

This item was submitted to [Loughborough's Research Repository](#) by the author.  
Items in Figshare are protected by copyright, with all rights reserved, unless otherwise indicated.

## Decreasing freshwater demand: dual supplies

PLEASE CITE THE PUBLISHED VERSION

PUBLISHER

© WEDC, Loughborough University

VERSION

VoR (Version of Record)

PUBLISHER STATEMENT

This work is made available according to the conditions of the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) licence. Full details of this licence are available at: <https://creativecommons.org/licenses/by-nc-nd/4.0/>

LICENCE

CC BY-NC-ND 4.0

REPOSITORY RECORD

Stear, R.M., Jeremy Parr, and Michael D. Smith. 2019. "Decreasing Freshwater Demand: Dual Supplies".  
figshare. <https://hdl.handle.net/2134/31746>.



## Decreasing freshwater demand: dual supplies



*R.M. Stear, J. Parr and M.D. Smith, WEDC*

This paper is a follow-up to the paper given at the 22nd WEDC Conference in New Delhi, India (Smith, Stear and Parr, 1996) which described the first stage of research (*Phase 1*) into the feasibility of using seawater for non-potable uses, particularly toilet flushing. That research found just six locations currently using such a dual supply system (Cayman Islands, Gibraltar, Hong Kong, Kiribati, Marshall Islands, US Virgin Islands). It also highlighted that there is considerable interest in any ideas that reduce the demand on freshwater resources. There are many regions in the world where water limitations are proving to be a severe constraint on development. Publicity material from the UK Government highlights the fact that 70 per cent of the world's population live within 50km of the sea (ODA, undated). Up to 40 per cent of domestic water consumption is typically used for toilet flushing, and so the use of seawater is an obvious choice as a medium for conveying sewage for coastal areas, in order to reduce demand on potable water resources. Indeed, it was commented at the New Delhi conference that the Government of India is considering the use of seawater in such dual supply systems as a potential solution to the problems of water supply in its coastal urban areas.

Phase 1 identified the potential for the use of seawater and highlighted issues of concern to potential users:

- the cost of the infrastructure;
- corrosion of the infrastructure;
- additional odour production due to increased sulphate reduction;
- the treatability of the saline sewage;
- usefulness of end products.

It also described how these issues can be overcome:

- proper selection of infrastructure materials can negate concerns about the corrosive effects of saline wastewaters;
- proper network design can negate concerns about additional odour production;
- saline sewage can be biologically treated as long as the salinity variation is not too great.

However, there appear to be justifiable concerns about the infrastructure costs and usefulness of the end products of a such dual systems (when compared to the reuse potential of non-saline end products).

A second study (*Phase 2*) was agreed with the project sponsors, which sought to investigate the operational aspects of dual fresh/salt water supply systems, along with

their potential application in urban coastal fringes. This paper describes the findings of Phase 2.

### Phase 2 methodology

- The issues of the practical implementation and operation of dual systems were addressed by undertaking study visits to Majuro Atoll in the Republic of the Marshall Islands and Tarawa Atoll in the Republic of Kiribati, both in the western Pacific Ocean. Both of these have existing fresh/salt water dual supplies. In addition to this field visit, authorities in Gibraltar and Hong Kong, which have similar dual systems, were contacted.
- An assessment of the potential for dual systems was made through contacting authorities in developing urban locations. In addition to this, an appraisal of the potential for the system in the Gaza Strip was made during a field visit to the area.

### Operational experience of saline systems

Unpredictable rainfall and the limited freshwater resources for expanding populations has resulted in dual supply systems being installed in both Majuro and Tarawa. The dual fresh/salt water supply networks of Majuro and Tarawa are very similar in that they both:

- serve only the most populous areas of the atolls;
- use groundwater from under the sea bed (salinity of 20-35‰), and not seawater directly (salinity of 35‰) as the sewage medium;
- discharge untreated sewage into the ocean via a short sea outfall.

The systems differ in that:

- the majority of the fresh water supply is made up from groundwater in Tarawa as opposed to surface run-off and catchment in Majuro (the rainwater runoff from the airport runway);
- there is less aid money available for operation and maintenance tasks, and for extensions to or upgrading of the infrastructure in Tarawa. Kiribati is a poor country with the community relying on essentially subsistence living. The dual supply system was installed via Australian aid projects. Majuro, by comparison, has clearly undergone considerable westernisation under American influence since the Second World War and this leads to an attitude of financial security. Western afflictions such as alcoholism and diseases such as diabetes are rife.

Table 1. Comparisons of water services in Majuro and Tarawa

	Majuro	Tarawa
<b>Population</b>	25500	25000
<b>Estimated potential population served by salt water system</b>	13000	20000
<b>Supply hours</b>		
fresh	24 hrs on, 24 hrs off	7 hrs per day
salt	not at low tides	24 hrs per day
<b>Salt supply completed</b>	1988	1982
<b>Connection charges:</b>		
fresh water		
domestic	\$100	A\$20 (\$15.75)
commercial	\$400	A\$100 (\$79)
salt water	\$100	A\$100 (\$79)
sewerage	\$100	A\$100 (\$79)
<b>Tariffs:</b>		
fresh water		
domestic	\$6/1000 gal (\$1.6/m <sup>3</sup> )	A\$1/m <sup>3</sup> (\$0.79/m <sup>3</sup> )
commercial	\$6/1000 gal (\$1.6/m <sup>3</sup> )	A\$5/m <sup>3</sup> (\$3.94/m <sup>3</sup> )
salt water	\$7/month	no tariff
sewerage	part of rates	no tariff

note A\$ = Australian dollar, \$ = US dollar

Pertinent issues about water resources and the salt water system are summarised in Table 1.

### Analysis of issues of concern

The visits to the Pacific atolls provided no clear evidence either for or against the financial and economic suitability of dual systems, as the systems were employed in both locations without a financial or economic analysis of all of the alternatives available. It is hard to draw meaningful conclusions from the very limited cost information available. Obviously, saline sewerage is only possibly viable in situations where sewerage is a realistic option. This generally discounts the poorest communities.

The corrosive effects of the saline sewage on pipelines, pumps and valves was not found to be of major concern. Corrosion *outside* of the network, in consumers properties, was considered to be more of a problem. This was essentially because the distribution and sewerage networks had been designed to avoid corrosion problems by the use of plastic pipes and stainless steel fittings, whereas the toilet cisterns in individuals houses had not. It is believed that wear and tear due to abrasive sand particles in the salt water supply system may be as much of a problem as the salinity of the supply.

There was no significant odour problem at either location (over and above any usual sewage odour). It should be noted, however, that this may have been due (in both systems) to the continual flushing of the sewers with salt water as a result of cistern failure which allowed water to flow constantly from the cisterns to the toilet bowls. This

continuous flushing caused an extra problem of high energy costs associated with pumping. This problem could be minimised by introduction of a tariff to recover costs for the quantity of salt water used, which would encourage proper maintenance of toilet cisterns.

### Experience from Gibraltar and Hong Kong

Although these locations could not be visited, correspondence with the relevant authorities revealed some salient issues:

- both systems appear to function satisfactorily;
- design decisions to minimise residence times in sewerage systems has prevented significant odour production;
- the use of plastic materials satisfactorily combats corrosion in both the supply and sewerage networks;
- a thorough cost benefit analysis should be undertaken to assess alternatives before changing the current system.

*'The alternative to providing sea water is to desalinate more and the costs would be well in excess of maintaining the separate systems'* (Mr M Perez, Lyonnaise des Eaux, Gibraltar).

Contacts in Hong Kong revealed that an estimated 60 per cent of the population of Hong Kong use seawater for toilet flushing - this would amount to some four million people. Tang (1996) describes some of the aspects of the system in Hong Kong. The experience from Hong Kong demonstrates, albeit in a highly developed location, that

dual salt/fresh water supply systems can certainly be utilised in heavily urbanised areas.

### **Application of saline systems to other locations: Case study of the Gaza Strip**

The Palestinian Water Authority and other prominent organisations in Gaza were sceptical about the prospects for using a dual fresh/salt water supply in Gaza. The reasons given were:

- reservations about investing in a (perceived) unproven technology;
- concern about the costs of the infrastructure;
- concern about the usefulness of the end products (the policy is to encourage reuse of treated wastewater in agriculture).

The concern about infrastructural costs is understandable. It is certainly the case that dual systems would not be financially viable in all locations. However, it is not clear how the benefits of potable water saving would weigh against the cost of additional infrastructure, especially in situations where upgrading is needed anyway. Research on the financial appraisal of dual systems needs to be undertaken.

Lack of awareness about dual supply schemes in successful operation has led to a neglect of this issue as an option. The experience of the research team involved with Phase 2 has shown that such systems can, and do, work. It is argued here that use of dual supply schemes should at least be considered, along with other potable water saving options.

### **Conclusions**

1. *Dual supply systems are a technically viable option.*
  - dual fresh/sea water systems are currently operating satisfactorily in several locations world-wide;
  - there is no reason to assume that, on a technical level, they could not work elsewhere.
2. *Dual supply systems can be considered as an option for implementation, with decisions being made on a full and equitable local comparison of alternatives, with a true appreciation of the real costs of water provision.*

- however, dual systems can obviously only be applicable in situations where investment in sewerage is an option - therefore, by its nature, not the lowest income developing areas, but more middle income communities;
- dual systems appear to be more applicable to small discrete locations (such as islands or new developments) rather than generally to large urban developments due to the problems of retro-fitting a dual supply network.

The decision whether to implement a dual supply system is not just a technical issue, but is subject to the same difficult decisions that affect any development choice - questions that can only be addressed locally. Is it appropriate and affordable to the community? Can the operation and maintenance requirements be performed adequately? In short, is it better than the alternatives? To answer these questions, it is argued that what is required is a full and equitable evaluation of all of the alternatives.

### **References**

- ODA (undated). *Water for life: Water and British aid in developing countries*, Overseas Development Administration publicity material, UK Government.
- SMITH, M.D., STEAR, R.M. and PARR, J., 1996, *Seawater for non-potable uses*, Proceedings of 22nd WEDC Conference, New Delhi, India, pp 241-243.
- TANG, S.L., 1996, *Strategic sewage disposal in Hong Kong*, Proceedings of 22nd WEDC Conference, New Delhi, India, pp 244-247.

### **Acknowledgement**

The authors would like to express their gratitude to the Overseas Development Administration of the UK Government for funding this research. The views expressed herein are, however, solely those of the authors.

---

R.M. STEAR,  
J. PARR, Lecturer, WEDC.  
M.D. SMITH, Specialist in Water Supply and Wastewater,  
WEDC.

---