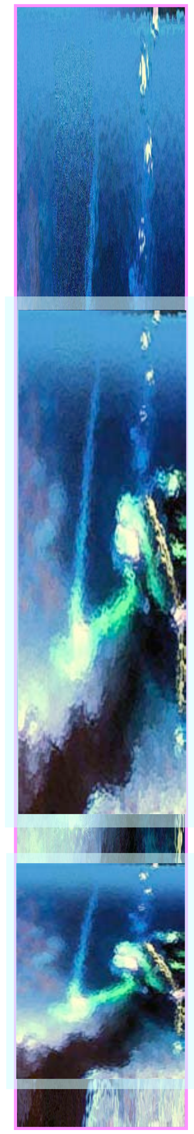

FRESH WATER CRISIS

NOVEL TECHNOLOGY TAILORED FOR AUSTRALIA

Preliminary Financial Draft Overview

December 2004

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OVERVIEW

I n t r o d u c t i o n

1. Preamble

The improvement of water quality is the greatest environmental challenge nations are facing today. Untold financial resources are currently devoted to achieving the priority of ensuring the sustainable use of water, to improve water quality and to combat the threat of scarcity.

Global modellers assume that there are ways to increase the water limit by using technical measures (storage facilities and desalination) as well as some non-technical solutions like bringing people closer to the water or water closer to the people. However, many of these concepts are not feasible today. There is much opposition to constructing any more dams, desalination is still very costly and unaffordable for the most of the world, and the other two options for relocating population or providing long distance transfer (export) of water result in many social problems.

While addressing water-related problems, it is important to see water as a regional, not a global resource. It requires the application of new scientific, technical and engineering knowledge. Creating partnerships and undertaking developments attuned to regional conditions are thus essential.

2. Australia

Australia is a sophisticated, modern economy, with a Government aware that innovation is imperative to secure its future prosperity.

Australia also presents a good example of scarce water and over consumption, in a global worldwide water crisis. Much of its landscape has critical salinity and water quality problems that need urgent action. More alarming, its groundwater is likely to be endangered by blind operations on a still illknown underground system, threatening this important strategic resource. Since growth is unsustainable without water availability, Australia must reverse this dramatic present situation by turning to new sources of fresh water, and improving both water management and the way it handles underground water resources.

Although these problems are severe, Australia has the potential, experience and will to change the present course of events. It also benefits from exceptional coastal assets. A new technique exists overseas, not implemented yet in Australia. It appears to be the right process as part of a strategy to substantially overcoming this two-fold scourge of drought.

3. A Novel Technology

A team of French scientists has scored a first by harnessing a source of fresh water 36 meters below the Mediterranean sea, half a mile from the coasts on the Franco-Italian border (July 2003). They are now successfully implementing the technique in the Mediterranean basin (France, Italy, Spain), with exploitations under development in the Middle East littoral.

The process not only provides access to new sources of fresh water, it also enables monitoring the operations of the underground systems, which is of paramount significance. The technology can be reproduced in Australia, knowing that fresh water resurgences at sea exist everywhere in the world where areas of limestone and carbonated mounts border the coasts (such as Australia, Vietnam, New Zealand, for a few).

The technique aims at exploring and operating sub-sea springs located on the littoral, thus capturing a portion of groundwater that naturally discharges at sea from the deep aquifer, getting lost in the ocean. The process is not to be compared to offshore oil extraction; it is much less intrusive, simple and low cost. The expected flow rate ranges as an average from 80 to 150 litres a second; the head flow (0.5 to 1 m^3/sec.) is monitored at will, and risks of contamination avoided.

These submarine springs gush in shallows (usually 40 meters depth) within a few miles from the coasts. They can be detected through aerial and maritime surveys, by thermic and acoustic means (fresh water is cooler and less dense than sea water; it does not mix and rises towards the surface). Once localized, the spring is assessed to determine its potential for operation. The flow is harvested, thrust upward through a capturing unit by Archimedes' principle (no pump is required). After complete operation, a pipeline installed in the seabed can bring water to shore for commercial exploitation; it can connect to the existing distribution network or a treatment plant, according to the quality of the water (a slightly brackish water is perfectly good for agricultural use and mixed with water from other sources it is drinkable too).

The process is innovative, operative and low cost (four to twenty times less costly than desalination [(1)]). It also constitutes a world first in understanding the still unknown discharge phenomenon and monitoring the underground operations; the technique then responds CSIRO[(2)] Government Interactions priorities. Full operation can be complete over one year, possibly less (depending on seasonal variations); installation of the tapping device requires ten days of careful work (at 40 meters depth). Besides, the technique is safe for the environment, non intrusive and brings a renewal of lively marine activity in the restored salinity. By respecting and adopting the characteristics of nature –such as adaptability, diversity and creativity– tapping sub-sea springs appears to be thus truly sustainable.

4. A Unique Opportunity for Western Australia

This new technology offers a unique opportunity for marketing and investment development activities in Australia.

The process can have the support and backing of stakeholders. Exploiting offshore fresh water addresses the water issue locally while allowing a gain in technology benefiting the States. It also enables the management of groundwater in coastal systems, one of the key issues of the NRM[(3)] Policy and Research priorities. Financial evaluation is only one element of a comprehensive evaluation of the option. For councils, many actions are aimed at delivering social or other non-financial outcomes; an offshore plant meeting financial as well as social criteria is likely to create a strong case for adoption.

The management program can also be considered attractive investments for an independent entrepreneur. The risk is low because we can be relatively confident about the return (as long as the tapping equipment continues to operate, the savings will be realised); and we can calculate the potential savings relatively accurately (based on projected water prices and past experience of water potential). The annual return on funds invested should be appreciably above the cost of capital, due essentially to a relatively low investment within a highly favourable regulatory framework (the extraction of fresh water from submarine springs appears to be covered by a West Australian law, the *Mining Act 1978*).

The financial attractiveness of investing in this innovative technology fully appears when considering all the costs and benefits, not expecting investments to pay for themselves too quickly, and considering risk as well as return. Once first demonstrated with a pilot plant in a growing urbanised agricultural area, such as the South West region, the project could replicate along the West coast and nation-wide. Meanwhile it could provide valuable means and markers to scientists and benefit from Research funding. Developing such a technology could also engage the entrepreneur on the humanitarian scene and UNESCO's milieu. Western Australia would then demonstrate that sustainability is the right balance between innovation, planning and preservation of the general organization, and lead the way.

Elements for Evaluation

To evaluate the financial attractiveness of the project, investors may begin with estimates of:

- the project's capital cost,
- projected output, and
- annual revenues, expenses, and deductions.

And they may also wish to prepare:

- a pro forma earnings statement,
- debt redemption schedule, and
- statement of after-tax cash flows.

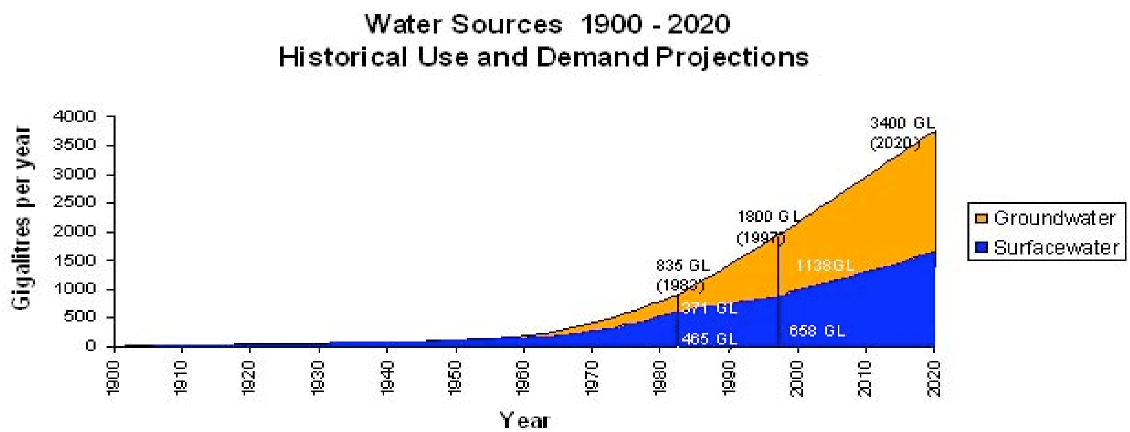
Annual after-tax cash flows could be then compared to initial equity investment to determine available return. For another perspective, before-tax, no-debt cash flows might also be calculated and compared to the project's total cost.

Financial evaluation is only one element of a comprehensive evaluation of the option.

Resources Unsustainable Development

Australia has one of the world's largest aquifer systems, the Great Artesian Basin (GAB) which covers an area of 1,7 million sq.km and has a storage volume of 8,700,000 GL. Each year the GAB currently supplies 570 GL of water for a variety of uses dominated by pastoral enterprises.

A study was undertaken by the Australian Academy of Technological Sciences and Energy (AATSE). This was published in 1999 and examined current and projected water usage in Australia based on 18 regions and 55 industry groups.



It was concluded that if *"these outcomes are measured against regional water availability, it is clear that such growth is unsustainable in some areas."(…)*

With specific reference to the South West of Western Australia, the projected needs will be very difficult to achieve, as it would require actions such as the diversion of southern-flowing rivers, discovery of new groundwater sources, and reallocation of water from pasture irrigation to urban, mining and industrial uses.

Western Australia

Western Australia is the largest state in Australia, with an area of 2,5 million sq.km and a population of 1,8 million. It occupies one third of the continent but it is inhabited by less than one tenth of the population. 85% of the population resides in the Perth Coastal Plain. Compared to WA's neighbouring state, South Australia, it has better levels of rainfall and runoff. However, because of extensive clearing of land for dryland agriculture (such as growing of wheat and other grains and sheep farming), many of the larger rivers in the State have become brackish or saline.

"The last major divertible surface resources close to the Perth – Bunbury axis have now been developed and all that remain are a number of rivers that flow into the Southern Ocean. These rivers have high conservation values."

This legacy has a major impact on the option of being able to divert any more freshwater resources to meet WA's future projected needs. Accordingly, since the mid 1980s a growing proportion of both private and public water use has come from ground waters, through accessing aquifers on the coastal plain.

Regulation framework

The extraction of fresh water from submarine springs appears to be covered by a West Australian law, the *Mining Act 1978*. Even though the Federal Government has jurisdiction over all offshore areas, following a 1975 High Court case, subsequent reciprocal arrangements between the States and the national government mean that each State is responsible for management for exploration and extraction of resources in offshore areas up to the edge of the continental shelf.

Section 25 of the Mining Act 1978 deals with mining on the seabed, extending from *"the mean low water springs level of the sea and the seaward limits of the territorial waters of the State"*. It sets out the process of consultation to be undertaken before approval will be given, that requires the Ministers responsible for the *Fish Resources Management Act 1994*, the *Marine and Harbours Act 1981*, the *Land Administration Act 1997* and the *Environmental Protection Act 1986* must to be first consulted before mining can be approved.

Water Industry in WA

The Government of Western Australia has prepared 'A State Water Strategy' to ensure a sustainable water future for the State. The Ministerial Taskforce on Water is ultimately responsible for the coordination of all water strategy in Western Australia.

The Water Taskforce is chaired by the Premier's Chief Policy Adviser. It includes the Project Director State Water Strategy, representatives of Government Agencies involved in the State Water Strategy (Department of the Premier and Cabinet, Department of Environment, Water Corporation, Department for Agriculture, Department for Health), and Ministers' Water Advisers.

The Water Taskforce reports on a regular basis to the Premier's Water Cabinet Sub Committee (Premier, Ministers for the Environment, Government Enterprises, Finance and Energy, Agriculture, Planning and Infrastructure). The State Water Strategy implementation Unit oversees and co-ordinates the tasks of the Strategy Management Report with Government Agencies and advisory groups.

The Water Industry in Western Australia comprises:

- The Economic Regulation Authority (Water Division) that regulates and licences the provision of water services.
- The Water and Rivers Commission that manages and protects natural water resources.
- Utilities such as the Water Corporation, Aqwest and Busselton Water Board that provide water services to customers. (The Water Corporation is the largest licensee which services around 96% of the water service market.)
- The Office of Water Policy that provides advice to the Industry Minister (Minister for the Environment) on water industry policy and high level strategic planning.

The process of harvesting sub-sea fresh water springs has been revealed to the different stakeholders in the course of 2004. Supportive responses have followed, with relevant technical hydro-geological data.

Perth Region Groundwater

Over 50% of the water supplied to the Perth area comes from groundwater supplies.

In the Perth region, part of the Swan Coastal Plain, the superficial aquifer is on average about 50 meters thick. The Gnangara mound occurs to the north of city (between the ocean, the Swan River, Ellenbrook and Moore River and centred about 15 kilometers north-east of Wanneroo), and the smaller Jandakot mound occurs to the south (between the ocean and the Swan, Canning and Serpentine rivers).

Below the superficial aquifer, there are a number of confined aquifers, the largest and most extensive of which are the Leederville, which is typically several hundred meters thick, and the Yarragadee, which is often greater than 1,000 meters thick.

Coastal aquifers

The coastal aquifers[4] are important strategic resources for the future. They are, however, fragile in their environment and require the application of specific water-management techniques.

The widespread karst aquifers along the South West coast seem to be under-exploited. Due to their complex structure and heterogeneity, as well as their vulnerability to contamination in general, these groundwater resources are used partially for a harvesting policy although they represent important reservoirs.

As the coastal region is attractive for many activities (agriculture, tourism, industry, etc.), it is characterised by a higher population density than the rest of the State. The coastal aquifers provide a major contribution to maintaining and developing activities. However, their exploitation is constrained due to the presence of the sea and the risk of salt-water wedges. Tapping the discharge at sea seems thus appropriate.

Contamination

Few data are available concerning the coastal karst aquifers and more specifically the salt-water intrusion. Due to the heterogeneity of the karst systems and to the existence of both submarine and coastal springs, it can be assured that salt-water intrusion definitely does exist, but its extent is not well known, as karst compartments may also exist. The karst structure remains difficult to be determined.

In the deep coastal aquifers, salt-water contamination may be globally local. Its origin may be due either to human interference such as overexploitation or vertical leakage from shallow to deep aquifers through old poor-quality boreholes, or to natural condition (the geologic layers and their hydrodynamic properties close to the coast).

Karst systems are extensive in the South West region and the major outlets are inventoried; however, the heterogeneity of the karst structures enable little data concerning their hydrodynamic properties. Besides, large under-exploited groundwater resources in the karst aquifers are difficult to capture, especially when the major outlets are submarine.

The process gives access to submarine outlets. The conditions of insulation of the source are tested to recover fresh water without penetration of salt water. This technique avoids the threat of destroying the systems, such as for example in mining environment where lowering the water table, even by small amount, may expose the soils to the air and create sulphuric acid which leaches into the waterways.

Fresh marine discharge

The quantity of water that flows out to sea from the underground represents 2% of the total fresh water discharge at sea (the other 98% come from rivers essentially). This underground discharge then mixes and gets lost in the ocean.

The process will thus impact a fraction of this 2%. No measurable imbalance may occur.

Anecdotal stories from fishermen obtaining fresh water from upwellings[5] in the ocean abound around the WA coast, but no firm locations are known. “Last year, during a community forum about the Yarragadee issue that was held as part of a series in Nannup, a very ancient gentleman from Nannup stood up and told the audience a remarkable story of a fishing trip in the 1930's. Offshore from Capel the small boat's driver headed for an area where the ocean was bubbling. In an area the size of a tennis court the water was fresh. This was a major outlet of the Yarragadee aquifer. It was out of sight of the land. (Apparently there is no longer enough pressure to cause the ocean surface to bubble, however the water is still there.) They filled up a bucket with fresh water and carried on with their boat trip.” This was related to us by the Hon. Chrissy Sharp, MLC. We found track of the old gentleman (because of his age, it was advised to communicate his son’s telephone number only, if required).

Impact on the Environment

Tapping, at its source, large amounts of water is safe since this water is discharging and would otherwise be lost in the ocean. Extensive forests overlying this deep aquifer will not be impacted upon if its water level is lowered.

Besides, the marine ecology is not disturbed; in an open environment, fresh water uprises rapidly to the sea surface, with very few horizontal influences. Fresh water would have a tendency to slow down the development of marine species; once the salinity level is restored, a strong activity occurs again, the tapping device becoming part of the natural restored environment.

The hydro-geological assessment is then carried out with few disturbances. (In the case of onshore drilling study, a bore field would consist of 40 to 50 bores sites; the operators have to negotiate their access to the national parks and state forests to complete their work.)

Research

Australia has one of the most advanced research team. One of CSIRO's strategic objectives is to service the needs of government for informed policy setting based on sound scientific analysis. CSIRO has asked details on the process. It has included management of groundwater in coastal systems as one of the key issues that is in the paper presented to the NRM Policy and Programs Committee. The paper is meant as a roadmap as to what may be research priorities for the Commonwealth, states, universities, etc.

This new technology has far reaching implications in understanding the still unknown discharge phenomenon. The collection of underground discharge at sea presented particular challenges. Its main difficulty was isolating the flow from saline water; a new specific method had to be developed. The success of the operation sprung from a methodological approach using inverse modelling to characterize the functioning of the deep aquifer system and elucidate the spring's functioning, thus investigating the interaction between the source at sea and its reservoir. Through to the follow-up of multiple markers, monitoring sub-sea springs gives access to the operations of the underground systems. It then makes it possible to know the dimension of the storing reservoir, medium flow, quantity of stored reserves, and finally the way in which water circulates in the networks.

Harnessing fresh water from seabed and monitoring the source constitutes a world *premiere*. Australian Research could benefit from ten years of committed teamwork between French scientists and European hydrogeologists, and a four-millions-euros successful 3 years project.

Water Prices

In the past in Australia, water has not been treated as an economic resource which should be charged out at its full cost, and has been used to promote regional development and closer settlement in semi-arid inland areas through the development of irrigation schemes.

Another problem has been that as governments usually supplied the capital to establish the irrigation infrastructure out of consolidated revenues, water charges paid by irrigators usually failed to meet the costs of delivery.

Since the 1990s, water policy in Australia has changed in a right way, to emphasize resource sustainability rather than infrastructure or regional development.

South West Case Study

Installing a pilot plant in the growing urbanised areas of Busselton, Bunbury and Dunsborough is a real possibility that:

- their domestic water supplies can be met from that source;
- this source will free up the water that they now extract from the Leederville aquifer;
- water from the Leederville aquifer can then become available for agricultural purposes.

In terms of agriculture and horticulture, the South West is identified as an important food basket for the State:

- it appears to have the potential to be increased by adding the viticulture and the dairy industry;
- it has been noticed that the productivity of pastures is declining as a result of the poor quality water that the farmers are being forced to use.

This process to extract water gives then the assurance that the future requirements for domestic, agricultural, environmental, commercial and industrial uses are catered for.

Costs

Each case study is to be considered as unique and requiring a special quote from the relevant proponents. The further prices have been communicated by the French company as mere information (they can in no way be considered as contractual).

Exploration costs

The exploration phase consists of the localisation of sources offshore and their study over one year in order to determine the technical and economic conditions for their production, with the creation of a hydro-geological model.

Costs are determined by the size (in km^2) of the zone to be investigated and its potential, i.e. the density of sources to be studied. They range from AU$ 2,800- to AU$ 8,000- per square kilometre investigated. (Access to any existing geological material impacts on these costs.)

As an example,
100 km^2 with high potential: exploration cost of AU$ 800,000-.

Operation costs

The offshore engineering phase involves the designing, supplying and installation of the capturing unit, with the instrumentation of the source flow.

The capturing system is tailor-made. Seabed typology, depth and source flow impact on the costs. Installation and instrumentation are part of the costs.

As an average,
at a depth of 40 meters, a distance from the coast of 1 km.

- head flow: 0.5 m^3/s.	operation costs of AU$	1,300,000-
- head flow: 1 m^3/s.	AU$	2,700,000-

Pipeline to shore

The tapping station is offshore; a pipeline takes the water to the shore. The pipeline is buried in the sea floor. Its cost varies with the head flow and hydraulic constraints; seabed, stream and waves also impact on the pipe cost.

As an average, in harshest conditions in the Mediterranean,
cost ranges from AU$ 150- to 450- per linear meter per diameter in inch.
Variation of the pipe diameter with the head flow:

- head flow: 0.5 m^3/s.	31.5 inches
- head flow: 1 m^3/s.	39.4 inches

The full operation can be completed over a period of 12 months. It requires:

- a reduced team of specialists: the French crew has a demonstrated expertise of 30 years in oil and water extraction all over the world, specialised in geo-technical surveys of the seafloor and offshore areas and maritime work;
- planes and vessel equipped with high-tech means for the exploration phase.

The installations are conceived for an exploitation of 40 years minimum.
Working on the basis of a concession being granted for 30 years seems optimal.

Conclusion

Innovation, developing new skills, generating new ideas through research, and the commercialisation of those ideas are Australia's development objectives. Tapping sub-sea springs appears to be at the forefront of environmental technologies by delivering commercial solutions to environmental problems. This new technology gives the assurance of profitable development by private sector entrepreneurs, while matching Federal and States policies and innovation strategy, answering researchers' needs, and contributing to the world challenge of reversing the dramatic water crisis. Western Australia presents two rare assets: its coasts and its community. This capacity of people to innovate and adapt combined to unexploited resources will provide fast and accurate development to an advanced expertise to counter environmental threats, in a context where almost half of global trade is focused in the Asia Pacific, with Western Australia serving as a base.

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Appendix

[1] DESALINATION - If we refer to an average cost for desalination of AU$1.00 per cubic meter, capturing sub-sea fresh water springs is four times less costly for water requiring special treatment before use (drinking water), twenty times less costly for fresh water without any treatment (industrial or agricultural use).

[2] CSIRO - Commonwealth Scientific and Industrial Research Organization.

[3] NRM - Natural Resources Management.

[4] AQUIFERS - "Geological formations such as those composed of sand, sandstone and limestone which contain useable quantities of groundwater are called aquifers. The aquifer closest to the ground surface is called the shallow or unconfined aquifer (its upper surface is the water table) but there are also deeper confined aquifers (sometimes called artesian) where the water is confined under pressure between relatively impervious layers." (Water Corporation)

[5] UPWELLINGS - These sources of fresh water at sea can exist only if the head of soft water in the aquifer is sufficiently high to push the seawater column. For example, for an underwater source located at 30 m. under the marine level, for balance between fresh water and seawater, i.e. without flow, the two columns must have the same mass. Mass = height x section x density. Density of seawater is 1.03, whereas that of fresh water is 1. Thus, for a flow of fresh water under the sea occurs, with two columns of the same section, the height of the fresh water column must be higher than [height x 1.031]; then, for a 30 m. depth, either a column of 30.93 meter fresh water, or a load of +0.93 m. of the aquifer above the marine level. Consequently, for sufficient loads exist to overcome the seawater mass, the source must be fed by flows running from a range of enough importance dominating the coast. (after Michel Bakalowicz)

Acknowledgements

Charlotte Verany has a background in international trading and management roles in France. Extensive stays in Australia lead her to inquire into the issues confronting Western Australia that arise from the present and future sustainable supply, quality, retention and maintenance of water services throughout the State.

She hopes that the bold non-academic extensive use she has made of eminent works and researches on the fresh water issue will be forgiven and considered as admiration for their authors. Support of her Western Australian friends is gratefully acknowledged.

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