EVAPOTRANSPIRATION SYSTEMS FOR DOMESTIC WASTEWATER REUSE IN REMOTE ABORIGINAL COMMUNITIES

Martin Anda, Goen Ho & Christine Harris
Remote Area Developments Group, Inst. for Environ. Science, Murdoch University. WA

Abstract

In the past, sewage ponding in Aboriginal settlements was commonplace as a result of overcrowding combined with inappropriate septic tank and leach drain design, installation and operation. The response over the past 10 years has been to develop reticulated sewerage systems to lagoons when the funds become available. These are often successful in terms of operation, improved public health, and low-maintenance but are expensive and wasteful of limited water supplies. Evapotranspiration is an effective for on-site domestic effluent disposal in areas of Western Australia with soils of low permeability. Evapotranspiration systems have been established in a number of communities both for research/demonstration and as specified by architects. The systems usually follow two septic tanks for the disposal of all domestic effluent. A case study will be presented for a remote Aboriginal community with dry composting toilets and where the ET systems installed for greywater only have been monitored over the last two years since installation. This paper will report on the background to essential service delivery in remote Aboriginal communities, wastewater management generally in these locations, and the implications for environmental health conditions, before addressing specific issues of evapotranspiration system design and performance. The use of evapotranspiration has enabled reuse of effluent for successful examples of revegetation and food production and points to the need for a holistic approach to design and service delivery in these communities that includes a total environmental management plan.

Keywords
evapotranspiration, on-site, permaculture, reuse, revegetation, remote Aboriginal communities, wastewater.

1 Introduction

This paper represents continuing investigations into the use of evapotranspiration (ET) for on-site effluent disposal or reuse in remote Aboriginal communities and follows on from the early research by the Remote Area Developments Group (RADG) (McGrath *et al.*, 1990 & 1991) where simulations and field trials established design criteria for local conditions. The objective of the present study was to describe the experience with systems installed since that time, some new approaches in the application of ET, and further research and development that may be necessary.

2 Background

In assessing the ecological sustainability of nutrient and hydraulic loading rates with on-site effluent treatment systems, Gardner *et al.*(1996) explained that for septic tank systems allotment sizes of up to one hectare maybe required for a single household. However, for transpiration and aerobic treatment systems the area could be considerably less with up to 4,000 square metres being required.

In urban areas of increasing density septic tank systems may no longer be an option, particularly in areas where groundwater contamination and subsequent flow to surface waters may occur. In Perth this has motivated the State Government to extend reticulated sewerage to the remaining 25% of the metropolitan area. This will result in some 400,000 homes being sewered to three centralised treatment plants, producing a total ocean outfall of some 300 million litres/day. This is an enormous resource for a largely arid continent. The centralised nature of these operations mean that there is not enough land nearby to reuse the effluent. Possible alternatives include expensive dual reticulation or the more cost-effective 'sewer mining' which has been demonstrated in Canberra and proposed for

Mosman Park in WA. The latter could lead to a decentralised community-scale approach with variety of localised reuse options available after on-site treatment.

The trend in remote Aboriginal communities has also been a shift from on-site septic tank systems to reticulated systems with lagoons. The motivating factor for this mode of technology-practice has been public health and not environmental degradation.

The 1997 Environmental Health Needs survey of WA Aboriginal communities (EHNCC, 1998) found in the area of sanitation that only 17 communities or 3% of the population surveyed (15,696 in 213 communities) were without adequate sewage disposal facilities. There were 90 communities across the state that did not have pump-out equipment for their on-site systems, i.e. those communities without a reticulated sewer to lagoons. Of the communities with lagoons six were inadequately fenced, thus allowing the possibility of children and dogs to go swimming in them. This survey shows that while sanitary conditions are not entirely satisfactory, there have been considerable improvements over the past 20 years.

Overcrowding in houses or fluctuating household populations often resulted in flooded leach drains. Irrespective of the number of houses in an indigenous settlement, occasions will always arise where there is a large number of people residing in the house for up to several months at a time. The leach drains were often installed in soils of low permeability with the same design criteria as those used for non-Aboriginal urban centres. Sometimes the entire system had been installed incorrectly: no connection to the house, no leach drains installed after tanks, incorrect grades. Moreover, the on-site systems were often not maintained to the level required. (The same has often occurred in non-Aboriginal urban centres). For example, equipment or trained personnel were not always available for septic tank pump-out, or diverter valves were installed without the community's knowledge and not used. Thus the common sewer is advantageous in this situation. However, there has also had an economic incentive. On-site systems were normally included in State Government housing budgets. Centralised systems were seen to be superior and were included in Federal Government infrastructure budgets. Consequently large, centrally-controlled capital works programs (CHIP-NAHS, HIPP) have tended towards installation of sewers to lagoons. These are also the preference of the large engineering consulting firms contracted by ATSIC for reasons of professional experience as well as the aforementioned reasons.

A survey by the Centre for Appropriate Technology (Marshall & Lloyd, 1998) of sewerage systems in Aboriginal communities across Australia found that all of the typically used technologies of wastewater management were adequate but it was the installation, operation and maintenance where the problems arose. The Centre has found this to be generally the case for all technology systems transferred to Aboriginal communities, i.e. delivery of physical infrastructure was the primary focus rather than local or regional capacity-building. Their study presented many other wastewater technology options for consideration, with recommendations for a number of those not yet used in remote communities to be trialed; for example, novel absorption trenches and simple greywater recycling systems.

Technology transfer to Aboriginal communities has been driven by the assumption that indigenous people in remote communities seek a lifestyle reflected in physical infrastructure like that of most Australian suburbs. Indeed the general practice of many engineers, planners and bureaucrats involved in service delivery to remote communities has been to transfer urban models to the bush. The tendency to date has been the development of compact settlement layouts not dissimilar to those of the suburbs around Australian cities. These settlement forms have sometimes evolved from missions and government reserves established by Europeans in the last century or early in this century where the people had been forcibly relocated or settled in times of desperation. Different family and language groups were required to live in close proximity causing tension, aggravation and clashes. These settlement forms lend themselves quite efficiently towards reticulated power, water and sewerage as well as roads, particularly in terms of cost-effectiveness. Such systems also require low maintenance. However, operating costs such as diesel fuel for electricity and pumping are high.

These centralised systems of physical infrastructure or 'essential services' in the so-called "list of 48" main WA Aboriginal communities were maintained by the State Government agencies Water

Corporation and Western Power. The trend leading to the recent corporatisation of these agencies has also led to the outsourcing of essential service maintenance for the list of 48 commencing 1998. The list of 48 communities was increased to 56 and a set of criteria was established for inclusion of others with time. Three regional service providers have been contracted by the State Government and a positive outcome was the selection of Aboriginal resource agencies for two of the regions. The contract provides for a scheduled maintenance program as well as emergency repairs. The service provider is responsible for maintenance of sewers and pump stations while the community is responsible for a range of lower skill tasks. The service provider is required to provide training and employment of Aboriginal people over time.

Maintenance of on-site sewerage systems still remains the responsibility of community councils and/or householders.

Capital works programs for the installation of essential services physical infrastructure by ATSIC (through its CHIP-NAHS and HIPP) on the other hand, show little sign of devolution to regional Aboriginal organisations. These programs are controlled by large engineering firms as national or State Program Managers and regional or single-site Project Managers. The benefits of this approach have included the tight supervision and resultant better installation of physical infrastructure by non-Aboriginal contractors. Nevertheless such an ongoing arrangement is contrary to the recommendations of the 1991 Royal Commission into Aboriginal Deaths in Custody. The successful experience of indigenous organisations such as the Ngaanyatjarra, Pitjantjatjara and Tangentyere Councils in Central Australia show that it is possible to build up a capacity for capital works delivery within such organisations. Capacity-building could indeed be a condition of contract by ATSIC on the Program Managers. Since the 1970's there has occurred the development of indigenous land councils, legal services and medical services – there appears to be no reason why similar development could not occur towards indigenous technical organisations. The establishment of the Kimberley Aboriginal Housing Essential Services Corporation Pty Ltd in 1998 to project manage all Kimberley housing construction may be a step forward.

In the search for more effective and better coordinated service delivery to remote communities, the State Government, in collaboration with ATSIC, commenced "demonstration" projects in 1996 at Jigalong in the Western Desert and Oombulgarri in the East Kimberley. Both of these settlements have a core population of several hundred people with considerable annual and seasonal fluctuation (358 and 426 respectively were recorded in 1997 by the Environmental Health Needs Coordinating Committee). The objective was the "normalisation" of essential services to a standard comparable with small non-Aboriginal towns of the region. It has become apparent that this process, with the simultaneous involvement of a large number of outside bureaucrats, engineers, planners, architects and subcontractors, is too big and cumbersome. At Jigalong community management is insufficiently developed to deal with the incessant meetings and coordination responsibilities. The indigenous leadership cadre is few in number and it is continually engulfed in crisis management, leading to burn-out. The community has shut itself down to meetings with outsiders on several occasions during the process to recuperate. It would seem that capacity-building of community management instead of new and larger water supply and sewage lagoon systems may be a more appropriate starting point.

These projects also aim to improve these communities as large regional indigenous centres – Ooombulgarri a former mission and Jigalong a former government ration depot – as opposed to supporting the many culturally-associated outstations of the region. The rationale is that centralised populations can be more easily served by cost-effective centralised essential services.

It is worth reflecting on the reasons why the outstation movement commenced in the 1970's and why the 'return to country' (away from towns and missions) began. Their purpose was to move back to traditional territory for a focus back onto cultural and land-based activities and to leave behind some of the negative influences of mainstream Australia.

Preferences by indigenous people toward a more dispersed settlement layout has been well documented (Morel and Ross 1993, Moran 1997) with a number of well-spaced clusters (each consisting of some 5-10 houses) often considered a more appropriate layout. Such a layout lends itself better to a household or small-scale on-site treatment system for each cluster, with adequate land available for soil absorption or transpiration as identified in the first paragraph of this paper.

The Winun Ngari Aboriginal Resource Agency based in Derby and servicing numerous small communities of the West Kimberley is perhaps an example of an emergent, more sustainable, small-scale approach towards development of an Aboriginal technical service. Although it does not have responsibility for implementation of capital works or essential services management and maintenance, it has been very active in supporting technology trials in the outlying communities over the last five years. These trials have included land management activities, permaculture for local food production, composting toilets and greywater reuse. This self-motivated initiative is one that should be supported by government as recommended in the Royal Commission into Aboriginal Deaths in Custody and with its successful growth into larger project management it could then be promoted statewide as a "demonstration" project. The agency developed a dynamic administration of both Aboriginal and non-Aboriginal technical personnel for the execution of these projects. One program funded through the National Landcare Program extended itself right across the Kimberley to Frog's Hollow where evapotranspiration trenches were trialled for greywater reuse.

Having provided a background to technology-practice in Aboriginal communities of WA with particular reference to sewerage systems, this paper will now review the experience to date with evapotranspiration for wastewater disposal or reuse. Systems have been installed at Frog's Hollow (Kawarre) in the East Kimberley; Parnngurr, Irrungadji and Jigalong in the Western Desert; Kalgoorlie and Tjuntjuntjarra in the Goldfields.

3 Current Regulation

The WA State Health Act provides regulations for the design and installation of on-site systems including evapotranspiration (ET). However, its requirements are prescriptive and do not allow for site-specific design.

The Australian Standard for on-site effluent disposal AS1547-1994 (Standards Australia) provides a procedure for sizing evapotranspiration (ET) and evapotranspiration-absorption (ETA) systems. The upgraded standard (A/NZS1547) soon to be published will be more comprehensive in its coverage of such systems with a performance-based approach instead of a prescriptive one. Thus greater diversity and innovation will be possible.

The Aboriginal Housing Directorate of Homeswest provides a standard and basic specification of sewerage systems for its housing contracts, for septic systems or common effluent disposal to lagoons.

The Northern Territory Government is perhaps more advanced in this area with the 1996 *Code of Practice on Small On-site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sewage Effluent*. A revised edition of this code is expected to be released this year. Moreover, it has developed a 1998 *Environmental Health Standards for Remote Communities*. The latter refers to the former for the performance of sewage disposal systems.

The WA Health Department has recently called for tenders for the preparation of its own set of environmental health standards. These will also need to specify requirements for effluent disposal in Aboriginal communities.

In February, 1999 a 12-month trial of domestic greywater recycling came to an end in WA. In the shires of Bassendean, Kalamunda and Kalgoorlie/Boulder householders had been permitted with the use of licensed plumbers to install approved on-site greywater recycling systems. In the latter shire, where clay soils and low rainfall occur, ETA trenches are ideal. No subsidies or other incentives were offered and only four systems were installed with a significant opportunity lost to gather information on the performance of new and innovative systems. Nevertheless, the Water and Rivers Commission prepared a policy statement and guidelines for greywater recycling with the support of the Minister who was to table this in Parliament for legislative amendment to the State Health Act. It was widely known that in the order of 20% of householders recycle greywater without permission. This trend will no doubt continue, particularly in rural areas. Once greywater recycling is approved the next logical step is to conduct trials of dry composting toilets in residential areas with typical lot sizes that one would find in urban areas.

4 System Characteristics

ETA systems can be used in those areas where soil is high in silts and clays, rainfall is low, and pan evaporation is high. These systems cost considerably less and require less maintenance than reticulated systems with lagoons (McGrath *et al*, 1991). As with conventional leach drains some form of primary treatment is necessary ahead of the system – two septic tanks with total wastewater, a grease trap for kitchen effluent, and a sullage (single small septic) tank is normally required for greywater.

Evapotranspiration (ET) systems are those which include a lining in permeable soils or in the case of highly impermeable soils infiltration is so low that it is not significant in relation to evaporation and transpiration. Effluent is distributed in a bottom layer of gravel and, when the effluent fills this layer, an upper layer of coarse sand wicks the effluent to the surface where it evaporates. Plants in the sand layer transpire effluent. McGrath *et al.* (1991) documented the relative contributions of these effects to disposal assuming no soil infiltration.

Evapotranspiration-absorption (ETA) systems are used in soils of low permeability, where there is no risk of groundwater contamination, and where the effect of transpiration by surrounding deeper rooted perennials can contribute to effluent disposal. Percolation into the soil and transpiration from plants directly on the trench also contribute to effluent removal as in the ET systems. In other words, wastewater reuse for plant growth can be a major objective in addition to disposal.

Variations of the water balance method were used for sizing ET and ETA systems by McGrath *et al.* (1991), Australian Standards (1994) and Otis (undated). Further work is necessary with the method to provide more detail on the effects of transpiration.

5 Case Studies

The ET or ETA systems known to have been installed in WA Aboriginal communities are listed in Table 1. These have either been installed with RADG involvement or by the use of RADG design criteria.

The first RADG ETA trenches were installed in conjunction with four RADG-designed ablutions facilities (known as the Remote Area Hygiene Facility –RAHF) for Aboriginal town camps on the fringes of Kalgoorlie in 1990. Not knowing the exact number of persons that would use the facilities they were oversized at approximately 12 m long x 2000 mm wide x 1000 mm deep in rocky clay soil. The RAHF comprised pour-flush toilet directly over septic tank, laundry and shower. Thus largely greywater discharged into the trench. No ponding was observed over the five years for which they were monitored. Native seedlings failed to establish on the trenches due to insufficient moisture in the first summer and with no supplementary irrigation provided.

Later the same year an ETA system was designed for the Kawarre Aboriginal community in the Purnululu area of the East Kimberley region. The system was installed in black soil at 20 m long x 1200 mm wide x 900 mm deep to receive greywater direct from two ablutions blocks with shower and laundry (dry pit toilets were used). No ponding was observed in its first two years of operation after which the facilities were no longer used (Mike Ipkendanz Architect, *pers. comm.*, 1999).

ETA trenches were installed in loam soil after two septic tanks for all the wastewater from two houses in Irrungadji Aboriginal community at Nullagine in the East Pilbara region in 1991. Each trench had been designed for 15 people with an area of 45 square metres and a depth of 1000 mm but on-site installation reduced the size to that normally used for conventional leach drains: 22 m long x 1300 mm wide x 1000 mm deep (McGrath, 1991). The vegetation planted on and around the trench failed to establish due to lack of protection from children playing. After many visits no cases of ponding were ever observed.

An ETA trench was installed in rocky clay soil in the Mardiwah Loop Aboriginal town camp at Halls Creek in the East Kimberley region in 1991 after a RAHF with pour flush toilet. The same design as Kalgoorlie was used except depth was reduced so that overall dimensions were 12 m long x 2000 mm wide x 800 mm deep. This facility was used by up to 40 people each day. Over the next two years eight more ablutions facilities (3 pour-flush and 5 standard dual-flush with two septic tanks) were installed, each with similar sized ETA trenches. Each of these facilities was used by 10-20 people. Vegetation self-seeded on all trenches and in some cases seedlings planted directly on the trenches established as shrubs. On numerous visits over subsequent years only one case of major ponding was observed. This was on a heavily used pour-flush RAHF with a 200-litre soakwell in the ETA trench which assisted to distribute effluent in the early designs. The soakwell had become full of sludge after 2-3 years, indicating the facility was overloaded but also that dual septic tanks may have been more appropriate.

Table 1: Summary of ET Systems installed in WA Aboriginal Communities

Year of installation & community	Annual Rainfall (mm)	Pan Evap. (mm)	Soil type	# installed @ Length (m) x width (mm) x depth (mm).	Influent
1990 Ninga Mia	260	2600	Rocky clay	4 @ 12x2000x1000	Laundry, shower, pour-flush toilet
1990 Kawarre	680	3000	Black soil	1 @ 20x1200x900	Ablutions block
1991 Irrungadji	330	n.a.	Clay loam	4 @ 22x1300x1000	All domestic wastewater
1991-93 Mardiwah Loop	530	3200	Rocky clay	9 @ 12x2000x800	Ablutions blocks
1992 Parngurr school	310 (Telfer)	n.a.	Clay loam	n.a.	n.a.
1994 Parngurr house	310 (Telfer)		Clay loam	1 @ 12x3000x?	All domestic wastewater
1996 Pia Wadjari	210 (Gasc Jnctn)	3000	Sandy clay	1 @ 6x500x300 1 @ 6x500x300	Kitchen Laundry
1996 Wurrenranginy	680	3000	Rocky clay	1 @ 15x1200x800	2 houses ablutions + school canteen
1997 Tjuntjuntjarra	190 (Rawlinna)	2400	Sandy clay loam	11 @ 6x600x600	4x laundry, 4x shower, 1x kitchen, 2x house
1998 Jigalong	270 (Mundiwindi)	n.a.	Sandy clay loam	5 @ 12 x 2000 - 300 x 600	Greywater only
1998 Irrungadji	330	n.a.	Clay loam	4 @ 16 x 2000 - 300 x 600	All domestic wastewater
1999 Tjalku Wara			n.a.	1 @ 22 x 380 x 1100	Greywater
1999 Wongatha Wonganarra	234	3500	n.a.	5 @ 22 x 380 x 1100	Greywater

An ETA system was installed on the Education Department school at Parnngurr (Cotton Creek) Aboriginal community in the Rudall River region of the Western Desert in 1992. No details are available other than the soil is a clay loam.

An ETA system was installed on a new 3-bedroom house at Parnngurr in 1994. The septic tank design was of the old style rectangular 2-compartment constructed in-situ. The ETA trench was approx. 12 m long x 3 m wide with depth unknown. No plantings had been implemented.

At Pia Wadjari community in the Midwest region several houses had been constructed with septic tank ETA systems. One had become blocked and overflowed as a result of not pumping out the sludge from the tanks. In 1996 an ablutions facility discharged laundry effluent directly onto the ground. Several makeshift kitchens attached to houses also discharged effluent directly to the ground. Shallow ETA trenches were installed into the sandy clay soil for these to provide an interim solution to this severe public health problem. Dimensions of each were approx. 6 m long x 500 mm wide x 300 mm deep.

At Wurrenranginy Aboriginal Community (Frog Hollow) in the East Kimberley in 1996 two houses (each with four occupants) with a common kitchen, washing machine, and hand basin, discharged directly into an ETA trench of dimensions 15 m long x 1200 mm x 800 mm deep. The showers discharged directly onto garden beds where plants such as papaya were grown. The school kitchen for about 35 children with a sink and hand basin discharged into a grease trap and then the same ETA. Native grasses had established on the surface (Mike Ipkendanz Architect, *pers. comm.*, 1999).

In 1997, at Tjuntjuntjarra Aboriginal community in the Great Victoria Desert, fourablutions facilities had been discharging effluent from washing machines and showers directly to the surrounding ground for about 18 months due to the contractor having left without constructing the specified effluent disposal system for each facility. Each facility comprised a laundry, a shower and a Clivus Multrum dry composting toilet and was used by 10-20 people typically. The vault of the latter was installed below ground level in an excavated pit open for maintenance access. In two of the facilities effluent had flowed into the pit and filled the vault thus rendering the dry composting process dysfunctional. A number of dwellings (Atco site huts) were discharging greywater directly onto the ground also. With limited time and resources available each of the ablutions facilities was fitted with two ETA trenches and each dwelling with a single ETA trench all with dimensions 6 m long x 600 mm wide x 600 mm deep. The latter ETA trenches were each preceded with a standard grease trap. Each trench was planted with a mix of native shrubs and fruit trees, most of which established successfully and flourished. The success rate of this remedial action was high but only on the low water use households – elderly and singles quarters (Katie Angel, *pers. comm.* 1999). Family households typically had sick babies and required high water use with these systems ponding. The standard grease traps were too small to effectively remove solids and grease.

At Jigalong Aboriginal community in the Western Desert five ETA trenches were installed in sandy loam soil (approx. 300 mm depth) over clay for new housing in 1998, using a modified design (by Halin Orion, Arid Tropical Permaculture, Wittenoom) with dimensions 12 m long x 2000 mm wide (at surface, 300 mm at base) x 600 mm deep. Only greywater was discharged to the ETA trenches but the East Pilbara Shire EHO demanded that the contractor install two septic tanks and a chlorine dosing system. The blackwater went to the sewer after a single septic tank. The greywater plumbing side was designed to overflow to sewer.

The ETA trenches were designed in an L-shape and positioned on the morning sun (east) side of the house as part of a holistic design process that took into account social and ecological design factors for the house yard and occupants as described in the following section. The L-shape allowed growth of trees around the SW corner of the house and the placement was ideal for growth of sensitive fruit trees, themselves within an outer windbreak of hardy native shrubs. Moreover once vegetation is established the hot easterly winds will be cooled by this microclimate before they strike or enter the house. It has not been possible to gather data on performance since commissioning.

At Irrungadji again four ETA trenches were installed in 1998 on new houses the modified profile and dimensions 16 m long x 2000 mm wide (at surface, 300 mm at base) x 600 mm deep. All household wastewater discharged into two septic tanks before entering the ETA trench. Again the design process followed principles outlined below and no information is available on performance.

6 Ecological Design

"Ecological design" seeks to reconcile the cultural activities and natural ecologies on a site to sustain each of their needs in an integrated fashion.

Many concerns have been raised in relation to implementation of wastewater reuse without proper management or maintenance: public health risks, groundwater contamination, mosquito breeding, flooding during winter rainfall, sludge build-up and blockages. However, there is another issue for concern that may lead to some of these problems and others indirectly: poor design (or no design). This includes not just the design of the system itself, but the manner by which the system is integrated into the landscape. Australian standards such as AS 1547 do, for example, specify minimum setbacks from houses and lot boundaries, provide ways of avoiding inundation and give design criteria for terraced disposal fields on slopes.

There are very few practical design methodologies that may enable the most appropriate placement of a wastewater reuse system in the house yard or community landscape. Two examples are:

- *hydroscaping*(Colwill, 1996) for water-sensitive garden aesthetic design; and
- * *permaculture* (Mollison, 1988) for sustainable food production design.

Hydrozoning will allow the placement of the wastewater reuse system in accordance with a garden layout designed for aesthetics and plant groupings of similar water needs.
Permaculture draws on a wider range of design tools including *zoning* for energy efficiency and *sector analysis* of the natural influences on the site (sun, wind, slope, fire, view). Zones 1 to 5 in permaculture refer to areas of planting types (intensive salad beds, low maintenance orchards, through to natural bushland) placed in relation to house or settlement according to frequency of visits. Design with sectors allows the appropriate placement of windbreaks, shade trees, water tanks, zones and other elements in the landscape. This is particularly useful in the design of indigenous settlements, given that a large proportion of people's lives (including cooking, relaxing, sleeping) is spent in the yard around the house rather than in it. Often of particular concern to the occupants is the need to view adjacent houses or the community entrance for coming and goings and certain directions into the surrounding country where there may be sites of significance. Such considerations affect the placement of the aforementioned elements.

The use of a design approach prior to installation enables placement of the wastewater reuse system in a landscape with respect to the vegetation type that it will support, its position in relation to other elements and natural influences on the site, and the cultural needs of the house occupants. If such considerations are ignored with a focus merely on the technical design of the system itself then improper management and maintenance and poor performance may still be the longer term outcome.

The Permaculture approach has been used in the placement of ETA systems at Jigalong and Irrungadji by the Design Coll@borative (in which RADG participates). The ETA trenches are placed by the following criteria:

- On the east (morning sun) side of the house for the benefit of associated fruit trees;
- 2 m min. from house to allow planting of sensitive annuals in this microclimate, use as a walkway, or so as to be close enough for fruit tree care and harvest;
- 2 m min. from yard fence to allow establishment of windbreaks for protection of hot summer winds;
- Moreover the ETA trench is carefully integrated with water harvesting swales and basins as part of the yard landscaping design.

7 Conclusions

On-site wastewater reuse by means of evapotranspiration-absorption can yield both public health and sustainability benefits in remote Aboriginal communities. The tendency however is towards reticulated sewers pumping to oxidation ponds. While these are reliable, perform well and are relatively low maintenance there is still a requirement for visiting technicians to maintain the sewers and pump stations. If managed correctly, wastewater reuse in remote Aboriginal communities can not only result in water savings but also improved public health through dust suppression from revegetation, improved nutrition from locally grown food, and fewer system failures from decreased loading on treatment systems.

The results of 10 years research and development by RADG on ET systems shows that they have not failed in any way similar to the rate that standard leach drains were failing at the time the work started. Observations to date indicate that design by use of WA Health Act regulations and AS1547-1994 results in oversizing and death of plants, particularly when combined with the fact that houses can be empty for several months each year for cultural reasons over the hot summer months. The recent investigations into the ET systems at Tjuntjuntjarra have shown that house overcrowding combined with an over-reduction in size (50% of standard) results in ponding which is unacceptable for public health even though plantings thrived.

The shallow modified ETA system with greater length dependent on house size is beneficial for plant growth and to ensure plant survival during periods of reduced influent sensitive species should be placed at the beginning with hardier species at the end. Further trials are necessary to monitor this arrangement. Overall further research is necessary on these systems across WA to evaluate hydraulic performance, to determine plant transpiration contributions to disposal for specific designs, and to define clearer design guidelines for future implementation.

References

Colwill, John (1996), *The Waterwise Garden and How to Create One*, Water Authority of WA, Perth.

Environmental Health Needs Coordination Committee (1998), Environmental Health Needs of Aboriginal Communities in Western Australia: The 1997 Survey and its Findings, Homeswest, ATSIC, AAD, Health & Family Services, WAMA, HDWA, Perth.

Gardner, Ted, Geary, Phillip & Gordon, Ian (1997), *Ecological Sustainability and On-Site Effluent Treatment Systems*, Aust J Env Management, Vol 4, September, pp144-156.

Marshal, Glen & Lloyd, Bob (ed) (1998), *Sewage Systems in Remote Indigenous Communities*, CAT Report #98/8, Centre for Appropriate Technology, Alice Springs.

McGrath D, Ho G & Mathew K (1990), *On-site Wastewater Disposal in Clay Soils - The Use of Evapotranspiration Systems and Conventional Methods*, in Mansell, Stewart & Walker (eds), Proceedings of the UNESCO Regional Seminar on Technology for Community Development in Australia, South-East Asia and the Pacific, Alice Springs, 9-11 July, Development Technologies Unit, University of Melbourne/Centre for Appropriate Technology.

McGrath D, Ho G & Mathew K (1991), The Effectiveness of Evapotranspiration Systems in Disposing of Wastewater in Remote Aboriginal Communities, *Water Science and Technology*, **23**, 1825-1833, IAWPRC, London.

McGrath D R (1991), *Installation of Evapotranspiration Systems at Irrungadgi Community, Nullagine*, in Ho G (ed), Seminar on Appropriate Technology for Remote Communities, Newman, RADG, Murdoch University.

Mollison, Bill (1988), *Permaculture: A designer's manual*, Tagari Publications, Tyalgum.

Moran, Mark (1999), *Improved Settlement Planning and Environmental Health in Remote Aboriginal Communities*, #cat 99/6, Centre for Appropriate Technology, Alice Springs.

Otis Richard (undated – 1980?), On-site Wastewater Disposal: Evapotranspiration and Evapotranspiration/Absorption Systems, Rural Systems Engineering, Madison, Wisconsin.

Petronella Morel and Helen Ross (1993), Housing Assessment for Bush Communities, Tangentyere Council, Alice Springs.

Territory Health Services (1996), *Code of Practice for Small On-Site Sewage and Sullage Treatment Systems and the Disposal or Reuse of Sullage Effluent*, Northern Territory Government, Darwin.

Territory Health Services (1998), *Environmental Health Standards for Remote Communities in the Northern Territory*, Northern Territory Government, Darwin.

Standards Australia (1994), *Disposal systems for effluent from domestic premises*, AS 1547 - 1994, Standards Australia, Homebush, NSW.

Standards Australia/Standards NZ (1998). *On-site Domestic Wastewater Management*, AS/NZS 1547-Draft, Issued: November, Homebush/Well.