PRINCIPLE 7: KNOW YOUR CATCHMENT
ASSESSMENT OF RECREATION ON WATER QUALITY AND WATER TREATMENT COST

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KEYWORDS
Drinking water quality, protozoan parasites, recreation, water treatment, modelling, faecal shedding

SOURCE WATER PROTECTION PRINCIPLES
Knowledge of catchment land use and activities and hydrological or hydrogeological processes is critical to understanding the dynamic source water risk. Without 'knowledge of your catchment', it is impossible to implement proactive and effective drinking water source management.

CASE STUDY DETAILS:
Year: Initial field investigations started in 2011 with updates in 2020.
Locations: Recreation Dams, Perth-Hills Metro Region, Western Australia
Teams: Water Corporation and Murdoch University

CASE STUDY OUTLINE:
Key drivers:
Why did the project occur, and what issues were addressed?

- In Western Australia (WA), water quality of Public Drinking Water Source Areas (PDWSA) is managed by restricting the type of recreational allowed in catchments. With increasing public pressure to access these areas, the challenge for management is to understand (1) the microbiological pathways and risks posed by full-body contact recreation on reservoir quality, (2) the consequences of event-based contamination and (3) the cost of recreation in catchments on water treatment capital and operational expenses.
- Human pathogens pose the greatest acute risk to water consumers. This study was intended to provide information on the influence of recreation on the level and type of microbiological contamination of source waters. Pathogens of concern are *Cryptosporidium* and *Giardia*, primarily because of their resistance to chlorine disinfection, their small size, long survival time and association with enteric water-borne disease (at a low effective dose).
- The project was triggered by the outcomes from an Upper House Parliamentary Inquiry that assessed the influence of recreation on public drinking water source areas in WA. A plethora of information was derived from the Inquiry, which showed the critical importance of understanding our water drinking water sources and the risk of contamination from recreational access.
- Research shows recreation in water bodies can result in microbiological contamination from the shedding of faecal material and pathogens. From a public health perspective, the main concern is potential contamination with human pathogens.
- There have been previous investigations on the effects of recreational access on drinking water reservoirs. This study specifically focussed on understanding the levels of contamination, mode of transmission, risk outcome and design of water treatment systems.

Approach taken:

- In the greater metro area, three reservoirs were selected that are used for irrigation and recreation, as such they do not have controls over access to the reservoir protection zone (2-km boundary above high water mark) or restrictions on activities in the outer catchment.
- A monitoring program was designed and implemented over three years. The sampling frequency was both fixed-interval and episodic-based monitoring (aligning with peak recreation events). Samples were collected from the reservoir and analysed by Murdoch University.
- Data for the most frequently used (popular) reservoir was selected for analysis as there was supporting information that included recreational access and visitor numbers.

- A numeric model was developed to simulate the shedding of *Cryptosporidium* and compare these counts with those measured in the reservoir.
- A planning study was undertaken to determine the level of treatment required to deal with changes in WQ attributed to recreational access and meet the water quality requirements of Department of Health, WA. Treatment processes were costed to determine the capital and operational costs. Costs were compared with the capex and opex for treatment used for protected reservoirs in the metro area.

Outcomes:

Summary of outcomes:

- Sampling showed low oocyte counts during the winter and during periods with low visitor numbers to the reservoir. However, during the warmer periods, the number of recreators increased and gave rise to a corresponding increase in oocyst counts (Figure1). Recreation included full-contact activities such as swimming, paddling, sailing and water skiing, see Figure 1.
- A large proportion of water samples tested positive for *C. hominis* and this shows the primary source of contamination is derived from humans.
- During hot weather, over 300 people have been observed swimming in the reservoir. In total, there are between 88,000 and 100,000 visitors each year.
- Human infectious strains of *Cryptosporidium* in the reservoir were detected, with significantly higher prevalence during peak holiday periods (refer to Figure1).
- Numeric modelling allowed a comparison of the theoretical oocyst shedding rate with the measured in-situ oocyst counts.
- A planning study estimated the cost of treating the reservoir water based on the projected challenge. In addition to pathogen removal, treatment processes were selected to address turbidity, algae, algal-toxins and hydrocarbons from boat engine fuel and lubricants (detected in the recreated reservoirs).
- Based on a 50 ML/day water treatment plant, the capital cost was estimated at $150 million with operating cost of $5 million per year. A 100 ML/day treatment option was estimated to have a capital cost of $190 million, with similar operating costs. These costs were based on desk-top estimates and excluded site-specific considerations (that could increase costs up to 50 percent).
- In comparison, a protected reservoir used for drinking water supply (with low pathogen risk) supplying 50ML/day, would require the use of chlorine disinfection with a capex of around $1.5 million and opex of $0.3 million/year.
- In 2020, the costs were reassessed using the latest treatment technology. It was found that there was minimal change in the overall capital and operational cost, once adjusted for inflation.
- The Inquiry showed the cost of operating recreational sites (rangers, rubbish, toilets, enforcement, road maintenance, fire breaks and administration of the business and site) was not recouped from the income generated from recreational visitors.

Measurable impacts of the activities:

- The modelling and field data provides strong support for the finding that faecal shedding by recreational users is an important contributor to *Cryptosporidium* detections in this reservoir.
- Faecal shedding rates cited in the literature were used in the model and provided agreement between simulated and measured data.
- Figure 1 shows a time series plot of measured oocyst counts in comparison to recreation numbers and simulated oocyst counts. This shows contamination episodes corresponded to the peak influx of recreators during school and public holiday periods. Oocyst counts during the cooler periods were significantly lower and corresponded to observations of low recreation activity.

Lessons learnt and critical success factors

- Modelling of oocyst counts in the reservoir supports the field observations that faecal shedding by recreational users is an important contributor to *Cryptosporidium* detections.

- Peak oocyst counts are associated with periods of high visitor numbers during Christmas, New Year and Easter public holidays. At these times, over 2000 visitors may come to the reservoir to recreate on any one day. The reservoir is a popular destination for water skiing.
- Faecal shedding rates used in the literature were used in the model and provided an acceptable agreement between simulated and measured data.
- Full contact recreation and shedding accounted for substantial numbers of human infectious protozoan parasites in the reservoir with minimal access to the upper catchment areas.
- Protozoan parasites pose a considerable risk to recreators and potentially to downstream water users who may use the water without adequate treatment.
- Removal of protozoan parasites requires advanced multiple-barrier treatment with the lower cost capital option, based on a 50 ML/day treatment plant, estimated at $150 million with annual operating costs of $5 million.
- Changing government policy to allow full contact recreation in public drinking water source areas would entail a major increase in capital cost of water treatment of at least a hundred-fold, compared with protected catchments without full contact recreation.
- The design of the monitoring program was important, and the frequency was linked to periods when visitors frequented the reservoir and thus helped inform our understanding of the role of faecal shedding on reservoir microbiological quality.
- Numeric modelling provided an opportunity to interpret information on recreation numbers, in-situ dilution, oocyst settling rates, and faecal shedding rates.

Significance of the findings:

- The project explained the risks and risk-based events that influence the microbial quality of reservoirs and potential consequences for public drinking water supply.
- Effective management of reservoirs and catchments requires a risk-based approach to understand and quantify the sources, processes and consequences of contamination.
- For drinking water policy in Western Australia, the project helped demonstrate there is no scientific, technical, economic or social justification to move away from the current preventative risk-based management approach regarding recreation in, or near, public drinking water sources.
- Furthermore, from a community survey, the public in WA support the use of high-quality undisturbed catchments that provide high quality water and require minimal treatment.

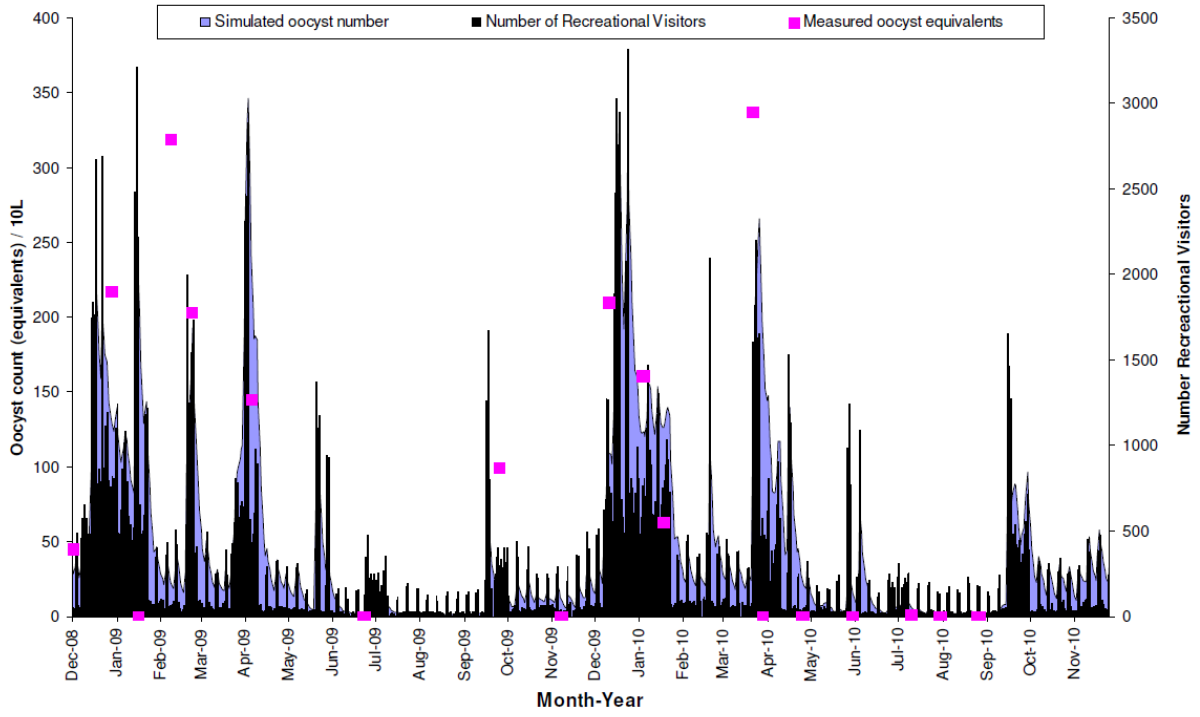

Figure 1: Time series plots of *Cryptosporidium* oocyst counts (equivalents) in comparison to derived recreation visitor numbers, rainfall, reservoir storage volume and simulated oocyst numbers.

Resources:

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