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Water Proofing Homelands: Integrating Approaches for Small Water Supply Reliability

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Water proofing homelands; integrating approaches for small water supply reliability in the Kimberley, WA

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1 Abstract

The Kimberley region is home to nearly a quarter of Western Australia's Aboriginal population (DIA 2005). Water system reliability is an ongoing issue for remote community water supplies in the region (ABS 1999), (DIA 2005), (Popic 2006:77), (O'Mullane 2003:44) affecting around 160 small communities with populations of less than 50 people (ABS 2001). Uneven coverage of water supply maintenance for most small remote communities and homelands in the greater Kimberley region lies with Homelands Resource Agencies. They are often overwhelmed with responsibilities for a wide range of essential services and technical support including housing, energy, fire prevention, sanitation, waste, water supplies and more. The difficulties in providing the skills base required to perform this myriad of essential services is not adequately resourced. If funding is reduced at Federal and State levels, this problem will be exacerbated. While 80 communities with populations over 50 are maintained under the WA Remote Area Essential Services Program (RAESP) (DIA 2005), for communities of less than 50 people and their Resource Agencies, reliable access to basic water supply remains patchy. In the Malarabah region of the Kimberley, a small homelands essential service maintenance program provides basic routine maintenance to power & water supplies for 24 outstations. A research project conducted from 2004 – 2006 explored elements of water system reliability in these communities and provided an assessment of their risks, vulnerabilities and potential improvement measures.

Water infrastructure, quality protection measures and the availability of baseline water resource information remains an issue for water supply management in homelands. Residents expressed a desire to have more controls over local water quality and quantity, including contamination response measures, fire-response storage and ability to manage local water demand. Remote residents were conscious of their increased vulnerability due to distance and wet season inaccessibility. There are many actions that residents can take locally to increase water security, and opportunistic capacity building around the issues has been part of the action research approach. However, the findings illustrate a gap at the human-technology interface, identifying a need to build community capacity for local water management. This gap is closely linked to the vulnerability of small communities and their ability to locally control the quality and sustainability of their water supplies and fortify against threats to water security. Supported by a regular maintenance regime, a participatory approach to whole of water cycle planning at the community level is proposed to address this gap. In supporting the expressed needs for greater self-management, a dual benefit can be achieved. Funding of maintenance regimes could be expected to be more efficient as residents can take greater steps to secure their supplies before seeking external emergency assistance, and communities are empowered to increase their independence on homelands. Increasing reliability of infrastructure through supporting local management and aspirations can have direct flow on effects for health and wellbeing, family stability, education and livelihoods activities (DFID 2001; DIA 2005). In the Australian Indigenous context, this suggests that an investment in essential infrastructure support systems provides an investment in the future stability of community life in remote locations.

These findings have implications for homelands with and without an existing maintenance regime, to take steps to 'waterproof' communities against water quality and quantity vulnerability and facilitate sustainability of local water supplies. This work may also inform future policy approaches to improving essential services reliability for small communities in remote locations.

2 Background

The 1999 Community Housing and Infrastructure Needs Survey identified that equipment failure was the major cause of water restrictions in remote Indigenous communities in Australia, and that the region worst affected was the Kimberley (ABS 1999). A water restriction refers to a restriction on the amount of water that could be used, or the purpose for which water could be used and included reasons such as drought, equipment breakdown, inadequate storage, maintenance issues and poor water quality (ABS 2001:81-82). The 2001 survey indicated water restrictions in Indigenous communities nationally affected 28% of communities with a population greater than 50 or nearly 30,000 people (ABS 2001). In recent years, many larger communities have secured essential service agreements with State governments and their service providers (CGA & WA 2000:iv) (WA); (Willis, E., Meryl Pearce, Tom Jenkin and Simon Wurst with Carmel McCarthy 2004)(SA), (IES 2005) (NT)). Trends in the 2001 survey indicate that with over 14,000 people in communities with populations less than 50 not covered by this survey (ABS 2001), the population not receiving reliable water supplies is much higher. In the 12 months prior to the survey, equipment breakdown was the primary determinant of water restrictions, causing 61% of restrictions to large community supplies nationally. In Western Australia, the essential services (water, power, sewerage) in the 80 large, remote and town-based discrete Indigenous communities with populations over 50 are maintained under the WA Remote Area Essential Services Program (RAESP) (Popic, D. 2006:77). The incidence of failures to water infrastructure is inversely proportional to population size (ABS), suggesting smaller communities are more likely to be affected. Equipment breakdown was the only reported cause for water restrictions experienced in the Kimberley region, encompassing the Kullarri (Broome), Malarabah (Derby) and Wunan (Kununurra) former ATSIC regions (Fig 1).

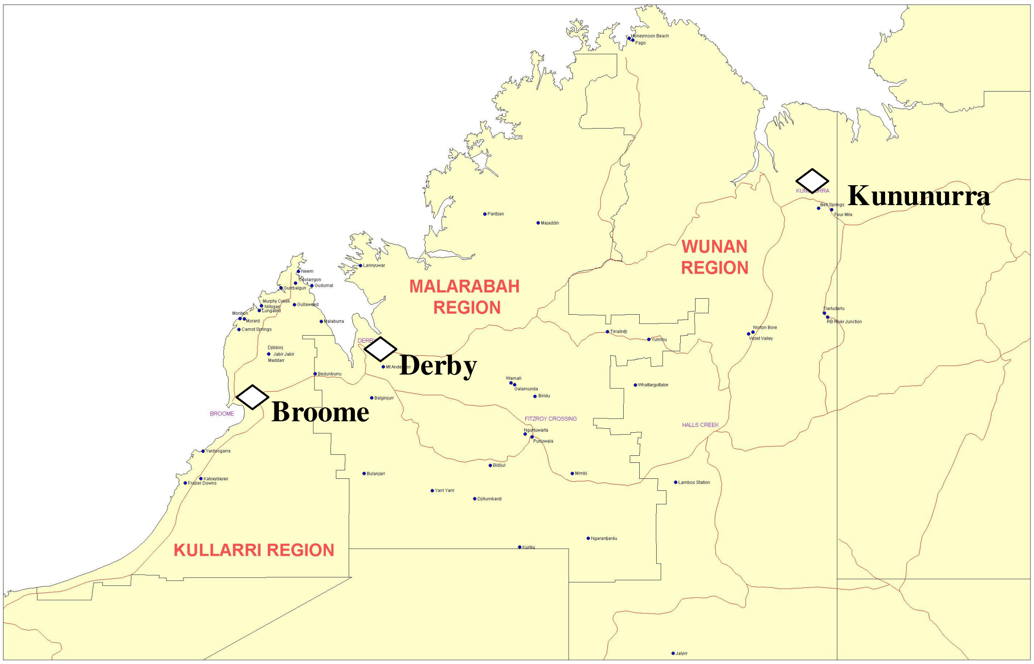

Figure 1: Kimberley ATSIC Regions Map.

There are 162 communities in the Kimberley region with populations of 50 people or less (a total of 2400 people), where detailed information on water systems (other than primary source) was not collected (ABS 2001:81-82). However, these communities are not usually part of an organised service arrangement for the maintenance of water supplies (Commonwealth Government of Australia, 2000:iv) and could be expected to experience higher incidences of equipment breakdown.

For communities of less than 50 people and their Resource Agencies, reliable basic water supply access and provision remains patchy. Responsibility for water supply maintenance for most small remote communities and homelands in the greater Kimberley region lies in some cases with private contractors, but mostly with Homelands Resources Agencies; often overwhelmed with responsibilities for a wide range of technical and essential services including housing, energy, fire prevention, sanitation, waste management, water supplies and social support. The diverse technical skills base required to perform this myriad of functions is limited due to diseconomies of scale and reduced availability of appropriately skilled personnel in remote locations. Policy and funding shifts at Federal and State levels suggest that this problem will be exacerbated if the funding gap grows. Approaches are required that can provide a basic level of technical support to water supply management in remote locations whilst strengthening complementary local water management skills and thereby community independence. The provision of services to remote Aboriginal communities also has a significant impact on service delivery in regional towns, as transient populations can increase pressure on services and social conditions in regional centres (DIA 2005). Finding new approaches to supporting remote communities to live happily and safely on homelands is of paramount importance not only for the individual residents but also to reduce negative social and economic pressure on services delivered in regional centres.

3 Introduction

In the Malarabah region of the Kimberley in north-west WA, the Centre for Appropriate Technology (CAT) has managed a small homelands essential service maintenance program for 24 outstations since 2002. This program is funded federally and provides basic, routine maintenance to power and water supplies. In 2004, CAT conducted a phone survey with 19% of 128 small remote communities (with populations less than 50) from the Kimberley region to develop a more detailed understanding of the issues affecting water system reliability in these smaller communities (O'Mullane 2004). The survey found that 79% of these communities had experienced system failure and that 'equipment breakdown' was a diverse category, not attributable to a singular mechanical determinant. Service delivery and maintenance were found to be major causes of equipment breakdown (O'Mullane 2004). An action research project was developed to identify and develop ways to address some of the main causes of water system failure in the region. This paper presents the data and learnings to date from this research project conducted since 2004.

4 Methodology

Water infrastructure data collection

Baseline information on outstation water supply source and infrastructure was collected through observation, conversations with residents, relevant publications and historical water resource reports. Information was collected on hydrogeology, water quality, treatment systems, road access, seasonal conditions and water 'histories' and collated in an internal database.

Water quality

In addition to historical data (where available), some microbiological and water chemistry testing was carried out at the request of residents where microbiological water quality was a concern, or where residents were interested in specific chemical constituents based on taste, odour or regional knowledge.

Maintenance Program

As the research has come from the unique position of within the organisation also managing the maintenance program; there has been the ability to both capitalise on the contractor's service visits for data collection and also alter management processes to improve the program as the research progressed. This provides a uniquely responsive action-research approach, where important suggested improvements such as 'no survey without fix', improvements to information management, water supply data collection and opportunistic capacity building can be taken up during operations.

The contractor's notes on maintenance repairs, faults and failures were utilised as a data source and also entered into the database. Costs for materials are also recorded.

5 Results

Water supply infrastructure

18 of the 24 communities used ground water as their primary water source. Four communities used surface sources (soaks and a river) whilst two communities carted their water supply. Majority reliance on ground water means that most communities are ultimately reliant on a functional bore, a power source and a working pump. Solar powered bore pumps provide 14 of the 24 communities' water pumping needs, while five communities use diesel generators and two use petrol to power electric pumps, one is supplied by a windmill and the two communities carting their water supply did not require power (Figure 2a). Age and condition of the equipment has a bearing on equipment reliability, although equipment of all ages can fail. Two thirds of the study communities had pumping equipment that was at least 10 years old whilst one quarter of the communities had equipment that was estimated to be 5 years old (Figure 2b). One fifth of the primary water pumping equipment was greater than 15 years old.

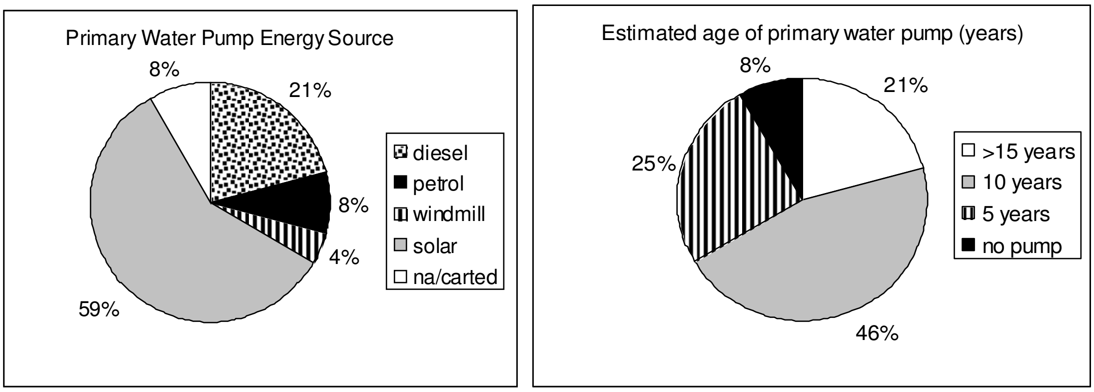

Figure 2:(a, left) almost 60% of the study communities had solar powered water supplies, and almost 10% had to cart water; and (b, right) Two thirds of the water pumping infrastructure in the study communities is greater than 10 years old.

Storage tanks were of varying ages, sizes and quality (Figure 3a). Particularly in communities not near a surface water source, water supply security is directly related to storage tank size. At least 5 days' supply is desirable for water security to provide adequate response time (especially in remote areas) if a major bore or pump failure occurs. To determine the number of days' storage capacity available on the study communities, total capacity was divided by the usual resident population based on 100L/person/day as the minimum quantity required to provide a basic supply for consumption, cooking and hygiene requirements (NHMRC 2005:14). Figure 3b below illustrates that half the study communities had at least 5 days storage capacity; however three communities had no water supply storage facilities whatsoever.

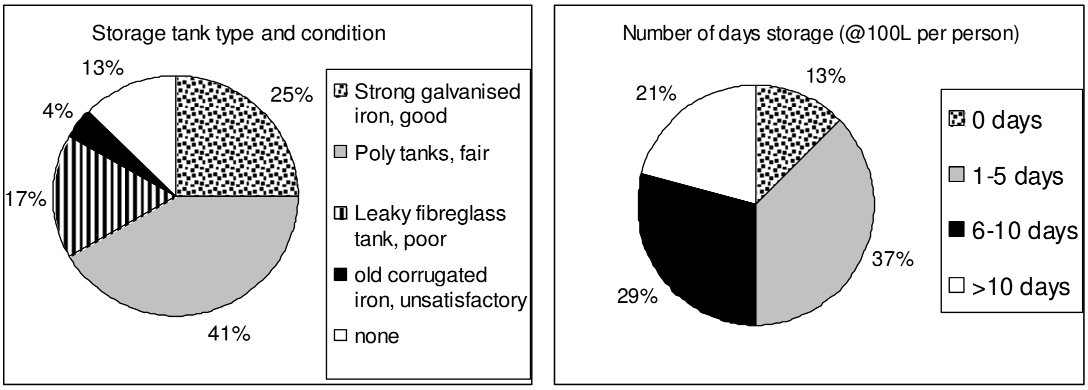

Figure 3: (a, left) two thirds of communities had storage tanks of adequate condition and (b, right) half had at least 5 days storage capacity. 3 communities had no water storage facilities.

In the absence of a secondary or back-up supply, the additional water supply security gained from large storage tanks is undermined somewhat, as storage tanks were the sites of 10 water system failures during the study period. 75% of the communities surveyed had no backup water supply to access in the event of a critical water system failure or a rapid population influx.

Water restrictions

There were a total of 45 major water restrictions recorded during the study period (Figure 4), affecting 75% of the study communities. There was a diversity of sites of discrete restrictions within the water systems, the majority in storage tanks, closely followed by ongoing restrictions from insufficient source water. Storage tanks failed due to scouring and splitting, calcium blockages, and infrastructure age. Restrictions caused in the pipes/distribution system were due to external accidental damage (cows, cars, fire), calcium blockages and mechanical failure of components (mostly pumps and power sources) was by far the greatest cause of restrictions (21 cases).

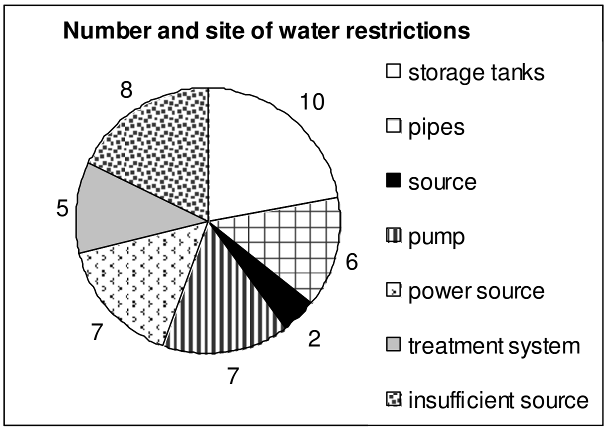

Figure 4: Water restrictions reported in the communities by location in the water supply system.

Water Quality

A total of 15 communities out of 24 reported ongoing water quality issues during the study period, and 9 of those also reported quantity problems during the same period (Figure 5a). Two communities had ongoing water quantity problems and three did not report a water issue during the period. In four communities this information was not collected. Only four of the water quality issues raised by communities were related to chemical constituents. Total Dissolved Solids (TDS), which caused two tank failures and ongoing pump and pipe issues in a number of communities, was raised by only three. At one community, residents could taste salt in their water supply and were interested in alternative sources, whilst another had concerns about colour and suspended solids affecting aesthetics. Microbiological quality was of most concern to residents, alongside quantity concerns such as running out either in the short or long term. Five communities had UV treatment systems installed (Figure 5b), however there were five occasions where UV systems were the source of a water system failure and required repair during the study period. There were no other disinfection methods observed in these communities.

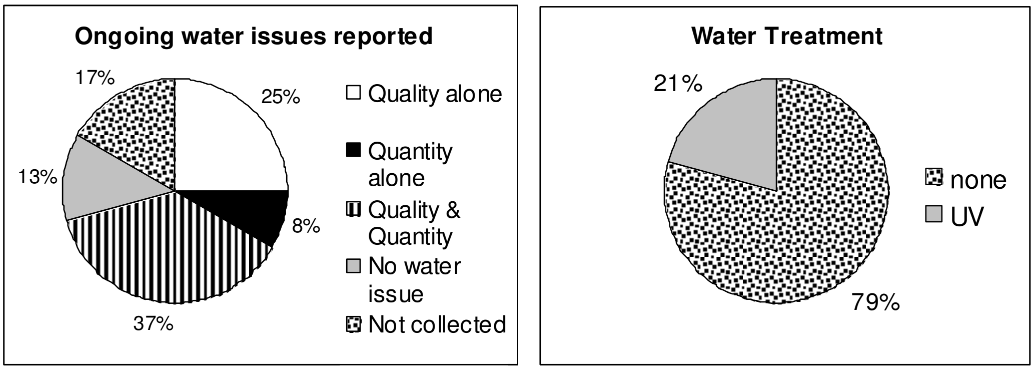

Figure 5: (a, left) Ongoing water issues observed in the field and reported by communities.
(b, right) Water treatment was only in 21% (5) of the 24 communities, and two experienced system failures at the beginning of the study period.

There were 12 communities in which microbiological water quality was of concern. Two communities reported gastric episodes from the past, while others asked for their microbial quality to be tested for verification. Requests for testing mostly came from those who were drawing from a limited surface water supply with little catchment protection (springs, soaks and rivers) and some were for bore supplies where residents were uncertain of the cleanliness of the bore or the water system.

Water quality protection measures
Very few basic water quality protection measures were in place in small community water supplies, with only six of 24 bores having basic perimeter fencing. Many bore and surface water supplies were regularly traversed by animals such as cattle and horses, exposing them to risk from faecal contamination. Most bores had minor or non existent protective concrete collars and many were unsealed at the surface, offering little protection from potential contamination via preferential flow down the bore shaft. Many storage tanks were also open (missing lids or not constructed as closed systems) to birds, frogs and other animals and therefore potential faecal contaminants. Another mechanism for water quality protection is positive pressure in the distribution system so that in the event of breaks in the system, water will flow outward. Some communities had pressure issues, particularly where systems were reliant on pressure pumps for reticulation or where storage tanks or their float switches were not configured to sufficient height to deliver pressurised gravity feed at all stage levels in the tank.

Community water concerns
Residents' articulated concerns about their water supplies (from a total of 11 communities) provide valuable insight into perceptions of risk and vulnerability. 10 communities requested technical assistance and advice on a range of water and related technical issues. Residents expressed a desire to have more controls over local water quality and quantity, including contamination response measures, sanitation, mosquito control, fire-response storage and ability to manage local water demand. External factors such as satisfaction with the routine maintenance program were also discussed. Remote residents were conscious of their increased vulnerability due to distance and wet season inaccessibility and many wish to equip themselves to better meet these challenges. Where water systems had failed in the past, residents articulated feeling vulnerable or uncertain about their water options. The expressed perceptions by residents on vulnerability and water supply needs provided a valuable social context for the analysis of water system reliability data, i.e. what does it mean for residents if a tank fails or a pipe breaks in a location 400km from the nearest service centre?

Water system reliability
The impact on residents from malfunctioning or damaged essential infrastructure or compromised water quality will be greater where they have few remedial options or alternative supplies. Distance from service centres, whether the community has a telephone, the number of times they experienced water restrictions or were cut off by road in a 12 month period and microbial risk are characteristics that increase the vulnerability of water supplies. Remedial characteristics that reduce vulnerability include number of day's water storage capacity, presence of a back-up water supply and use of a disinfection method.

Deciding on the best tools or interventions that can be undertaken to reduce the greatest infrastructure vulnerabilities requires an analysis of the interactions of these factors in reducing risk. A factor was developed to estimate relative microbial risk based on scores allocated from field assessments, for source quality (based on protection measures, where 1= soak (greatest risk), 0.8=carted, 0.5=river, 0.1=bore (lowest risk)), storage hygiene (where 1=unprotected, 0.5=partial protection, 0.1= protected) and the presence of a disinfection method (1= none (risk remains), 2= disinfection (half the risk if disinfected)). These data were plotted against adjusted community occupancy and road distance data (ABS 2001) (although this data may vary slightly from year to year depending on the wet season) to develop a representation of the risks to the study community water supplies and potential effects on community stability (Figure 8). A pattern emerged in the data that links the risks and remedial water supply factors.

The risk factors have been plotted across the lower x axis in Figure 8. The mitigating factors reducing vulnerability; number of days' community on-site water storage capacity, availability of alternative water supplies and availability of disinfection technology are displayed along the upper x axis (Figure 8). A 'vulnerability score' is proposed, which may provide a method to rank communities according to vulnerability to water supply failures or restrictions, and to assess methods for intervention at each location. The 'vulnerability score' is calculated by incorporating risk factors on the numerator (summed or multiplied according to their effect on the water supply) and remedial or risk reduction measures on the denominator, calculated as per Figure 6 below. This score is plotted in Figure 8 for each community.

$$Vs = \frac{(\text{travel time} + \text{duration unoccupied} + \text{cut off by road} + \text{phone}) \times \text{microbial risk factor}}{(\text{number of days water storage} \times \text{backup water supply} \times \text{disinfection})}$$

Figure 6: A 'vulnerability score' is proposed to explain the relative risks of different community water supply characteristics and to assess the most effective methods for mitigation.

All communities were over 60km from the nearest town; the furthest being over 600km away from a service centre, represented by black columns. Note that community vacancy periods generally increase with distance from service centres (Figure 8 and 8 below). Distance, combined with the capacity and condition of infrastructure available on the site, has clear ramifications for vulnerability to water supply failures. Figure 7 presents a magnification of plotted data from two communities for clarity.

Communities with high risk factors (bottom x axis) and low 'buffering capacity' in remedial factors (upper x axis) will return a high vulnerability score, such as community 'Mg'. From Figure 8 and Figure 7, community 'Mg' had three water restrictions over 12 months, no backup supply and little storage capacity. Community 'Mi' has a lower vulnerability score due to the availability of a backup supply and 9 day's storage capacity. If community 'Mg' were to connect a back-up supply such as rainwater tanks or augment storage capacity, their relative risk would reduce by dividing by the number of days augmented storage capacity. For microbial risks, installation of a disinfection measure would reduce their risk by half. This is a coarse factor to describe the interaction of a number of key determinants of water supply vulnerability identified in this project and may assist in allocating resources to community water supplies based on greatest risk.

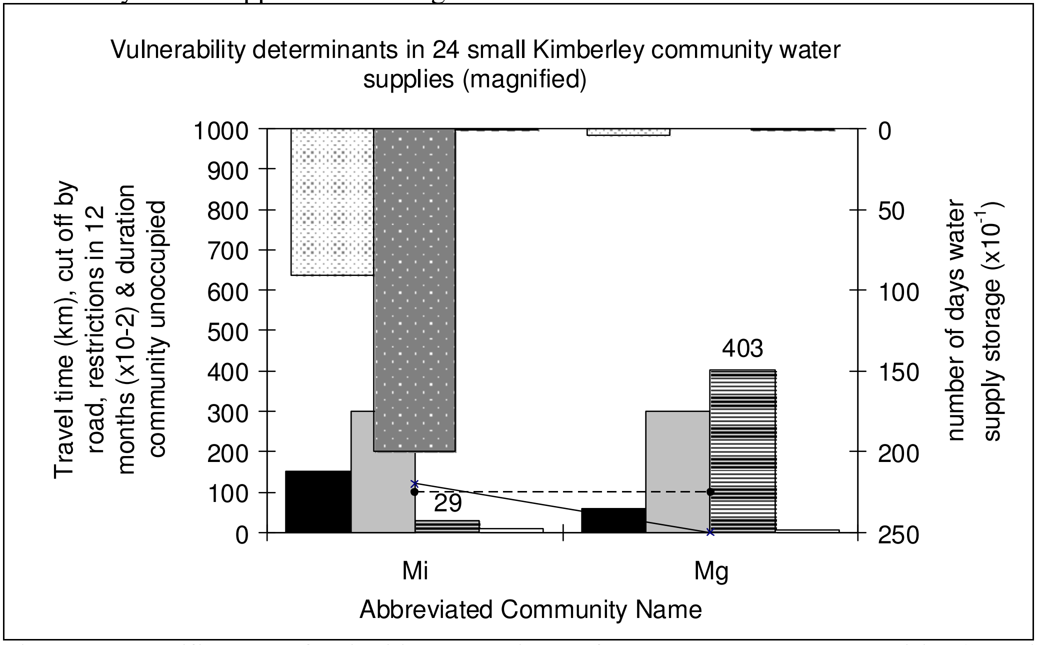

Figure 7: Magnified plot of reliability determinants for two case study communities (key Fig 8).

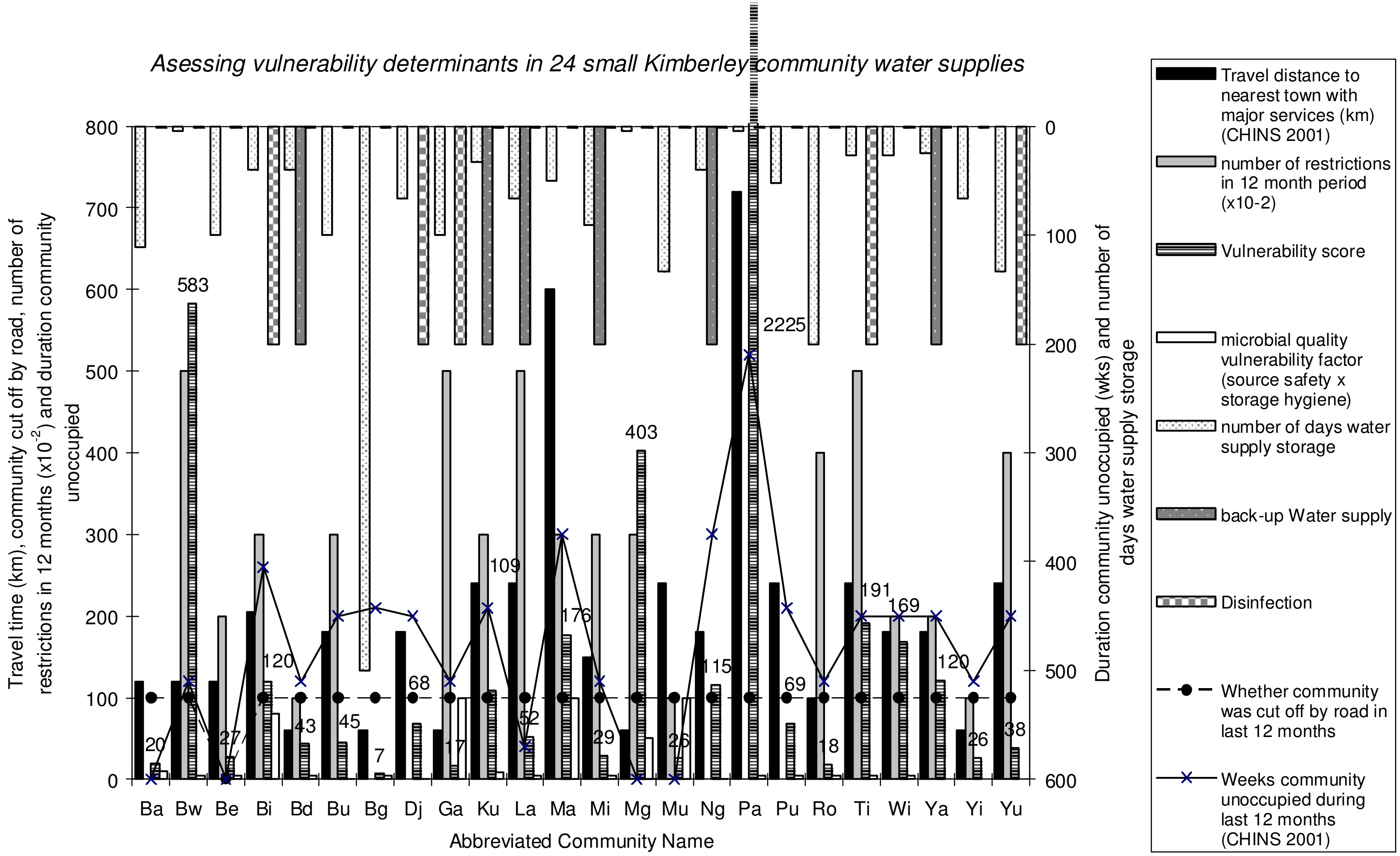

Figure 8: Water restrictions compared against key characteristics of the 24 study communities that influence water supply reliability; including travel distance to service centres, number of days water supply storage, usual wet season effects and remedial measures such as disinfection, back-up water supplies and relative microbial quality based on field observations. The 'vulnerability score' responds well to the community water supplies identified as having the greatest water risks, and may provide a way to assess risk reduction measures. See also Figure 7 above for magnification of two communities' indicator values.

6 Discussion

Reliability determinants can be grouped into two major categories – infrastructure management and local water management. Water quality protection remains a greater issue in small communities, with nearly 63% of study communities having water quality concerns, compared to State surveys where 37% of all WA communities reported their quality as unsatisfactory (EHNCC 2004). From field assessments it is apparent that simple, low cost measures could make dramatic improvements to water quality protection and system reliability. Equipment failures affected 75% of the 24 Kimberley homeland case study communities in the 2 year study period. Mechanical failure caused 50% of the water restrictions recorded. Whilst these communities have been under a maintenance regime and this figure is expected to decline, there are 135 other small remote Kimberley homelands with no maintenance regime where the failure rates could reasonably be expected to be worse.
The results also illustrate that remoteness increases the vulnerability of communities to water supply system failures and there are practical steps that can be taken to address these issues. Whilst vulnerability of ageing infrastructure can be reduced in part with appropriate selection and upgrades to infrastructure and regular maintenance, technological fixes are only half the picture. Two thirds of the water issues reported were related to quality and most of those microbial, whilst 45% of the issues reported were regarding quantity. Many of these issues can be largely overcome with local management techniques such as source protection, diversification and demand management. Indeed, communities are increasingly seeking technical information about their own supplies and ways to improve them, indicating a need for capacity building on demand-side approaches to improving local water management. It is not just infrastructure but the informed management of a suite of key areas that will increase overall water system security. The vulnerability of small communities can be reduced by increasing their ability to locally control the quality and sustainability of their water supplies, and opportunistic capacity building around the issues has been part of the project approach. However, there is a need to develop a way to strengthen homelands water reliability with technical and capacity building around water management.

A participatory approach to whole of cycle water planning at the community level is proposed to address this gap. This approach would have implications both for homelands with and without an existing maintenance regime, to reduce vulnerability to water quality and quantity risks and increase sustainability and independence of communities. Improving water system reliability will require an integrated approach that includes local water management and where possible, a support network through ongoing regionalised maintenance for better water and subsequent environmental health outcomes for communities. Lessons learnt from this process can assist to develop micro-macro level links (DFID 2001): links between on-ground realities, external management and policy to aid in better water management and environmental health for remote homelands.

7 Conclusions

1. Despite adverse water supply conditions, people aren't moving away because of water. Residents have strong reasons to want to stay on homelands settlements and are doing so; working through difficult environmental health conditions.
2. Many of the current water quality and quantity management issues could be addressed through strengthening infrastructure and developing local capacity for water management issues. A vulnerability analysis of community water supplies may provide a method for prioritising infrastructure upgrades for homelands most at risk and assessing which intervention will have the greatest impact on reducing risk. This work will be further explored at the completion of the research project.
3. An enabling approach that builds local capacity should lead to better health and wellbeing outcomes for families on homelands by increasing community ownership and management of infrastructure. Given the uncertainty around future homelands

investment, this is a significant step towards greater community independence and security.

4. A regionalised maintenance program improves water supply security in homelands. Technology can't run reliably without basic routine maintenance nor can it be sustained from external maintenance alone, and this is especially so in remote places, where the impacts of failures can mean communities are days or months (depending on the season) without external technical support. Existing investment in supply-side approaches (externally management maintenance programs) will be strengthened by improvements to demand-side (local management) capacity.

8 Recommendations

1. The existing regionalised maintenance program provides increased water security to homelands and the model should be continued and expanded to other regions.
2. Planned upgrades to existing infrastructure are required in some homelands and will be required more so as infrastructure ages. Increased funding for small-scale essential remedial works would also deliver strong outcomes in water quality security for minimal investment.
3. A trial capacity-building and technical support program for homelands is recommended to develop an informed local water management capacity to complement the external support.

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