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.

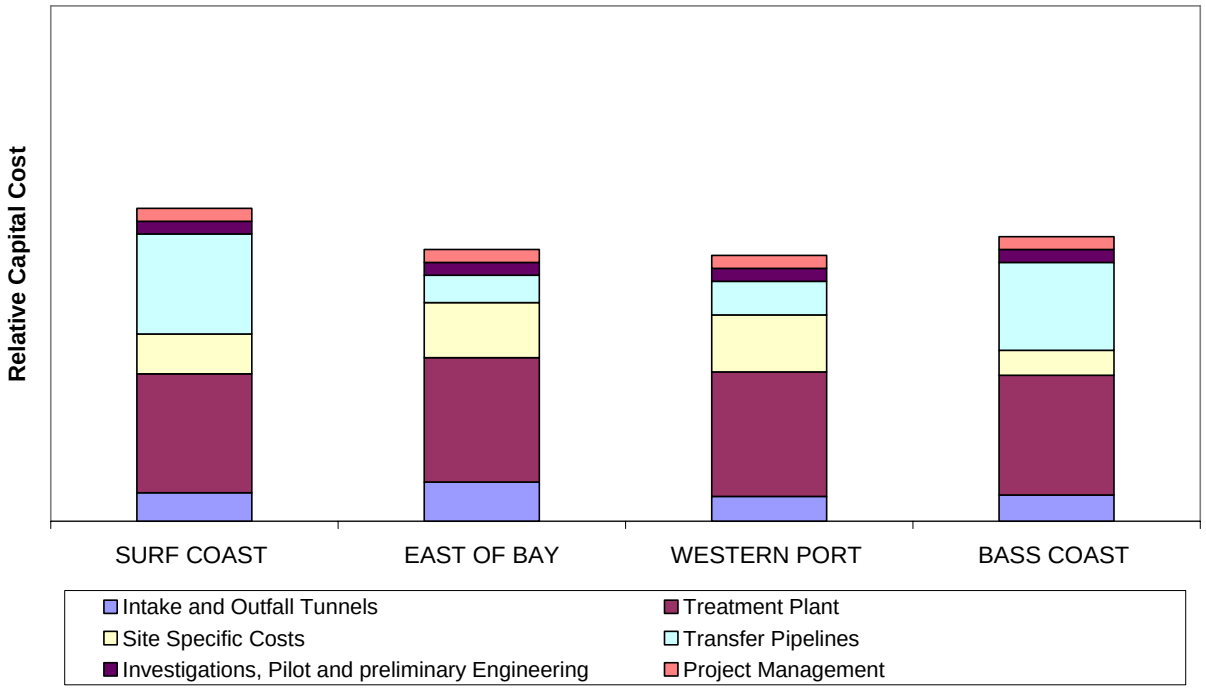

Figure 29 – Base Case Capital Cost Comparison of Short Listed Locations

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.

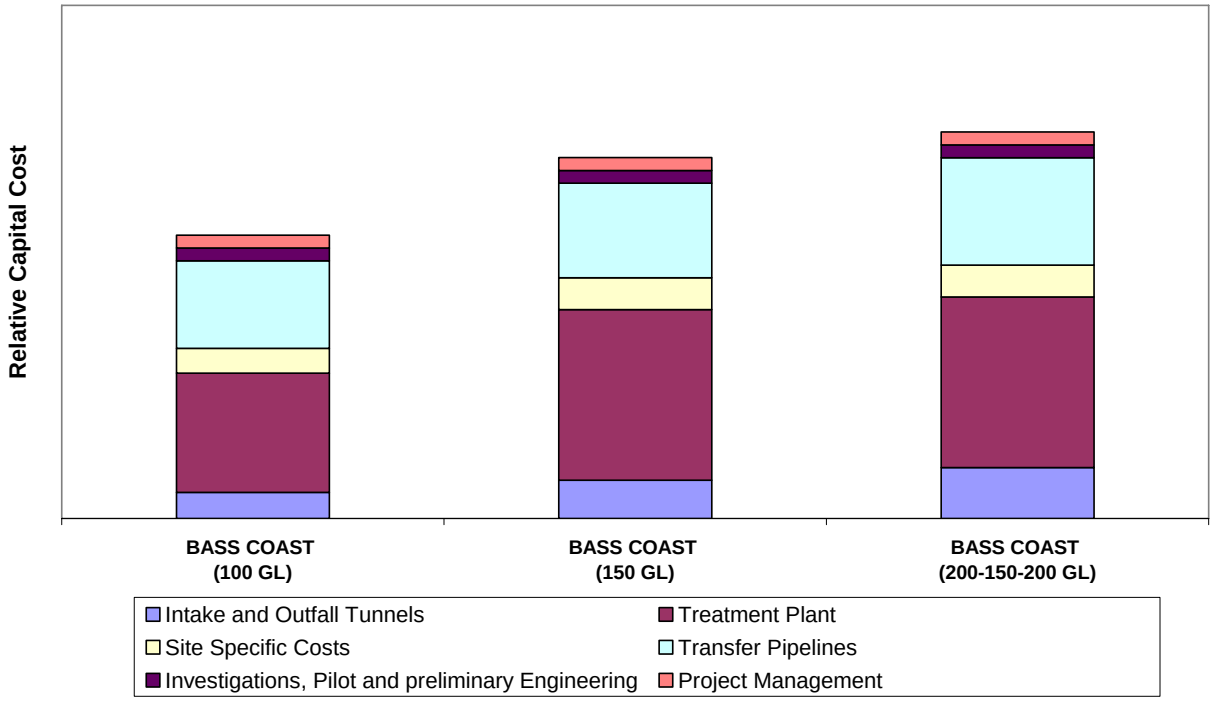

Figure 30 – Comparison of Different Size Schemes for the Bass Coast Location

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.

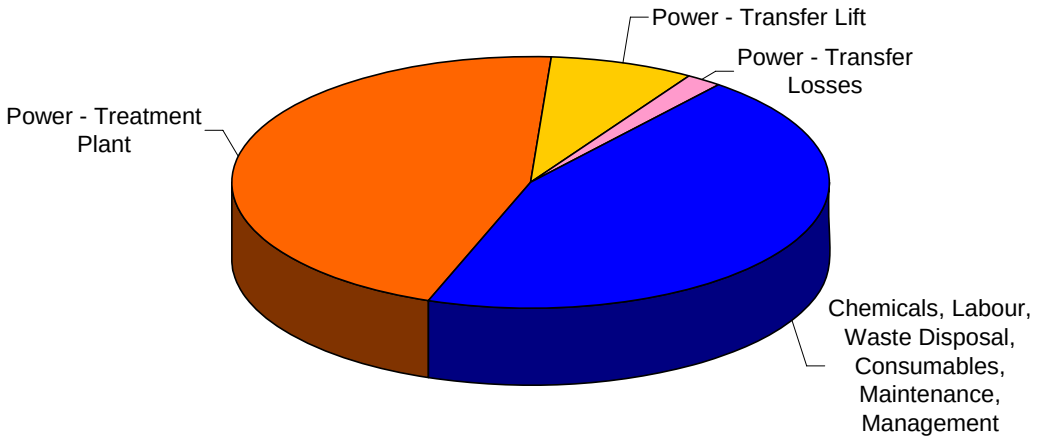

Figure 31 – Relative Breakdown of Operating Costs (Bass Coast)

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.

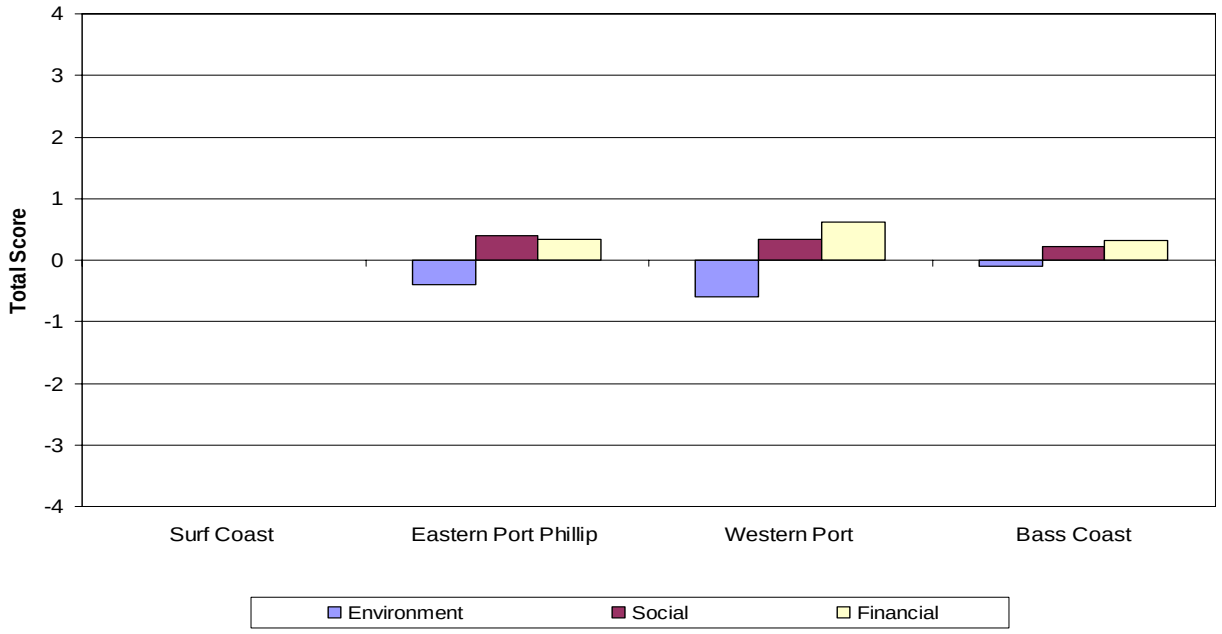

Figure 32 - Multi Criteria Analysis Scores

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.