Centre for Appropriate Technology

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Sewage Systems in Remote Indigenous Communities

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Author Glen Marshall – Edited by Bob Lloyd

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A report by consultant : Glenn Marshall,
WaterWays Asia-Pacific
POBox 294 Alice Springs NT, 0871
Email wwap@ozemail.com.au

Edited by Bob Lloyd

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Summary

Poor performance of sewage systems and inadequate sewerage hardware has consistently been identified as major contributors to poor health in remote Indigenous communities. The efficient removal of waste has been identified as a high priority by many organisations involved with improving Indigenous health. In addition the Aboriginal and Torres Strait Islander Commission (ATSIC) is concerned that the problem has not been solved despite considerable funding levels being directed towards the problem. To help understand the issues involved, ATSIC suggested that the Centre for Appropriate Technology (CAT) undertake a study of the status of sewage systems in remote Indigenous communities. The emphasis on remote communities in particular is because it is thought that the problems experienced by such communities are quite different from those communities with access to large town non-Indigenous service provision.

This desktop report is the first stage of such a study. It is a desktop study in the sense that it has been compiled from existing information including available databases, supplemented with telephone inquires to community personnel where the existing information was thought lacking. The problems of using desk based information gathering methodologies are well known and it is realised that what people express verbally is not always correct. It is hoped to match the information gathered in this report against the field situation in stage two of the study. The survey details the current status of sewage systems located in remote Indigenous communities in Australia with regards to the funding, regulation, construction, use and maintenance of systems. Common problems with system hardware, use and management are identified based on published information, existing studies and conversations with personnel involved with the running of remote community sewage systems.

In total the survey identified some 1,100 remote communities in WA, NT, SA and Qld with a total population of around 76,000 people. The communities ranged in size from large towns of several thousand people to small outstations comprised of a single family. The larger communities dominated in terms of population with two thirds of the population living in 91 larger communities (population greater than 200).

Only four types of sewage systems were found to be in common use, these being: full sewage systems, common effluent disposal (CED) systems, septic tank systems and pit toilet systems. The first two (centralised sewage systems) were in use in 95 of the medium to large communities containing 59% of the total remote population. The other two (on-site sewage systems) were in use in 831 small to large communities comprising 38% of the remote population. In addition one percent of the population was identified as having no access to a formal sanitation system while the situation with regards to the remaining two percent was not determined due to a lack of available information.

Overall most communities with centralised systems reported satisfaction with the performance of the systems and felt that they kept people adequately separated from sewage. The evidence obtained suggested that the main reason for successful operation of centralised systems was the effectiveness of formal recurrent maintenance programs, which generally kept systems in good working order. Some problems with the centralised systems were identified, however, with the main ones

appearing to stem from high solids loads entering systems because of inappropriate use of toilets.

In contrast on-site septic systems appeared to have significant failure rates across many communities with evidence suggesting that poor installation, inappropriate use and lack of maintenance were the prominent reasons for the failures. Because of the distributed nature of the on-site septic systems is likely that even a few failing systems in a community may subject a good proportion of the community to sewage-related health risks. If the problems identified with septic systems are verified by field surveys, then it will mean a broad range of issues must be tackled to improve septic system performance. Pit toilet systems on the other hand seemed to be used successfully on many outstations and provided a level of reliability not achieved by septic systems. Pit toilets, however were found to have a poor image and many communities were reluctant to retain them if flush toilet options were available.

Specific problems identified by the survey with regards to sewage systems in remote communities are summarised as follows:

Water borne sewage systems

- Poor initial construction of internal wet areas and household drainage pipes
- Blocked flush toilets due to both misuse and inappropriate use by children and adults
- Leaking taps and taps left running causing overload of water borne disposal systems (both on-site and centralised)

Centralised sewage systems

- Septic tanks (for CED systems) filling with solids due to irregular pump out of tanks allowing solids through to the pipe network and lagoons
- Break down of pumping station infrastructure, often due to high intermittent solids loads
- Deterioration of old sewerage pipes
- Lagoon failure due to high water loads and inadequate maintenance
- Poor initial construction of some systems

On-site sewage systems

- Septic tanks filling with solids due to irregular pump-out, allowing solids to wash through and clog absorption trenches.
- Poor initial construction and/or undersizing of septic tanks and absorption trenches causing system failures.
- Poor siting of systems allowing vehicle damage or restricted access for maintenance.
- Inappropriate site conditions including non-absorbing soils (clays), rocky ground and high water tables.
- Irregular maintenance of all aspects of septic systems, particularly leaks and septic tank pump-out.
- Poor image of pit toilets.
- Inadequate disposal of grey-water where pit toilets are used.

A handful of communities reported that they had overcome most of the above problems and that their sewage systems were currently working well. It appeared this was achieved slowly and was the result of careful planning, ongoing user education, replacement of failing hardware and good management of systems. Some communities with successfully operating systems were found to have pooled their resources to create local service provider organisations servicing all sewage systems.

In addition to the above four common types of systems a range of alternative sewage systems were examined for their potential applicability to remote communities. It was concluded, however, that very few of these types of systems were as appropriate as the common systems and would most likely suffer the same problems in regard to inappropriate management and use.

From an organisational aspect there appeared to be a lack of communication between different tiers of government in respect to the provision, use and maintenance of sewage infrastructure that could be improved through better co-operation between government departments. Community councils, in particular, appear to need technical and financial assistance to develop adequate maintenance programs for infrastructure currently under their control.

Although the health risks of sewage systems failures are of obvious paramount importance the cost of the systems need to be taken into account when recommending a particular type of system to any community size.

In terms of installation costs for centralised systems a preliminary review of HIPP/NAHS installations by ATSIC found that the cost per connection was around $25,000 for full sewage systems and $22,000 for CED systems. They also found that the cost generally dropped rapidly with increasing numbers of connections. For the centralised systems mentioned above, the cost per connection for systems with only 20 connections was in the region of $35,000 whereas the cost per connection for systems with around 150 connections was in the region of $16,000.

Maintenance costs for centralised systems were the subject of a study by Sinclair Knight and Mertz. This study suggested that for full sewage systems the annual community bill would run between $12,000 and $16,000 depending on community size. The corresponding funds needed for CEDs were considerably higher at between $27,000 and $38,000 primarily due to the high costs associated with septic tank pump-outs.

For on-site septics tank systems initial costs are taken to range between $8,000 and $21,000 for remote locations depending on configuration with an average of around $12,000. Maintenance costs are thought to be between $15,000 and $22,000 per community depending on community size for pump-outs and between $200 and $300 per household for in house maintenance.

If a conclusion could be arrived at from only the desktop study, it was that in general the basic technologies per se were adequate; the problem areas concerned the installation, operation and maintenance of the sewage systems in the remote Indigenous communities. Fieldwork, undertaken at the Centre for Appropriate Technology in other areas, suggests that the difficulties of operating and maintaining any technology in a remote location cannot be overemphasised. If the above basic conclusion is supported by a field study then the solution would point to increased funding for operation and maintenance, training and institutional support.

Having pre-empted the above general conclusion the three immediate recommendations based on the findings of the desktop survey would be that:

- A detailed field survey of sewage systems and sewage system management should be undertaken on selected communities to 1) verify or otherwise the general findings of this current survey, 2) gauge the relative impact of different problems identified, 3) prioritise areas for targeting future improvements.
- A more thorough study of the financial and economic costs of installing and operating the different types of systems for different community sizes be undertaken.
- And finally that a watching brief on the types of alternative on-site sewage systems that are coming onto the market be kept.

Glossary

Absorption trench:	Underground trench, which accepts effluent from a septic tank, allowing it to be absorbed into the surrounding soil.
Aerobic bacteria:	Bacteria that grow in the presence of oxygen. Such bacteria are generally more efficient at wastewater treatment than anaerobic bacteria.
Aerated Wastewater Treatment System (AWTS):	An onsite sewage treatment system that treats effluent by introducing air to the effluent, promoting efficient biological treatment by aerobic bacteria.
Aggregate:	Clean crushed rock, gravel or other inert material used in absorption trenches to aid the spread of effluent.
Alternative sewage systems:	Sewage systems, which differ from the four common sewage systems.
Anaerobic bacteria:	Bacteria that grow in the absence of oxygen, such as in septic tanks and primary settling lagoons.
Biochemical Oxygen Demand:	A measure of the organic content of sewage in terms of oxygen required for bacterial oxidation and stabilisation. The standard test measures oxygen used in 5 days at 20 degrees C.
Black-water	All effluent coming directly from a water borne toilet system.
Centralised sewage system:	A community sewage system that removes sewage from houses and transports it through a reticulated pipe network to a treatment facility for ultimate treatment and disposal.
Common effluent disposal (CED) system:	A centralised sewerage system that uses septic tanks at individual premises to capture solids from wastewater before transporting the effluent to a central treatment facility.
Desludging:	Removal of the accumulated sludge and scum (solids) from a septic tank.

Disinfection:	A process that destroys, inactivates or removes harmful microorganisms.
Effluent:	Partially treated liquid sewage from treatment lagoons, septic tanks or other treatment systems. Most effluent should be kept separate from people unless it is known to be safe.
Evapo-transpiration trench:	A relatively shallow onsite disposal trench where effluent is largely evaporated or transpired through plants growing on the trench.
Faecal coliforms:	Bacteria that indicate faecal pollution. Currently used as the standard indicator for pathogens in wastewater.
Full sewerage system	A centralised sewerage system, which transports wastewater directly from houses, through a pipe network to a treatment facility.
Grey-water:	All household wastewater except for toilet wastewater.
Long-term Acceptance Rate	The long-term acceptance rate at which effluent can be absorbed into the soil of an onsite disposal system, expressed in litres per square metre per day.
On-site sewage system:	A sewage system for treating and disposing of sewage within the household property boundary.
Potable water:	Water suitable for human consumption whether used as drinking water or in the preparation of food.
Primary treatment:	Removal of large solids and some organic matter from raw sewage. Primary treatment occurs in septic tanks and primary settling lagoons.
Pumping station:	A wastewater collection chamber situated at low points in a centralised sewerage system pipe network, containing pumps which pump wastewater further through the pipe network.
Scum:	Material floating on the surface of a septic tank, usually containing fats, oils and greases.
Secondary treatment:	Removal of most suspended solids and organic matter from wastewater, along with some removal of nutrients (primarily nitrogen) and

	pathogens. Secondary treatment is achieved by a series of treatment lagoons.
Septic tank system:	An onsite sewage system which uses a septic tank and disposal trenches, usually located in the yard adjacent to the house.
Sewage:	Raw wastewater and solids (also Black-water)
Sewerage:	The physical pipe network, which conveys sewage.
Sludge:	The solids, which are removed from wastewater by primary and secondary treatment.
Sullage tank:	Septic tank for sullage (grey-water) only
Treatment lagoons:	Treatment ponds for purification of raw wastewater and for the additional treatment of primary or secondary treated effluent.
Wet areas:	Rooms in a house where plumbing is used (bathroom, laundry, toilet, and kitchen)

Abbreviations

AAD	Aboriginal Affairs Department
ACC	Aboriginal Co-ordinating Council
AP	Anangu Pitjantjatjara
ATSIC	Aboriginal & Torres Strait Islander Commission
AWTS	Aerobic (Aerated) Wastewater Treatment Systems
BOD	Biochemical Oxygen Demand
CDEP	Community Development and Employment Programs
CED	Common Effluent Disposal
CHIP	Community Housing & Infrastructure Program
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DNR	Department of Natural Resources
DOGIT	Deed of Grant in Trust
DoSAA	Division of State Aboriginal Affairs
EHN	Environmental Health Needs (survey)
ESO	Essential Services Officer
HH	HealtHabitat
HINS	Housing and Infrastructure Needs Survey
HIPP	Health Infrastructure Priority Projects
IRCIWSC	IRC International Water and Sanitation Centre
LDC	Lange Dames & Campbell
LTAR	Long Term Acceptance Rate
NAHS	National Aboriginal Health Strategy
OATSIA	Office of Aboriginal and Torres Strait Islander Affairs

PAWA	Power and Water Authority
RADG	Remote Area Development Group
RAESP	Remote Area Essential Services Program
RSP	Regional Service Provider
SKM	Sinclair Knight Merz
SS	Suspended Solids
TAFE	Technical and Further Education
THS	Territory Health Services
UPK	Uwankara Palyanyku Kanyintjaku - an environmental and public health review within the Anangu Pitjantjatjara Lands
VIP	Ventilated Improved Pit (toilet)

Section 1: Introduction

Aim & objectives

Aim

The specific aim of the desktop survey is to document the current status of sewage systems serving remote Indigenous communities in Australia. By understanding the present situation it is hoped that the long-term health situation in such communities can be improved.

Objectives

To achieve the aim the study had the following objectives:

- To assess the situation with regards to the types of systems present in remote communities. – ***What's out there?***
- To document the present operational experience of each system type including the overall management of the systems. – ***Are they working?***
- To identify existing problems with regards to the different systems. - ***What are the problems?***
- To look at the future trends in system installations. – ***How will things change in the future?***
- To provide a preliminary assessment of alternative system types. – ***Are there alternative systems that can be used?***
- To suggest ways of improving sewage management on remote communities. – ***How can we improve the situation?***
- To document the present regulations. - ***What are the current regulations?***
- To take a preliminary look at the costs of systems. – ***How much do they cost?***

The target communities

It was decided at the outset that the study would be limited to remote communities only. The reason was because it was thought that the installation, operation and management of sewage systems in remote communities entail unique problems that are not experienced elsewhere.

Remote Communities

For the purposes of this study, a 'remote community' was defined as:

> *Any discrete Indigenous community or outstation which was not directly serviced from a non-Indigenous town, and where sewage was managed largely within the community.*

This (rather loose) definition was adopted because many peri-urban Indigenous communities and "town camps" either use town sewage systems or potentially have access to sewage management services of the town. The definition is loose because we are not defining the exact distance that the remote community has to be from the non Indigenous centre. The use of this definition thus precludes several discrete Indigenous communities of Western Australia, Northern Territory, South Australia and Queensland adjacent to non-Indigenous centres, and all Indigenous communities of New South Wales, Victoria, ACT and Tasmania. The definition was relaxed a little in Queensland to include several large discrete Indigenous communities close to non Indigenous centres because of these communities effective control of their own sewage systems. An example of such a community is Yarrabah, which is, located only 45 kilometres from Cairns.

It is thought that the number of "borderline" communities, that is those that may or may not be called remote depending on the strictness of the definition, are small compared to the total remote population and that their inclusion (or exclusion) will not affect the general analysis of the situation.

Community size

For the survey, communities were divided into three population categories. The categories chosen were as follows:

- *Large communities* population over 200
- *Medium communities* population 50 to 200
- *Small communities* and *outstations* population less than 50

This categorisation was adopted because it provides a reasonable separation of communities with different sewage system types and management regimes.

Survey methodology

The background literature revealed that relatively little information has been recorded about the management of sewage systems in remote Indigenous communities. As a result, much of the data for this survey was collected from telephone conversations with relevant personnel associated with the management of sewage in remote communities. The sources of information included Commonwealth and State/Territory government personnel from a range of departments (health, water resources, housing, environment, policy), industry contractors associated with government agencies or communities, and a range of community personnel (advisers, Essential Service Officers - ESOs, plumbers, environmental health workers, residents). In all over 200 persons were contacted across Australia.

The information gathered was concentrated in four distinct aspects, each aspect generally used different information sources. The four aspects were general community information (including sewage system type), physical performance of sewage systems, administration of sewage systems and information regarding alternative sewage systems.

General community information was obtained primarily from the 1992 "Housing and Infrastructure Needs Survey" funded by ATSIC (referred to as the HINS database). From this database community names, locations, populations and sewage system types were obtained. This information was updated where possible using state government databases (available in WA and NT only), other pertinent recent surveys (e.g. the Environmental Health Needs Survey in WA), Australian Bureau of Statistics data and direct contact with government and community personnel. In many cases the HINS data concerning sewage system types on individual communities was found to be out of date or inaccurate, possibly because of poor wording of the survey categories in the original survey form.

Physical performance: Information on the physical performance of sewage systems was mainly gathered mainly by telephone conversations with government, industry and community personnel directly associated with community sewage management. A handful of published studies was also identified which discussed the performance of on-site sewage systems. No existing study, however, was found looking at just centralised sewage systems.

Administration: The administration of sewage systems included the maintenance regimes developed by individual communities, the regulation of systems by government agencies and the funding for installation and maintenance of systems by various tiers of government. Information on these aspects was gathered from a range of sources including Commonwealth and State government agencies, industry contractors employed by government agencies and a range of community personnel.

Alternative systems: Information on alternative sewage systems was collected from Australian system manufacturers, state government publications, various overseas aid publications and the Internet.

Information reliability: Because of the inherent problems associated with gathering data from informal telephone conversations it was attempted to gather information from a diversity of sources to build a full and accurate picture of each aspect of sewage management. At all times it was found necessary to remain aware that people present not only facts during such conversations, but also opinions based on their particular knowledge, involvement or bias. There is considerable evidence to suggest that one person's understanding of a particular aspect of a sewage system often does not correspond with the actual situation, or that people sometimes have a vested interest in presenting information in a particular light. One field study undertaken by CAT in Coen in northern Qld showed significant problems with the package aerobic systems looked at, whereas indications obtained from some institutional sources before the study were that systems were performing well (Downs 1997). These types of discrepancies between field information and opinions obtained from institutional sources reinforce the need for the follow up field study.

Confidentiality of data

Much of the detailed data that was gathered during this survey is confidential to the communities concerned. To protect this confidentiality, wherever possible, only aggregated information is presented in this report. There are occasions, however, when individual community data has been presented to clearly indicate a particular situation in regard to sewage management.

Indigenous health and sanitation

Current Indigenous health status

There is considerable literature describing the overall health status of Indigenous people[1]. Indigenous health status in remote communities remains far worse than for non-Indigenous Australians, despite improved access to health services in the past two decades. People continue to suffer because of homelessness, overcrowding, economic disadvantage, social dysfunction and poor living conditions. The consistent excess of respiratory, skin, ear, eye, infectious and parasitic problems observed in Indigenous people implies that inadequate living conditions are an important contributing factor to poor health. This is particularly so for children where infectious diseases cause diarrhoea, giardia, hepatitis, worms and other conditions which remain significant health problems in remote communities (Gracey 1992; Pholeros et al 1993; Miller & Torzillo 1996). Conditions, such as diarrhoea, are known to contribute to chronic malnutrition, which then exposes children to a cycle of recurrent infection and malnutrition (Pholeros et al 1993).

In 1987 a pioneering report looked at the links between health and the provision of infrastructure in the AP lands in northern South Australia (known as the UPK report). This report focused on the availability, adequacy, and maintenance of infrastructure within houses necessary to maintain health (health hardware) such as a water supply, waste removal, washing facilities, etc. To address some of the problems identified, in 1990 the Federal Government initiated the National Aboriginal Health Strategy, a program that is to continue at least until 2000 (ATSIC 1997).

Health consequences of inadequate sanitation

In remote Indigenous communities, inadequate sanitation may result from a variety of sources. Such sources may include adults or children defecating on the ground around living environments, unclean toilet rooms, a lack of facilities to wash hands after defecation, or a failing sewage system leaving contaminated wastewater in houses or yards. In addition there are considerable problems associated with the removal of liquid wastes from washing machines, shower areas and kitchen sinks. Dogs and other animals living close to the community may also present significant sanitation risks. There is substantial evidence to suggest that even a few instances of sanitation failure within a community can affect the health of the entire community because of the ease with which infectious diseases can spread (Pickford 1985; IRCIWSC 1991).

The most prevalent excreta-related diseases are diarrhoea and worm infections that are directly or indirectly transmitted through faecal material. Viruses, bacteria and protozoa can cause various diarrhoeal diseases. Transmission is mainly through the ingestion of faeces of infected persons via a faecal-oral route. Small children are particularly susceptible to this form of transmission, as they tend to put many things in their mouths. Insects, such as flies and cockroaches, can also be a transmission route by feeding on faeces and food, spreading pathogens between the two via their bodies. Worm infections are also reported to be common in Indigenous communities (IRCIWSC 1991). Other problems can occur with inadequate sanitation, such as pooling wastewater, providing sites for mosquitoes to breed, which in turn may lead to other mosquito borne diseases.

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[1]See Miller & Torzillo (1996) for a list of references up to 1996.

Previous research

Despite widespread anecdotal evidence that failing sewage systems create health problems in remote Indigenous communities, there has been limited research conducted on the reasons for sewage system failures, or the links between sewage system failures and poor health. This survey has identified only six studies that have examined in detail the function of remote Indigenous on-site sewage systems on remote Indigenous communities, and none which has comprehensively examined the performance of centralised sewage systems. No study was found which analysed all aspects of sewage management on remote communities, or studies that developed formal strategies to improve sewage management within communities.

The first major study to detail the inadequacy of sewage systems in remote communities was the UPK report (Uwankara Palyanyku Kanyintjaku - An Environmental and Public Health Review) conducted on the Anangu Pitjantjatjara Lands of SA (NHC 1997). The report defined and quantified the physical environment in which people lived and showed that inappropriate hardware often prevented people practising healthy life choices. The survey undertook detailed analysis of on-site sewage infrastructure in houses and found that much of it was inadequately sized or placed to provide reliable service. Subsequent changes to in-house wet area fixtures and drainage from wet areas were recommended to make them more appropriate for the living conditions experienced on Pitjantjatjara communities.

The UPK report was followed up in 1992-3 by a "Housing for Health" survey of one Pitjantjatjara community, Pipalyatjara, to examine the impact of hardware changes undertaken after the UPK report (Pholeros et al 1993). The survey, which entailed four quarterly surveys over one year, gathered detailed information on on-site sewage system function in houses including use patterns, water consumption, types of sewage system breakdowns, maintenance requirements and cost of maintenance. It was the first detailed study in Australia to examine all aspects of sewage system function, use and maintenance on an Indigenous community and provided an important methodology which was repeated on other communities. The survey concluded that the UPK changes had made significant differences to in-house sewage function, but that problems still existed particularly in the area of poor initial construction and particularly in relation to underground works.

A recent sewage study, also conducted at Pipalyatjara, in 1996 by researchers from the University of Wollongong (Khalife et al 1997) was even more specific, looking in great detail at the sewage systems in three houses. The study examined the chemical and microbiological aspects of the wastewater to determine if these varied significantly from non-Indigenous wastewater. The study found, however, that wastewater quality in the Indigenous households was roughly equivalent to that found in non-Indigenous households. Other findings were that system overloads were common due to high and variable household populations and that the microbiological quality of the wastewater was not significantly reduced by the septic system. The Wollongong study recommended the trialling of three modified on-site sewage systems at Pipalyatjara to improve overall performance. These trials are expected to commence in late 1998 or early 1999[2].

[2] Pers comm. Stephi Rainow, Environmental Health Officer, Nganampa Health Council. 14 July 98.

Since the Housing for Health survey of Pipalyatjara, there have been at least two similar surveys conducted on other remote Indigenous communities. One was conducted in Pormpuraaw, north Qld in 1997 by CAT et al and another was conducted by CAT in Kintore, central Australia in 1997. Both examined the function of on-site sewage systems as part of a wider survey, and both contain important information on the function of on-site sewage systems.

Three regional surveys have been commissioned by the NT government since 1994 to determine the function of on-site systems on medium to large remote Indigenous communities in the NT. All surveys were commissioned to examine the potential for systems to function better if upgraded. The first survey was conducted in 1994 by Lange, Dames & Campbell (LDC), who examined the function of sewage systems on 16 NT communities, and concluded that a range of factors was responsible for on-site septic system failure, including inappropriate use, poor specification & construction, and inadequate maintenance. Basic options and cost estimates were provided for upgrading systems, although no recommendations were made to improve maintenance procedures on communities. In 1997 the NT government commissioned a second similar survey. This survey, conducted by Sinclair Knight and Mertz (SKM) , looked at 15 remote NT communities, including four surveyed previously by LDC. This survey gave similar conclusions as to why septic systems failed but also conducted an appraisal of conditions on each community to assess whether on-site systems were capable of functioning if properly sized, installed and maintained. The cost of upgrading existing systems compared to the cost of installing centralised sewage systems was calculated. In 1998 the NT government commissioned yet another survey of additional community sewage systems but the results of this latest survey are not yet available.

As mentioned no study was found which examined the function of centralised sewage systems on remote Indigenous communities. However, ATSIC has recently commissioned a report (to be undertaken by Ove Arup, the program manager of several NAHS sewage projects). This study will determine the cost of installing HIPP/NAHS-funded centralised sewage systems in remote communities in WA and the NT (ATSIC 1998). Some of the preliminary results of this study are reported in the present report.

Existing Indigenous sewage projects

The HIPP & NAHS schemes

In 1990, the National Aboriginal Health Strategy (NAHS) was initiated by the Commonwealth government to target primary and environmental health need in Indigenous communities by providing capital funding for essential service works and community infrastructure developments (ATSIC 1997).

In the period 1990/91 to 1994/95, $232 million of NAHS funds were allocated to ATSIC to achieve this aim. An evaluation of NAHS in 1994 found that there were major deficiencies in the scheme and doubts were cast on the impact the program had on Indigenous health (ATSIC 1997). Major changes were recommended to the way NAHS projects were targeted and delivered and to this end in 1994 ATSIC established the Health Infrastructure Priority Projects (HIPP) scheme as a national pilot program of large-scale capital works using new procedures. HIPP introduced triennial funding arrangements, which allowed adequate forward planning of projects, and out-sourced program and project managers to facilitate improved project planning and delivery. HIPP is expected to deliver approximately 58 projects worth around $150 million over the period 1994-1999 (ATSIC 1997).

A review of HIPP projects undertaken in 1996 showed they were far more targeted than previous projects and so NAHS funding, using the same delivery methodology, was extended for the period 1996/97 to 1999/2000. $219 million has been allocated to the States for NAHS programs (in addition to the HIPP funding), managed by the same program and project manager arrangements piloted through HIPP.

HIPP & NAHS Sewage Projects

An important aspect of HIPP/NAHS projects is the provision of adequate sanitation to remote Indigenous communities. As such, there are currently approximately 37 major HIPP/NAHS sewage system installation or upgrade projects planned, under construction or completed on remote communities across WA, NT, SA and Qld. Most are large communities receiving new or upgraded centralised sewage systems, although three septic system upgrade programs are planned which cover a number of smaller communities in WA, NT and SA. The funds released to current HIPP/NAHS sewage projects is approximately $20 million and $25 million for NAHS

Section 2: The Existing Situation

The cost per household for sewage system provision depends critically on the community size. This is for the obvious reason that the infrastructure needed for centralised systems is large and needs to be apportioned over many households to obtain reasonable costs per household. In addition the cost of operation of the systems depends on both the household size and the change in household size as fluctuations in numbers are more easily handled by centralised systems than single household systems. It was thus important to see what size communities exist in remote areas and to get some idea of household sizes and population movements

Demographics of remote communities

Remote population

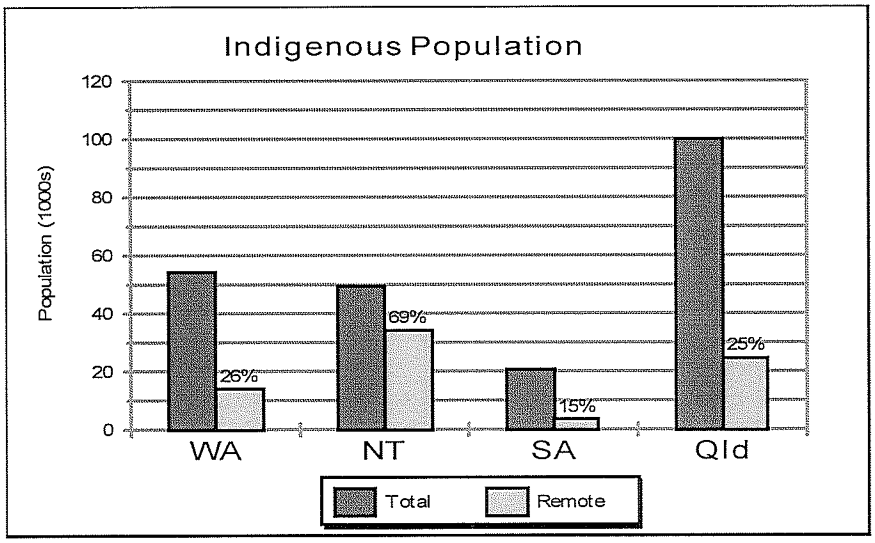
The present study identified a total remote population of around 76,000 Indigenous people in the three states and the Northern Territory. The NT was found to have the highest remote population with over 34,000 people, whereas SA had the lowest remote population of 3,280 people, most of who live in the Anangu Pitjantjatjara Lands of north-west SA. The NT has by far the highest proportion of Indigenous people living in remote communities compared to Indigenous people living in non-remote centres of the NT (69%). The next closest state is WA with 26% of the Indigenous population living in remote communities. A detailed summary of population data is shown in Table 1 and Figure 1.

Table: 1

Indigenous population	WA	NT	SA	Qld	Total
Total (1)	54,100	49,600	21,300	100,500	225,500
Remote (2)	14,067	34,167	3,280	24,627	76,141
% Remote	26	69	15	25	34

(1) Source: ABS Census 1996 - preliminary figures
(2) Source: Data gathered during this survey.

Figure: 1



Remote community size

The study identified some 1,122 remote communities in the three states and the NT. Communities ranged in size from single family outstations to large towns. The largest remote community identified was an island community in Qld with 3,300 inhabitants. Of the total remote population, nearly two thirds of people (64%) were found to live in 91 large communities (with a population greater than 200). 17% of the remote population lived in 125 medium sized communities (between 50 and 200 persons), while the remaining 18% of the remote population lived in 906 small communities or outstations (with fewer than 50 inhabitants). A detailed breakdown of community numbers and relative populations is given in Table 2, Figures 2 and 3.

Table: 2

	Number of remote communities in population range						
	Small		Medium		Large		
	0 to 20	21 to 50	51 to 100	101 to 200	201 to 500	over 500	Total
WA	181	60	25	20	13	3	302
NT	377	146	30	23	31	11	618
SA	63	14	2	2	6	0	87
Qld	41	24	11	12	15	12	115
Total #	662	244	68	57	65	26	1122
Population	5776	7922	4944	8532	21198	27769	76141
%	8%	10%	6%	11%	28%	36%	100%

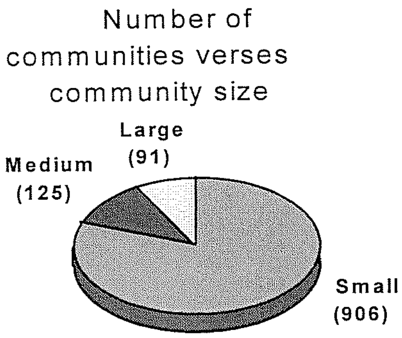


Fig. 2

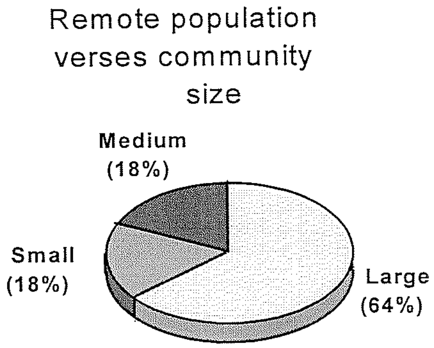


Fig. 3

Significant differences exist between the states and the NT as far as the distribution of community sizes is concerned. The NT has the highest number of small communities or outstations (523) reflecting a long history of outstation development. Queensland has the largest communities (more than 500 inhabitants) at twelve, and also the largest single community (3,300 persons). SA has no single community with more than 500 persons although the AP Lands in the NW of the state have a large combined population (around 3,000). For the small communities and outstations it is highly likely that they would not all be occupied at any one time. Figure 4 shows the state-by-state distribution of community sizes and figure 5 the community size and total population.

Figure: 4

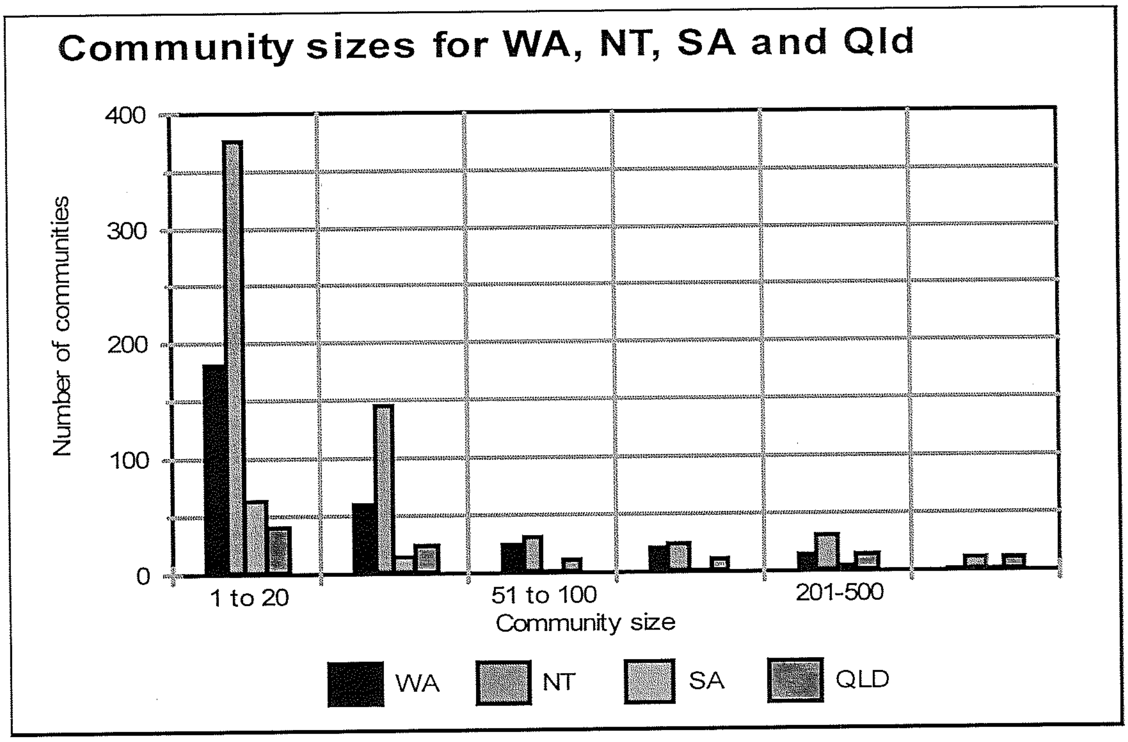
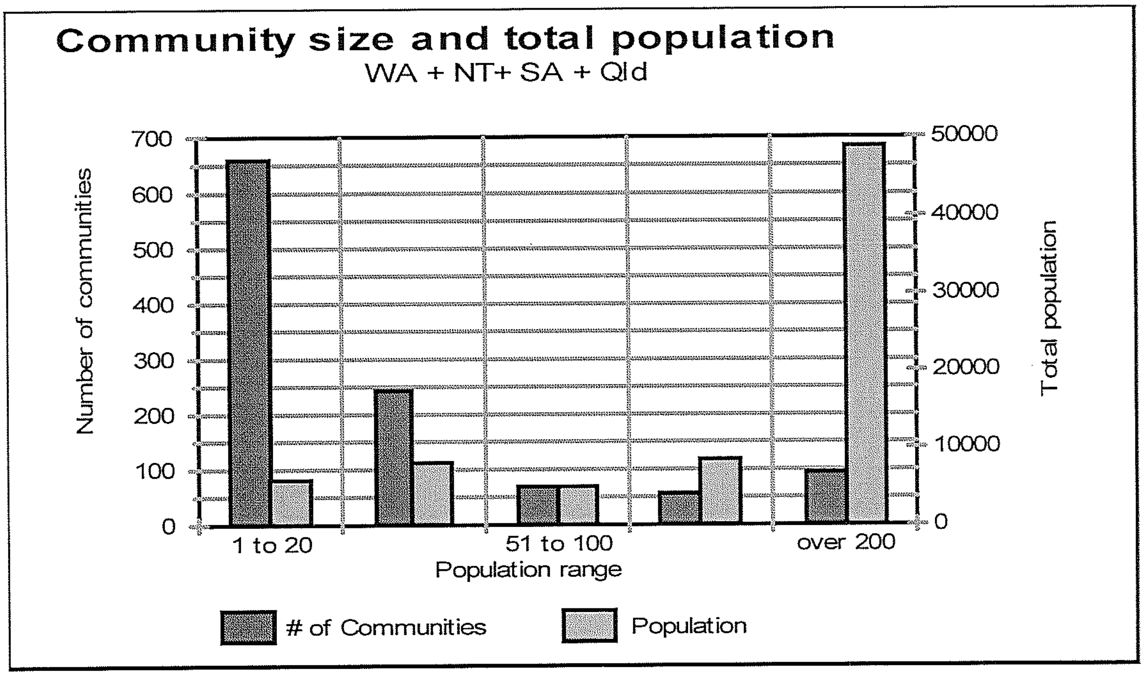


Figure: 5



Remote household size

High populations in remote community households are reported to be very common, with the reasons apparently being a shortage of housing and high mobility between houses (Jones 1994). Several studies have measured house populations, including a survey of 15 NT communities which found average populations ranged between 2.0 and 4.6 persons per bedroom (LD&C 1994). In Pipalyatjara, SA, average populations per house were found to be 8, 7.5 and 10.6 persons in three different surveys over several years (NHC 1987; Pholeros et al 1993; Khalife et al 1997). High household populations often result in overcrowding which in turn puts pressure on sewage infrastructure used within dwellings.

Population changes in remote communities

Significant population fluctuations between and within remote communities are known to occur due to social, cultural and climatic reasons. The resulting high fluctuations in individual household populations have the potential to cause serious impacts on sewage system performance. One detailed study of population movements in an Indigenous community was the "Housing for Health" survey of Pipalyatjara, SA by Pholeros et al (1993). The total population of Pipalyatjara fluctuated considerably during the 10-month survey, ranging from 40 people to 132 people. The Pipalyatjara survey also showed individual house populations regularly fluctuated between zero and thirty people at short notice, and retained these extreme population levels for up to several months on end. There is other evidence to suggest such population fluctuations are common across many remote populations of WA, NT, SA and Qld, especially for the small and medium size communities. Fluctuations of this magnitude can overload sewage systems to the point where they fail.

Within individual states, there is some evidence to suggest broad-scale population shifts between communities of different size categories. In WA, comparisons of data obtained during the 1991 HINS survey and the more recent 1997 WA EHN survey suggested that there might be a trend towards reduced populations in the smaller outstations and increasing populations for the major centres. Of the five population brackets used in the present report, the lowest (0 - 20 persons) showed 20 communities having a reduced population in 1997 compared to 10 increases. For the highest bracket (>200 persons) three showed a decreased population from 1992 to 1997 whereas 13 showed an increase during the same period. It might be noted, however, that errors in the enumeration of the smaller communities due to outstation populations sometimes being counted separately and sometimes with the main centre might confuse this type of conclusion. In Queensland, there is anecdotal evidence to suggest people are moving to outstations from larger communities, particularly on Cape York Peninsula. A report by Cooke (1994) found a large number of people, presently living in the larger communities, were keen to move to outstations. There are also indications that this movement is beginning to occur[3].

Sewage systems used in remote communities

Types of sewage systems in remote communities

The present study identified four basic sewage technologies in common usage. These were:

- full sewage systems
- common effluent disposal (CED) systems
- on-site septic systems
- pit toilets and grey-water systems

Full sewage systems and CED systems are both "centralised" sewage systems, while septic systems and pit toilet systems are "on-site" sewage systems. The basic technologies employed were virtually identical across each state and the NT although the management of those technologies was found to vary significantly between states. In addition the study identified a handful of communities with sewage technologies other than those identified above.

Populations served by the different sewage systems types

Figure 6 shows the different types of sewage systems in place as a function of the population served. For the combined study area, centralised sewage systems were found to service 59% of the remote population and on-site systems serviced 38% of the population. The remaining 3% of the population were found to have either no sewage, alternative systems or their status was not determined. Table 3 shows the remote population serviced by different sewage systems in the different states. The table shows there were significant differences between the states and the NT in regard to the type of centralised system or on-site system preferred. For centralised systems, full sewage systems were preferred in the NT and Qld, while CED systems were favoured in WA and SA. For on-site systems, pit toilets were rarely used in WA or Qld as primary sanitation systems, but were far more prevalent in the NT and SA. Further discussion on system preferences is given in the respective sections. Figures 7 and 8 show the use and relative use respectively of common sewage systems on remote communities for the different states and the NT.

[3] Pers comm. Stuart Downs, Project manager, Centre for Appropriate Technology, Cairns, 30 Jul 98.

Figure: 6

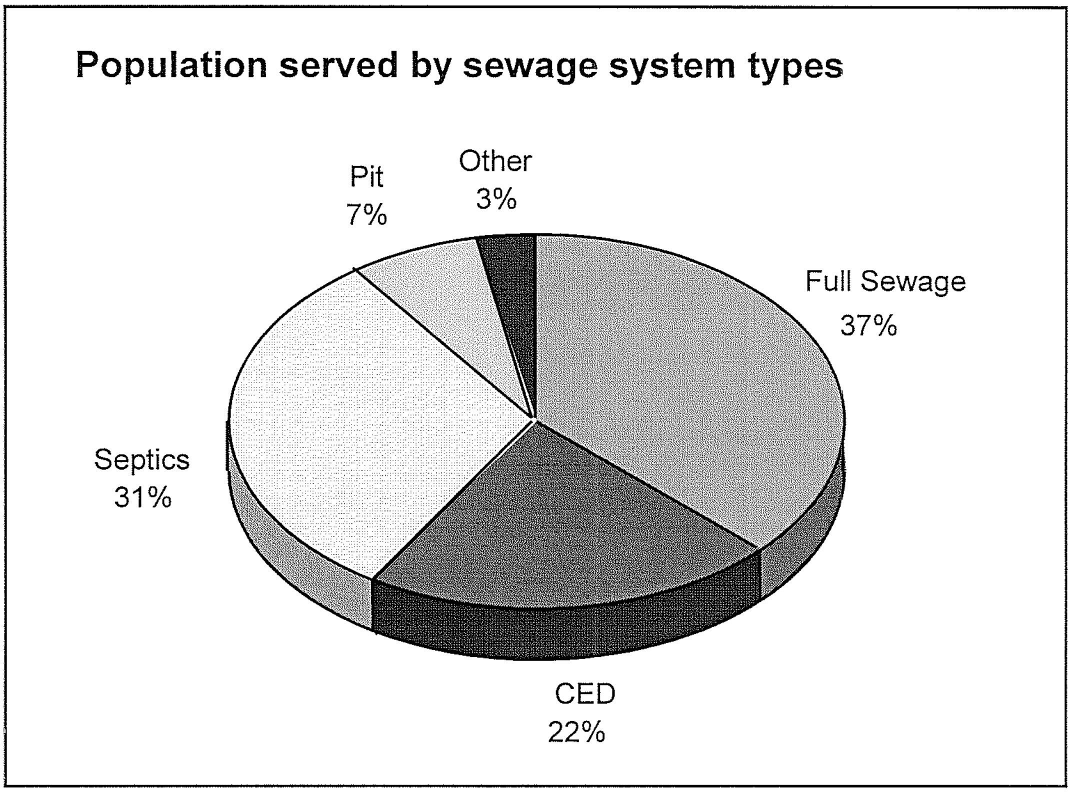


Table: 3

System Type	Population Serviced (%)									
	WA		NT		SA		Qld		Total	
Full sewage	970	(7)	15364	(45)	0	(0)	11690	(47)	28024	(37)
CED sewage	7059	(50)	3024	(9)	1744	(53)	4470	(18)	16482	(22)
Septic tanks	4620	(33)	11049	(32)	661	(20)	7570	(31)	23900	(31)
Pit toilets	360	(3)	4071	(12)	841	(26)	425	(2)	5697	(7)
Other	*130	(1)	**185	(0.5)	0	(0)	0	(0)	315	(0)
None	250	(2)	229	(1)	34	(1)	0	(0)	513	(1)
Not determined	678	(5)	245	(1)	0	(0)	472	(2)	1395	(2)
Total Population	14067	(100)	34167	(100)	3280	(100)	24627	(100)	76141	(100)

Notes: * Centralised vacuum system at Kupungarri, WA
** Centralised septic tank effluent system at Peppimernati, NT

Figure: 7

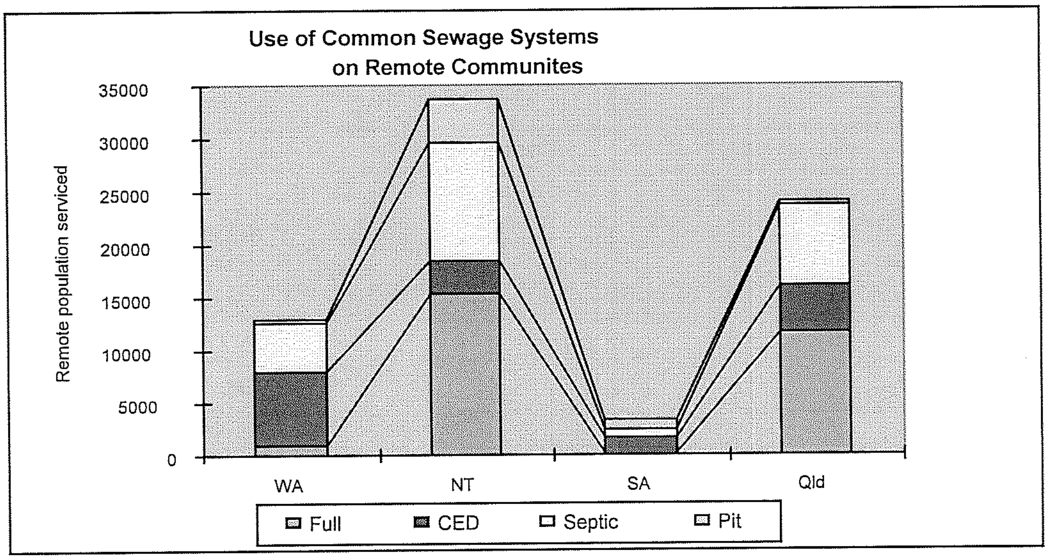
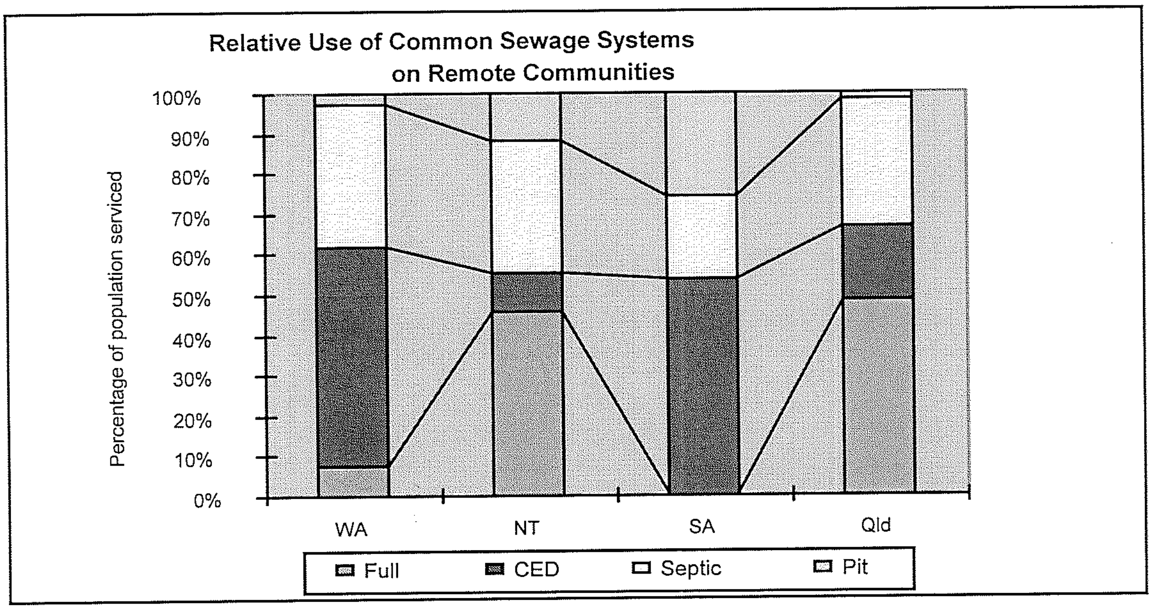


Figure: 8



Number of sewage systems in place

The number of communities using different types of sewage systems across the states and the NT is shown in Table 4. It is clear that there is a distinct difference between the number of communities using centralised sewage systems (95) and the number of communities using on-site systems (831). However, centralised sewage systems are generally installed in large communities and so service a large percentage of the remote population. Thus whereas centralised systems are only installed in 8% of communities they service 59% of the population. On the other hand 74% of communities use on-site systems (septic systems and pit toilets) but these only service 38% of the total remote population. Table 5 shows the type of sewage systems used by communities of different sizes. The table shows distinct variations in system use across different community sizes.

Table: 4

Sanitation System...	Number of Communities & Outstations Serviced					
	WA	NT	SA	Qld	Total	% popn.
Full sewage	2	30	0	12	44	(37)
CED sewage	31	9	7	4	51	(22)
Septic tanks	150	292	15	63	520	(31)
Pit toilets	26	209	58	18	311	(7)
Other	1	0	0	0	1	(0)
None	11	29	7	0	47	(1)
Not determined	81	49	0	18	148	(2)
Total Communities	302	618	87	115	1122	(100)

Table: 5

Sanitation system	Number of remote communities in WA, NT, SA & Qld in population range						Total Communities
	Small		Medium		Large		
	1 to 20	21 to 50	51 to 100	101 to 200	201 to 500	over 500	
Full sewage	0	0	0	5	21	18	44
CED sewage	0	1	7	14	22	6	50
Septic tanks	264	160	37	35	22	2	520
Pit toilets	222	70	19	0	0	0	311
Other	0	0	0	2	0	0	2
None	41	4	2	0	0	0	47
Not determined	135	9	3	1	0	0	148
Total communities	662	244	68	57	65	26	1122

The types of system will now be reviewed as a function of the size of the community.

- **Large Communities - 64% of remote population** (91 communities with more than 200 inhabitants). The data indicate that all inhabitants of these communities use water borne flush toilets. No communities of this size were identified as using pit toilets as their primary sanitation system. 74% of large communities currently use centralised sewage systems and 26% currently use on-site septic systems. Several communities in this category with on-site septic systems were found to have plans to upgrade to centralised sewage systems. Eight such communities are currently earmarked for HIPP/NAHS upgrades to centralised sewage systems (seven of which are in the NT).

- **Medium Sized Communities – 17% of remote population** (125 communities with between 51 and 200 inhabitants). Here a greater range of sewage systems was found to be in use. 26 communities (21%) had centralised sewage systems. 72 communities (58%) used on-site septic systems, (five of these are earmarked for NAHS upgrades to centralised systems). 19 medium sized communities (15%) used pit toilets as the primary sewage system, 15 of these were NT communities which had made conscious decisions to retain pit toilets and not move to flush toilet systems because of reduced maintenance requirements.

- **Small Communities and Outstations - 18% of remote population** (906 small communities and outstations with between 0 and 50 inhabitants) Information on sewage system types was found for only 822 of these communities. Only one is known to have a centralised sewage system (Myatt, NT). Due to the small community sizes others are unlikely to receive centralised systems while the populations remain low. The exceptions are communities with particularly adverse site conditions for on-site wastewater disposal (e.g. several Torres Strait Island communities). Some of these latter communities may receive small-centralised systems in future. 424 communities (47%) had on-site septic systems, and this figure is likely to grow as new houses are constructed containing flush toilets. 292 communities (32%) had pit toilets. Many outstations (particularly in the top end of the NT and the Pitjantjatjara Lands of SA) had made conscious decisions to retain pit toilets due to lower maintenance requirements. Many other outstations with temporary pit toilets were in early stages of development (e.g. Cape York Peninsula outstations). These communities may choose to retain pit toilets or convert to flush toilets as infrastructure is developed. 45 communities (5%) had no sanitation systems at the time of the survey. It is likely that many of latter communities will gain flush toilets or pit toilets in the future if the communities themselves are not abandoned.

Water use in remote communities

The amount of water used on remote communities has a direct bearing on the performance of sewage systems, as much of it ends up in the sewage system. Water use in remote communities seems to vary according to a range of factors including population fluctuations, seasonal conditions community size, community water use patterns, leakage, maintenance and availability of reticulated water.

The "Housing for Health" survey of individual houses at Pipalyatjara, SA in 1993 showed a relatively constant water use of approximately 120 litres per person per day (Pholeros et al 1993). Surprisingly this average varied little even when households had between zero and thirty people living in them. Water use was higher in summer. Water use by non-Indigenous staff was surveyed at the same time and found to be twice as much (250 L/p/day) but this included garden irrigation, which does not contribute to wastewater flows in sewage systems. Another survey in Pormpuraaw, Qld (Cape York Peninsula) showed average water use was around 200 litres per person per day, with seasonal variations in use. As a comparison average non-Indigenous water use in southern Australian capital cities is around 280 L/p/day, of which 165 L/p/day ends up as wastewater. In Alice Springs, average water consumption is 1,300 L/p/day (much of this is used for irrigation), while in coastal towns of northern Qld, average water use was found to be around 800 L/p/day (see Pormpuraaw report, CAT,1997).

Many remote communities are known to have limited water supplies (particularly those in the arid zone and on some Torres Strait Islands). At Coonana in WA for example, water shortages have been extreme (FRDC 1994). Some TSI communities have to barge in water for several months of each year because limited aquifers are exhausted over the extended dry season[4]. Water conservation may become an issue

[4] Pers comm. Duncan Wallace. Engineer, Dept of Natural Resources, Cairns, Qld. 14 October 98.

for many remote communities in the future as current groundwater supplies are overdrawn or exhausted. In addition many communities have no water metering and so total water use is often not known.

Section 3: Centralised Sewage Systems

System Types

Common systems

The survey found that there were two main types of centralised sewage systems in use in remote Indigenous communities. These were full sewage systems (FSS) and common effluent disposal systems (CED). **Full sewage systems** transport wastewater directly from houses through a pipe network to a treatment facility. All wastewater and solids are transported. If site conditions do not allow gravity flow through the pipe system, then pump stations are used to pump wastewater through sections of the pipe. **Common effluent disposal (CED) systems** on the other hand incorporate septic tanks at individual households to capture solids in the wastewater. Effluent from the septic tanks then flows through a central pipe network to a simplified treatment facility. As with full sewage systems, CED systems often require pump stations to transport effluent through sections of the pipe network. The treatment facilities used by most communities are a series of effluent lagoons, or ponds. Wastewater flows sequentially through the lagoons and receives treatment from microorganisms, sunlight, wind, time and wave action. Reuse of effluent for irrigation purposes was identified on only a handful of communities.

Alternative Systems

Only two other types of centralised collection systems were found to exist in remote communities. One was a septic tank effluent pump system (STEP) at Peppimernati, NT, where individual septic tanks have separate pumps to pump effluent to central treatment lagoons. The other was a vacuum sewerage system at Kupungarri, WA. In this system effluent is sucked from individual septic tanks into a pipe network under constant vacuum pressure, and then delivered to central treatment lagoons. As a modification of the more typical centralised system the community at Palm Island, Qld uses a trickling filter before effluent lagoons to treat sewage. Further details on alternative collection, treatment and disposal/reuse systems are given later in this section.

Present use

Current situation

The survey found centralised sewage systems service some 45,000 people in nearly 100 remote Indigenous communities in WA, NT, SA and Qld. The population serviced is 59% of the total remote community population. Table 6 shows a summary of communities using centralised sewage systems for the states and the NT.

Table: 6

	Number of Communities				
Sewage System	WA	NT	SA	Qld	Total
Full	2	30	0	12	44
CED	31	8	7	4	50
Other Centralised	1	1	0	0	2
Total	34	39	7	16	96

Centralised systems were found to be usually restricted to larger communities with populations greater than 100 people (see Table 5). This distribution seems to be due to both the high installation cost of a centralised system and a perception that the operational problems of keeping a large number of individual on-site sewage systems all functioning adequately at any one time are greater than for a central system.

System Preferences

As shown in figure 8 there are distinct differences in preferences between the states and the NT for full sewage or CED systems. Western Australia and South Australia have historically favoured CED systems, while the Northern Territory and Queensland have favoured full sewage systems. The current HIPP/NAHS programs continue to reinforce these trends. The reasons for the differing preferences were examined.

- In **Western Australia**, the WA Water Corporation indicated that CED systems were favoured on communities because existing full sewage systems were having significant clogging problems from debris at pump stations. When the original decision to use mainly CED systems was made (around 1993) it was planned to move to full sewage as the debris problems were sorted out. As the problems were not solved the use of CED systems has continued[5].

- In the **Northern Territory** the PAWA (NT) indicated that full sewage systems were preferred because CED systems in the NT had been prone to failure from lack of septic tank maintenance. The Authority is of the view that full sewage provides better health outcomes for people, and so is the preferred system in the NT[6].

- In **South Australia** there has been a general preference towards CED systems. Over 100 CED systems have been installed in non-Indigenous communities since the early 1970s (VicDNRE 1997). CEDs in SA are preferred because of lower installation costs than full sewage systems, a proven ability to work well with proper maintenance and ability to use existing septic tanks to further reduce installation costs (VicDNRE 1997). SA Indigenous communities receive CED systems in line with this philosophy, despite significant differences in system use and maintenance from that of non-Indigenous communities[7].

- In **Queensland**, the Department of Natural Resources indicated that full sewage systems are mostly used because they are the most common system used in all Queensland towns.

The reasons for different system preferences as identified by this study may not fully encompass all factors considered by state agencies when deciding on system types.

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[5] Pers. comm. Fred Holden, Program Co-ordinator, Aboriginal Communities, NorthWest region, Water Corporation. 17 August 98.

[6] Pers comm. Robert Decet, water operations co-ordinator, Aboriginal Essential Services, Power & Water Authority. 12 August 98.

[7] Pers comm. Harry Vosnakis, senior project officer, Essential Services Team, Division of State Aboriginal Affairs. 16 July 98.

They do however, highlight differences in approach based on function of hardware, health concerns, historical preference and budget constraints.

Future trends

Future trends in centralised system are looked at as a function of community size.

Large communities

Although there are distinct differences on a state basis between full sewage systems and CED systems, there is a universal trend in all states for larger communities to upgrade from on-site sewage systems to centralised systems. The main reasons given by all states for changing to centralised systems are because of repeated instances of on-site system failures. The operational evidence that centralised systems keep people separated from wastewater more successfully than an on-site system is discussed further below. Of ninety-one large communities in WA, NT, SA and Qld with populations greater than 200 people, sixty-seven (74%) have centralised sewage systems, and eight more (giving a total of 82%) are earmarked for HIPP/NAHS conversions from on-site to centralised systems. Some state agencies indicate that large communities using on-site systems are likely be converted to centralised systems as future funding permits. There were, however, contradictory sentiments expressed by some agencies along the lines that because centralised systems are expensive to install, the option of retaining on-site systems in larger communities is being examined in some instances. In 1997 the NT Government commissioned a study to examine whether poorly functioning septic systems on medium to large communities could be upgraded to provide healthy function. This study by Sinclair Knight Merz (SKM) entitled "*The condition and suitability of existing septic tank/absorption trench systems on 15 Northern Territory Aboriginal communities*" recommended that four of nine communities with a population over 200 could retain on-site systems if upgrades were implemented.

Medium communities

Most medium sized communities seemed likely to retain the use of on-site systems into the near future unless populations increase significantly or existing site conditions are shown to be totally inappropriate for healthy on-site sewage disposal. The high cost of installing centralised sewage systems in medium sized communities would make the centralised option prohibitive unless mitigating circumstances applied. The SKM study of NT communities recommended all six communities with populations between 50 and 200 people should retain on-site septic systems.

Small communities

Most small communities and outstations seem certain to use on-site sewage systems into the future because of the prohibitive cost of providing centralised sewage systems, and the availability of enough space to provide adequate on-site sewage systems.

Operational Experience

Sources of information

In the course of this survey, operating experience with regards to centralised sewage systems in remote communities has been obtained from a variety of sources including Commonwealth and State agencies, water authorities, contractors, regional service providers and community personnel (advisors, ESOs, plumbers, environmental health workers). No comprehensive reports were identified which examined the performance of centralised sewage systems in remote communities. It must be stressed (again) that the information obtained has not been from the field and that it is thought that real field information is needed. There is considerable evidence to suggest that an administrator's understanding of the functionality of hardware in Indigenous communities often does not correspond with the actual situation.

General performance of systems

In general the telephone survey of the above sources has indicated satisfaction with the performance of centralised sewage systems. It appears they are generally able to keep community residents separated from sewage. In this respect they seem to be considerably more successful than on-site sewage systems. Full sewage systems in particular seem more successful than CED systems, because CED septic tanks require regular maintenance, which is often lacking in many communities.

Two of the main factors that have contributed to the success of centralised systems seem to have been the adoption of formal routine maintenance programs overseen by state agencies, and the adoption of dual pump systems in pump stations. DoSAA reports that when CED systems were first installed in remote SA communities in the late 1970s and early 1980s, there were no maintenance programs or dual equipment installed. When pumps inevitably failed due to lack of maintenance it took time to organise repairs resulting in sewage regularly flowing down community streets[8]. Since 1988 the function of SA CEDs improved significantly because of co-ordinated planning, significant capital works and upgrades to septic tanks and pipe networks, routine servicing of systems and provision of dual pump systems.

In summary, the reasons given why centralised sewage systems are thought more successful than on-site systems are that:

- dedicated personnel undertake the routine servicing of equipment
- dual equipment is now standard in pumping stations
- breakdown assistance is co-ordinated by regional or state agencies rather than under the control of the individual communities (except in Qld).

Problems with centralised systems

Centralised systems are not, however, problem free and failures still occur. Some of the problem areas identified by the present survey include:

[8] Pers comm. Grant MacLean. Team leader, Essential Services group, Division of State Aboriginal Affairs. 16 July 98

- blocked toilets in individual houses
- leaking taps or taps left on which cause high water loads to flow through to central treatment & disposal facilities
- septic tanks (for CED systems) which fill with solids due to irregular pump out, allowing solids through to the pipe network and lagoons, which are not designed for solids
- poor initial construction of centralised systems
- deterioration of old sewerage pipes
- lagoon failure
- break down of pumping station infrastructure, often due to high intermittent solids loads

These problem areas are discussed in more detail below.

Blocked flush toilets

Blocked flush toilets were reported to be a major problem in many communities in all states and the NT.

Telephone surveys indicated blockage frequency ranged from sporadic to common. No clear trends, however, were identified. Ali Curung, NT (430 inhabitants) reported no toilet blockages in the three months prior to August 1998[9], while Lockhart River, Qld (500 inhabitants) reported that toilet blockages were very common[10].

The cause of the blockages was attributed to children putting various objects down toilets, adults using rags/newspaper/etc instead of toilet paper, and adults using the toilet as a rubbish bin to dispose of large wastes (e.g. nappies, sanitary pads). Many communities reported that toilet paper is rarely kept inside toilets, instead being stored for individual use. A one-year survey at Pipalyatjara, SA by Pholeros et al (1993) made 48 survey visits and only found ten toilet rolls in the entire time. This is apparently because toilet paper is expensive in community stores (prices up to $4 per roll were reported during the survey) and is quickly used by high house populations or children playing.

To try and solve the problem of inappropriate items blocking toilets, many communities were found to have some form of ongoing toilet education campaign, although many showed no major commitment to this. Some communities had formal campaigns sponsored by State Health Departments or used posters and stickers to encourage good use. One plumber at Hopevale, Qld reported that static poster campaigns reduced blockages for a short time, but quickly lost their impact. Many schools were found to include appropriate toilet use in their curriculum, although the impact of this type of initiative was not ascertained. Another way that communities were trying to rectify the situation was to use ESOs and Environmental Health Workers to constantly remind people about the proper use of toilets. Nganampa Health Council reported that this approach successfully reduced toilet blockages to very low levels in Pitjantjatjara communities. They added, however, that constant reminders were required to ensure blockages did not recur[11]. Other communities reported similar experiences. In the NT, government agencies have discussed the

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[9] Pers comm. Robert Donovan, community plumber, Ali Curung, NT. 12 August 98.

[10] Pers comm. Dave Clark, community executive officer, Lockhart River, Qld. 12 August 98.

[11] Per comm. Stephi Rainow. Public Health Officer, Nganampa Health Council. 14 July 98.

possible subsidisation of toilet rolls at community stores to make them more affordable. Others have suggested introducing large industrial size toilet rolls (and holders) which would last longer and perhaps more importantly would last between pay-days.

There were no alternative flush toilet designs identified by the present study that could provide a physical solution to the blockage problem. AP Services, who maintains approximately 500 toilets on Pitjantjatjara communities (CED and on-site), reported that S-trap toilets seemed to have less blockage problems than P-trap toilets. They attributed this reduction to solids flushing more easily through downward flowing S-traps rather than horizontal flowing P-traps[12].

The NT government has recently introduced new Environmental Heath Standards for housing, which specify that houses with four bedrooms or more must have two separate toilets. This is to ensure that if one toilet is blocked, there is a second toilet available.

Leaking taps

Leaking taps (and/or taps left on) was reported to be a significant problem in many communities across WA, NT, SA and Qld. In addition to the problem of wastage of often precious water supplies this problem results in considerable volumes of clean water entering sewage systems causing increased wear of pump infrastructure, reduced detention time of effluent in lagoons and possible overloading of lagoons. A survey of fifteen NT communities in 1997 by Sinclair Knight Merz found twelve had leaking taps to varying degrees. One source at DoSAA reported that in many SA communities CED systems are "running like creeks" due to leaking fixtures and taps left on, resulting in lagoon overflows[13].

The reasons for leaking taps and taps left running were identified as both physical problems with hardware and attitudinal problems with regards to water use and conservation. Leaking taps were often due to poor quality water corroding washers and tap seats (either acidic water or highly mineralised water). Missing tap handles also seemed to be a significant problem resulting in taps when left fully or partially on not able to be turned off. In addition to hardware failures, there also appeared to be a high incidence of attitudinal problems; people just not bothering to turn taps off after using them. State and NT government agencies, which maintain central sewage infrastructure, consistently indicated their dissatisfaction with the amount of water entering CED and full sewage systems. These authorities, however, seldom were involved with household leak repair programs or water conservation programs. The responsibility for repairs to leaking taps was almost always found to be vested in community councils.

AP Services, which maintains infrastructure on Pitjantjatjara communities, reported that in 1986 only 51% of water fittings were in working order, this percentage increasing to 95% in 1996. The reasons for the improvement were given as: regular maintenance visits to all communities three times per year, and swift repairs to reported leaks in between regular visits[14]. Some outstation resource centres reported

[12] Pers comm. Stephi Rainow. Public Health Officer, Nganampa Health Council. 14 July 98.

[13] Pers comm. Harry Vosnakis, senior project officer, Essential Services Team, Division of State Aboriginal Affairs. 16 July 98.

[14] Per comm. Stephi Rainow. Public Health Officer, Nganampa Health Council. 14 July 98.

ESOs regularly visited outstations to inspect function of infrastructure and fixed any leaking taps immediately, while other outstation resource centres seemed to have only intermittent maintenance programs. There is an obvious need to examine this significant community problem more closely to ascertain the frequency of each reported approach, and ways to improve repair programs.

In one initiative in this area, DoSAA is soon to start a survey of water consumption and availability in remote communities in SA to determine the sustainability of current water use on remote communities. This program may lead to increased wastewater re-use and programs to reduce water consumption.

For the issue of taps left running there have been several solutions suggested. One is to initiate water conservation campaigns such as in non-Indigenous towns, although experience in those towns shows campaigns must be regularly varied to maintain community interest. Installing water meters and charging for water was not suggested by any organisation contacted during this study. It seems the experience of electricity metering, where residents find difficulty in paying periodic bills, has dulled this approach. Surprisingly no communities were identified to be running formal water conservation campaigns, although a video and booklet on "Saving Water for Healthy Communities" has recently been published for remote communities by the Remote Area Development Group in WA (RADG 1998). It was reported several times that ESOs and Environmental Health Workers encouraged people to turn off taps if not in use. It has been reported in non-Indigenous communities that the change from on-site to centralised sewage systems stimulates higher household water use (VicDNRE 1997). No data was found from Indigenous communities to indicate similar trends or otherwise.

There appears to be an obvious need to further examine this significant community problem, and to ascertain the relative success of different approaches to improving the situation.

Septic tanks filling with solids

In many communities with CED systems, it was reported that solids were being washed through poorly maintained or undersized septic tanks. CED sewage systems are not designed to carry large solids loads, having flat grades and small diameter pipes than full sewage systems. The solids cause problems by building up in pipes, clogging pump station pumps or filling primary lagoons with sludge. Individual communities and state government agencies responsible for centralised CED infrastructure commonly reported this problem.

There seemed to be two main reasons why septic tanks filled with solids. One is that many communities do not have access to appropriate septic tank pump-out equipment, and the other is that most communities do not have routine pump-out programs for septic tanks. In WA, this current survey identified 31 communities with CED systems, with nine of those communities (29%) reporting no access to septic tank pump-out equipment (1997 WA EHN survey). In WA, SA and NT, maintenance responsibilities for CED systems are divided between the community council (inside properties) and state government agencies (pipe network and treatment facilities). In Qld maintenance responsibilities were the total responsibility of community councils. In addition it was ascertained that the majority of the CED communities had no routine maintenance programs in place. Instead, septic tanks appeared to be serviced only if they visibly failed with obvious effluent pooling around the tank. In WA, NT and SA there seemed to be little effort from state agencies to assist communities to develop routine septic tank maintenance programs, despite each of the state agencies expressing concerns that overflowing solids create significant maintenance problems in pipe networks and treatment facilities.

To solve the problem of solids filling septic tanks in CED systems, it is obvious that communities must have access to pump-out equipment and they must have in place regular pump-out schedules. Unfortunately it appeared that few communities seemed to have both of these essentials in place at the same time. One exception, and good example of implementing a structured maintenance program, was found in the Pitjantjatjara lands of SA, where AP Services provides an annual pump-out of all CED septic tanks on five major communities. AP Services also reported that most septic tanks in the AP lands have been surveyed in the two years prior to 1998. Small or corroded tanks have either been replaced in that time or are earmarked for upgrades via a 1999 NAHS septic upgrade program[15]. The result is a considerable lowering of dysfunctional sewage systems (see the UPK and HH studies to see the status change from the mid 1980s onwards). The key to success in this instance seems to be that individual communities have come together to create a regional organisation able to concentrate on maintenance issues without having to deal with domestic community problems.

Poor construction

Poor construction of centralised sewage systems was identified as a problem in some communities. Difficulties have included inadequate pipe grades, under-specified materials, poor joints between pipe sections allowing storm-water ingress and careless back-filling allowing sediment ingress.

The reason for faulty systems, particularly those installed in past decades, seemed to stem from complacency and laxness on the part of construction contractors and a lack of quality control monitoring by funding agencies and (or) regulatory agencies. For example the CED system at Papunya, in the NT was recently surveyed using a special in-pipe sewerage camera and was found to have sections running uphill[16]! This basic fault allowed solids to accumulate in pipes and greatly contributed to the chance of blockages. In SA, DoSAA reported that one diligent staff member closely monitored construction of most remote community CED systems in the late 1980s and early 1990s for quality control. This one person they felt ensured quality installations and stopped significant recurrent problems occurring as experienced in other states[17]. Despite this assurance some SA communities still reported problems with poor construction. It was reported that Amata, in the AP lands for instance has had ongoing problems with a rising main constructed using under-specified material[18].

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[15] Per comm. Stephi Rainow. Public Health Officer, Nganampa Health Council. 14 July 98.

[16] Pers comm. Robert Decet, water operations coordinator, Aboriginal, Essential Services, Power & Water Authority. 12 August 98

[17] Pers comm. Harry Vosnakis, senior project officer, Essential Services Team, Division of State Aboriginal Affairs. 16 July 98.

[18] Pers comm. Harry Vosnakis, senior project officer, Essential Services Team, Division of State Aboriginal Affairs. 16 July 98.

Monitoring procedures and regulations appear to be tightening in nearly all states and in the NT. All current centralised sewage installations are funded by ATSIC through HIPP/NAHS grants and managed by state program managers (Ove Arup in NT and Qld, PPK in WA and SA). Program managers are responsible for quality control of installations, and general reports from ATSIC are that program managers are ensuring that quality control measures are undertaken[19]. In the NT, PAWA wants to move against poor construction by making construction contractors camera sewerage pipes before handing them over for commissioning, to ensure the systems are installed to specifications[20].

Deteriorating infrastructure

Several communities reported that older centralised sewage infrastructure had deteriorated with age and were now giving problems. In the NT, many systems are around 20 to 25 years old and some of the original asbestos-cement pipes were deteriorating badly. PAWA is concerned that some pipes cannot be pressure-cleaned for fear of gouging away the pipe walls[21]. On communities such as Ali Curung in the NT, PAWA are slowly replacing deteriorating asbestos-cement piping with new PVC piping[22]. Most pipe systems are now installed using long lasting plastics, which is recognised as being far more resistant to corrosion than concrete, steel or the old asbestos-cement pipes. Deterioration of concrete septic tanks and pump stations also seems to be a problem in many communities. The deterioration is because specific compounds in wastewater degrade concrete, particularly compounds which develop in CED septic tank effluent. In the AP Lands of SA, badly corroded septic tanks were found to be common. These are being replaced in a NAHS septic upgrade program[23]. Pump stations also require regular patching to stop concrete corroding. One manufacturer of sewage hardware in Darwin indicated his company is developing a pump station made from concrete and lined on the inside with a high-density polyethylene plastic that will be resistant to corrosion from sewage effluent compounds[24]. At Palm Island, Qld, electrical control equipment in pump stations was reported to be in major need of upgrading[25]. Treatment lagoons were also reported to be deteriorating badly in several communities due to erosion from wave action and a lack of regular maintenance.

High solids load affecting pump stations

It was reported that significant pump failures were encountered in many pump stations in communities because of unmanageable debris being washed through sewerage systems. All state sewage maintenance agencies indicated pump failures were an ongoing problem in pump stations but that total pump station failures were now uncommon. However, these still occurred, as evidenced in SA where 13 pump

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19 Pers comm. David L'Verty, Manager Social and Cultural Branch ATSIC, Perth, WA, 14th May 1998

20 Pers comm. Robert Decet, water operations coordinator, Aboriginal, Essential Services, Power & Water Authority. 11 May 98

21 Pers comm. Robert Decet, water operations coordinator, Aboriginal Essential Services, Power & Water Authority. 11 May 98

22 Pers comm. Robert Donovan, plumber, Ali Curung community, NT. 12 August 98.

23 Per comm. Stephi Rainow. Public Health Officer, Nganampa Health Council. 14 July 98.

24 Pers comm. Robert Miln, Everlevel Drainage Systems NT. 20 May 98.

25 Pers comm. John McAleer, environmental health officer, Palm Island, Qld. 11 August 98.

stations across all communities in the AP lands were reported to suffer roughly one failure every two months due to pump failures or censor probes shorting out[26].

The main reason for pump failures was given as their inability to handle the large volume and the composition of solids contained in effluent generally reported to enter remote community sewerage systems. Items such as cans, bottles, tampons, rocks, dead animals, rags, metal and other debris were commonly said to enter systems. CED systems rely on septic tanks to capture these solids, but because the tanks are not emptied regularly they commonly overflow allowing the solids to then wash through to the pipe network. In some cases it was reported that houses have been connected to CED systems without having the intermediary septic tank installed. Full sewage systems allow all solids straight into the pipe network. Many community personnel reported their amazement at what items could be forced down a flush toilet. Although many communities also indicated that manhole covers were often not properly in place, allowing a more probable access route for large items to find their way into the sewerage pipe network.

State maintenance agencies have trialled a variety of devices to manage solids at pump stations. Most of these devices use screens or baskets before pumps to capture solids, but such devices also require daily clearing and so blockage problems still occur if they are not cleared promptly. Macerators are also used or have been trialled to shred solids, but problems are still encountered with metal shards wearing down pumps. Another solution; wide orifice pumps, are used by PAWA in the NT with some success[27]. It seems further developments are required in this field before reliable operation is achieved. However, the use of dual pumps in pump stations and standardised equipment across communities seems to have reduced many of the emergency breakdown problems encountered in previous years.

Lagoon failure

Significant overflow of effluent from lagoons or people using lagoons for swimming and hunting were reported during this study. All aspects of lagoon failure have considerable and obvious health risks.

Data obtained during the study indicated that the majority of lagoons in remote communities are fenced to prevent normal access by people or animals. The WA EHNS in 1997 indicated that of 33 communities with lagoons, only two reported that lagoons were not fenced. Other states appear to have similar provisions. However, several communities reported breaches of lagoon fences. Often these breaches were attributed to children using the lagoons as swimming pools (see CAT swimming pool report, 1998). At Yuendumu (in the NT) the ESO indicated that local inhabitants regularly cut lagoon fences to allow water-bird hunting and access for cattle to grass and water[28]. As a consequence the cattle damaged the lagoon walls and stirred up mud in the lagoons. This damage would be expected to decrease treatment performance.

Several lagoons were suggested to have significant overflow of effluent. The WA EHN survey in 1997 indicated that 6 communities of the 33 communities with lagoons

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26 Pers comm. Harry Vosnakis, senior project officer, Essential Services Team, Division of State Aboriginal Affairs. 16 July 98.

27 Pers comm. Bob Dennis, manager Rural operations Barkly region, PAWA, NT. 20 July 98.

28 Pers Comm. Tony Jutna, Essential Services Officer, Yuendumu community, NT. 12 August 98.

reported 'high' or 'excessive' overflow, 13 reported 'low' or 'moderate' overflow, 9 reported no overflow and 5 did not reply. Overflows may be due to minimal evaporation from ponds because of small surface areas or high humidity (particularly in tropical wet seasons), high storm-water inflows due to deteriorating pipe networks, or high water loads from leaking taps or taps left on. At Kowanyama in northern Queensland, it was reported that children swam in the river immediately downstream of a lagoon overflow point[29].

Summary of the advantages & disadvantages of centralised systems

There seemed to be reasonable agreement that the major advantage of centralised sewage systems over on-site sewage systems was the formers ability to better keep people separated from wastewater on remote communities. The major impediment to centralised systems being installed in all communities was given as the high cost per connection for small communities.

Full sewage systems had a lower overall incidence of failure than CED systems, because there were no septic tanks to maintain in a full sewage system. Full sewage systems were, however, more expensive to install than CED systems.

System	Advantages	Disadvantages
Centralised sewage	• all wastewater removed off-site • less prone to failure than on-site systems • cope better with high loads from individual houses • generally long-lasting infrastructure	• expensive to install, especially in rocky or undulating areas • can encourage higher water use
Full Sewage	• Lowest operation and maintenance costs • septic tanks not required	• generally the most expensive option to install (large pipes, steep grades) • pump stations and treatment lagoons must handle high solids loads
CED sewage	• less expensive to install than full sewage (smaller pipes, flatter grades) • can use existing septic tanks • reduced organic loading at treatment lagoons	• septic tanks must be regularly pumped-out • sludge facility required • more chance of wastewater surfacing in yards from septic tanks

Regulations

Regulations with regards to centralised sewage systems are divided into two main areas of responsibility. The first are the regulations for installation of sewage systems

29 Pers comm. Su Groome, project officer, Centre for Appropriate Technology, Cairns, Qld. 16 July 98.

and the second are regulations for environmental discharges from sewage treatment facilities. These areas are discussed below.

Licensing of installations

In each state and the NT, state government Health Departments are responsible for the licensing of wastewater installations to ensure systems are correctly designed to meet the needs of the community. The organisations in each state are:

• Western Australia:	Health Department of WA
• Northern Territory:	Territory Health Services
• South Australia:	SA Health Commission
• Queensland:	Queensland Health (delegated to Local Government)

Licensing of discharges

Wastewater discharges from centralised sewage systems to the wider environment must be licensed in each state and the NT by state government bodies. All are moving away from prescriptive licence requirements which set limits on wastewater quality (typically 20 mg/L BOD and 30 mg/L suspended solids) towards individual assessments of the effects that discharges will have on the receiving environment. The organisations in each state are:

• Western Australia:	Department of Environment
• Northern Territory:	Department of Lands, Planning & Environment Environment Protection Division
• South Australia:	Environmental Protection Agency
• Queensland:	Department of Environment

In Western Australia, the Department of Environment indicated that it is moving towards a requirement for zero discharge from sewage lagoons (i.e. total containment). This requirement may be relatively straightforward to achieve in the arid regions of WA, but in the tropical north it will mean communities will require large storage capacity lagoons to store wet season flows. Fred Holden, the program co-ordinator for Indigenous communities in the north-west of WA (WA Water Corporation) believes this requirement will be very difficult to achieve across the state[30]. In Queensland, the Department of Environment indicated that all sewage systems in Qld would have to treat effluent to tertiary standards by 2010 if discharging to coastal waters[31]. A regulation that could have significant implications for remote Indigenous communities.

Funding

Funding arrangements for the construction and maintenance of centralised sewage systems are similar in WA, NT and SA and differ in Qld. Funding for construction of sewage systems is currently provided solely by ATSIC via CHIP and HIPP/NAHS grants.

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[30]Pers. comm. Fred Holden, Program Coordinator, Aboriginal Communities, NorthWest region, Water Corporation. 17 August 98.

[31] Pers comm. Brynn Mathews. Senior Environmental Officer, Dept of Environment and Heritage, Cairns, Qld. 13 August 98.

In **Western Australia**, ATSIC funds capital works for essential services infrastructure in all WA remote communities and outstations. This funding, currently running at $8.4 million per year, is for power, water and sewage works (where installed). At present the Aboriginal Affairs Department (AAD) funds the maintenance of essential services on 48 designated larger communities, and under a Commonwealth-State agreement contributes $4.2 million per year towards maintenance. Both organisations have recently pooled their funding to be managed by a state contracted program manager under new "Remote Area Essential Services Program" (RAESP) arrangements (DCMS 1998). HIPP/NAHS funds are also provided by ATSIC for sewage capital works, and total $12 million for 19 separate projects to be completed by 2000[32].

In the **Northern Territory**, most capital funding for centralised sewage schemes is currently provided by ATSIC HIPP/NAHS grants which total $27 million for 25 projects to be completed by 2000. PAWA used to contribute funding towards capital works until recent years but suspended capital works funding when HIPP/NAHS grants became available[33]. ATSIC also provides some capital funding for sewage through its Community Housing and Infrastructure Program (CHIP). This latter funding amounted to $100,000 in 1996/97[34]. Maintenance funding is provided by PAWA for centralised sewage infrastructure.

In **South Australia**, a Commonwealth-State funding agreement has been in place for several years for Indigenous community sewage systems. ATSIC contributes $2.7 million per year for capital works and upgrades to CED systems, while the Department of State Aboriginal Affairs (DoSAA) matches this with $2.7 million per year for maintenance of CED systems. This funding, however, does not include funds for the maintenance of septic tanks or plumbing fixtures on individual properties. ATSIC provides $200,000 per year for septic tank maintenance on all SA Indigenous communities, including CED systems[35]. The money is administered by DoSAA and contracted directly to communities or AP Services. ATSIC also provides HIPP/NAHS grants for capital sewage works, and has committed $2.5 million for 4 projects until 2000.

In **Queensland**, most capital works funding for centralised sewage systems is currently derived from ATSIC HIPP/NAHS grants. This funding is running at $4 million for 11 projects to be completed by 2000. A small amount of ATSIC CHIP funding is also provided in this state, but this only amounted to $37,000 in 1996/97[36]. As far as maintenance is concerned the Queensland government currently provides no specific funding for essential services on Indigenous communities. DOGIT (Deed of Grant in Trust) communities are expected to collect rates or community levies to cover the cost of maintenance. The level of rate collection was reported not to be high at present and was not sufficient to cover maintenance costs. As a result, communities seemed to use other "general purpose" funds, provided by the then Department of Family Services, to undertake maintenance of essential services including sewage systems. The Office of Aboriginal and Torres Strait Islander Affairs

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[32] Financial data supplied by ATSIC Housing Infrastructure & Health Policy Section. 15 June 98.

[33] Pers comm. Mick Dejong, Aboriginal Essential Services, Barkly Region, Power and Water Authority, NT. 12 May 98.

[34] Financial data supplied by ATSIC Housing Infrastructure & Health Policy Section. 15 June 98.

[35] Pers comm. Harry Vosnakis, senior project officer, Essential Services Team, Division of State Aboriginal Affairs. 16 July 98.

[36] Financial data supplied by ATSIC Housing Infrastructure & Health Policy Section. 15 June 98.

(OATSIA) and the Aboriginal Co-ordinating Council (ACC) have recently announced that a $9 million pilot maintenance program is to be conducted on four DOGIT communities over three years[37].

Installation and maintenance costs

Installation costs

The installation cost of a centralised sewage system is dependent on many factors, which means giving an average figure can be misleading. The main factor affecting cost is the ground condition and resultant cost of trench excavations (whether ground is rocky or undulating). Other factors include the:

- density of housing
- length of sewer lines required
- number of household connections
- number of pumping stations and manholes required
- size and number of sewage lagoons required
- remoteness of the community

An evaluation by ATSIC of installation costs for fifteen HIPP/NAHS centralised sewage schemes on remote communities of WA and the NT indicated that the cost per connection for full sewage systems ranged from $15,300 to $36,500 with an average of $25,500 for ten systems (ATSIC 1998). For CED systems the costs were only slightly lower between $15,100 to $32,900 and with an average of $22,100, for five systems.

It is important to note that the cost per connection generally drops rapidly with increasing numbers of connections. For the HIPP/NAHS schemes mentioned above, the cost per connection for systems with only 20 connections each was in the region of $35,000 whereas the cost per connection for systems with around 150 connections was in the region of $16,000.

Operational and Maintenance costs:

Sinclair Knight Merz (1997) estimated that the typical annual maintenance costs for full sewage systems in the NT ranged between $12,000 and $16,000 depending on community size. A breakdown of the costs is given below.

Full Sewage System	**Annual Maintenance Cost**
Pump station power	$2,000
Weekly inspection housekeeping	$6,000/$4,000
Specific maintenance, equipment and civil structures	$3,000
Unforeseen repairs	$5,000/$3,000
Total (population > 300)	**$16,000**
Total (population < 300)	**$12,000**

The above estimate does not include in-house plumbing fixture maintenance, which is likely to be significant in many communities.

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[37]Pers comm. Kate Vasey, Senior Program Development Officer. Aboriginal and Torres Strait Islander Infrastructure Program, Department fo Aboriginal and Torres Strait Islander Policy Development, Qld.. 21 July 98.

For CED systems, there is the additional cost of desludging septic tanks. SKM (1997) provides an estimate of septic tank maintenance for on-site systems, which may be similar to CED septic tank maintenance costs. The estimated annual cost for maintaining on-site septic tanks is shown below.

CED Septic Tanks	Annual Maintenance Cost
Depreciation of de-sludging equipment	$5,000
Annual cost of de-sludging (varies with number of houses, e.g. 5/10 houses per year)	$4,000/$2,000
Inspection 1 day per month	$3,000
Structures maintenance	$10,000/$5,000
Total (population > 300)	**$22,000**
Total (population < 300)	**$15,000**

Typical lifetimes for centralised sewage schemes were estimated by SKM (1997) to be around 50 years.

It is apparent that more information is needed in the area of detailed economic evaluation and that a study based on life cycle costing for centralised sewage systems is needed. Such an evaluation would provide important data for planning and funding agencies.

Construction

Construction of centralised sewage systems in remote communities in all states and the NT is contracted out to private firms. State program managers (Ove Arup & Partners in the NT and Qld; PPK Environment & Infrastructure in WA and SA) oversee all current sewage system installations under the ATSIC HIPP/NAHS program. It is the program managers who are contractually responsible for providing systems that meet quality assurance standards. The NT Power and Water Authority, which is responsible for system maintenance after installation in the NT has indicated that it is moving toward introducing the requirement for construction firms to run in-pipe cameras through the entire sewerage system before commissioning to ensure systems are constructed to required standards[38].

Maintenance

In WA, NT and SA the maintenance of centralised sewage infrastructure is separated into two areas. Maintenance of infrastructure within property boundaries (leaking taps, blocked toilets, pump-out of CED septic tanks) is the responsibility of community councils and is generally undertaken by community plumbers, environmental health workers, CDEP teams or others. Maintenance of centralised infrastructure is the responsibility of state government bodies and is generally undertaken by Essential Services Officers (ESOs) funded by state government grants to community councils. This sharp differentiation of responsibilities appears to have been detrimental to system performance in many communities, especially where community councils do not undertake the necessary level of maintenance. The lack of maintenance results in significant clean water inflows and inappropriate solids inflows to centralised systems (as detailed elsewhere). In Qld all maintenance

[38]Pers comm. Robert Decet, water operations coordinator, Aboriginal Essential Services, Power & Water Authority. 11 May 98

responsibilities currently lie with individual DOGIT communities and are undertaken by community plumbers, water officers or others within the community. The Dept of Natural Resources in that state provides some assistance if emergency breakdowns occur[39].

Maintenance of centralised sewage system infrastructure is generally conducted at three levels: regular monitoring, routine maintenance and breakdown maintenance. Regular monitoring generally involves the (daily) checking of pump station function, clearing of screens and basic maintenance of lagoons and is generally conducted by an Essential Services Officer or equivalent. Communities have indicated different ESOs perform these roles with varying diligence. Routine maintenance generally involves the periodic (monthly to quarterly) servicing of pumps and pump station infrastructure by specialist personnel who visit communities specifically to undertake the tasks. Breakdown maintenance is generally conducted either by the ESO if possible, or by specialist personnel mobilised specifically to undertake repairs. Different states have different arrangements for these three levels of maintenance.

In **Western Australia**, new arrangements for maintenance of centralised sewage systems were introduced in July 1998. Three "Regional Service Providers" (RSPs) now undertake routine maintenance works in the three remote regions of WA (Goldfields/Central Reserves, Gascoyne/Pilbara and Kimberlies) under the "Remote Area Essential Services Program" (RAESP). This program has replaced state-wide maintenance works previously contracted out to the WA Water Corporation. All RSPs are private contractors who report to a state contracted program manager (in this case Ove Arup & Partners) who ensure works are conducted to an appropriate level. The new corporate arrangement is designed to provide better value for money for the Aboriginal Affairs Department (& ATSIC) than previous government contracts and to encourage greater participation by Indigenous people in the maintenance of infrastructure. RSPs are paid a lump sum fee for planned maintenance and a schedule of rates to cover unplanned maintenance or breakdown. Regular maintenance on communities continues to be undertaken by community-based ESOs funded by AAD grants to community councils.

In the **Northern Territory**, regular maintenance is conducted by ESOs funded by Power and Water Authority (PAWA) grants to individual community councils. PAWA personnel or PAWA subcontractors conduct routine maintenance approximately twice yearly. Emergency maintenance is undertaken by either the ESO if possible, or by PAWA or a PAWA subcontractor[40]. PAWA is slowly undertaking a program of pressure cleaning sewerage mains and running cameras through the pipes to determine conditions of pipes, joins, seals, etc. Clean out is expensive, with the system at Papunya recently costing $30,000[41]. PAWA stressed that maintenance of remote community sewage systems was expensive and there were no funds collected from communities to assist with the task. The Aboriginal Essential Services division of PAWA is thus currently heavily subsidised by other sections of the organisation. PAWA also indicated that as the organisation moves towards

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39 Pers comm. Duncan Wallace, Engineer, Dept of Natural Resources, Cairns Qld. 14th October 98

40 Pers comm. Allan Ogden. Manager, rural operation, Southern Region, Power and Water Authority, NT. 20 July 98.

41 Pers comm. Robert Decet, water operations coordinator, Indigenous Essential Services, Power & Water Authority. 11 May 98

corporatisation, that they may seek to re-examine their relationship with Indigenous communities[42].

In **South Australia**, regular maintenance is conducted by ESOs funded by Division of State Aboriginal Affairs (DoSAA) grants to individual community councils. DoSAA or DoSAA subcontractors conduct routine maintenance. Emergency maintenance is undertaken by either the ESO if possible, or by DoSAA or a DoSAA subcontractor. For long term maintenance of CED systems, DoSAA flushes CED pipe networks every five years or so, but hopes to reduce this to a 2-3 year flush program[43]. Lagoons require desludging every 2-3 years. For pump-out of CED septic tanks in the AP Lands, AP Services undertakes all pump-outs on all AP communities with CED systems. This appears to be a successful arrangement in ensuring all tanks are pumped out on a regular basis (annually) and that pump-out equipment is used to its maximum capacity and receives the servicing it requires.

In **Queensland**, the state government currently has limited direct involvement in the maintenance of essential services on DOGIT communities. DOGIT communities are treated the same as all other Queensland local government organisations, and are meant to charge council rates to fund maintenance of infrastructure. Since few rates or levies are currently collected on DOGIT communities, communities must find other funding arrangements. Most DOGIT communities employ community plumbers or water officers to undertake all maintenance of water and sewerage infrastructure (inside and outside of property boundaries). These are funded by a general community grant provided by the Department of Aboriginal and Torres Strait Islander Policy and Development (previously referred to as the Department of Family Services). The function of DOGIT sewage systems appears to have been declining as a result of these ad hoc arrangements and many of the HIPP/NAHS projects in Queensland are needed to upgrade existing systems to restore proper function. The Department of Natural Resources currently provides some technical advice to DOGIT communities for maintenance issues, and has a small amount of funding to undertake breakdown maintenance in emergencies[44]. As mentioned the Department of Aboriginal and Torres Strait Islander Policy and Development (DATSIP) and the Aboriginal Co-ordinating Council (ACC) have recently announced a pilot maintenance program to be conducted on four DOGIT communities over three years to educate community residents and councils in the holistic maintenance of all community infrastructure[45]. Other DOGIT communities are not earmarked to receive any state government assistance for the duration of the pilot program.

Alternative systems

Only three alternative centralised sewage systems were identified in remote communities during this survey. These were a septic tank effluent pump (STEP) system at Peppimernati, NT, a vacuum sewerage system at Kupungarri, WA and a

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[42] Pers comm. Allan Ogden. Manager, rural operation, Southern Region, Power and Water Authority, NT. 20 July 98.

[43] Pers comm. Harry Vosnakis, senior project officer, Essential Services Team, Division of State Aboriginal Affairs. 16 July 98.

[44] Pers comm. Kate Vasey, Senior Program Development Officer. Aboriginal and Torres Strait Islander Infrastructure Program, Department fo Aboriginal and Torres Strait Islander Policy Development, Qld. 21 July 98.

[45] Pers comm. Kate Vasey, Senior Program Development Officer. Aboriginal and Torres Strait Islander Infrastructure Program, Department fo Aboriginal and Torres Strait Islander Policy Development, Qld.. 21 July 98.

trickling filter treatment plant at Palm Island, Qld. The lack of alternative systems seemed to indicate that the two common centralised systems might be adequately managing wastewater on communities at present. The main change that may affect remote communities in future is potential regulatory requirements that stipulate that effluent must be treated to tertiary levels before discharge to the environment. This change would require more sophisticated treatment than present effluent lagoons can provide. A brief description of alternative sewerage pipe systems and treatment systems is given below, and Australian suppliers of systems are listed in Appendix A.

Variable Grade Sewers

Variable grade sewers (VGS) are a variation of CED schemes but differ in that VGS permit positive and negative pipe grades, which follow the topography of the area. Consequently some sections of the pipe system are permanently full of septic tank effluent. VGS are usually cheaper than CED systems because excavations are less, but there is an increased risk of blockages caused by solids accumulating in low points of the pipe system. VGS have performed well in the USA but would potentially have significant problems in Indigenous communities because of excess solids entering the reticulated pipe system from poorly maintained septic tanks and uncovered manholes. No VGS systems are known to be currently installed in Indigenous communities.

Septic Tank Effluent Pumping (STEP)

STEP systems are also a version of CED systems. In this variation septic tank effluent drains to a sump, usually at each household or group of households, and is pumped to a small diameter pressure pipe system, which transfers the effluent to a treatment facility. Pump operating costs are generally low, but they require servicing and parts replacement periodically, which may not happen on many remote Indigenous communities at present. Each house also needs a reliable power supply to run pumps. A STEP system is presently used at Peppimernati, in the NT. Indications are that it generally works satisfactorily but there have been some problems with solids clogging septic tanks and pump rotors[46].

Grinder Pumps

Individual household grinder pumps macerate all wastes and convey the material under pressure through small diameter pipes to a central treatment facility. Septic tanks are not required. Grinder pump systems have the same advantages as STEP systems such as small diameter pipes, shallow depth and are ideal for undulating topography and suited to areas with high rock levels or groundwater. Hybrid systems are used in New Zealand, pumping macerated sewage from residential pockets to conventional systems. No grinder pump systems are known to be installed on remote Indigenous communities, and potential problems may occur if excess solids are flushed down toilets or power supplies fail.

Vacuum Systems

In this novel system individual household wastewater drains to a holding tank. The wastewater is periodically sucked from the tank into a reticulated pipe system under

[46] Pers comm. Bill McLennan, Essential Services Officer, Peppimernati, NT. 17 October 98.

vacuum pressure. The vacuum is created at a central collection station, which means power is not required at each household. If the pipes are damaged the vacuum is lost and repairs must be quickly effected. Vacuum systems have similar advantages to STEP and grinder pump systems, namely small diameter pipes, the ability to follow topography and to curve around obstacles. No manholes are required in this type of system. A vacuum system was installed at Kupungarri, WA in October 1997. The supplier currently maintains the system, and maintenance is expected to be handed over to the regional service provider in late 1998. Indications are that the system had significant start-up problems and these are only now being overcome[47]. The long-term performance of the system remains to be seen, although past problems with vacuum systems have been frequent blockages due to introduction of large solids (a common problem in remote communities), and faulty seals at plumbing fixtures and pipe joints.

Hybrid Systems

Hybrid schemes integrate different of types of sewage systems into one scheme. For example a full sewage scheme could service much of a community, while an outlying area may have a CED system connecting into the FS system. Other houses may retain on-site septic tanks and absorption trenches. Hybrid options may mean different maintenance regimes are required for different parts of the system, which puts extra pressure on maintenance personnel and potentially requires different maintenance equipment. No hybrid systems are known from remote Indigenous communities.

Oxidation ditches

Oxidation ditches are a treatment process using concrete lined ditches or tanks with aeration equipment to introduce oxygen to wastewater thus speeding the treatment process. Generally activated sludge/extended aeration processes are used and a high quality secondary effluent (good BOD, high SS removal and some nitrogen removal) can be achieved with a hydraulic retention time of around 24 hours. Phosphorus reduction can also be achieved by chemical dosing if required. The ditches require fairly active management by skilled personnel, which may prove problematic on many remote Indigenous communities where ESO turn-over is often quite high. The process also consumes significant electrical power.

Package treatment plants

These treatment plants are usually fabricated steel structures using either an activated sludge/extended aeration process, rotating biological contactor process or intermittent decant extended aeration process to treat wastewater. With good operator attention these systems can achieve good effluent qualities for BOD and SS, but require additional chemical dosing for nutrient removal. This type of system requires skilled operating personnel and requires power and chemical inputs. This level of skill may not be achieved consistently on remote communities. Buffer distances to housing and water bodie are significantly less than for effluent lagoons because the aerobic mode of operation significantly reduces odours, and only a small land area is required to house the system.

[47] Pers comm. Tony xx, community advisor, Kupungarri, WA. 11 August 98.

Constructed wetlands

Constructed wetlands are generally used to 'polish' effluent overflowing from treatment lagoons, and may provide a good low-technology option for remote communities if additional treatment is necessary. Wetlands are constructed so that effluent flows evenly through the whole wetland where reductions in BOD, SS, nutrients and pathogens occur. Once established the system requires little maintenance. In remote communities, people may be tempted to hunt and gather bush-food and animals from a constructed wetland, which may provide health risks. No constructed wetlands are currently known to exist in remote Indigenous communities.

Irrigation Re-use

Irrigation re-use of lagoon effluent is becoming increasingly common in non-Indigenous towns of Australia, and thus may provide a viable option to dispose of effluent and create employment opportunities in Indigenous communities. Secondary treated effluent contains significant nutrients which can be used for growing vegetation. Effluent re-use schemes already operate in many areas in Australia to grow cabinet timber trees, firewood, fruit trees, grain crops, vegetable plots and to irrigate sports fields, tree belts and open spaces. Only three remote Indigenous communities were identified by this survey to be re-using lagoon effluent for irrigation purposes. Fregon, Neppabunna and Ernabella in South Australia provide basic filtration and chlorination of lagoon effluent, which is used to drip irrigate a wood lot for firewood at Ernabella and shade trees around Fregon and Neppabunna. Essential Services Officers maintain these systems. It was indicated that re-use schemes were only instigated because of high water use in those communities and a need to deal with significant lagoon overflows[48]. The Ernabella wood lot is set-up as a rotating wood lot where trees are irrigated until they become self-sufficient and then a new section of trees is planted and irrigated. No firewood has been harvested to date from this scheme.

Dual Reticulation Systems

Dual reticulation systems can return treated effluent to the community for re-use. Two pipe systems are used, one to convey fresh water into houses for drinking, cooking and washing, and another to convey treated (& disinfected) effluent for toilet flushing, yard use and open space irrigation. Such systems have been installed in a few mainstream communities around Australia, but have been found to be very expensive to install, especially where the community already exists and pipes need to be laid around existing infrastructure. Treated effluent needs to consistently meet strict standards to ensure it does not present a health hazard to residents, and so the treatment facilities need to be strictly managed by skilled personnel. This level of management is not present or affordable on remote communities at present, and dual reticulation systems are unlikely to be installed as a result.

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[48]Pers comm. Grant MacLean. Team leader, Essential Services group, Division of State Aboriginal Affairs. 16 July 98

Section 4: On-site Sewage Systems

System types

Common systems

Two main types of on-site sewage systems were found to be used in remote communities, namely septic systems and pit toilet systems. **Septic systems** dispose of wastewater from waterborne flush toilets and other bathroom, laundry and kitchen infrastructure. Wastewater and solids flow into a septic tank, which is usually located in the yard adjacent to the house. The septic tank is, as the name implies a large tank and is designed to capture solids and treat the waste by anaerobic (septic) microbial action. Clarified effluent overflows from the septic tank to underground absorption trenches where it either soaks into the soil or is taken up by vegetation over the trenches. The clarified effluent is high in bacterial content and must be kept separated from people. **Pit toilet systems** on the other hand are dry systems that deposit the excreta in an excavated pit beneath the toilet room. Pit toilets are generally located away from the house. Often the pit is ventilated to reduce odour and fly problems. Wastewater from other areas of the house (grey-water) is either informally managed or managed in a grey-water-only septic system.

Present use

Current situation

The survey found that on-site sewage systems service some 30,000 people in over 830 remote Indigenous communities of WA, NT, SA and Qld. This usage amounts to serving around 38% of the total remote community population. It is also likely that most communities that were identified with 'not determined' sewage systems also used on-site sewage systems. Table 7 shows a state-by-state summary of communities using on-site sewage systems.

Table: 7

Number of communities

Sewage System	WA	NT	SA	Qld	Total
Septic tank	150	292	15	63	520
Pit toilet	26	209	58	18	311
Total	176	501	73	81	831

A comparison of the percentage of people using each on-site system shows 81% used septic systems and only 19% used pit toilet systems. The survey found that this break-up was because all medium to large communities, which are serviced by on-site sewage systems, used septic systems. It was only on smaller communities and on outstations that pit toilet systems were used as the primary sewage system.

Table 7 shows a distinct difference, however, in on-site system preferences between the states surveyed. WA and Qld mostly used septic systems while the NT had similar numbers of communities with septic systems and pit toilet systems. SA had more communities using pit toilet systems. These differences reflect a greater number of small communities in the NT and SA, plus deliberate policies in the NT and SA for many outstations to retain pit toilet systems.

Preference for septic tank systems

There was a strong preference found for septic systems, more particularly for flush toilets over dry toilet systems. This preference seemed to reflect the aspiration of remote community populations to use the same technologies as other people in Australia. During the course of the survey it was remarked several times by Indigenous people that flush toilets are 'proper toilets' and that pit toilets are regarded as 'bush toilets'. The reasons given for this preference seemed to include practical as well as social/cultural reasons. For instance one reason given was that flush toilets are usually located within the main house, making them more convenient to use than pit toilets which are generally located away from the house. Another reason seemed to be that many pit toilets were not well designed and had associated fly and odour problems.

Use of pit toilet systems

Where pit toilet systems were used in the smaller communities and outstations the acceptance was found to be confined to specific regions. Two categories emerged, the first category of outstations deliberately chose to use pit toilets because of the lower maintenance requirements over septic systems. These outstations were found mainly in the "top end" of the NT and in the AP Lands of northern SA. In the top end, nine of thirteen major outstation resource centres, servicing approximately 154 of 200 outstations, had a policy of using only ventilated improved pit (VIP) toilets. In contrast, throughout the remainder of the NT, sixteen of the eighteen major outstation resource centres used septic systems in at least some outstations, and those contacted indicated no distinct policy on the type of on-site sewage system used. This difference may reflect the longer history of outstation development in the top end, and particularly in Arnhem Land. In the Pitjantjatjara lands 58 of 68 outstations with on-site systems use VIP pit toilets in preference to septic systems. Pit toilets in both regions seemed to be generally accepted because they were well designed and constructed and were generally reported to be clean, odour-free and fly-free.

The second category of outstations seemed to regard pit toilets as an interim technology to be used only until septic systems were installed. On Cape York Peninsula in Queensland, where outstation development is only now beginning to receive institutional support, many outstations only had access to basic unventilated pit toilets. These basic systems were reported to have significant problems with regards to odour and flies. In these cases it is not surprising that people aspired to more familiar septic tank systems.

Communities with no sewage systems

47 communities (1% of the remote population) were identified to have no formal sanitation system. Most communities in this category were small outstations. It is likely these communities would gain septic tank flush toilets or pit toilets in future if not abandoned.

Grey-water and yard-tap wastewater

It was regularly reported that in communities where older pit toilet systems were in use there were no formal grey-water disposal systems. In such situations the grey-water generally was allowed to run onto the open ground, into vegetation beds, swales or into basic soakage pits. Perhaps more importantly, in many outstations yard taps were reported to be commonly used for washing adults, children & clothes and for preparing food. It might be noted here that there are no state regulations controlling disposal of yard tap wastewater. As an indication of the health problems that this situation may present, it was reported by the Kalumburu community Health Clinic registered nurse in WA that hookworm was an ongoing problem in the community. The perpetuation of this disease was thought to be because hookworm was harboured in moist soil around yard taps and failing wastewater systems in the dry season. The parasite then spreads through community soils in the wet season where it enters people bodies through their feet[49].

Future trends

Future trends in on-site sewage system use can be considered in terms of community size.

Large communities

For larger communities in all states and the NT there is a general trend to convert from on-site septic systems to centralised sewage schemes. As mentioned in the previous section, this trend was mainly due to repeated instances of on-site system failures and continuing health problems in remote communities using on-site systems. Of ninety-one large communities in WA, NT, SA and Qld with populations greater than 200 people, sixty-seven (74%) have centralised sewage systems, and eight more, giving a total of 82%, are earmarked for HIPP/NAHS conversions from on-site to centralised systems. State agencies indicate other large communities using on-site systems are likely be converted to centralised systems as future funding permits. The centralised systems, however, are expensive to install (see previous section) and there is some indication that state governments now appear to be re-examining the option of retaining on-site systems in larger communities. In 1997 the NT Government commissioned a study to examine whether poorly functioning septic systems on medium to large communities could be upgraded to provide healthy function. This study by Sinclair Knight Merz (SKM) entitled "*The condition and suitability of existing septic tank/absorption trench systems on 15 Northern Territory Indigenous communities*" recommended that four of nine communities with a population over 200 could retain on-site systems if upgrades were implemented.

Medium sized communities

Most medium sized communities seem likely to retain the use of on-site systems into the near future unless populations increase significantly or existing site conditions are shown to be totally inappropriate for healthy on-site sewage disposal. The high cost of installing centralised sewage systems in medium and small remote communities would make the centralised option prohibitive unless mitigating circumstances

[49] Pers comm. Nigel Jefford, registered nurse, Kalumburu Health Clinic, WA in 1994-5.

applied. The SKM study of NT communities recommended all six communities with populations between 50 and 200 people should retain on-site septic systems.

Small communities

Most small communities and outstations seem certain to continue to use on-site sewage systems into the future because of the appropriate scale and cost of the systems for the circumstances prevailing. The survey found many communities are moving progressively from pit toilet systems to septic systems as funding allows. Very few communities indicated a desire to move in the other direction i.e. replacing existing septic systems with pit toilets. As mentioned this tendency seemed to be part of the political/social aspiration to have 'proper toilets'. Several smaller communities and outstations were identified to have both flush toilets and pit toilets at individual houses. A survey in Pipalyatjara in SA (Pholeros et at, 1993) found that in such situations people preferred to use the flush toilet and mainly used the pit toilet for disposing of nappies, rags etc. However, when the house population exceeded approximately 12 to 15 people, the pit toilet began to be used regularly as a second toilet. The pit toilet was also used in cases of failure of the flush toilet.

Operational Experience

Sources of information

In the course of the survey, operational experience with regard to on-site sewage systems in remote communities was obtained from a variety of sources including published reports, State agencies, water authorities, contractors, regional service providers and community & outstation personnel (advisers, ESOs, plumbers, environmental health workers, residents). Operational information obtained from published field surveys of on-site systems in NT, SA and Qld communities has provided some indication of problems with system hardware (Sinclair Knight & Merz 1997; Lange Dames & Campbell 1994; Pholeros et al 1993; CAT 1997; NHC 1987, Khalife et al 1997). These indications were supplemented with telephone surveys of community personnel. There were, however, few published references found to detail the reasons why the management of sewage systems failed. Poor sewage system management has often been touted as a major impediment to proper system function. It is felt that field information should be gathered in this regard.

General performance of systems

Telephone information obtained from community personnel responsible for system maintenance tended to suggest that the adequate performance of septic systems was higher than that found by the small number of field studies. As mentioned in this report there is other evidence to suggest that informal requests for information from people involved with community infrastructure tend to overestimate the functionality of that infrastructure.

A survey of 16 NT communities by Lange, Dames & Campbell in 1993/94 indicated that only six communities (or 37%) had all septic systems performing satisfactorily at the time of surveys. Other communities ranged from 33% to 95% of septic systems functioning satisfactorily (without visible failures) because of various factors.

The HH study at Pipalyatjara (1992-93) with reference to on-site septic systems suggested that:

> "These in-ground, usually unseen services, *consume more maintenance resources than any other part of the house or yard.*" Their italics.

A HH study at Pormpuraaw in northern Queensland in 1996 found that only 54% of the houses had access to a working toilet and only 32% had the ability to properly dispose of wastewater from the houses, before a repair program was implemented (CAT 1997). A similar study undertaken by CAT at Kintore in the NT, in 1997, found that only 50% of houses had access to a working toilet before a repair program was put in place (CAT 1998).

No formal studies conducted on the performance of pit toilet systems in remote communities were located, but general indications from this survey were that pit toilet systems were able to provide satisfactory sanitation performance with little maintenance and minimal system failures.

Problems with on-site systems

A number of sources indicated widespread and on-going problems with on-site septic systems but few problems with pit toilet systems. However, as mentioned, pit toilets suffered severe image problems and additionally tended to be treated with suspicion by both local government bodies and environmental protection agencies.

The list of reasons given for problems with on-site systems is given below; each problem area is then discussed in more detail.

Septic systems

- blocked flush toilets due to inappropriate use
- leaking taps and taps left running which saturate and overflow absorption trenches
- septic tanks filling with solids due to irregular pump-out, allowing additional solids to wash through and clog absorption trenches
- poor initial construction of indoor wet areas, drainage lines, septic tanks and absorption trenches
- undersizing of septic tanks and absorption trenches
- poor siting of systems allowing vehicle damage or restricted access for maintenance
- use in inappropriate site conditions including non-absorbing soils (clays), rocky ground and high water tables
- irregular maintenance of all aspects of septic systems, particularly leaks, repairing damaged access points and septic tank pump-outs
- in some cases, high use of detergents, disinfectants and antibiotics

Pit toilet systems

- poor image of pit toilets
- not acceptable to some local government agencies and environmental protection agencies
- inadequate disposal of grey-water where pit toilets are used

Blocked flush toilets

Again flush toilets were seen to be the weak point in the system. The issues surrounding blocked flush toilets in houses with on-site sewage systems were found to be the same as for houses connected to centralised sewage systems. The reader is therefore referred to that section.

Leaking toilets & taps

Leaking toilets & taps or taps left running were again reported as a significant problem in many communities using on-site septic tank systems. The same comments regarding the waste of water therefore apply here as for the centralised systems. The more serious problem for on-site systems is the increased likelihood of decreased detention time in the septic tank and saturation of the absorption trenches leading to pooling of effluent in yards.

Septic tanks filling with solids

On many communities it was suggested that solids are washed through poorly maintained or undersized septic tanks into absorption trenches where they clog the soil interface resulting in trench failure. This problem often results from septic tanks not being regularly pumped out. Most communities contacted reported lack of regular pump outs of tanks. A "Housing for Health" survey of Pormpuraaw, Qld (600 inhabitants) undertaken by CAT in 1996 found many septic tanks were totally filled with solids and were the prime reason why septic systems were failing (CAT 1997). In this case the clogged tanks had to be dug out by hand to restore function.

Two obvious reasons were identified for a lack of pump outs, either no appropriate equipment being available or poor (or no) scheduling of equipment if it was available. The 1997 WA EHN survey indicated that of 147 WA remote communities using septic systems only 51 (35%) reported access to septic tank pump-out equipment. Pump out equipment was generally contained on purpose-built trucks or on special trailers. Another option found was portable pumps and a separate cartage tank for the effluent. One community reported solids were pumped onto the ground in corners of yards! An obvious serious health risk for house occupants and others.

However, even if the appropriate pump out equipment was available the overwhelming majority of communities with such equipment were found not to have regular pump out schedules for septic tanks[50]. It is generally accepted that with "normal" use septic tanks should be pumped out every one to two years to stop build-up of solids, however, only a handful of communities reported this type of pump out schedule. Most communities indicated that a septic tank was only pumped out when the septic system visibly failed. Some communities reported that they had pump out equipment, but it was generally being used for emergency work and was not available for scheduled pump out programs. There was evidence to suggest that emergency pump outs were commonplace due to poorly constructed or inappropriately used systems. Many older septic tanks seem to have been buried without accessible inspection points or pump out openings thus making pump out impossible until remedial work was done to the pipe-work.

[50] Several communities reported that pump out equipment was broken down due to a lack of maintenance

Poor construction

Poor initial construction of on-site systems was one of the major problems reported to this study by sources from all states and the NT.

Examples of poor initial construction that were cited were numerous and included:

- toilet pans not secured to the floor,
- internal wet area floors not sloping to floor drains,
- undersized or inadequate floor drains and drainage pipes,
- no overflow relief gullies installed,
- excessive bends in drainage lines,
- drainage lines which ran uphill or had inadequate grades,
- inadequate inspection openings in drainage lines,
- drainage lines not buried deeply enough and damaged by vehicles,
- kitchen drainage lines too long (allowing greases to congeal),
- construction debris left in drainage lines,
- installation of already damaged septic tanks,
- no inspection openings provided on septic tanks,
- septic tanks totally buried and often non locatable without considerable search effort,
- inadequate cover slabs on septic tanks,
- absorption trenches not installed at all,
- no aggregate used in absorption trenches or wrong grades used.

All of these problems have been documented in several reports (SKM 1997; LD&C 1994; NHC 1987; Pholeros et al 1993; CAT 1997). One of the main difficulties with on-site septic systems is the obvious problem that much of the construction is buried underground and thus poor (or absent work) is difficult to identify. In many cases, systems were reported to fail as soon as people began to use them, and in other cases very high maintenance resources were sunk into poorly constructed systems to keep them intermittently functioning. Ngaanyatjarra Services, the group that services central desert communities of WA, indicated that most septic systems with ongoing maintenance problems were generally found to be poorly installed. When the original problems were rectified, maintenance requirements dropped dramatically[51]. Detailed examination of septic systems in the Pitjantjatjara Lands, SA and Pormpuraaw, Qld (NHC 1987; Pholeros et al 1993; CAT 1997) showed significant minor installation flaws which caused septic systems to fail under the high use conditions often experienced.

Both government and community sources indicated that poor construction was more of a problem prior to five years ago and has improved in recent years because of more stringent inspection of installations. All still acknowledge, however, that poorly constructed systems continue to be installed.

Undersizing

Undersized septic tanks and absorption trenches were reported as a frequent problem in communities across all states and the NT, particularly for systems greater

[51] Pers comm. Des White, building supervisor, Ngaanyatjarra Services, Alice Springs. 17 July 98.

than five years old. Undersizing relates to the inability of the system to cope with wastewater loads generated from the house, and is generally the result of small capacity septic tanks, small capacity absorption trenches, high populations and/or leaking/running taps.

A survey by Sinclair Knight & Merz in 1997 of fifteen NT communities with septic systems concluded that septic tanks with capacities less than 3,000 L were very prone to failure under normal use conditions. That survey and others by Lange Dames & Campbell 1994 and CAT 1997 found many septic tanks in NT and Qld communities were around 2,500 L in capacity. The CAT survey in Pormpuraaw found that most absorption trenches were 10 to 12 metres long instead of the minimum length of 20 metres as specified by the Qld code.

High average household populations in communities have been recorded by several surveys (UPK 1987; Pholeros et al 1993; CAT 1997; LD&C 1994). The survey by Lange, Dames & Campbell in 1994 indicated a direct link between house populations and higher rates of malfunctioning septic systems. Of fifteen communities surveyed, eight communities had house populations of 3.1 to 4.6 people per bedroom and averaged 22% septic system malfunction rate, while the remaining seven communities had populations of 2.0 to 2.8 per bedroom and averaged 4% failure rates. Pholeros et al (1993) found that high population movement between houses at Pipalyatjara, SA put pressure unevenly on septic systems.

The main reason for small capacity tank systems emerged that old state codes allowed smaller systems in the past that may have been appropriate for non-Indigenous households but have now been shown to fail under normal use conditions in Indigenous communities. For instance early NT regulations specified 2,500 L septic tanks for all houses until 1989, when it was changed to 4,000 L. Then in 1996 a new code was formulated which specifies various capacity split systems based on house size (e.g. three bedroom houses requires both a 4,000 L sullage tank and 3,000 L sewage tank)[52]. Recommended sizes in other states are presently around the 3,000L mark. The regulations pertaining to various states and the NT are discussed in a later section below.

The survey also identified several larger communities where individual household lot sizes were too small to accommodate adequately sized absorption trenches as specified by current codes. This problem was particularly acute in areas where soil conditions were marginal for absorption of effluent (e.g. Coen, Qld as identified by Downs 1997).

Poor siting

It was commonly reported that poor siting of septic tanks and trenches caused system failures. Poor siting generally related to vehicles being able to access and damage tanks or trenches, or sites that could not be easily accessed by pump out trucks when required.

Evidence of poor siting was obtained from published reports and from telephone conversations. Lange, Dames & Campbell (1994) examined septic systems on 16 NT communities, and noted instances of septic tanks within two metres of front

[52] The new NT code is to be legislated in 1998

entrances to houses, septic tanks located in driveways and absorption trenches located in trafficable areas. In many cases they found that vehicles had damaged septic tanks and pipe-work. The older fibreglass tanks were particularly prone to this sort of damage. Such tanks are now rarely installed in communities because of these problems. Heavy machinery, which is used to clean up yards and remove rubbish (e.g. bobcats and trucks), were also reported to commonly damage septic tank cover slabs and inspection openings. Trenches were found to be damaged by vehicles caving in trench tunnels or compacting the soil, which reduces its absorption capacity. It was quite commonly reported that pump out trucks have to drive over absorption trenches to access septic tanks. Many communities indicated that house lot sizes were too small to allow appropriate siting of tanks or trenches (e.g. Downs 1997).

Inappropriate site conditions

Inappropriate site conditions for on-site sewage systems were reported by a number of communities and included:

- soils with poor absorption ability (e.g. clays or black soil),
- rocky ground, high groundwater (often of a seasonal nature),
- poor site drainage,
- sandy soils containing potable aquifers,
- flood-prone areas, and
- communities where individual lot sizes were either too small to install absorption trenches or not suitable for other reasons.

Many communities suggested combinations of the above factors occurred. Mona Mona in Qld has clay soils and seasonal water tables close to the surface, making disposal of effluent in trenches very difficult[53]. Sinclair Knight Merz (1997) found eleven NT communities (of fifteen examined) were problematic for on-site sewage disposal because of one or a combination of the above problems. At Pormpuraaw, Qld, soils were found to be very sandy and effluent was potentially moving through to water supplies in a bore placed close to absorption trenches. In communities with high seasonal water tables, septic tanks have been known to float out of the ground.

Irregular Maintenance

Irregular maintenance of both community water supplies and wastewater disposal systems was identified as one of the main problem areas on communities contributing to septic system failures. In fact many of the problems discussed earlier are the result of a lack of adequate maintenance.

The Housing for Health survey of Pipalyatjara in 1993 by Pholeros et al (1994 p.80) examined the installation, use and maintenance of infrastructure in detail and made the following conclusions in relation to maintenance:

- house population has no relationship to the type or frequency of essential health maintenance.

[53] Pers comm. Stuart Downs, Project Engineer, Centre for Appropriate Technology, Cairns. 12 July 98.

- faults in all parts of the (wastewater systems) accounted for the major maintenance cost. This was true when calculated as a total cost to the community or as individual maintenance items.
- the majority of all maintenance work was not the result of misuse, overuse or poor design but rather the result of poor initial construction
- given appropriate design of health hardware, the maintenance of essential health hardware does not constitute a major maintenance cost.

High use of detergents, disinfectants and antibiotics

During the course of this survey, it was commonly stated in reports and suggested by community personnel that excessive use of bleaches, detergents, shampoos & other cleaning agents on communities and the extensive use of antibiotics by community residents, disrupt the biological processes in septic tanks. There has been little research to confirm or deny this suggestion, although limited research tends to suggest the affect may not be significant.

Pholeros et al (1993) measured the total consumption of detergent, shampoo and bleach in twelve houses at Pipalyatjara, SA and found a total average weekly consumption of 23.2 kg laundry detergent, 13.0 kg shampoo and 6.1 kg general cleaners (mainly bleach based). Because of population concentrations in a minority of houses, most of these cleaning agents were discharged into a handful of septic systems. A follow up study by Khalife et. al. (1997) at the same community in 1996 used a field laboratory to gauge the biological activity of wastewater through the septic system, and found indications that biological activity was similar to septic systems in non-Indigenous communities despite higher chemical use.

Poor image of pit toilets

Pit toilets were regarded by many remote Indigenous people as 'bush toilets' as distinct from flush toilets which were described as 'proper' toilets. Even in communities where ventilated pit toilets were known to work very well (e.g. Bawinanga outstations, Maningrida, NT) people suggested that they would prefer flush toilets[54].

There appeared to be several reasons for the poor image of pit toilets. The major reason that seemed to be put forward was in fact the image itself. People wanted to have flush toilet systems. These systems were perceived to be part of the image created of proper living that was centred on the larger Indigenous communities and large non-Indigenous towns. In addition to this social factor, there were several physical factors influencing the preference for flush toilets. Such factors as better toilet comfort and more convenient location. Other physical reasons given were that 'basic' unventilated pit toilets generally have strong odours and many flies in the toilet room.

Inadequate disposal of grey-water (including yard taps)

Inadequate disposal of grey-water was reported on many smaller communities and outstations particularly where the only sanitation infrastructure was pit toilets.

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[54] Pers comm. Conversations between the author of this study and Indigenous residents of Bawinanga outstations. 2 August 98.

Many outstation resource centres contacted by this study indicated that grey-water was not managed by any formal system and was generally allowed to run onto the open ground, into vegetation beds or into basic soakage pits. There seemed to be a general perception on many communities that grey-water was harmless. Several studies, including the one by Khalife et al in 1997 have shown stored grey-water to have similar concentrations of E-coli (bacteria) as black-water (sewage effluent). In Queensland, some communities were found to irrigate grey-water onto yards via sprinklers (as permitted by the current Qld. Code).

In addition to traditional (piped) grey-water sources many community yard taps create wastewater equivalent to grey-water. In some regions such as Arnhem Land in the NT, yard taps were found to be commonly used on outstations for washing adults, children & clothes and for preparing food[55]. Very few examples were found of formally managed yard tap wastewater.

Summary of the advantages and disadvantages of on-site systems

There seemed to be widespread agreement that on-site systems were more prone to failure than centralised systems. Both were seen to suffer from similar levels of inappropriate use within houses, but the part of centralised system infrastructure outside of individual properties was thought to perform better because of formal maintenance programs overseen by State government agencies. Although there were some notable exceptions, on-site systems in general suffered from a distinct lack of formal preventative maintenance programs. Another major disadvantage of on-site systems was that system failures resulted in effluent being exposed within the living environment. It was agreed that even one failing septic system had the potential to expose a considerable portion of the community to health risks. Small children were thought to be particularly at risk. There was also widespread evidence to suggest that septic systems had a far greater failure rate than pit toilet systems.

System	Advantages	Disadvantages
On-site systems	• less expensive than centralised systems • can be added incrementally as communities grow	• more prone to failure than centralised systems • one failing system can create health risks for whole community
Septic systems	• community people generally prefer flush toilets • simplest on-site system for managing waterborne wastes	• need reliable water supply • high ongoing maintenance requirements • high failure rate • often poorly constructed • infectious diseases remain active in wastewater for long periods • more expensive than pit toilet systems • not suitable on all sites (rocky, clays, high groundwater)

[55] Pers comm. Various Arnhem Land outstation resource centre personnel contacted during this survey.

System	Advantages	Disadvantages
Pit toilet systems	• pit toilet remains functional under most use conditions • less expensive than septic systems • pit toilet easily constructed by community members	• still requires a disposal system for grey-water • pit toilets regarded as 'bush toilets' by many people • pit toilet often located away from the house and not convenient

Funding sources

The installation cost of on-site sewage systems for new houses is factored into the budget for all new government funded housing in WA, NT, SA & Qld. These on-site systems must comply in all cases with relevant State or Territory regulatory Codes.

Where existing houses have inadequate sewage systems, the individual community or resource centre is responsible for upgrading or replacing each system. No specific Commonwealth or State/Territory government funding is provided for ongoing upgrade programs. There are however several current major NAHS funded septic upgrade programs scheduled in approximately thirty communities across the three states and the NT. Under these programs damaged or undersized septic tanks will also be replaced and inadequate absorption trenches will be remedied.

Recurrent maintenance funding for on-site septic systems is supposed to come from property owners or renters via rent collection or community levies. However, the majority of communities do not yet collect adequate funds to cover such maintenance. As a result, funds for intermittent or breakdown maintenance were often taken from other 'general revenue' community sources. ATSIC makes available limited CHIP funds for recurrent maintenance of housing infrastructure, including septic systems[56]. Improved collection of rents is hoped to provide adequate funding for septic maintenance, provided communities can devise adequate recurrent maintenance programs. AP Services indicated that rent collection currently averages around $800 per house per year for houses in the AP lands, with a further $1,700 per house contributed by ATSIC CHIP funding for housing maintenance. It was indicated that, in the AP lands, this amount has been sufficient to target safety and health aspects of houses[57].

Installation and maintenance costs

This survey identified no detailed analysis of installation and maintenance costs for on-site sewage systems in remote Indigenous communities. It is felt that such an analysis is important given the large sums of money invested into on-site sewage infrastructure by government funding agencies and individual communities, and to assist future planning of sewage management.

The installation cost of on-site systems varies considerably depending on the type of system installed (septic system or pit toilet system) and on various other factors which are discussed below.

56 Pers comm. Terry Mowles, Housing, Infrastructure and Health Policy division ATSIC, Canberra, 23rd July 98.
57 Pers comm. Stephi Rainow. Public Health Officer, Nganampa Health Council. 14 July 98.

Septic systems

For septic systems the main factors affecting cost are the:

- State & Territory Codes, which determine the tanks capacities; these are often different for similar household situations
- soil conditions which determine absorption trench lengths
- accessibility of aggregate for absorption trenches
- ease of site excavations
- remoteness of the community, which affects transport costs

Sinclair Knight & Merz (1997) provided an estimate of septic system installation costs in the NT. These costs varied from $7,700 to $20,700 depending on the details of the system configuration (the base was a three bedroom house in favourable soil conditions) details are shown below:

Table: 8

A single 4,000 L septic tank and approximately 40 m of plastic tunnel, absorption trench.

Item	Cost
Supply and install 4,000 L septic tank	$3,000
Supply and install aggregate	$1,700
Supply and install 40 m trench	$900
Supply and install concrete collar and s lab	$1,000
Supply and install AT protective fencing	$600
Locate and connect house drain	$500
Total	$7,700

Table: 9

A 4,000 L sullage tank and 3,000 L sewage tank and approximately 70 m of absorption trench

Item	Cost
Supply and install 4,000 L sullage tank	$3,000
Supply and install 3,000 L sewage tank	$2,000
Supply and install aggregate	$3,000
Supply and install 70 m	$1,500
Supply and install concrete collar and slab	$2,000
Supply and install AT protective fencing	$1,000
Locate and connect house drain	$700
Total	$13,200

Table: 10

A 4,000 L sullage tank and 3,000 L sewage tank and approximately 170 m of absorption trench

Item	Cost
Supply and install 4,000 L sullage tank	$3,000
Supply and install 3,000 L sewage tank	$2,000
Supply and install aggregate	$7,000
Supply and install 170 m trench	$4,500
Supply and install concrete collar and slab	$2,000
Supply and install AT protective fencing	$2,000
Locate and connect house drain	$700
Total	$20,700

Preliminary costs for a NAHS septic upgrade program in another state puts the cost of installing septic tanks and absorption trenches at around $12,000 per on-site sewage system. Thus we might take it that on-site septic systems would range in cost between $8,000 and $21,000 for remote locations depending on configuration with an average of around $12,000.

Estimated lifetimes for on-site septic systems appear to vary considerably. One estimate by SKM (1997) was that concrete septic tanks should have a 50-year life and absorption trenches a 10-year life.

Pit toilet systems

Code-approved pit toilet systems generally involve the construction of a pit toilet and installation of a grey-water septic system.

Many small communities and outstation resource centres reported constructing and installing their own pit toilets. Bawinanga Aboriginal Corporation, an outstation resource centre at Maningrida, Arnhem Land, NT costed their pit toilets at $3,500 for total construction and installation. The Centre for Appropriate Technology in Alice Springs sells a range of VIP pit toilet rooms for $1,600 to $3,200 ex workshop.

Grey-water septic systems have smaller septic tank capacities and shorter absorption trenches than all-waste septic systems. Actual sizes vary according to different state and Territory Codes. Installation costs will therefore vary accordingly.

As an example of comparative installation costs between septic systems and pit toilet systems, the cost of installing Code-approved on-site systems are given in table 11 below.

Table: 11

On-site System in NT	Cost
3,000L sewage tank & 4,000L sullage tank & 70 m trenches	$13,200
VIP Pit toilet 4,000L sullage tank & 40 m trenches Total	$3,500 $7,700 $11,200

Maintenance costs

The maintenance costs for on-site systems will vary considerably depending on the type of system installed, the type of maintenance regime in place, the quality of the original construction and many other factors. This study found few reports of estimated maintenance costs, and there is an obvious need to gather further information to aid future planning of on-site system maintenance.

Septic systems

Sinclair Knight Merz (1997) indicated typical annual maintenance costs for NT septic systems at $15,000 per annum for communities with less than 300 people and

$22,000 for communities with greater than 300 people. The costs are broken down as follows:

Table:12

Septic System	Annual Cost
Depreciation of desludging equipment	$5,000
Annual cost of desludging (will vary with the number of houses)	$4,000/$2,000
Inspection 1 day per month	$3,000
Structures maintenance	$10,000/$5,000
Total (population > 300)	**$22,000**
Total (population < 300)	**$15,000**

These estimates do not include in-house plumbing fixture maintenance, which is likely to be significant in many communities. They also do not consider the cost of replacing inadequate existing infrastructure, which would be a considerable total cost for most communities contacted by this study. Neither do they include the cost of emergency servicing of poorly constructed systems which continually fail.

At Amata, SA in 1994, maintenance costs over nine months were found to be $323 per house for in house plumbing: that is water in - waste out (NHC 1994).

Cost breakdowns were as follows:

- labour - plumber - average per house $148 (range $17-$630)
- water in - average materials per house $140 (range $17-$618)
- waste out average materials per house $35 (range $5-$180)

There is considerable evidence to suggest that the cost of maintaining on-site sewage systems is proportionately high compared to costs for the maintenance of other housing infrastructure. Housing for Health surveys of Pipalyatjara, SA (Pholeros et al 1993) and Pormpuraaw, Qld (CAT et al 1997) calculated comparative costs for repairs of basic housing infrastructure. These showed that relative repair costs for plumbing and septic systems were 31% (Pipalyatjara) and 41% (Pormpuraaw) of the total repair costs of the house. At Pipalyatjara, a further breakdown in figures showed that the comparative cost for essential health maintenance of houses resulted in plumbing and septic systems accounting for 71% of the total maintenance costs[58]. At Pipalyatjara, plumbing and septic system maintenance averaged $175 per house (range $10 - $2340) over a one year period.

Pit toilet systems

No indicative maintenance costs were identified by this study for pit toilet systems. Information gathered during this survey indicated that pit toilets require virtually no maintenance for several years until pits fill and the toilet needs to be relocated. Grey-water septic systems would be expected to require far less desludging than sewage septic systems because of reduced solids inflow, and blockage problems are potentially far less frequent when no flush toilet is involved. Hence on-going maintenance costs should be far lower for grey water only septic systems.

[58] Essential health maintenance repairs are those considered essential for the continued provision of safety and health in houses. This excludes repairs to the general fabric of the house and yard, such as stoves, concrete slabs, pressure water cleaning of houses.

Regulations

Regulations for in-house wet area fixtures and on-site disposal systems are set by the appropriate State and Territory organisations.

In-house fixtures

Wet area fixtures installed in new remote houses of WA, NT and SA must meet minimum specifications developed specifically for remote communities. In-house fixtures in the NT are regulated by new "Environmental Health Standards for Remote Communities in the NT", which specifies that four bedroom houses must have two showers/baths, two separate toilet rooms and all toilets must have hand washing facilities nearby. In SA, wet areas must be separated from other areas, either vertically or horizontally, and specific items such as vandal-proof tap handles must be fitted. WA is currently developing remote housing specifications. Qld currently has no specific standards for remote communities.

On-site sewage systems

Regulations for on-site sewage systems are set on a state-by-state basis; generally by health departments. Regulations control the specification of new systems and quality of construction, but do not monitor or regulate ongoing performance of systems. Only the NT has separate regulations for remote Indigenous communities.

Each state and the NT use similar broad principles for specifying and regulating on-site systems, based on two Australian Standards documents *AS/NZS 1546.1 - 1998 On-site domestic wastewater treatment units Part 1: septic tanks* and *AS 1547 - 1994 Disposal systems for effluent from domestic premises*. Each state and the NT have variations in size and configuration requirements. A revised and amended AS 1547 document is due for release in early 1999. The different codes and examples of relative system specifications are shown in Table 13.

Table: 13

State	Name of Code	Year Written	Author	Separate specifications for remote Indigenous communities	Septic tank volume for 3 br house	Absorption trench length for 3 br house*
WA	Health (Treatment of sewage and disposal of effluent and liquid waste) Regulations 1974 (as amended 29 July 1997)	1989 (for septic tank section)	Health Department of Western Australia	No	3,180	24
NT	Code of Practice for small on-site sewage and sullage treatment systems and the disposal or reuse of sewage effluent	1996	Territory Health Services	Yes	3,000 (sewage) 4,000 (sullage)	60
SA	Standard for the construction, installation and operation of septic systems in South Australia	1995	South Australian Health Commission	No	3,000 (combined)	30
Qld	Interim code of practice for on-site sewage facilities	1998	Department of Natural Resources	No	3,000 (combined)	30

* assuming sandy loam soils

Table 13 shows that the NT Code has separate large capacity specifications for remote communities, which differ from other NT on-site situations. This has been done to attempt to minimise the adverse impact of highly fluctuating house populations and lack of system maintenance on remote communities. The effectiveness of these NT systems will only be known after several years of operation. Territory Health Services (THS) reported significant initial resistance from service providers and community maintenance personnel to the larger systems when first introduced.

For pit toilet systems, all new government funded houses must include an approved grey-water disposal system with the pit toilet. This generally means a large sullage tank and associated absorption trench. The NT code includes a discrete section on approved grey-water systems. In SA, grey-water guidelines are being developed. In WA, draft grey-water reuse guidelines have been published, although these are directed more at non-Indigenous urban and rural reuse rather than on remote Indigenous communities (Health Dept of WA 1996)

Alternative system approvals

All state/Territory codes have provisions to allow trialling of alternative systems not approved by current codes. The provision generally involves installation and close monitoring of a system on one community before an assessment is made and wider approvals are granted if successful.

Some states have demonstrated a reluctance to allow particular systems to be trialled because of preconceived perceptions they will not work. The Health Department of WA refused to allow trials of aerated wastewater treatment systems (AWTSs) on remote communities because it felt that power supplies and maintenance practices were not reliable enough to guarantee proper function[59]. Similarly, the NT Territory Health Services refused for nine months to allow trials of a grey-water disposal/reuse system on Maningrida, NT outstations because of prior perceptions it would not work, despite anecdotal evidence to the contrary. In this case, however trials were finally approved and the systems are functioning well to date[60].

Yard taps are not covered by any State/Territory regulations, despite being used on many outstations for washing people & clothes, preparing food and cleaning utensils. It seems to be an area that warrants investigation by regulators.

Quality Control

All state and Territory codes have provisions to regulate the quality of systems constructed. Many communities in WA, NT and SA report that system installation has improved considerably in the past five years or so, due to more diligent inspection of new systems by regulators. However the significant number of poorly installed systems still identified in all states seems to attest to the inadequate enforcement of these regulations in many circumstances.
Each state and Territory currently has different mechanisms in place to control construction quality. In the AP Lands of SA, four organisations are certified to inspect

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[59] Pers comm. Barry Bowden, Environmental Health Officer, WA Health Department, 24th March 98
[60] The author of this study designed and sought approvals for the systems at Maningrida outstations.

installations. This is in recognition of logistical difficulties in attending construction sites when systems are ready for inspection. The particular organisations for the AP lands are the SA Health Commission, the Aboriginal Housing Unit, the AP Services building supervisor and the individual community ESO. In WA and until recently in the NT, health department environmental health officers are responsible for inspecting new installations. WA Health admitted that they do not get to inspect all systems before they are commissioned[61]. In the NT the inspection system did not seem to work well in the past because the THS was often not informed of new installations and they did not have enough personnel or funding to attend all construction sites[62]. The NT has now moved to allow self-certification of installations in remote communities by licensed and insured plumbing contractors. If a non-licensed contractor does the installation then an inspection fee of $400 applies. If work is found to be inadequate (and is not rectified) then the contractor would face an insurance claim and could be de-registered as a licensed NT plumber. It remains to be seen if this new NT system achieves its aim of properly installed on-site sewage systems. In Qld the new draft Code allows self-certification by contractors who will be regulated by individual local governments. This provision means DOGIT communities will have to regulate the quality of contractor work on their own communities; a provision which will depend heavily on the diligence and expertise of the community personnel overseeing construction.

Ongoing monitoring

There are currently no regulatory requirements in any of the states or the NT for on-site sewage systems to be regularly inspected for proper function and maintenance. This is left to individual communities to oversee. The draft Queensland code recommends two yearly inspections of septic tanks by local government or approved agents, but apparently does not enforce this recommendation.

Maintenance

Maintenance of on-site systems is generally the responsibility of individual communities or outstation resource centres. Maintenance of properly installed and utilised systems generally involves on-going leak repairs, regular septic tank pump-out (generally one to three year cycle), regular "rodding" of drainage lines from houses and clearing of absorption trench areas.

Many communities reported that there was inadequate maintenance of on-site sewage systems. The reasons for poor maintenance are discussed elsewhere, and seem to be part of a general lack of infrastructure maintenance on most communities.

On the other hand a small number of communities reported successful maintenance of on-site sewage systems. Septic tanks were pumped out annually, drainage lines were rodded approximately every year, leaks are reported and repaired promptly and systems generally functioned well as a result. It seemed that communities which had developed local service provider organisations for on-site sewage management, such as those developed by Pitjantjatjara communities with AP Services and Ngaanyatjarra communities with Ngaanyatjarra Services, were proving successful

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61 Pers comm. Barry Bowden, Environmental Health Officer, WA Health Department. 13th October 98

62 Pers comm. Chris Clark, Environmental Health Administrator, Territory Health Services, NT. 14 July 98.

with on-site sewage management. The success appeared to be because these types of organisations could concentrate on providing effective maintenance programs and effective use of equipment to several communities at once, rather than relying on limited personnel and equipment in individual communities to perform tasks.

Nearly every community reported that poorly installed septic systems were a major factor in ongoing maintenance requirements. Communities that had upgraded originally poorly installed systems reported far fewer maintenance requirements than prior to upgrades. A consequence of poorly sized, installed or utilised systems was the need to pump-out septic tanks; sometimes on a monthly, weekly (or even a daily) basis to stop overflow from the septic tank or absorption trenches. This concentration of effort is obviously a major drain on limited resources and personnel.

Most medium to large communities (and the larger outstation resource centres) employ personnel such as plumbers, water officers, general tradesmen, health workers or CDEP maintenance crews. One of their tasks is usually to maintain on-site sewage systems. It appeared in many communities that these personnel are so busy with emergency maintenance and other tasks that they have no time to develop or undertake recurrent maintenance programs. Smaller communities and outstation resource centres often relied on unskilled personnel to help maintain infrastructure. It was reported to this study that in several communities the community adviser undertook basic breakdown maintenance of equipment. In addition staff turnover was suggested to be very high in many communities. The turnover problem was thought to be detrimental to developing long-term strategies for maintenance of infrastructure.

Many communities reported that there were no local residents involved with the maintenance of on-site sewage infrastructure. Other communities reported significant local involvement, including community members undertaking plumbing apprenticeships to enable them to maintain community water and wastewater infrastructure. A few communities reported that there were trained local people in the community who were currently not involved with any community maintenance activities. Training programs for Indigenous people are offered in each state by TAFEs and other institutes for community members to receive infrastructure maintenance training, including septic system maintenance. It was apparent that strategies should continue to be developed that encourage community members to take a much greater role in the maintenance of community sewage infrastructure.

Alternative systems

Several alternative on-site sewage systems were identified by this study. Some have been trialled on remote Indigenous communities, while others are potentially applicable to communities but have not yet been trialled in such situations. Most of the identified alternative systems are manufactured in Australia, although few companies manufacture systems specifically for remote community applications. Each of the systems is discussed further below, including potential applicability of systems in remote communities, and potential/actual problems that may be encountered. Detailed descriptions of how each system works are not included here, but can be obtained from various publications such as Pickford 1985, Ludwig 1996, SCU 1996, VicDNRE 1997

Septic tank effluent filters

A recent innovation introduced to Australia from America in the mid 1990s is the septic tank effluent filter. The filter is a mesh tube or filter media located at the outlet of the septic tank, through which the effluent must pass before leaving the tank. Studies have shown the filter reduces the volume and size of suspended solids, which are washed from the septic tank which, reduces the chances of absorption trenches clogging. No effluent filters are known to have been trialled on remote communities at present, although a trial is soon to take place at Pipalyatjara community in SA[63]. The effluent filters are a passive technology requiring no power or chemical input, and can be retrofitted to existing septic tanks. One potential question mark over effluent filters is whether they continue to function well if large amounts of rubbish, plastic, nappies and/or newspaper enters the septic tank, as is often reported to occur. These may coat the effluent filter and stop effluent leaving the tank. Community trials of effluent filters seem well warranted, as they may be an important addition to septic tanks on remote communities to stop overflow of solids to absorption trenches.

Composting toilets

Composting toilets have been used in Australia for many years, particularly in National Parks and the homes of environmentally active people. Only a small number of composting toilets have been trialled on remote Indigenous communities, and indications are that they have had limited success, seemingly because of minor design problems and inappropriate use and maintenance by householders who have had no history of using such systems. Such systems have the potential to function well and may prove useful in communities where water is scarce or there are concerns that groundwater may be polluted by pit toilets or septic systems.

Composting toilets are commercially available in Australia or can be owner-built. Five Australian manufacturers of composting toilets were identified by this study, and these being:

- Clivus Multrum - continuous flow, large single chamber unit
- Closet Deposit - similar to Clivus Multrum unit
- Rota Loo - batch unit with rotating small bins on spindle
- Nature Loo - batch unit with replaceable small bins
- Dowmus - continuous flow chamber emptied by auger

Owner built models includes the Farrellones batch system that has two chambers side-by-side. One chamber is used until full then sealed while the second chamber is used. When the second chamber is full the first has finished composting and is ready to be emptied and used again. An owner-built unit similar to this is being trialled on a remote Indigenous house near Alice Springs. The unit which has been successfully operating for over one year is located on the veranda of the house and the chambers are buried to ground level. The owner reports that maintenance has been minimal to date, although the system does not receive high use[64].

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[63] Pers comm. Stephi Rainow. Public Health Officer, Nganampa Health Council. 14 July 98.
[64] Pers comm. Olive Veverbrant, home owner. Larapinta Drive homeland, Alice Springs. 3 June 98.

A one-year trial of 30 composting toilets on five Torres Strait Islands in 1996 (ICC 1996), appears to be the most comprehensive trial that has been undertaken yet of these types of systems. This trial has looked at three commercially available units (Dowmus, Rota Loo and Nature Loo). It appears, however, that the trial was not very well conceived as many units, which serviced private houses, were installed in quite public locations. In addition internal flush toilets were retained at some sites during the trial which confounded the acceptance rates. The results showed mixed success with the electric exhaust fans failing early in the hot, humid, corrosive climate of the composting chamber. The composting process was reported to work well in most cases with only a few cases of anaerobic piles recorded; apparently because liquid drains did not function correctly. Some of the Dowmus composting chambers, which were buried in the ground, 'popped out' due to the high water table. Inappropriate maintenance of systems by residents was recorded and appeared to be the result of a lack of sufficient user education. Such instances included:

- failing to place organic material in the base of bins before use,
- placing partially composted full bins on-line again before emptying them,
- failing to rotate or replace bins at appropriate times,
- failing to act when exhaust fans or excess liquid drains stopped working, and
- discarding plastic bags, nappies and rags into the toilet (ICC 1996).

Composting toilets are known to have been trialled in the WA remote communities of Wilson's Patch in the Goldfields region, and by Winun Ngari Resource Agency in the West Kimberley region (Anda et al 1997). No composting toilets are known to have been trialled in SA communities, and though it is suspected that informal trials of composting toilets have occurred in the NT none were identified by this survey.

Aerobic wastewater treatment systems (AWTS)

Aerobic wastewater treatment systems (AWTS) are small on-site package treatment plants, which mechanically introduce oxygen to wastewater to speed the treatment of effluent to secondary levels. Treated effluent can then be either disposed of into absorption trenches or chlorinated and used for spray irrigation. Approximately 22 different Australian manufacturers of AWTS were identified by this survey, all using the same basic principles but with some variations in design (see Appendix A for a list of manufacturers). Such systems have been in common use in Australia since the late 1980s, but only one AWTS installation is known to have occurred in remote Indigenous housing at Coen, Qld. In this case twenty-five systems were installed in 1994 but regular failures occurred over several years due to a range of problems including, frequent power interruptions, insufficient maintenance and poor system selection (Downs 1997). In addition there were insufficient qualified personnel to service equipment when failures occurred, resulting in effluent commonly seeping from the AWTS units onto yard surfaces. It was also suspected that fluctuations in the volume of wastewater entering the system (from fluctuating populations in houses) affected system performance. During the course of the survey there was considerable misgivings expressed by state regulators concerning the introduction of AWTS to remote Indigenous communities, due to concerns over unreliable power supplies, pump failures, fluctuating wastewater loads, lack of regular maintenance and inadequate disinfecting of irrigated effluent. As mentioned earlier the WA Health

Department has rejected all applications for AWTS trials on WA remote communities for these types of reasons[65].

Aqua privies

Aqua privies are used overseas, particularly in developing countries, for sanitation but are relatively unknown in Australia. They consist of a water-filled septic tank immediately below a toilet pan and are designed so that no water is required for flushing. Any effluent overflow from the septic tank is generally discharged to small absorption trenches. Gough Plastics, a company located in Townsville, Qld, are now manufacturing a modification of the aqua privy in Australia under the name of "The Hybrid Toilet System". This unit has a septic tank below the toilet, followed by a secondary tank, which provides additional detention time for effluent treatment and some extra aerobic treatment. The added time is claimed to reduce pathogens to very low levels[66]. The system is usually located away from the house, which may present similar acceptance problems as experienced by pit toilets. It appears that odours from the unit are controlled by a solar powered exhaust fan, which also may present problems if fan failure occurs (as happened with many exhaust fans on composting toilets trialled in the Torres Strait Islands in 1996). The Hybrid Toilet unit is said to require very little maintenance and is sized for continual use by 10 persons, which is important for remote community applications. User acceptance will only be gauged via field trials in communities. The Hybrid Toilet may provide a viable alternative to pit toilets where groundwater tables are high, and to composting toilets where high levels of maintenance are not expected to occur and it is recommended that trials of this system be encouraged.

Sand filters

Sand filters are generally sited after a septic tank to provide additional treatment of effluent before disposal or reuse. Septic tank effluent is pumped onto the top of a sand filter. The effluent then trickles through the medium receiving treatment via biological, chemical and physical processes. The treated effluent is collected from the bottom of the sand filter and then either directed to absorption trenches or disinfected and reused for irrigation. No onsite sand filters are known to be installed in remote Indigenous communities, although there may be potential for their use in some communities where groundwater may be contaminated by septic tank effluent. Several aspects of sand filters, however, may make their reliable performance problematic in remote communities. For instance their reliance on electric pumps and the need to desludge the septic tank regularly to stop solids being pumped to the sand filter.

Reed-beds

As with sand filters, reed-beds are generally sited after a septic tank to provide additional treatment of effluent. The reed-bed is a lined hole in the ground filled with gravel and planted with reeds. Effluent flows through the gravel voids and receives treatment from bacteria living on reed roots, which also grow in the gravel voids. The major difference from sand filters is that reed-beds generally require no pumps or chemicals to function because all effluent flows by gravity from the septic tank to the

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[65] Pers comm. Barry Bowden, Environmental Health Policy Officer, WA Health, Perth. 24 March 98.

[66] Information obtained from a Gough Plastics promotional brochure on "The Hybrid Toilet System". Undated.

reed-bed and then to absorption trenches. Reuse of the effluent for irrigation, however, generally requires a pump. Again no reed-beds are known to be installed on remote communities. It seems likely they would, however, have a useful function in certain situations to provide passive, additional treatment of effluent before disposal. Such situations may include where water-tables are relatively high or soils are marginal for absorption of septic tank effluent (reed-beds produce effluent with less dissolved organic matter than usual septic tank effluent, allowing effluent to soak more easily into many soils). Reed-beds may be more appropriate in tropical climates than arid regions, mainly because reeds are expected to be able to survive better if a house is not occupied for an extended period of time. It is recommended that trials of reed-beds be encouraged.

Absorption mounds

Absorption mounds are recommended for use by several state codes where water tables are close to the surface or seasonal rainfall is high. An absorption mound is essentially an absorption trench raised above ground level and surrounded by a mound of soil. Septic tank effluent must be pumped to the mound, which raises concerns for remote communities where power supplies are not reliable, pump maintenance is irregular or septic tank pump-out is irregular.

Novel absorption trenches

Standard absorption trenches use plastic tunnels or slotted pipe to distribute septic tank effluent evenly along each trench. Both of these materials are susceptible to damage from rough installation or vehicles driving over the absorption field. A new type of trench tunnel is being promoted by the Atlantis Corporation, Sydney . This new material is called the "Atlantis Drainage Cell" and is similar to standard tunnels but uses much heavier duty plastic, which the manufacturer claims to be more resistant to vehicular damage. Some of the Atlantis Drainage Cells are to be trialled by Territory Health Services in selected remote Indigenous communities of the NT which are currently receiving HIPP/NAHS septic upgrade programs.

Another improvement often recommended for absorption trenches is to alternate between parallel trenches. This procedure allows individual trenches to be periodically rested and restored to better function. This type of improvement can be achieved by installing a distribution box and three parallel trenches, two of which are active at any time. Trenches can be alternated every six to twelve months by rotating pipe elbows in the distribution box. The third resting trench is on 'standby' as an overflow trench if effluent volumes become large (because of high house populations or water use). It is also recommended that trials of this alternating system be encouraged.

Simple grey-water systems

For communities using dry toilet systems, grey-water must still be disposed of adequately without creating health or environmental problems. Most state codes specify the use of standard septic systems with reduced capacity for grey-water disposal, but other alternative systems do exist for grey-water disposal. An Alice Springs based company (WaterWays Asia-Pacific) has designed one such system. Trials of the system are in place on several outstations surrounding Maningrida, NT. Grey-water is directed to small silt/grease traps then to absorption beds planted with fruit trees. Residents or other service personnel easily tend to the silt/grease traps with a bucket and shovel.. Other grey-water systems are known to direct grey-water to mulched swales planted with fruit trees. There appears to be much scope for developing simple, region-specific grey-water systems, which work effectively but are less, complicated than current code-specified systems.

Webs Wonder Dunny

This, obviously Australian system, was developed for pit toilets on outstations surrounding Yirrkala, Arnhem Land, NT originally because of fly and odour problems inside the toilets. The "Webs Wonder Dunny" (WWD) uses a plastic flap beneath the toilet seat which remains closed until someone sits on the seat. The weight of the person trips a mechanism, which opens the flap, the flap closes again when the person stands up. It was reported to this survey that the toilets using the WWD flaps were the same basic design as other standard VIP pit toilets. These toilets have operated successfully without flies and odours across Arnhem Land. It is therefore suspected that the toilets built on Yirrkala outstations had a design flaw which allowed odours and flies to be a problem. The invention may, however, warrant further investigation.

Section 5: Conclusions

As repeated (several times) it is felt that coming to any conclusion from the evidence obtained from a desktop study, without confirmatory field results, is fraught with difficulties. Nevertheless a general feeling emerged that the basic sewage technologies available per se were adequate; the problem areas concerned the installation, operation and maintenance of the sewage systems in the remote Indigenous communities. Fieldwork, undertaken at the Centre for Appropriate Technology in other areas, suggests that the difficulties of operating and maintaining any technology in a remote location cannot be overemphasised. If the above basic conclusion is supported by a field study then the solution would point to increased funding for operation and maintenance, training and institutional support.

Section 6: Recommendations

The aim of this desktop study has been to document the current status of sewage disposal in remote Indigenous communities. It is anticipated that the study will be used as a baseline for field studies to validate or not the information found so far. As such detailed recommendations regarding the operation of sewage disposal will have to await the field component. As there have been some indications that information obtained from the personnel responsible for the operation and maintenance of sewage systems may not always agree with the limited number of field reports examined, it is thought that the field component of a national study should proceed as soon as possible. This study should:

- verify or otherwise the general findings of this current survey,
- gauge the relative impact of different problems identified,
- prioritise areas for targeting future improvements

In addition the lack of information available on system costs has prompted us to recommend that an economic analysis of life-cycle costs for different sewage system types on remote communities be undertaken.

Finally, due to the number of new alternative systems coming onto the market it is recommended that a watching brief be kept on alternative on-site sewage systems currently installed in remote communities and outstations to determine their potential to improve current problems.

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Appendix A

Sewage Technology	Company	Location	State	Telephone	Type of system	Hydraulic loading
Absorption trenches	Atlantis Corporation	Chatswood	NSW	02 9419 6000	Absorption trenches (strong plastic)	
Absorption trenches	EcoMax	Fremantle	WA	08 9335 1600	Absorption trenches with amended soils	
Aqua Privy	Gough Plastics	Townsville	Qld	077 747 606	Hybrid Toilet System'	10 persons
AWTS	Aerated Sewage Systems	Seven Hills	NSW	02 9672 3255	Concrete AWTS	2 - 500 persons
AWTS	Bio treat	Balgowlah	NSW	02 9949 5499	Concrete AWTS	10 persons
AWTS	Biocycle	Warriewood	NSW	02 9979 7144	Concrete AWTS	Single household & larger
AWTS	Clearwater Treatment Industries	Wagga Wagga	NSW	02 6931 5043	Concrete AWTS	Single household - 150,000 L/day
AWTS	CSR Humes	North Sydney	NSW	02 9925 2376	Concrete AWTS	Single household
AWTS	Earth Safe	Wallsend	NSW	02 4955 8377	Concrete AWTS	Single household
AWTS	OzFlo Systems	Guilford	NSW	02 9632 9970	AWTS	10 persons
AWTS	Sepa Waste Water Treatment	Caringbah	NSW	02 9525 4788	Concrete AWTS	Single household
AWTS	Aqua Treat	Winnellie	NT	08 8947 2133	Concrete AWTS	10 persons
AWTS	Aqua-nova 2000	Oxenford	Qld	07 5573 6644	AWTS	10, 20, 25, 50 persons
AWTS	Enviroflow	Rocklea	Qld	07 3274 3136	Fibreglass AWTS	10 persons
AWTS	Suncoast Waste Water Management	Ilkley	Qld	07 5445 0767	Ozzi Kleen' plastic AWTS	10 persons
AWTS	Super-Treat Systems	Carseldine	Qld	07 3263 8298	Plastic & concrete AWTS	20 persons
AWTS	Taylex Clearwater 2000	Ernest	Qld	07 5571 5122	Concrete AWTS	Single household
AWTS	Aquacycle Waste Water Treatment	Lockleys	SA	08 8235 2001	Concrete AWTS	20 - 3,000 persons
AWTS	Envirocycle	Sheidow Park	SA	08 8381 9116	Concrete AWTS	10, 15, 25, 50, 100 persons
AWTS	Septek Aerobic Filter System	Summertown	SA	08 8390 1177	Sand filter	Single household
AWTS	Septreat	Willunga	SA	08 8586 2828	Concrete AWTS	Single household
AWTS	Diston Sewage Purification	Bayswater	VIC	03 9720 3866	Concrete AWTS	3000 - 5000 L/day
AWTS	Envirosep Sewage Treatment	Montrose	VIC	03 9761 9720	Concrete AWTS	2,000 L/day
AWTS	Septech Industries	Bayswater	VIC	03 9729 8655	Concrete AWTS	10 persons
AWTS	Biomax	Balcatta	WA	08 9345 3071	Concrete & fibreglass AWTS	10 - 60 persons

Sewage Company Location State Telephone Type of system Hydraulic loading

Sewage Technology	Company	Location	State	Telephone	Type of system	Hydraulic loading
Centralised sewerage	Airvac - RSM	Willoughby	NSW	02 9417 8133	Vacuum sewer systems	up to 3000 persons
Centralised sewerage	ANI Kruger	Nth Sydney	NSW	02 9925 8900	Range of sewage treatment technologies	> 1000 persons
Centralised sewerage	Evolution Engineering	Ultimo	NSW	02 9212 6700	Range of sewage treatment technologies	Large systems
Centralised sewerage	Henry Walker Water Treatment	Carlton	NSW	02 9546 7855	IDEA sewage systems	50 - 20,000 persons
Centralised sewerage	Sepa Waste Water Treatment	Caringbah	NSW	02 9525 4788	Package Treatment Plant	Small - large systems
Centralised sewerage	Super-treat	Castle Hill	NSW	02 9634 1723	Package Treatment Plants (activated sludge)	up to 2,000 persons
Centralised sewerage	Syskill	Castle Hill	NSW	02 9899 1791	Biowrap' rotating biological contactor	Large systems
Centralised sewerage	Aqua Treat	Winnellie	NT	08 8947 2133	Rotating biological contactor	15 - 1,000 persons
Centralised sewerage	Aquatec-Maxcon	Ipswich	Qld	07 3281 2299	Package treatment plants	100 - 100,000 persons
Centralised sewerage	Enviro-Technologies	Rocklea	Qld	07 3277 8803	Package treatment plants	10 -1,200 persons
Centralised sewerage	Enviroflow	Rocklea	Qld	07 3274 3136	Package Treatment Plant	10 - 20,000 persons
Centralised sewerage	WaterTech	Booval	Qld	07 3816 0961	Modified Effluent Drainage Schemes	up to 2,000 dwellings
Centralised sewerage	Aeroflow	Coromandel	SA	08 9370 3130	IDEA sewage systems	100 - 20,000 persons
Centralised sewerage	Diston Sewage Purification	Bayswater	VIC	03 9720 3866	Trickling contactor	20,000 - 75,000 L/day
Centralised sewerage	Environmental Solutions International	Osborne Park	WA	08 9242 2422	Biological nutrient removal	Large systems
Centralised sewerage	Treatwater	Cannington	WA	08 9451 7598	Sequencing batch reactors	100 - 5,000 persons
Composting toilet	Closet Deposit	Cabarita	NSW		Dry composting toilet	6 persons
Composting toilet	Clivus Multrum	Strathpine	Qld	07 3889 6144	Dry composting toilet	4,6,12,18 persons
Composting toilet	Dowmus Resource Recovery	Maleny	Qld	07 5499 9828	Wet & dry 'Dowmus Biolytic Filter'	6 - 8 persons
Composting toilet	Nature Loo	Milton	Qld	07 3252 0733	Dry composting toilet	max. 6 persons
Composting toilet	Environment Equipment	Braeside	VIC	03 9587 2447	Rota-Loo' dry composting toilet	4, 8, 15 persons
Constructed wetlands	Woodlots & Wetlands	Castle Hill	NSW	02 9651 2931	Constructed wetlands	Large systems
Constructed wetlands	WaterWays Asia-Pacific	Alice Springs	NT	08 8952 4942	Constructed wetlands	10 - 1,000 persons
Constructed wetlands	Rellney	Woodville	SA	08 8268 4844	Constructed wetlands	Large systems
Incinerating toilet	Hi Tech Pacific	Bentleigh	VIC	03 9589 5611	Incinolet' electric toilet	6 - 10 persons
Pit toilet	Outback Septics	Nhulunbuy	NT	08 8987 2319	Webs Wonder Dunny' toilet pan	Single toilets
Sand filter	Envirotech Treatment Systems	Brisbane	Qld	07 3366 2954	Sand filter	10 - 100 persons
Sand filter	J&L Aerobic Sand Filtration System	Parafield	SA	08 8258 8739	Sand filter	< 10 persons
Septic tank filter	Taylex Clearwater 2000 (distributor)	Ernest	Qld	07 5571 5122	Zabel' septic tank filter	Individual septic tanks
Septic tank filter	WaterTech (distributor)	Booval	Qld	07 3816 0961	Orenco' septic tank filter	Individual septic tanks
Septic tanks	Abbey Fibreglass	Smithfield	NSW	02 9725 4871	Fibreglass & plastic septic tanks	

Technology

Septic tanks	Advance Concrete & Pre-cast	Riverstone	NSW	02 9627 1900	Concrete septic tanks
Septic tanks	CSR Humes	Nth Sydney	NSW	02 9925 2376	Concrete septic tanks
Septic tanks	Rescrete Industries	Riverstone	NSW	02 9627 2666	Concrete septic tanks
Septic tanks	All Cast (NT)	Darwin	NT	08 8947 2981	Concrete septic tanks
Septic tanks	Darwin Fibreglass	Winnellie	NT	08 8947 1192	Fibreglass septic tanks
Septic tanks	Viking Fibreglass Industries	Darwin	NT	08 8984 4142	Fibreglass septic tanks
Septic tanks	Everhard Industries	Geebung	Qld	07 3265 3999	Plastic & concrete septic tanks
Septic tanks	Everhard Industries	Adelaide	SA	08 82121700	Concrete septic tanks
Septic tanks	Envirosep Sewage Treatment	Montrose	VIC	03 9761 9720	Concrete septic tanks
Septic tanks	Melbourne Precast Concrete Tanks	Bayswater	VIC	03 9729 0966	Concrete septic tanks
Septic tanks	Septech Industries	Bayswater	VIC	03 9729 8655	Concrete septic tanks
Septic tanks	Innotech Industrial Supplies	Midvale	WA	08 9274 8115	Concrete septic tanks