Large scale desalination projects in Australia: An overview and lessons learned

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TCTA

A new word for water

Overview

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2. Gold Coast Desalination Plant, Brisbane
3. Port Stanvac Desalination Plant, Adelaide
4. Kwinana Desalination Plant, Perth
5. Southern Desalination project, Perth
6. Lessons learned
7. GWI's "Top Ten Desalination Disasters"
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Rationale and Context

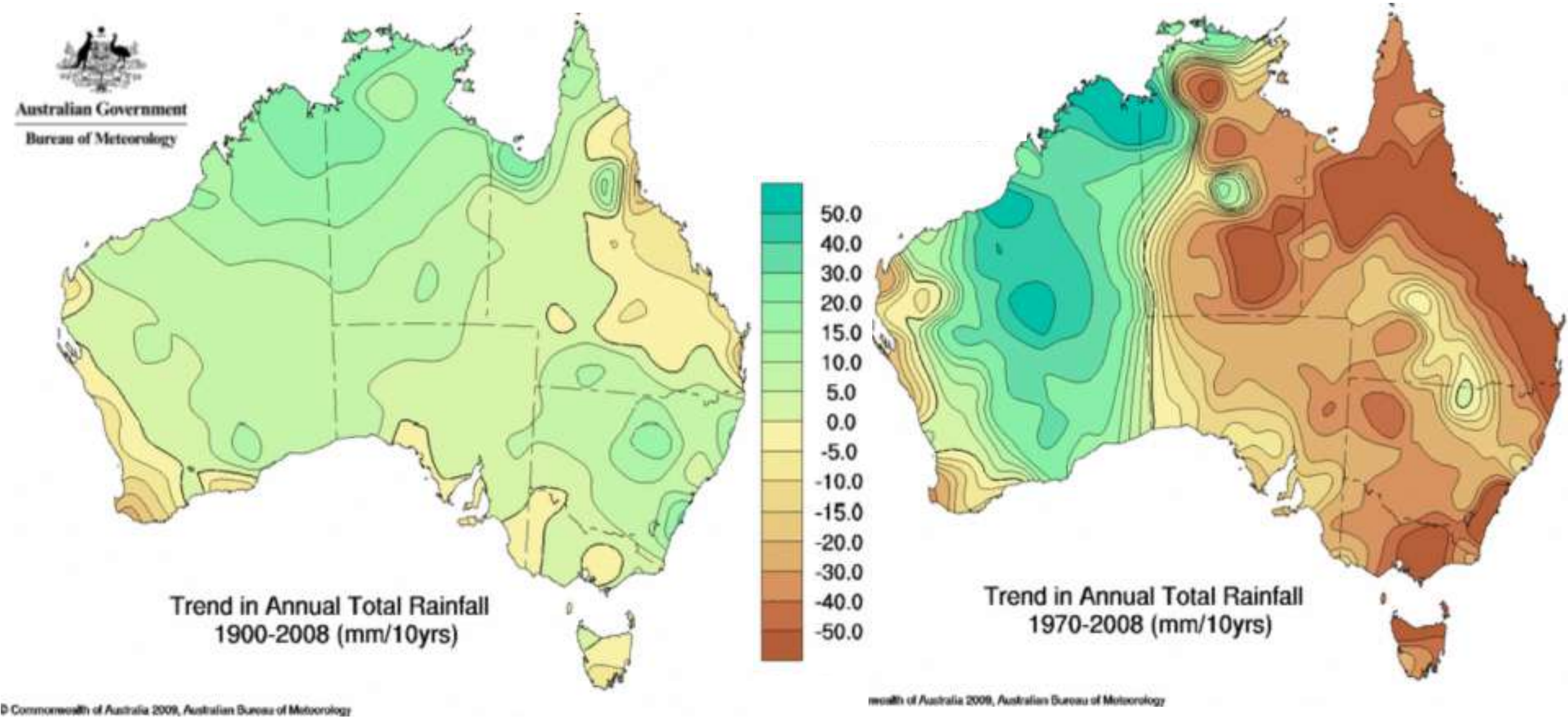
- DWA “recognizes desalination of a variety of waters as an important current and future source of water”
- The National Desalination Strategy earmarks TCTA for roles in financing and implementation of large-scale desalination projects, and for hosting a centralised hub of knowledge in this field.
- TCTA has committed to establish the said knowledge hub.

Rationale and Context

During June 2012, TCTA visited Australia and Singapore to study large scale desalination and reuse projects, and water resilience in general.

Rationale and Context

Why Australia? Massive drought 2003-2010 – “The Millennium Drought”. Since 2006, they have launched 6 major desalination projects, in 5 cities.



Rationale and Context

Aim of the study tour: To gain a broad learning of the key elements of large-scale desalination projects, inter alia:

- Considerations relating to **feasibility** and **site selection**.
- Considerations around **institutional arrangements** and **procurement processes**
- **Financing** options
- Regulatory approval and environmental considerations

Gold Coast Desalination Plant (Brisbane)

Gold Coast Desalination Plant (Brisbane)

Project considerations	Prolonged drought and high rate of population growth. Queensland Government decided to establish a climate-independent water resource.
Site selection considerations (Tugun)	• Least environmental impact – site was already disturbed, previously used as a landfill • Lowest NPV of shortlisted sites • Sufficient power supply was available at short notice

Gold Coast Desalination Plant (Brisbane)

Type	Sea Water Reverse Osmosis (SWRO). Project covers 6 ha.
Capacity	133 Ml/d, expandable to 167
Capital Cost	R9.15 billion
Completion date	Operational Feb 2009, handed over to Qld State in Oct 2010 (Brisbane was flooded in Jan 2011…)
Institutional arrangement	A 10-year DBO contract

Gold Coast Desalination Plant (Brisbane)

Bulk water utility	Seqwater
Contractor	The Gold Coast Desalination Alliance (Veolia Water, John Holland, Sinclair Knight Merz and Cardno).
Marine and other works	1.5 km marine intake and outlet tunnels (2.8 metre inner diameter, reinforced by six segment rings, 200mm thick, made from steel and fibre reinforced concrete), a 25km pipeline to connect the Seqwater grid, a 1.9 kl/s pump station, a 125 Ml potable water reservoir.

Gold Coast Desalination Plant (Brisbane)

Process train	Pre-treatment: 3mm screen filters, coagulation and settlement, coal and sand media filters. RO: Dual pass, to remove Boron and bromides. Re-mineralised with lime and CO_2. Disinfected by Chlorination. Fluoride added.
Specific power consumption	3.58 kWh/m^3
Energy recovery	One dual-work exchanger energy recovery (DWEER) device per RO train, 97% efficiency
Key contractors / designers	Halcrow: Marine works. Bosfa: Tunnel segments. BlueScope Lysaght: Plant cladding. GHD: Plant preliminary design.

Gold Coast Desalination Plant (Brisbane)

Issues
Issues relating to quality and specification were detailed in a report by WaterSecure to Qld Govt in July 2009. **Plant life expectancy may be compromised**. Issues included: • Methane releases from the landfill site • Numerous corrosion issues • Leakages due to pipe thread incompatibility • Sub-standard materials, and poor application of “value-engineering” solutions • Excessive vibration of energy-recovery devices • Contaminated groundwater intrusion due to poor civil works. • No proof that marine tunnel can be drained, due to concerns over the quality of marine works.

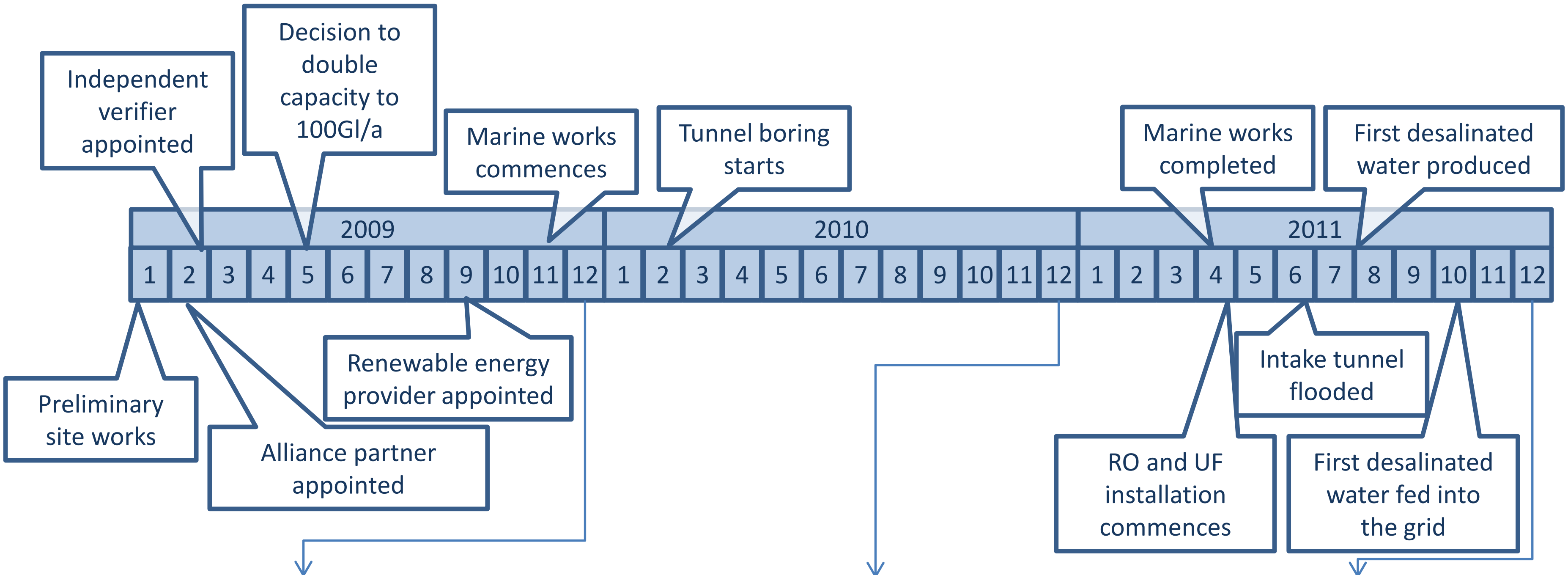
Gold Coast Desalination Plant (Brisbane)

Energy recovery device braced against the plant building structure

Evidence of early onset corrosion

Port Stanvac Desalination (Adelaide, South Australia)

Port Stanvac: Milestones & Progress



Port Stanvac Desalination

Project considerations	Historic reliance on surface water resources (River Murray and the Adelaide Hills catchment area): about 200 Gl/year. During 2006-2009 this yield dropped to <50 Gl/year. 2006: Desal Working Group established 2008: Decision to double capacity to 100 Gl
Site selection considerations (Port Stanvac)	• Accessibility of relatively deep seawater • Optimal marine dispersion characteristics • Good access to the water supply network • An industrial site

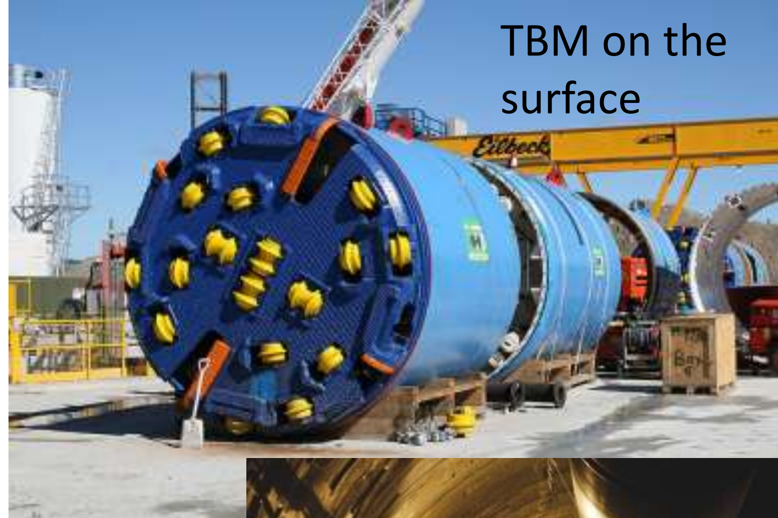
Port Stanvac Desalination

Type	Sea Water Reverse Osmosis (SWRO) + 13 km transfer pipeline. Site footprint is 32 ha.
Capacity	Initially 50 Gl/a, now being expanded to 100 Gl/a (about 300 Ml/d). Will supply about 50% of Adelaide's current demand.
Capital Cost	About R15 billion (A$1.83bn)
Completion date	Dec 2012 (to 100 Gl)
Institutional arrangement	Funded and owned by SA Water, as lead agency of the State. DBOM procurement approach (TCTA has obtained an overview of the contractual arrangements).

Port Stanvac Desalination

Bulk water utility	South Australia Water (SA Water)
Contractor	D&B contract awarded to AdelaideAqua D&C Contractor (A joint venture of McConnell Dowell, Abigroup and Acciona. 20-Year O&M contract awarded to AdelaideAqua (JV of Acciona and Trility).
Marine and other works	2.4 km of tunneling took 40 weeks, two TBM’s. Intake is 1.4 km offshore. Nov ‘09, jack-up barge Santa Fe started vertical work. Feb ’10 boring started. Completed May ’11. Feed water pumped 60m vertical to plant.


Santa Fe jack-up barge



TBM on the surface


TBM being lowered into position


Completed intake tunnel


Santa Fe being towed away after completion of works

Port Stanvac Desalination

Process train	Pre-treatment by 3mm screening, 0.1 mm disk filters, then 0.04 micron Ultra-filtration (UF). RO: Cartridge filters, then Acciona RO, <48.5% recovery. 56-70 bar pressures. Post treatment by Lime, Fluoride, Chlorine and CO_2.
Specific power consumption	Predicted it will be in the range of 3 to 3.5 kWh/m^3
Energy recovery	Rotor-type. Used to pressurise 50% of the feed water for RO, with aid of a small booster pump.
Key contractors / designers	Plant design: Woodhead architects Engineering design: SMEC Technical studies and investigations: Aurecon

Port Stanvac Desalination

Issues / Observations

- Project characterised by robust approach to procurement, consistent political support and intensive community involvement.
- An interpretive centre (below) allows public education.
- Robust approach to transparency and public communication.
- Appears to have avoided many of the earlier mistakes.

Kwinana Desalination (Perth 1)

Kwinana Desalination (Perth 1)

Project considerations	Long-term decline in surface water yield was evident by 2005: ‘74-’97 average of 161 Gl/a had declined to an average of 115 Gl/a for ‘97-’04. Twelve new bores and two new dams added 40 Gl/a to supply, but Water Corp adopted a strategy to diversify. Desalination construction tender awarded in Apr 2005; the first large-scale desalination project in Australia.
Site selection considerations (Kwinana)	• An established industrial site, with adequate electrical infrastructure • Yet, Cockburn Sound is environmentally sensitive, resulting in extensive impact studies and on-going monitoring.

Kwinana Desalination (Perth 1)

Type	Sea Water Reverse Osmosis (SWRO). Site footprint is 4 ha.
Capacity	45 Gl/year or 144 Ml/day, expandable to 250 Ml/day.
Capital Cost	A$387 m (~R3.16 billion) in 2006
Completion date	Nov 2006
Institutional arrangement	Owned by Water Corporation. An alliance arrangement, but separate contracts for D-B and O-M.

Kwinana Desalination (Perth 1)

Bulk water utility	Water Corporation
Contractor	D-B by the Multiplex Degremont JV, and O-M by an alliance between Degremont and Water Corporation. Term 25 yrs.
Marine and other works	An open intake (no tunnel), designed and built by RPC Technologies. Intake and discharge piping were assembled on shore in 6m lengths, and jacked through sheet piling to approximately 150m offshore. The remaining piping systems were then assembled in 50m flanged lengths and jointed underwater using divers.

Kwinana Desalination (Perth 1)

Construction of the sheet piling.

Kwinana Desalination (Perth 1)

Construction of the sheet piling.

Kwinana Desalination (Perth 1)

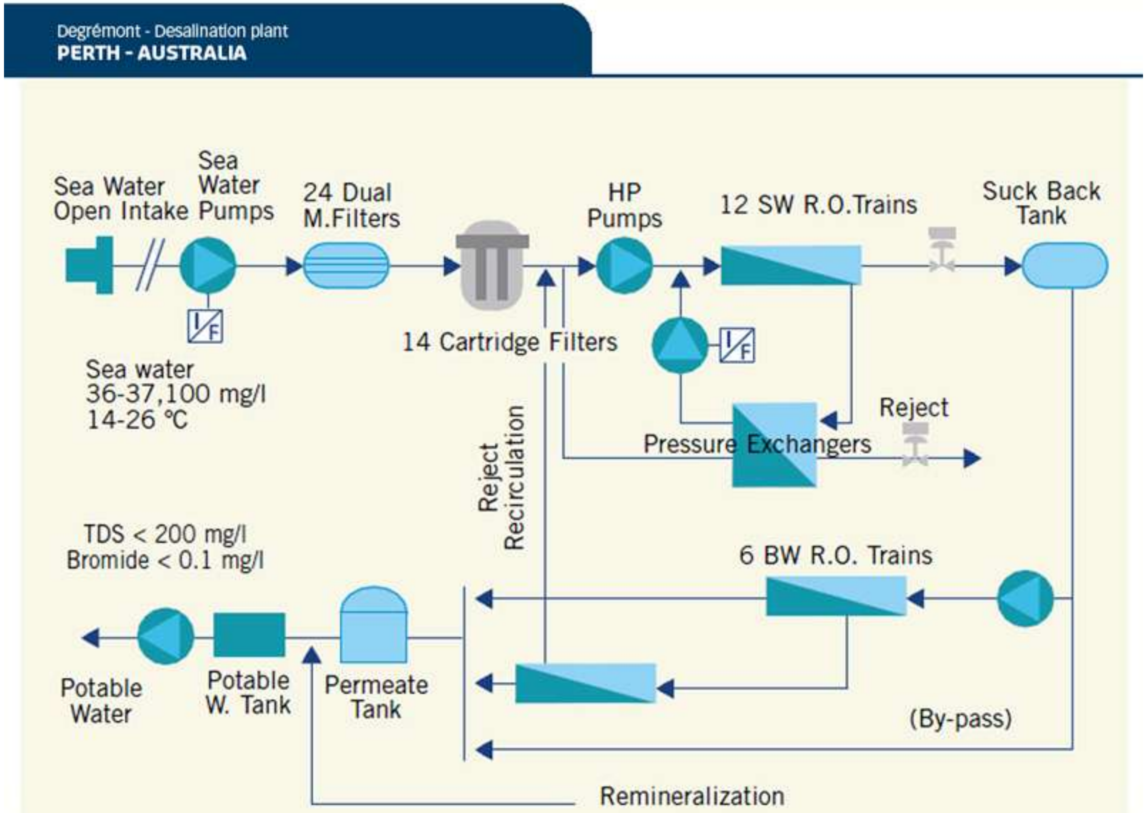
Intake and discharge piping
being assembled on shore

Kwinana Desalination (Perth 1)

Pipe sections being placed on sea bed, and jointed by diving crews.

Kwinana Desalination (Perth 1)

Process train	**Pre-treatment:** Screens, then dual media filters, then cartridge filters. **RO:** 12 Trains 1st pass with PX rotor energy recovery devices, assisted by booster pumps. 6 Low pressure trains 2nd pass. **Post treatment:** Hydrated lime, gaseous chlorine and CO_2



Kwinana Desalination (Perth 1)

Specific power consumption	2.2 kWh/m^3 for RO only, then 1 - 1.3 kWh/m^3 for pre/post-treatment and pumping to storage, hence 3.2 - 3.5 kWh/m^3 overall.
Energy recovery	12 Arrays of 16 ERI PX rotor-type devices. Captures 98% of the hydraulic energy from the 1st pass brine, and aided by a small booster pump, contributes to the 1st pass input.
Key contractors / designers	Mechanical installations: McConnell Dowell Lime systems: Transmin Energy supplier: Western power

Kwinana Desalination (Perth 1)

Issues / Observations
• Relatively problem-free project • Became Perth’s single largest water source (17%), upon completion (will be surpassed by the Southern plant). • Western Australia is a largely arid region, with a long history of water constrains. It appears that public acceptance of desalination was relatively easy. • Project is characterised by setting the standard for environmental approval procedures, and a very intensive on-going ocean monitoring programme.

Southern Sea Water Desalination Project (SSDP or Perth 2)

Southern Desalination (Perth 2)

Project consider-ations	Evidence of a 20% reduction in average rainfall, and a 60% reduction in run-off over the past decade. With "Perth 2" the aim is to "drought-proof" Perth - this plant will take the reliance upon desalinated water to 50%. Together with groundwater, Water Corp. will be independent of surface water for next 10 yrs.
Site selection consider-ations (Binningup)	• Site was already disturbed (a quarry) • Good proximity to the water grid • Open coast line, allowing better brine dispersion • An 8 m high sand mound was created to shield noise and light from nearby settlement of Binningup.

Southern Desalination (Perth 2)

Type	Sea Water Reverse Osmosis (SWRO). 100 yrs design life, 25 yrs on mechanical and electrical equipment. Site footprint is 40 ha. Other components: A 28 km, 1.4m dia. pipeline to 4 new summit tanks at Harvey (A$30m), and a 2 km pipeline from the tanks to Harvey-Stirling trunk main (A$30m).
Capacity	Ph1: 50 Gl/yr, Ph2: another 50 Gl/yr (A total of 290 Ml/day)
Capital Cost	Ph1: A$955m, Ph2: A$450m, Total A$1.4 bn (~R11.44 bn)
Completion date	Ph 1: Sep 2011, Ph 2: Dec2012

Southern Desalination (Perth 2)

Institutional arrangement	Owned by Water Corporation. A "competitive alliance contract" approach was followed. One contractor selected to build and run the plant for 25 years. Strong emphasis on knowledge transfer.
Bulk water utility	Water Corporation
Contractor	The Southern Sea Water Alliance (Tecnicas Reunidas, Valoriza Agua, AJ Lucas and WorleyParsons).

Southern Desalination (Perth 2)

Marine and other works	Tunnelling was selected to minimise marine impact and beachfront disturbance. Design involved two intake and one outfall tunnels, each 860 m long, with 2 “velocity cap-type” concrete intake structures, 10x13m, each weighing 400t. When drilling was done, the two 150t TBM’s were retrieved from the sea bed. A 330m long, 1.6m dia. HDPE pipe was sunk into a trench to extend the outfall.

Southern Desalination (Perth 2)

Lowering the TBM into the Intake Pump Station

Southern Desalination (Perth 2)

Installing the velocity cap intake structures (risers), using a heavy-lift barge

Southern Desalination (Perth 2)

Process train	**Pre-treatment:** Screens, micro-filtration. **RO:** Dual pass, using split hybrid RO elements from Dow Water & Process Solutions. **Post treatment:** Hydrated lime, gaseous chlorine and CO_2

Specific power consumption	Could be <3 kWh/m^3
Energy recovery	Isobaric energy recovery devices from Energy Recovery Inc (ERI)
Key contractors / designers	Marine works: Dempsey Australia Tunnelling: Zublin Australia Intake pump station structure: GFWA

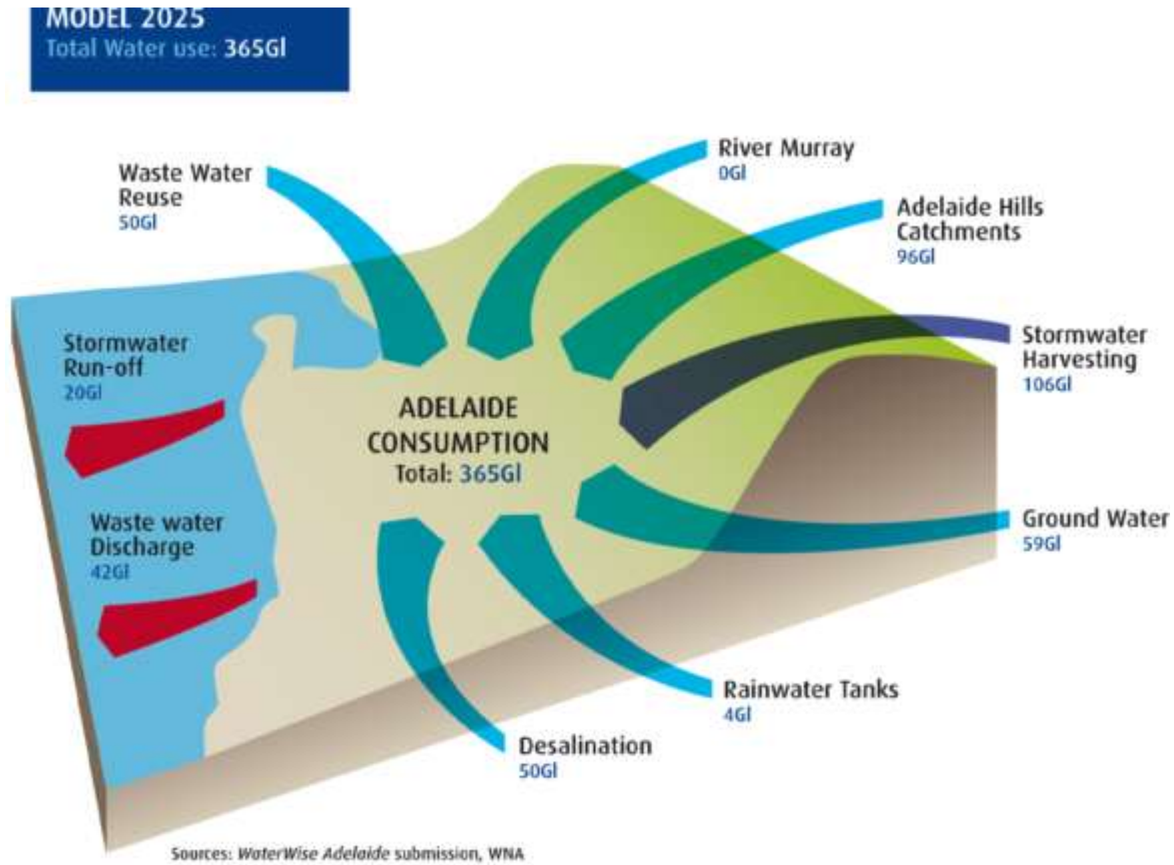
Southern Desalination (Perth 2)

Issues / Observations
• Many lessons from Kwinana were taken into SSDP Ph1, and then from Ph1 into Ph2. • Engagement with the affected community was exemplary • The “competitive alliance” procurement approach appears to yield very positive results.

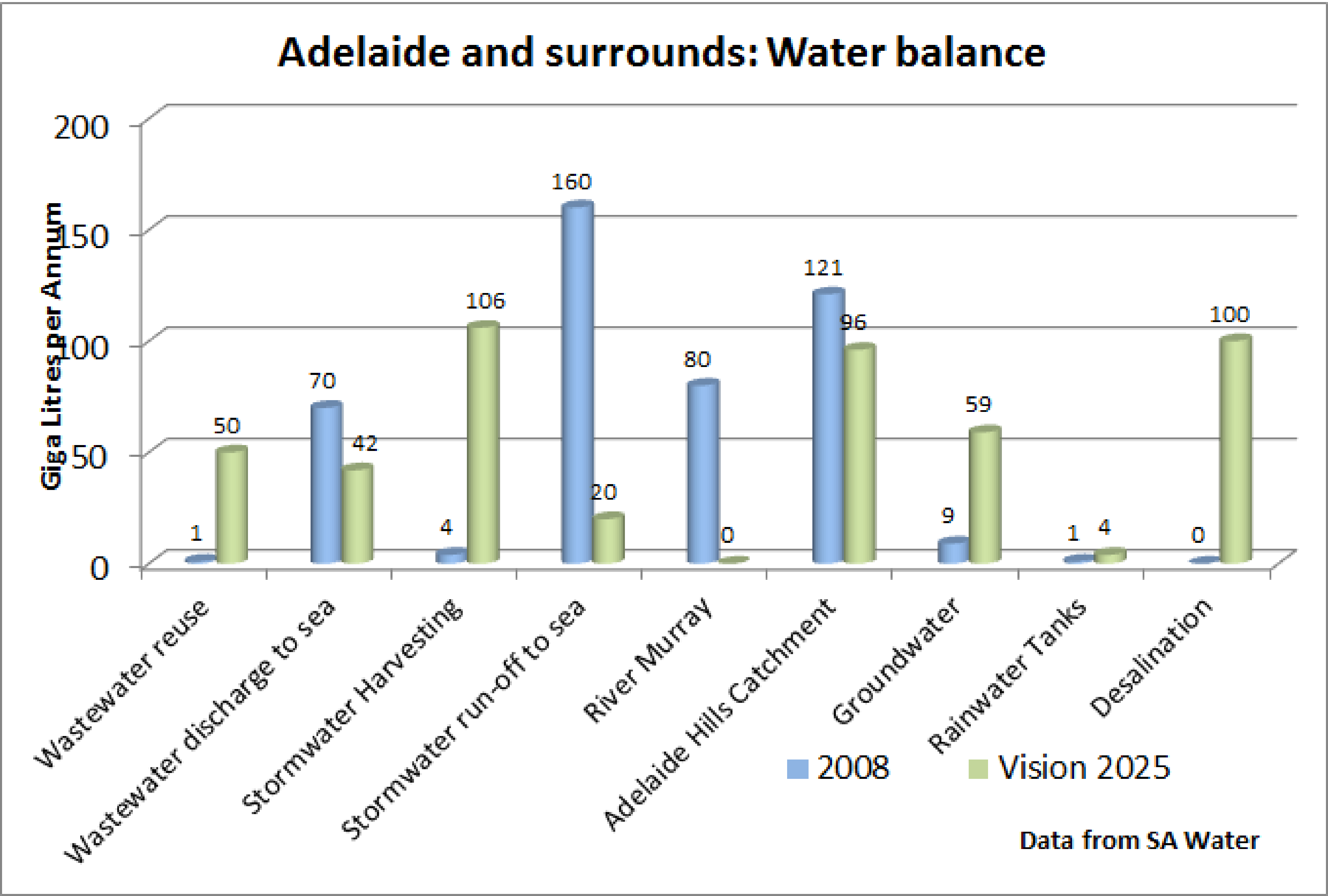
Lessons Learned

1. Water Resource Diversification:

Develop a portfolio of reliable water resources, including sea water desalination and/or wastewater reuse, to minimise the dependence upon surface resources (i.e. establish climate independence).



Adelaide water resource diversification: Vision towards 2025



Lessons Learned

2. Prioritise Wastewater Reuse:

Where possible, pursue wastewater reuse options first:

- Much lower capital and operating costs;
- “Fit-for-use” principle: Recycled water can substitute potable water through dual reticulation systems or irrigation schemes;
- Consumer education is essential.

Lessons Learned

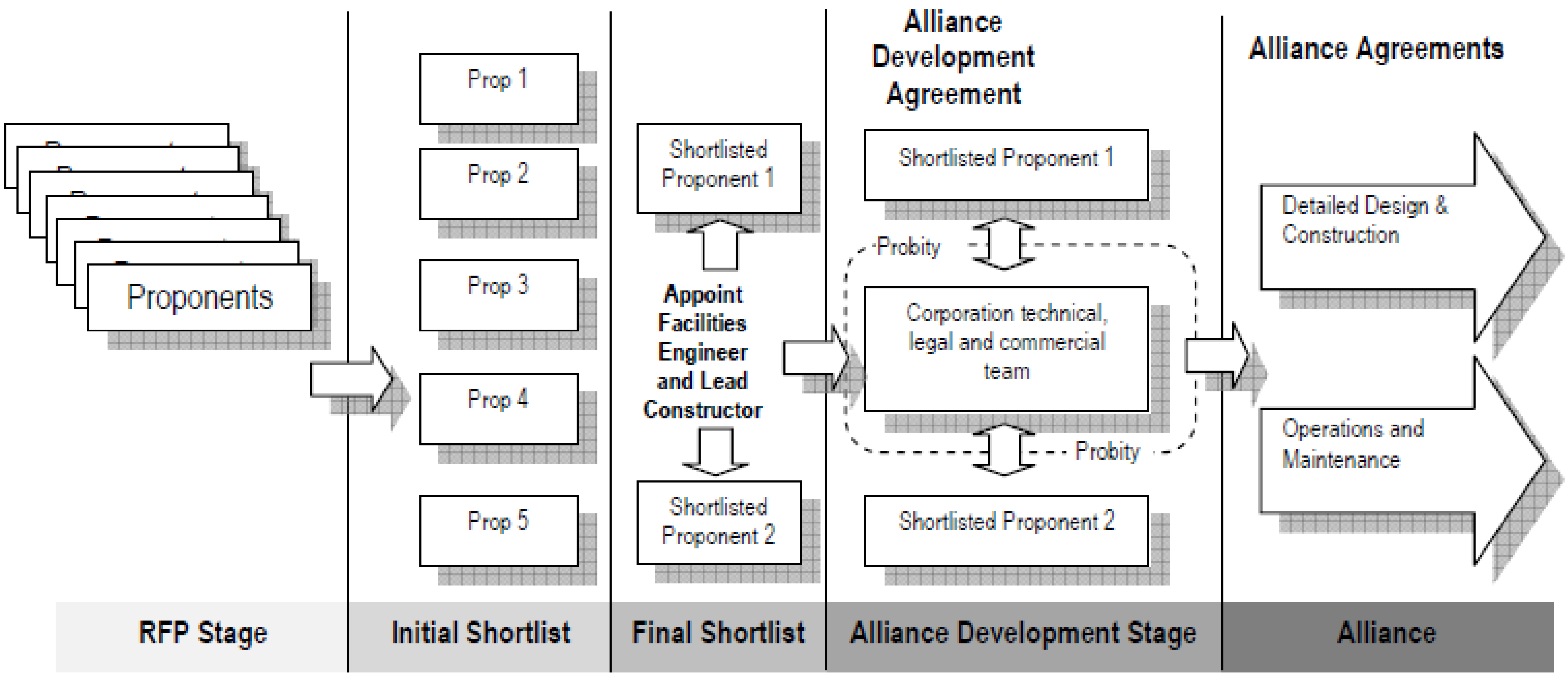
3. Procurement models:

<table>
<tr><th>Risk from agency perspective:</th><th>EPC contracts</th><th>Alliance (Favoured by the Australian projects)</th><th>BOT Concession</th></tr>
<tr><td>Capital efficiency</td><td>High. Instances of contractors bidding low, but recovering margins on project variances are escalating. Requires robust spec and contracting.</td><td rowspan="2">Moderate, but can be mitigated through the transparency and risk-sharing of the alliance structure. Essential that agency be knowledgeable and hands-on.</td><td rowspan="2">Moderate. In extreme cases, the risk of the concession-holder failing, would be a concern.</td></tr>
<tr><td>Operational efficiency</td><td>High. Design and engineering flaws can curtail plant life-span, supply consistency and marginal cost of product.</td></tr>
<tr><td>Demand-side risk: Off-take not sustained</td><td colspan="2">Very high, and seems to materialise often.</td><td>Demand-side risk transfer may not be feasible</td></tr>
</table>

Lessons Learned

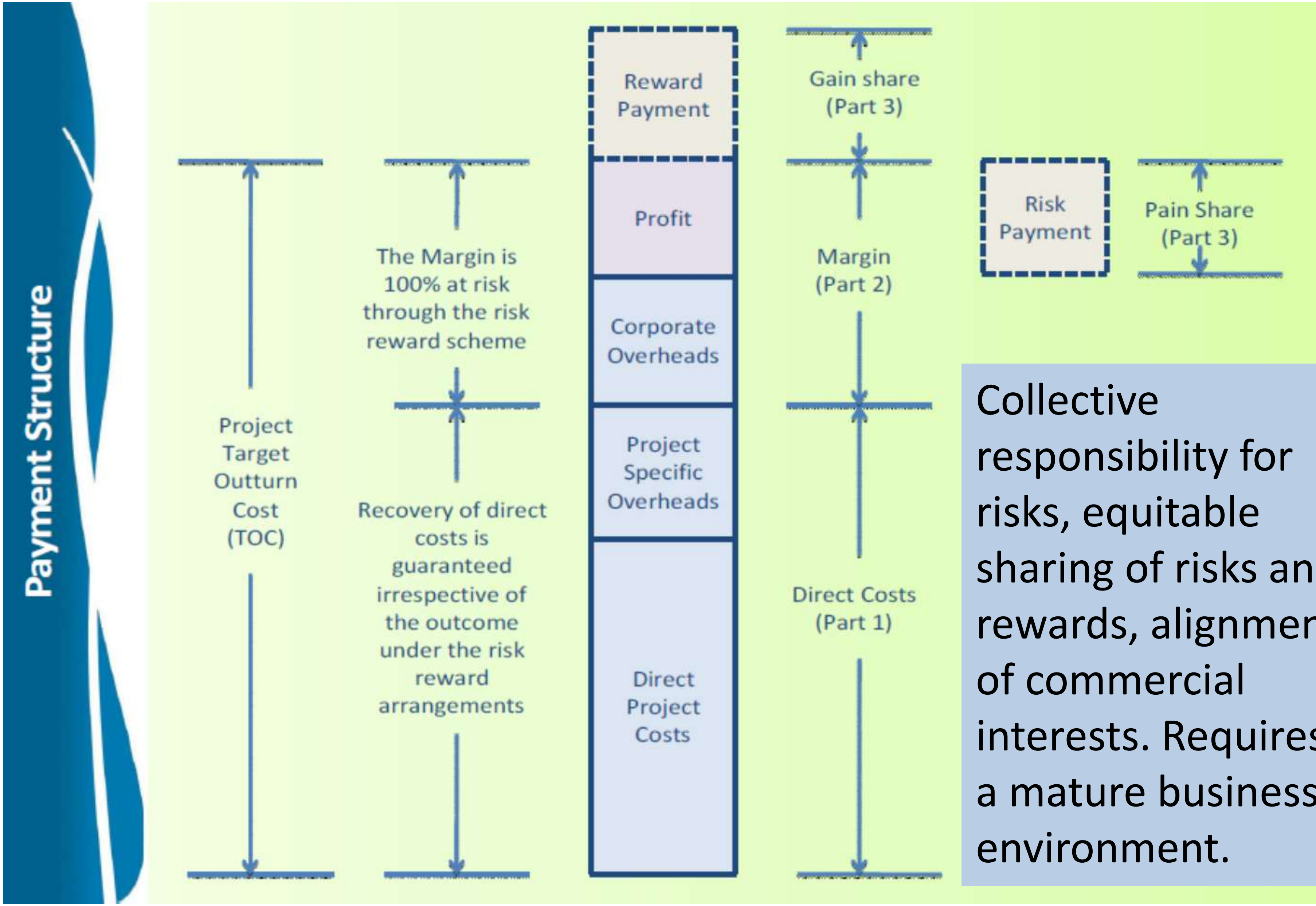
3. Procurement models (Cont.):

Australian projects favoured an "Alliance" approach, through a "Design, Build, Operate, Maintain" (DBOM) model. **Rigorous evaluation and dual-stage elimination of competitive bids**:



Lessons Learned

3. Procurement models (Cont.): The alliance philosophy



Collective responsibility for risks, equitable sharing of risks and rewards, alignment of commercial interests. Requires a mature business environment.

Lessons Learned

4. Stakeholder Management and Public Participation:
Extremely important - desalination projects often attract fierce criticism on grounds of (inter alia) environmental concerns, tariff escalations and conflicting priorities.

An approach based on the following seems effective:

- Engage and consult
- Educate: Promote science, not quasi-science
- Be transparent
- Communicate often and clearly
- Listen, respond and act

Lessons Learned

5 Site Selection: Complex considerations with a long-term impact:

- Proximity to power, water and transport grid
- Site elevation
- Comprehensive and extended period of sea water characterisation
- Prior utilisation of site
- Geo-technical survey
- Characterisation of off-shore currents

All implications are quantified and modelled for NPV comparison.

The Port Stanvac site, prior to construction.

The Southern site (Perth 2, near Binningup) prior to construction.

Lessons Learned

6. Design and Engineering:

- Know and understand the available technology, and how it suits the specific project (e.g. matches the feed water characteristics), when going to the market.
- Metallurgical specification and "value engineering" solutions should be implemented with caution.
- Sub-standard civil works, especially on marine intake structures, are very hard to remedy later.

Lessons Learned

7. Achieving Value for Money:

- Capital and operational efficiency can vary, depending on how well the project is designed and executed.
- Site selection, permitting/approval, appropriate specifications, alliance partner selection, community engagement and diligent procurement are all key factors.
- Benchmarking demonstrated how some of the later Australian projects achieved greater efficiencies, learning from the mistakes of the earlier projects:

Project Capital Efficiency Benchmark

	Installed Daily Capacity	Installed Annual Capacity	Cost in dollars (millions)	Capital Efficiency $'millions / GL installed capacity
	MLD	GL	AUD millions	
Victorian Desalination Project	435	146	5,500	$37.74
Gold Coast Desalination Project	125	42	1,200	$28.66
Sydney Desalination Project	250	84	1,900	$22.69
Southern Seawater Desalination Project (Perth 2)	140	47	955	$20.36
Adelaide Desalination Project	300	101	1,824	$18.15

Government of South Australia

SA Water

Project Operational Efficiency Benchmark (with Renewable Energy)

	Installed Daily Capacity	Installed Annual Capacity	Operating Cost per annum (millions)	Operating Efficiency $'millions / GL produced
	MLD	GL	AUD millions	
Victorian Desalination Project	435	146	600	$4.11 **
Sydney Desalination Project	250	84	258	$3.07
Adelaide Desalination Project	300	101	129.9	$1.29

Government of South Australia

SA Water

GWI's Top Ten Desalination Disasters

Rank	Project	Comment
1	Wonthoggi, Australia	$1bn additional EPC costs
2	Hong Kong MSF	A big stand-alone MSF which never ran
3	Carboneras, Spain	Farmers failed to pay for the water
4	Tampa Bay, Florida	Foul-up on the EPC contract
5	Carlsbad, California	Nearly a decade in permitting
6	Ad Dur RO, Bahrain	Pre-treatment failure
7	Point Lisas, Trinidad	EPC costs spiral, and parties dispute
8	Santa Barbara, California	Rained off
9	Jeddah 1 MSF, Saudi Arabia	"Acid attack"
10	Palm Jumeirah, UAE	Demand miscalculation

"…the biggest risk in the desal business is not technology or operations – it is on the demand side. If a water agency contracts a desalination plant it does not use, it ends up wasting a whole lot of money, no matter what happens." (Christopher Gasson, GWI Publisher, Oct 2012)

Conclusions

- South Africa will enter the large-scale desalination market probably within the next 3-5 years (AMD may be sooner). Our understanding of such projects, and the capacity to procure them, needs to be developed now.
- Even in advanced environments, and despite mature technologies being employed, expensive lessons are still being learned. Our challenge is to anticipate and avoid such lessons locally.
- Our study of both failures and successful projects will continue, and culminate in a knowledge hub.

Questions?

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