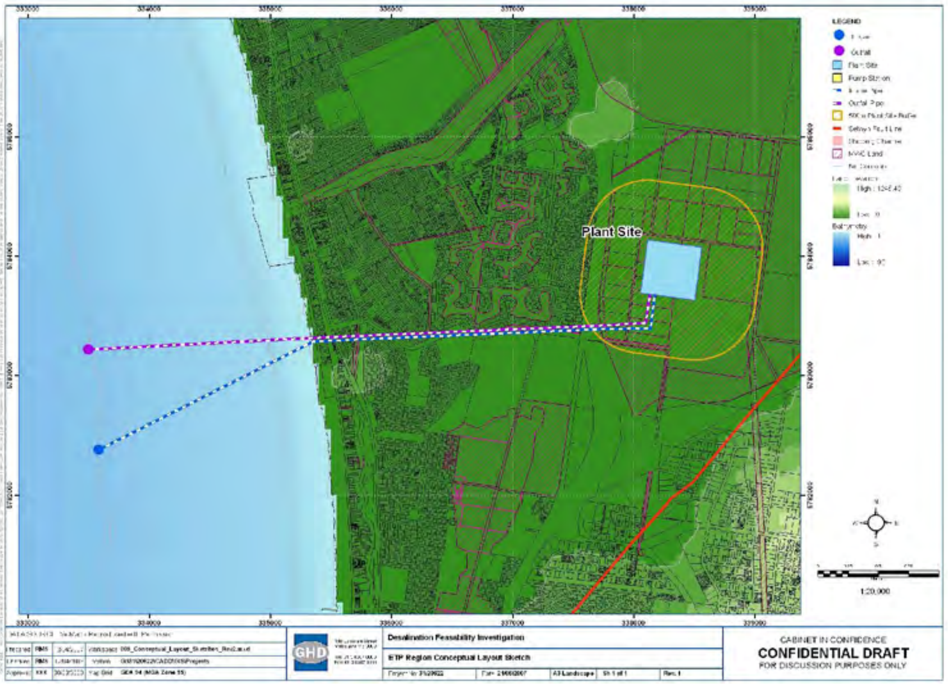
» DAFF Pre-Treatment (higher energy)

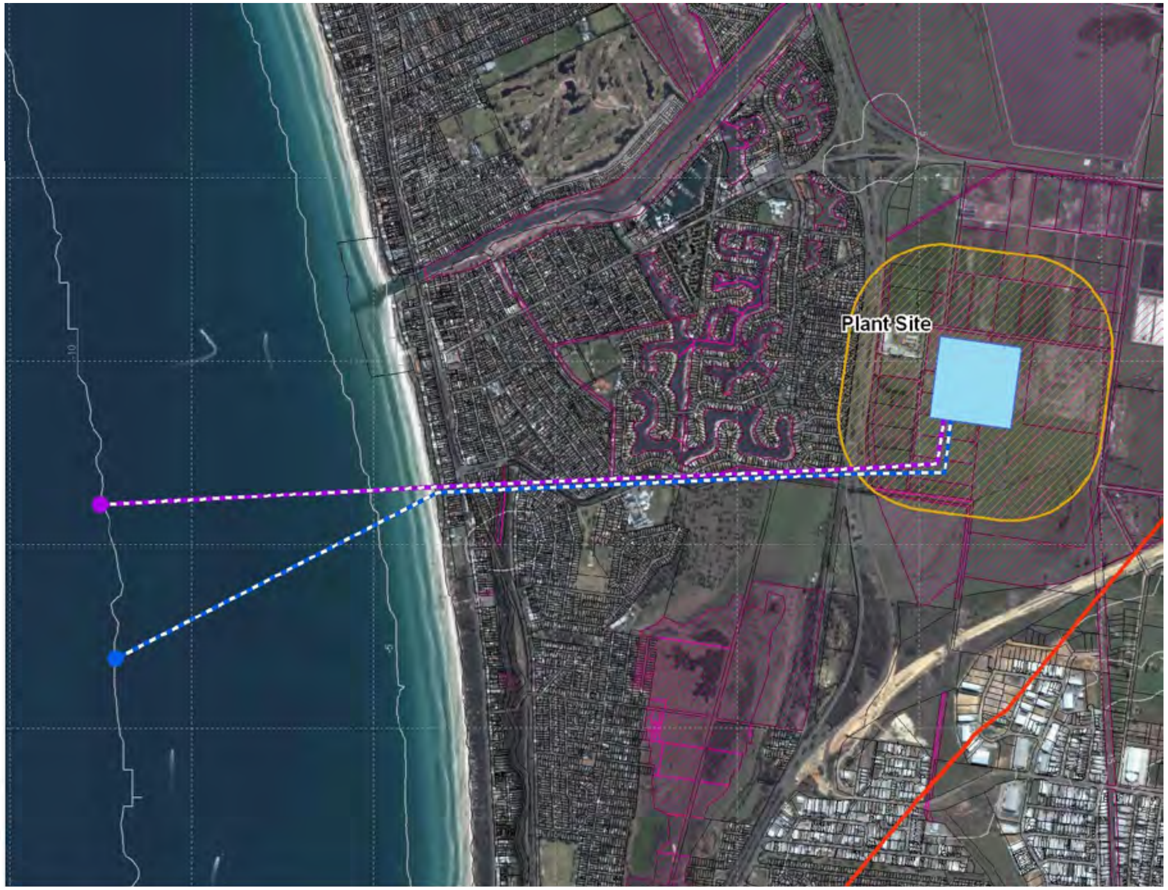
» Tunnelling under/near houses

» Potential Increase in Background Salinity of Bay

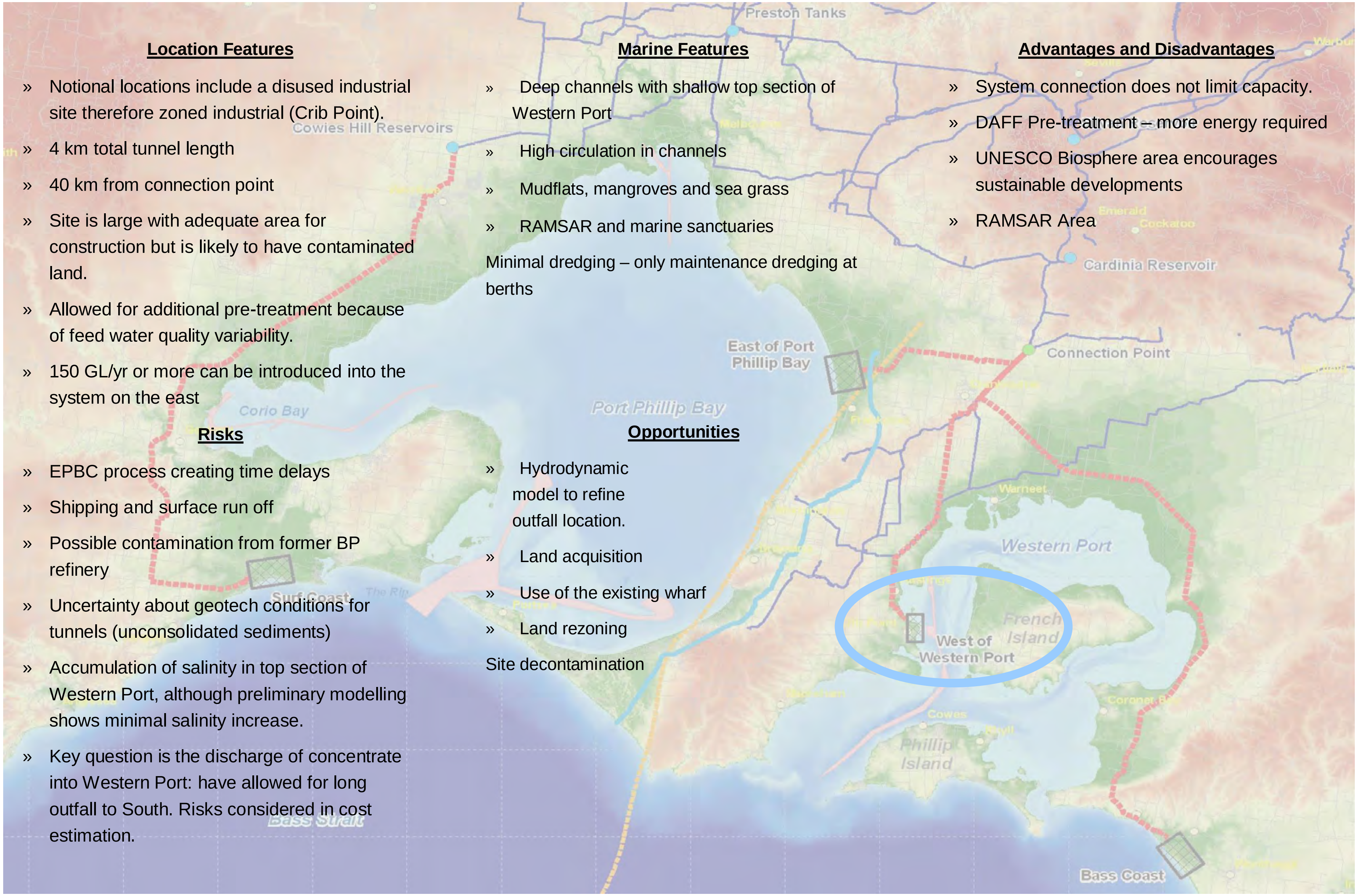
Potential Port Phillip Bay Location: East of Port Phillip Bay







Potential Western Port Location: West of Western Port



Location Features

- Notional locations include a disused industrial site therefore zoned industrial (Crib Point).
- 4 km total tunnel length
- 40 km from connection point
- Site is large with adequate area for construction but is likely to have contaminated land.
- Allowed for additional pre-treatment because of feed water quality variability.
- 150 GL/yr or more can be introduced into the system on the east

Risks

- EPBC process creating time delays
- Shipping and surface run off
- Possible contamination from former BP refinery
- Uncertainty about geotech conditions for tunnels (unconsolidated sediments)
- Accumulation of salinity in top section of Western Port, although preliminary modelling shows minimal salinity increase.
- Key question is the discharge of concentrate into Western Port: have allowed for long outfall to South. Risks considered in cost estimation.

Marine Features

- Deep channels with shallow top section of Western Port
- High circulation in channels
- Mudflats, mangroves and sea grass
- RAMSAR and marine sanctuaries

Minimal dredging – only maintenance dredging at berths

Opportunities

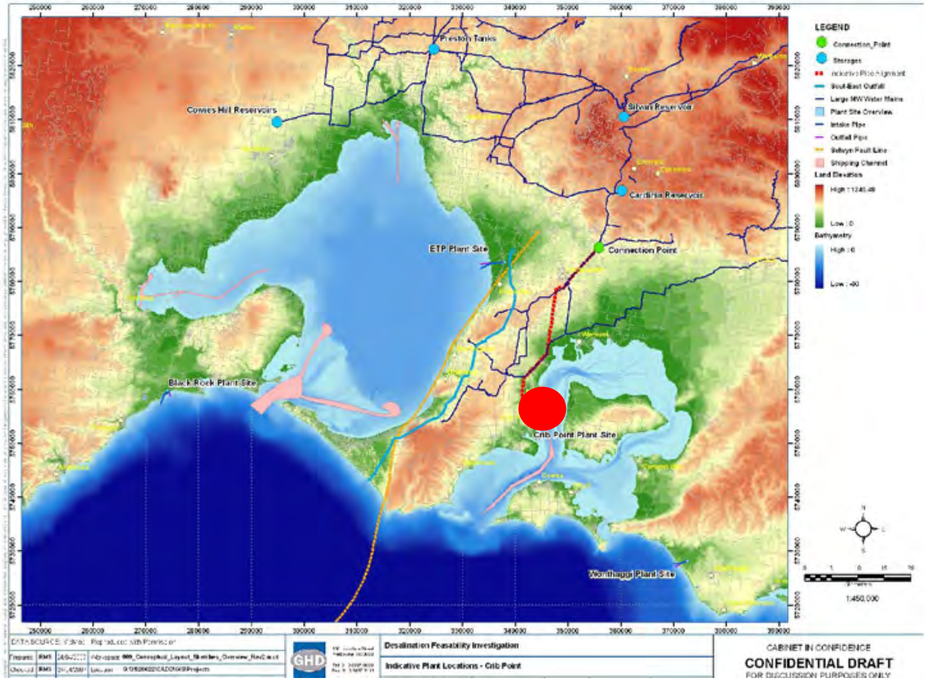
- Hydrodynamic model to refine outfall location.
- Land acquisition
- Use of the existing wharf
- Land rezoning

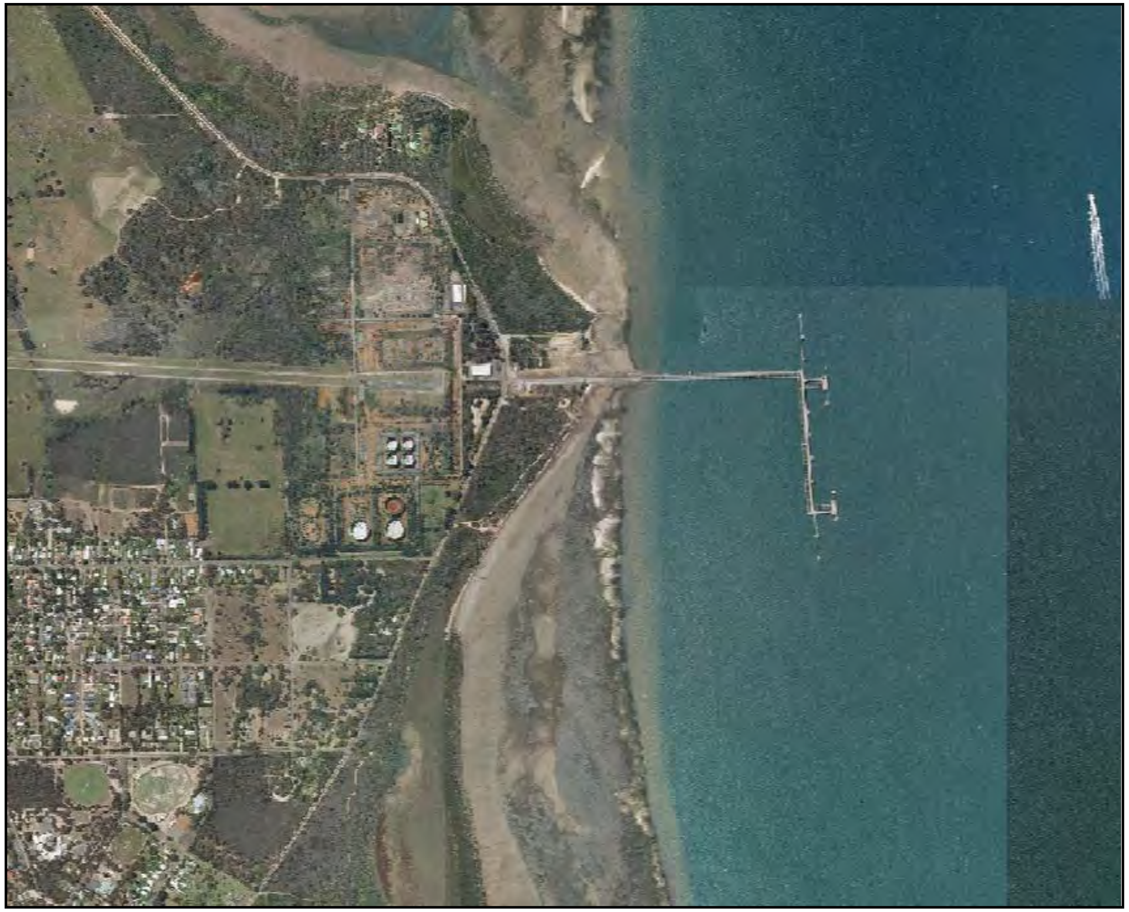
Site decontamination

Advantages and Disadvantages

- System connection does not limit capacity.
- DAFF Pre-treatment – more energy required
- UNESCO Biosphere area encourages sustainable developments
- RAMSAR Area

Potential Western Port Location: West of Western Port





Potential Location to the East: Bass Coast

Location Features

- Notional site on privately owned rural land between Kilcunda and Wonthaggi
- Some land is close to the coast
- 85 km from system connection point
- 3 km total tunnel length for intake and outfall
- 150 GL or more can be introduced into the system on the east
- Local farming and ‘holiday houses’

Risks

- Water quality risks due to Wonthaggi Outfall and Powlett River
- Risk on particular site selection until a range of due diligence studies are performed: for example there are areas of past coal mining underground which could restrict tunnelling and construction options and increase costs.

Marine Features

- Open Ocean providing clean inlet water
- Sandy Reefs which impacts on jackup barge.
- High Wave Environment
- Powlett River is closest freshwater inflow approximately 2 km to the north west.
- Wonthaggi wastewater outfall is approximately 3km to the south east.

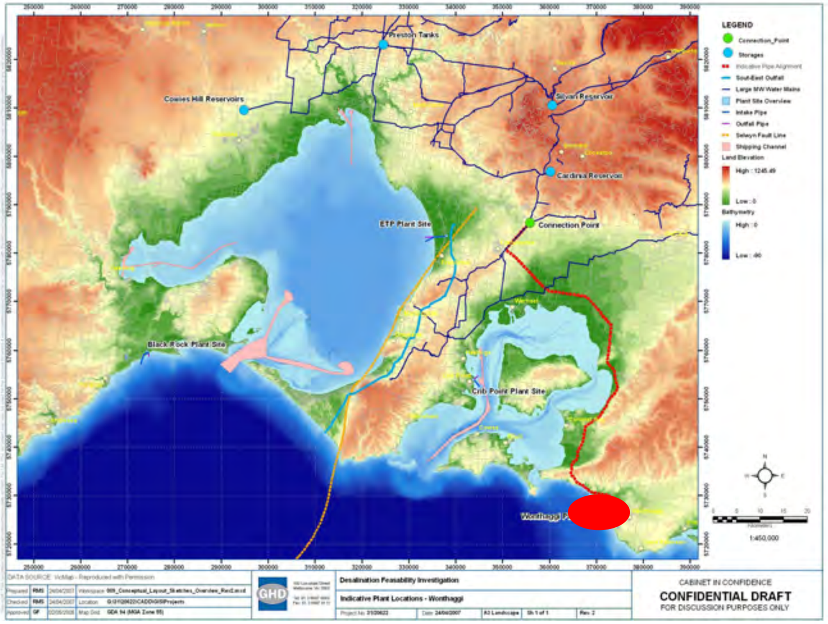
Opportunities

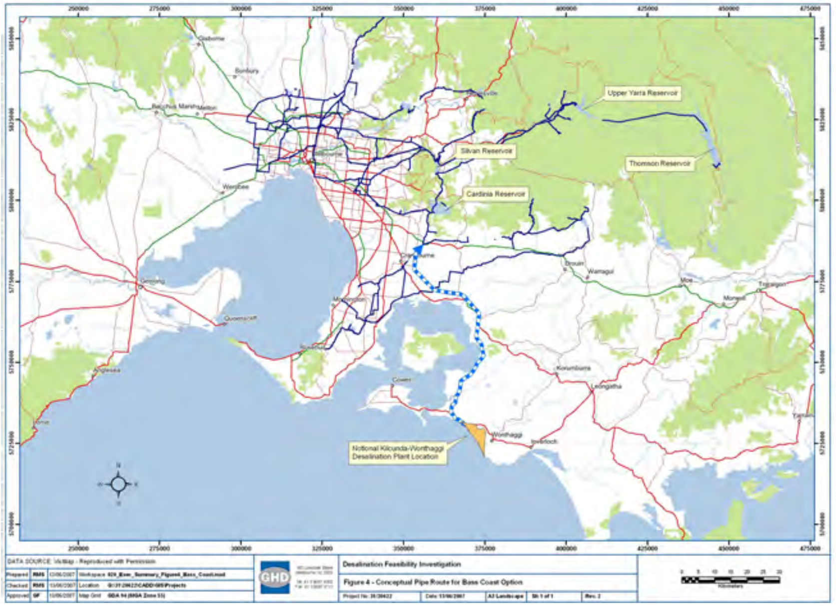
- Opportunity to supply water to local communities

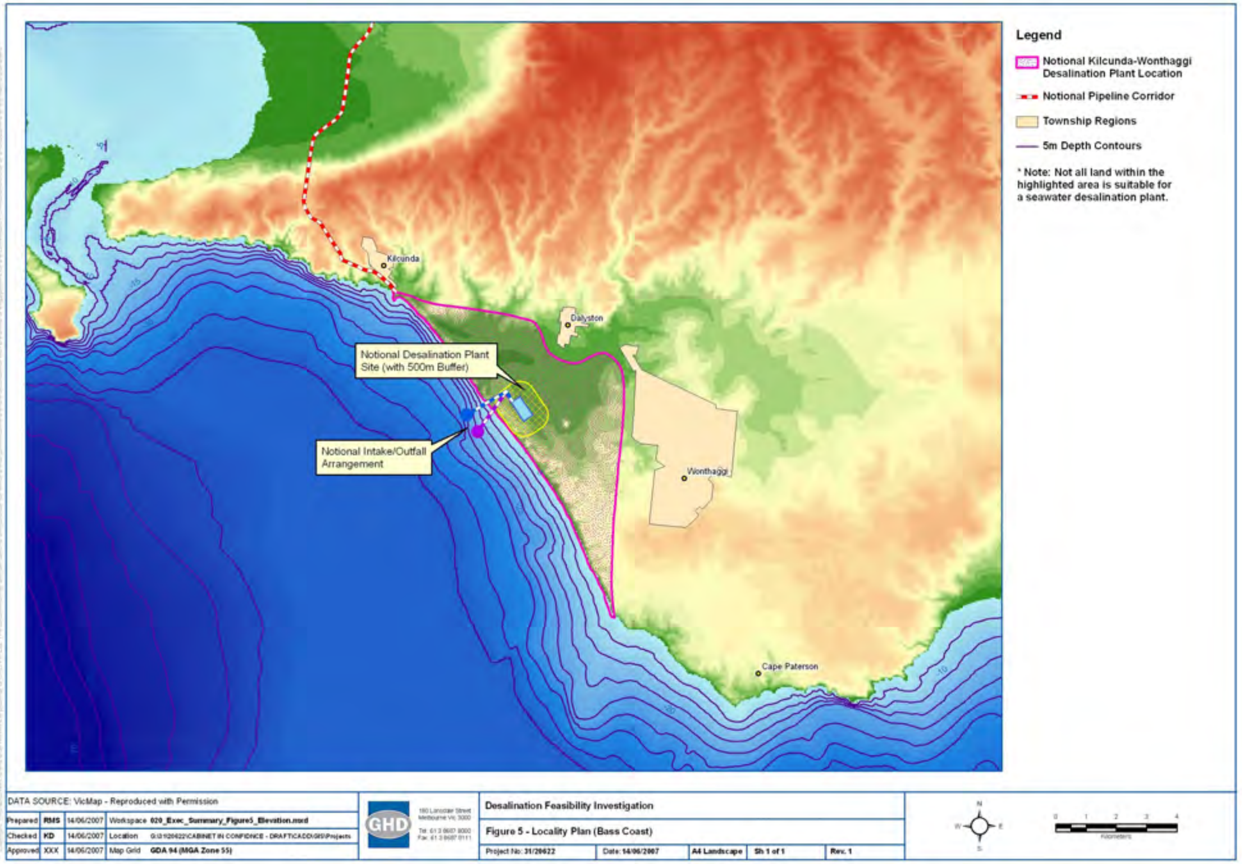
Advantages and Disadvantages

- Less pre-treatment than bay sites - media filtration reduces costs
- System connection does not limit capacity.
- Once all local environment, social and physical constraints are taken into account there may be limited space for construction.
- Least Developed Location so Greenfield sites available
- More Access Roads Required
- Visual Impact

Potential Location to the East: Bass Coast







9. Comparison of Short Listed Schemes

This chapter briefly summarises the key points that were considered when comparing the short listed schemes. It includes a summary of risks and opportunities and a multi-criteria assessment.

9.1 Source Water Quality

The final water supplied will be required to meet the requirements of the Australian Drinking Water Guidelines and the Victorian Safe Drinking Water Act. This Act requires an assessment of risks in the source water, which for a seawater desalination project is the seawater itself. Source water quality for each location will vary due to natural and human influences. Fluctuations in source water quality will impact on the treatment process. If the treatment process is not designed for these fluctuations, the final water quality may be compromised.

Aside from fluctuations in water quality, other source water quality risks which pose either a potential risk to final water quality or a risk to the process equipment need to be considered and managed. Examples of these two contrasting risks include municipal outfalls which could pose a water quality risk, and oil slicks which could damage the RO membranes.

Further investigation and risk assessment is required to develop a drinking water quality management plan, which would define the risks and how they will be managed. This study included a preliminary review of the source water quality and the risks at each of the short listed locations. The following sections summarise some of the key risks that were identified.

9.1.1 Surf Coast

A desalination plant located on the Surf Coast would draw source water from Bass Strait. Being an ocean source the water quality is expected to be relatively consistent, showing less variation in salinity, suspended solids and temperature than estuarine locations. Similarly there is a reduced risk of algal blooms relative to bay locations.

The location is some distance (approximately 20 km) from The Rip, the passage through which all shipping to the ports of Geelong and Melbourne must pass. As such shipping poses a relatively low risk to this location.

Barwon Water's Black Rock Waste Water Treatment Plant is located on the Surf Coast. The outfall from this plant creates an uncertainty for the source water quality that a desalination project might have to deal with in this area. The outfall poses a time risk as further investigations into the outfall's potential impact might be required. Should a material water quality risk be established, it can be managed through measures such as upgrading the waste water treatment plant and locating the seawater inlet away from the effluent outfall. Further investigation is required.

9.1.2 East of Port Phillip Bay

The nominal site for a desalination plant to the East of Port Phillip Bay is at Melbourne Water's Eastern Treatment Plant (ETP) site. A seawater intake in Port Phillip Bay would be located somewhere offshore from the beach at Carrum.

Drawing from in the bay, the source water salinity and temperature is expected to vary seasonally. Similarly the suspended solids concentrations and the frequency of algal blooms is expected to be higher based on historical data.

The intake location is not far from the Patterson River, which drains a catchment of suburban Melbourne. This is an unprotected catchment and there may be contamination in the inflows. After wet weather events the flow from the Patterson River will increase. These flows will create more estuarine conditions characterised by lower salinity and higher suspended solids. Pre-treatment at this location will need to be designed to cope with a higher suspended solids concentration than locations on Bass Strait. Such stormwater flows to the bay may be contaminated with trace amounts of oils, chemicals and metals not otherwise expected from 'natural' freshwater inflows.

Human influences include recreational boating, with the boat ramp at Carrum being the bay's busiest. There is a small source water quality risk associated with oil and chemical spills from recreational craft. There is shipping but it is some distance from the shore in this location.

9.1.3 West of Western Port

A plant located on the West of Western Port will draw water expected to show greater salinity, temperature and suspended solids variations than an ocean location. Freshwater influences after wet weather events are expected to impact on the water quality.

A plant in this location is likely to have its intake structure located in the deep water next to the main shipping channel for the Port of Hastings. The shipping using this channel poses a risk to the source water quality of oil and chemical spills. Future possible expansion of the port could increase the shipping traffic.

9.1.4 Bass Coast

Like the Surf Coast location, a desalination plant on the Bass Coast will draw water from Bass Strait. Being an ocean environment the water quality is expected to be relatively consistent, compared with Port Phillip Bay and Western Port. Suspended solids concentrations and the frequency of algal blooms is expected to be lower in Bass Strait.

The Powlett River flows into Bass Strait in this area. The catchment is predominantly agricultural (grazing), posing a risk of fertilisers and biocides in these flows. Dispersion of the flow from the river into the wider marine environment is expected to be relatively quick in this energetic open ocean area.

Human influences on the source water quality are expected to be minor, with no significant shipping near to any inlet location. The Wonthaggi Waste Water Treatment Plant discharges to Bass Strait south east of the township. This outfall is small when compared with the Black Rock outfall. It is not expected that the Wonthaggi outfall will have a significant impact on the source water quality of a Bass Coast location. Should further investigations reveal a potential risk, options include upgrading the Wonthaggi Waste Water Treatment Plant or recycling treated effluent from the plant.

9.2 Geology Summary

Preliminary desktop investigations into geology were conducted, and were used to inform assessments of construction risk and to develop cost estimates. The following summaries outline the outcomes of these investigations.

Substantial geo-technical investigations including both onshore and offshore drilling are required before further tunnelling and other designs development can be completed.

9.2.1 Surf Coast

Geological Setting

The near surface geological formations comprise a wide variety of Quaternary age deposits varying from alluvial and swamp deposits in stream valleys to dune sand and Aeolian deposits near the coast. These deposits are generally thin and restricted in areal extent.

Underlying these deposits is Quaternary basalt (Newer Volcanics), which in this area is intercalated with clay and basalt boulder horizons. The volcanic unit is reported to be in the order of 15 m thick. Previous geological investigation indicates that the basalt does not extend for a significant distance offshore.

The basaltic materials are underlain by a sequence of Tertiary age marine sediments consisting of calcareous clay and silt, limestone and marls, which extend offshore. The Tertiary marine limestone/marl materials are overlain by a variable thickness of unconsolidated sand and boulders.

Offshore, the seabed is thought to consist of Tertiary marine limestone with a highly variable cover of sand. The thickness of sand on the seabed is recorded to vary from 1.5 m near shore, increasing with distance from shore to greater than 2.5 m depth at 1.2 km offshore.

Tunnelling Implications

With the current level of knowledge of the geology at this site, the implications for tunnelling involve potential difficulties in tunnelling through highly variable strength materials, especially in transition from very hard basalt to moderate strength marl and limestone. There may also be potential difficulties and risks in tunnelling at shallow depth below the seabed with uncertain depth of sand cover on the seabed.

9.2.2 Eastern Side of Port Phillip Bay

Geological Setting

The geological profile at this location comprises relatively thin Quaternary sediments overlying Tertiary sediments. The Tertiary sediments are in turn underlain at depth by Tertiary Older Volcanics basalts and Silurian sedimentary basement rocks. The depth to the Older Volcanics basalts is reported to be in the order of 40m. The basalts are reported to have an average thickness of 12m.

The Quaternary sediments are generally between 6 and 8 m in thickness, and consist of unconsolidated sand, clay and sandy clay. The underlying Tertiary sediments consist of poorly consolidated sands, clayey sands and marls.

Tunnelling Implications

The shaft should designed to be deep enough to ensure it passes through the unconsolidated Quaternary sediments. The underlying Tertiary sediments may present a relatively favourable material for pressurised Tunnel Boring Machines (TBM) tunnelling from onshore to offshore, although more information on their vertical and lateral location and geo-technical and hydrogeological characteristics would be required to determine their suitability.

The deeper Older Volcanics and Silurian sedimentary rocks are much harder rock formations, and their potentially highly variable strength and hydrogeological condition may make tunnelling by TBM more difficult. These harder rock formations may exist at a sufficient depth to be unlikely to be consistently intersected by the proposed tunnel alignment.

Selwyn's Fault exists in this area. The position of the fault in this area is highly speculative, and the position on published maps may be up to 2 km in error. However, this fault is contained within basement rocks, and is unlikely to affect a relatively shallow tunnel confined to the Tertiary sedimentary formations. This may conflict with other design drivers for deeper tunnels. Further investigation is required.

9.2.3 West of Western Port Bay

Geological Setting

The near surface geological profile along the proposed alignment is relatively well known. A thin surface cover of Quaternary alluvial sediments exists in restricted areas of the site. It is unlikely that tunnelling would intersect these materials. Tertiary consolidated sediments underlie these alluvials, and consist of ferruginous clayey sands. The average thickness of the Tertiary sediments in this area is about 15m.

Underlying the Tertiary sediments are mudstones, claystones and sandstones of the Silurian bedrock formation. The depth to these hard sedimentary rocks is unclear, with the Silurian rocks outcropping about 1 km to the north of the proposed alignment. It is entirely possible for the Silurian rocks to be less than 20m below the surface in this area.

Tunnelling Implications

The depth to Silurian bedrock is not known at this site. The design approach for tunnelling may depend on the construction implications of shallow bedrock.

The Tertiary sediments at this site are reported to consist of fine-grained ferruginous clayey sand, medium to coarse sand, lignite and clay. Tunnelling in these materials would require a very different TBM methodology than if tunnelling in the deeper Silurian bedrock materials. The feasibility of tunnelling in either formation will be dependent on obtaining more detailed information on their geotechnical characteristics. It is likely that any tunnel alignment will need to avoid transiting from the soft ground Tertiary formations to the hard rock Silurian bedrock formations.

9.2.4 Bass Coast

Geological Setting

The geological profile in this area comprises Quaternary alluvial and Aeolian deposits overlying Cretaceous sedimentary rocks. The Quaternary deposits are unconsolidated and probably relatively thin (<10m). The underlying Cretaceous sedimentary rocks consist of interbedded sandstone, siltstone and mudstone, with minor carbonaceous mudstone and black coal horizons. Rocks belonging to this formation are recorded as outcropping along the proposed alignment and along the coastline adjacent to this location. The thickness of the Cretaceous sedimentary sequence is highly variable, as these rocks have been vertically offset by numerous faults.

The onshore evidence indicates that the offshore section of the proposed alignment will be underlain by Cretaceous rocks with a variable cover of unconsolidated deposits at the seabed.

Underlying the Cretaceous sediments at unknown depth are hard, indurated Silurian basement rocks consisting of sandstone, mudstone and slate. These Silurian rocks outcrop locally at Wonthaggi township, and they may exist a relatively shallow depth under parts of the alignment. However, drilling in close proximity to the proposed alignment (bores generally between 40m and 60m in depth) has not penetrate the Cretaceous formation, indicating that the Silurian bedrock is greater than 60m in depth below surface at this location.

Tunnelling Implications

The Cretaceous rocks near this location have been mined for black coal between 1936 and 1968. An obvious constraint on tunnelling in these materials is being able to define the location of prior mining workings.

A further constraint on tunnelling methodology within the Cretaceous formations is the presence of lignite and black coal seams. Although records indicate that these seams are very thin in this area (a maximum thickness of a few cm), there is no information available at this point on the potential for the presence of flammable gas within these seams. This has implications for tunnelling costs.

9.3 Risks and Opportunities

Whilst a wide range of risks is potentially applicable to a project of this nature, many/most are manageable by careful site/process selection, design, analysis and impact assessment.

The key risks requiring careful oversight at all locations are set out below:

- Effects of climate change on intake and discharge water quality parameters and on ocean water levels
- Potential increases in tender prices for desalination equipment supply/construction due to excess of demand over supply
- Feed water fluctuations affecting plant throughput
- Limited opportunity for pilot testing in the event of project fast tracking
- Community opposition and lack of engagement
- Delays in planning and environmental approvals
- The ability of the procurement and construction industry to respond in a timely manner
- Availability of adequate power supply for testing, construction and operation
- Subsequent desires to significantly increase plant capacity
- Unknown geological and geo-technical issues.

These matters and others should be considered and managed as part of any subsequent stages of the project, and are part of normal risk management project development and procurement processes for such major projects.

9.4 A Specific Opportunity: Use of the South Eastern Outfall (SEO)

A plant located to the East of Port Phillip Bay could theoretically use the existing South Eastern Outfall (SEO) from ETP to discharge concentrate to Bass Strait at Boags Rocks rather than Port Phillip Bay. Analysis of flow data for the SEO from before the current period of water restrictions (and lower sewer flows), reveals that the available capacity of the SEO constrains the volume of water that could be produced by a desalination plant to somewhere between 70 and 80 GL/y. During wet weather events the desalination plant would need to be shutdown temporarily to enable ETP to use the full SEO capacity for discharging the higher flows of treated effluent.

Use of the SEO into the future is likely to follow one of two possible paths. Flows from ETP are expected to continue to grow as Melbourne's population increases. These higher flows could further constrain the operation of the desalination plant meaning the production of water will decrease. Alternatively, if large scale recycling of ETP effluent is to be implemented, then the capacity constraints on the desalination plant are likely to ease. Under either scenario it is likely a desalination plant's operation will be stopped when wet weather flows occur. This will lead to a more expensive and risky stop/start operating regime.

Discharging concentrate via the SEO will require a detailed assessment of the materials of construction of the existing rising main, tunnels, pipeline and other structures. The increase in salinity and chloride levels resulting from discharging brine is expected to impact on the rate of concrete corrosion and hence the life of the existing asset. Increased flow rates will also make maintenance more difficult, and potentially increase the rate of erosion currently experienced. Preliminary investigation into these issues has made it apparent that the existing rising main from ETP to the Frankston Tunnel is unlikely to be suitable for saline water, hence allowance for a new parallel 10 km rising main is required. Pumping concentrate this distance would add to the energy costs of a desalination plant.

Existing recycled water customers supplied from the SEO would not accept an effluent/concentrate mixture of varying salinity. Such customers would need to be supplied by either a dedicated recycled water distribution pipe from ETP or from South East Water's treatment plants which discharge to the SEO.

The effect at Boags Rocks is unknown, however under normal conditions the flow is roughly equal parts effluent and concentrate, producing a salinity similar to seawater. This would assist in the dilution and mixing and the buoyancy effects of the existing effluent would be reduced. Conversely, during wet weather events, the flows would be expected to be mostly fresh water, and during low flows from ETP they would be saline. This varying salinity needs further investigation to determine if there would be a need to extend the Boags Rocks outfall. Any such outfall would uniquely be capable of operating with either fresh water or saline concentrate, which would be a design challenge.

9.5 Cost Comparison

9.5.1 Base Case Comparison

As outlined in Section 2.4, because the Surf Coast ultimate plant size is constrained to 100 GL/y without significant augmentation to the Melbourne transfer system, the “base case” for comparing the capital costs of the four locations was taken to be a plant of 100 GL/y.

The capital costs for each of the short-listed locations has been divided into the following key project elements: Intake and Outlet Tunnels, Desalination (Treatment) Plant, Site Specific Costs and Design, Transfer Pipelines, Investigations, Pilot Plant and Preliminary Engineering and Project Management.

Figure 29, below, shows the capital cost breakdown for each of the four short listed locations. It illustrates the relative contribution of the various elements of the project to the overall costs. Review of this figure shows that the main element increasing the costs of the Bass Strait locations relative to the two Bay locations is the transfer pipelines. However, higher site specific costs and higher treatment costs for the Bay locations reduce the overall cost differences.

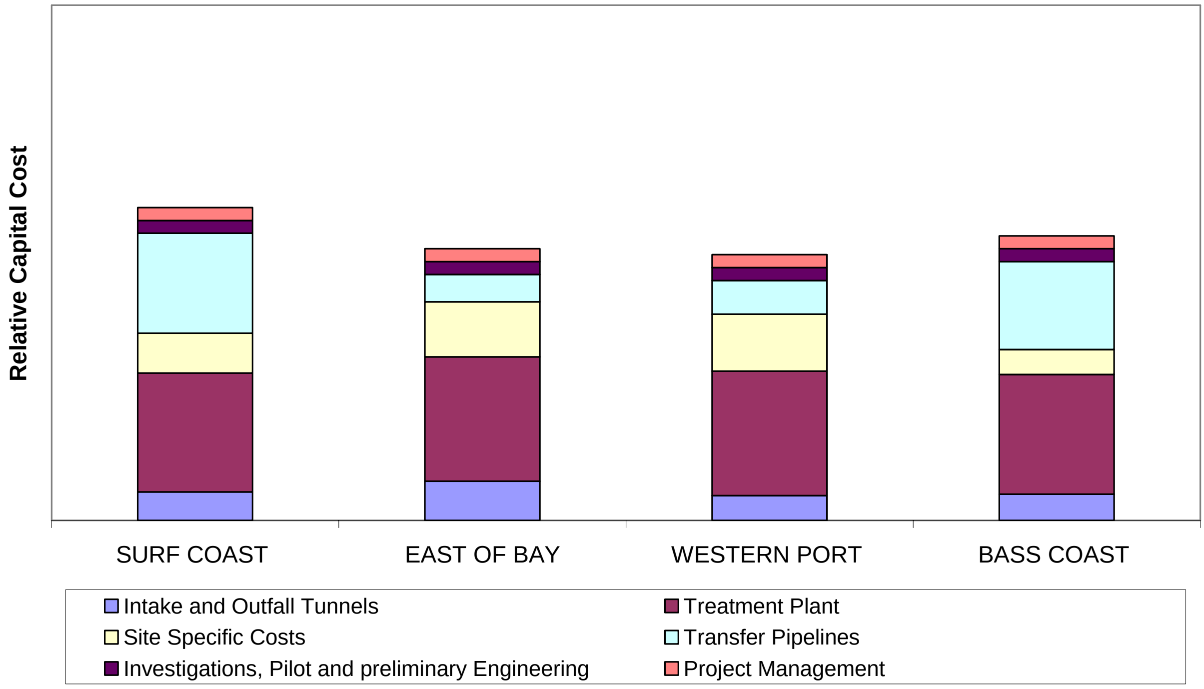


Figure 29 – Base Case Capital Cost Comparison of Short Listed Locations

It is noted that this study has undertaken a range of more detailed risk-based analyses of cost (which generate a range of costs and associated probabilities) for plants at various locations and sizes. These costs are not provided in this report for reasons of potential commercial sensitivity should the project proceed further to a procurement stage.

9.6 Capital Cost Comparison for Larger Schemes

The Surf Coast, Port Phillip Bay and Western Port locations all have constraints which suggest larger schemes are more difficult. These various constraints have been discussed elsewhere in the report. The Bass Coast location has the most flexibility to accommodate larger schemes, and therefore it was adopted as the location to explore cost differences for larger sizes.

Costs for a scheme based around a plant located on the Bass Coast have been considered for a range of sizes. The sizes presented in Figure 30 refer to the capacity of the intake and outlet tunnels, the desalination plant and the transfer pipelines. For example the option (200 – 150 – 200 GL) has intake and outlet tunnels and transfer pipelines sized for a 200 GL/y scheme and a desalination plant sized for 150 GL/y. Such a scheme allows the desalination plant to be later expanded to 200 GL/y without having to significantly alter the intake and outlet tunnels and the transfer pipelines.

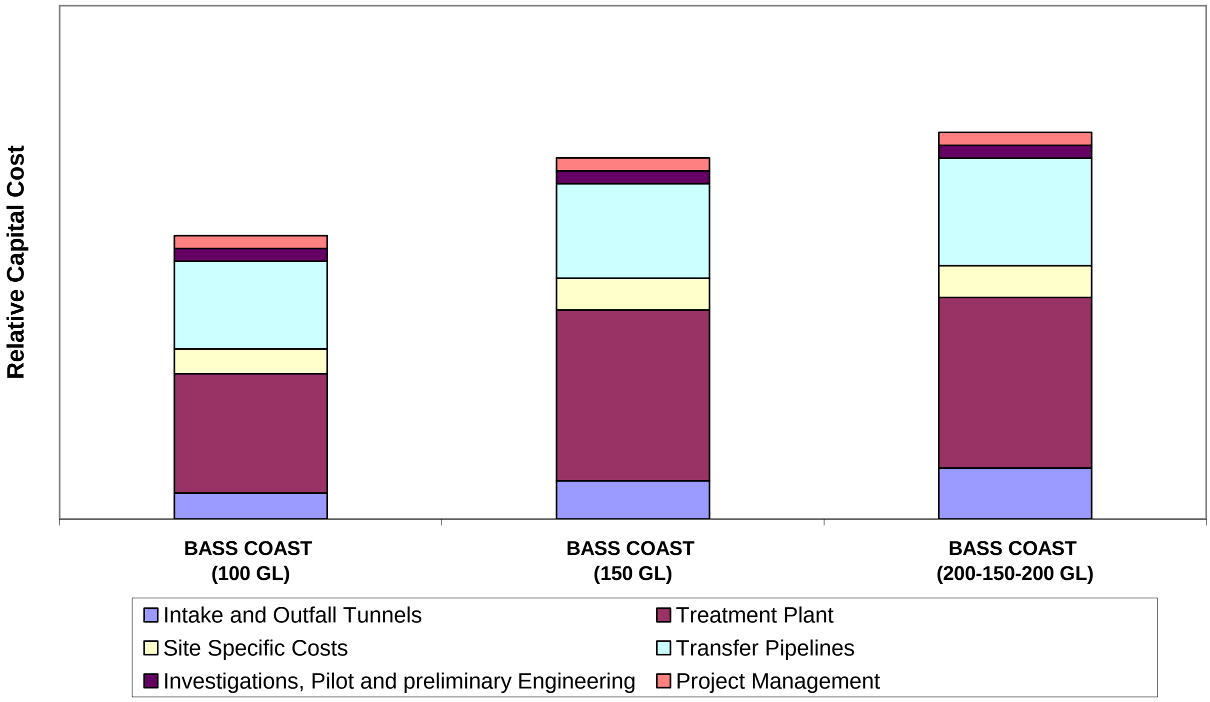


Figure 30 – Comparison of Different Size Schemes for the Bass Coast Location

Table 14 presents the costs for the different sized schemes for the Bass Coast which are shown in Figure 30 above.

Table 14 Comparison of Cost Estimates for Bass Coast Location

Plant Size GL/y (Tunnels – Plant – Transfer)	100 - 100 - 100	150 - 150 - 150	200 - 150 - 200
Cost	2.3	2.9	3.1

9.6.1 Operating Costs

Operating costs have been estimated including labour, energy, waste disposal, plant maintenance, general management and consumables (chemicals, filter cartridges etc). Membrane replacement is expected to be required every five years on average.

Table 15 Estimated Annual Operating Costs (2007 $Million), Based on the Bass Coast Location

PLANT SIZE	100 GL	150 GL
TOTAL OPEX ($M pa)	90	132

Figure 31 which follows, illustrates the relative contribution of various elements to the overall operating costs.

The operating cost estimates are based on a power cost of $10 c per kW hr, which reflects an estimate of the cost of renewable energy. Earlier sections of this document discuss the basis for this figure.

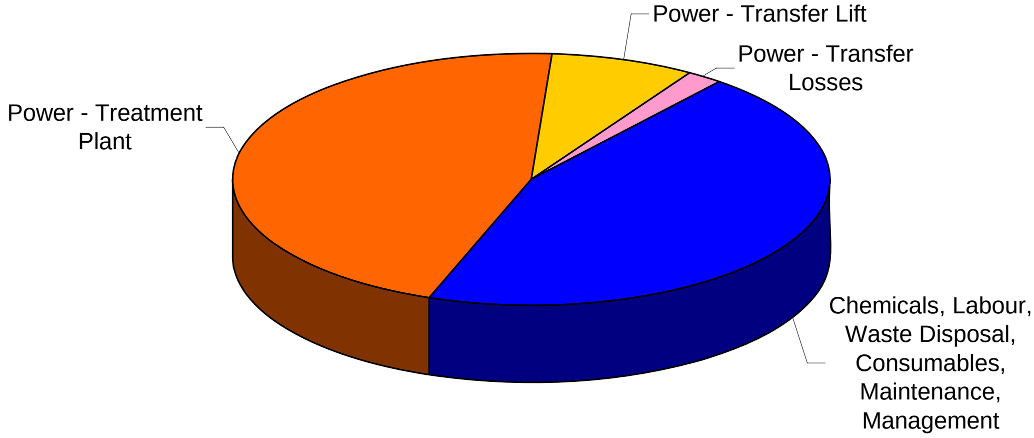


Figure 31 – Relative Breakdown of Operating Costs (Bass Coast)

9.7 Multi-criteria Analysis

The short list of locations includes sites with particular features, which lead to different environmental, social and economic outcomes. The following section summarises the outcomes of a multi-criteria assessment, which was undertaken to assess these various factors.

9.7.1 Criteria for Analysis and Outcomes of Scoring Process

The multi-criteria analysis included the following criteria:

Financial

- Difficulty of construction in marine environment
- Construction
- Risks to source water quality: Impact on plant performance
- Contaminated Land and/or Acid Sulphate Soils
- Capital Cost
- Access Roads
- Power supply to the site
- Geology
- Shipping nearby

Environmental

- Entrainment and Impingement
- Concentrate Outlet location
- Terrestrial Environment

Social

- Perception of Risks to Water Quality: Final water quality eg health.
- Cultural Heritage
- Air Quality, Noise and Traffic
- Landscape and Visual Amenity
- Land use and strategic planning
- Some Specific Aspects of Local Communities
- Recreational boating nearby

The analysis included a range of sensitivity testing on the weightings used. The scores assigned to the four short listed locations were developed in a workshop that included engineering, environmental and social specialists, and included staff from Melbourne Water. The adopted weightings had the following total percentages: Financial 40 %, Environmental 30% and Social 30%.

This approach to Multi-Criteria analysis involves the selection of a base case to which other options are compared. Given that this analysis involves the comparison of different locations for a desalination plant, it was decided that one of the locations should be arbitrarily chosen as the base case. The Surf Coast was chosen at random, and therefore it has a zero score for each element. The other locations are therefore scored lower or higher versus the Surf Coast.

The results for the analysis are set out in the following figure.

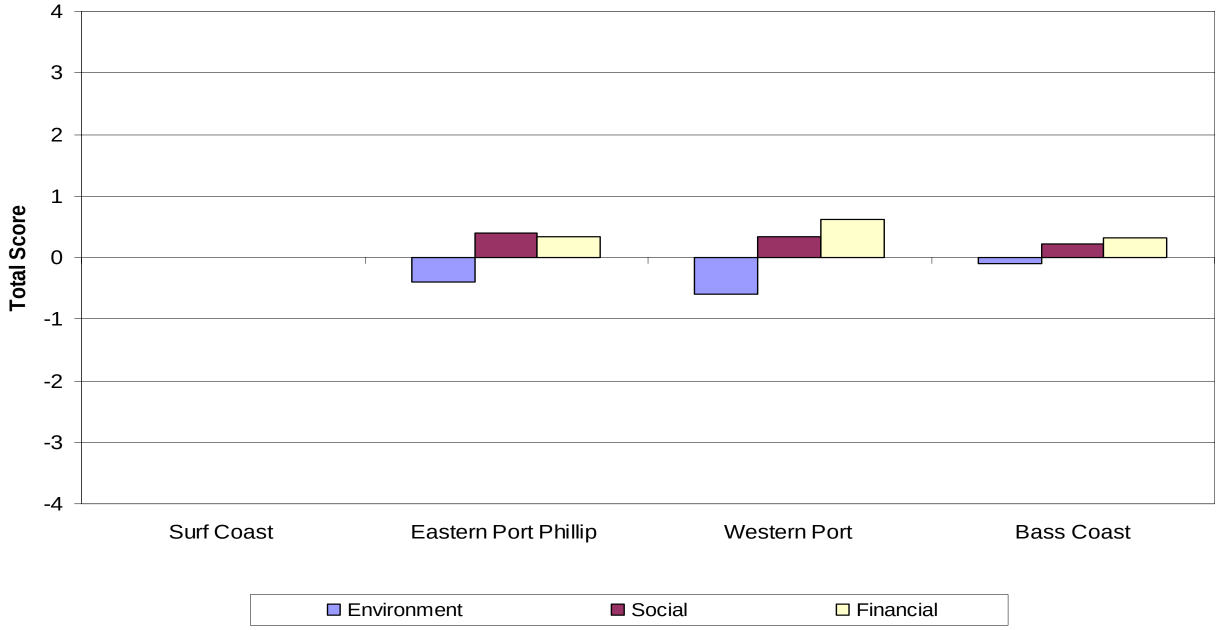


Figure 32 - Multi Criteria Analysis Scores

Review of this figures shows that there are only minor differences between the options. Analysis of the reasons for this outcome suggests that the following factors have affected the outcome:

4. The short listed sites all have some unique advantages and disadvantages, which tend to cancel each other out when analysed in total.
5. During the development of the short-listed schemes, various environmental and social risks were identified. The concepts were then modified – where possible – to minimise the risk or mitigate the impacts. This led to an increase in the costs for schemes to mitigate the environmental and social risks identified. For example, at sites with a possible impact on the local marine environment, longer tunnels were adopted to avoid the local impacts.

9.7.2 Summary of Outcome of Multi Criteria Analysis and Need for Strategic Review

The differences in cost, environmental impact and social impact between the locations do not appear to offer sufficient differentiation to suggest one site is firmly favoured over another. Therefore it is necessary to consider possible wider strategic objectives that may be of importance in selecting a possible locations. The following section sets out some possible strategic objectives for seawater desalination, and provides a comparison of the various locations against those possible strategic objectives.

9.8 Strategic Review of Locations

The four locations under consideration have particular strategic implications. For example, in some cases there are constraints on the volume of water supplied. In other cases there is more or less risk of delays if a project is being implemented relatively quickly.

There are also other augmentation options under consideration for Melbourne which influences the strategic considerations of the locations.

The following table summarises some key areas where there are strategic differences between the locations.

Table 16 Strategic objectives of the project and how they apply to each location

Possible Strategic Objective	Surf Coast	East of Port Phillip Bay	West of Western Port	Bass Coast	Favoured Locations for Strategic Objectives
Allow for future expansion: the need to select a site that can be economically expanded to 150 GL/yr or more in future.	This location does not meet this objective, as there is a constraint on the amount of water that can be sent to the west of the city of approximately 100 GL per year.	This site may not meet this objective, as environmental and social concerns may preclude concentrate return to the bay. If the existing south-eastern outfall is used, there is a constraint of approximately 70 GL per year.	This site should meet this objective, provided sufficient land is acquired. There may be some constraints related to overall salinity additions to Western Port, so hydrodynamic modelling for this site should include analysis of larger plants.	This site will meet this objective, provided sufficient land is acquired.	**All but Surf Coast and possibly not East of Port Phillip Bay** **Bass Coast is least constrained**
Combine with other Options: Integrate efficiently and economically with any new water supply from the East	This site will meet this objective, as it sends water to the west.	These sites should meet this objective, unless the combined volumes of the proposed augmentations exceeds the demand on Cardinia and Silvan, which typically account for more than 70% of Melbourne's demand.			**All but Surf Coast are least constrained**
Combine with other Options: Integrate efficiently and economically with any new water supply from the North and West	This site may not meet this objective, as there is only limited capacity to accept water in the west of the city.	These sites should meet this objective, as they send water to the east of the city.			**All but Surf Coast**

Possible Strategic Objective	Surf Coast	East of Port Phillip Bay	West of Western Port	Bass Coast	Favoured Locations for Strategic Objectives
Meet Demand Requirements: Implement with Low Risk of Time Delays	This site may not meet this objective, due to the time required to understanding and managing the water quality risks from the existing outfall.	This site may not meet this objective, due to the time required to understand and manage the risks of concentrate return to the bay, or to use the SEO.	This site may not meet this objective, due to the time required to understand the ecological implications in the RAMSAR area, and to acquire and rehabilitate the land.	This site has been assessed as the site with the lowest risks for time delays (although risks still exist, such as the acquisition of rural land, history of coal mining in the area, and construction in the active open ocean).	**Bass Coast**

This review shows that analysis of strategic objectives does provide a differentiation between the locations. When the wider strategic plan for water supply in Melbourne is under consideration, and the role of desalination in that plan is considered, these factors can be used to assist in selecting the most appropriate location. Important factors will include: the volume of water required, both now and into the future, the timing required, and the need to integrate with other options.

9.9 Conclusion on Site Comparison

A summary of each site in relation to key evaluation criteria is presented in Table 17.

Table 17 Summary of Significant Differences in Evaluation Criteria Between Locations

Criterion	Surf Coast	East of Port Phillip Bay	West of Western Port	Bass Coast
Ability to provide up to 200 GL/yr in the long term.	Constrained to 100 GL/yr.	Likely to be constrained by risks related to concentrate disposal.		Feasible
Risk to Delivery Timeframe	Moderate.	High.	High.	Least.
Risk of Impact on Marine Ecology	Lower than bays.	Higher than ocean.	Higher than ocean.	Lower than bays.
Visual Impact on Landscape	Currently open and relatively undeveloped landscape.	Already developed.	Already developed.	Similar to Surf Coast.
Source Water Quality	Black Rock outfall nearby.	Natural variation in quality in the bay, Patterson River nearby.	Natural variation plus risk due to proximity of shipping channel.	Wonthaggi outfall, Powlett River nearby. Lowest Risk Location.
Other Significant Factors	Opportunity to use existing wastewater treatment plant site at Black Rock.	Risks regarding the use of the South Eastern Outfall for concentrate discharge.	RAMSAR Area Potentially contaminated site.	History of coal mining.

The short-listed locations have different advantages and disadvantages. The study concluded that the key difference between the locations is how they fit into the strategic context of water supply augmentation planning for Melbourne.

Other parallel studies have been considering the capacities and timing required for augmentations to Melbourne's water supply. Under the assumption that:

1. The location for seawater desalination ought to be able to accommodate a plant that can produce up to 150 GL per year potentially expandable to 200 GL/year in the long term, and;
2. The water should be provided as soon as practical;

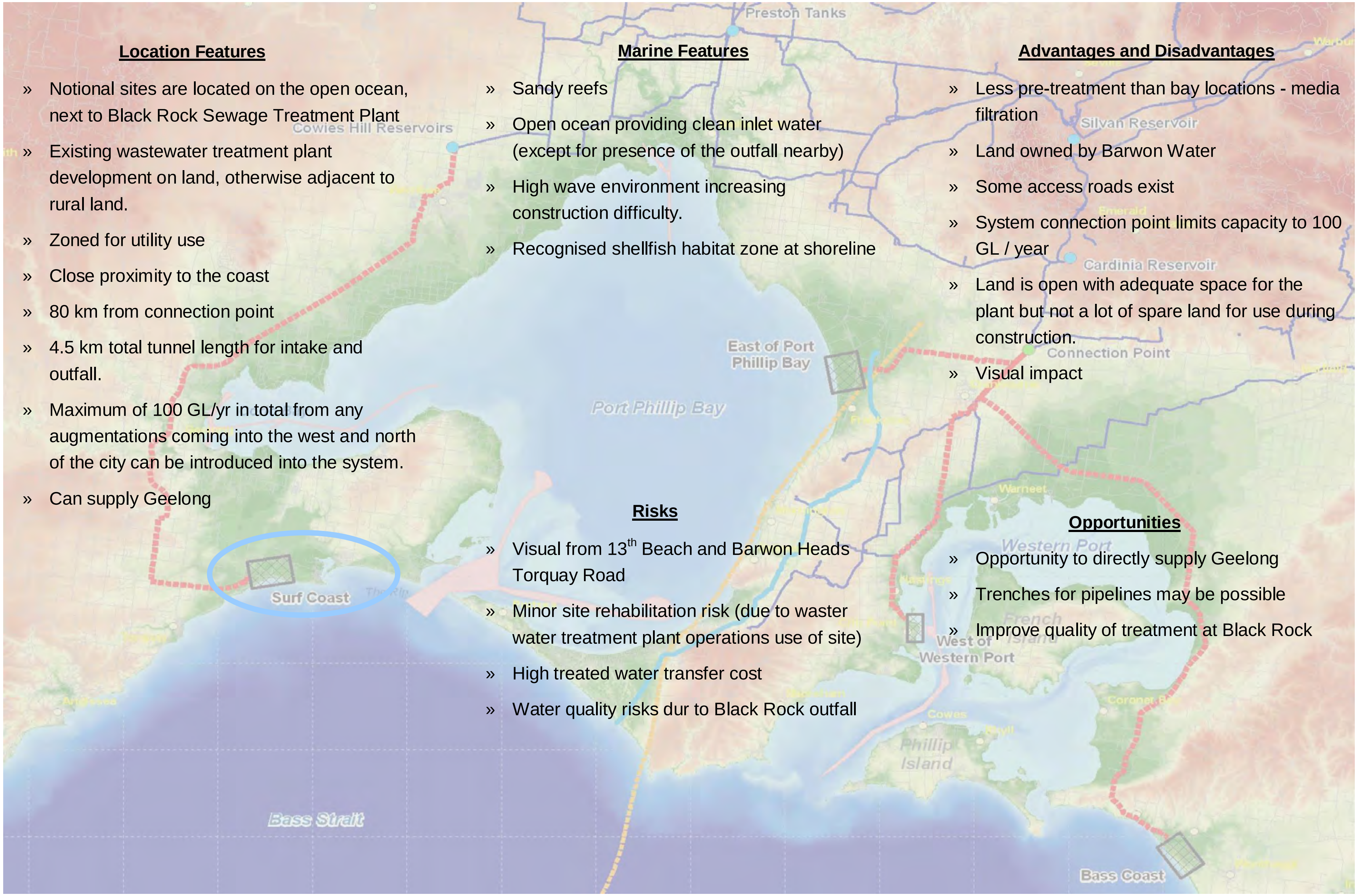
the location for the desalination plant should be to the east of the city, to allow supply of up to 150 GL/y and ultimately 200 GL/y, and that the location with the least risk to timely delivery should be adopted as the preferred location.

On this basis, the Bass Coast location is preferred, as the sites on Port Phillip Bay and Western Port have risks that could lead to significant delays. It is not possible to supply more than 100 GL per year from the Surf Coast site without significant changes to the water supply system in Melbourne.

The Bass Coast location is therefore preferred, subject to:

1. Due diligence including a range of technical and environmental studies on the various Bass Coast sites that are available;
2. Community consultation; and
3. Resolution of approvals and planning matters.

Potential Location to the West: Surf Coast



Location Features

- Notional sites are located on the open ocean, next to Black Rock Sewage Treatment Plant
- Existing wastewater treatment plant development on land, otherwise adjacent to rural land.
- Zoned for utility use
- Close proximity to the coast
- 80 km from connection point
- 4.5 km total tunnel length for intake and outfall.
- Maximum of 100 GL/yr in total from any augmentations coming into the west and north of the city can be introduced into the system.
- Can supply Geelong

Marine Features

- Sandy reefs
- Open ocean providing clean inlet water (except for presence of the outfall nearby)
- High wave environment increasing construction difficulty.
- Recognised shellfish habitat zone at shoreline

Advantages and Disadvantages

- Less pre-treatment than bay locations - media filtration
- Land owned by Barwon Water
- Some access roads exist
- System connection point limits capacity to 100 GL / year
- Land is open with adequate space for the plant but not a lot of spare land for use during construction.
- Visual impact

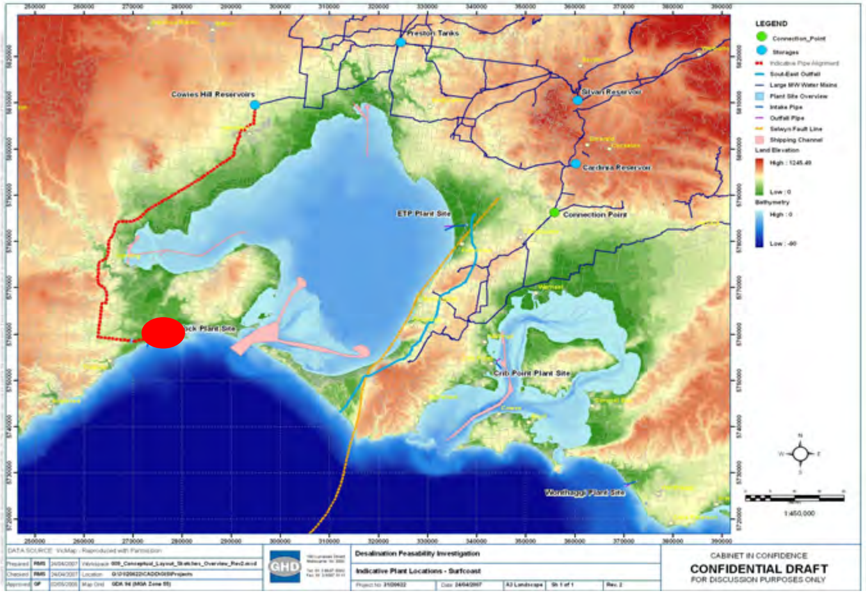
Risks

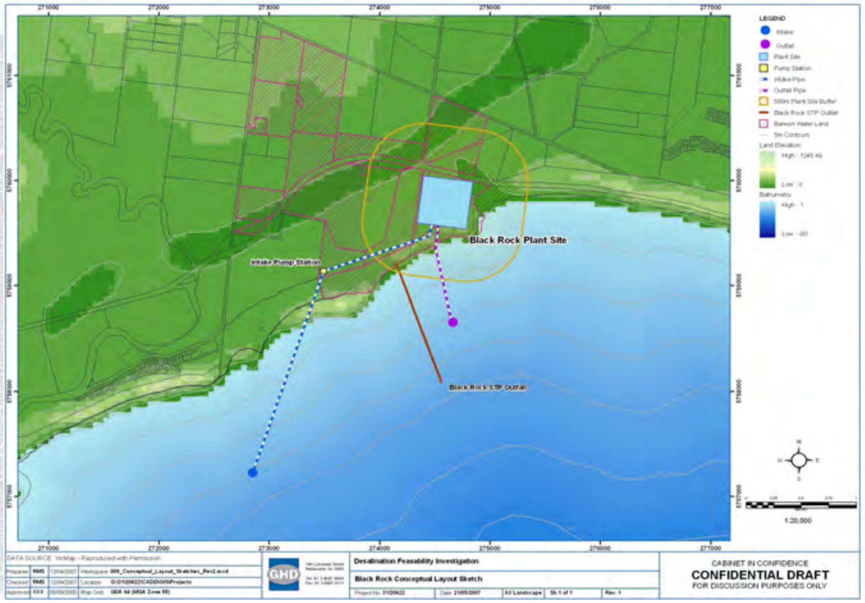
- Visual from 13th Beach and Barwon Heads Torquay Road
- Minor site rehabilitation risk (due to waster water treatment plant operations use of site)
- High treated water transfer cost
- Water quality risks dur to Black Rock outfall

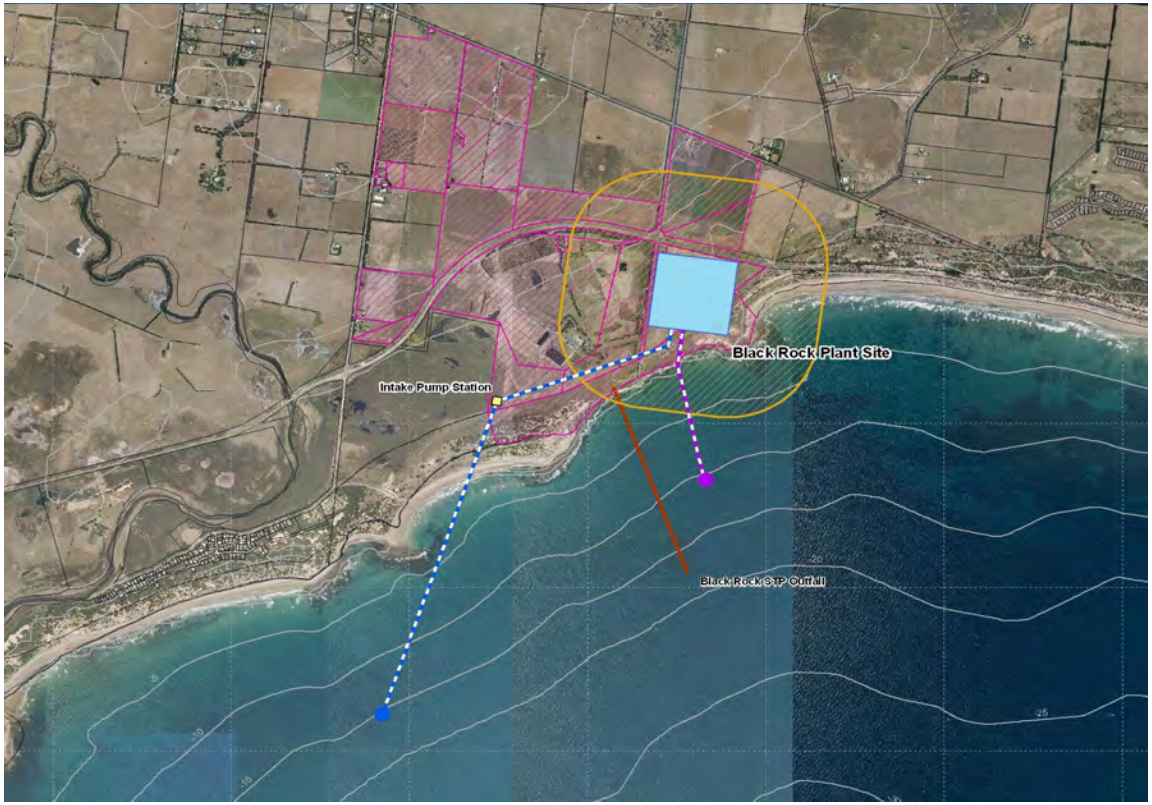
Opportunities

- Opportunity to directly supply Geelong
- Trenches for pipelines may be possible
- Improve quality of treatment at Black Rock

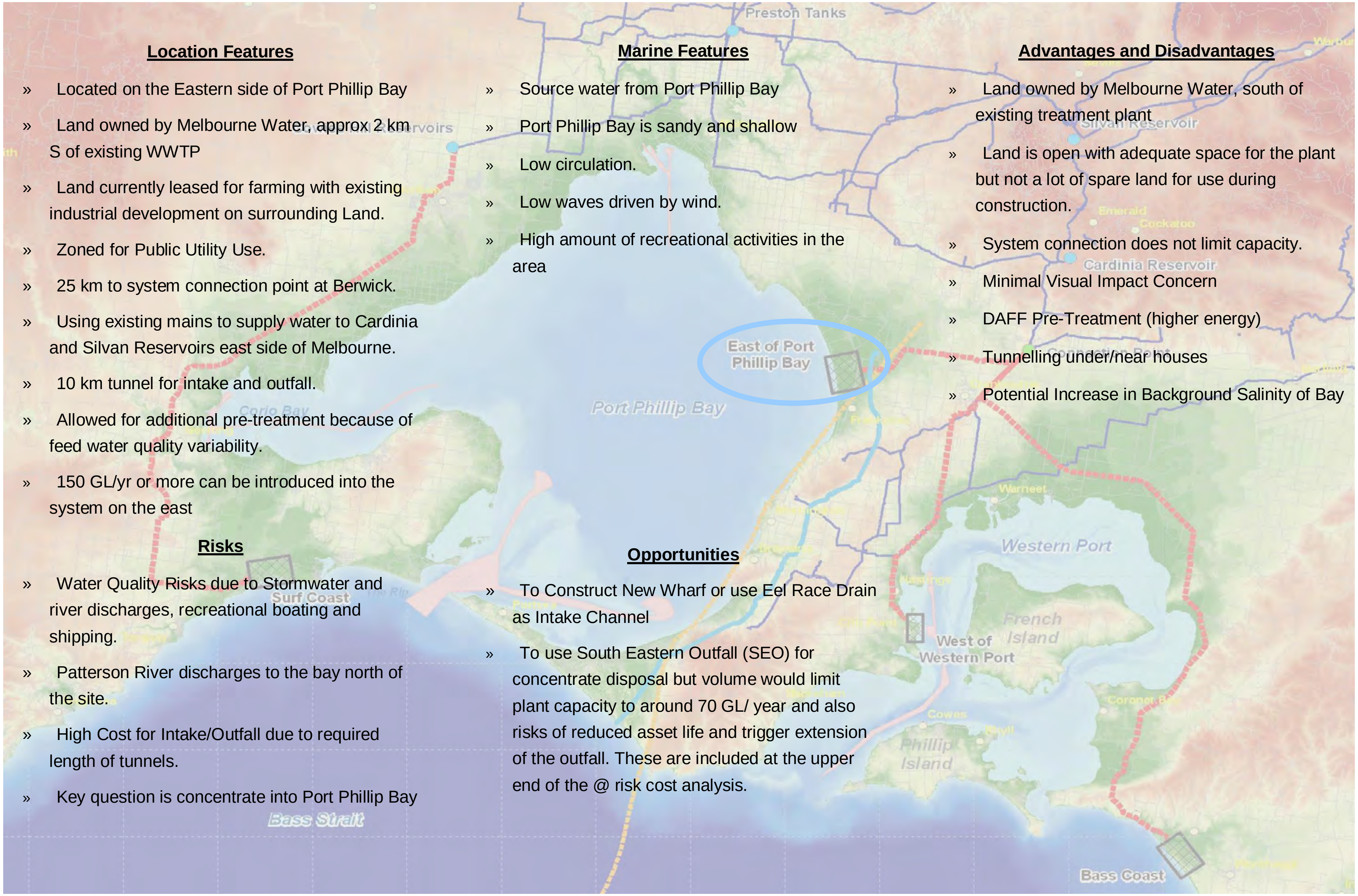
Potential Location to the West: Surf Coast







Potential Port Phillip Bay Location: East of Port Phillip Bay



Location Features

- Located on the Eastern side of Port Phillip Bay
- Land owned by Melbourne Water, approx 2 km S of existing WWTP
- Land currently leased for farming with existing industrial development on surrounding Land.
- Zoned for Public Utility Use.
- 25 km to system connection point at Berwick.
- Using existing mains to supply water to Cardinia and Silvan Reservoirs east side of Melbourne.
- 10 km tunnel for intake and outfall.
- Allowed for additional pre-treatment because of feed water quality variability.
- 150 GL/yr or more can be introduced into the system on the east

Risks

- Water Quality Risks due to Stormwater and river discharges, recreational boating and shipping.
- Patterson River discharges to the bay north of the site.
- High Cost for Intake/Outfall due to required length of tunnels.
- Key question is concentrate into Port Phillip Bay

Marine Features

- Source water from Port Phillip Bay
- Port Phillip Bay is sandy and shallow
- Low circulation.
- Low waves driven by wind.
- High amount of recreational activities in the area

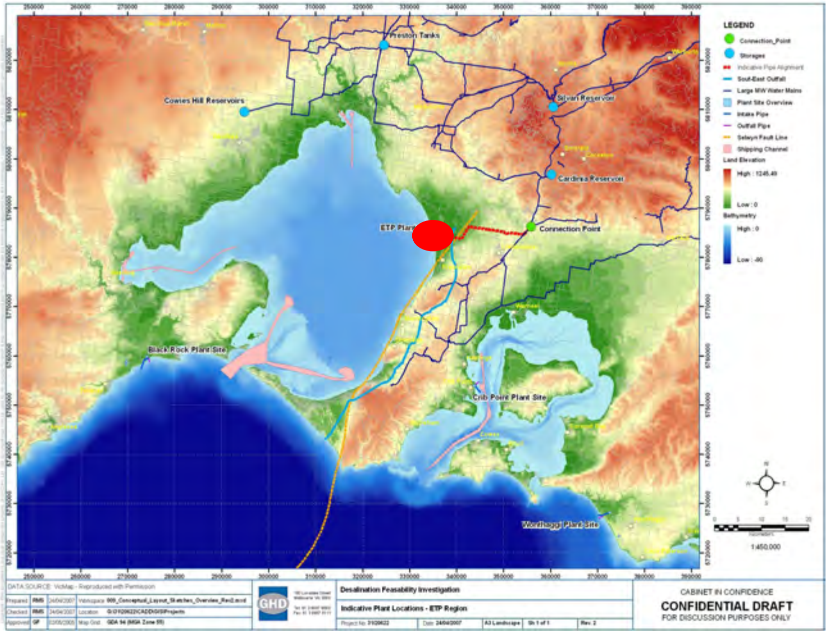
Opportunities

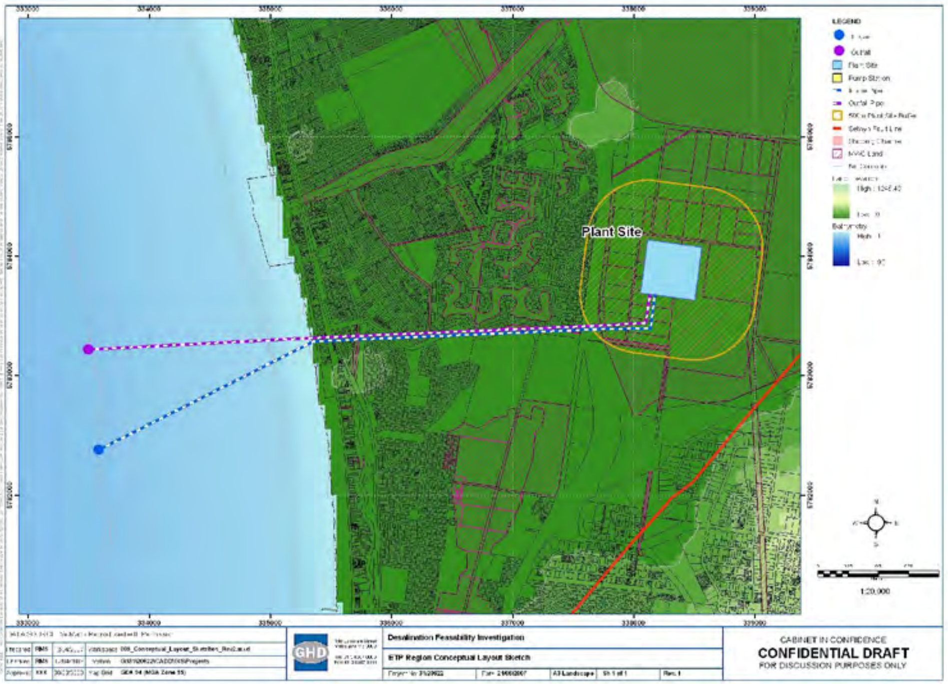
- To Construct New Wharf or use Eel Race Drain as Intake Channel
- To use South Eastern Outfall (SEO) for concentrate disposal but volume would limit plant capacity to around 70 GL/ year and also risks of reduced asset life and trigger extension of the outfall. These are included at the upper end of the @ risk cost analysis.

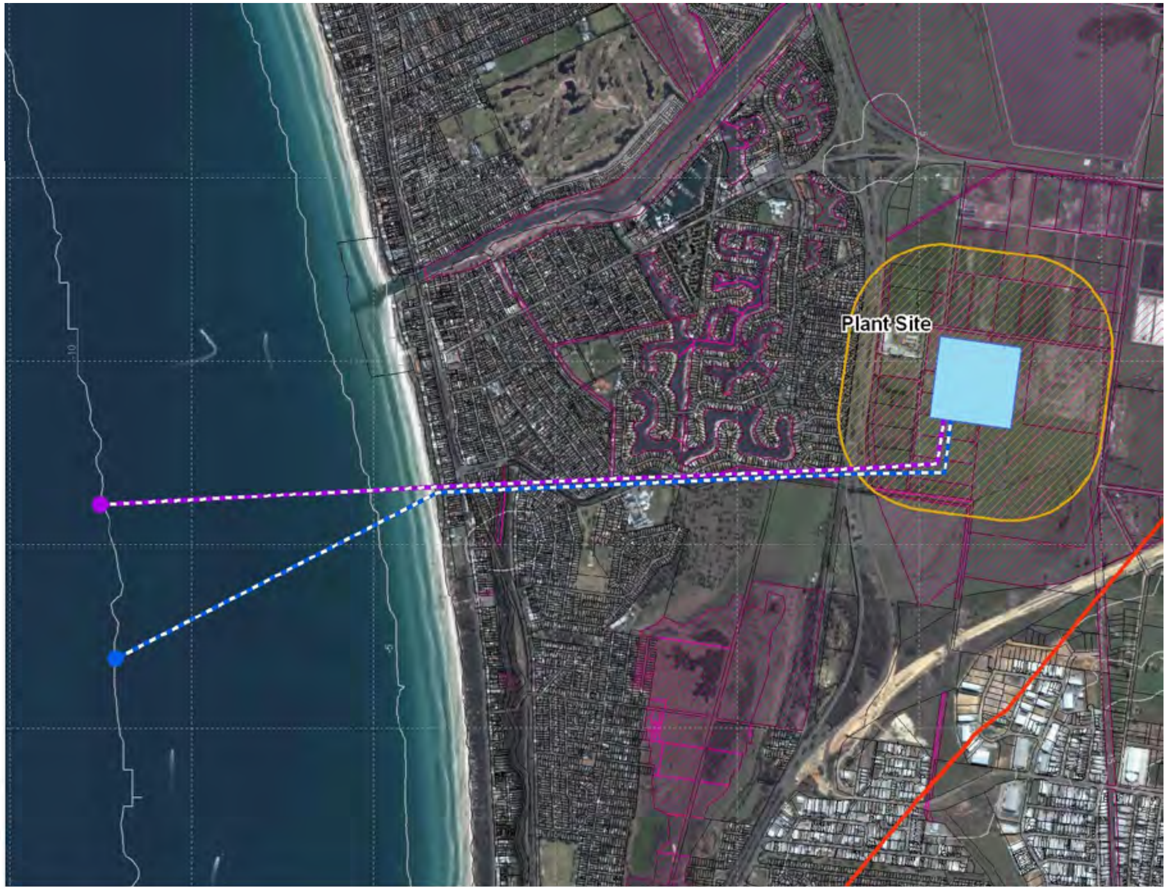
Advantages and Disadvantages

- Land owned by Melbourne Water, south of existing treatment plant
- Land is open with adequate space for the plant but not a lot of spare land for use during construction.
- System connection does not limit capacity.
- Minimal Visual Impact Concern
- DAFF Pre-Treatment (higher energy)
- Tunnelling under/near houses
- Potential Increase in Background Salinity of Bay

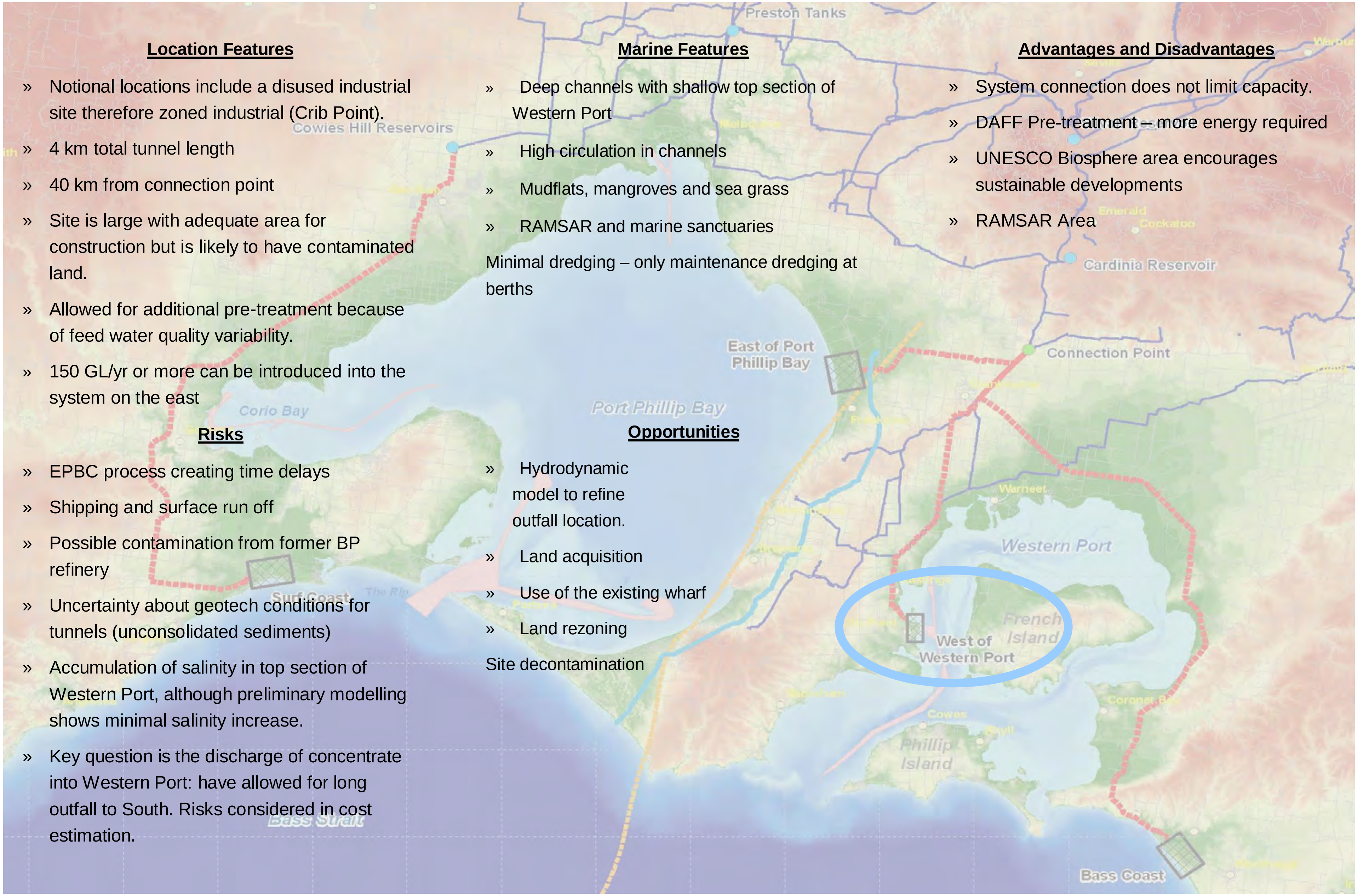
Potential Port Phillip Bay Location: East of Port Phillip Bay







Potential Western Port Location: West of Western Port



Location Features

- Notional locations include a disused industrial site therefore zoned industrial (Crib Point).
- 4 km total tunnel length
- 40 km from connection point
- Site is large with adequate area for construction but is likely to have contaminated land.
- Allowed for additional pre-treatment because of feed water quality variability.
- 150 GL/yr or more can be introduced into the system on the east

Risks

- EPBC process creating time delays
- Shipping and surface run off
- Possible contamination from former BP refinery
- Uncertainty about geotech conditions for tunnels (unconsolidated sediments)
- Accumulation of salinity in top section of Western Port, although preliminary modelling shows minimal salinity increase.
- Key question is the discharge of concentrate into Western Port: have allowed for long outfall to South. Risks considered in cost estimation.

Marine Features

- Deep channels with shallow top section of Western Port
- High circulation in channels
- Mudflats, mangroves and sea grass
- RAMSAR and marine sanctuaries

Minimal dredging – only maintenance dredging at berths

Opportunities

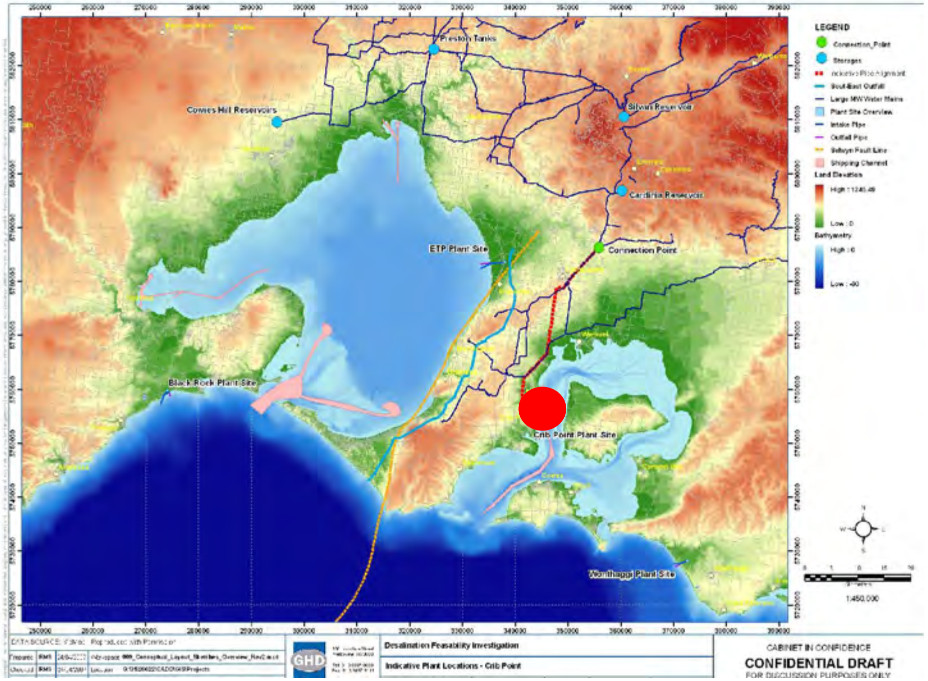
- Hydrodynamic model to refine outfall location.
- Land acquisition
- Use of the existing wharf
- Land rezoning

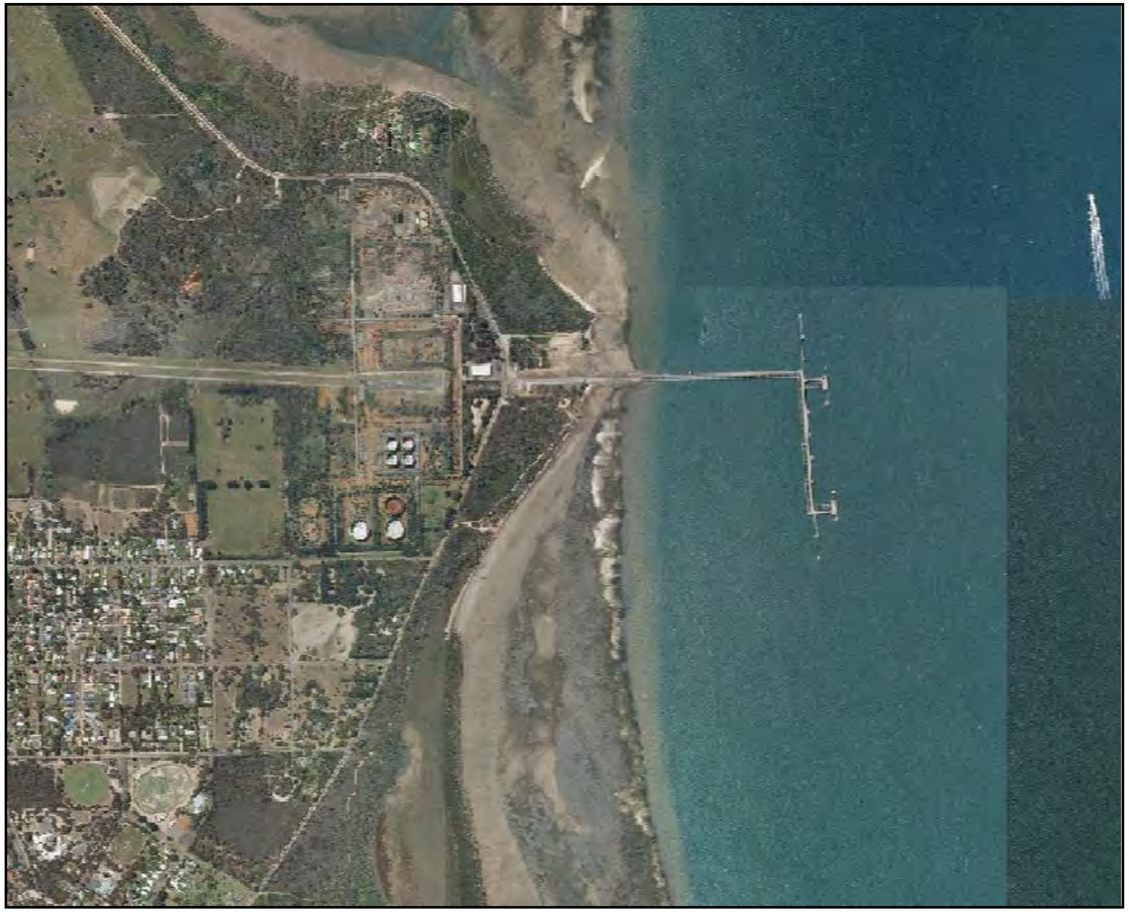
Site decontamination

Advantages and Disadvantages

- System connection does not limit capacity.
- DAFF Pre-treatment – more energy required
- UNESCO Biosphere area encourages sustainable developments
- RAMSAR Area

Potential Western Port Location: West of Western Port





Potential Location to the East: Bass Coast

Location Features

- Notional site on privately owned rural land between Kilcunda and Wonthaggi
- Some land is close to the coast
- 85 km from system connection point
- 3 km total tunnel length for intake and outfall
- 150 GL or more can be introduced into the system on the east
- Local farming and ‘holiday houses’

Risks

- Water quality risks due to Wonthaggi Outfall and Powlett River
- Risk on particular site selection until a range of due diligence studies are performed: for example there are areas of past coal mining underground which could restrict tunnelling and construction options and increase costs.

Marine Features

- Open Ocean providing clean inlet water
- Sandy Reefs which impacts on jackup barge.
- High Wave Environment
- Powlett River is closest freshwater inflow approximately 2 km to the north west.
- Wonthaggi wastewater outfall is approximately 3km to the south east.

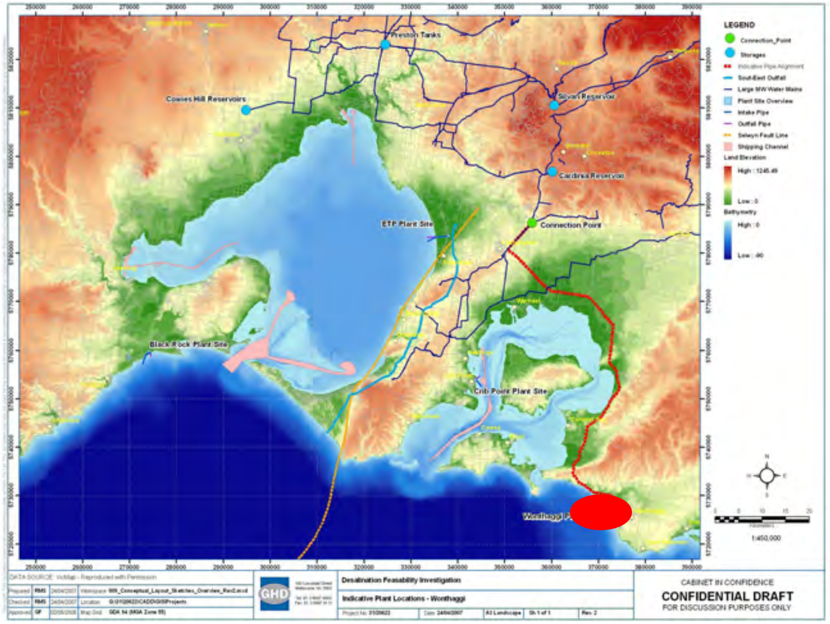
Opportunities

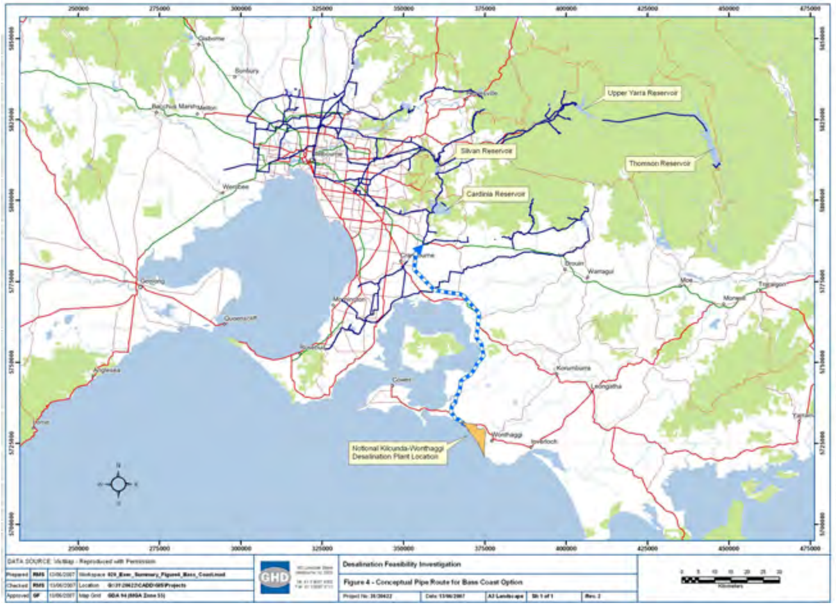
- Opportunity to supply water to local communities

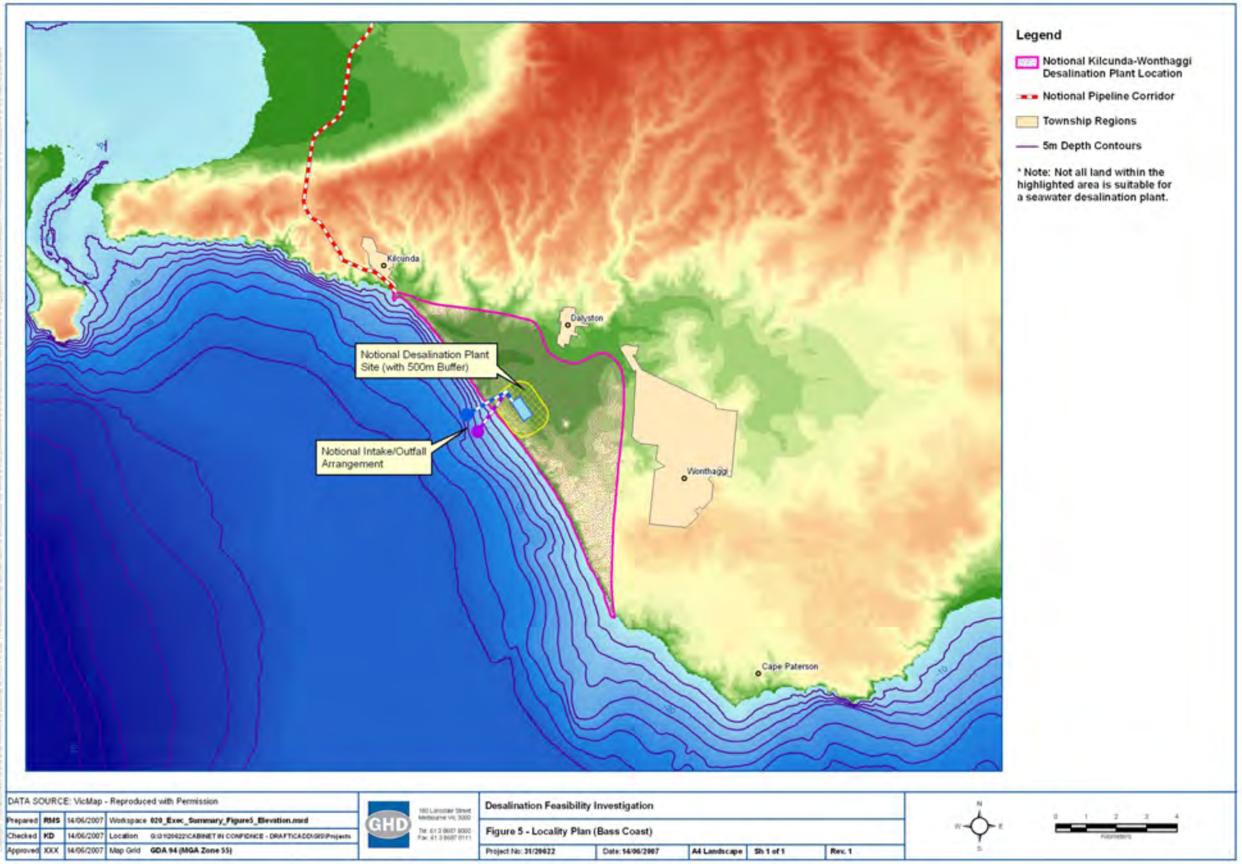
Advantages and Disadvantages

- Less pre-treatment than bay sites - media filtration reduces costs
- System connection does not limit capacity.
- Once all local environment, social and physical constraints are taken into account there may be limited space for construction.
- Least Developed Location so Greenfield sites available
- More Access Roads Required
- Visual Impact

Potential Location to the East: Bass Coast







10. Project Timing

10.1 General Discussion

There is some variation in the predicted construction times for the different locations, and the times are also dependent on the approach to contract delivery. In broad terms, and based on Australian experience, the project - at the preferred location - might be expected to have two phases.

First there would be a period of around 1½ to 2 years studying seawater quality, evaluating geology, undertaking a range of investigations and environmental assessments, community consultation, pilot testing, and developing design concepts further. This phase would also include engagement with the contracting community, developing contract documentation and tendering. Then there would typically be a further 2½ to 3-year period of detailed design, construction and commissioning before water is available. There will be some overlap between the phases.

10.2 Risks to Timely Delivery

The program set out above describes the range of activities which are required at any plant location. There are differences between the locations which result in various possible risks of extending the program by impacting on activities which lie on the critical path. The project risk analysis included an examination of the impact which various risks could have on the time to implement the project. Table 18 sets out a summary of the various risks that the program could be extended for the various locations, and also includes a summary assessment of the relative overall risk of delay for the different locations.

The lower risk cells for each component are highlighted in green.

Table 18 Risks to Timely Delivery

Component	Surf Coast	East of Port Phillip Bay	West of Western Port	Bass Coast
Time to reduce uncertainty related to various environmental and social impacts.	Victorian Safe Drinking Water Act requires assessment and management of source water quality risk. This may be time consuming if anywhere near the Black Rock outfall, due to possible need for quantitative analysis.	Until hydrodynamic modeling and ecological studies are resolved and interpreted, there is uncertainty over the concept of concentrate discharge to Port Phillip Bay. This creates a risk of time delay.	The RAMSAR listing may trigger EPBC. In any case, the need for investigations to understand and demonstrate acceptable impact creates a risk of time delay. Some sites may be contaminated land, with consequent need for potentially time consuming investigation.	There is a need to address site acquisition and zoning. The Wonthaggi outfall needs to be considered, but it is much smaller and also sites can be found further away than for Black Rock, so risk of delay is not regarded as significant.

Component	Surf Coast	East of Port Phillip Bay	West of Western Port	Bass Coast
Geotechnical investigation and subsequent design development.	Weather delay to marine geotech investigations is a higher risk in the open ocean locations due the need for calmer weather to drill offshore.	Lower risk than for open ocean.	Similar to Port Phillip Bay.	Similar to the Surf Coast.
Pilot Testing and water quality investigations related to design development	Apart from the issue of the Black Rock outfall (covered above), the Bass Strait location offers more consistent water quality and therefore reduced need for extended pilot testing.	Water quality variation in the Bay suggests need for pilot testing to develop and demonstrate pre-treatment concepts. The time required may be extended if a need to experience particular water quality events (eg heavy rain and river inflows) is seen to be important.	Similar to Port Phillip Bay, with additional concerns related to shipping and consequent impact on pre-treatment concepts.	Similar to Surf Coast.
Construction (Tunnelling) for the Inlet and Outlet, various complications which could increase time to complete.	Geology – Basalt ridges, energetic open ocean environment reducing time available for marine construction.	Geology – Fault and other complications. Bay provides more calm conditions for marine works. Longest tunnels , some tunnelling under houses, roads, railway etc.	Old alluvial silt filled valleys potentially intersect tunnel route. Bay provides more calm conditions for inlet works.	Geology – coal seams and history of mining may create complications, energetic open ocean environment reducing time available for marine construction.

Component	Surf Coast	East of Port Phillip Bay	West of Western Port	Bass Coast
Additional Complications unique to the Particular Location, which could increase time to complete.	Potential need to increase level of treatment at Black Rock to manage risk or perception of risk related to the outfall.	Need to resolve operation with the SEO as concentrate disposal option.	Contaminated land potential onsite which will need investigation and unknown quantity of rehabilitation.	Need to identify appropriate, sites, perform due diligence and investigations and acquire land.
Summary of Risks that Timeline for Implementation is Increased	**Moderate Risk**	**Moderate to High Risk**	**Moderate to High Risk**	**Least Risk**

The Bass Coast location is considered to pose the least risk to delivery timeframes, while the East of Port Phillip Bay and West Western Port locations pose the greatest risk. To quantify these delivery risks, further investigation into the specific locations is required. The cost estimates for each location currently include allowances to mitigate some of these risks. Investigations to quantify these risks will have the added benefit of ultimately providing greater confidence in the cost estimates.

11. Next Steps

This section outlines activities that typically occur when a major seawater desalination project is taken forward from feasibility study into implementation. These lists are drawn from the experience gained at other major seawater desalination projects around Australia. In general these tasks fall into five key categories:

- Technical, environmental and scientific investigations
- Planning, land use and approvals matters
- Further design and engineering
- Procurement strategy
- Community consultation and engagement

Each of these categories are explained in further detail below. Discussion of the tasks as presented here is not intended to be prescriptive, nor is the list of tasks exhaustive.

11.1 Technical and Scientific Investigations

Investigations are required to gather information that will assist in the development of the design and provide a greater understanding of the approvals required. Table 19 outlines some of the key investigations likely to be required.

Table 19 Description of Likely Technical, Environmental and Scientific Investigations

Task	Description
Geotechnical Investigations	Preliminary site assessment via a desktop study to produce an outline geological model of the site, preliminary definition of geological processes, identification of geological risks and outlining the scope of additional surveys and monitoring Site investigation including onshore and offshore components. Onshore borehole drilling and geophysical surveys at the plant site and along the pipeline corridor. Offshore borehole drilling, CPT testing and geophysical surveys to enable projection of a 3D geophysical model along tunnel alignments.
Ecological Investigations	Surveys of the ecological impact of construction and operation both on land and in the marine environment. Data gathered will be required for the planning and approvals process and assist in minimising potential impacts through design improvements
Hydrodynamic Modelling	Computer modelling of the ocean conditions considering bathymetry, tidal and climatic data. Results are required to assist the design and location of the intake and outlet structures, consider potential water quality risks and to minimise the impact of the concentrate discharge.

Task	Description
Visual Impact Assessment	Preliminary design of buildings and facilities and their placement on potential sites to determine the aesthetic impact on the landscape. Results of the assessment feed into design of the treatment plant's buildings and facilities and to assist the community consultation process.
Water Quality Risk Assessment	Studies to determine risks the treated water quality posed by the feedwater quality. Typical risks include freshwater influences (rivers, drains), discharges (municipal, industrial) and other effects (shipping, algal blooms etc). Studies may show a quantitative risk assessment (QRA) is required to properly determine the risk to the final water quality and public health.

11.2 Planning, Land Use and Approvals

Planning and approvals covers the legislative aspects of locating and operating the desalination plant. Work is required to ensure the relevant approvals are obtained before construction can commence. Approvals are required from a range of governmental bodies and cover a range of aspects of such a project ranging from zoning and land use issues to environmental approvals. The various approvals processes pose a potential time risk to any process, as appeals against developments can occur for a number of reasons.

A summary of the various environmental acts that could apply and approvals that may be required is discussed earlier in this report.

11.3 Further Design and Engineering

Various technical data is required for further design development. Table 20 outlines some of the key investigations likely to be required.

Table 20 Description of Likely Further Design and Engineering Tasks

Task	Description
Water Quality Sampling	Sampling of the marine environment to gain an understanding of the typical seawater composition (metals, organics, physical attributes) and their expected variation is required to develop the design of the pre-treatment and reverse osmosis processes.
Further Design Development	Progress through a functional design phase to enable a detailed design to be undertaken. How the design process is managed is largely determined by the procurement strategy.
Develop Delivery Approach	Contractual arrangements to enable engagement of contractors and equipment suppliers. The delivery approach will be determined by the procurement strategy.
Pilot Plant Testing	Running a small scale plant to determine suitable pre-treatment processes and associated required chemical dosing.

Task	Description
Power Supply Arrangements	Arrangements with relevant power companies and local authorities to enable provision of a high voltage supply to the site. Power supply may be upgraded in stages. Initial supply needed to run the construction equipment such as tunnel boring machines. Ultimate supply to power the plant and enable commissioning and on-site testing prior to operation.

11.4 Procurement Strategy

A number of risks have been identified in the feasibility study. Further investigation will resolve some of these risks, and reveal others. These risks may be shared in some proportion between the government and the private sector. The procurement strategy adopted will define the nature and extent of the risk shared with the private sector.

The large seawater desalination projects in Australia have adopted a variety of procurement strategies including competitive alliance in Perth, a pure alliance in Gold Coast and a possibly a Design Build and Operate in Sydney.

Selection and development of the appropriate procurement strategy is a key next step if seawater desalination is taken forward as a major augmentation.

11.5 Community Consultation and Engagement

A large seawater desalination project will generate considerable community interest. It is important for all such projects to develop a wide ranging community communication and consultation program. A significant effort will be required to develop and manage a communication process if a seawater desalination project proceeds as a major augmentation for Melbourne.

Broad issues raised elsewhere in community consultation which are specific to seawater desalination, rather than examining the broader question of water supply planning, might be expected to include:

- What will be the impact on home water bills? How much will industry pay?
- Concerns over a wide range of perceived environmental impacts, including water quality, marine life etc.
- How will greenhouse gas be handled?
- How will construction of the plant and pipeline affect people who live nearby?
- How will operation affect local communities?
- Why is the plant not located somewhere else?
- Why not use alternative technology?
- Who will own the plant?

Development of a comprehensive and appropriate community consultation and communication program is a key next step if seawater desalination is taken forward as a major augmentation.

12. Conclusions

A feasibility study was conducted into seawater desalination as one option to provide a major augmentation to Melbourne's water supply.

This study has concluded that it is feasible to desalinate seawater to produce up to 100 GL/y from four short-listed locations. The Surf Coast, East of Port Phillip Bay, West of Western Port and the Bass Coast were short listed as possible locations. Conceptual project designs have been developed for each location. The concepts include intake and outlet tunnels and marine structures, seawater screening and pumping to the plant, pre-treatment of the seawater, reverse osmosis desalination, post-treatment, pumping and transfer to suitable connection points in the existing metropolitan water supply system.

The volume of water which potential locations can supply to the system is constrained by several factors. Locations to the east of the city could connect into the Cardinia and Silvan Reservoir system, allowing more than 200 GL/y to be introduced to the existing system. Locations to the west could introduce up to 100 GL/y into the existing system via the Cowies Hill Reservoir. There are other constraints to total volume that can be produced at the desalination plant locations themselves, particularly in relation to disposal of concentrate. The conclusion of this analysis was that the Bass Coast location offer the most flexibility for expansion to 200 GL/yr.

Environmental implications and limitations of the project were considered. Preliminary assessments of the greenhouse gas contribution of the project show that the electricity consumption of the plant, whilst operating, outweighs either direct emissions from construction and operations or embedded emissions from materials and chemicals used. It appears feasible to supply an annual equivalent amount of renewable energy to supply the plant. The renewable energy generation plant(s) could be located elsewhere in Victoria. The operating cost estimates allow for a current estimate of the cost of renewable energy.

Marine considerations include feedwater quality and impact of concentrate discharge. For the locations drawing water from Port Phillip Bay and Western Port, the conceptual design allows for more variable feedwater quality, than in Bass Strait, by the inclusion of additional pre-treatment.

Marine impacts of the concentrate discharge are expected to be minimal in Bass Strait given the proposed diffuser design and the open ocean environment. Both Port Phillip Bay and Western Port have environmental and social values, which suggest that the return of the concentrated seawater to these water bodies would need careful consideration. Understanding wider area effects would also need further study.

The short listed locations have been assessed against a wide range of technical, financial, environmental and social factors. An assessment was made of the risks to timely delivery of the project for each location. The conclusion of these assessments is that the most significant difference between the locations is how they might fit into the wider strategic plans for water supply in Victoria. For example, if there is a need for future expansion to 200 GL/year supplied to the east of the city, and if there is also a need to provide the augmentation to meet particular timeframes, then the Bass Coast location is favoured.

The report includes a set of next steps that need consideration if seawater desalination is adopted as a major augmentation for Melbourne's water supply,

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