Water Conservation on Salt Spring Island:
Report 2 - A Literature Review To Predict Feasibility for Two Different Wastewater Reclamation Options

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Report 2 of 2 - Prepared For SSIWPA by its Conservation and Efficiency Working Group to fulfill SSIWPA Workplan 2017 tasks 8, 8a, and 8c.

Report Purpose

Salt Spring Island Watershed Protection Alliance Steering Committee Conservation and Efficiency Working Group (CEWG) was assigned these tasks:

1. Assess and compare water conservation technology and efficiency of existing systems (SSIWPA Workplan 2017 #8), including:

> **2.** Rainwater harvesting efficiency and alternatives (SSIWPA Workplan 2017 #8a)
> **3.** A literature review to address technical feasibility of direct-to-potable and indirect-to-potable experience at large scale, long-established commissioned projects, in order to assess feasibility and potential for reuse of Ganges wastewater treatment plant effluent (SSIWPA Workplan 2017 #8b).

4. Identify policy initiatives that could be used to increase the conservation and efficiency of water use on Salt Spring Island (SSIWPA Workplan 2017 #8c).

Reports:

1) A report co-authored by CEWG members Ungerson and Kline and reviewed by CEWG member Peace. It presents evidence for a broad range of applicable technologies, methods, and resources that can be implemented to increase water supply, and efficient water use across system and consumer types, on Salt Spring Island. These technologies are all being used globally, successfully. Some are even being utilized in British Columbia and the Gulf Islands.

2) A report authored by CEWG member Peace and reviewed by the CEWG members is a literature review of some global examples of wastewater reclamation that predicts some of the economic and social feasibility conditions that would be required for such wastewater reclamation models to be applied for use in Ganges, Salt Spring Island.

The two reports above should be considered with the previously published standalone report:
Anderson, K., A. LeBlanc, C. Lloyd and D. Wilcox. 2017 “Rainwater Harvesting: An Investigation of the Current Use on Salt Spring Island” Royal Roads University Undergraduate Environmental Science Program. The CEWG members were project advisors to the Royal Roads University Rainwater Harvesting study on Salt Spring in 2016-17.

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SSIWPA Steering Committee.

Executive Summary

The Ganges Wastewater Treatment Plant discharges about 450 m^3 of highly treated sewage effluent to the Ganges Harbour daily. This research investigated the feasibility of reclaiming the effluent for reuse as drinking water. The main findings are that it is technically feasible to treat effluent to drinking water standards; it is likely treatment costs per m^3 are not much more than the present cost of primary and enhanced secondary treatment and public acceptance of the drinking water product is by far the most difficult challenge.

In general, the public accepts reclaiming our highly treated sewage effluent for reuse as non-potable water. For example, non-potable supply could serve many high water volume beneficial uses like, irrigation, toilet flushes, and laundry. However, high distribution costs confound the economic feasibility of non-potable water reuse for two main reasons. There are few irrigation customers close enough to the WWTP to justify the cost of pipelines and other conveyance infrastructure. Similarly, for residential and commercial customers, the process required to retrofit ‘purple pipe’ systems within homes and businesses presents significant technical and economic obstacles.

Recommendations

Generate a public engagement strategy to inform and educate Salt Spring Island residents about Indirect to Potable and Direct to Potable methods to reclaim highly treated Ganges Wastewater Treatment Plant effluent.

1. Include the public in all phases of a comprehensive communication strategy.
2. Aim low: a balanced presentation of information about the technologies may be a worthwhile objective.
3. Follow BC Government guidance for communication strategy (BC Ministry of Environment, 2013, Sec. 17).
4. Make use of local knowledge, publically available information and literature to flesh out and enhance the guidance provided by BC Government.

Report 2 A Literature Review to Predict Feasibility for Two Different Wastewater Reclamation Alternatives – Salt Spring Island, B.C.

Scope: Alternatives to reclaim and recycle the greywater outflow from the Ganges Wastewater Treatment Plant

Rationale: The potential for wastewater reclamation on Salt Spring Island represents a civic-scale method to conserve raw water supplies. A comparison of the volume of drinking water distributed by the North Salt Spring Water District (NSSWD) to the volume of effluent Ganges Wastewater Treatment Plant (WWTP) discharged to the ocean suggests reclamation would conserve a substantial volume. According to annual averages, the WWTP discharge (450 m^3/day) is about one third of the amount distributed by NSSWD (*North Salt Spring Waterworks District Drinking Water Quality Report*, 2016, p. 1; *Gulf Islands and Port Renfrew Wastewater and Marine Environment Program 2014 Annual Report*, 2015, p. 11).
Generally, projects that reclaim sewage effluent for beneficial use produce non-potable or potable water for reuse. The extent of wastewater treatment determines whether the reclaimed water is suitable for non-potable use like, landscape irrigation or, potable reuse like, drinking and cooking.

This review focusses on wastewater reclaimed to a potable standard because the cost of equipment, operation and conveyance are too high for “the small number of (potential non-potable reclaimed water) users” (*Ganges Sewer System Reclaimed Water Feasibility Study Salt Spring Island , BC Prepared by Capital Regional District*, 2009, p. 23). For context, the supply of Ganges WWTP treated effluent would exceed demand by greater than 10:1(*Ganges Sewer Sustem Reclaimed Water Feasibility Study Salt Spring Island , BC Prepared by Capital Regional District*, 2009, p 12; *Gulf Islands and Port Renfrew Wastewater and Marine Environment Program 2014 Annual Report*, 2015, p. 11).

Three aspects of feasibility comprise this review; health and safety (technical), economic and public acceptance. Commissioned, sewage-effluent reclamation projects located in other jurisdictions illustrate commercial feasibility at scales that range from small like, Ganges to large like, San Diego, California. Commissioned, sewage effluent reclamation projects support all aspects of fesibility.

Definitions:
“Direct to Potable (DPR) water reuse is the immediate addition of reclaimed wastewater to the water distribution system” (Crook et al., 1998, p. 21).

Indirect to Potable, sometimes described, as ‘indirect potable reuse’ (IPR) wastewater treatment plants are much more common than direct to potable. “In IPR, municipal wastewater is highly treated and discharged directly into groundwater or surface water sources with the intent of augmenting drinking water supplies” (Rodriguez et al., 2009, p. 1175). For example, a treatment plant may convey potable water to an environmental buffer such as a lake.

Health and Safety: Technical Feasibility of Direct-to-Potable and Indirect-to-Potable Wastewater Reclamation

Scale: Full-scale (large) treatment plants
Scope: Health and safety at commissioned projects

Introduction

The water shortages on Salt Spring Island fit within a global context where; “More than 4 billion people live in parts of the world where freshwater scarcity directly threatens human water security or river biodiversity” (Grant et al., 2012, p. 681). A general solution for developed countries includes recognition that “existing water infrastructure needs reengineering to sustain a high standard of living while reducing its environmental footprint and sustaining or restoring biodiversity (Grant et al., 2012, p. 681). Direct-to-Potable (DPR) and Indirect-to-Potable Reuse (IPR) are reengineered water infrastructure that rely on the “principle (that), domestic wastewater can be collected, treated to remove human pathogens and other contaminants, and then reused for potable or non-potable purposes” (Grant et al., 2012, p. 681).

For many, turning to highly treated sewage effluent as a raw water source for drinking water is a last resort. In fact, water experts “strongly endorse the generally accepted concept that drinking water should be obtained from the best quality source available” (Crook et al., 1998 p. ix). In addition, discarding the convention for ‘best source’ confounds drinking water health and safety guidelines because “drinking water regulations were not established to judge the suitability of raw water supplies heavily contaminated with municipal and industrial wastewater” (Crook et al., 1998, p. x)

Thirst or, acute need for potable water supply combined with advances in wastewater treatment technology drive municipal adaptions to chronic water shortage. The proliferation of wastewater reuse schemes in jurisdictions such as, San Diego and Orange County, California demonstrates civic-scale adaptation to wastewater reclamation (Crook et al., 1998, p. 1).

Health and Safety

In many populated areas, long-term, gradual degradation of raw source water quality and quantity required public health experts to adapt. The development of new methodologies to assess drinking water quality followed degradation of raw water quality and improvements in wastewater treatment. First, analysis of the ‘best quality’ raw water sources many communities rely on revealed significant degradation caused by “upstream discharges of wastewater.” For example, “more than two dozen major water utilities use water from rivers that receive wastewater discharges amounting to more than 50 percent of the stream flow during low flow conditions. Although most water systems using such raw water supplies meet current drinking

water regulations, many of the concerns about planned, indirect potable reuse also apply to conventional water systems" (Crook et al., 1998, p. 2).
Pristine, raw source water is out of reach for most jurisdictions. However, most wastewater treatment removes the vast majority of pathogens and contaminants before effluent discharges back to a river. In other words, "Highly treated wastewater does not differ substantially from some sources already being used as water supplies" (Crook et al., 1998, p. 18). Therefore, an enlightened public recognizes raw source water and wastewater effluent often share similar quality parameters.

Improvements in wastewater treatment outcomes offset the loss of quality in raw water supplies. Consequently, "in the absence of an absolute, ideal water standard, the ability of a water reclamation facility to produce potable water should be judged—chemically, microbiologically, and toxicologically—in comparison with conventional drinking waters that are presumed to be safe" (Crook et al., 1998, p. ix). A caveat to the following synopsis of performance standards states, "standards cannot guarantee that the water poses no health hazard (Crook et al., 1998, p. 20). Put another way, "No water treatment is ever without risk, including conventional drinking water treatment and traditional drinking water sources" (Rodriguez et al., 2009, p. 1189).

A comprehensive review of existing projects evaluated the strengths and weaknesses of judgement parameters such as; technical feasibility, epidemiology, toxicology, quality assurance monitoring and the precautionary principle (Rodriguez et al., 2009, p. 1180). The review concluded "It is accepted that advanced treatment can produce recycled water in compliance with drinking water standards and guidelines (Rodriguez et al., 2009, p. 1174). Integration of the multiple parameters serves to increase vigilance in health and safety.
Below, a summary lists the main points of the multiple parameter evaluation methods categorized above. First, "Cities with limited water resources are considering Indirect-to-Potable (IPR) as a feasible option for the sustainable management of water because it is a water supply alternative not dependent on rainfall and it is possible to achieve high quality recycled water in compliance with drinking water standards and guidelines" (Rodriguez et al., 2009 p. 1175).
Second, epidemiological, "In 1998 the US National Research Council (NRC) published the evaluation and recommendations of a multidisciplinary team of experts that explored the viability of augmenting potable water supplies with recycled water. The report concluded that, from the information available, the risk from IPR projects were similar to or less than the risks from conventional sources, (Rodriguez et al., 2009) (Crook et al., 1998). In other words, IPR is safe as or, safer than conventional drinking water sources.

Third, "toxicological testing is the primary component of chemical risk assessments for IPR projects" (Rodriguez et al., 2009). However, for a number of reasons, risk assessment is a blunt tool for IPR projects. For examples, reliable information on effects is available for a very limited set of toxins, many available studies depend on extrapolations of toxicological analyses to animals, and risks posed by individual toxins do not predict risks posed by chemical mixtures (Rodriguez et al., 2009).

Monitoring implies compliance. This means authorities accept a system is capable of compliance in normal conditions. However, compliance testing alone is not enough to protect public health (Rodriguez et al., 2009, p. 1185). Practical limits like the cost of testing a large set of contaminants and the fact that water distribution precedes laboratory results underscore the limitations of compliance monitoring (Rodriguez et al., 2009, p. 1185). To address the gaps, risk managers combined hazard assessment protocols with risk assessment matrices to create new protective, methodologies. For example, Australian Drinking Water Guidelines (Rodriguez et al., 2009, p.1184) adopted a Life Cycle Analysis and Hazard Analysis and Critical Control Points (HACCP) methodology that formerly advanced risk management decisions in food and pharmaceutical industries.

Finally, the precautionary principle recommends “a cautious approach is required to manage the health risk associated with recycled water for drinking” because, “Contaminants have been detected at low concentrations in highly treated recycled water and any potential health impacts need to be evaluated.” “Therefore, an analysis of potential human and environmental risks and the involvement of the community before any implementation proceeds need to be carefully undertaken on a case-by-case basis” (Rodriguez et al., 2009, p. 1175). The precautionary principle also applies to effluent discharges to natural waters. Better wastewater management implies reduction of wasting to the environment (Salgot, 2008, p. 191)

There are encouraging shifts within jurisdictions where populations realize significant benefits from the routine reuse of highly treated wastewater. For example, California, Washington, Arizona and Florida operate IPR projects that require treated wastewater to meet drinking water quality standards before discharge to the receiving environment (Rodriguez et al., 2009, p. 1183).

The largest scale project is in Orange County, California. The Groundwater Replenishment System of Orange County Water District (GWRS/OCD) project serves a population of greater than 3,000,000 people. GWRS/OCD withdraws and replenishes about one quarter of the groundwater in the Orange County Groundwater Basin annually. Conservation of the estimated 600,000,000 m^3 of groundwater in the aquifer helps Orange County maintain municipal water supply and protect water quality in the aquifer (“What we do,” 2018). The existence of large projects that deliver drinking water from reclaimed sewage effluent is a testament to the health and safety of IPR wastewater treatment systems.

Figure 1. History of Potable Reuse in California

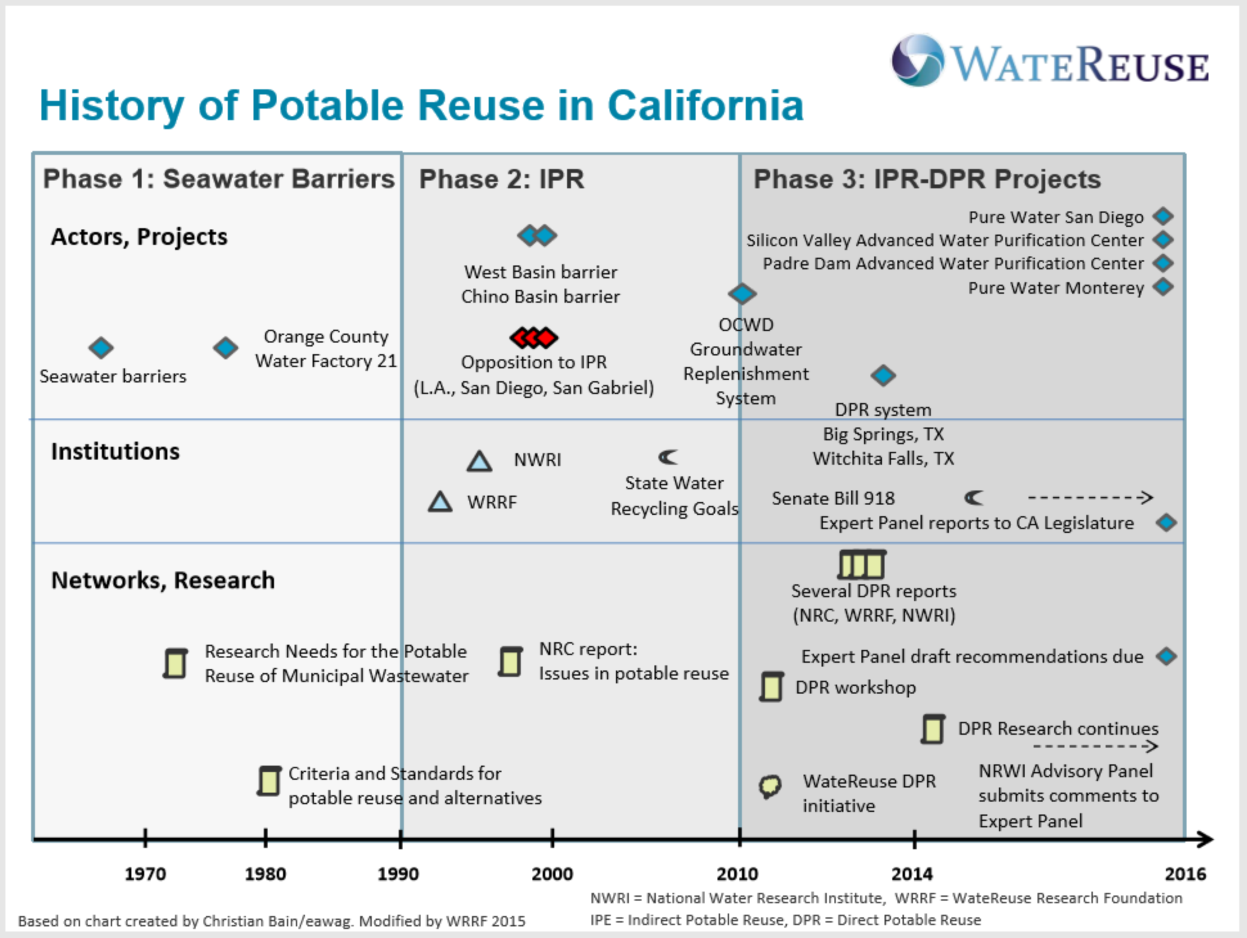

Figure 1. A summary of major IPR-DPR project expansions in California. Retrieved from Water Reuse Association.

Unfortunately, public acceptance lags behind proof of technical prowess in reclaiming drinking water from highly treated sewage effluent. In many global-scale jurisdictions inadequate communication between water reuse organizations and their stakeholders doomed plans (Khan & Gerrard, 2006, p. 192). Elements of the literature caution against developing reuse plans prior to public consultation. Primarily, this is because among some ten barriers, public perception was the principal barrier to public acceptance and hence, implementation (Salgot, 2008). These findings suggest that getting off on the right foot with public perceptions of IPR is as important as proving the systems are a reliable source of healthy and safe drinking water (Rodriguez, et al., 2009; BC Ministry of Environment, 2013, p. 42).

Examples of Commissioned Indirect-to-Potable Water Treatment Plants

Four full-scale, commissioned, indirect to potable treatment plants suggest the importance of public perception. Windhoek, the Capital of Namibia is the best example because that system commissioned in 1968. There, a population over 325,000 live at 1700 m elevation with less than 40 cm annual precipitation and a spring for water. Today, direct to potable treatment of sewage wastewater supplies 35% of average demand and has the capacity to meet 90% of peak demand (Rodriguez et al., 2009). Anecdotally, it is apparent residents of Windhoek take pride in their ability to reclaim the water (Khan & Gerrard, 2006, p. 194). That is exemplar public perception that arguably exceeds 100% acceptance.

Large-scale indirect to potable reuse projects in California dominate the literature reviewed to date. Combined, Orange County and San Diego demonstrate decades of technical achievement and a lamentable lag in public acceptance, which polls at less than 40%. Notwithstanding lag, apparently, public acceptance is strong enough to support full production capacity in San Diego Orange County, California. The GWRS Orange County District project serves roughly 2.5 million people.

In 1978, the Upper Occoquam Sewage Authority (UOSA) of Virginia initiated advanced wastewater treatment to abate declining water quality in the over-developed basin. Stiff public resistance emerged. Resistance ranged from a Supreme Court challenge to a nickname “The Second Battle of Manassas,” derived from a local Civil War battle. An unfortunate outcome was a 15-year lag between commissioning the full-scale plant and ramping up to full production. Public resistance to purchase the treated water caused the delay in production. One could infer successful public consultation efforts started 15 years too late. Since 1998, UOSA supplied 50% of average demand and, authorities in the region recognize the reclaimed water source as the cleanest (Rodriguez, et al., 2009).

In summary, there is ample evidence to show that large-scale, direct and indirect to potable wastewater treatment systems deliver safe drinking water to significant populations.

Introduction

The Ganges Harbour Wastewater Treatment Plant (WWTP) discharges effluent to the harbour via a 5 km outfall pipe. The average daily discharge is roughly 500 m^3 /day (*Gulf Islands and Port Renfrew Wastewater and Marine Environment Program 2014 Annual Report*, 2015, p. 11). Information about the cost to treat sewage effluent to a drinking water standard should help readers determine the economic feasibility of sewage effluent reclamation in Ganges. In addition, a conceptual exercise illustrates the price difference between civic and individual scale techniques to produce or conserve drinking water resources.

Treatment Costs at Existing Plants

Briefly, IPR and DPR plants produce drinking water at prices similar to the cost of conventional treatment systems. Table 1 draws on consumer prices to infer the cost of IPR/DPR treatment systems are similar to conventional. The reliance on consumer prices obscures municipal subsidies to water utilities and the parcel tax imposed on NSSWD ratepayers. Municipal subsidies may be substantial. On Salt Spring, the parcel tax adds to the cost of drinking water per cubic metre according to the rate of individual consumption. For example, a $650 annual parcel tax on an individual that consumes about 330 litres per day pays approximately $5 per cubic metre in addition to the metered rate (North Salt Spring Waterworks District: Bylaw 281, 2018; NSSWD Bylaw 276, 2016, p. 4). The relatively low density of customers in the NSSWD distribution network suggests the cost of pipelines and associated conveyance utilities accounts for a difference. In other words, the distance between customers on Salt Spring Island is substantially greater than the distance between customers in Las Vegas, Orange County and Calgary.

Table 1. Comparison of Drinking Water Prices: IPR / DPR vs Conventional Treatment

Jurisdiction	Approximate price in $ per m^3	Population
Cloudcroft, New Mexico (reuse)	2.38	850
Windhoek, Namibia (reuse)	0.72	300,000
Orange County, CA (reuse)	1.26*	3,000,000
Oakville, Ontario (conv)	1.00	200,000
Las Vegas, Nevada (conv)	1.00	640,000
Calgary, Alberta (conv)	1.00	1,240,000
Salt Spring Island, NSSWD	2.24	5,500

Table 1. Consumer price as a proxy for the cost of drinking water treatment illustrates the consumer cost of Direct to Potable and Indirect to Potable water treatment is similar to conventional treatment systems. *The Orange County value is an operating cost. Adapted from North Salt Spring Waterworks District Drinking Water Report, 2016; NSSWD Bylaw 276, 2016 & Review of Cost versus Scale, Guo et al., 2014.

Economy of Scale

Many existing Indirect to Potable (IPR) and Direct to Potable (DPR) plants serve populations much larger than Salt Spring Island. For examples, the IPR system in Orange County serves over 3,000,000 people. The DPR in Windhoek serves a population of roughly 300,000. So, questions about economy of scale at a smaller WWTP are natural. A study of cost versus scale that relied on “commercially-available technology of proven reliability” (Guo & Englehardt, 2015, p. 147) found optimum economy begins at the 100 home scale in suburban settings (Guo & Englehardt, 2015, p. 160; Guo, Englehardt, & Fallon, 2016, p. 812).

For example, Cloudcroft, New Mexico, has a population 850, which doubles in summer. The IPR system there produces water at a total cost of $2.38/m^3 (Guo et al., 2014, p. 230). The 378.5 m^3/day capacity of the Cloudcroft treatment plant is less half that of Ganges WWTP. All of the above values are in US dollars and include operation and maintenance costs. More significantly, the costs above include the cost of conveyance or, pipelines to distribute the product.
The experience in other jurisdictions does not predict costs to implement an IPR or DPR system on Salt Spring Island. Mainly because the cost implications of geographic factors like topography and distances affect the cost of conveyance in ways that are specific to the setting. Instead, data from distant jurisdictions suggests the cost of IPR and DPR treatment systems is similar to conventional treatment systems.

Graph 1. Cost Functions for Water Reuse Unit Processes

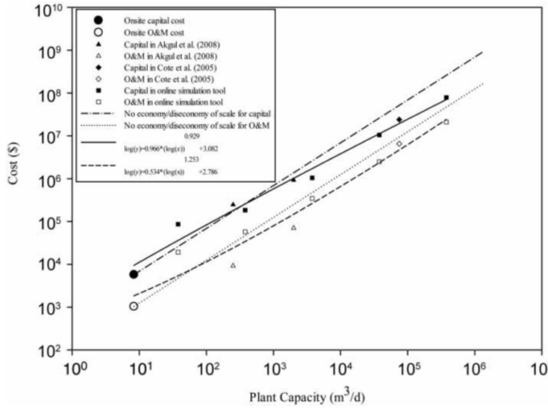

Figure 4 | Approximate cost of RO treatment plant capacity based on Côté *et al.* (2005), Akgul *et al.* (2008), Water Research Foundation (2009) and US EPA (2007), and Englehardt *et al.* (2013). Conditions: constant 2012 US dollars proportional to the GDP deflator (US Bureau of Economic Analysis 2013).

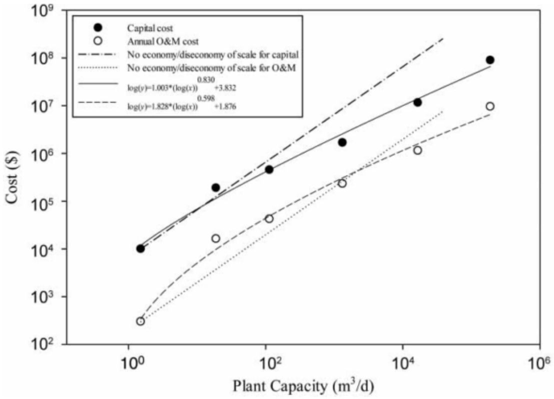

Figure 5 | Approximate cost of ultrafiltration and microfiltration based on Water Research Foundation (2009), US EPA (2007), and Englehardt *et al.* (2013). Conditions: constant 2012 US dollars proportional to the GDP deflator (US Bureau of Economic Analysis 2013).

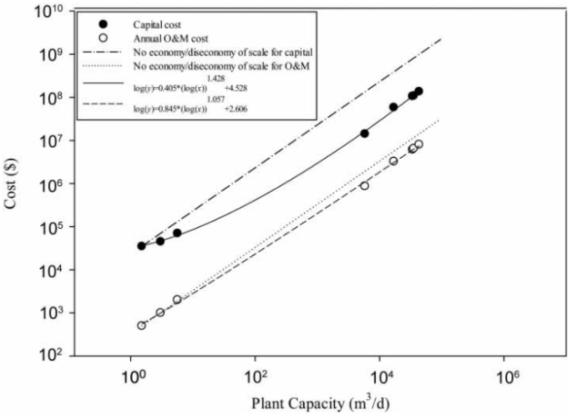

Figure 6 | Approximate cost for mineralization of COD by peroxone based on MWDSC & James M. Montgomery Consulting Engineers Inc. (1991) and Englehardt *et al.* (2013). Conditions: constant 2012 US dollars proportional to the GDP deflator (US Bureau of Economic Analysis 2013).

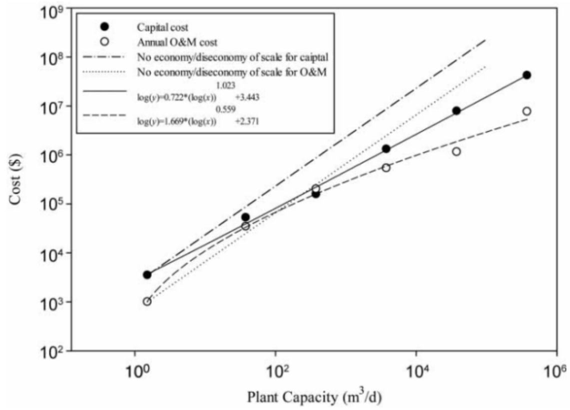

Figure 7 | Approximate cost of GAC based on Water Research Foundation (2009), US EPA (2007), and Englehardt *et al.* (2013). Conditions: constant 2012 US dollars proportional to the GDP deflator (US Bureau of Economic Analysis 2013).

Graph 1. Selected unit processes illustrate approximate cost ($) versus plant capacity (m3) including Operations and Maintenance. The trends show cost vs scale is approximately directly proportional (straight line) for each unit process. Figure 4 illustrates Reverse Osmosis Unit. Figure 5 shows Ultrafiltration and Microfiltration. Figure 6 shows mineralization of Chemical Oxygen Demand (COD) by peroxone. Figure 6 shows Granulated Activated Charcoal (GAC). Reproduced with permission from “Review of Cost versus Scale: Water and Wastewater Treatment and Reuse Processes” by T. Guo et al., 2014, Water Science and Technology, 69, p. 227-228.

Cost of Conveyance

Generally, conveyance costs may dwarf the cost of sewage effluent treatment. An approximate value for normal pipeline installation is $1,000,000 /km. New pipeline installations in an existing right of way are more expensive and there are additional costs to consider (K. Wahlstrom, personal communication, February 22, 2017). For example, an estimate of the cost to incorporate an existing pipeline into a grey water distribution system for landscape irrigation use on Rainbow Road such as the Recreation Centre and School District playing fields exceeded $1.5 million (*Ganges Sewer Sustem Reclaimed Water Feasibility Study Salt Spring Island , BC*

Prepared by Capital Regional District, 2009, p. 23). The capital cost of conveyance prevented implementation of that grey water project (Harris, 2017, p. 1). Furthermore, the energy cost of water conveyance is typically 4 times greater than the energy cost of water treatment (Guo et al., 2016, p. 811). It is important to recognize that the cost of conveyance is likely to dominate the economics of decisions about water utility infrastructure.

Attributes of local geography like, distances and topography influence costs significantly so, examples taken from distant jurisdictions illustrate the concept. Wichita Falls, Texas, home to a large air force base, is a recent example. In 2011, the 100,000 population entered into a years-long drought that triggered reclamation of wastewater effluent. Commissioned in 2015, a 27 km pipeline accounted for one third of the $30 million project cost. The normal capacity of the IPR system is roughly 41,000 m^3/ day or, 100 times more than the Ganges WWTP (D. Nix, personal communication, September 15, 2017). Not including operations and maintenance, the total capital cost spread over the twenty-year design life works out to less than $0.10/ m^3.

Cost of Individual Project Compared to Civic Scale Project

An arithmetic approach to compare a variety of water production and conservation technologies considers price, and the amount of water returned over a warranty period. This approach applied to utility scale treatment systems and hi-efficiency appliances like dishwashers generates a screening-level analysis of relative cost. This approach excluded operation and maintenance costs.

Example of the arithmetic illustrates the concept.

Consider a hi-efficiency washing machine with a 5-year warranty costs $500 more than a conventional machine and conserves one cubic metre of water per year. The cost of conservation works out to $100/ m^3. The following examples follow the same approach.

A hi-efficiency dishwasher with a 3-year warranty costs $600 more than a conventional machine and conserves 1.8 m^3/ year. The cost of conservation works out to $74/$m^3$.

A rainwater collection system with a 20-year warranty costs $20,000 to install and harvests 30 m^3/ year. The cost of water supply works out to $33.33/$m^3$.

A water well with a treatment system has a 20-year warranty, costs an estimated $25,000 to install and produces an estimated 365 m^3/year. The cost of water supply works out to $3.42/$m^3$.

The Wichita Falls IPR treatment system has a 20-year warranty, cost $30,000,000 to install and produces 22,104,400 m^3/ year. The capital cost of water supply works out to $0.07/$m^3$.

The above comparisons suggest that of the methods compared above, a civic-scale IPR and/or DPR water conservation project is the least expensive method to conserve water resources on Salt Spring Island.

Conceptually, reduced dependence on rainfall is the main advantage of IPR and/or DPR. Roughly speaking, for the price of developing 100-200 new private residential water wells, Ganges could install a treatment plant that unlike water wells is not as dependent on rainfall. Residential subdivision planners budget about 1.3 m^3/day for an individual household. By that budget, an IPR/DPR plant in Ganges could provide enough drinking water to supply approximately 300 households.

Public Acceptance of Direct-to-Potable and Indirect-to-Potable Wastewater Reclamation

Introduction

"Our idea of dirt is compounded of two things, care for hygiene and respect for conventions. The rules of hygiene change, of course, with changes in our state of knowledge" (Douglas, 1966, p. 7). If we think of dirt as something that is out of place (Douglas, 1966, p. 8), it is easy to understand how reuse of highly treated sewage effluent offends conventions (Hochstrat, Wintgens, & Melin, 2008, p. 212). In contrast, our advanced state of knowledge allowed large and small jurisdictions to treat sewage effluent for reuse as drinking water for more than 50 years.

For examples, "three plants located in the central basin of Los Angeles County" commissioned in 1962 serve a population over one million. Windhoek, Namibia commissioned DPR in 1968 and Orange County, California serves a population less than 2 million with an IPR plant commissioned in 1975 (Rodriguez et al., 2009, p. 1190-1197). Astronauts installed a new DPR system on the International Space Station in 2008 (Carter, Tobias, & Orozco, 2013). The unit operating cost on the space station is \$177/m^3 or \$0.18/litre (Guo, Englehardt, & Wu, 2014, p. 230).

The delay in adaptation to expensive advances in knowledge and technology suggests market failure, "Although reuse is publicized as one of the main solutions for water scarcity, there are few countries where the practice has really been implemented at full scale" (Salgot, 2008, p. 191). The principal reason for the lag in adopting water reclamation projects is the lack of public acceptance (Salgot, 2008, p. 192). Experience with implementation suggests an effective communications strategy may underpin successful implementation of water reuse projects.

For example, Daniel Nix, Utility Operations Manager, Wichita, Texas, involved the public in all phases of planning and development of a new IPR system. He summarized public response to the 3-year effort "The public will always surprise you." Faced with a serious water crisis, public opinion registered in the range of "over-acceptance" (personal communication, September 15, 2017).

Water Management Characteristics

Management characteristics help distinguish factors of water shortage. For example, an urban setting with above average precipitation and a population that consumes an exorbitant volume of water may experience an acute shortage. In contrast, a setting with less than average precipitation where the population consumes water conservatively may not experience a shortage. The reuse of highly treated sewage effluent "is supposed to depend on long-term deficiencies in the water balance or frequency and severity of droughts" (Hochstrat et al., 2008, p. 209). Within droughts, water management factors such as "precipitation, population density and water use" determine the severity of water shortage (Hochstrat et al., 2008, p. 210). Spider diagrams are a technique to chart water management characteristics. Figure 1 shows characteristics at national and regional scale (Hochstrat et al., 2008, p. 211). This spider diagram illustrates factors of water shortage stress. Water management characteristics adapted to Salt Spring Island may be a useful technique. For examples, a spider chart of SSI, Delta, and Penticton BC may be a useful way to evaluate multi-factor water stress. A chart (or charts) of the 17 water districts on SSI may be a useful way to illustrate vulnerability to water shortage relative to water districts.

Figure 1. Spider Chart Comparing Major Water Management Characteristics in Mediterranean Countries and Regions

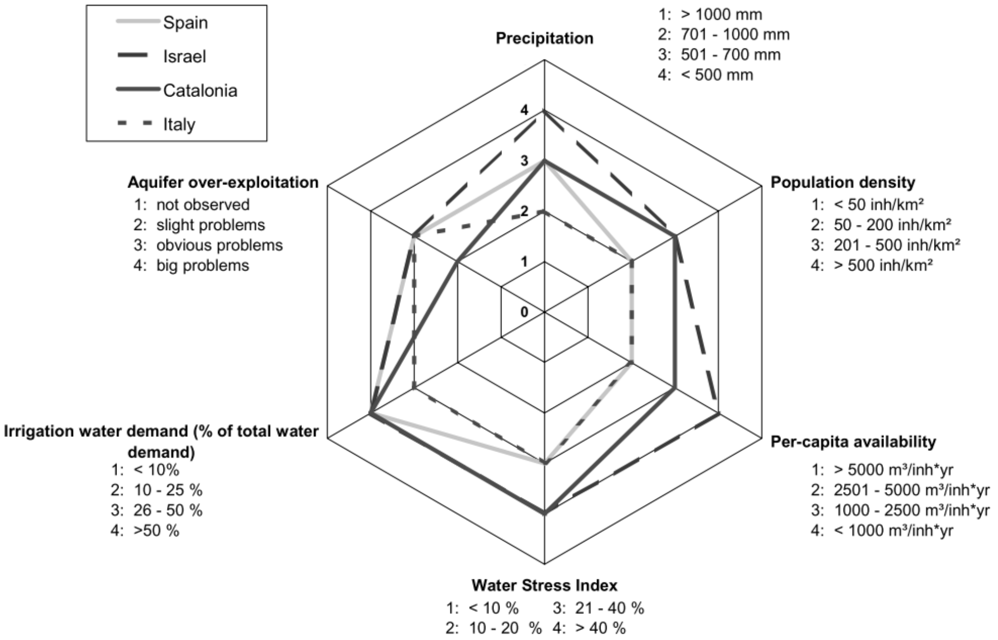

Figure 1. Spider chart comparing severity of water shortage. Abundant water characteristic charts at the centre. Shortage increases away from the centre. Each point of the web is a factor. The more a jurisdiction charts toward the perimeter, the greater the water shortage. This spider chart illustrates multi-factor water stresses are highest in Israel. Reproduced from "Development of Integrated Water Reuse Strategies," by, R. Hochstrat et al., 2008, *Desalination*.

Public Acceptance as a Necessary Condition

Public utilities require acceptance or customers are not likely to purchase the product (Salgot, 2008, p. 192). Early studies showed acceptance declined as degree of contact with reclaimed water increased. Additional analysis indicated significantly less acceptance where an actual project would deliver reclaimed water to the tap of a survey respondent (Bruvold, 1988, p. 46-47). Figure 2 shows public acceptance of actual projects in California, plotted with Windhoek, an exemplar of public acceptance (Khan & Gerrard, 2006, p. 192).

Figure 2. Public Acceptance of Waste Water Reuse.

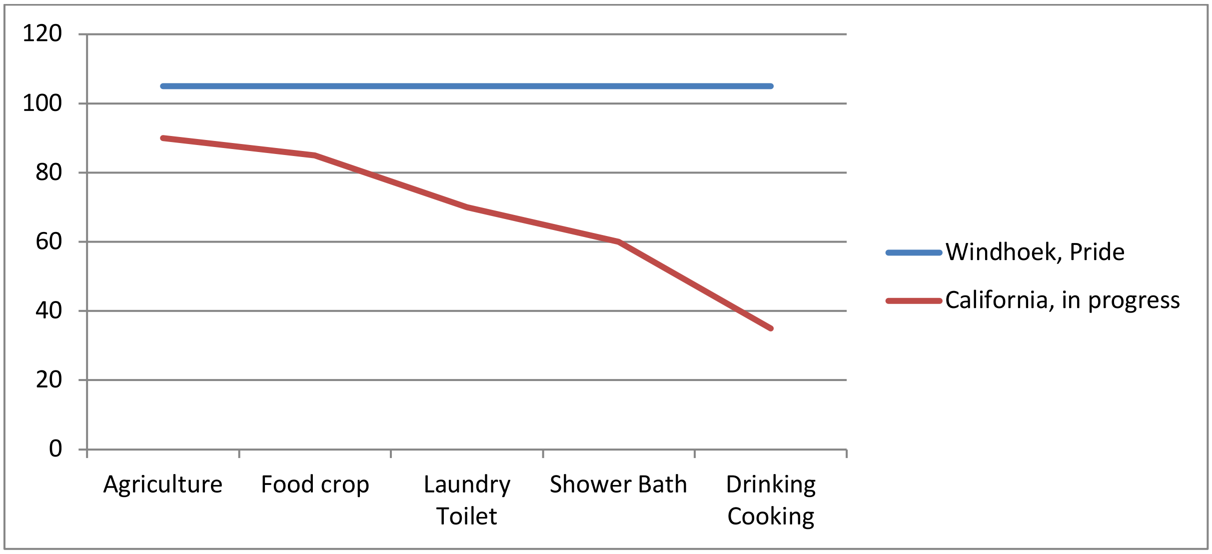

Figure 2. Public acceptance declines as human contact with reclaimed wastewater increases. The vertical axis is percentage public acceptance. The horizontal axis is degree of human contact on the scale lo-hi. Adapted from “Public opinion on water reuse options.” By W. Bruvold, 1988, Journal (*Water Pollution Control Federation*) and “Stakeholder communications for successful water reuse operations.” By, S. Khan & L. Gerrard, 2006, *Desalination*.

Factors that Affect Acceptance

In California, researchers investigated how respondents who already received reclaimed water determined approval and disapproval of water reuse projects. The study included a balanced, educational component prior to respondent interviews. Results indicated respondents “favored reuse options that conserved water, enhanced the environment, protected health and held down treatment and distribution costs.” Interestingly, in this study, the relation between degree of human contact and acceptance as illustrated in Figure 2 disappeared (Bruvold, 1988, p. 47). The addition of a neutral, educational element to the study design suggests the dissemination factual knowledge is an important element of fostering public acceptance. Some twenty years later attitudes about water reuse “remain largely unchanged” (Khan & Gerrard, 2006, p. 193).

Criteria for successful implementation of water reuse include water scarcity, trust in suppliers of reclaimed water, trust in suppliers of information, credibility of information sources, encouraging opportunities for community involvement and an effective communication plan (Khan & Gerrard, 2006).

Stakeholder communication design.

The following summary of successful, public engagement campaign methodologies illustrates key messages and approaches required to foster public acceptance. The idea is for readers to determine the degree conditions for successful implementation exist in Ganges. For example, is there an acute water shortage on Salt Spring Island? Political leadership and the support of water authorities is also critically important (Salgot, 2008, p. 196). The general idea is that the greater the risk of water shortage, the greater the need for communication about the issue. The following design elements include a summary.

a) *Defining and identifying successful communication*. The original aim defines success. Aiming low like, an information program about water reuse may be a good start. Whatever the aim, the best strategy is to provide balanced evidence and let stakeholders “draw their own conclusions.”
b) *Early and continuous communication*. Public engagement should be part of the earliest planning activities.
c) *Listening and seeking clarification*. Two-way communication is crucial. Listening to concerns often leads to better program delivery.
d) *Risk communication*. The willingness of stakeholders to respect the views of others is fundamental (Khan & Gerrard, 2006).

Key messages in stakeholder communication.

“The first step of the communications program will be to let stakeholders know that there is a serious, long-term water shortage problem that is in urgent need of being addressed” (Khan & Gerrard, 2006, p. 197).

a) *Water reuse organisations earn their good reputation.* “At some point, the community will need to place its trust in the water reuse organization to protect public health and the environment.”
b) *The reuse project has a critical need and clear purpose.* “Raising and maintaining community awareness of the importance of the underlying issues and the role that water reuse has in addressing those issues should remain a high communication priority.”
c) *Reuse water is safe for its intended users.* “Safety should be promoted as the utmost concern of the water reuse organization.”
d) *Water reuse helps conserve drinking water supplies.* “Water conservation efforts help but are often not enough to offset increased demand.”

e) *Water reuse is beneficial to the environment.* "The reuse of water benefits the environment by reducing the amount of treated wastewater discharged to rivers, bays and oceans."
f) *Water reuse may have significant positive economic impacts.* "water reuse organizations should tread carefully and avoid any suggestion that the principal advantage of a water reuse scheme is merely that it is the cheapest option."
g) *Water reuse is preferable to alternative strategies.* "The most favourable approach is to communicate the advantages and disadvantages of all the options and demonstrate how the preferred option is the most suitable."
h) *Water reuse is successfully practiced in many other places.*
i) *All water is reused*. "A proportion of every glass of water we drink has already been through insects, plants and animals — including people. (Khan & Gerrard, 2006)

Local Jurisdictional Requirements and Public Acceptance

Jurisdictional requirements may arise from local, regional and provincial sources. At the local level, two salient questions require acceptable resolutions. First, "Who will own the IPR / DPR facility?" Second, "Who will pay for it," (K. Wahlstrom, personal communication, September 22, 2017)? Provincial health standards and Municipal Wastewater Regulation (MWR) legislation contain specific IPR requirements (BC Ministry of Environment, 2013, p. 11; Harris, 2017, p. 2). Specific requirements for IPR projects include prior approval from a regional director at the Ministry of Environment (MoE), an enhanced Environmental Impact Study and consultation with "other ministries and agencies, local governments and local residents/landowners/businesses" (BC Ministry of Environment, 2013, p. 11). In addition, the BC Municipal Wastewater Regulation does not include guidance for Direct to Potable water reclamation. However, the MWR contains provision to substitute regulatory requirements. Where different requirements align with the intent of the regulation, a MoE director may authorize a substitution (British Columbia Environmental Management Act Municipal Wastewater Regulation, 2018, Sec. 8).

The BC Municipal Wastewater Regulation helps to ensure health and safety of highly treated wastewater effluent for reuse as drinking water. BC guidance on implementation of IPR fits within a broader context of legislation that normalizes reclamation of highly treated wastewater effluent. For examples, in 1991, the European Economic Community enacted European Council Directive 91/271/EEC concerning urban wastewater treatment that stated "Treated wastewater shall be reused whenever appropriate" (Hochstrat, Wintgens, & Melin, 2008, p. 210). In 2017, the California legislature directed the state water board to "adopt uniform water recycling criteria for direct potable reuse" regulations by 2023 (Garcia, 2017, p. 4). In 2008, Florida enacted a wastewater outfall program that "requires wastewater utilities to cease disposal of treated wastewater to ocean outfalls by 2025" (Guo et al., 2016, p. 811). In BC, there is a moratorium on wastewater discharge to Saanich Inlet (British Columbia Environmental Management Act Municipal Wastewater Regulation, 2018, Sec. 98).

Finally, the BC Reclaimed Water Guideline includes strategic communication considerations. Preparation, in the form of understanding public perceptions is a large part of the strategy. For example, “How can public acceptance be fostered proactively, before potentially negative reactions can take hold?” The recommendations for a communications plan include “Starting public education early,” and ensuring on-going public education and outreach (BC Ministry of Environment, 2013, p. 42).

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