BEST PRACTICE HUMAN WASTE MANAGEMENT WORKSHOP

Workshop Proceedings and Papers
Canberra & Jindabyne
March 2000

Compiled by
Karen Civil, Environment ACT and
Brett McNamara, Australian Alps national parks

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## Australian Alps Best Practice
### Human Waste Management Workshop
27 - 31 March 2000
WORKSHOP PAPERS & PRESENTATIONS

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### OLIVER VAUGHAN

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PROFILE
Rod Baxter
Senior Project Manager
Business Development and Marketing Environment ACT

Rod has a background in landscape architecture and planning and has a particular interest in new approaches to more sustainable building. Over the past 15 years he has worked in Adelaide and Canberra and been involved in a broad range of design and environmental planning projects which include:

- Xeriscape demonstration gardens;
- Large scale land rehabilitation and re-afforestation projects;
- Development of urban parkland and public places;
- Nature based tourism developments;
- Design and construction standards for urban landscapes; and
- Planning and policy development for more sustainable development in both urban and natural areas.

In the past two years Rod has spend a large part of his time as project manager for the revitilisation of Tidbinbilla Nature Reserve. An important part of this project has been the construction of a self-sufficient visitor centre that conserves and recycles natural resources. Winter heating relies almost entirely on solar energy while evaporative cooling keeps the building cool in summer. The waste water system achieves very high quality discharge that is used for irrigation.
LOOS WITH VIEWS - A POTTED HISTORY OF 'AMENITIES' DESIGN IN THE CANBERRA REGION
Rod Baxter - Project Manager, Business Development and Marketing, Environment ACT

Introduction
From the fingers of open space that permeate the urban area to the Alps, Canberra has some spectacular natural landscapes. Not surprisingly people like to congregate at many of the more easily accessible areas to enjoy the delights of the wonderful natural settings. This leads to the inevitable need for the addition of 'amenities', or put more simply, 'bush dunnies'.

Fifteen years ago the standard 'amenities' block consisted of four flushing toilets, equally shared between male and female, surrounded by concrete block walls and a reinforced concrete roof. External work consisted of a water tank filled from a stream and a septic tank with associated dispersal trenches.

Septic systems constructed during the 1970's made many sites more accessible for outdoor recreation. This was particularly the case for river recreation areas where a permanent water supply was not only the attraction for people but also the supply of water for the flushing toilets.

The need to be close to a permanent water supply in order to fill a tank, and the consequent need to dispose of effluent immediately adjacent to the source of water, now seem strangely incompatible objectives. The last 10 years or so has seen a turn around in the way we addressed the common needs of our park visitors. Rather than recreating the visual and toxic blots of the past, briefs for new toilets promoted unique design approaches, which demanded attention to aesthetic and environmental considerations.
More recently though, as construction money has been harder to find, more standardised and lower cost packages have emerged. These off the shelf options are able to meet environmental standards at lower cost than one off designs and are suitable for a range of applications.

Out of these changing 'fashions' come a number of interesting design and siting issues that are briefly described in the context of several case studies I have been involved with over the past few years. The sewage systems are only briefly mentioned, as the point of the paper is more to do with the integration of buildings into the natural environment.

Googong Foreshores
On the edge of one of Canberra's main potable water reservoirs this facility was designed for peak use of 1,000 a day but has an average of only 10 users a day. Clivus tanks were selected as the composting system, which necessitated a two storey structure.

The design and siting threshold question was 'do we minimise the visual intrusion of the building, by reducing its apparent height to only a single story?' This would have been easily achieved by utilising the change in slope at the end of the car park. A more comprehensive site analysis however suggested other opportunities to maximise the views from the building and enhance the arrival experience.

Without good design resolution this bolder approach carried a risk of poor integration of the bulk of the building with the natural landscape setting. Notwithstanding that risk the decision was made to maximise the views and sense of arrival, and without a lot of difficulty, the two storey building was made to sit comfortably on the site. This was achieved by use of a large curved deck that provided access to the first floor public level and at the same time allowed service vehicle access the ground floor level. 'ibis gave depth to the structure and together with the curved roof, reduced the apparent height of the building when viewed from the car park.

The building also saw the use of less robust materials such as hardwood and corrugated iron. Neither vandalism nor high maintenance have been problems, and after more than 10 years no signs of deterioration are evident.
Set in a small gully away from the car park the 2 storey structure sits comfortably in the landscape and provides the best viewing platform over Googong Reservoir. Orroral Valley
This toilet is constructed on the site of a demolished tracking station that was an integral part of NASA's 1969 Apollo II Moon landing. It is an interesting historical site that deserved some attention to careful integration of any new structure. This was achieved with the design of an elegant two story building that housed Clivus tanks in the ground floor and toilet cubicles on the first floor.

More important than the building aesthetics was the need to ameliorate the -18°C winter temperatures that would slow down the composting process. This was achieved by passive solar design, double glazing, insulation of the slab, walls and ceiling slab and high internal thermal mass. This has been very successful and minimum temperatures in the ground floor are always much higher than the ambient external temperature. This fact is always greatly appreciated by any search and rescue or research activities that need an overnight base during the winter. Downstairs in the Honeysuckle toilet is one place people know they will be out of the cold.
Kambah Pool
At a remote site on the Murrumbidgee River this facility combined the design requirements of both Googong and Orroral. It also presented an additional challenge of handling waste, given some concerns coming out of Tasmanian research about the ability of Clivus to perform adequately in cold climates. Kambah Pool used a new system ‘Nature Loo’ that provided the additional level of protection of being able to wheel out waste in the event of a total collapse of the composting process.

Similar to Googong, Kambah Pool provides a generous sense of arrival and provides outstanding views over the Murrumbidgee River.

Honeysuckle Campground and Booroomba Rocks
A knowledge base about alternative composting systems and the arrival on the market of ‘design and construct' packages was an opportunity to reduce our costs and utilise more standard products. The single cubicle DOWMUS system at Booroomba Rocks and the larger DOWMUS system at Honeysuckle Campground are two examples of complete installations that we are likely to use again at other sites. The benefits of ‘off the shelf’ designs are:
More economical;
Reduced delay in obtaining planning approvals because designs are already available; and
Usually quicker to install on site because of the higher level of pre fabrication that is built into the design.

Tidbinbilla Visitor Centre
Tidbinbilla Visitor Centre is a demonstration of more sustainable building technologies. It is a self sufficient building that conserves and recycles natural resources. For example, winter heating relies almost entirely on solar energy while evaporative cooling keeps the building cool in summer. The building itself was conceived as all interpretive display, that in turn houses displays about the natural and cultural history of Tidbinbilla Valley.
An important element of the design is the recycling pavilion that includes recycling bins, a worm farm and the highly visual Biological Aquatic System (BAS) Wastewater treatment system. The BAS relies on the sun, oxygen, aquatic plants, snails, bacteria and microbes to form a 'living machine' that breaks down contaminants in the wastewater. The system works entirely on biological processes and there is no need for the addition of any chemicals.

The final step in the process is ultra violet disinfection but along the way the wastewater travels through a series of hydroponic gardens and marshes where nutrients, suspended solids and pathogens are taken up by living organisms. The system is clearly visible from the car park and is an important introduction to what Tidbinhilla is trying to achieve through environmental education.

The design concept for the new visitor centre at Tidbinhilla was 'building as interpretation'. From the mud brick thermal mass walls through to the waste water treatment we tried to highlight opportunities for people to better understand principles of more sustainable development. An entirely 'transparent' waste water treatment process known as the Biological Aquatic System was a good opportunity to show the public the principles of waste water recycling.

**Conclusion**

The construction of flushing toilets and septic systems in our natural areas could be seen as a laudable response to the needs of visitors during the 1960's through to the early 1980's. The presence of flushing toilets was no doubt a great incentive for many to get out and enjoy the areas. In many cases I assume that prior to the flushing toilet the areas had no facilities at all. The emergence of landscape design and architectural input in the provision of park facilities, combined with acceptance of new waste management technologies has created new opportunities to provide more sensitive and appropriate structures. Hopefully this quest for the perfect bush dunny will continue as designs are refined and as we better match user needs with capital and maintenance costs of providing facilities.
PROFILE
Kerry Bridle
School of Geography & Environmental Studies University of Tasmania
Kerry is a plant ecologist specialising in plant community dynamics in Tasmanian alpine areas. She completed her Masters in Environmental Studies in 1990-92 on organic soils under upland and alpine vegetation in southwest Tasmania. Her PhD thesis examined the effects of different species of vertebrate herbivores on alpine vegetation on the Eastern Central Plateau, Tasmania.

Kerry has been working with Prof Jamie Kirkpatrick of the University of Tasmania for about 8 years (5 of them full-time). She is currently working on an ARC grant awarded to Prof Kirkpatrick and Dr Peter McQuillan (titled ´Australian alpine vegetation dynamics and environment-plant-invertebrate relationships´), and is also employed on a grant from the CRC for Sustainable Tourism. This project examines the impacts of non-toilet human waste disposal on natural ecosystems in Tasmania.
THE IMPACTS OF NON-TOILET HUMAN WASTE DISPOSAL ON NATURAL ECOSYSTEMS IN TASMANIA - RESEARCH PLAN AND JUSTIFICATION

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2. Department of Primary Industry, Water and Environment Box 44a, GPO, Hobart Tasmania 7001

Abstract
Walkers and rafters in the back country of Tasmania form a substantial segment of the interstate and international tourism market. At present their disposal of faeces and urine follows general minimal impact bushwalking guidelines developed by the Parks and Wildlife Service. These guidelines seem not to be appropriate for disposal in ecosystems that have shallow, nutrient-poor soils, and have not been tested for their effects in any ecosystems. This project will use replicated field experiments to determine the impacts on vegetation and soils of human waste disposal in the ecosystems most used by back country tourists in Tasmania, particular emphasis will be placed on the effects of root cutting, changes to soil nutrient levels, the breakdown rates of different types of paper and the effects of depth of burial on the probability of excavation of wastes by native animals. The results of these experiments will be used to develop ecosystem-specific guidelines for human waste disposal that will minimise deleterious impacts on conservation values, while minimizing inconvenience to users. The adoption of these guidelines will be facilitated by co-operation in the project between the relevant land management agencies and the University of Tasmania.

Introduction
Ecotourism is a growing segment of the tourism market, with particular attraction for international visitors. This attraction ultimately relics on the reality of a sustainable natural environment and pleasant experiences for those many tourists who venture into wild country. The disposal of human wastes, if not achieved sustainably, has the potential to make the tourist experience both unpleasant and unhealthy. This potential has been unfortunately realised in some well-used parts of the wild country of Tasmania. There are few data available on human waste disposal impacts on the highly varied natural environments of Tasmania, although there is good observational evidence to suggest that sustainability limits have been exceeded in some environments in some areas. Therefore, the issue addressed in this project is the impact of human waste disposal in wild country areas away from toilets, and the significance to the tourism industry is the maintenance of wild country integrity and attractiveness.

This project is part of the activities of the Tourism CRC. It will run over three years commencing January 4 2000. The aims of the project are:

1. To determine the relative impacts of disposal of human wastes on vegetation and soils in Tasmanian vegetation types that occur in areas used for wild country camping with particular emphasis on: a) the impact of digging; b) the impact of nutrient accessions; c) the persistence of toilet tissue; d) disturbance of burials by native animals.
2. To develop habitat-specific prescriptions for human waste disposal in wild areas that will be consistent with longterm maintenance of natural values, while being acceptable to users.

3. To effectively disseminate the results of the study to users and land managers.

**Project description**

Minimum impact guidelines for walker behaviour have been disseminated to those who camp in the wild country of Tasmania for more than a decade. These guidelines have been highly effective in changing the behaviour of back country users in critical areas, such as the use of fire and the avoidance of water pollution (O'Loughlin 1988). The guidelines for the disposal of faeces require burial to at least 15 cm depth at least 100 m from lakes or streams. This depth is not attainable over most of the glaciated country of Tasmania (Kirkpatrick and Bridle 1999), and the excavation process, to whatever depth is attainable, requires the severance of a dense mat of roots. Cutting of roots occurs even where excavation takes place in bare ground, as in fjældmark treads (Kirkpatrick, pers. obs.). This severance has the potential to harm vegetation well away from the disposal hole. The degree of damage from digging is highly likely to vary markedly between vegetation and soil types, as is the rate of recovery from damage. The project will determine the nature of these responses in the range of environments used by back country campers.

The rate of degradation of human faeces, toilet paper and tampons, once buried, is also likely to vary considerably between vegetation and soil types. For example, low temperatures and anaerobic soils will slow the rate of decomposition (Liddle 1997). The rate of decomposition has direct relevance to the duration of the health hazard presented by the deposit. The project will determine decomposition rates in buried deposits in the range of environments used by back country campers.

Native animals do not have the human aversion to eating faeces, and may excavate to obtain a meal, with obvious public health implications, such as the already realised ubiquity of (Giardia in possum populations. This project will determine the depth of burial that precludes such excavation using an area with the full range of mammals found in the back country.

Urine is rich in nutrients, especially nitrogen. Huts in the wilderness generally have a ring of introduced herbs around their doors, probably largely for this reason (Kirkpatrick 1997). This project will determine the threshold levels for significant vegetation change in response to urination for the major environments used by back country campers.

In North America at least one author has argued that `pack it in - pack it out' should pertain to faeces (Meyer 1994), an option used in Australia only on some commercial ratting operations. The research described above almost certainly will not reveal a widespread need for such methods of disposal, but will almost certainly result in changes in minimal impact bushwalking guidelines for particular environments. The adoption element of the project will involve liaison with critical groups of users and the personnel in the management agencies responsible for policy-setting and implementation, and publicity in relevant media. It will also involve the production of refereed scientific papers, a step necessary to validate conclusions in the eyes of the public.
Methods

Vegetation responses to digging and the breakdown rate of toilet paper and tampons will be determined at sites in the major vegetation types/environments used for faecal disposal in the back country of Tasmania. These will include western alpine vegetation, eastern alpine vegetation, subalpine rainforest, callidendrous rainforest, subalpine eucalypt forest, buttongrass moorland, heathy eucalypt forest, grassy eucalypt forest and coastal dunes. At each site, replicated diggings and controls will be located randomly in those places suitable for disposal. Depth and the wet weight of root mass by 5 cm depth slices will be determined. Permanent vegetation plots will be established around each hole and the covers and heights of plant species, both live and dead, mapped. Known dry weights of toilet paper and tampons will be placed in mass bags at 5 cm, and 15 cm where possible, in each hole. The mass bags will be sequentially removed for measurement of the changes in dry weight through time and the vegetation plots will be remeasured at least twice a year for two years.

A solution approximating human urine in pH, nutrient composition and magnitude will be randomly applied, with varying degrees of repetition, to the vegetation/environment types indicated above, in a replicated manner with controls. The vegetation in the plots will be mapped and remapped as above, except that three remeasurements will be made.

An area with high concentrations of native vertebrates and deep soils will be selected. In this area a substance approximating human faeces in its non-pathological characteristics will he buried at various depths in a random pattern, and disturbance by animals recorded.

A steering committee consisting of representatives of bushwalkers, rafters, climbers, conservation groups, the ecotourism industry, the Parks and Wildlife Service and Forestr) Tasmania will be established, and information on the progress of the project promulgated through their in house publications, their web sites, and through the mass media. Papers based on experimental results will be submitted to refereed journals.

References

PROFILE
Buzz Burrows Environment Equipment
Buzz is finalising his Masters Degree in Environmental Science at Monash University, Clayton. Buzz has a personal commitment to Ecologically Sustainable Development and believes that everyone has a right to live in a sustainable way.
RESEARCH & DEVELOPMENT OF COMPOSTING TOILETS THE ROTA-LOO TECHNOLOGY.

Buzz Burrows - General Manager, Environment Equipment Pty Ltd.

Introduction
Over the last 50 ears science and technology has advanced at a staggering rate in many of the so-called hard sciences. But it has only been in relatively recently years that multidisciplinary approaches to global and environmental problems have taken place. It has been through these pursuits that advances have occurred in ecological and environment sciences.

'Composting' is one of the most fundamental natural processes and is as basic and important as life and death itself. Composting has developed from a once simple activity to become more than an Art to the agricultural or horticultural enthusiast and is now a science in itself. Testament to this is the increasing number of publications and University courses on the subject. As we increasingly understand the internal and external processes involved in composting we also begin to realise the benefits of ecologically processing organic matter compared to most of our current practices. The biological processing of human waste will have profound effects on the way we manage our natural and built environments and habitats both now and in the future and it is the reason I am here to speak with you today.

Understanding the composting process has given us the tools and criteria by which to design and construct the most appropriate sanitation systems for any given geographical or climatic conditions. Understanding the relationships between the many variable in the composting processes has allowed us to minimise risk and maximise efficiency when dealing with human waste management.

As research and development in this science increases our knowledge so will our systems evolve and become more efficient. We at Environment Equipment Pty Ltd are about to commence a significant demonstration and research project in conjunction with SCIRO and a Victorian Water Authority. This project will focus on alternative methods of dealing with the wastewater and sanitation for domestic residence in an urban setting. CSIRO is just one, among a growing number of research institution from around the world, looking for more appropriate ways of dealing with human waste as it becomes increasingly apparent that reticulated sewerage systems are less economic or ecologically viable in the medium to long term.

For today's presentation we would like to highlight the importance of the Rangers and other Managers of National Parks for becoming familiar with the science of composting. This will allow for those people ultimately responsible for the park 's infrastructure to better analyse and evaluate the different technologies available for human waste disposal and ascertain for themselves which systems will work. Two of the most objective reference available for such an understanding are:

1. The "Centre for the Environment" at Cornell University. http://www.cfe.cornell.edu/compost
2. "The Humanure Handbook" by Joe Jenkins available through Environment Equipment Pty Ltd.
The process of composting relies on the interplay of many different variables which when combined in the right quantities allows for the rapid and odourless degradation of organic materials. The science of composting is the understanding of how each of the many variables in the composting process interacts with the next and how the different balances of each ingredient will influence the behaviour or characteristics of the others. Whilst the composting process is as old as the hills or more correctly as old as the dirt, our understanding of the process is relatively new and expanding all the time. To understand the basics of composting we will look at several of the key factors involved.

1. The Phases of Composting.

2. Composting Physics
   - Temperature Curve
   - Mechanisms Of Heat Loss
   - Aeration
   - Moisture

3. Compost Chemistry
   - C/N Ratio
   - Oxygen

4. Odour Management
   a) Factors leading to Anaerobic Conditions
      - excess moisture
      - inadequate porosity
      - a rapidly degrading substrate
      - excessive pile size

From the information presented we will then take a closer look at the Rota-Loo composting system and see how many of its features and variations in design are ideally suited for managing human waste in remote cold climate areas.

1. The Phases of Composting.

In the process of composting microorganisms break down organic matter and produce carbon dioxide, water heat and humus, the relatively stable end product. Under optimal conditions, composting proceeds through three phases: 1) the mesophilic, or moderate temperature phase, which lasts for a couple of days. 2) thermophilic, or high temperature phase, which can last for a few days to a couple of months, and finally. 3) a several-month cooling and maturation phase. Different communities of microorganisms predominate during the various composting phases. Initial decomposition is carried out by mesophilic organisms, which rapidly break down the soluble, readily degradable compounds. The heat they produce causes the compost temperature to rapidly rise.

As the temperature rises above about 40°C, the mesophilic microorganisms become less competitive and are replaced by others that are thermophilic, or heat-loving. At temperatures of 55°C and above, many microorganisms that are human or plant pathogens are destroyed. Temperatures over about 65°C will kill many of the composting microbes and the process
becomes one of desiccation where the organic material dries out and doesn't reduce in volume.

During the thermophilic phase, high temperatures accelerate the breakdown of proteins, fats, and complex carbohydrates like cellulose and hemicellulose, the major structural molecules in plants. As the supply of these high-energy compounds becomes exhausted, the compost temperature gradually decreases and mesophilic microorganisms once again take over the final phase of 'curing' or maturation of the remaining organic matter.

2. Compost Physics.

The rate at which composting occurs depends on physical as well as chemical factors. Temperature is a key parameter determining the success of composting operations. Physical characteristics of the compost ingredients, including moisture content and particle size, affect the rate at which composting occurs. Other physical considerations include the size and shape of the system, which affect the type and rate of aeration and the tendency of the compost to retain or dissipate the heat that is generated.

a) Temperature Curve

Compost heat is produced as a by-product of the microbial breakdown of organic material. The heat production depends on the size of the pile, its moisture content, aeration and C/N ratio. Additionally, ambient (indoor or outdoor) temperature affects compost temperatures. David Delporto of Sustainable Strategies in Connecticut USA has identified a principle factor he calls Q10, which states that for every 10°C that can be introduced to the composting environment the rate of composting can be doubled. The composting process only starts at around 4-5°C below this all bacteria are dormant.

Decomposition occurs most rapidly during the thermophilic stage of composting (40-60°C), which lasts for several weeks or months depending on the size of the system and the composition of the ingredients. This stage also is important for destroying thermosensitive pathogens and fly larvae. The U.S. EPA has regulations in place which specifies that to achieve a significant reduction of pathogens during composting, the compost should be maintained at minimum operating conditions of 40°C for five days, with temperatures exceeding 55°C for at least four hours of this period. In terms of public health and safety this is an important issue, it must be noted however that the same results can also be achieved at slightly lower temperatures for longer periods of time as long as no fresh material is being added to the compost. This point alone identifies the importance of using a batch system for micromposting human waste. Joe Jenkins, in his thoroughly research book "The Handbook" recognises that batch composting piles ensure that all parts of the pile are subjected to the high internal temperatures. thereby ensuring total pathogen destruction.

After the thermophilic phase the temperature begins to drop and can't be restored. At this point decomposition is taken over by mesophilic microbes through a long process of curing or maturation. Although the decomposition rate is slower, chemical reactions continue to occur that makes the remaining organic matter more stable and suitable as humus, for use with plants.
Mechanisms of Heat Loss

The internal pile temperature at any point during composting depends on how much heat is being produced by microorganisms, balanced by how much is being lost through conduction, convection and radiation. Through conduction energy is being transferred from atom to atom by direct contact; at the edges of a compost pile, conduction causes heat loss to the surrounding air molecules.

Convection refers to transfer of heat by movement of a liquid such as air or water. When compost gets hot, warm air rises within the system, and the resulting convective currents cause a steady but slow movement of heated air upwards through the compost and out the top. In addition to this natural convection, some composting systems use ‘forced convection’ driven by blowers or fans. This forced air increases the rate of both conductive and convective heat losses. Much of the energy transfer is in the form of latent heat (the energy required to evaporate water).

The third mechanism for heat loss, radiation, refers to electromagnetic waves. The warmth generated in a compost pile radiates out into cooler air. The smaller the bioreactor or compost pile, the greater the surface area-to-volume ratio, and therefore the larger the degree of heat loss to conduction and radiation. Insulation is therefore important to reduce these losses in small compost bioreactors.

Moisture content affects temperature change in compost; since water has a higher specific heat than most other materials, drier compost mixtures tend to heat up and cool off more quickly than wetter mixtures, providing adequate moisture levels for microbial growth are maintained. The water acts as a kind of thermal flywheel, damping out the changes in temperature as microbial activity ebbs and flows.

Aeration

Oxygen is essential for the metabolism and respiration of aerobic microorganisms, and for oxidizing the various organic molecules in the waste material. At the beginning of the microbial oxidative activity, the O2 concentration in the pore spaces is about 15-20% (similar to the normal composition of air), the O2 concentration varies from 0.5-5%. As biological activity progresses, the O2 concentration falls below about 5%, regions of anaerobic conditions develop. Providing the anaerobic activity is kept to a minimum, the compost pile acts as a bio-filter to trap and degrade the odourous compounds produced as a by-product of anaerobic decomposition. However, should the anaerobic activity increase above a certain threshold, undesirable odours may result.

Maintaining aerobic conditions can be accomplished by various methods including forced air flow, the inclusion of aeration pipes, increasing the porosity of the compost mixture or by adding the Rota-Loo organic, (non bacterial) bio stimulant. 'this specially designed product is an aqueous extract of seaweed, which has been formulated to stimulate the aerobic bacteria and enzymes and not allow them to degrade into and anaerobic phase. This product not only eliminates odour but it also increases the rate of microbial action and therefore decomposition.
d) Moisture

A moisture content of 50-60% is generally considered optimum for composting. Microbially induced decomposition occurs most rapidly in the thin liquid films found on the surfaces of the organic particles. Whereas too little (<30%) inhibits bacterial activity, too much moisture (>65%) results in slow decomposition, odour production in anaerobic pockets, and nutrient leaching. All organic materials have different moisture levels. Often the same materials that are high in nitrogen are very wet, and those that are high in carbon are dry. Combining different materials can help develop and optimal composting mix.

Compost Chemistry.

a) C/N Ratio

Of the many elements required for microbial decomposition, carbon and nitrogen are the most important. Carbon provides both an energy source and the basic building block making up about 50% of the mass of microbial cells. Nitrogen is a crucial component of the proteins, nucleic acids, amino acids, enzymes and co-enzymes necessary for cell growth and function.

The ideal C/N ratio of composting is generally considered around 30:1, or 30 parts carbon for each part nitrogen by weight. At lower ratios, nitrogen will be supplied in excess and will be lost as ammonia gas, causing undesirable odours. Higher ratios mean that there is not sufficient nitrogen for optimal growth of the microbial populations, so the compost will remain relatively cool and degradation will proceed at a slow rate.

As composting proceeds, the C/N ratio gradually decreases from 30:1 to 10-15:1 for the finished product. This occurs because each time that organic compounds are consumed by microorganisms, two-thirds of the carbon is given off as carbon dioxide. The remaining third is incorporated along with nitrogen into microbial cells, then later released for further use once those cells die.

One of the most crucial elements in composting toilet systems is that the majority of nitrogen is in liquid form. This raises two issues. Firstly, too much urine in the system can cause anaerobic and therefore odorous conditions, and secondly, to balance the carbon to nitrogen to a ratio consistent with efficient decomposition, a great deal of carbonaceous bulking material may need to be added. Faecal material is also fairly high in nitrogen and can be balanced out with carbonaceous material such as toilet paper. Ideally what needs to be done is to take the majority of the urine out of the equation. Two ancillary products in the Rota-Loo range help achieve this.

1. The Waterless Urinal,
2. The Separating Pedestal.

The type of toilet paper used in a composting toilet system can also effect the rate of decomposition. Newspaper, for example, is slower to breakdown because it is made up of cellulose fibres sheathed in lignin, a highly resistant compound found in wood. Some course toilet papers are manufactured from recycled papers and cardboard and have been through the recycling process a few times. Excessive recycling breaks down the fibre lengths making them difficult to re-bond naturally, when this happens, “size” an inorganic plastic bonding agent is normally added which encapsulates the fibres and makes them inaccessible for composting.
b) Oxygen

Another essential ingredient for successful composting is oxygen. As microorganisms oxidize for energy, oxygen is used up and carbon dioxide is produced. Without sufficient oxygen, the process will become anaerobic and produce undesirable odours, including the rotten egg smell of hydrogen sulfide gas.

Even though the atmosphere is 21% oxygen, aerobic microbes can survive at concentrations as low as 5%. Oxygen concentrations greater than 10% are considered optimal for maintaining aerobic composting. The pile size of a composting toilet system can therefore be an issue. If the pile size is too large and not regularly maintained with bulking materials oxygen will on average only be able to penetrate to a depth of 30cm. Pile sizes should therefore be kept to a maximum of 60cm in diameter.

Odour Management

Odour is possibly the most common problem associated with composting toilets systems and failure to adequately address the issue has led to some installations being closed down. This never has to be the case, for the most part odour can be controlled as long as a basic understanding of the process involved in their creation are understood. In 99% of cases odour problems are the result of low oxygen or anaerobic conditions. Anaerobic odours include a wide range of compounds, most notoriously the reduced sulphur compounds (e.g. hydrogen sulphide, dimethyl sulphide and dimethyl disulphide), volatile fatty acids, aromatic compounds and amines. Ammonia is the most common odour that can be formed aerobically as well as anaerobically, and thus has its own management options.

Significant release of anaerobic odours from a composting system is usually a symptom that some important management factor has been neglected or misunderstood. The most common factors, which result in anaerobic odours, are:

1. Excess moisture,
2. Inadequate porosity,
3. A rapidly degrading substrate,
4. Excessive pile size.

All of these factors make it more difficult for oxygen to penetrate throughout a pile before it is depleted, or allow airflow to short-circuit around large zones which become anaerobic. Because oxygen diffuses so much slower in water than in air, excess moisture reduces oxygen penetration. This reduction occurs in two ways. Firstly, because moist compost hydrophilic (it loves water), water is strongly held to the surfaces of particles, so as water content increases the thickness of the aqueous film surrounding each particle increases. The second, closely related effect, is a matrix effect due to capillarity—water fills the smallest pores first, and thus creates water filled zones between particles, which slow oxygen diffusion and result in anaerobic clumps.

The particle size distribution, bulk density and porosity of a compost mixture are the second group of factors that can lead to anaerobic conditions. These physical characteristics of the compost mixture can interact with high moisture levels to reduce oxygen transport. Small particle sizes reduce the number of large pores and increase the likelihood that oxygen will need to diffuse a long way through small pores. The shape, size and structure of particles will affects how they settle, with tight packing arrangements increasing the bulk density and
reducing the air filled porosity. In effect this explains why in some composting installations, especially in areas with high usage, that porous hulking material may be required.

The oxygen content at any location in a composting pile reflects a balance between oxygen supply and oxygen consumption. Rapidly degrading substrates such as food scraps and human manure consume oxygen much more rapidly than leaves or digested sewerage sludge. Oxygen consumption is a function of substrate characteristics (C/N ratio, bioavailability, moisture, particle size) and environmental conditions (temperature, moisture, oxygen concentration and pH). To provide for the increased oxygen demand of a rapidly degrading substrate, oxygen supply must also be increased. In forced aeration systems this can often be accomplished by increasing the fan or blower size. With passive systems, any restrictions on oxygen transport such as inadequate porosity or excess moisture must be reduced. A final alternative, which is commonly practiced with food scraps and humanure, is to reduce the pile size.

Composting toilets come in many shapes and sizes, in all of these systems the correct and appropriate pile size will have to balance the heat generated by microbial decomposition and system design with the heat lost through conduction, convection and radiation. Passively aerated systems, which depend on diffusion and natural convection for oxygen transport, usually have a large open surface area to encourage air movement, with corresponding convective heat losses. This large surface area also results in conductive and radiant heat loss. Because heat loss in these systems is largely a function of exposed surface area (as well as ambient temperatures) and microbial heat generation largely a function of volume (assuming the environmental conditions are near optimum) for any material and configuration there will be an ideal surface to volume ratio. Larger piles with a smaller surface to volume ratio, will tend to overheat, while small piles will be too cool. The ideal pile height for a composting toilet with rapidly degrading substrates will be close to 1 metre.

Key Points
The points just covered will help any manager of composting toilet systems to better understand the dynamic process that is slaking place inside their system. This basic understanding will also be extremely helpful when evaluating the many different types of composting toilets systems available on the market, to determine which one is going to meet and full-fill all the requirements for an efficient composting toilet system.

In a nutshell, one has to remember that to achieve an efficient system that there are basically three things that they have to look for in a systems design. How does the system deal with.

1. Minimal liquid retention and drainage.
2. Oxygen flow,
3. Heat (Internal & External temperatures).

Rota-Loo Design
The Australian designed Rota-Loo composting toilet system has evolved over the many years since its start in 1974 and it has evolved in response to a growing and better understanding of the requirements for efficient and effective composting. The Rota-Loo design has been finally tuned to meet the requirements of composting and minimum maintenance.
The internal turntable houses a number of removable composting bins. Each bin has a series of drain holes and air holes located in its base and around the outer surface are of the pile. Inside each bin is a filter material made from a non-woven, inorganic geo-textile material. This material has a flow rate of around 300 lts/sqm, which means that all liquids can easily drain through whilst allowing oxygen to penetrate the pile from the base. The filter material also has a porosity of 170 microns, which means that no solids greater than 0.175mm will escape the bin, therefore ensuring that all solids remain in the bin. Once the liquid has drained from the bin it is stored in the base of the outer container. The complete separation of liquids from solids also ensures that the pile remains aerobic and reduces the possibility of odours. The bin design allows for the most appropriate and manageable amounts of waste material to be stored, which can be quickly and easily composted by allowing oxygen to penetrate to the centre of the pile and which can easily be moved. Once the initial bin has been filled, the turntable is simply rotated to allow a new bin to take the waste as the first remains inside the system without any fresh material being added just composting away. Once all the bins have been filled and the first bin has returned to the front position, it can then be removed so that its humus contents can be emptied into a small hole in the dirt. The bin replaces and the cycle started again.

One of the most important aspects of the Rota-Loo system is that it has its own heat source. The SoltranTM building is an integral part of the Rota-Loo concept and enables the system to become one of the most efficient in the world, especially in cold climates. The Soltran design incorporates a 10mm twin-wall polycarbonate glazing placed at a 60° angle facing north at the rear of the building. The area under the glazing is insulated and almost airtight except for a few bleeder holes allowing new air into the void. The air inside the SoltranTM is heated by the sun and drawn into the Rota-Loo via the air inlet and through the system by a fan. Whilst the fan is used to vent the internal system in can also cause heat loss from the pile. The heat being generated by the SoltranTM can overcome the heat loss from the pile and in fact increase the available heat well above the ambient. The increased heat within the local environment will again assist in a more rapid degradation of the organics as well as providing a high internal temperature for the pathogen kill. As mentioned earlier, pathogen kill is an extremely important public health and safety issue and the most natural way of killing pathogens is through a factor of heat and time.

An experimental Soltran building has been in operation for several years on the Routburne Walking Track on the South Island of New Zealand at an altitude of 6000 feet. A Rota-Loo toilet was used for several years at Greenpeaces’ Mawson base in Antarctica with an outside temperature of around -35°C until the base was disbanded and the unit moved to its new home in the South Pacific.

Inducing and retaining heat in to a composting toilet system is the key to a successfully operating high altitude or cold climate system. The Mobile Rota-Loo shown here is a unique system incorporating passive solar design the functionality of the standard composting toilet and mobility. The material used in the construction of the Mobile is a polystyrene, insulated, 50mm colourhond sandwich panel. This is the same material, which is used in coolroom construction. Its thermal properties are excellent for retaining generated heat and allowing the composting process to continue even under extreme conditions. The versatility of the Mobile allows for its superstructure to be easily changed. The trailer section can be replaced with skids and lifting lugs, making the unit ideal as a remote location toilet facility which can double as an emergency shelter. The compact building can be air lifted into place or several put on the back of a truck and dropped off with a Hyab crane.
Urine and Excess Liquid

Probably the most difficult management issue for any composting toilet system is how to deal with excess liquid and urine. Not only is it the cause of most anaerobic odour problems it is sometimes difficult to get rid of.

The safest way of dealing with urine is to evaporate it off. To do this effectively, requires a fair amount of energy. This can be generated quite easily with an Excess Liquid Tank and a SoltranTM Module (Overhead- Rota-Loo & Soltran cutaway). The stored liquid in the base of the Rota-Loo is drained into an Excess Liquid Tank (ELT) placed in the base of the SoltranTM. The ELT has its own dedicated venting system to allow for maximum airflow over the greatest surface area in the hottest conditions. A stainless steel sheet is placed horizontally in the middle of the ELT. The unit is sealed with a clear sheet of 3mm-polycarbonate glazing on the top. A dedicated fan in the vent pulls the warm air from the apex of the Soltran, across the liquid, which falls onto the superheated stainless steel sheet and quickly evaporates it.

In larger facilities or where high numbers of people are expected or in very cold climates with little possibility of generating heat naturally, other strategies are available such as LPG evaporators. (Overhead- LPG Evaporator). These systems are expensive, around $10,000.00 per unit but are able to convert large amounts of urine into urea salt crystals in only a few hours and at fairly economical rates compared to alternative means of removal.

The Last Word

Now that you have a better working knowledge of the composting process and how the Rota-Loo toilet system is designed to meet the necessary requirements, there leaves for me to mention one last strategy that is filtering through from the research institutions.

"SEPARATE AT SOURCE". This means that where possible separate the urine from the faecal material before they go into the pile. This can be achieved by using waterless urinals and separating pedestals. As mentioned earlier, this will eliminate the possibility of anaerobic conditions, increase the decomposition rate by balancing the C/N ratio and help solve many maintenance issues, some of which I haven't raised as yet such as fly or insect control.
NEVILLE BYRNE
POO TUBES PROTECT THE BUSH

Author.
Neville Byrne - Chief Ranger, Murray Central District, Parks Victoria

Presenters:
Neville Byrne - Chief Ranger, Murray Central District, Parks Victoria Calif John Bath — Army Adventurous Training Unit

Abstract
Now the challenge of Minimal Impact and Leave No Trace can be taken a step further.

No longer do you have to be content with just carrying out your rubbish, using a portable stove, or walking softly through the environment. Never again will you need to look back over your shoulder as you leave a natural area and wonder whether your human waste is a threat to the natural area you have just enjoyed. Now you can take full responsibility to make sure you leave no solid wastes at all in wilderness areas.

Poo tubes have been developed to be the environmentally friendly way to make sure your human wastes are properly treated. Tested by groups from the Australian Army to bushwalking leaders, they have proved popular and given the users a strong sense of satisfaction in further protecting the environment and leaving no trace of passing through the bush.

Introduction
Human waste management in natural areas has traditionally focussed on visitor nodes and high use areas. This usually leads to consideration of the relative merits and operating efficiencies of composting toilets, closed systems, sewered facilities, and even traditional "long drop" toilets.

However visitor numbers are also increasing in more remote areas, as greater numbers of people become confident and familiar with the skills necessary to explore and recreate "away from the bitumen". These remote visitors still create human waste, but toilet development may be inappropriate or impractical in remote and natural areas for a wide range of reasons including aesthetics, zoning restrictions, wilderness qualities or environmental values.

Users of more remote areas with few (if any) toilet facilities also have a high potential to spread specific pathogens (such as Giardia or Cryptosporidium spp) into water sources through current waste management techniques.

Contemporary waste management programs (such as the Pack-it-in-Pack-it-out liner campaign) have focussed on creating an attitude of personal responsibility and action; so why cannot the same ethic be developed for toilet wastes?

For many people, talking about (much less doing something with) bathroom unmentionables is a real turn-off and difficult concept to deal with.
But leaving human wastes in natural areas is no longer appropriate, as the volume of vast eventually builds up and creates contaminated water supplies and soils. Cold climate areas in particular slow the decomposition process and accentuate the problems of waste accumulation.

We need to re-focus our attention onto ensuring that human wastes are not left in remote and natural areas, but rather are transported to facilities that humankind has developed to effectively deal with increasing volumes of human waste.

**Current waste management techniques in remote areas**

For many years, land managers, bushwalking and outdoor clubs, and rucksack publications have advocated the concept of burying human wastes in the bush where there are no constructed toilet facilities. We have encouraged people to dig a hole, make sure the hole is less than 15 cm deep to keep it in the "biologically active zone"-. cover it with soil, and attempt to hide the tell-tale evidence of a toilet site.

At other times we have promoted a latrine-culture to mitigate the cumulative effects of many "cat-holes' by a large groups spending an extended time in one location.

These techniques result in soil disturbance and waste concentration and are inappropriate in the growing number of moderate to high use areas, particularly fragile alpine environments.

Some enthusiasts implore their fellow busbies to even bum used toilet paper. to reduce the potential for unsightly refuse if animals dig up the buried waste.

In fact we know very little about the so-called "biological zone", how deep it might be in different environments, and what are the real rates of decomposition of human wastes in latrines and toilet holes.

A new wave of outdoors persons concerned about the impacts of many toilet holes are advocating that in low use areas, toilet wastes be spread across the soil or rocks rather than being buried. The theory goes that the waste will more quickly dry out and/or be consumed by foraging animals, without soil disturbance by humans or animals. Toilet paper would of course either be carried out or burnt in these situations.

Users of river systems (such as canoeists and rafting parties) are very conscious of not polluting their own drinking water, and have adopted a range of carry-out techniques that include converted ammunition boxes or drums. Overnight ski touring parties have resorted to towing fibreglass sleds with precariously balanced plastic drums that threaten to overtake the skiers on downhill sections with potentially embarrassing consequences.

**A New Approach**

A number of factors have combined to create a novel solution that has the potential to surpass these crude attempts in protecting our bush areas from the effects of toilet wastes.

- Some remote areas, such as alpine areas covered in deep snow, and areas of extensive rock outcrops do not lend themselves to digging shallow holes into a supposed biologically active layers of soil.
A number of groups have expressed concern that we fail to take personal responsibility for all our wastes, rather only concentrating on the relatively easy aspects of litter control.

A third and powerful driver has been the Australian Army striving to develop covert techniques that mask the presence of occupying infantry and other soldiers.

Enter the Age of the Poo Tube. Poo-Tube Development

"Poo-tubes" developed out of a co-operative project between the Australian Alps Liaison Committee (AALC), the Victorian Bushwalking and Mountaineer Training Advisory Board (which trains outdoor leaders) and the Australian Army Adventurous Training Corps.

The AALC provided seed funding and the other two groups developed and promoted the idea with much-needed guinea pigs. In 1996-97, the first prototype was manufactured and trailed on multi-day bushwalking trips and army maneuvers.

The initial squat and rotund tube, while working effectively as a receptacle for the transport of waste material, was too cumbersome and consumed excessive space in already crowded rucksacks.

A number of various were suggested, including the use of heavy duty but flexible rubberised bags to enable the waste to be more easily 'moulded' into the already full backpack.

By 1998, the second generation of poo-tube had emerged. This much-improved model was longer but narrower, enabling it to be easily strapped to the outside of a backpack, avoiding concerns of the potential effects of untimely leakage or breakage of the container. This latest model comprises a 45-50cm length of 150mm polytubing or storm-water pipe fitted at the base with a sealed stopper and at the top with a wide-mouth screw lid. The efficacy of the sealed base and screw lid fitted with a large 'O-ring' seal meant that all smells and any liquid were contained within the cylinder.

Using the Poo-tube
Various techniques were tried and eventually perfected for getting the human waste into (and out of) the poo-tube without contaminating either the user or the poo-tube.

The tried and true method has been referred to as the 'fish & chip' method whereby the waste is deposited on several layers of greaseproof paper and then rolled up like 'fish & chips' before being placed carefully in the poo-tube.

The greaseproof paper provides a reliable, compact and flexible wrapper for the human waste; and is far superior to newspaper which (not only get easily wet and tore at the moment of transfer but also) created too much bulk in the poo-tube. Greaseproof paper was also acceptable for subsequent deposit in septic and sewerage treatment plants on return from the outdoor trip.

The poo-tube is lined with a disposable plastic bag to keep the inside of the tube clean, if the fish & chips package should leak or burst. It is recommended that the plastic bag be washed for re-use, or before discarding into sanitary land-till.
A key aspect of the use of poo-tubes is the safe and effective disposal of the waste on return to 'civilisation'. The contents of the poo-tube can be deposited (by prior arrangement) in a municipal or alpine resort sewerage treatment works, emptied into a septic tank, or progressively flushed down a domestic toilet in small quantities.

Capacity and promotion
The capacity of the poo-tube has proven to be adequate for use by a group of four people on a 3-day trip, or a group of eight on a weekend or overnight trip. In groups, it is always wise to volunteer to carry the poo-tube for the first part of the trip, leaving other party members to share the carrying for the remainder of the trip as the volume in the poo-tube slowly increases with each rest stop or camp.

The concept of carrying-out your personal waste has received only limited promotion to date, with leadership training programs and army exercises being the most common exponents of this ultimate minimal impact technique. All participants have responded well despite initial reservations, and were proud of their extra efforts to leave no trace'.

The development and use of poo-tubes has been reported in Wild magazine, and there have been several enquiries regarding making personal versions of the poo-tube. At a total cost of less than $30 per unit, they are a cheap and effective waste transport system.

**Advantages**

- Poo-tubes have the capacity to significantly reduce the volume of human waste left in remote and cold climate environments, where use levels are growing and natural decomposition rates are impaired.
- The technique provides added protection to mountain catchments against small point contamination sources.
- Poo-tubes are cheap to manufacture, and lend themselves to commercial production.
- The poo-tube is easy to carry, easy to use and easy to clean. It could be simply marketed to the conscientious outdoors person or gear freak.
- Most importantly, poo-tubes engender a strong sense of personal responsibility for properly dealing with a major source of waste and easily builds on other well-accepted waste disposal and minimal impact programs.

As use of remote areas increases, there will be a strong need to mitigate the growing accumulation of human waste in such environments, and to encourage visitors to carry out their wastes to appropriate facilities away from these natural areas. Poo-tubes won't be to everyone's liking, but as they progressively become more common, so will their acceptance as an important component of the minimal impact philosophy.
PROFILE
Dr. Leonie Crennan
University of Technology, Sydney

Dr Leonie Crennan was responsible for the system design and project management of the trial of site-built 'alternating-batch' composting toilets in the World Heritage Area in Tasmania. This project, which was a joint undertaking between the Centre for Environmental Studies at the University of Tasmania and the National Parks Service, was carried out between 1991 and 1996. The systems installed have provided a sustainable waste management strategy in a remote alpine high conservation area since that time. Prior to the design of these systems, Dr Crennan conducted extensive investigation and review of existing composting toilet systems in operation on the East Coast of Australia and a number of major alpine parks in the USA, and in domestic contexts in China and Japan.

Since the Tasmanian project, Dr Crennan has conducted technology transfer sanitation projects in Tonga, Fiji and Kiribati for UNESCO and AusAID. She has also been involved in other environmental protection strategies in the Asia-Pacific region.
RESEARCH INTO THE EFFECTIVENESS OF COMPOSTING TOILETS

Dr Leonie Crennan — University of Technology Sydney

During the late 1980s commercially supplied composting toilets (CTs) were installed on the Overland Track in the Lake St Clair/Cradle Mountain World Heritage Area in Tasmania to overcome problems that included: concentrated visitor presence in sensitive remote areas; degradation of low nutrient vegetation by leaching pits and unconfined faecal deposits; nutrient fed algal growths around campsites and huts; the possible spread of enteric diseases to native animals and human from soil and water pollution from human excreta; and destruction of bushland created by visitors seeking private off the track sites for defecation. Despite the best intentions, the CTs that were installed were not satisfactory - the excreta had failed to compost or break down due to inappropriate toilet design, causing maintenance problems and health risks to staff.

A joint project was commenced in 1991 with the Tasmanian Parks Service and the Centre of Environmental Studies at the University of Tasmania to establish why the existing installations were not performing as expected, and if these problems could not be remedied, then to provide an alternative design. The challenge was to provide sanitary facilities that would better protect the environment from human waste, be acceptable to the visitor and function in areas where very little maintenance is available due to the remote location and limited management funds.

As the problems in the existing toilets could not be remedied without considerable expense and effort, the first trial design was built into the shell of a failed Clivus Multrum installation in 1992 at Pelion Plains. This campsite is the halfway point of the Overland Track and the intersection of many walking tracks. It is a three-day walk from either end of the park and attracts the highest number of overnight campers, including international visitors. The installation of this trial toilet was preceded by 14 months research into dry sanitation techniques in Australia and overseas. Common problems that were observed in existing CT installations, regardless of climatic or geographic conditions were as follows:

- compacted or slurried excreta in the end-product chamber where composted refuse was expected
- awkward and unhygienic maintenance design features
- leaching concentrates due to nil or inadequate provision for liquid run-off
- odours and symptoms of malfunction disguised by battery operated fans
- prevailing 'emperor with no clothes' syndrome - ie staff making an accurate assessment that "the thing just isn't working" but feeling that "eventually it must" or "maybe we just don't understand the mysteries of composting toilets and' cant recognise how it really is working".
- uncomposted excreta being removed from CTs and disposed of by desperate staff in a mariner that threatened their health and the environment.
The trial design concentrated on incorporating the following features and installation conditions: adequate drainage of the pile, simple convection ventilation of composting chambers and toilet room; minimum necessity for contact with the pile by maintenance staff, robust and simple bulking agent requirements, physically and aesthetically easy to inspect pile and empty the end-product chamber, adequate sizing, facilitation of aeration of the pile, provision for liquid run-off, alternating composting chambers to allow problems to be remedied without shutting down the system, and simple to build, install, and dismantle if necessary. The toilet system was designed in consultation with maintenance personnel and the installation was monitored by Parks staff and the author for a range of physical and social indicators.

A second trial toilet was built in 1994 at Pine Valley in a similar high usage alpine location in the World Heritage Area. The site was selected according to need, geographical suitability and relatively easy access (a 30 min. boat ride and 3hrs walk from the ranger station) for comprehensive monitoring. Data loggers were installed to measure temperature changes in the pile and surrounds. User numbers were roughly recorded, and liquid run-off was collected and analysed. Both toilets were trialed in the most demanding circumstances — cold and wet conditions in a high usage remote area.

According to local maintenance managers, both toilets have successfully broken down the excreta pile since installation. All that remains is the 'bulking agent' and any non-biodegradable rubbish that was thrown down the toilet. The bulking agent is added to the deposited excreta to assist with aeration, drainage, and carbon/nitrogen balance in the pile. Further research is required to find an ideal bulking agent for the Tasmania application and to streamline run-off treatment in that alpine location. It is important to use a hulking agent that has maximum potential for decomposition as it maximises the capacity of the system and reduces the requirement for removal of the end-product. Laboratory tests recorded nil or very low pathogen indicators in the pile samples. Personnel removing the first end-product from the fallow pile at the Pine Valley toilet in 1999, four years after installation, were handling nutrient enriched rice husks with an earthy odour and no evidence of human excreta. Although the normal precautions were observed there was minimal risk to health in this activity.

The design has since been used and further evolved in Pacific island countries where shortage of water supply and high groundwater makes traditional sewage treatment such as septics, reticulated sewerage systems and pit latrines inappropriate. The design has also worked well in these rigorous contexts, the only difference being that the degradation process has occurred more rapidly due to the warmer conditions. Dry leaves were used as bulking agent, because they were easily collected from under trees in the vicinity of the toilets. The end-product resembled forest topsoil and the volume was greatly reduced in comparison to piles where rice husks were used due to the rapid decomposition of the leaf bulking agent.

The technology of dry sanitation is relatively simple, as are other on-site sewage treatment methods. The more difficult and critical aspect is community/user/staff education, engaging the support of the local regulatory bureaucracies, and developing the right system for the context. Physical constraints such as geography, climate, access, and availability of biomass for bulking agent are relevant but the human element must be evaluated and incorporated in design considerations.
The following examples are questions that may need to be asked:

- who is going to use these toilets? the general public travelling by bus or car, eco-tourists, campers, bushwalkers, club members? Can they be relied upon to perform simple maintenance tasks such as applying the correct amount of bulking agent after individual use of the toilets, or will it require application by maintenance staff. Are the users likely to vandalise?
- who will maintain the toilet? how often? what is the attitude of potential maintenance staff to composting toilets? have they been included in the selection of an appropriate sanitation strategy, and the design process. 'Ownership' of the facility by staff responsible for management greatly increases the successful performance of the system.

It is advisable to trial one or two composting toilets in a new location or region before general application. Even if the design has been used elsewhere it allows staff and users to become acclimatised and also allows the toilet design to be adapted and evolve with the prevailing circumstances. It is very useful to observe the full cycle of usage, decomposition and end-product removal with its physical and social impacts. Trialing a composting toilet design can takes years especially in high altitude locations but it is well worth the investment of time and patience. There are two many instances of multiple application that have resulted in considerable cost and inconvenience to sanitation managers. It is important to remember that the evolution of composting toilets is in its infant stages. Due to lack of adequate institutional support for on-site sewage treatment strategies, especially dry sanitation options, the research and development to date has been conducted by small businesses and managers of recreational areas, often in response to crisis when the traditional systems have failed or been recognised as inappropriate. Funding is often limited for ongoing monitoring and design adaptation in these contexts, and everyone wants an easy off-the-shelf foot-proof system. There isn't such a creature, yet. But composting toilets can provide a relatively effective method of human excreta management and their use and development should be pursued.

In conclusion, the most challenging component of composting toilet research and development is the cultural and social considerations. All societies have taboos relating to defecation and most people are reluctant to change their toilet habits. It is not just a matter of coming up with a design that protects the environment and treats waste effectively and economically, it is also essential to ensure that people will use and maintain the facility. Unfamiliar technology requires more energy in terms of presenting the facility as the logical and viable choice. It requires pre-installation consultation with staff and potential users as well as ongoing support and education.
PROFILE
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Snowy Mountains
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PROFILE
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THE HYBRID TOILET SYSTEM
GENERAL PRINCIPLES AND SYSTEM DESIGN DRIVERS
Ian Gough & Andrew Gough - Gough Plastics; Mark Langford- Townsville City Council
Abstract
In October 1996, James Cook University, Townsville City Council, Port Moresby City Council, Sustainable Wastewater Technologies and Gough Plastics set out to produce a toilet system ideally suited to the environment of the Asia Pacific Region.

The toilet systems that were evaluated were those in use in many countries. The most common system found was variations of the septic tank system. The authors discussed at length the advantages and disadvantages of composting systems. The conclusion was there was currently no composting system available that was a viable long term alternative. The team then set about utilising the best of all the waste treatment technologies available, in both large and small scale capacities.

In simplistic terms, the Hybrid Toilet System (HTS) consists of a non-flushing drop toilet feeding directly into a septic tank filled with water, which then delivers, via displacement, clarified effluent to the secondary treatment unit. On completion of treatment the effluent is then dispersed to ground via a gravel bed. This paper outlines the processes and construction of the HTS.

1. Introduction

Through his work in Papua New Guinea and remote aboriginal communities in Australia, Dr Paul Turner of James Cook University came into contact with a very poor standard of sanitation. A great need for an appropriate treatment system was identified. Over a four-year period working with Mr Mark Langford of the Townsville City Council and Mr Andrew Gough of Gough Plastics, a process was developed to attack the problem of sanitation. The National Capital District Commission of Papua New Guinea financed prototype testing of the system for application in and around Port Moresby and so the hybrid Toilet system came into being.

During the initial design concept stages we evaluated as many of the current systems as possible, looking at, not only Australian customs and habits, but also many other countries around the globe. The most common system of waste disposal we looked at was the septic tank system. While not ideal and not very successful in most cases, extremely resource wasteful and a high pollution generator it is the system most countries of the world are familiar with. Normally, there is to some extent some form of septic tank management infrastructure.

The team looked long and hard at composting type systems and went part way to designing a new compost system. They found, during their research that, when they looked at the ongoing personal involvement required by the user of the compost toilet, and giving consideration to the cultural taboo's surrounding waste contact in other countries as well as Australia, the conclusion reached was that they could not see them being a long term viable alternative.
Similar to the standard septic tank, the composting systems studied were unable to accept any large amount of shock loading without severe overload occurring.

This paper outlines how the system work, which in simplistic terms, consists of a non-flushing drop toilet feeding directly into a septic tank filled with water, which then delivers, via displacement, clarified effluent to the secondary treatment unit. On completion of treatment the effluent is then dispersed to ground via a gravel bed.

2. Early Development Of The Hybrid Toilet System In Australia

2.1 Methodology
Sub-surface flow gravel bed systems are widely used in Europe and the United States of America (USA); these systems do suffer problems but represent the most cost efficient treatment of partly treated effluents. The goal of this project was to develop a system that required no mains power, and delivered high quality effluent with low Erroll levels. Plastic tanks were used to protect ground water.

2.2 Research and Design
Working with the Department of Primary Industries (DPI), as one of the pilot studies for the development of wetland guidelines for Queensland, one of the authors, Mark Langford, was able to use the four-year studies research and literature as a basis for the secondary treatment unit design. Having constructed and managed the development of SF and SwF systems in the Townsville City Council pilot, this greatly assisted in the adaptation of the systems into the project.

A particular trial "Sewage treatment using Aquatic Plants and Artificial Wetlands" (Roser & Associates 1987) showed that a gravel bed control performed well with no plants present. This system showed the greatest potential for development. Faecal coliform removal was one of the main concerns in dealing with remote communities that use ground water as drinking water. This system looked promising in this regard.

The design of the prototype consisted of a primary tank volume of 770 L and a secondary tank volume of 670 L, tilled with gravel, with an operating volume of 260 L. Gravel used was 10-15mm diameter, flow length was 3.5 m, and depth was 400 mm. The tanks were off-the-shelf polyethylene tanks provided by Gough Plastics as illustrated in Fig.1.
2.3 **E.P Loading and Testing of Prototype**

The system was designed for 10 person [adult] loading, each depositing 200 g of faecal waste and 1 litre of urine per day. This waste consisted of 2 kg of raw primary sludge and not 10 L but 20 L, of effluent to mimic a high sludge level in the primary tank at full load. Effluent dosed was of a quality of 30 biological oxygen demand (BODs), 30 total suspended solids (TSS) and Knoll of 400,000 colonies/per 100 mL representing a higher loading than urine would represent. Each day 2 kg of sludge and 20 L of effluent was dosed at one time, on the weekends the unit would be dosed with a pump and timer system, pumping raw sewerage to the unit with a loading of 300 mg/L BOD5 and 250mg TPSS shock loading the unit. Effluent detention in the primary tank was 35 days, before flowing to the secondary tank, for a further 11.8 days of treatment The gravel bed design was a conventional one, two baffles were used to cut down on short circuiting and a small solar powered fan assisted air flow across the gravel bed.

3. **Test Results after Three Month Trial**

The primary tank was seeded with 40 L of digester sludge on 31st January 1997 when dosing started; the system was left to dispel plant effluent from the secondary tank before testing was commenced. It can be seen that there was a slow decrease in quality over time, testing on the 26th March 1997 was ten days after a malfunction of a timer controlling a dosing pump. Instead of 20 L of raw sewage being dosed per day, approx. 60-80 L was dosed per day for three days. This represented three times the volume. The effluent results were still good, but there was a ten fold increase in Fool( levels due to hydraulic overload [80 L = 80 person use].

Raw sewage was used as a loading factor as it represented a highly soluble waste that would travel faster through the system and impact on the effluent quality. Using primary sludge in this situation it would settle quickly and lack the soluble waste required to shock the treatment system. Pit toilets and flushing septic systems have effluent levels of as high as 300 mg/L BOO and E.coli of 600,000 — 800,000 colonies/100mL. As seen in Table 2, the prototype effluent is of better quality and has less impact on ground water than a standard septic system.

The effluent from the unit was observed to have a bio-film carry-over that may represent the BOD loading. On further investigation, a pond area just inside the secondary tank outlet was found which grew a scum that discharged as effluent passed through it. It was agreed to install a small pea gravel bed of 4 to 5 mm dia. at the outlet. This modification proved successful and was included in the final system.

The results gave an indication that the system had good potential and was worth redesigning. The points to be improved are listed below.

**PRIMARY TANK**

1. Extend sludge and effluent detention i
2. Redesign lank outlet pipe to minimise carry over [solids]
3. Design nestable tank for transport [Gough Plastics]
SECONDARY TANK
1. Improve flow system to completely stop any short-circuiting
2. Effluent to flow though aerobic and anaerobic zones
3. Vertical, horizontal and rotational flow design
4. Nitrification and denitrification and maybe P removal
5. Detention time increase to reduce E.coli levels
6. Increase evaporation out of the unit
7. Design nestable tank for transport Gough Plastics

As a result of die trials the various changes were made to the system and its operation

4. Modifications to Original System
4.1 Primary Tank Design Changes
The primary tank volume was increased to 900 L. which gave an effluent detention of 45 to 75 days at full sludge level, 10 days longer than previous trial. This extended volume gave approximately a three to five-year period before a sludge pump out is required. A sludge gauge, as shown in Fig.2 was designed to accurately show the level of sludge in the primary tank.

Figure 2 “Sludge Gauge”

The outlet dropper in the primary tank, shown in Fig. 3, is designed with a vertical face intake bend. Solids can rise and fall without entering the outlet, so stopping solids carry-over and reducing loading on the secondary system.

Figure 3 "The outlet dropper"
4.2 Secondary Tank System
The flow path was dramatically redesigned to combat short-circuiting and to control effluent entering and leaving treatment zones. "This was seen as a major break through in the system. The effluent flows down a 100 mm pipe to the bottom of the first gravel column 380 mm in dia. and 950 mm in depth. Effluent then flows upward through the column to the top and crosses into second 500 mm dia column of gravel. Effluent then travels down to the bottom into the final gravel column on the opposite side of the outlet, then navels 950 mm upwards and around to the outlet. The path of the effluent is shown in Fig. 4. From this flow path, the effluent is subjected to anaerobic and aerobic treatment zones creating nitrification and some denitrification. Oxygen is supplied to the gravel surface by natural and assisted ventilation by means of a solar powered fan. This air movement also increases the evaporation rates from the system by up to 50% and greater depending on climate. The pipework layout also vents odours from the drop toilet. Detention times were increased to 25 days with a standard loading of 12 l. per day and greater dependent on evaporation. The tank volume is 600 L. which when filled with gravel has a volume of 300 l.

4.3 Pathogens
The holding time in the system was increased to encompass the life period of most pathogens. and decrease water born disease by using the Hybrid as a sanitation barrier in remote communities. {Ref; WHO Data}

4.4 Hybrid Gravel Bed Loading
As the gravel bed system is unique in its design, only standard subsurface flow wetland guidelines and loadings can be applied to this system in regards to clogging as by Crites. Nolte & Associates 1992. The gravel bed has a surface area of 0.6 m2 and a depth of 950 mm. Normally SF wetlands are around 500 mm in depth and are plug flow systems.

5. The Results
5.1 Primary Tank Effluent
Using the results obtained from the prototype above, loading rates can be applied to the hybrid gravel bed. The aim was to investigate any short-term risk of clogging in the gravel bed. The recommendations to prevent clogging require a maximum of 200 g m2 BOD5 and 80 gm-2 TSS.
1. Hybrid Loading Rates

<table>
<thead>
<tr>
<th>Volume</th>
<th>BOD5</th>
<th>SS</th>
<th>Anti-clogging maximums</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>216 mg L</td>
<td>186 mg L</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>BODS Loading 200 g</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TSS Loading 80 gm</td>
</tr>
</tbody>
</table>

As seen above, the BOD loading is well under anti-clogging levels. There appears no risk of clogging and an extended life is expected with such low loadings on the system. Algae and root clogging have no influence, as the gravel bed is totally enclosed in a tank.

Table 2 Hybrid Effluent Results {Rock & Gravel test unit;}

<table>
<thead>
<tr>
<th>Date</th>
<th>BOD5</th>
<th>NFR</th>
<th>E.coli/100 ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.06.97</td>
<td>15</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1.07.97</td>
<td>22</td>
<td>17</td>
<td>120</td>
</tr>
<tr>
<td>16.07.97</td>
<td>24</td>
<td>5</td>
<td>55</td>
</tr>
</tbody>
</table>

Dosing started 12th May 1997. and to ensure treated effluent used to fill the secondary unit was dispelled, a period of 36 days elapsed. The first test results on the 18th June 1997 indicate the last of the effluent used to fill the unit. After this point true effluent results can be seen in Table 2. The Hybrid unit was fully loaded at 10 EP through out the testing. The Prototype was shock loaded with a lower effluent detention period and a conventional gravel bed. As the Hybrid unit has a greater effluent detention period with a totally redesigned gravel bed system, it was able to take overload periods and buffer the load through its extended treatment process of 75 to 100 days of effluent contact in the unit.

The Townsville City Council, James Cook University, National Capital District Commission of Port Moresby, Mark Langford and Gough Plastics class the Hybrid unit as an ongoing project. The process has been patented with respect to its application in the water and wastewater industry here in Australia and overseas.

5.2 Final Results

The end result of our research was a waste treatment system with the following design requirements:

1. The method of waste removal had to be able to be easily performed without personal contact by either the waste removal contractors, where available, or by the user, in remote areas.
2. The frequency of waste removal had to be measured in years, approx 5 - 7.
3. There had to he a simple reliable method of measuring the sludge volume in the unit, which would indicate both the volume required for removal and the date of removal.
4. The unit would require no flushing water.
5. The systems has to be loosely based around the known technology of the septic tank and the potential existing infrastructure
6. The inherent ability to accept infrequent but potentially severe overload situations.
7. The ability to fit into a structured data based controlled waste removal control program, which could be overseen by the relevant local authorities and or operated by the authority.
8. Design a system that was as low profile as possible.
9. The entire treatment process had to be completed within the system and be totally isolated from high water tables and high rainfall and on discharge, have the absolute minimum impact on the surrounding environment.
10. The system had to be cost effective, be easily transported, assembled, and have an exceptionally long product life.

From the results, the authors believe they have managed to achieve all of the above and far more.

**Monitoring**
As part of the package that is offered with this system, a monitoring program is also available. Monitoring includes the installation of counters on the doors, and monitoring the level of sludge build-up in the primary tank using a sludge gauge. These data are recorded on a spreadsheet every month and a pump-out time can be predicted in advance, and this also highlights any necessity to install additional units.

**Size and Costs**
The technology has now been utilised into a number of different sized systems. Currently they are 6, 10, 25, 50, 100 & 150 EP units. The authors have always considered the HTS suitable for large-scale application and the following table outlines the relevant costs.

**Price Per Person Per Day (over 5 years) for 10,000 people.**

A Population of 10,000 people would require 66 x 150 EP HTS This cost would be $1.2 million total
To achieve a Per person per day, you divide $1.2m by 10 000 people $ 129.27 divide this by \((365 \text{ days} \times 5 \text{ years}) = 1,825 \text{ days}\) = $0.070 per person per day over 5 yrs

**Conclusion**
For many years people have searched for a solution to fill the void between sewage treatment plants and pit toilets. "the authors believe the I hybrid Toilet system offers this on-site solution. The HTS can be left unattended for extended periods of time, cope with greater than 100% overloads, handle floodwater intrusion, effectively captures parasites forming a faecal-oral disease barrier, and requires minimal maintenance.

As a testimony to the design outcomes of the unit, Hybrid Toilet Systems are now installed and operating in two of the worlds finest National Park Islands; Hinchinbrook and Fraser.

Continued research and development is currently working on greywater treatment, an on-site wastewater stream not processed by the HTS. Together with plans for the world's first Rotationally moulded mains pressure Solar Water I 'cater, it is hoped that by combining these three products together, the results will deliver extremely good effluent quality from a single unit that treats both blackwater and greywater.
From this research and development, today's I-ITS evolved. The company that owns the worldwide patent rights is called Pacific Waste Technologies, made up of Gough Plastics, James Cook University, Sustainable Wastewater Technologies. Townsville City Council and the National Capital District Commission of Port Moresby.

9. References

IAN GUNN
PROFILE
Ian Gunn
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Ian Gunn lectured in environmental engineering at The University of Auckland for 29 years up to 1997 after 11 years professional experience. He has been involved in the on-site wastewater management area for over 30 years, travelled extensively internationally studying technology and practice, been involved in developing NZ and Australian Standards in this area, authored the NZ design manual for on-site systems, and presented papers at numerous conferences in NZ, Australia and the US in the on-site wastewater management field.
REMOTE AREA HUMAN WASTE MANAGEMENT - THE NEW ZEALAND EXPERIENCE

Ian Gunn - Environmental Engineer, Auckland UniServices Ltd, New Zealand

Abstract

The NZ Department of Conservation (DoC) has responsibility for managing extensive visitor facilities throughout the country's national and forest parks. These encompass a wide variety of land and water-scapes including alpine, mountain, upland and lowland forest, river, and coastal and lakeside areas. Human waste systems for remote areas include a range of drum toilet and lift-out systems, vault toilet and composting toilet systems. A key element in provision of "dry" toilet systems is achieving a user friendly environment incorporating effective venting for odour control. Based on a review of local and overseas (North America) experience, DoC has produced a concept and design manual together with a set of site and system selection guidelines. Case studies based on local and US experience provide a useful information resource in the manual.

Introduction

Management of human waste in remote areas is of particular concern and interest to the New Zealand Department of Conservation through its responsibilities for managing the conservation estate throughout the country, including national and forest parks, scenic reserves, and the national walkway system. Facilities include picnic areas adjacent to parking at road accessible reserves, rest and picnic stops on walking tracks, basic camping sites at foreshore, roadside and walk-in locations, and overnight hut accommodation on walking tracks and mountain climbing routes. DoC staff throughout the country have shown an innovative capacity to adapt traditional techniques and evolve new ones in achieving environmentally effective solutions in areas remote from normal servicing locations.

In the early 1990s DoC was faced with increasing visitor numbers throughout all areas under its management, and was conscious of the inadequacy of many of the pit toilet systems for remote area locations. Composting of solid waste to provide a more environmentally and user-friendly operation, while at the same time producing a mature product with easier and lower volume handling costs, seemed a good idea. A research project was initiated with Lincoln University to examine the operation of a solar assisted compost toilet unit in a remote alpine walking track location. A further research project with The University of Auckland was set up to review all aspects of human waste servicing. The key output of this project was the production of a concept and design manual [Ref 1], followed by a set of system selection guidelines [Ref 2].

Review of USA Experience

US National Park Service: During the 1980s the Rocky Mountains National Park carried out studies into solar toilet systems to service high altitude remote area hiking and climbing trails [Ref 3]. The challenges were cold temperatures, high winds, and a four month summer season resulting in some 5000 uses/toilet. The aim of the programme was to replace the 300 litre capacity bucket fly-out system and avoid the use of helicopters which were expensive to operate and subject to hazardous flying conditions at high altitudes and windy conditions. The objective was to de-water and consolidate human waste for carry-out by pack animals.
The typical toilet system is based on separation of urine and faecal solids, 'solar warmed air
drying of the solids pile assisted by photocell powered fan venting, and a cascade of evaporative
trays to deal with liquid. Solids wet weight is reduced up to 70%, and the wood shaving pads
that wick up the urine on the evaporator trays allows moisture to pass into the wind induced
airflow across surface of the trays.

The most critical factor in ensuring the success of this solar toilet system is regular and
informed maintenance. Weekly visits during high season use are essential to provide toilet
paper, clean the unit, ensure all equipment is functioning, and to monitor solids build-up. The
contents of the solids container is shoveled into triple plastic bags and sealed, then stored until
packed off the mountain. Llamas, with their good nature and special training as pack animals,
have proved more acceptable to both maintenance workers and the user public than pack horses.

This type of system is less applicable to wet climate conditions as in NZ than the dry climate
summers of the Rocky Mountains [Ref-1]. Recent units have no roof in order to reduce the wind
profile. although the windy conditions are a distinct advantage in evaporating liquid from urine.
The success of the Rocky Mountains units has been the commitment to maintenance, and
selection of a technology consistent with the local environment. Where the same unit has been
trialed outside the Park, it has not been successful due to a lack of maintenance commitment.
No trials have been undertaken in NZ to date.

US Forest Service: The San Dimas, California. Technology and Development Centre of the US
Forest Service has investigated the use and development of vault toilet systems for remote areas
over some 20 years. Its key findings have been on odour management via ventilation. By
constructing the toilet user compartment with a special air vent inlet and providing a 300 mm
diameter vent pipe placed to maximise wind shear suction, a fresh air flow into the compartment
achieves odour free conditions. This unit is termed the SST (sweet-smelling-toilet). Wind tunnel
testing confirmed the importance of wind shear airflow compared to solar assisted airflow, and
the Service has produced a design manual incorporating their venting principles [Ref.4]. The
SST units are now manufactured commercially in Oregon, with pumpout vaults. The DoC NZ
manual has incorporated the venting principles of the SST, and the new wind shear venting
arrangements are being incorporated into pit privy units, pumpout vaults. and compost toilets.

**Review of New Zealand Department of Conservation Experience**

During the 1993/94 research project at The University of Auckland, a survey of DoC staff
throughout NZ was undertaken to obtain information on existing practice. The results of the
"dry" toilet systems (waterless toilets) survey are set out in Table I.

Respondents were asked to rank the success of the units on a 10 point scoring system based on
four items. environmental protection, user convenience, economics, and case of
cleaning/maintenance [Ref. 1]. The table ranks these in increasing order of success index and
the table entries reflect the state of typical servicing success as of 1993. Replacement systems
were planned for several of the low scoring systems, with fly-out drum toilets proposed for high
altitude systems where rock cavity disposal had been practiced over the years.

<p>| Table 1: Waterless Toilets Survey Results (1993) |</p>
<table>
<thead>
<tr>
<th>Location</th>
<th>Site</th>
<th>Capacity</th>
<th>Details</th>
<th>Success Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Egmont National Park</td>
<td>Kapuni Lodge, new and old Syme Huts</td>
<td>10/day peak use</td>
<td>Dry vaults, details unknown (possibly pit toilets)</td>
<td>28%</td>
</tr>
<tr>
<td>2. Egmont National Park</td>
<td>Holly, Pouakai and Waiaua Huts</td>
<td>30/day peak use</td>
<td>Crude pit toilets, buildings relocated</td>
<td>33%</td>
</tr>
<tr>
<td>3. Franz Joseph Glacier, West Coast</td>
<td>Almer Hut (1700m)</td>
<td>12 beds; 100 bed nights/yr</td>
<td>Pit toilet ins natural fissure</td>
<td>42%</td>
</tr>
<tr>
<td>4. Mt Cook National Park</td>
<td>13 huts throughout Park</td>
<td>20 to 1000 per year</td>
<td>Open pit toilets where frozen material is shoveled into drums for lift-out (moisture drains locally)</td>
<td>45%</td>
</tr>
<tr>
<td>5. Fox Glacier, West Coast</td>
<td>Neve Hut (2400m)</td>
<td>30/day peak use</td>
<td>Mini-vault toilet using rubbish bag — sealed and placed in crevasse.</td>
<td>53%</td>
</tr>
<tr>
<td>6. Glenorchy. Otago</td>
<td>Routeburn Falls Hut</td>
<td>60/day peak use</td>
<td>&quot;Soltran&quot; composting toilet, solar ventilation and liquid evaporation, summer operation only</td>
<td>58%</td>
</tr>
<tr>
<td>7. Nelson Lakes National Park</td>
<td>Nelson Lakes camping area</td>
<td>500/day peak use</td>
<td>23 pit toilets on porous soils; molly</td>
<td>70%</td>
</tr>
<tr>
<td>8. Lake Tarawera, Rotorua (see also No. 8A below)</td>
<td>Hot Water Beach campground</td>
<td>50/day peak use</td>
<td>Toatrone and Ecolu composting toilets installed side by side under trial (development phase)</td>
<td>73%</td>
</tr>
<tr>
<td>9. Franz Joseph Glacier, West Coast</td>
<td>Castle Rocks Hut (1200m)</td>
<td>4 beds; 20 bed nights/yr</td>
<td>Pit toilet using natural rock fissure</td>
<td>75%</td>
</tr>
<tr>
<td>10. Lake Waikaremoana</td>
<td>Hut and Walking tracks</td>
<td>200/day peak use</td>
<td>10 units ventilated concrete/plastic lined vault systems with portable vacuum pump and tanker unit</td>
<td>85%</td>
</tr>
<tr>
<td>11. Mt Cook National Park</td>
<td>Kelman Hut, Tasman Glacier</td>
<td>1400/year</td>
<td>Ventilated vault using 450 litre fly-out drums; evaporation being considered</td>
<td>85%</td>
</tr>
<tr>
<td>12. Kaueranga Valley, Coromandel Forest park</td>
<td>Pinnacles Hut</td>
<td>50/day peak use; 10,000 a year</td>
<td>Ventilated vaults using 500 litre fly-out drums. Hot-box attic ventilation (more systems planned)</td>
<td>88%</td>
</tr>
<tr>
<td>8A. Lake Tarawera, Rotorua</td>
<td>Hot Water Beach campground</td>
<td>200/day peak use</td>
<td>Upgraded Ecolu (fibreglass)and Bioloo (plastic) large capacity compost toilets</td>
<td>98%</td>
</tr>
</tbody>
</table>

**Venting Technology for Vault Toilets**

Under moderate temperature ranges pit and vault "dry" toilet systems can be odorous and insect ridden and distinctly user-unfriendly. In cold and high altitude conditions low to freezing temperatures limit such problems, work of the US Forest Service San Dimas Technology and Development Center has provided the most authoritative principles for sound venting technology aimed at all but eliminating odours [Ref. 4]. Their guidelines have been incorporated into the NZ design manual [Ref. 1]

The main cause of odour impact on users is the reverse flow of air from the storage compartment of vaults and pits up the toilet riser into the user compartment, the exact reverse of that intended by the ventilation system. Overheating of user compartments due to sun exposure can draw cold air down a vent pipe through the waste area and up the pedestal; turbulent external air flows across high level wall vents can create similar back pressure down, instead of up, the vent pipe.

Adopting the principles for effective venting results in a user compartment with a single wall vent
of specified size and a location determined by the prevailing wind direction, together with a vent pipe of 300 mm diameter and rising straight from the vault to terminate 1 metre
above the highest point on the roof. The wall vent enables wind to pressurise the compartment, and the vent pipe delivers a wind shear suction within the vault. Thermal assist can be provided to the vent pipe by aligning it to the sun, and enclosing the pipe to around eave level in a black painted sheet metal shroud. The shroud creates a warm air column around the vent pipe while sheltering it from any cooling breezes. This venting system is equally applicable for pit, vault or composting toilets. The SST (sweet-smelling-toilet) vault system is made commercially by Romtec in Oregon for the US market, and is based on a pumpout vault which can be serviced in remote areas by 4WD ATVs and pumpout trailers. Vaults are charged with a 250 mm depth of water into which the solid waste pile submerges as it grows, thus controlling odour generation from exposed waste. Rain water entering the vent pipe is thus beneficial in maintaining water cover. In heavy rainfall areas where pits and composting toilets need to be protected from moisture ingress, a plate cover can be provided, but designed so that the wind shear effect across the top of the 300 mm vent pipe is interfered with as little as possible. For NZ high rainfall areas a sleeved water seal gutter on the vent pipe provides capture of rainwater moving down the internal surface of the pipe.

Composting Systems

The Routeburn research: The Falls Hut on the Routeburn Track in Mount Aspiring National Park was provided in 1985 with a two unit Soltran compost toilet to gain experience in composting systems for remote areas. Hut occupancy is around 5000 user nights over a 200 day season, and the toilet produces some 800 to 950 kg of compost per year. The Soltran is designed to drain urine into separate evaporator tanks warmed by solar convection, with warm air continuing into the compost chamber to provide heat support to the compost pile, and thermal ventilation of vapour to atmosphere. Paul Chapman, with a background as a DoC field officer, undertook a detailed investigation of the unit during the early 1990s as a university research project sponsored by DoC Ref. 5]. He found that contrary to expectations, the temperature in the compost pile did not rise much above ambient, and thus heat generated in the solar chamber was not being transferred to the compost chamber. The cause was that water vapour carried from the evaporator tank condensed in the compost chamber, adding to the total moisture content of the solid material, and that subsequently the heat gain from condensation was lost from evaporative cooling. That evaporative cooling is further accentuated by the high air flows needed for odour control venting, and thus surplus heat removal maintains composting temperature close to ambient.

Key composting design and operational factors established by Chapman include provision for separation of urine and faecal matter, addition of bulking material, and control of loading relative to exposed surface area on the compost pile. Of greatest significance was the loading regime. The one month load, three months rest for each of the four carousel compartments of the Soltran was changed to 3 weeks load. 9 weeks rest in order to produce good compost via thinner active composting layers. Ambient temperature is critical to determining composting rate, and temperature sets the overloading limit. He was able to predict user level capacity against ambient temperature in order to prevent overload. It was also found that degradable bulking material (such as leaf litter) produced more heat energy than non-degradable material (such as sawdust), but resulted in structural collapse and compaction of the pile, inhibiting air access for maintaining aerobic conditions.
Hotwater Beach, Lake Tarawera: The initial trial of compost toilets at this remote area lakeside camp site near Rotorua was set up in 1992/93 to deal with high watertable impacts on traditional pit privies. Two systems based on the Clivus Multrum concept were installed, the Toatrone imported Swedish unit, and the Ecolu, a locally manufactured unit in fibreglass (Table 1, No. 8). Each unit was installed with an excess liquid drain, and 150 mm vent pipes 600 mm above roof line fitted with H shaped cowls [Ref 1]. The units have been monitored and upgraded over the last several years (Table 1, No. 8). The smaller household Toatrone has been replaced with a local unit of larger capacity, the small diameter liquid drain holes replaced with 100 mm diameter low-level air inlet, and the vent pipes increased to 200 mm diameter to achieve wind shear venting. The original loading rate of 50 persons/day has now reached a short term peak of 200 persons/day [Ref. 6]. The key to successful operation and performance is regular maintenance by DoC field officers. This involves daily 10 minute visits at peak loading to add bulking material (native timber sawdust and long grass), check and level pile height, clean the unit, clear spider webs from vent inlet and outlets, and top up toilet paper. Monthly service is satisfactory during winter, and weekly service at either side of the peak in summer months. Mature odourless compost is cleared annually, with tests showing complete reduction of faecal bacteria. The compost is thus used as an above ground mulch for a native tree planting programme in the camp site vicinity. Regular and informed maintenance is vital to ensuring communal compost system success.

**Design Manual Guidelines for NZ**

The provision of a design manual could be somewhat presumptuous if it presented a static view of technical rules. The fact is that DoC field officers throughout the country have used specialist trade and professional skills to couple local experience and innovative ideas to come up with solutions for specific servicing challenges. DoC case studies and trials have achieved considerable success in local situations that could never have been obtained by following design rules alone, and hence the design manual was developed by combining design principles and concepts alongside case studies from NZ wide experience. Servicing options are listed and illustrated alongside their technical features and benefits/constraints in use, with limited sizing criteria provided. Venting principles are dealt with in detail, composting principles explained, and commercial compost units contrasted with Paul Chapman's ambient temperature unit based on his research findings. Wet vault and waterborne wastewater servicing systems are also covered, and case studies based on US National Park, Forest Service, and Army Corp of Engineers remote area facilities are set alongside DoC case studies as presented to a 1994 national workshop of DoC staff and advisers.

The problem with such a design and concept approach is the lack of specific direction in system selection for less experienced officers in the field. Guidelines for site and system selection require consideration of three elements, user requirements (and loading), site and environmental constraints, and technology and servicing options. Because of the considerable complexity in matching multiple requirements across these three elements, the guidelines set out a four stage process in narrowing down system selection. A multi-choice decision chart listing visitor facility, site/environmental characteristics, and servicing system, is supported by two further decision charts, one linking servicing solution and visitor facility, the other linking servicing solution and site/environmental characteristics. A four stage process is proposed to first, match visitor facility with site characteristics, second, to match visitor facility with technologies, third, make preliminary selection of options, and fourth, peer review the selected options by experienced staff. The guidelines are provided to assist in
decision making, but it is emphasised that there is no substitute for use of knowledgeable and experienced personnel in achieving appropriate system selection [Ref. 2].

References
PROFILE
Sarah Holmes Area Coordinator
Outward Bound Australia, ACT
OUTWARD BOUND AUSTRALIA WASTE REMOVAL METHODS
Sarah Holmes - Outward Bound
History of Outward Bound
Outward Bound is a non-profit, outdoor education organisation that was conceived after World War II in England, by a German named Kurt Hahn.

It developed through the need for people to get life experience by discovering more about themselves, learning skills and increasing their confidence to cope with the hardships of life.

Today Outward Bound Australia (OBA) operates in over 48 countries around the world and in over 10 mobile areas around Australia. OBA offers courses for all ages and all walks of life. Courses are run in a range of environments from coastal, to alpine, to tropical.

Due to the huge range of environments we operate in, and the large numbers we can operate with, we are very conscious of the potential impact we may have on the environment.

Most courses incorporate a river component and many utilise set campsites which can suffer from what we call ‘poo land mines’ (ie Too many pit toilets dug by the groups at that site). In consultation with National Parks, land owners and at our own discretion, we have trialed and used different types of waste removal methods to reduce this impact

Poo Tubes and Bomb Canisters
Two types of waste removal methods are used. One designed specifically for skiing expeditions where the waste is carried by the instructor and the other for drive in locations or on the river.

Poo Tube
In consultation with National Parks, it was decided that all waste had to be removed and carried out, to either he placed in a long drop or in a septic system. The poo tube was designed by an OB staff member specifically for ski courses and trialed on ski expeditions. It was designed to be:

- Lightweight, sturdy and shaped to fit on an instructor's pack to be carried
- Easy and hygienic to be used by the participants
- Easy and safe to empty and dispose of waste.

Construction
- PVC piping (5mm thick)
- Sealed at both ends by screw on, rubber sealed lids (access from both ends)
- Diameter of 100 cm and length 96 cm
- Volume 0.75 m³
Use
1. Place paper towel on rock or compacted snow
2. 'Poo'
3. Wrap it up in paper towel
4. Place it in the tube

Emptying
1. Use protective clothing — long, thick rubber gloves, goggles, face mask
2. Open both ends and slide into long drop or septic
3. Hush out with water and disinfectant

Strengths
- Easy to carry (needed 2 for group size 10 for up to 6 days)
- Little handling by participants
- Easy to empty

Weaknesses
- Emptying into long drops/septic is not 100% hygienic (risk to emptier due to splash factor)
- Residue in tube
- Not necessarily suitable for diarrhoea
- Need to be aware of gas build up

Bomb Canister
Bomb canisters are the most frequently used method of waste removal. They have been used for approximately 7 years. They are usually dropped to a campsite or carried on the river. They are designed to be used anywhere, but not carried by the group. They are difficult to purchase or obtain—0B has had difficulty buying them recently, but occasionally comes across them in Army surplus stores etc.

They are designed to be:
- Strong and durable enough to be carried in the back of a cruiser
- Easy to be used by participants, ie can sit on them or squat above them
- Completely sealed
- Pressure valve

Construction
- Steel bomb canister
- Pressure valve
- Sealed at one end, lid at the other

Use
1. Open lid, place layer of toilet paper, then 'poo' (no urinating)
2. Cover poo with toilet paper
3. Replace lid

Emptying
1. Use protective clothing — long, thick rubber gloves, goggles, face mask
2. Open lid
3. Tip into long drop / septic
4. Clean out with disinfectant and scrubber
PROFILE

Michael Ivill NSW NPWS
Field Supervisor Tumut District / South West Slopes Region
Michael's career began in the ACT Parks Conservation Service where he was employed as a Ranger working in most of the reserves and in Namadgi National Park and then at head office managing a volunteer program.
Michael left the ACT in 1993 to pursue a Ranger career with the QLD National Parks & Wildlife Service, where he was employed as Ranger in Charge of a sub district attached to the Great Sandy Management unit in Maryborough. His duties included maintaining facilities, such as campgrounds, picnic grounds and associated works.

In 1995 he was lured back to NSW and took up a position in Dorrigo National Park with NSW National Parks & Wildlife Service as a Field Supervisor in charge of field operations. He later moved from Dorrigo to his current position in Tumut District.
TOILET DESIGN & TECHNOLOGY IN KOSCIUSZKO NATIONAL PARK - WHAT WORKS, WHAT DOESN'T
Mick Ivill — NSW National Parks and Wildlife Service Introduction
Kosciuszko National Park is one of the most diverse and unique conservation reserves in the world. This uniqueness draws visitors from not only Australia, but from many other countries.

An unavoidable fact of life for park managers is visitor's impact on the resource being managed. This impact could be rubbish left in a campground, a walking tracks eroding because of over use, or toilet waste. In the northern part of Kosciuszko National Park we have over 30 toilets, these toilets are in campgrounds, picnic areas, and backcountry locations. The average size of these toilets tanks are 2,5000 litres, and are usually pumped out by waste contractors on a yearly basis. Tumut District over the past 3 years have been changing these pit toilets into systems that contain the waste both solid and liquid into plastic tanks that are pumped out.

Pit Toilets
A traditional pit toilet in Kosciuszko National Park consisted of a hole in the ground, over which a concrete slab, frame, pan and seal and roof were installed. These toilets were notoriously smelly, the pit contents leaked out into the surrounding ground water, and the frames were prone to vandalism and weather Maintenance on these units was high. Pumping these toilets out was also very difficult as the liquid waste usually leached away leaving the solid waste in a hard block. This required the toilets to be filled with water 2 to 3 days before the toilet was pumped out so complete pump-outs were possible. Again this was very maintenance intensive

Changes in environmental legislation and more effective toilet design have meant pit toilets have no place in modern National Parks. This has brought about the new designs in toilets. composting and sealed tank units.

Composting Toilets
There are many different designs of composting toilets, all of which have application in modern natural resource management. At this point I won't go into the use of composting in Northern Kosciuszko.

Sealed Tank Toilet
This type of toilet is really on an upgraded version of the pit toilet. The major changes are in the frame which has gone from wood to steel, ventilation pipe in larger, fume extractor fitted to top of vent pipe and all waste goes into a 4mm thick plastic tank buried underneath the floor slab. The advantage of this unit over previous designs is
Reduced maintenance due to steel frame and sheeting
Reduced smell due to extractor vent on roof
• Reduced vandalism due to frame sheeting easily replaceable • All waste both solid and liquid is contained and taken off site

Construction of Sealed Tank Toilet
The NSW National Parks & Wildlife Service require a Review of Environmental Factors (REF) to be completed before any construction can begin. Once this approval has been granted a site is chosen bearing in mind slope, aspect, surrounding drainage and location to facilities.

Stage 1
A hole is dug to accommodate a 3,700-litre tank (see above) with about 300-millimeter gap around tank to accommodate concrete and gravel. Once the hole is completed the haste of the hole is lined with fine gravel (crusher dust) and is spirit leveled flat. A sheet black builder's plastic is cut to the diameter of the hole and placed over the crusher dust.

The tank is checked for leaks, the lid is sealed and there are no weak spots in the wall of the tank. The tank is then lifted into place and the level is checked again to ensure flat even surface.
A concrete base about (2.1 meters) is poured in to the hole to about 30% of the total height of the tank. This concrete anchor holds tank in place and the weight stops ground water from pooping the tank out of the ground. The remainder of the sides of the hole is filled up to the top of the tank. The crusher dust is then dampened with water and compacted to ensure snug fitting of tank in hole.

A lid is then place over the opening in the top of the tank to stop gravel from filling the tank and the crusher dust is brought up to the very top of the tank. The crusher dust should be then watered again and left to settle for about 24 hours.

**Stage 2**

The site around the tank should be leveled by dumpy level ready for the concrete formwork, which will eventually become the floor slab. The slab should be big enough to accommodate a wheel chair and allow the chair to turn around before entering the toilet. Once the site has been leveled the formwork is constructed to a depth of 250 min thick and should include a path 1500-mm wide to allow a wheel chair access to the toilet. Again the level should be checked on the top of the formwork which will he the top of the slab or floor.

Once this has been completed the concrete reinforcing mesh is cut and placed on a bed of crusher dust over the top of the tank. The fiberglass toilet pan and seat and IOOND poly vent pipe is then cut into the hole in the top of the tank and secured in place. The pan will be pushed in to the concrete once poured this will hold this in place. The concrete is then poured; it is recommended that concrete standard is 20 mpa this binds to the reinforcing mesh creating a strong slab.

The slab is finished of to a slightly rough surface to stop slipping if it becomes wet. This slab is now left to dry for 48 hours. Covering the slab with plastic is recommended to stop the concrete from drying out to quickly. This will ensure a slab that is completely cured and crack free, thus reducing expensive maintenance later on

Once slab or floor is cured the frame is bolted to the slab using M12 dynabolts, four bolts per corner of slab. The door closer springs (Zenith 300) and padbolt are attached to the door.

To finish of the frame the toilet is clad in colour of choice colourhond roof and wall sheets and ridge capping. The roof is also finished with 2 sheets of clear polycarbonate these replace the normal roof sheets. This allows light into the toilet. Finally the turbo vent is placed over the vent pipe to extract smelts from the tank; this reduces the smells inside the toilet. The area around the toilet is restored with straw hay and appropriate grass seed is then applied.

**Acknowledgments**

Thanks must go to NPWS employees Bernie Heath, Tony Stubbs and Andrew Baker for taking our toilet system from a timber framed toilet with a hole in the ground, to our current pump-out system. Tumut District is extremely happy with our toilet design as it not only provides a high standard of public facility, but it also brings us into alignment with State and Commonwealth Environmental pollution regulations.
PROFILE
Garry Kerans Managing Director Integrated Eco Villages
Integrated EcoVillages specialises in the design and construction of innovative wastewater treatment systems and associated building structures.

The company has installed composting toilet systems in a number of locations within the region, including Namadgi National Park as well as a unique cold climate system at Charlotte Pass.
ECOVILLAGE WASTEWATER SOLUTIONS
Garry Kerans - Integrated Eco Villages Summary

For genuine ecological sustainability of a human settlement there would need to be no imports of energy or resources from outside the boundaries or range of that settlement and no environmental effects downstream or outside of the habitation area. This paper explores the potentials of a relatively closed system by exploring the wastewater cycle of a single household. The problems all originate at this source and reuse is more achievable from this base.

Ecologically Sustainable Design (ESD)
For this term to truly infer a future potential or merit of a product or process there is the inference that the activity can somehow take place in a closed system. In reality this possibility is not likely in all but the smallest of activities and highly unlikely in something as complex as human habitation in a biological system.

It does make sense however to address ESD as an ideal practice that can be approached ever more closely as our knowledge of ecological systems increases and our need to create less impact on these systems grows. It certainly does not make environmental, financial or social sense to persist with an open system ideology and go on building new dams, new and larger sewage treatment plants and more complex buried pipework infrastructure to deal with the world's population increases. The graphic No. 1 highlights the differences between the open and closed system approaches to providing and retaining our water catchment's resources.

The resource recovery systems that are required for ESD call upon the minimum area feasible to support a population and generally must mitigate the impacts of the development downstream. In the driest inhabited continent on earth we have a vested interest in conserving our valuable water reserves and the practices outlined in the following text convey current best practice from our perspective.

Household Focus
The focus is on environmental and financially sound solutions for an individual household because if the costs and impacts don't work for the smallest unit of the human ecosystem then there is much less likely hood that the system can perform well as a whole. In multi unit developments the same basic stipulations apply as they do in modern solid waste management practice:- reduce demand, re-use whenever possible and recycle if necessary within a small geographical distance. This distance element is an imperative in wastewater because the cost to transport a product has a great bearing on the net energy cost to the consumer and this impacts on the sustainability of the solution. eg a pipeline takes energy to fabricate, construct, maintain and keep running - the environment and someone has to pay for this expenditure.

Big, Bold and Costly
It is possible to look at large scale environmental solutions and this has been tried in a number of centres around the globe. The closest and best developed is the Rouse I Lill Sewage Treatment Plant (STP). This new plant utilises modern sewerage treatment techniques to breakdown the effluent to a suitable standard before it moves through a number of shallow ponds. After an extended period of breakdown this treated effluent is then pumped back through the STP where it is filtered and then chlorinated. "This treated effluent is then
supplied back to the houses in a second (treated) water supply network. There is an increase of $6,000 in the cost of this well serviced land in comparison to similar sized blocks in the surrounding area. The cost per kilolitre for the recycled water is not appreciably less than the cost of the potable water supply. There are many advantages to the close coupling of the STP to a new housing development but in this instance it could be that the journey that the effluent is travelling could put the cost of this recycling system's infrastructure outside of most Council's and individual's funding arrangements.

Close Coupled Systems

To save the sizeable cost of the pipeline and pumping costs in dense urban areas a more localised catchment management practice is advisable. Generally in practice the smaller the reuse cycles are geographically the more sustainable and cost effective is the solution. House hold sized systems are ideal in some respects because there is also a one-to-one responsibility relationship between the operational responsibility for the system and the user of the back yard. eg If any part of the system does break down the occupier will be affected and seek a solution. Any health risks are also reduced when there is this one-to-one connection between the persons making the wastewater and those using the areas irrigated by the same waste water. eg If a household member has a 'bug' it is not probably going to make a large public health difference if the bug is also present in their more expansive external garden environment. It could even be argued that the surface spraying of undisinfected wastewater may be admissible if it wasn't for the possibility of off-site runoff of undisinfected wastewater.

When I mention the reuse of wastewater it is usually) in the context of recycled treated greywater. The main contributions to greywater being the washing water waste generated from bathrooms generally (bath, shower, hand basin and floor wastes) as well as that from the laundry. Kitchen waste is excluded because of the clogging effects it has on the pre-filters. These filters are necessary to reduce the amount of hair and lint in the system. These materials tend to produce sludge forming deposits and also clog the small pumps in the systems. Urine can also be safely added to the greywater system at any stage of it's production, it is usually a sterile liquid which is valuable to the surface layers of a garden because of it's high nitrogen levels. Doesn't it make more sense to pee in the shower that eventually feeds the garden than to use water to flush a pure fertiliser into contamination with faeces. Please see graphic 2 'Ecologically aware household's food energy nutrient cycle'

In composting toilets urine has been shown to be broken to ammonia by a bacteria, micrococcus ureae, and this has four main disadvantages.

- Ammonia smells
- the ammonia is detrimental to aerobic composting bacteria
- the valuable nitrogen fertiliser is lost
- the remaining fertilisers are unbalanced, and hence are less available to plants.

This information has evolved out of research done by Professor Mats Wolgast of Uppsala University, Sweden.

There are a number of composting toilet options presently available in Australia. The line drawing 3 indicates a number of the Health Department approved solutions available in Australia. All have a small inline fan in common because this is necessary to establish a draught down the toilet pedestal and remove the odours from the toilet room. For the purpose of this analysis the specific details of the various composting toilet types is not as important as the general water saving function of these devices.
**Water Balance**

Water resource management has two main aspects to address when approaching environmental sustainability, supply of clean potable water and disposal of the nutrients added to this clean water that render it unusable for reuse again. It may make sense to call these challenges catchment management and resource cycling. It is not appropriate to consider full ground disposal of contaminated wastewater if there is any short fall of potable supply from the local region.

In this respect, if we are to stop building new dams as populations increase, we have to make the very best use of the water we have used inside our homes. It does not make sense to focus on water savings inside a dwelling and then poorly manage the wastewater produced from the occupants as well as the water necessary to keep our gardens intact. External water use accounts for 47% of household usage, Brisbane data UWRP 73 - see graphic 4

**Potentials for Reuse**

An elegant solution exists which requires the use of subsurface irrigation (see sub subsurface irrigation graphic 5 and 6 REWATER brochure) as a key which enables household internal water use to roughly balance external garden requirements. Review pie charts in Potentials for reuse graphic. In this chart the greywater produced from a household almost exactly equals the water required externally if sub surface irrigation is utilised.

If the subsurface form of irrigation were not used there would either be

1. a severe shortfall in the amount of water available from the household that would need to be made up by potable sources or
2. some of the garden areas would need to dry out or be converted to a xeroscape (low water need) areas. There are also other benefits when networks of sub surface forms of irrigation are used instead of surface spraying.
   a. Much greater areas can be kept alive by the wastewater because there are less evaporative losses. when the water is distributed at the root zone of plants.
   b. The nutrients are better used if they are distributed over a large area and just below the surface in the most active zone of the soil.
   c. There are major sewerage system savings due to the reliable nature of an extensive drainage distribution network in the soil. Trench systems are usually deeply buried in the less active layers of the soil profile and regularly glog or seal themselves after a period of regular usage. There may not be the need of a buried sewage pipeline infrastructure at all.
   d. Chlorination is not required if the effluent is disposed of by sub surface means. Health Departments require disinfection if any effluent if it is surface sprayed.
   e. Viral and bacterial pathogens are readily adsorbed or inactivated in the active surface layers of the soil i.e the top 300 mm (Farwell,1993) providing the suspended solid levels in the effluent are kept low i.e. <20 mg/litre.
A Practical Example - Condamine Court, Australian Capital Territory (ACT)

In 1996 ACT Housing commissioned Integrated EcoVillages to design, construct and monitor a greywater system for 70 public housing home units they were redeveloping near the centre of Canberra city. The system was designed to treat the greywater from a second drainage pipe network that accepted all the laundry and bathroom wastewater from these 70 units. Once the effluent was treated, clarified and filtered it went into a 120 KL storage tank. From this point a moisture sensing irrigation computer controlled a pump and distribution system which feed the treated water out to the various zones of the sub surface irrigation network on the 4,500 square metre site. See graphic 7 'Condamine Court Recycling Scheme'

The wastewater production rate was estimated at 160 litres per person per day by the authorities but the flow data indicates that this was optimistic as only about 110 litres per person per day is being produced. Possibly there needs to he a diversity factor built into wastewater production information as there is in water supply pipeline sizing. This development does have water saving and pressure reduction devices installed throughout the units and this could he another contributing factor which could account for the shortfall in actual wastewater production.

Because of this shortfall the treatment system is working even better than predicted but the landscaped areas around the development are not receiving enough in Summer to keep the lawn areas fully green.

Wetland

Also built into the treatment system of Condamine Court is a constructed horizontal flow artificial wetland. (Please see generic graphic 8 on treatment wetlands)

This self regulating treatment method uses reeds and other water plants instead of compressors to pump oxygen into the wastewater. The oxygen that is naturally pumped down to the roots of the reeds enables aerobic bacteria to survive and function in the depths of the gravel bed around the roots and these bacteria are faster workers when it comes to breaking down wastes. To adequately treat wastes using this more aesthetic and 'natural' method does require quite large areas of land to be set aside for the purpose in cool climates. About 10 square metres person for treatment of secondary effluent to a standard suitable for discharge into a water course and up to 20 square metres per person if re-use of the effluent is planned.(pers. comm. 'Ebb and Flow' wetland specialists UK)

Settlement basins and treatment lagoons are becoming common place for stormwater treatment and in the whole picture of catchment management they are indispensable. When all the household or community water tanks and wastewater storage is full during a wet or prolonged cool spell with low transpiration losses the overflows must be managed to conserve water quantity and quality. The concept of stormwater runoff as waste to be drained to the nearest large river cannot be sustained in the larger picture when it is obvious that a community cannot supply all it's summer water needs from a roof tank supplies. The location of potable water supplies in dam storage sites at a considerable distance from the demand area is becoming ever more difficult to support. The option of localising storage is far preferable because the area under development is going to be an affected environment anyway. In years to come there may even be a direct relationship between density of population in a given community's bioregion and it's water catchment resources. Without such a relationship there is always a non sustainable element to progress. Of course the bioregional area could be increased to take in sufficient catchment, such as Sydney's
requirement for a new dam out at Braidwood - 300 Kms away, but then the independence and
growth potential of the 'invaded' region is jeopardised. In this process the infrastructure and
ongoing costs to supply water at such distances weigh ever more heavily on the shoulders of the
city workers of the day and ever increasing living costs do not demonstrate a sustainable
practice. The more people need to work the more resources they are expending. This is because
the cost of living is a clear indication of the energy and material supply costs of a particular
lifestyle.

**Sand Filter**

Dosed aerobic sand filters are also very effective in the final treatment of effluent prior to
storage or direct reuse. It is important that this type of biological and physical filter is designed
and constructed appropriately. There are set dosing rates and volumes for various effluent input
qualities. To save the expense of digging up your sand filter if it fails in the short term it is worth
while purchasing the right materials and correctly designing the sand filter dosing and collection
pipe networks. The draft Victorian 'Code of Practice for Domestic Wastewater' 1994 provides a
brief but clear guide towards the design of aerobic sand filters.

A large sand filter of 65 cubic metres in volume is used as the final treatment process on the
Condamine Court site and effluent sample have consistently been below 5 mg per litre for both
BOD and Suspended Solids.

**Verification of Ideology from an Alternatives Source**

The international company, MEMTEC Limited ACN 002 490 208 of Sydney has arrived at a
similar solution to that proposed by us and have incorporated their trade technology, micro
filtration, as the stormwater/ treated wastewater treatment mechanism. See Memtec graphics.9&
10 .

The Memtec system does not however propose any direct onsite re-use of effluent and relies
more heavily on the second pipe supply of non potable water to each allotment. They also
require two extra pipeline networks, a potable supply from the dam and a small bore sewerage
pipe system to the non potable storage ponds.

Memtec's advanced technology is presently used to filter potable water sources at the dam
supplies and it has also been called upon to extract clean irrigation water from mixed sewerage
effluent (Southwell Park in ACT) and treat to reusable standard the wash down waters at
Taronga Zoo in Sydney.

**Economics of Re-Use Technologies**

It is in this area that the geographical and social aspects of a community begin to interact with
sizing and infrastructure limitations of the non potable wetland storage and re-use plant. If the
population being serviced by the reuse plant is small (less than 150 households) then the cost per
capita to maintain the treatment plant could be prohibitively high. As the household number
increases above 150 households the length and cost of the pipeline that returns the treated
effluent to the homes increases as well as the necessary size of the storage non potable storage
pond(s). The topographical limitations in siting this stormwater/ excess waste water storage
down hill from the dwellings and yet to the side of the zone that would be subject to periodic
high volume floodings then becomes a critical design factor.

The potential housing development's design layout and siting needs to take these elements into
account and overlay these with the solar, circulation, privacy and pure design aspects of the
construction.
General Principles of Design for Wastewater Reuse - Medium Density Housing.

1. Keep wastewater as high as possible - both by location of dwellings on the land as well as by reducing the depth of burial of wastewater pipes. Pumpwells are expensive both to install and maintain.

2. Consider the distribution system at the same time as the collection pipe network - A Common trench saves money but it's location may be determined by the direction of the gravity falls in the collection network.

3. Save pumps use plants - Where possible use plants to oxygenate and strip nutrients. The by products are much more readily bought back into the food chain as mulch and the cost of the process is less than chemical treatment supplies.

4. When pumps are required make them perform as much aeration work as possible. Air allows more efficient waste assimilating bacteria to survive and do 'work'.

5. Separate wastewater qualities - It is essential to retain and age wastewater effectively to attenuate pathogens. To achieve this it is essential that short-circuiting is prevented in treatment tanks, wetlands and sand litters.

6. Design in cleanout mechanisms and system observation locations
   Someone has to be responsible for the maintenance of the treatment plant and their earls observations are essential to prevent breakdowns that may be very costly to repair. ie Sand filters can not take being submerged for any length of time, a water level inspection window and /or alarm could detect a flooding problem early and save a substantial dig out task.

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Elizabeth works as the Environment Officer in the Australian Antarctic Division's Expedition Operations Branch. Her work involves the implementation of government and international requirements at three Antarctic stations, at Macquarie Island (in conjunction with Tasmanian Parks and Wildlife) and at Heard Island when the Division has an expedition there. She is involved in the day to day management of issues including the protection of wildlife, quarantining against introduced organisms, waste management, including human waste management and the prevention of marine pollution.

Elizabeth has a Bachelor of Agricultural Science and PhD (Botany) from the University of Melbourne and has worked as a scientist in the Antarctic and on Macquarie Island. Her PhD was on fungi involved in decomposition on Macquarie Island and her subsequent work in Antarctica included ecological studies, studies on introduced fungi in Antarctica and the remediation of oil spills. This work provided Elizabeth with a sound basis for her present. Elizabeth finds it very satisfying to be involved in management where she can apply her research findings in management.

Elizabeth has had nine trips to the Antarctic or Macquarie Island, and was the first female Australian scientist to go to our continental stations (Casey, in 1979).
HUMAN WASTE MANAGEMENT IN THE ANTARCTIC

Elizabeth Kerry, Australian Antarctic Division

Introduction
Antarctica and the sub-Antarctic fit well into the theme of this conference. Antarctica is approximately 1000 km from South America, the nearest landmass. It is just under 3000 km from Australia at the nearest point. Sub-Antarctic Macquarie Island is 1526 km from Hobart and Heard Island 3686 km from Perth. All these areas support a unique flora and fauna, and no-one would argue that they are cold.

As in other natural areas, human activity in Antarctica inevitably brings with it the risk of environmental impact, including contamination by human waste. As one of the world's last unspoilt wilderness areas, any unnecessary impact should be considered excessive. Some consider that we should not even be there. However while we are, the management of human waste is an important aspect of overall management. Antarctica's remoteness and climate control, or at least influence, the types of systems which can be used.

This lecture will cover management practices for human waste in the Australian Antarctic Territory (AAT) and at Heard and Macquarie Islands, together with the laws under which we operate and the ways in which we work to ensure compliance.

Values at Risk from Human Waste
The values at risk include wilderness and aesthetics, and integrity of the indigenous flora and fauna. The most obvious risks are to the wilderness and aesthetic values of the area. Impacts are likely to be greater in the Antarctic, as low temperatures limit decomposition rates, and any untreated human waste is likely to remain for long periods. Enrichment by human waste is one of the major risks to the flora because of its potential to change the balance of ecosystems.

Another major area of concern is the possibility of introducing diseases to wildlife populations in human waste (fresh meat supplies are also of concern). Such a possibility has been indicated by the isolation of antibiotic resistant bacteria, considered to be of human origin, from the Ross Sea near McMurdo station's sewage outlet (Smith and McFeters 1999). Antibodies have been found to Newcastle disease, avian influenza and Infectious Bursal Disease Virus in Antarctic bird populations (Kerry et al 1999). Antibodies to brucellosis, or contagious abortion, which is common in domestic animals, have been reported in Antarctic seals. Although no cases of these diseases have been reported, there have been unexplained deaths in penguin and seal populations. These findings have alerted Antarctic nations to the need for management practices which limit the chance of contact. This includes reassessment of our waste management practices, and our (already strict) regimes for the introduction of fresh meat.
Controls, Constraints on Human Waste Management Antarctica

The "Madrid Protocol" or "Protocol on Environmental Protection to the Antarctic Treaty". which is part of Antarctic Treaty System, imposes strict regulations on the management of all wastes in Antarctica. It requires that most wastes are removed, usually to the country of origin. Human waste is one of the few exceptions to this requirement, but with this exemption come strict controls. The Madrid Protocol covers signatories to the Antarctic Treaty. This includes Australia which claims 42% of Antarctica and therefore has a big stake in its management. Australia complies and in many cases exceeds Madrid Protocol requirements. although there is always room for improvement.

Macquarie and Heard Islands


Practical constraints: Antarctica, Macquarie and Heard Islands

At the practical level the lack of water (at continental stations) has limited the use of modem treatment plants. The environmental impacts of fuel usage for sewage treatment must also be considered. The limitations and costs incurred by working in these remote locations must also be taken into account. For example it is costing us approximately $1500 to hire an appropriate container to transport sewage sludge back to Australia this summer, and that is only for one station.

Occupational Health and Safety issues also need to be considered, especially with people handling human waste. No concerns have been raised to date.

Human Waste Management in Antarctica Background

Antarctica covers 13 million square kilometres, twice the size of Australia. Over 99% has permanent ice cover, to a mean thickness of 2.16 km (4.7 km maximum). This icecap influences world climate by acting as a heat sink and holds 90% of the world's fresh water. Much of it is unspoilt by human activity, although locked within it are particles from atomic tests (also of natural events such as dust storms).

The remainder of the Antarctic Continent is classified as ice-free land, that is areas where there is no permanent ice cover. These areas are of major importance as they support most of Antarctic's terrestrial flora, and most species of Antarctic wildlife breed there. However most stations are also on ice-free land, and some occupy sites at key locations. For example Australia's Davis station is in the Vestfold Hills, one of the largest stretches of ice-free land in Antarctica and Casey station is in an area with some of the best stands of vegetation in Antarctica.

The Southern Ocean is also of major importance, as it supports a complex and highly productive ecosystem which among other things is the food source for Antarctic and sub-Antarctic wildlife. It is subject to human waste from both ships and stations.
Ships include those transporting supplies and people to and from Antarctic stations, also fishing vessels and an increasing number of tourist vessels.

Man first occupied Antarctica 100 years ago. Australia's first stations were built on Heard and Macquarie Island over 50 years ago and on the Antarctic Continent in 1954 (Mawson station).

Most early methods of human waste management involved the disposal of untreated solid waste in the sea, and urine on land or into the sea (Table I). We then moved to treatment of the solid waste at stations, either by burning or chemical treatment. The remains were disposed of at sea. Current waste management practices reflect the general communities' increasing responsibility towards the environment, although the "comfort factor" has also been accommodated. The systems we use still have their disadvantages; in fact burning waste had some advantages over our present systems. I'll discuss this further later.

**Station and field practices**

Approximately 20 people over-winter at each station each year and numbers increase to 60 to 80 over summer. Sewage produced at stations is treated there. In addition most solid human waste from field huts or camps is returned to the station for treatment. The only exception is for long inland traverses when disposal into crevasses is permitted.

Solid human waste from the field may be treated in station treatment plants or (more often) incinerated. The process of return to the station is simple, acceptable and effective. Drums and plastic bags are supplied and the waste is double bagged for return to the station. It is often frozen which makes it safer and easier to manage than it would be in warmer climates. Low temperatures also minimise unpleasant odours.

To date the main restriction on the disposal of urine has been to prohibit its release into ice-free areas or into fresh water systems. These are sites with special values, and include a number in the AAT. We now have a system in place to ensure that urine is returned from most field sites. The only exceptions are for camps by the sea (provided that there are tide cracks available for disposal) and long inland traverses, where the same rules apply as for solid human waste. However even then expeditioners are encouraged to return it wherever possible.

Urine is returned to stations in drums. In some cases 210 litre drums are left in the field for long periods and collected by over-snow vehicles whenever possible. 20 litre sealable drums are used for short trips and returned after each trip. "the urine is tipped into the sewage system. Low temperatures are both an advantage (freezing makes storage and transportation easy: low temperatures slow microbial action and reduce odour) and disadvantage (the need to thaw for easy access to the sewage system).

The systems operating restrict impacts to immediate station areas and therefore protect the rest of the ice-free land. This regime also acts to protect the vast ice-covered areas of Antarctica, with their high wilderness and aesthetic values.
Sewage treatment at stations
Rotating Biological Contactor (RBC) treatment systems were installed at our continental stations in the 1980s and 1990s. They could only be installed once there was a secure water supply, and places like Davis have had a very limited water supply until the early 1990s. These systems replaced the gas-burning or chemical systems in operation at the time (Table 1). They also fitted better into the new station building plans.

There are some concerns about the RBC systems. For example while they cater well in winter, raw sewage may be released at peak times. In addition the effluent from the RBC is piped into the sea. Sludge is cleaned out from the plant periodically, and is then spread thinly onto the sea-ice. This is based on the theory that ultraviolet light would destroy any organisms remaining after the sewage treatment.

We are now upgrading our procedures following concerns about the possibility of transmitting diseases from sewage to Antarctic wildlife. The effluent will be treated by an Ultra-Violet steriliser, the first of which has just been installed at Casey station. Similar UV plants will he installed at other stations next year. This summer we have also started to return the sewage sludge to Australia.

Although our systems are not perfect we more than comply with Madrid Protocol requirements (maceration only is acceptable). Many other nations do less, for example the United States only macerates sewage at McMurdo before releasing it into the Ross Sea. As already discussed, this may have serious implications for wildlife.

Southern Ocean concerns
With increasing numbers of ships travelling in the Southern Ocean there is concern about the increasing amount of sewage likely to be discharged. Under the Madrid Protocol untreated sewage may not be discharged within 12 nautical miles of land or ice shelves. Sewage stored in holding tanks must be discharged at a moderate rate, and when ships are travelling at 4 knots or more. Our ships comply, and do more, for example MV Aurora Australis operates a sewage treatment plant at all times. Tourist ships travelling in the AAT area must be covered by Environmental Impact Assessments which require them to comply with Madrid Protocol requirements. However there is no control over non-signatories, which for example is likely to include the pirate fishing boats frequently reported around Heard Island.

Human waste management on Macquarie and Heard Islands
Human waste management on these islands must take into account their rich and unique flora and fauna. The potential for impacts on the Southern Ocean by the release of sewage must also be considered.

Macquarie Island
Macquarie Island is 34 km long and 5 km wide at its broadest part. It is part of Tasmania and managed jointly by Tasmania and the Australian Antarctic Division (the AAD provides logistics and manages the station and field huts). There is a permanent station at the northern end, which accommodates approx 20 people in winter and up to 80 in summer. Station sewage is macerated and released directly into the ocean. This is based on the fact that the
ocean around Macquarie Island is very active and that dilution and degradation of the sewage is likely to be rapid.

There are field huts throughout the island, many of which are now occupied for long periods. Most of these are on the coast, and human waste is disposed of directly into the ocean. Recently refuges have been built inland and these are being used more than was anticipated. However a system of bagging solid human waste and disposing of it in the ocean appears to be working well.

**Heard Island**

Heard Island is approximately 20 X 20 km, differing from Macquarie Island in having an active volcano, Big Ben, rising to 2745 metres.

The Management Plan requires that shipboard toilet facilities are to be used wherever possible and that ship holding tanks are to be discharged outside the Territory. It also requires that human waste from persons remaining on shore for extended periods should, where practicable, be disposed of below the high water mark at sites where conditions exist for rapid dispersal. Chemical treatment of sewage is not allowed. Wastes generated at inland sites are to be disposed of in a way that minimises impacts on vegetation and wildlife.

There was a permanent station on Heard Island between 1947 and 1954. Since then there have been two Australian wintering expeditions as well as numerous visits during in summer (Australian expeditions, tourist visits, visits from other nationals). An Australian expedition is being planned for the 2000/01 summer, comprising 25 to 30 people for 4 months. Amongst other things, thought is being given to the treatment of human waste, especially to alternatives to sea disposal. One of the concerns with sea disposal is that waste would not be flushed readily from Atlas Cove, one of the main camp sites. Equipment being considered includes one of the latest models of gas burning toilets and maritime sanitation devices. The gas burning toilets are favoured as they burn to a sterile mineral ash which can easily be returned to Australia. Compared with this the maritime toilet does not destroy all bacteria and viruses and is designed for use at 10°C or more.

**Implications and Key Points for other Remote Cold Natural Areas**

We can't boast any state-of-the-art techniques or equipment. However I think that our story demonstrates the effectiveness of centralising sewage treatment facilities at stations and returning waste from the field wherever possible. Such procedures depend on the goodwill of expeditioners, but the system works, provided that the expeditioners are well trained, and know their responsibilities.

This brings me to a key point: the importance of education, including lectures wherever possible, videos, and posters at main venues and at all field sites. We are lucky in that we have a "captive audience". All wintering expeditioners are required to participate in a comprehensive education program before travelling south. All people travelling south with us must attend a pre-departure briefing. There are also briefings on the ship before disembarkation, and continuing education while at the station. People must comply, or risk prosecution in some cases.

Many of our expeditioners are committed environmentalists. However as with visitors to other natural areas we need to cater for people from a range of backgrounds and with
different levels of understanding of ecology and the environment. We try to give everyone as good an understanding of Antarctic ecosystems as possible. Understanding of the basis of regulations makes people more willing to comply.

Finally, our case demonstrates the importance of systems appropriate to individual circumstances. Ours works for us, but we are continually looking to ways to improve.

Bibliography

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PROFILE
Paul Lachapelle
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Paul is currently a Research Assistant in the School of Forestry at the University of Montana, Missoula, MT, USA. He has been involved in waste management application and research since 1995. First, as field employee with the Green Mountain Club in Vermont, USA, then as the designer of a mesophilic composting system in the White Mountains of New Hampshire, USA with the Randolph Mountain Club.
He was employed with the United States Forest Service San Dimas Technology and Development Center conducting research including the testing of a solar Hot Box to pasteurize toilet compost in Yosemite National Park. He has spent over 18 months in Nepal serving two terms as a United States Department of Defense National Security Scholar where he conducted research concerning sanitation and planning at the village level and with Rotary International working as a consultant to build toilets in remote locations.
Most recently, he has worked with the American Alpine Club on a feasibility study in the Cirque of the Unclimbables in the Northwest Territory, Canada to mitigate impacts of recreation. He has published widely on the subject including articles on the Hot Box technology in the journal Mountain Research and Development 17(2) and Park Science 19(1) and sanitation in Nepal in the journal Himalayan Research Bulletin 17(1).

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INTERNATIONAL PERSPECTIVE ON HUMAN WASTE MANAGEMENT IN COLD CLIMATE NATURAL AREAS:
A CASE STUDY OF MT. EVEREST NATIONAL PARK, NEPAL

Paul Lachapelle — School of Forestry, University of Montana, USA

Abstract

Recreational activities that individuals pursue in cold climate natural areas provide millions of people with important, and needed social psychological benefits, yet at the same time lead to impacts of cold climate ecologies and cultures that are often pernicious and difficult to resolve, particularly in developing countries. Recognizing that tourism and recreation are a global force, that impacts, particularly in cold climate natural areas are often difficult to mitigate and that the people affected by visitation should play a intricate role in policy setting, this paper presents a case study outlining strategies to alleviate the problems associated with improper sanitation in Mt. Everest National Park, Nepal. Using a methodology based on "Participatory Rural Appraisal," the paper details meetings with community members and issues raised relating to village sanitation and the coordination of several public toilets in the park.

Introduction

Recreation, including certain tourist-related activities continues to grow globally and at an unprecedented rate. Recreation and tourism have become social, economic and environmental forces of almost unbelievable proportion as few regions, including remote cold climate locations, have escaped their influence. Recent advances in recreation-related technologies, such as "breath-able" fabrics and light-weight outdoor equipment enable recreationists to participate in activities that were impracticable or impossible only a decade ago. Additionally, high-tech gadgetry including Global Positioning Systems, cellular phones and powerful new off-road vehicles provide the opportunity for cold climate recreationists to venture farther and into more remote terrain with greater ease and feeling of security.

Tourism is the world's largest industry, measured in jobs, with much of it based on natural environments. The World Tourism Organization estimates that the number of people traveling internationally is expected to increase from 612 million in 1997 to about 1.6 billion by the year 2020. Worldwide, the tourism industry generated an estimated $4.4 trillion in retail expenditures during 1998. The recreational activities that individuals pursue in cold climate natural areas provide millions of people with important, and needed social psychological benefits, while at the same time leading to impacts of cold climate ecologies and cultures that are often pernicious and difficult to resolve. Among these difficult problems is the issue of sanitation and potential for ground and surface water pollution. Water tends to be the focal point of an outdoor recreation experience, both for aesthetic and subsistence reasons and therefore is particularly susceptible to impact from use.
Eco-tourism has become the latest buzzword to describe "responsible travel to natural areas, which conserves the environment and improves the welfare of local people" (Lindberg and Hawkins 1993). Promoted as a culturally and environmentally sound method of travel, ecotourism has experienced a 30 percent annual increase as compared to a four percent increase in the overall U.S. travel industry (Honey 1999). Practitioners of ecotourism are said to apply the principles of low-impact travel with benefits that directly influence the local communities. Most importantly, ecotourism is said to promote education and a sense of awareness of not only nature but also human-nature interactions. The World Tourism Organization predicts that by the year 2000, the majority of the increases in worldwide tourism receipts will come from active, adventure, nature and culture-related travel (Honey 1999). However, the crucial aspect of this new paradigm in travel is the extent to which the people who are affected by visitation play a role in management and planning.

Recognizing that tourism and recreation are a global force, that impacts, particularly in cold climate natural areas are often difficult to mitigate and that the people affected by visitation should play a intricate role in policy setting, this paper presents a case study outlining strategies to alleviate the problems associated with improper sanitation in Mt. Everest National Park, Nepal. Using a methodology based on "Participatory Rural Appraisal," the paper details meetings with community members and issues raised relating to village sanitation and the coordination of several public toilets in the park.

**Background: Mt. Everest (Sagarmatha) National Park, Nepal**

Mt. Everest (Sagarmatha) National Park in Khumbu, Nepal remains one of the most used and studied protected forested area in the developing world. The park is visited annually by over 17,000 tourists (Sagarmatha Pollution Control Committee, 1997) who spend an average of 24 days (Robinson 1992). The park attracts approximately 20 percent of all trekkers and nearly half of all mountaineering expeditions to Nepal (Stevens 1993). It has been calculated that every tourist comes accompanied by as many as three Nepalese support staff and/or packstock (Bjonness 1980). Visitors are concentrated in two distinct trekking seasons, March to May and September to December and primarily travel two routes along the valleys of the Dudh Kosi and the Imja Khola rivers. With nearly 3,000 inhabitants, the local Sherpa people are as much of the landscape as the Himalayan mountains themselves. Tourism has influenced almost everyone in the park. In 1985, 65 percent of all Khumbu families derived income from trekking (Stevens 1993). Odell and Lama (1998) report that trekking in the park generates Nrs 140 million (US $2.4 million) annually to the local economy with independent trekkers spending an average of $10 a day and trekking companies spending $7-8 a day per trekker for supplementary food, incidentals and portering.

Throughout the 1980's, momentum gradually built that refuted the conventional wisdom of the "Himalayan dilemma;" that massive deforestation was occurring, that hill farmers were responsible, and that these same people were not informed enough to understand complex ecological processes (Ives and Messerli 1989; Thompson and Warburton 1985). The "Himalayan dilemma" paradigm was applied to the Khumbu region of Nepal and in 1976 with the aid of the New Zealand government, the government of Nepal created Mt. Everest National Park with strict regulations upon the Sherpa people including where to collect fuel and construction wood and what type of development could occur outside of preexisting village settlements. While western-oriented conservation tactics on use can sometimes work in developed nations, implementing restrictions and management schemes are far more complicated and involved in an area where residents are acutely dependent on local resource
use and have traditionally decided land use patterns for themselves. Recognizing these difficulties, Lachapelle (1998) notes that there exist four distinct issues that have prevented adequate management of toilets, water quality and sanitation conditions in Mt. Everest National Park. First, numerous interest groups, both government and non-governmental, have apportioned work requirements and responsibilities for the infrastructural obligations in the park. Second, community will to address sanitation issues in many of the densely populated and/or popular sites in the park seems lacking either because the communities are ill-equipped or all-together neglect certain public sanitation needs. Third, there is no regulatory body that consistently enforces sanitary rules from the original park management plan. Lastly, various development initiatives in the park have created a cycle of dependency and expectance to build and maintain sanitation structures.

**Khumbu Toilet Project**

The Khumbu Toilet Project was initiated in 1998 to alleviate the problems associated with sanitation, particularly those in public settings (Fenton and Lachapelle 1998). Working with financial support from Rotary International., University District Rotary Club in Seattle, Washington, USA and guidance from the Rotary Club of Kathmandu North, Nepal, members of the project conducted a feasibility with the following objectives:

1. To identify community definitions of sanitation problems,
2. To distinguish and classify problem areas,
3. To build toilets where a specific need exists and where future satisfactory maintenance patterns could be met,
4. To plan for the long term preservation of sanitation needs specific to toilet construction and maintenance with the possibility of initiating more comprehensive sanitary objectives to include potable water, drainage, and sanitation education.

One of the main areas of conflict in Nepal between local people and parks is the absence of local people's participation in the management of the area (Banskota and Sharma 1998). While considering methodologies to conduct the feasibility study, a planning and management initiative was agreed to based on the "Participatory Rural Appraisal" model as outlined by Chambers (1994) or "Participant Action Research" model as outlined by Griffin (1987). The tenets of both methodologies are similar; the technique is used to "enable local people to share, enhance and analyze their knowledge of life and conditions to plan and act" (Chambers 1994:953). These methods recognize that 1) local people are creative and capable and should do much of their own investigation, analysis and planning, 2) "outsiders" have roles as catalysts and facilitators and 3) the weak and marginalized people in a community should be empowered.

Community members preferred the development of a sanitation infrastructure based in several of the more populated villages instead of the mountaineering base camps for several reasons. Primarily, members of the community felt because of the great distance between villages and base camps the potential for illness was inconsequential. Moreover, conflict between village inhabitants and mountaineering expeditions who reside at base camps regarding improper sanitation techniques appears to be minimal or none existent. Although the impacts from activities at even the most popular base camps on the potable water supplies in villages downstream remains indeterminate, it seems extremely unlikely that the impacts occurring at base camps present a greater risk than present visitor use in the villages. Presently, a regulation is in place at several of the popular base camps in the park (including
Mt. Everest and Pumori). As mandated by the Nepalese Ministry of Tourism and Civil Aviation (MTCA), the Sagarmatha Pollution Control Committee (SPCC), the local conservation watchdog group, must regulate the transportation of human waste from popular base camps in the park to be "collected in portable plastic drums or barrels and brought down to the proper disposal site...designated by SPCC" (SPCC 1997:4). In the spring 1997 season, this amounted to over 2000 kg of human waste brought from Mt. Everest and Pumori base camps (SPCC 1997:annex 5). The impacts at the disposal sites and the level of compliance is unknown to the author. A more significant problem according to community members is the concentration of visitors in several of the villages in the park.

The majority of the international visitors and Nepalese support staff and porters supplying goods to the park are not involved in mountaineering and either stay in the trekking lodges available in villages or in tents provided by outfitters of organized tours near the lodges. Thus, the study choose to target the areas that appeared to be more greatly impacted by tourism and with a greater threat to public health and safety. Of particular concern was the village of Namche Bazaar, the largest settlement in the park with an approximate population of 700. This village has received the greatest concentration of trekking lodges over the past 20 years and due to its strategic location, has been described as a "requisite stop for all Khumbu visitors" (Brower 1991:83). Namche Bazaar is located at an elevation of 3440 meters and in its coldest month of January, experiences a mean temperature of -0.4°C (minimum mean temperature of -7.9°C) and a July mean of 12°C (Brower 1991).

Partnerships were formed with members of existing political organizations in the region known as Village Development Committees (VDC). These organizations are made up of local residents who are democratically-elected to five year terms and address political, economic and social issues while supervising all of the villages and small agricultural settlements in the park. While it was not the point of the feasibility study to comment on the representation of the VDCs, we felt comfortable that these organizations were indeed representative of the needs and abilities of the community.

With partnerships formed with several village leaders who were concerned about their local sanitation problems and wanted help constructing public toilets in their villages, problem areas were identified and potential solutions discussed. We identified several problem areas in the park, most notably the public market area in Namche Bazaar where a weekly gathering of merchants draws hundreds of people to bargain for goods and services. Most people arrive at the market several days before the selling starts and stay in make-shift shelters made of burlap or plastic. There are no public toilet facilities for these people and the area appears extremely unsanitary with signs of human excrement behind buildings and other areas that afford some semblance of privacy. Worse still, this market is located directly above the village water supply area. The most effective toilet design was determined by the VDC to be a traditional Sherpa-style composting toilet, made of local stone and imported cement, for reinforcement and using leaves from nearby forests. Other problem areas identified included the monastic settlement of Tengboche and the villages of Lukla and Loboche. Formal agreements were initiated in three villages for the construction and on-going maintenance of public toilets. The project now awaits final approval for land tenure compacts to be settled in Namehe Bazaar.
Conclusions
This paper presents a case study of a sanitation initiative in several popular villages in Mt. Everest National Park, Nepal and the management and planning implications. Using a methodology that affords local control of planning, management and the long-term maintenance objectives of an initiative, issues were defined, problem areas identified and a maintenance agreement formalized regarding public toilets in several settings. By allowing the local communities to plan and decide the course of action, this sanitation initiative stand a greater chance of success than former projects.

Literature Cited
CHOOSING THE RIGHT WASTE MANAGEMENT OPTION:

A DECISION MAKING MATRIX FOR MANAGING SANITATION IN NATURAL AREAS

Paul Lachapelle - School of Forestry, University of Montana, USA

Abstract
In the United States, officials with the four wilderness managing agencies (U.S. National Park Service, U.S. Forest Service, U.S. Bureau of Land Management and U.S. Fish and Wildlife Service) are faced with balancing wilderness preservation values and the minimum tool policies of their respective agencies. One example is the management of sanitation, particularly human waste and the often intrusive infrastructure that accompanies its treatment and disposal. Because the treatment and disposal of human waste is a potentially serious public health hazard if mismanaged, it sometimes requires an elaborate infrastructure, including buildings and use of helicopters or pack stock. Often, these applications conflict with the fundamental assumptions of wilderness designation. A paradox exists between public health concerns and the use of a minimum tool allowed by the agency to deal with human waste treatment and disposal. What is needed is a framework for balancing these interests to make explicit various sanitation options available to managers. This paper provides a matrix and flow chart for considering various sanitation techniques while incorporating minimum tool options and concerns about related impacts.

Introduction
The issue of sanitation in natural areas presents a troublesome paradox. On one hand, managers must provide for the preservation of the natural character of the resource while protecting the resource from impacts, including surface and ground water pollution caused by improper human waste disposal. The implementation of permanent structures to treat or store waste and the consistent use of helicopters or pack stock to transport waste or materials presents a challenge for managers concerned with providing an untrammeled natural environment while protecting vulnerable natural resources and human health and safety.

In the United States, legislation known as the Wilderness Act of 1964 (Public Law 88-577) is a unique legal authorization applied to undeveloped land. The act enables agencies managing federal land (U.S. National Park Service, U.S. Forest Service, U.S. Bureau of Land Management and U.S. Fish and Wildlife Service) to preserve areas in their natural state and allow natural processes to continue unimpeded by human actions. The law includes the characterizing phrases "untrammeled by man," "retaining its primeval character" and "man's work substantially unnoticeable," yet it also explicitly states that the areas are to be managed with "no use of motor vehicles, motorized equipment...no other form of mechanical transport, and no structure or installation...except as necessary to meet minimum requirements for the administration of the area." The notion of "minimum requirements" in wilderness areas mandated to be managed for "the preservation of their wilderness character" presents some ambiguity. The choice of a minimum tool is largely at the discretion of the land manager. Hendee (1990) refers to the "minimum tool rule" as "the minimum regimentation necessary to achieve established wilderness management objectives" and depends "on a manager's judgment about the degree of regulation necessary to achieve objectives and the likely effectiveness of various regulatory and nonregulatory actions in certain situations."
Thus, management decisions can be based on subjective judgements, personal values or even administrative convenience.

Managers may neglect sanitation issues at specific sites or may implement a sanitation strategy with an emphasis on mechanized transport or an elaborate infrastructure that is incompatible with social values or biophysical constraints. Several studies of wilderness managers have indicated that steps to improve resource conditions are taken only after "substantial damage...had occurred" (Shindler 1992). Cole (1996) asserts that managers have been reluctant to attack problems directly, stating, "Two oft-cited wilderness management principles, that indirect management techniques are best and that use limits should be a last resort, have become so entrenched in the wilderness community that they have paralyzed many management programs." However, a new wave of purist sentiment has occupied recent discussion regarding management objectives in wilderness. Nash (1996) describes the wilderness experience as "delicate" and one that is "vulnerable to seemingly insignificant disturbance." Even the amount of noise heard that comes from outside of wilderness can elicit high levels of concern among wilderness recreationists (Shafer and Hammitt 1995). Noss (1991) posits that our desire to manage wilderness is "exceedingly arrogant" and thus what is needed is recognition of a humility value that represents "self-imposed restraint in a society that generally seeks to dominate and control all of nature." Recognizing restraint will prove increasingly difficult as use and intensity of wilderness continue to grow.

**Problem Statement**

Since 1965, recreation use in wilderness in the United States has grown by nearly 400 percent (Hampton and Cole 1995), increasing substantially during the 1990's in most wilderness areas and likely to intensify (Cole 1996). The protection of water resources is a vital component of wilderness integrity, and thus researchers commonly look to water to quickly determine the state of health of an entire watershed or ecosystem (Herrmann and Williams 1987). Several surveys in the United States reveal that the public believes preserving water quality is the most important value and reason for protection in federally designated wilderness areas (Cordell and others 1998; Kloepfer 1992). Both standing and free-flowing water in wilderness is often the focal point of backcountry recreation; it tends to be limited and subject to ever-increasing consumptive, polluting and competing uses (Aukerman 1986). Marion and others (1993) found that only 52 percent of national parks had implemented some type of water quality monitoring program. Heninnann and Williams (1987) cite four reasons for a lack of water quality research in wilderness as the difficulty of access to sites, difficulty in discriminating the effects from background water quality levels, the magnitude of the action to the consequence and the limited opportunity for control in the wilderness environment. Research regarding water quality in backcountry locations reveals that certain backcountry locations with pristine-looking water can be contaminated with pathogenic organisms (Tippets 1999; Aukerman and Monzingo 1989; Suk 1986; Varness 1978). New and potentially dangerous organisms such as Giardia lamblia and Cryptosporidium are particularly worrisome because of their disabling effects and prevalence in some backcountry locations (Perry and Swackhammer 1990). While it has been difficult in the past to discern whether recreation is the cause of fecal contamination of water, new techniques have become more sophisticated. Human fecal contamination in recreation settings has been documented using a method that extracts the DNA from coliform bacteria to determine the source (human, beaver, horse, etc.) of the pollution (Tippets 1999).
The primary concerns of human waste disposal are, 1) the transmission of disease-causing organisms and, 2) the aesthetic concerns of improper human waste disposal or the accompanying sanitation infrastructure. The public is shown to be increasingly intolerant of sanitation problems. In their study of social and ecological normative standards, Whittaker and Shelby (1988) found that the standard for human waste represented a no-tolerance norm, in which 80 percent of the respondents reported that it was never acceptable to see signs of human waste. Increased use has led to increased social and biophysical impacts, particularly in sites not conducive to the decomposition of human waste. A recent study reports that 25 percent of National Park Service managers in the United States find human waste to be a common problem in many or most areas, and 43 percent consider it a serious problem in a few areas (Marion and others 1993). Increasing wilderness use, the severity of public health issues and lack of tolerance by the public combined with biophysical constraints, changing social values toward wilderness and limited human waste treatment and disposal techniques creates a complex situation for managers who must determine the application of a minimum tool.

Discussion
The matrix (table 1) and related flow chart (figure 1) were created to help managers design and maintain sanitation programs and infrastructures while incorporating minimum tool options and concerns about related impacts. Information contained in the matrix and flow chart were gathered from the limited quantity of research on water quality and human waste management in backcountry settings and makes explicit the technology or technique to treat and dispose of human waste, minimum tool options and related impacts. The flow chart presents various scenarios and actions relating to sanitation management options. The matrix establishes descriptions and related impacts of various sanitation techniques. Determinations of opportunity classes are based on Stankey and others (1990) and designed to define resource, social and managerial conditions considered desirable and appropriate in wilderness. Opportunity classes associated with techniques are approximated to gauge the severity of obtrusiveness. Within the matrix, Class I implies little or no evidence of site management, while Class IV implies extensive use of onsite management and site modification.

Numerous organizations including the United States Forest Service, Leave No Trace and the National Outdoor Leadership School detail the positive and negative attributes of various sanitation techniques in the backcountry. Clearly, no means of human waste disposal in the backcountry is without ramifications, and no one method can be unconditionally recommended for every situation. Even urine, which is ordinarily sterile, can attract wildlife that defoliate plants and disturb soils. (Hampton and Cole 1995; Cole 1989). Good judgement is the key to proper human waste disposal. Hampton and Cole (1995) maintain that disposal techniques are best when they: 1) diminish human, animal and insect contact, 2) encourage decomposition and 3) avoid polluting water sources. The fate of pathogenic organisms in human waste deposited on or in soils is highly variable and depends on numerous factors including soil type, moisture and temperature.

The "cat hole" method allows for aerobic decomposition by microbial activity within individual shallow holes in the ground. Hampton and Cole (1995) report that this is the preferred method in nearly every outdoor environment. However, research has documented the ineffective break down of coliform bacteria using this technique (Temple and others 1982). Use of the cat hole procedure should not be attempted in areas with less than optimal
<table>
<thead>
<tr>
<th>Incineration</th>
<th>Waste is cooked in propane-fired High-use chamber locations</th>
<th>Latrine structure; Pack stock or helicopter required for transport of propane and ash</th>
<th>Odor; Impacts related to use of Aesthetic concerns pack stock (seed dispersal, of latrine structure; trail erosion) and Noise or trail helicopter (wildlife issues); erosion issues related to transport Odor;</th>
<th>Class II to IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dehydration</td>
<td>Waste is dried in straining system; can High-use use passive solar assistance locations</td>
<td>Latrine structure; Liquid treatment system; Pack stock or helicopter required for removal of solids</td>
<td>Odor; Impacts related to use of Aesthetic concerns pack stock (seed dispersal, of latrine structure; trail erosion) and Noise or trail helicopter (wildlife issues); erosion issues related to transport Odor;</td>
<td>Class II to IV</td>
</tr>
<tr>
<td>Vault with no liquid separation</td>
<td>Liquid and solid waste is collected in high-use sealed vault locations</td>
<td>Latrine structure (Wallowa-style); Pack stock or helicopter required for removal of vault</td>
<td>Odor; Impacts related to use of Aesthetic concerns pack stock (seed dispersal, of latrine structure; trail erosion) and Noise or trail helicopter (wildlife issues); erosion issues related to transport Odor;</td>
<td>Class II to IV</td>
</tr>
<tr>
<td>Vault with liquid separation</td>
<td>Liquid and solid waste is separated high-use Liquid treatment system; (esp. Temperate) Pack stock or helicopter required for removal of solids</td>
<td>Latrine structure; Noise or trail helicopter (wildlife issues); erosion issues related to transport Odor;</td>
<td>Impacts related to use of</td>
<td>Class II to IV</td>
</tr>
<tr>
<td>liquid separation using strainer and liquid treatment system locations</td>
<td>Liquid treatment system; (esp. Temperate) Pack stock or helicopter required for removal of solids</td>
<td>Aesthetic concerns pack stock (seed dispersal, of latrine structure; trail erosion) and Noise or trail helicopter (wildlife issues); erosion issues Surface or ground water related to transport pollution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology / Technique</td>
<td>Description</td>
<td>Appropriate Use</td>
<td>Minimum Tool Requirement</td>
<td>Potential Social Impact</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-----------------</td>
<td>--------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Smear</td>
<td>Waste is spread thinly on surface to allow decomposition by microbial activity and UV radiation</td>
<td>Low-use</td>
<td>Educational displays; Periodic monitoring</td>
<td>Aesthetic</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>&quot;Cat hole&quot;</td>
<td>Waste is buried in individual shallow holes to allow decomposition by microbial activity</td>
<td>Low-use</td>
<td>Educational displays; Periodic monitoring</td>
<td>Aesthetic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Trench Latrine</td>
<td>Waste is buried in shallow trench by group to allow decomposition by microbial activity</td>
<td>Low-use</td>
<td>Educational displays; Periodic monitoring</td>
<td>Aesthetic</td>
</tr>
<tr>
<td>Individual</td>
<td>Waste is carried-out in tube or bag</td>
<td>High-use</td>
<td>Educational displays; Provisions of bags or tubes</td>
<td>Social</td>
</tr>
<tr>
<td>Pack-out</td>
<td>Waste is carried-out in ammo can or pack-out bag locations</td>
<td>High-use</td>
<td>Educational displays; Provisions of bags or tubes</td>
<td>Social</td>
</tr>
<tr>
<td>Pit</td>
<td>Waste is deposited in unlined hole in ground by multiple parties and decomposes anaerobically</td>
<td>High-use</td>
<td>Latrine structure; Field Staff required for on-site maintenance</td>
<td>Odor;</td>
</tr>
<tr>
<td>Composting</td>
<td>Waste decomposes through mesophilic or thermophilic methods using wood chips</td>
<td>High-use</td>
<td>Latrine structure; Field Staff required for on-site maintenance</td>
<td>Aesthetic concerns Impacts related to use of Class II to IV of latrine structure; pack stock (seed dispersal, noise or trail) and erosion issues</td>
</tr>
</tbody>
</table>
Figure 1--Flow chart of sanitation options for wilderness managers.

**SCENARIO**

Are site conditions (soil, climate, use, visitor characteristics) adequate for low maintenance on-site treatment and disposal?  
→ No

Can education (on-site staff, signage, media) mitigate impacts?  
→ No

Can visitors be expected to comply with "pack-out" requirements?  
→ No

Is a sanitation infrastructure (buildings, helicopters, pack stock) compatible with social values and biophysical constraints?  
→ Yes

Are management options available to maintain an on-site facility?  
→ No

Consider prohibiting or limiting the number of visitors.

→ Yes

**TECHNIQUE**

Smear method  
Cat hole method  
Group trench latrine  

Individual pack-out  
Group pack-out  

Pit  
Composting  
Incineration  
Dehydration
conditions for decomposition, including moderate temperatures, presence of organic matter in the soil and low chance of being found by potential users. The group trench latrine is a technique in which the waste is buried in a shallow trench used by a small group. This technique can also apply to parties camping in alpine conditions and in snow. However, waste deposited in permanent snow conditions will most likely take hundreds if not thousands of years to decompose (Ells 1997). The smear method, also known as surface disposal, is a technique in which the waste is spread thinly on the surface to allow aerobic decomposition by microbial activity and breakdown by ultraviolet radiation. The method works well in low-use locations where others are not likely to find the waste (Cole 1989). The individual pack-out method is gaining popularity in high-use areas. The waste is double-bagged, or single-bagged and placed in a tube. However, because of social acceptability issues, compliance is often low (Drake 1997). Numerous commercial options are available for the pack-out of group waste (Meyer 1994). The waste is sealed in an ammunition can or other secure receptacle and then carried out. This method is most common on river trips where the receptacle can be placed in a boat.

Treatment and disposal techniques that generally require a structure (outhouse) include pit toilets. Pit toilets offer a simple and relatively low maintenance method of waste treatment. However, these toilets are often anaerobic, characterized by slow decomposition and producing ammonia which is odorous. In addition, their use can affect water quality, depending on water table and flow path characteristics (Leonard and Plumley 1979). Composting toilet options involve the aerobic breakdown of waste in a sealed bin or tank. These methods operate favorably in locations where the climate is temperate and there is regular maintenance. Numerous composting methods have been tested and used in various applications (Lachapelle 1997; Land 1995a; Davis and Neubauer 1995; Yosemite National Park 1994; Weisberg 1988; Jensen 1984; Cook 1981). Although not a popular option, incineration offers an alternative that has been applied in backcountry settings. Mechanical difficulties have often been cited as a limiting factor. The use of dehydrating toilets is used primarily in extreme conditions such as alpine or desert locations and has received mixed reviews (Drake 1997; Mt. Rainier National Park 1993; McDonald and others 1987). Surface and ground water pollution can result from liquid discharge and the dehydrated solids must still be removed from the site. Vault toilets can either incorporate a liquid treatment system or be large enough to accommodate the liquid. (Land 1995b; Leonard and others 1981). Helicopters or pack stock such as mules are generally used in these situations because of the great weight and volume factors of transporting the waste. However, pack stock can contribute to fecal contamination of surface and ground water sources.

Conclusions and Recommendations

Several trends in the United States suggest that managers must design and maintain sanitation programs and infrastructures with an emphasis on incorporating minimum tool options and concerns about related impacts. First, use and impact have intensified and are expected to grow. Second, there is little research on sanitation and related public health concerns that result from wilderness use. Third, monitoring programs appear to be lacking.

Options for managers are often limited depending on social values and biophysical constraints. Cole and others (1987) describe five strategies for managers when dealing with human waste issues as 1) reducing use (prohibiting or limiting the number of visitors), 2) modifying the location of use (locate facilities on durable sites), 3) modify type of use and visitor behavior (education), 4) increase resistance of the resource (provide sanitation
infrastructure) and 5) maintain or rehabilitate the resource (remove waste from toilets). The matrix and flow chart incorporate these strategies in order to make explicit various sanitation techniques, minimum tool options and related impacts. Since these options present the manager with numerous potential management actions, they must all be considered in relation to social values and biophysical constraints. While a reduction in use can conceivably lessen the sanitation impact, Cole and others (1997) report that reduction levels can sometimes result in more negative than positive consequences. This has been described as the "toothpaste effect," in which limits on one area may expand to other areas when "pressed" by management actions (Cole 1993). Priorities should be well-developed in order to identify, monitor and publicly report the internal and external threats to wilderness values (McCool and Lucus 1990).

Increasingly, issues associated with visitor use and intensity, the severity of public health impacts and lack of tolerance by the public regarding sanitation has created a complex situation of determining methods of balancing minimum tool requirements and wilderness values. The difficult issue of sanitation options in wilderness would benefit from increased discussion and research. The situation remains a challenge for managers who strive to ameliorate the problems associated with sanitation in wilderness.

**Literature Cited**


This paper describes the initial experiments and continuing application of a solar "Hot Box" used to pasteurize composting toilet end-product from backcountry toilets in Yosemite National Park in the United States. This technology stems from a 1996 U.S. National Park Service and U.S. Forest Service cooperative project to demonstrate that a passive solar device could inoculate the end-product from composting toilets and meet stringent U.S. Environmental Protection Agency regulations for surface disposal. The Hot Box has been used for 3 seasons in Yosemite National Park and has proved to be remarkably successful at treating the end-product. The author provides detailed accounts of the experiments and application of the Hot Box in this field environment and suggests the application of such a device may be appropriate in cold climate natural areas.

Introduction

In many cold climate locations, impacts occur quickly and can be difficult to predict, monitor and/or mitigate. Managers of cold climate locations experiencing demand increases will need to determine appropriate methods that minimize impact while recognizing the aesthetic and maintenance costs of each method. One method that has proved beneficial in the reduction and inoculation in composting toilet end-product is the use of a passive solar pasteurizing device (termed the "Hot Box") that has been used for three field season at Yosemite National Park (NP), California, USA. In 1996, the United States Department of Agriculture, Forest Service (USFS), San Dimas Technology and Development Center and the United States Department of Interior, National Park Service (NPS), Yosemite National Park, conducted a cooperative study in the development and operation of the Hot Box to treat the end-product from composting toilets used by hikers in the backcountry. While considerable research had demonstrated the operation and maintenance of both mesophilic or thermophilic composting toilets in the backcountry (Davis and Neubauer 1995; Land 1995a,b; Yosemite NP 1994; Mount Rainier NP,1993; Weisberg 1988; McDonald and others 1987; Jensen 1984; Cook 1981; Leonard and others 1981; Leonard and Fay 1979; Leonard and Plumley 1979; Ely and Spencer 1978; Fay and Walke 1977), few studies had explored proper methods of composting toilet end-product disposal. Since complete pasteurization of composting toilet end-product by either treatment can not be guaranteed and depends on the quality of maintenance and site conditions, heat treatment from the Hot Box is one method to ensure pathogen reduction.

The study demonstrated that the Hot Box could consistently meet U.S. Environmental Protection Agency (EPA) heat treatment requirements and produce a class A sludge that could be surface-applied as outlined in 40 Code of Federal Regulations (CFR) Part 503 (Lachapelle and Clark 1998; Lachapelle and others 1997). According to the regulation, this heat treatment is a function of time and temperature (for example, two hours and 30 minutes with a temperature of 65°C is necessary to inoculate the sludge). However, Feachem and others (1983) report that destruction of all enteric pathogens (with the possible exception of...
enteroviruses and Ascaris sp. eggs) is guaranteed when a temperature of 65°C is maintained for 30 minutes (correspondingly 50°C for 24 hours, 62°C for one hour, or 70°C for 10 minutes). The study demonstrated that the EPA time-temperature requirement could consistently be met in Yosemite NP, an area that proved ideal because of high ambient air temperatures and consistent sunlight throughout much of the summer. The 1996 study demonstrated that temperatures of 88°C can be sustained for several hours with ambient air temperatures above 25°C. Field staff at Yosemite NP have used the Hot Box to pasteurize large quantities of end-product during the summers of 1997 through 1999. Field staff report that the Hot Box operates well and requires minimal labor under optimal conditions.

Hot Box Description and Application

The Hot Box is a nearly air-tight container that allows the sun's short-wave radiation or light energy to pass through the glazing. The contents of the Hot Box absorb the light energy and convert it to long-wave radiation or heat energy which becomes trapped inside the box. The outside walls, floor and removable tray are fabricated from an approximately .5 cm thick aluminum sheet. A single transparent Lexan® Thermoclear polycarbonate sheet is used as the solar glazing and is bolted at an angle specifically designed to maximize the angle of incidence during the summer solstice for the chosen latitude (at Yosemite NP, 38 degrees north latitude, a 15 degree angle was chosen). The inside walls and floor are insulated with 5 cm poly-isocyanurate closed-cell foam. A door is positioned at the back of the Hot Box in order to gain access to the tray. The original Hot Box measured 122 cm x 94 cm x 69 cm at the highest end and 46 cm at the lowest end. Four new Hot Box's, measuring 122 cm x 122 cm x 61 cm at the highest end and 20 cm at the lowest end have recently been built and appear to be more efficient because of their larger glazing and decreased internal air volumes.

The 1996 USFS/NPS study concluded that end-product pile depths in the tray of 12 cm or less and two and one-half hours of direct sunlight with ambient air temperatures exceeding 28°C were most effective at meeting the time-temperature requirement. Additionally, a moisture content of 60% or less allowed for maximum temperature attainment. Field staff would mix the end-product in the Hot Box tray several times during the heat-treatment process (up to several days depending on ambient air temperatures, moisture content of the compost and cloud cover) to ensure thorough pasteurization. After pasteurization, the finished compost was again bagged and brought to local flower gardens and spread thinly on the surface. Operators reported that the pasteurized compost resembled mulch and not human waste in both texture and odor and was therefore more tolerable to work with.

Applicability of the Hot Box in Cold Climate Natural Areas

The Hot Box can be used in a number of pasteurization applications either in the inoculation of composting toilet end-product (as demonstrated in the 1996 USFS/NPS study) or presumably for the treatment of raw fecal matter. While the testing and application of the Hot Box has been used primarily during periods of mild to warm ambient air temperatures, several assumptions can be made as to the applicability of the Hot Box in cold climate natural areas. In all of the experiments of the Hot Box with compost pile depths of 12 cm or less and a moisture content of 60% or less, the average difference in internal and external temperatures was 43.3°C. When the chamber was empty, a maximum internal temperature of 122.4°C was recorded with a maximum ambient air temperatures of 35.6°C making a difference of 86.8°C between internal and external temperatures.
Although the empirical testing of a passive solar heating device in cold climate areas is limited, several studies exist that illustrate the potential of the Hot Box in these environs. Ciochetti and Metcalf (1985) tested a hot box solar cooker to pasteurize water in the winter in Sacramento, California with average ambient air temperatures in November of 11.7°C, in December of 7.8°C and in January of 7.2°C and were able to heat water to 59.0°C, 48.2°C and 52.2°C respectively. Vaishya and others (1985) also tested a solar cooker in the winter months with ambient air temperatures of 17°C and were able to achieve temperatures inside the cooker of 95°C. Thus, it appears that in order to in a cold climate environment, methods must be adopted that maximize the efficiency of the device. Several factors affect the efficiency of the Hot Box. These include heat gain into the Hot Box, heat loss from the Hot Box, heat transfer within the Hot Box, structural materials of the Hot Box, materials and design of reflectors and solar glazing, and the volume of the chamber. However, estimating the power efficiency of the Hot Box is a complicated task due to multiple heat gain, loss and transfer mechanisms.

Heat loss from the Hot Box consists of conduction, convection and radiation. Heat is lost by conduction, when it travels through the molecules of materials of the Hot Box to the air outside. Conduction from the walls can be reduced by increasing the thermal resistance of the walls, floor and glazing. The second form of heat loss is by convection. Hot air has a tendency to move upwards due to its lower density. Any air leaks in the Hot Box allows the hot air to move out of the box and cooler air from outside enters which subsequently lowers the temperature inside the cooker. Wind velocity increases the convective heat losses significantly and thus reduces the internal temperature. The third heat loss mechanism is radiation. Any hot object gives off heat waves, or radiates, to its surroundings (which are at a lower temperature). These heat waves are radiated through air or space and can escape directly through the glazing. While glass traps radiant heat better than most plastics, it is more susceptible to breaking and would increase the overall weight of the Hot Box. Thus, attention to leakage, density and weight of the materials within the insulated shell, the type of glazing, and proximity to wind should be paramount in future testing of the Hot Box. Additionally, reflectors mounted on the side could be used to maximize solar insolation and heat gain. Empirical testing of the Hot Box technology in varied applications including cooler ambient air temperatures is lacking and therefore further testing is necessary in order to gauge efficiency and promote design modifications.

Conclusion
The passive solar Hot Box has been used for three field seasons in Yosemite National Park, a location shown to be ideal to effectively pasteurize the end-product from backcountry composting toilets. Field staff in Yosemite National Park have reported that the Hot Box technology required a minimum level of attention and maintenance by the operator and produced a compost that is dryer and appears less offensive to handle and transport. However, pasteurization using the Hot Box occurs primarily in the summer months when ambient air temperatures average 25°C or above. The use of the Hot Box in cold climate natural areas is unknown and but with modifications to maximize efficiency, could present an effective pasteurization method of either composting toilet end-product or raw fecal matter.

While stringent regulations may negate the possibility that material treated in the Hot Box be surface-applied in a cold climate natural area, the Hot Box holds tremendous potential to save either transportation costs and associated impacts in areas where the material can be surface-applied on-site, or disposal costs where the material must be transported and disposed off-
site. Conceivably, this passive technology can serve as a sound and sustainable backcountry management technique, alleviating impacts, costs and extensive use of human, animal and mechanical resources for transportation while providing an added safety margin to field personnel.

**Literature Cited**


PROFILE

Brenda L. Land  
Civil/Sanitary Engineer  
USDA Forest Service  
San Dimas Technology and Development Center  
Brenda graduated from the Oregon Institute of Technology with a B.S. degree in Civil Engineering Technology in 1987. She started work at an Engineering Training for the Gifford Pinchot N.F. in Washington State immediately upon graduation. Duties included road construction inspection, and then facilities construction inspection. In 1992, Brenda transferred to the Allegheny N.F. as a Facilities Engineer, designing developed recreational areas. In 1994, she accepted the position of Sanitary Engineer at San Dimas Technology and Development Centre. This position is dedicated to finding solutions to human waste, wastewater, and potable water problems on National Forest Land.
CARRYOUT HUMAN WASTE TECHNIQUES AND ISSUES

Brenda Land — Forest Service, USA

Abstract

Human waste management in the backcountry is a challenging problem. One waste management method used to address the problem in some backcountry areas is a carryout program. The success of a carryout program depends mainly on terrain, visitor perception of need, and enforcement issues, than on climate.

Carryout programs begin with planning. Why do you want visitors to carry their human waste out? Human waste issues may be the most noticeable sign of a larger problem. Planning a user carryout program must include plans for collection and disposal.

Visitor and outfitter/guide removal has been successfully implemented on rafting rivers and mountain climbing routes. It has been less successful for hunting outfitter/guide groups. Successful programs are in areas with narrow use corridors, limited soil, high visitor use, a noticeable problem, limited or controlled access points, and more environmentally aware visitors. Carryout programs have better support if the problem is perceived as real rather than theoretical.

Introduction

A challenge facing public land managers in the United States is balancing recreational use with environmental protection. A land management plan that identifies that balance; such as ‘Limits of Acceptable Change’, ‘Recreational Opportunity Spectrum’, ‘Desired Future Condition’; (what are you trying to provide, and what are you trying to protect), should be developed as a first step. After a land management plan is developed, a ‘toolkit’ to help achieve and maintain the balance can be developed.

A waste management plan is one tool to use to achieve that balance, and should be consistent with guidelines in the land management plan. Ideally, a waste management plan should be scientifically defensible and objectively measurable. However, currently the science to support sound waste management practices in the backcountry is often missing, contradictory, or of limited practical value. The need to address the human waste issue may be based solely on a subjective perception that a problem exists.

One waste management method that is suitable in some backcountry areas is a waste carryout program. The success of carryout programs depends more on terrain, visitor perception of need, and enforcement issues than climate. Carryout programs are not very climate specific. A program that works during summer months can also work during winter months.

Visitor and outfitter/guide removal has been successfully implemented on a limited number of rafting rivers and mountain climbing routes. These areas share narrow use corridors, limited soil, high visitor use, limited or controlled access points, and more environmentally aware visitors.
Planning
A carryout program begins with a plan. Why do you want visitors to carry their human waste out? Who has to do it? How are they supposed to do it? Where do they put it if they do? What do you do with it after users carry it out? How are you going to enforce it? How are you going to pay for it?

Why do you want visitors to carry their human waste out?
What is the driving force behind the change from existing practices to new practices? Are there other issues that need addressed? Are there other management strategies that can accomplish the same goals? Carryout programs can involve a long-term commitment of money and labor. Is it really less expensive or labor intensive to maintain and enforce a visitor carryout program than to provide central collection and removal?

Human waste issues may be the most noticeable sign of a larger problem. Concentrated use may lead to soil erosion, compaction, vegetation damage, wildlife disturbance, riparian damage, or other environmental impacts. The Limits of Acceptable Change' (LAC) and 'Recreational Opportunity Spectrums Classification' (ROS Class) are two planning methods used by the US Forest Service and other land agencies to try to balance recreation with environmental protection.

Issues: Has there ever been any disease outbreak associated with human waste in the area? Has there ever been a documented case of animal disease associated with human waste in the area? Is there a measurable water quality change caused by human waste? Is there a noticeable problem, visual or odorous? A carryout program has better support if the problem is real or noticeable than if it is theoretical.

Who are the users of concern?
Outfitter/guide groups using a pack string to carry supplies, rafting groups, hikers and campers not using a pack string? The type of container used is dependent on method of accessing the backcountry. A five-gallon container that is suitable for use on large rafts is not suitable for backpackers. Containers that fit in panniers are needed for when pack strings are used.

The perception of the environmental impact of human waste disposal in backcountry areas varies between different user groups. The amount of persuasion, education, or scientifically defensible evidence of environmental degradation necessary to support a carryout program depends on the perception of the user group.

How are they supposed to do it?
Planning a user carryout program must include plans for collection and transport. The options for collecting and carrying it are limited by available transportation, length of trip, and disposal options. Larger, re-usable containers are preferable when pack animals, watercraft, or off road vehicles are available for transport. Plastic bags may be most appropriate container for hikers and backpackers.
Where do they put it if they do?

After they pack it out, what do they do with it? The type of container used to remove waste from the backcountry will influence collection and disposal options. Programs in the United States are using individual use plastic bags, plastic bag lined containers, and liner-less containers. Collection and final disposal of waste removed from the backcountry is provided at trailheads or other convenient locations. Users are not required to take it home for disposal.

Where plastic bags are used to carry out waste, receptacles are located at trailheads or parking areas. The collection receptacle should be animal-proof to prevent bears, coyotes, raccoons, feral dogs or skunks from scattering the content and tearing the bags. The receptacles must be emptied frequently enough to prevent them from overflowing.

Issues: Visitors may dispose of the plastic bags in vault toilets, trashcans, or leave them beside the trailhead when disposal locations are inconvenient or receptacles are overflowing. Other trash may be disposed of in the receptacles designated for bags. Sharp objects can puncture bags, creating a mess.

What do you do with it?

After it is collected, what do you do with it? If plastic bags are used, can the bags be disposed of in a landfill? Do the bags need to be incinerated? What is the cost of hauling and disposing of the collected bags? What regulations govern the disposal of bagged human waste? In some locations in the United States, individual collection bags are considered like disposable diapers or sanitary napkins and may be disposed of in landfills. Other parts of the country consider them under regulations governing medical waste or sewage.

If containers that do not use plastic bags are required, where are the containers emptied and cleaned? When containers are used by outfitter/guides, are you going to provide cleaning stations or require them to provide their own? Railer dump stations can be used to clean some types of containers. A SCAT Machine cleans the largest variety of containers. Both of these options need a water supply and wastewater disposal. The SCAT Machine also needs electrical power. The SCAT Machine is coin or token operated, and can pay for operation and maintenance costs.

How are you going to enforce it?

Is the program voluntary or mandatory? How will you enforce a mandatory program? In the United States, several rafting rivers have mandatory carryout programs. River rangers spot-check camps. Rafters are required to have a collection container with the rafting party. All waste; fire ashes, trash, and human waste; must be removed from the river corridor and disposed of in a proper location. Rafters can be lined, outfitter/guides can be fined and have their permit revoked. Some mountain climbing routes have a successful voluntary program. The carryout program is strongly encouraged, but no enforcement is attempted.

How are you going to pay for it?

User carryout programs involve an investment of time and money. Time is invested in feasibility studies and public input meetings. There are capital investment costs of collection facilities. There are operation and maintenance costs of collection and disposal facilities. There is enforcement costs in mandatory programs.
Other Issues

Other issues to be addressed in planning for individual carryout include how and where the bags will be available. Do users have to provide their own? Will you sell the bags or give them out free?

How are you going to educate visitors? Educational material should appear professional, not homemade. Permit entry areas are the easiest to ensure visitors receive the information.

Collection points for any carryout program should be established near trailheads or river takeout points. The more convenient the collection point is, the more likely that the removed waste will be disposed of in an appropriate manner.

The collection location must be kept clean. It is difficult to convince visitors that you believe in the environmentally beneficial need to remove human waste, when the collection location is unsanitary.

The collection facilities must be maintained. Malfunctioning washing facilities, overflow lag vaults, or over filled receptacles can present a real health hazard, as well as a nuisance.

Case Study 1: Successful River Carry-out Program

One of the first user carryout programs was started on the Salmon River in Idaho. This program followed the steps of land use planning, identifying the need, looking at alternatives, implementing a waste management plan, reviewing effectiveness and revising the program.

It is a mandatory program. Permits are required to float the river. Educational material is included with the permit. Compliance is excellent with the outfitter/guides, raft, canoe, and kayak groups. Compliance is not as good with motorboats, jet boats, and fishing groups.

When the program was first implemented, plastic bags were used to line the collection containers. Collection receptacles were provided at the river take-out locations where users could dispose of the bags. A disposal facility was built at a local wastewater treatment plant, where the collected bags were dumped, ripped open, washed, and screened. The plastic and other debris was removed by screens and sent to a landfill. The bag contents, along with septic tank and vault toilet waste were metered into the waste stream for the treatment plant.

Two problems were encountered with this program. The first problem, the collection points were not adequately maintained. The collection receptacles were not emptied often enough. Bags would break or tear and spill their contents on the ground. When the containers were too full, bags were disposed of in inappropriate locations. The second problem occurred at the disposal facility. The equipment used to shred and remove the plastic bags frequently clogged, resulting in an unacceptable operation and maintenance cost.

An alternative to plastic bags was decided on for two sections of the river. Washing facilities (SCAT Machines) were installed at two locations. Bag-less collection containers are required.

Boats, rafts, and other watercraft are required to carry a watertight container for collection and transport of human waste. Locations for disposal of collected material are posted on bulletin boards near the take-out points. Scat Machines are located near two of the take-out points. Trailer dump stations are also located along the main travel surrounding the area.
The Scat Machine is used to empty and wash many of the popular portable toilets used by river runners. It will not clean the portable toilets more commonly used on motorboats. The Porti-jon type toilets are cleaned at trailer dump stations, or taken home to clean.

The bag-less program is well received by outfitters and private rafting groups. Some problems have been encountered with the Scat Machine when wood cinders plug the unit (fire ashes also must be removed from the river corridor). The Scat Machine located in Riggins, Idaho is at an attended site. Tokens are sold at a gas station/convenience store, and the owner maintains the unit. The store sees an increase in retail sales because the unit is located behind his store. The Scat machine uses a large quantity of water and needs electrical power. Electricity, water supply, and wastewater disposal are constraints to installation. There are currently five SCAT Machines installed near rafting river takeout point in the United States. Two more are planned to he installed this year. The Rogue River in Oregon, and the Deschutes River in Oregon are implementing carryout programs as soon as the washing facilities are completed.

The SCAT Machine costs about $25,000 US, installed, at locations with existing water, power, and sewer systems. Operation and maintenance costs are paid for with fees collected from users.

Case Study 2: Successful Climbing Route Program
Mount Shasta, in northern California, is the second highest volcano in the United States at 14,162 feet (4,317 meters). Permits are required in the Mt. Shasta Wilderness area, but there is no quota on the number of permits issued. Over 15,000 people attempt to climb the Mount Shasta every year (from permit application data). Avalanche Gulch is the most popular climbing route, with an estimated 10,000 people choosing this route up the mountain. Bunny Flats Trailhead is the main take off point.

Mount Shasta has had a bag carryout program in place since 1994. The program was started by two climbing rangers who saw the need to do something about the problem. By late summer, Avalanche Gulch smelled like an open sewer. The program currently consists of an educational brochure that discuss the reasons for the 'Pack-it-Out' program, individual collection bags, with directions for use, and collection containers for used bags. It is a voluntary program.

The two Climbing Rangers, Dan Towner and Mat Hill, started this program in 1994, with limited support from management. The traditional planning steps were bypassed. They started with how to collect it, and how to dispose of it. After the first few years that the program was in place, collection and disposal procedure was modified.

The educational 'Pack It Out' brochure is included with permits. A poster is also placed on the Bunny Flat Trailhead Bulletin board. Bags are available at the Ranger Station, Trailhead, and local climbing equipment rental shop. The collection point is at Bunny Flat Trailhead, where a dedicated receptacle is placed. The receptacles are moved into a tree cooler for storage until they are hauled to Sacramento, CA, about 250 miles away, to a medical waste incinerator for final disposal.
The program has been a phenomenal success and has gained management support. Although the program does not have complete compliance, it has been very successful in raising awareness of the issue. The most popular climbing routes are noticeably cleaner. In 1999, over 10,000 bags were purchased and given to visitors, at a cost of $1,500: nearly 4,000 pounds of human waste were collected and incinerated for $1,800 (excluding transportation). During the 2000 season, the program will be expanded to Northgate access point.

Case Study 3: Unsuccessful Outfitter/Guide Program for Hunting Groups

This program has not yet been successfully implemented that I know of. There have been a few attempts, but they have not progressed beyond the public input stage. There is a lot of resistance in this user group to carryout programs. Shallow pit toilets are the dominant current method or human waste disposal. The perception that a real problem exists is missing.

Issues include a lack of scientifically defensible proof that there is a real problem with the current method. Hunter camps are below tree line, where soil is available to dig pit toilets. There is a different perception of environmental impacts among this group.

Summary

Carryout programs can be a viable alternative to building structures in the backcountry. Successful carryout programs in the United States share some common elements. The need is either apparent as on popular mountain climbing routes, or measurable, as on rafting rivers. They share heavily used, narrow corridors. The primary users enjoy the surroundings, and notice human impacts that detract from setting.

Carryout programs do not relieve the Agency of the responsibility to ensure the waste is properly disposed of. Providing and maintaining facilities for the collection and disposal of the removed waste requires a commitment of resources.
PROFILE
Cameron Leary
Ranger
Kosciuszko National Park
NSW National Parks & Wildlife Service
As the Ranger in charge of the Main Range area of Kosciuszko National Park for the past six years, Cameron has been heavily involved in all facets of the assessment, design and monitoring of human waste management systems in fragile environments. Prior to his working in Kosciuszko National Park, Cameron was the Senior Ranger on Lord Howe Island (World Heritage) where the management of human waste was also a serious issue.
WASTE MANAGEMENT IN KOSCIUSZKO NATIONAL PARK

Cameron Leary - Ranger Kosciuszko National Park

In 1994, I arrived at Kosciuszko National Park fresh from a six year secondment on Lord Howe Island (World Heritage listed) were one of the largest environmental problems faced by the island was the contamination of the ground water supply by septic tanks and pit toilets. With this experience fresh in my mind I began to familiarise myself with my patch of Kosciuszko National Park, which was the summit/main range area.

As it was winter one of my first experiences was with the problem of human waste in the area around Seamans Hut which is a popular short break and camping location on the main range for cross country ski tourers. As spring came the problem became even more apparent with the melting of the snow around the hut and nearby areas. The solution to this problem did not appear that it would come easy and to this date hasn't.

Roll on summer and one of the first questions asked of me was "where are the toilets?" There were none.

Not realising the problem was so big in the summer of 95/96 the service installed two (2) portable toilets at both Rawson Pass and Charlotte Pass, both were filled at each location the first day. We added two (2) more portables to each location and started to monitor usage. The extent of the problem at these two locations is highlighted in the following figures:

95/96 Charlotte Pass 7800 litres Rawson Pass 13200 litres
96/97 Charlotte Pass 10840 litres Rawson Pass 19940 litres
97/98 Charlotte Pass 12500 litres Rawson Pass 24800 litres
98/99 Charlotte Pass 12840 litres Rawson Pass 25700 litres

As managers we could see the ever-increasing problem and started to look at options and planning of facilities for the areas. After discussions with staff, stakeholders and visitors to the area Charlotte Pass was deemed to be the priority area with a number of issues to be addressed, the foremost being the provision of toilet facilities at the area known as the "Gateway to the Main Range". Consultants then developed a management strategy for the Charlotte Pass area after a number of briefings with service staff.

Discussions were held as to the most appropriate type of toilet to be installed, bearing in mind that the same or similar system would most likely be utilised at Rawson Pass in the future, a great deal of research into available options was undertaken. As an environmental agency it was felt that ESD principles should be paramount and thus it was decided to proceed with a composting system. The NPWS also felt that this was an opportunity to restore confidence in composting systems amongst users whose faith had been severely eroded in recent times.
As composting systems had performed poorly in the past in the colder alpine areas of Australia it was not with some trepidation that we set into this project. Firstly we looked at all the known problems that had been encountered in existing composting systems and assessed what were the main contributing factors to the problems. We looked at how these issues could be addressed using new technology and hindsight. From this information, specifications and design criteria were drawn up and then circulated to composting toilet system manufacturers and suppliers.

Suppliers were asked to provide designs that met the criteria for both composting system and building design. NSW Department of Health regulations for composting systems were also required to be met by the supplier's designs. Seven different companies provided twelve designs. Of these only one offered any options beyond those already commercially available from existing suppliers.

Following a number of discussions in relation to the design specifications/criteria for both the composting system and building, Integrated Eco-Villages were contracted to construct the facilities at Charlotte Pass.

Management has taken a pro-active position in the area of human waste management within the park over the past four to five years in particular with the replacement of the pit toilets within the camping/picnic areas on a priority basis with pump-out units. Installation of composting toilet complexes at the popular camping areas of Geehi and Tom Groggier.

In order to better assess visitor expectations management has been undertaking visitor monitoring over a number of years however over the past two years an intensive monitoring program has been run utilising volunteer students.

Although this data has not yet been closely looked at there are a number of issues being raised regularly. One of the most prevalent is the expectation of visitors that toilet facilities be available at more locations throughout the main range area. Areas such as Blue Lake, Like Albina, Seamans Hut and Rawson Pass are sites often named by visitors for toilet locations. Management is already looking at suitable options for permanent facilities at Rawson Pass and a winter only facility at Seamans Hut.

As the main range area is deemed by management to be a remote/backcountry area where people should be primarily self sufficient any development could be viewed as intrusive and therefore should any development take place it would need to be of minimal impact and as visually unobtrusive as possible.

In acknowledging that the summit of Mount Kosciuszko is an extremely popular destination it must also be kept in mind that the area of the main range utilised to gain access to the summit is minimal compared to the area available for recreational pursuits within the alpine environment. Thus raising the question of where do we draw the line and when is remote/backcountry still deemed remote/backcountry as far as providing human waste services.
In making this decision practicality and logistics are the major factors to be addressed. For example, would it be practical to construct a toilet facility at a location such as the track junction above Blue Lake given the associated problems with this location. Some of those issues that would need to be addressed are design of structure, visual impact, type of system, access for builders, access for materials, logistics for ongoing maintenance, cleaning, disposal of waste material, winter access/maintenance.

Assessment of these issues would result in the decision that practically and logistically the building of a toilet facility at this location would not be feasible option. However when the same criteria are assessed for locations such as Rawson Pass or Seamans Hut, you would find that the result would come out much differently. Although there would be a number of practical and logistical constraints, options could still be pursued.

Kosciuszko National Park has developed a policy that makes it mandatory for commercial operators and military services groups to carry out human waste products. This policy has been readily accepted by user groups and has resulted in a number of innovations being developed for transporting waste material under many differing circumstances.

Service staff have been actively encouraging overnight park users to give consideration to the carrying out of human waste as a minimal impact technique. With the ever increasing numbers of people who are undertaking outdoor recreation pursuits and the increased pressure these numbers are placing on some of our more popular routes and areas, it is only a matter of time before restrictions on numbers, camp locations, and waste disposal become a reality.

Kosciuszko National Park managers will continue to pursue practical and logistically feasible alternative human waste management options. We welcome feedback from users and look forward to receiving information from other agencies/stakeholders about developments, problems, or solutions to human waste management issues.
PROFILE
Bob McConnell Secretary
American Alpine Club
Bob McConnell is an attorney, and is a counsel with the law firm Hendricks, Hendricks & Shakes. P.C. in Colorado Springs. While he no longer actively practices law, he assists, as needed, in resolving employer-employee and management-labour disputes. He is an honorarium instructor in the Business Department at Colorado University, The Springs.

Bob received an undergraduate degree in secondary education and a law degree at the University of Tennessee. He received an LLM in labour law at New York University. Bob was a labour lawyer and a criminal lawyer while on active duty with the Army. Before becoming a lawyer, he commanded infantry units in both Vietnam and Europe. He retired as a Colonel from the Army Reserve. He has published articles on many facets of management-employee relations and spoken frequently on issues relating to the work environment.

Bob is an avid outdoors man whose interests include telemark skiing, rock, ice, and alpine climbing. He has guided horse pack, bicycle, hunting, winter adventure, and climbing trips in Colorado, Peru, and Nepal. He was a member of the 1987 American Everest North Face Expedition, lead the 1990 and 1992 Everest Environmental Expeditions, and was a member of the 1994 Sagarmatha Environmental Expedition. He is Secretary of the American Alpine Club. His book Gentle Expeditions-A Guide to Ethical Mountain Adventure, was published by the American Alpine Club in 1996. He received the David Brower Award for outstanding service in the field of conservation in 1991.
KEY NOTE ADDRESS

Bob McConnell — Secretary American Alpine Club
Greetings

Let me first say how excited I am to be here with you, on this, day two of my first trip "down under" to Australia. As I prepared for my journey, friends, students, and cowboys at the Ranch all asked where I was going. To a person, they were envious of my having this opportunity. I must say that you have created quite a romantic appeal among us North Americans. Then they would ask why I was going to climb, on business? And I would reply, "no, I'm going to talk about shit". Well, those who know me very well weren't surprised because it's something I spend a fair amount of time talking about.

We are all now embarking on a five-day journey. And an important journey it is. Indications of its importance may be seen first in the efforts of those who conceived the idea, and who have spent so much time planning, organising, and making this conference happen. Our thanks to each of you. My special thanks go to Karen, Liz and Monica who, since December, have been so helpful to me. A second indication of the importance of our journey is the number and quality of delegates who are here. Thanks to each of you for taking the time, and making the effort to join us.

I am here to learn. I look forward to getting to know, and learning from each of you. We come from many different backgrounds, and bring unique skills and experience to this conference. Let's take full advantage of that. For example, as you have just heard, in another life I was a lawyer. What can we learn from that? Well, there is a cartoon in many US newspapers called Non Sequitur. They ran a series several years ago under the caption "word origins". One day it showed a caveman holding his nose as another walked into the cave leaving tracks behind him. A woman standing nearby said, "aw, jeez...you stepped in a pile of lawyer." I encourage everyone here with us on this journey to learn, and to share your earnings, not only in the sessions that follow, but also during our breaks, on our hikes, and perhaps even over an adult beverage in the evenings. We've just added a new staff member at the American Alpine Club. She spent two years a little north of here and has told me repeatedly that Coopers Red Label is the best. Well see

Perspective

Before we get too far down the road of mutual admiration, and sense of importance of what we are about, let's pause a moment to put ourselves, and the issue of human waste management in perspective. The United Nations recently announced that we now live with six billion other people on this earth. Not only are we six billion, the number is growing, and it's growing really fast. Many of you are familiar with the term exponential growth. That is what is happening to the world population. Let me draw a graph of what this looks like in the past three hundred years.
Exponential Growth

Take a piece of paper. Fold it in half and it is twice as thick. Fold it again and it is four times a thick. Fold it forty times. How thick would it be? If you could fold a piece of paper forty times, it would reach from here to the moon. That is exponential growth. Projections are that at this growth rate, there will be eight billion people on earth within fifty years.

What does a world of six billion people look like? I read last week that Americans today have eight times the material prosperity of their counterparts a little more than a century ago. What took a worker in 1890 an hour to produce now takes seven minutes. The article continued that "today's official poor have routine access to a quality of food, healthcare, consumer products, entertainment, communications, and transportation that even the Vanderbilts, the Carnegies, the Rockefellers, and 19th-century European royalty, with all their combined wealth, could not have afforded." Yet in the face of this prosperity, there is another reality. I have also read that one American uses the same amount of natural resources as fifty Asians. Of the six billion people on earth, only eight percent own a car. Two billion live without benefit of proper sanitation. One billion don't have regular access to safe drinking water. Close to a billion are chronically hungry. An estimated 35,000 people, mostly children, die from hunger every day. Wars killed an estimated 40 million people this past century.

Increasing Back Country Use.

So why do I bring up the issue of population growth? While the US is population is stable, and, indeed, without emigration would be shrinking. we are experiencing tremendous increases in the number of people who enjoy and recreate in the outdoors. More people are visiting our parks, national forests, and wilderness areas then ever before. I suspect that is true here in Australia as well. And I suspect that is one of the major reasons why we are together today. I will share some slides with you Wednesday night, and tell you some tales, tall and true, about my adventures. I have been blessed with the opportunity to explore and climb on all the continents except Australia, and that will happen next week. I have parted with people all over the world. There is one thing I have found we all have in common. One of us, any reasonably healthy human being, generates about a pound of poop a day, every day. A pound a day we generate, whether we are at home, or in a beautiful facility like this, or walking about Kosciuszko National Park, or waiting out a storm in the wilderness area where I guide in Colorado. Once we leave the land of flush toilets, the issue of what to do with that pound of poop becomes very problematic.

When our numbers were fewer, human poop had little different impact than poop generated by the mammals that frequented the areas we visited. Nature made use of the nutrients. The remainder was inconsequential in the grand scheme of things. Well, things have changed. Lord John Hunt, in his book The Ascent of Everest, tell us that when Sir Edmund Hillary reached the summit of Everest in May, 1953, theirs was the only climbing expedition in the entire Khumbu Valley. Forty one years later there were already four hundred people in Everest Base Camp when I arrived. Four hundred people. Four hundred pounds of poop. Every day. That is a ton of poop every five days. Everest Base Camp on the Nepal side is a 45 minute helicopter ride, or a five day hike from the nearest flush toilet. It's a camp about the size of a football field, on a glacier, at 17,000 feet. Were talking serious shit here!
And it's not just Everest Base Camp where this has become an issue. It is Denali, Aconcagua, and popular mountains all over the world. It is trails in Yosemite, Namadgi, and other national parks. It is back country hut systems in Austria and Canada. It is the Inca Trail in Peru. It's the penguin colonies tourists now visit in Antarctica. Human waste management is an issue anywhere people can't walk quickly to a flush toilet. It's an issue that won't go away. And, absent some change in people's desire to get away from it all, to return to nature, we can only expect the problem to get worse.

Solutions

So what do we do? Some would say "the only solution is to keep everyone out of these natural areas." Simple, no people, no problem. That's not attractive to me, or I suspect most of us here today. The fact that there are those who argue this position, at least in the US. does bring home the importance of solving the human waste problem.

Another thing that land managers have considered, and in some cases have implemented, is restricting the number of people who can visit a certain area. Concepts like carrying capacity and the meaning of solitude are being studied. The Grand Canyon is a perfect example. Boaters wait years for a permit to kayak or raft the Canyon. Or they pay to go on a commercial trip. Boaters don't like that. Moreover, once they do get a permit, regulations require they pack out everything they take in the Canyon, including human waste. Boaters don't like that either. But the Grand Canyon, which sees 10,000 visitors a year, is pristine.

So is regulation the answer? Since at least 1985, Nepal has had a regulation on climbing permits I have seen, that expeditions carry out all their rubbish and leave nothing behind. With all the hype that has followed the 1996 tragedy on Everest. you don't need to be a rocket scientist to know this regulation has been ignored for years.

What is the difference between a regulation that you carry everything out of the Grand Canyon, and a regulation that you carry everything back from a climb in Nepal? Obviously, a regulation is only meaningful if it is enforced. In the Grand Canyon, the regulation is enforced by peer pressure, largely by the commercial operators who make their living taking visitors through the Canyon.

I am personally not a 'limit the number of visitors' or a 'government regulations' kind of guy. I identify with Paul Petzoldt, founder of the National Outdoor Leadership School, who at age 82 came to Everest Base Camp in Tibet to pick up trash with me. Paul used to say "rules are for fools". But you can't argue with success. And the Grand Canyon is a remarkable success story in terms of human and other waste management.

Another approach is the "Leave No Trace" movement. This is non-governmental, and instead of limiting numbers or imposing regulations, relies on education and voluntary compliance. I like the concepts of leave no trace. But the only way to leave no trace is to stay at home. What LNT is really about is minimum impact. LNT concepts in the area of human waste are discussed in detail by Kathleen Meyer in her book I low To Shit In The Woods.

Her book takes us also to practical application at the individual, or small group level. Once we get beyond the "let's just keep everyone out" discussion, we face the pound per person per day reality. So we are back to the question, what do we do with it? In 1992, I came across the book Earthships, by Michael Reynolds. He uses passive solar energy to heat thermal...
mass and warm rammed earth, glass front living structures. He also developed a solar toilet that will cook shit into sterile dust. Michael lived at the time in Taos. So I went to see him, stayed in an earthship, and pooped in a solar toilet. I was impressed and asked Michael if we could build solar toilets with materials we could buy in a developing country. He assured me we could. The end result was that he and I spent six weeks in Sikkim in 1993 making solar toilets. Let me show you a short video about what happened. Solar toilets may be the answer someday. But were not there yet for less than $1,000 US for a system that will work in warm, dry sunny environments for a family of four.

Several years ago, Colorado Springs, where I live in the winter, bought composting toilets for one of the city parks near my home. Nice idea, but the combination of the 6,000 foot altitude, the number of visitors, and the apparent inability of visitors to follow simple instructions like "don't put tampons or beer cans in the toilet", led to their demise within a year. We're back to portable chemical toilets there. Several of the huts in the Tenth Mountain System in Colorado use composting toilets at altitudes of 11,000 feet. These are tumbler models. A scoop of saw dust is added after every deposit. and each summer the product is transported out by vehicle. The technology, for now anyway, is expensive, relatively labour intense and limited in the number of users it can support

The Alpine Club of Canada (ACC), which manages twenty or so huts used by skiers and climbers has used vault toilets for years. The vaults are leakproof drums which are either pumped out, or hauled out intact by vehicle or helicopter. We use this same technology at the Ranch where I guide. It works great as long as you have road access or the money to pay for a helicopter, and a sanitation facility to dispose of the waste that is hauled out. ACC has also experimented with propane fired poop cookers. These work well in huts with up to twenty visitors. The propane and the by product is flown in and out by helicopter. While the volume of the end product is substantially reduced by the cooking process, savings are almost offset by the cost of flying the propane in.

The US Park Service has experimented with passive solar dryers. These are glass covered racks placed facing south below the pooper. As in the propane system, the idea was to reduce the volume of waste that had to be flown out. There was one of these at the South Saddle of the Grand Teton for several years. But it wasn't there the last time I was at the Saddle in 1996 or 97.

Conclusion
Well, where does this leave us as we start our five day journey together? Jean Aspen wrote in her book Arctic Son, "We might ask ourselves, what is the point of "advancing" if it creates an ugly, limiting and dreary world? Obviously, we cannot all go back to living in cabins. There would be no wilderness left. for there are too many of us. Preserving wilderness is almost impossible with an exponentially increasing humanity. But could we not find a way to integrate beauty and nature into our cities?" I think we can and should integrate beauty into our cities. Even then, I wouldn't like cities as much as I like the mountains. We must do better than that. We can, and we must manage human waste in a way that allows reasonable numbers of us to travel in, and enjoy wilderness. I look forward to our journey together this next five days.
WARREN MATTHEWS
PROFILE
Warren Matthews, Environmental Health Officer Southern NSW Public Health Unit
Warren commenced employment with the NSW Health Department in 1974. He holds an
Associate Diploma in Health and Building Survey and a Diploma in health Inspection from the
Royal Society of Health (London).
Warren worked as an Environmental Health Officer in the Western Metropolitan Region of
Sydney until 1983 and then transferred to his current position in the Southern NSW Public I
Health Unit at Goulburn.

Among the many broad and varied duties, he has been involved in evaluation of composting
toilets and has overseen the installation and operation of composting toilets in domestic,
commercial and public locations in the Kosciuszko National Park and other parts of Southern
NSW.
WATERLESS COMPOSTING TOILETS IN NSW
Warren Matthews — Environmental Health Officer, Southern NSW Public Health Unit

Abstract
The safe handling and disposal of human waste is a vital element in maintaining human health.

Human waste contains a wide variety of pathogenic organisms including bacteria, virus, protozoa and helminths. The spread of potential lethal diseases can be avoided, by ensuring no direct contact with, or inhalation of aerosols from such pathogens.

Composting is an age old process, and there are perceived environmental benefits in the treatment and disposal of human waste without the use of water. While composting has been successfully applied to the treatment of municipal green waste and sewage sludge, the composting of a human excrement presents many challenges for designers and operators.

The NSW Health Department is working with local councils and manufacturers to better understand and monitor the performance of composting toilets in domestic, public and commercial settings including alpine and sub-alpine environments.

Introduction
I would like to share my experiences of waterless composting toilets as an Environmental Health Officer employed with the Southern NSW Public Health Unit.

I will discuss the legislative requirements in NSW, testing and performance guidelines and finally relate some personal experiences of composting closets in NSW alpine areas and elsewhere in southern NSW.

We will first set the scene by describing the composting process.

The Composting process involves the digestion of organic material by many types of organisms, and produces carbon dioxide, water, heat & humus or compost. To be effective, the process has specific requirements for oxygen, moisture, pH, temperature and carbon/nitrogen ratio. While bacteria (single-celled microorganisms) are responsible for most of the decomposition and heat generation in compost, other organisms such as fungi, moulds, yeasts, worms & invertebrates (centipedes, millipedes, slaters etc.) also play a role in composting.

Under optimal conditions, composting proceeds through three phases:

1) the mesophilic, or moderate-temperature phase, which lasts for a couple of days. Initial decomposition is carried out by mesophilic microorganisms, which rapidly break down the soluble, readily degradable compounds. The heat they produce causes the compost temperature to rapidly rise.
The thermophilic, or high-temperature phase, which can last from a few days to several months. Once the temperature rises above about 40°C, the mesophilic microorganisms become less competitive and are replaced by others that are thermophilic, or heat-loving. At temperatures of 55°C and above, many microorganisms that are human or plant pathogens are destroyed. Temperatures over about 65°C kill many forms of microbes and limit the rate of decomposition. During this phase, high temperatures accelerate the breakdown of proteins, fats, and complex carbohydrates like cellulose and hemicellulose, the major structural molecules in plants.

the curing and maturation phase can last for several months. As the supply of high-energy compounds becomes exhausted, the compost temperature gradually decreases and mesophilic microorganisms once again take over maturation of the remaining organic matter.

Waterless composting toilets rarely provide the optimum conditions for complete composting of human waste.

Legislation
Waterless Composting Toilets (WCT) are defined as a Sewage Management Facilities (SMF) under the NSW Local Government Act 1993.

Under Local Government Act Regulations, council must not approve the installation or construction of a composting toilet (SMF) unless the facility is the subject of a current Certificate of Accreditation from the NSW Health Department. WCTs which are designed and built by the home owner/occupier (and not manufactured for sale or as the result of plans which are distributed commercially) do not require certification by NSW Health, but are assessed on an individual basis by the Local Council.

The NSW Health Department's has developed an Accreditation Guideline for Waterless Composting Toilets (WCT) which also contains a performance standard for home built composting toilets.

These Guidelines include the following requirements.

1. Process Design Criteria
1.1 The WCT design must incorporate aerobic biological treatment of human excrement and domestic organic matter, excluding greywater. The process must achieve die-off of pathogenic organisms without production of offensive odours, and the end product must have a humus like consistency and appearance.

1.2 WCTs must be designed and manufactured to:

- ensure all organic material has been fully composted. The minimum retention time in the WCT must be nine months.
- ensure organic matter does not conic into contact with any person, or spill from the WCT, during operation, maintenance, removal, or cleaning.
- ensure the processes are not adversely affected by environmental conditions such as temperature, humidity, gases or acids (from the composting process), or sunlight, or by any cleaning procedures.
- maintain wastes within a moisture range of 40% to 75%.
• achieve a carbon/nitrogen ratio of 14:1 -
• adequately aerate the composting pile
• safely dispose of any liquid waste generated (refer AS/NZS 1547)
• consistently produce an end product which contains < 200 cfu per gram of Thermotolerant coliforms and nil Salmonella per gram.

2 Construction Requirements

2.1 The WCT must be clearly and permanently marked with the manufacturer's name or trademark, model identification, month and year of manufacture, and capacity of the WCT, and must:
• be provided with a display panel showing the number of chambers and the last dates the chambers were filled and emptied (batch systems only).
• be continuously vented through a vent pipe independent of other household venting systems (AS 3500.2)
• be vermin and insect proof
• maintain the stored wastes at temperatures conducive to aerobic biological decomposition (20°C-55°C).
• incorporate an air space between the upper surface of the scat and the untreated waste of greater than 400 mm. Alternatively, provide a cleanable barrier and a leveling device to preclude contact with untreated waste.
• Ensure no human contact with the compost heap can occur during any raking or waste removal procedures.
• incorporate a pedestal which, at its narrowest part does not exceed 190 mm
• incorporate surfaces which are easily cleaned without use of chemical agents.
• include a waste chute with a childproof, tight closing lid.
• be watertight to preclude infiltration, and prevent escape of liquids

2.2 Structural Soundness

2.2.1 The design of the composting tank or chamber is to be certified by a structural engineer. In relation to transportation, installation and operation, the following aspects must be considered:
• internal and external pressures including hydrostatic and geotechnical pressures when either full or empty
• mass of the tank and contents
• localised loads acting on the supports, lugs and/or other attachments and on internal baffles and ducting
• normal loads applied during transport and installation
• fatigue
• soil conditions
• corrosive environments
• ground anchorage.
2.3 Materials
- All metal components shall be of stainless steel or other non-corroding material
- All plastics, perishable components and any other material must resist exposure to ultraviolet radiation or adverse chemical or biological environments and must retain their integrity under normal operating
- Where plastic pipes and pipe fittings are used they shall be UPVC complying with AS 1260 or AS 1415.

2.4 Equipment
- All mechanical and electrical equipment must be suitable for continuous and intermittent operation.
- All the electrical components shall be in accordance with AS 3000 Electrical installation - buildings structures and premises

2.5 Noise
The maximum permissible noise level with all equipment operating simultaneously eg fans, shall be less than or equal to 40 dB measured on fast response at a distance of 1m from the nearest item of noise emitting equipment.

2.6 Access
2.6.1 The WCT shall have ready access, without any requirement for major dismantling of component parts, to the waste storage chamber, and removal chamber if included, to enable:
- retrieval of foreign objects or matter which may enter the WCT
- convenient periodic inspection, raking, turning or removal of waste as may be required by the design
- ease of applying water or bulking material as may be required by the design
- accessibility for cleaning & repairs (without coming into direct contact with composting material).

2.6.2 The WCT shall not be buried due to the need to maintain full access to the unit and provide appropriate drainage from the unit.

2.7 Removal and Disposal of End
2.7.1 The WCT shall he designed to allow the safe removal of the end product and the cleaning of any liquid separation grates or filter mediums. It must not be possible to remove humus through the toilet chute under normal operating conditions.

Removal of the end product, should not result in incidental contamination from freshly deposited faeces or urine.

Composted material is to be disposed of by burial within the confines of the premises in soil which is not intended to be used for the cultivation of vegetables or used in pastures where animals may graze. The minimum cover of soil over the composted material is 100 mm.

Composted material shall only be removed from the WCT during normal operation, through the access door provided for that purpose.
Disposable gloves and a disposable dust mask shall be worn by the person removing the compost from the WCT.

Material which has only been partially composted shall be removed from the WCT subject to the written consent of the Local Authority, which may issue instructions as to who may remove the material and the method of disposal of the material. Removal off-site requires the approval of the Local Authority.

3 Warranty and Guaranteed Service Life
3.1 All metal fittings, fasteners and components of the WCT other than any fans or motors shall have a service life of at least 15 years.

3.2 All mechanical and electrical parts shall have a minimum service life of 5 years and a minimum warranty period of 1 year.

3.3 The minimum warranty period for all labour and materials (other than those referred to in 3.2) shall be 3 years.

4 Quality Control
A manufacturer must obtain product quality assurance under the StandardsMark Quality Assurance Program or equivalent. A person who produces a standard design for distribution is exempt.

5 Installation
The manufacturer must supply:

- a full description of major mechanical and electrical component parts.
- instructions about locating WCT in a well-vented area, with protection of air hoses and air intakes from snow, ice or water vapour accumulations.
- diagrams of pipe work, ducting and electrical components to AS 3000 (or applicable).

6 Users Information
6.1 Operation and Maintenance Manuals

- Operational and Maintenance Manuals must be supplied and should include:
  - overview of the WCT and its intended use (eg continuous / intermittent, number of people served).
  - principle and function of operation.
  - start up procedure.
  - type of bulking material required.
  - frequency and quantity of bulking material required.
  - routine maintenance procedures.
  - public health considerations.
  - safety information when raking composting material (or applicable)
  - minimum retention time before end product is removed.
  - parts list with each part numbered and identified on an illustration, photograph or print.
  - user responsibilities.
  - warranty and service life of parts and of the whole unit.
  - a description of the method of disposal of the excess liquid.
- a safe and reliable method for removal and handling of end product materials shall be outlined according to the conditions of approval provided by the NSW Health Department.
- contact name and number for the company to deal with emergencies and regular maintenance enquiries.

6.2 Householders
Householders to be supplied with a list of signs of failure and suitable responses for at least the following:
- when additional bulking agent is required.
- rectification of odours.
- dealing with excessive liquid buildup in the chamber.
- insect control.
- equipment failure

7 Service Sheets
Service sheets are to be provided for use by service technicians

Test Criteria
The following test procedures must be followed before a WCI can be considered for accreditation by the NSW Health Department.

Test Criteria
Two test sites are to be chosen for evaluation of the WCT. The sites shall be chosen so as to reflect different climatic site conditions. Reports outlining performance of WCTs sited in other states or territories may be acceptable provided that all requirements of this guideline are fulfilled.

Note: Climatic variables such as temperature and humidity (moisture content) are critical factors which can affect and/or influence the composting process. Therefore, the working parameters relative to the composting process should be stated.

Loading
For a domestic installation, the test sites shall be occupied by no more than 10 persons. As design approval is granted for the actual number of persons used in the evaluation, the WCT is to be loaded at the design rated capacity.

Site Approval
If tested in NSW, written agreement for the testing site is to be obtained from the NSW Health Department and the local council. Site conditions may be imposed as considered necessary.

Testing Requirements
The WCT shall be installed in accordance with the manufacturer's instructions and specifications and in accordance with building requirements specified by the Local Authority. If an existing unit is submitted for testing, certification that the unit is constructed and installed in accordance with the manufacturers' instructions is required.
During testing, the WCT shall be operated and maintained in accordance with the manufacturer's instructions. The WCT is to receive both faeces and urine during the full term of the evaluation.

**Monitoring**

All compliance checking, monitoring, sampling and analysis is to be performed by a third party quality management system certification body accredited by the Joint Accreditation System of Australia and New Zealand (JAS-ANZ) and at the cost of the applicant. Sampling and analysis should he performed by a laboratory registered by NATA for that purposes.

**Access**

Access to the WCT by the manufacturer or their authorized representative shall be controlled by the testing agency. Unannounced visits to the test site shall be made by testing agency personnel at periodic intervals during the testing period.

An existing installation selected for testing shall be restored to a condition representative of a new installation prior to commissioning.

Operation during the test period should be in accordance with the manufacturer's instructions and will be carried out by the occupier of the premises.

An operating manual and checklist is to be provided for the use of the occupier of the premises.

A record of usage during a minimum three month period is to be kept and shall be considered representative of use during the testing period. Usage refers to deposition of both human faeces and urine. In addition a log of the number of occupants on the premises is to be kept on a weekly basis for the whole of the test period.

If at the end of the test period the WCT has not met the performance criteria, the manufacturer can either retest the WCT], or will be obliged to remove the WCT and to restore the premises to pre-test condition or to the satisfaction of the owner of the premises and the local authority.

**End Product Sampling**

End product sampling should be undertaken as follows.

- Disposable gloves and a disposable dust mask shall he worn while collecting the sample.
- Where a botching system (alternating chambers) is employed, samples to be collected from the centre of the pile at a point one quarter of the way up the height of the pile in each chamber.
- For continuous systems - samples to be collected from the base of the pile at the chamber clean out hatch.
- All samples shall be taken directly from the compost producing chamber. Samples must consist of the treated material and not the original bulking material.
- All samples are to be placed in sterile containers and labelled.
- Each sample is to be assessed for odour once the sample has been removed from the vicinity of the compost closet.
- The minimum number of samples to be taken at each testing event is three (3).
- The minimum weight of each sample is to he 100 grams.
Performance Criteria

The performance test criteria for WCTs are presented in Table 1.

Table 1 - Performance criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Performance criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odours</td>
<td>The WCT all not give rise to offensive odours at any time at the following locations or during the following circumstances:</td>
</tr>
<tr>
<td></td>
<td>a) the vent system at ground level</td>
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<tr>
<td></td>
<td>b) the toilet pedestals</td>
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<tr>
<td></td>
<td>c) the composting chamber</td>
</tr>
<tr>
<td></td>
<td>d) the composted end product immediately following removal from the chamber.</td>
</tr>
<tr>
<td>Consistency</td>
<td>The resultant product shall be friable and have a soil like or humus consistency.</td>
</tr>
<tr>
<td>Carbon/nitrogen ratio</td>
<td>Greater than 14:1.</td>
</tr>
<tr>
<td>Microbiological criteria</td>
<td>The resultant product is to comply with the following microbiological criteria.</td>
</tr>
<tr>
<td></td>
<td>a) Thermotolerant L. coli forms &lt; 200 cfu per grain</td>
</tr>
<tr>
<td></td>
<td>h) Salmonella nil per gram</td>
</tr>
</tbody>
</table>

Test Report

The testing agency shall prepare an evaluation report based on the design criteria, construction requirements and test criteria and testing experiences. The report shall include the following: identification of the type and model tested, compliance with drawings, rated capacity, loadings and testing methods.

- rated capacities of the WCT tested, including average, minimum, and maximum loadings (usage) specified by the manufacturer.
- schematic or design diagram to indicate integral components of the WCT tested.
- description of the test site.
- log of actual use during testing including stress loading with documentation of all supplemental loading (quantity and type) supplied during the test.
- a log of tests, compliance calculations, maintenance, equipment or component failures and any other factors pertinent to the test evaluation.
- results of sampling schedule and performance criteria.
- chronological list of any scheduled or unscheduled maintenance performed during the test.
- chronological list of pertinent equipment/component failures and actions required for correction.
- incidents relating to the testing agency equipment or personnel performance affecting test conditions, or data acquired during testing.
- quantity and type of wastes discharged or removed from the WCT or any of its components during testing.
**Approval**

An approval is granted for a period of five years, and may be subject to conditions.

**Batching system:** Approval may be recommended when at least two separate batch chambers meet the performance criteria specified in Table I for three consecutive testing events taken at three monthly intervals.

**Continuous system:** Approval may be recommended when the performance criteria specified in Table I are satisfied for three consecutive testing events taken at three monthly intervals.

At the anniversary of the approval date, the manufacturer shall provide the Health Department a list of all WCT installations within the state. A minimum of one and a maximum of 10% of installations shall be randomly chosen by NSW Health for additional testing. The WCTs selected are to be assessed to determine their compliance with the performance criteria. Sampling is to be performed by an independent agency and all analysis is to be determined by a NATA registered laboratory at the cost of the manufacturer.

**Field Survey**

A range of home-built and commercially manufactured closets (total 33) were inspected in Southern NSW in 1997 by Environmental Health Officers from the NSW Health Department and local councils. Sites included installations at domestic premises, public toilets & commercial establishments.

**Observations included:**

- Compost appearance (dry/wet)
- Presence of bulking agent
- Odour
- Presence of insects

Visual inspections indicated that conditions in almost all installations were not conducive to the composting process, due to the low mound temperatures, lack of bulking agent and excessive moisture (urine).

Insect breeding was evident in one of the domestic units.

With the exception of a home built unit, odour was a problem at most sites. The home built unit did not receive urine and was odour free. Urine was disposed of elsewhere.

In all installations, the waste chutes were either straight sided or converging (funnel shaped) resulting in excessive soiling. The waste chutes should be minimised, and shaped like an inverted funnel.

Excessive accumulation of urine was observed in continuous processing systems, and thus retarded the composting process. Insufficient bulking agent appeared to be a factor. While some manufacturer's instructions recommended the addition of a small amount of bulking agent weekly, it would appear that daily dosing is essential. Owing to the limited capacity of some commercially manufactured domestic units, the minimum 9 months storage may not be achievable.
The final product from Batch systems tended to be desiccated and not decomposed. Once moisture evaporated from full chambers, composting ceased. Human excrement and paper remained identifiable and well formed.

Temperatures were too low to destroy pathogenic organisms. My conclusion is that a more accurate description of Waterless Composting Toilets would be "Waterless Toilets" as conditions are rarely conducive to composting.

References

NSW Health Department "Guidelines for the Evaluation of Composting Toilets" August 1997

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Authors: Tom Riehard, Nancy Trautman, Marianne Krasny, Sue Predenbarg and Chris Stuart. Cornell University, Ithaca NY
ALISTAR PEARCE
PROFILE
Alistar Pearce
Te Anau Area Office
Department of Conservation New Zealand
Alistar trained as a Telecommunication Technician from leaving school. He became a Ski Bum with an interest in snow avalanche forecasting and developed a keen interest in the outdoors tramping, climbing, hunting, diving and flying microlites.
In 1980, Alistar joined the Park service in Fiordland National Park Te Anau and has been there ever since, apart from a two year secondment to Stewart Island in 92-93. His major job component has been tracks and huts, which is where his experience with sewage comes from.

He now specialises in environmental protection, radio communication, snow avalanche forecasting and management but still keep a hand in sewage removal.
AN OVERVIEW OF HUMAN WASTE MANAGEMENT IN FIORDLAND NATIONAL PARK

Shaun Elwood - Visitor Services, Southland Conservancy Department of Conservation, New Zealand
Alistar Pearce - Te Anau Area Office
Department of Conservation, New Zealand

Abstract
The South West New Zealand World Heritage Area, which incorporates Fiordland National Park, is a region characterised by a cool climate, high annual rainfall and dynamic landforms. Such attributes combined with the operational difficulties presented by remote areas provide a challenging environment in which to manage human waste. Recognition of the problems associated with human waste in the backcountry increased in prominence through the 1980s as general use levels of back country facilities increased, existing accommodation facilities in the form of backcountry huts were expanded and new tramping tracks were developed.

Alongside the increase in outdoor recreation activity, legislated resource management requirements and environmental monitoring conditions have directly influenced contemporary approaches to human waste management in protected natural areas. Over the past 15 years the investigation and development of innovative and specialised means of managing human waste in the backcountry has been undertaken that meets current logistical, cost and functional requirements. An increasing awareness has evolved amongst land managers of the unique adaptations and management approaches required ranging from waste containment in permanent snow fields to sites of high concentrated overnight use remote from road end access.

Effective waste management has also emerged as a significant factor in maintaining visitor satisfaction and experience of outdoor recreationalists at both high and low use sites within southern New Zealand.

Key Words: New Zealand, outdoor recreation, Fiordland National Park, human waste management

Introduction
The South West New Zealand World Heritage Area/Te Wahipounamu comprises a range of public lands managed for conservation values including the Fiordland, Mount Cook, Mount Aspiring and Westland National Parks. Fiordland National Park located in the lower South Island of New Zealand is the nations largest national park at 1.2 million hectares.

The Fiordland coast with mountains rising up to 2200m directly from the sea along the southern Alpine fault forms a harrier to strong westerly winds which travel across the southern ocean and Tasman Sea. This abrupt obstruction results in a very wet cool climate. There is a strong rainfall gradient across Fiordland with annual rainfall reducing from 7000mm in the west to 1200mm at the parks eastern boundary. The tree line is low (850-1000mm) for the latitude, 45° South, due to low summer temperatures caused by the oceanic

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influence on the climate. Rock and snow predominates at higher altitudes above the distinctive glacial formed V and U shaped valleys.

Included within Fiordland National Park are some of New Zealand's premier alpine ice and rock climbing locations, a combination of the Department of Conservation's most popular overnight walking tracks including the Milford, Routeburn and Kepler Great Walks and the tourist industry icons of Milford and Doubtful Sounds.

High levels of visitation to both the front and backcountry regions within the World Heritage Area, including Fiordland National Park present a range of challenges to the parks managers, the Department of Conservation (DOC). Of the issues presented by increasing visitation and use, the management of human waste is one significant component in the broad range of visitor management issues requiring consideration.

This paper provides an overview, and contemporary perspective, of human waste management within Fiordland National Park. A large component of the material detailed is derived from staff experience and knowledge of the history of waste management within the park, associated observations and evidence of visitor activity and behaviour.

Recreational Activity in the Fiordland Backcountry

The history of backcountry use and associated visitation has had a direct influence on the human waste management practices currently applied within Fiordland National Park.

After the Second World War use of the New Zealand backcountry increased to levels not previously seen since European colonisation. This growth through the 1950s and 60s was dominated by hunters employed on government deer control programmes, and in later stages commercial meat hunters. This period of intense, albeit dispersed, use was to see the establishment of a network of huts, tracks and routes accessing previously undeveloped and remote protected natural areas. At huts where hunters would stay on a regular basis, or be based from, human waste facilities consisted of a pit toilet.

Concern over the management of human waste in the backcountry remained low until a wider range of outdoor recreation activities became more prominent through the 1970's and into the mid 1980s. The expansion in outdoor use was facilitated by the presence of routes, tracks and huts associated with deer control operations. Backcountry use was still relatively low and dispersed but as the decade progressed specific locations and tracks increased in popularity, attracting a more diverse group of users. Tramping tracks that became popular during this period, such as the Milford, Routeburn, Greenstone and Hollyford remain so today. With the increasing use in the late 1970s parks management agencies began to progressively increase the capacity and standard of hut facilities on the popular tracks and backcountry sites where visitor concentration was occurring.

At low levels of visitation, the accepted approach to human waste in the backcountry was that it was not an issue of much concern, both from an environmental and public health perspective. Traditional backcountry users were also viewed to have lower expectations of those facilities to be provided. Where use was concentrated, such as at huts, waste management would consist of a pit or 'long drop' toilet facility. Environmental issues were not at the forefront of toilet design and siting.
Through the 1980s many existing facilities were upgraded or expanded, and new facilities predominantly huts, established. In 1988 the introduction of 'Hut Fees', as an attempt to go someway towards, although not wholly on a user pays basis, funding the management of back country accommodation were introduced by the Department of Conservation nationally. In common with only a few other major walking tracks the Routeburn and Milford Tracks already had a hut fees regime in place prior to 1988. The introduction of hut fees also saw a corresponding rise in visitor expectations of parks management and the facilities that were provided.

The 1990's have seen another period of increasing use within the backcountry of southern New Zealand. This increase has been characterised by;

- an increasing level of use by international visitors, with little New Zealand style backcountry experience. (65% of bednights on the Fiordland National Park Great Walks during the 1998/99 Great Walks season)
- the development of larger backcountry accommodation facilities (40 to 60 bunk huts)
- an increase in the expectation by visitors of the type and standard of facilities and experience they desire.

Over the 1998/99 Great Walks Season which runs between late October to mid April 52 500 bednights were spent by independent walkers across the Milford, Routeburn and Kepler Tracks.

Human Waste Management Practices in Fiordland

High use facilities

In 1979 the Department of Lands and Survey, a precursor to the current Department of Conservation, installed its first septic tank in Fiordland National Park. The tank was established at Lake Mackenzie Hut on the Routeburn Track. This development was a result of increasing use and the diminishing area available for digging pit toilets. The single small septic tank, purpose built below ground level, was filled to capacity within 18 months.

In the seasons immediately following the septic tank installation the sludge was emptied, using hand tools, into an adjacent pit provided for the winter toilet. While the tank eliminated the need for the regular construction of long drop pits, a means for removal of the sludge off site still had to be developed. In 1981 a septic system similar to that at Lake Mackenzie, was installed at Bowden Hut also on the Routeburn Track.

Although the installation of a septic tank at Fiordland National Park huts was a new approach to onsite waste management hut facilities operated by commercial guided walks operations on the Milford Track had used septic tanks since the mid 1970s. The septic tanks at guided walks huts also incurred the predominant operational issue of waste removal and disposal once the tanks were full. The common means then of waste removal from these tank was release and disposal of both effluent and sludge without treating, to either adjacent land or waterways.

Pit toilets were also standard at the Milford Track independent walker facilities. These 24 bunk huts were often at capacity during the summer walking season. Across the Milford Track, suitable sites for pit toilets were becoming scarce. This problem was exacerbated by frequent flooding and high water table levels across the hut sites. When pit toilets were full, either through use or seepage from water table levels, new pits were established and the toilet
shelter moved to cover the new pit. Additional problems included the need to undertake rock drilling and blasting to establish toilet pits on at least a seasonal basis.

By 1983 trials involving the removal of septic tank contents off site by helicopter for treatment and disposal outside of the park were well advanced. The techniques established for waste removal via helicopter were refined to include specially constructed flying tanks and a vacuum system for the transfer of sludge from the septic tanks to the flying tanks.

With the refinement and standardisation of the procedure for waste removal by helicopter a significant operational harrier was overcome. Using helicopter waste removal techniques increased the feasibility of operating medium capacity septic tank systems and supported their suitability for installation on the Milford and the then proposed Kepler Track. This refined procedure has since become standard practice across the Great Walks of Fiordland National Park.

The upgrade of public hut facilities on the Milford Track between 1984-86, included an increase to 40 bunks per hut, reticulated water, flush toilets and the installation of septic tank for the treatment of waste water. During 1987 and 1988 the Kepler Track was constructed providing a purpose built multi-day walking track suitable for high use levels. Development of the Kepler Track provided the opportunity to establish and design functional waste management systems prior to the three 40 bunk huts becoming operational (two huts were increased to 60 bunks in 1995). The systems implemented include sub-surface septic tanks and disposal trenches at the two huts in a forested environment and an above ground multiple septic tank and surface irrigation system at the higher altitude Luxmore Hut (1080m). Whilst Luxmore hut is situated above the bushline the land treatment area is located within the forest.

Huts on the Routeburn, Milford and Kepler Tracks are staffed on a permanent basis during the walking season providing an ability to manage the waste systems on a day to day basis and ensure working operation in the majority of situations. During the off season, the septic tank and associated foul water systems are not operated, due to a lack of staff presence onsite and climatic conditions including sub zero temperatures. Walkers are required to use pit toilets or dry vault units when utilising the facilities outside of the Great Walks season.

- As well as meeting capacity demands from hut use levels, the use of the septic tank systems within the high rainfall and cool environment of Fiordland has provided a means to;
  - Effectively treat the waste water
  - Greatly reduce the public health hazard
  - Ensure increased containment and control of waste in flood conditions.
  - Reduce the effect of high water tables (with the exception of tanks been forced up by rises in the water table)
  - Define the physical space required for long term onsite waste management, as opposed to expanding requirements of pit toilets
  - Allow for high levels of use with comfortable facilities, i.e. basic bathroom style setting.
While waste water systems are provided at huts, specific points of congestion between the Great Walk huts, often at vistas or alpine safety shelters, also required waste management. At these sites, as with other remote area but significant use sites, a waste management solution that is cost effective and also an aesthetically and environmentally acceptable solution is required. These toilet facilities had their own problems of altitude, exposure due to location above the bushline, been in often headwater environments and concentrated periods of high use, and a lower hydraulic loading than hut based facilities. The dry vault units, constructed from stainless steel and insulated panelling, are available year round and do not require staff maintenance on a regular basis.

Remote Location Sites
Increasing remote area use has generated the need for high durability low cost waste treatment systems that can be installed easily and require minimal ongoing operational input. At relatively low use huts (<1000 bednights p.a.) located at less accessible or remote sites, a composting toilet design has been adapted for use if replacement of pit toilets is required. These basic composting toilets, along the lines of a Clivus Multrum operation, are now becoming an accepted alternative for installation at locations where continued use of pit toilets is not practical or desired.

The design allows for liquid release, and has specifically accounted for the low ambient temperatures, high rainfall and relatively low levels of use (c.600 bednights per annum). The move to the composting unit also aims to reduce waste load and weight if the material has to be flown out; or provide a suitable material with low pathogen levels for mixing in with local forest litter at designated disposal sites adjacent to the facility if future trials prove the health hazard to be negligible.

While the composting unit is significantly more expensive to establish than a pit toilet, $1600 versus $6000 installed onsite respectively, the composting units have shown significant advantages including:
- Increased user comfort,
- Elimination of the requirement to establish new pit sites,
- Complies as a permitted activity under District Plans (RMA) as wastewater is not discharged dose to the water table
- A more eco friendly in the eyes of visitors
- A robust design
- Requires minimal maintenance and staff input of time (This is an advantage as regular management helicopter flights into these areas do not occur).

The one problem that these units do not overcome is that other wastes including food packaging, cans and litter is still placed into the units, although this is more a site specific issue. The first composting toilet installed in 1993 on the Dusky Track has not required removal of the composted waste since it was commissioned.
Current Waste Management Directions and Influencing Trends

The trend towards those points listed below, has ensured that managing associated visitor aspects such as user behaviour and attitudes, as well as funding issues and legislative responsibilities has altered the traditional direction of human waste management in the Fiordland backcountry.

- Increasing visitation to a wider range of remote but ecologically sensitive sites (such as tarns and alpine wetlands, riparian areas, headwater basins and permanently iced alpine sites).
- A rise in popularity of a wider range of remote location recreational (including cross country skiing, alpine climbing, sea and white water kayaking and helicopter access)
- Increasing use levels at managed sites of previously low concern (i.e. Dusky Track)
- An increasing use by day visitors to sites historically requiring overnight visitation.

A range of issues are now having an increasing bearing on how human waste management issues are dealt with within Fiordland National Park, these include:

- An increasing awareness amongst recreational users of protected natural areas of the issues associated with waste management, and the effect of this on a satisfying backcountry experience.

- Concern amongst backcountry walkers over the possible presence of water borne pathogens, predominantly Giardiasis, in both more popular and remote locations. Extensive testing for the presence of giardia has not been undertaken within Fiordland National Park. The occurrence of giardia in waterways within the park where it has been tested for, and reported associated symptoms, has generally been low (Headley, 1994). All Fiordland Great Walk hut water supplies originate from adjacent minor watercourses and are not tested, or treated.

- Concern over toilet and water quality consistently rate with visitors as a major impact issue. In surveys of independent walkers on Fiordlands (heate Walks (Cessford 1998a, Cessford 1998b, Cessford 1998c)) concern over uncertain water quality was the main impact bothering walkers on the Routeburn [rack, exceeding even crowding. Concern over water quality was only surpassed by crowding issues on the Kepler Track, and crowding and aircraft overflights on the Milford Track. While this most often reflects a general concern over water quality, rather than concern directly related to waste management issues, the two issues are becoming more directly linked by visitors.

- An increased focus on advocacy and public awareness to assist in human waste management. Management attempts to influence backcountry users in the disposal of, and conduct involving, human waste has been increasingly supported through advocacy and awareness programmes. Within Fiordland National Park it has traditionally been accepted that reference to the national Environmental Care Code and dissemination of its principles was sufficient. The Environmental Care Code has incorporated basic waste management principles but does not detail site or environment specific details, nor has it been used as a basis for other advocacy approaches at sites of concern. This focus will be increasingly important as a tool to encourage users to be more responsible for waste management.
• The development of backcountry facilities requiring less 'skill' to access, travel or utilise, and a perceived corresponding reduction in the skill base of users. This reduction in 'backcountry skill' is reflected on Great Walks with regular instances of human waste evident on the track itself. It seems walkers are less secure about venturing off the track to tend to their personal needs, and a lack of awareness of waterway contamination issues. With the provision of high standard facilities in the backcountry, such as the Great Walks huts (which provide sleeping hunks and mattresses, flush toilets and gas cooking rings), and the development of these tracks for lower skilled users the implications for general backcountry use have to be considered.

• The passing of legislation outlining specific responsibilities, standards and requirements to be adhered to human waste management sites. By definition this denotes application to backcountry facilities, which has impacted on park waste management practices.

• Under local body authority delegations through the Resource Management Act 1991 consents are required to be obtained for waste discharges to land or water including standard pit toilets, if they do not meet regionally prescribed requirements. Most consents issued prescribe the monitoring of water bodies in the vicinity of any land treatment waste water discharge area.

• The Building Act 1991 for the first time subjected central government agencies to the same building controls as local government and the private sector.

• The legislative requirements have also resulted in an increased awareness of the issues of compliance with environmental, cultural and resource management requirements as well as the general standards expected by users. This has resulted in park management allocating appropriate resources to deal with waste management, as well as recognise the issue as a speciality and train staff appropriately in waste systems operations, monitoring and occupational health and safety aspects.

• Visitors to high use sites, such as the Milford, Routeburn and Kepler Tracks are exhibiting an expectation of high standard waste management facilities and track/hut facilities. The application of hut fees and a part-user pays direction in facilities management may be influencing visitor perceptions, although this is associated with the prior experience of users.

• An awareness of cultural issues is increasing in significance. It is an offence to Maori values and beliefs for human waste to enter waterways in many instances, even if the dilution is such that it may be an acceptable engineering solution.

• Waste management is a significant operational and development cost in backcountry visitor site and facility management. The cost per users for waste management is also increasing at more remote low use but high impact sites, such as alpine and poorly drained locations.

• An increasing occurrence of structured sporting events in the backcountry. Multi sport and competitive Mountain running events, such as the Kepler Challenge, Tuatapere Wild Challenge and the Southern Traverse, pose alternate waste management issues. These events involve high levels of participation, and are conducted over a short time period and
site concentrated. It is often on events such as these that the views are expressed that existing toilet facilities are not convenient or are sited at inappropriate locations for competitors, or the facility cannot cope with the support crews based at checkpoints or control centres. The experience with multi-sport/mountain running events within Fiordland National Park has been that if correctly managed then impact is reduced to levels not differing from normal recreational use. Measures which can reduce the impact include:

1. Portable sealed vault units or chemical toilets are installed at locations of concern at the organiser's cost.
2. Competitors being instructed as to backcountry waste management protocol and informed of toilet locations
3. Any extra costs associated with permanent toilet management attributable to the event are covered by the event organisers

**Looking Forward**

While systems development of waste management solutions and installation was the traditional issue occupying human waste management that has been relatively overcome. It is now funding issues, advocacy and remote use site impact issues, plus user regulation that is an increasing focus in human waste management.

Over the past 50 years backcountry human waste management in Fiordland National Park has evolved to a stale where it is now more:

1. Culturally sensitive
2. Environment sensitive-

As we enter the 21st century Fiordland National Park finds itself in a situation of having:

- An increasing backcountry use through the park dominated by concentrated high use at selected sites and more dispersed but frequent use of remote areas
- To comply with increasing levels of legislative control governing facility and use/public health
- An increasing availability of suitable and appropriate tools and technology to manage human waste onsite in the backcountry.

The above attributes, new use trends, activities and developments will continue to ensure that human waste management issues remain a dominant aspect of visitor management within Fiordland National Park.

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REFERENCES


REMOVAL BY HELICOPTER OF SEPTIC TANK SLUDGE FROM FIORDLANDS GREAT WALKS

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Abstract
Systems to allow for the onsite disposal of human waste are in operation at all of Fiordland National Park 'Great Walk' hut sites on the Milford, Routeburn and Kepler Tracks.

To ensure efficient operation of the disposal systems the removal of excess waste off the site from the first stages of the onsite disposal systems is required on an annual, or biennial basis. Helicopters are used extensively to remove excess human waste from the on site disposal systems, via a range of methods, for disposal at a suitable receiving station off site.

The techniques employed during the aerial operations require on the ground transfer of the waste from the septic and holding systems to tanks designed for flying and disposal at the designated receiving station. Operational problems encountered have included the trial and establishment of suitable equipment, procedures for waste transfer between the on site system and the flying' tanks, weight efficiency and workplace health and safety issues.

Key words: Helicopters, outdoor recreation, Fiordland National Park, Great Walks, human waste management.

Introduction and Background
This paper outlines a human waste removal system designed to fly septic tank sludge from high use and remote backcountry huts. If conducted correctly the procedure detailed can be achieved with minimal cost and effort.

In 1979 the Department of Lands and Survey, a precursor to the current department of Conservation, installed it's first septic tank in Fiordland National Park at Lake Mackenzie Hut on the Routeburn Track. This was a result of increasing use and the diminishing area available for digging pit toilets. The single small septic tank filled to capacity within 18 months. The full tank was emptied by hand using a bucket to deposit the sludge into the hole provided for the winter pit toilet. After this messy operation one person had to be treated for an unexplained rash to his body. Within another 18 months the tank was full again, and the same procedure undertaken.

The current operational system for waste removal by helicopter was first trialed in 1983 in the management of the Routeburn Track. The system has since become standard practice as a component of the management of human waste across the Great Walks of Fiordland National Park.
The Fiordland Great Walks (Routeburn, Milford and Kepler Tracks) average 6,000 person nights per hut for a season (November to April) in an environment where annual rainfall across the tracks ranges between 5,000mm and 8,500mm.

Main Principle of the Fly Out System

- To transfer, through vacuum, the thick sludge from the septic tank into tanks that can be flown out by helicopter, without resulting in blocked transfer hoses or dirty hands, while flying in stores and fuel to the huts. This ensures that:
  - The septic tanks and onsite waste management systems remain functional
  - Health and environmental hazards are eliminated or minimised
  - The operation is cost effective

Operational Components Involved in the Fly Out System

1. Fly Out Tanks

Tanks designed to contain the sludge removed from the septic tanks are sized relative to the total all up flyable payload of helicopters available in your area. A good supply of Squirrel 35013, BA, B2 helicopters and one MD530FF helicopter operate in Fiordland that are capable of lifting 700kg. The flying tanks are sized so not too exceed a gross flying weight of 700kg when full. Lowering the fill level can reduce the gross weight for high altitude and difficult sites.

Tanks are constructed from 3mm rolled and pressed mild steel. This provides the following advantages:

- It is a cheap material to buy and fabricate, relative to stainless steel or alloy.
- Easy and cheap to work with and repair.
- Has an ability to absorb impacts and punctures. "These tanks get a hard time, whether being transported by road or air. They are rolled off decks onto rocks. Even experienced pilots sometimes drop full tanks onto rocks. Fibreglass is not an option because of its brittleness and poor puncture resistance.
- Provides a good weight to strength ratio (relatively small and light). For flying empty and moving around by personnel on site.
- Relatively good corrosion characteristics when dealing with sewage sludge. The original tanks are now 17 years old and show no significant structural rust problems.

Tanks are 1.5 metres high and 850mm in diameter. Taller tanks are difficult to work with and do not easily fit on trailers.

The top has a 380mm fitted lid scaled with an 0 ring. This is fixed with three stainless 12mm bolts that pull it tight onto the 0 ring. The lid has a 70mm male camlock fitting. The top of the tank has a 250mm hole for evacuating sludge by the commercial septic tank truck.

A means of indicating the fluid level when filling the tanks is essential if overflow is to be avoided. A sight glass positioned in the top enables an operator to avoid overflow.

The tank has two short chains welded to the side and fitted to a snap ring for helicopter stropping.
Little in the way of rust protection for the tanks has been undertaken. Some PA10 on the outside and within arms reach on the inside. The PA 10 is dark red. The tanks get very scratched and scrapped, so the surface rust matches the PA 10 colour and the tanks don't look so old after their first use.

2. Vacuum Pump

A small and light "Masport MT" low volume high-speed vacuum pump is used to create the vacuum in the flying tank. The pump is driven by a Honda 3.5 HP 2:1 reduction petrol motor. The two motor and pump are directly coupled together on a lightweight stainless steel carry frame (alloy welds are prone to cracking with the vibration). Component weight of this unit is around 40 kg (90 lb.).

The vacuum pump and a 70mm hose are used because;
- By sucking sludge up a 70mm line there is no chance of anything in the sludge (clothing, sanitary items, plastic bags etc.) blocking the hose.
- There are no impellers and valves for the above miscellaneous items to catch on.
- Sludge with relatively low fluid content is more easily sucked than 'pumped' (Le. positive displacement). There is therefore less need to use the liquid fraction in the septic tank to desolidify the sludge. This reduces the weight volume of waste, from liquid. that needs to be flown out.
- They are relatively small and lightweight.

Vacuum Hose Linking Pump to Flying Tank. This can either be 12mm heavy walled plastic hose. although some operators prefer to use a larger diameter 32mm hose.

Swan Neck.
This fits onto the top of the tank and curves around; down and out (like a swan neck) so the vacuum hose can be connected to the flying tank. This has two 70mm female camlock couplings.

Vacuum Hose Between Sludge Tank and Flying Tank.
We have both:
- True 70mm Vacuum hose which is heavy and awkward to use in cold conditions. Can pull more vacuum before collapsing, and;
- 70mm "Ducting" hose which is light, easy to use and flexible in cool conditions.

Hose length is dependent on local requirements including the distance from the sludge tank to flying tank filling site. We use 20 meters with a camlock male to female coupling at 10 meters for shorter hose runs.

One end has a 70mm male coupling and the other end has about 1.2 metre section of 70mm alloy irrigation pipe for going into the sludge.

Air is sucked out of the flying tank with the vacuum pump via the 12mm hose thereby inducing a vacuum in the tank and suction in the 70mm vacuum hose. The latter hose is placed into the contents of the septic tank.
How the System Works for Us.

All of Fiordland’s eight ‘Great Walks’ huts (Routeburn, Milford and Kepler Tracks) have septic tanks, either above or below ground level. The huts are also supplied with LPG gas for cooking and coal for heating during the Great Walks season between late October and April. These fuels have to be flown into the huts either at the start of, during, or the end of the walking season. The huts have no heating or cooking fuel supplied during the winter. Sludge is flown out as a back load when these fuels and supplies are flown in.

As the flying tanks are both heavy and aerodynamic (cylindrical), the outward flight to the deposit site is very fast (90+ knots) in good conditions. Therefore the only major cost of the operation is the flying in of the pumping equipment, six tanks and operating staff, this makes up a single helicopter load. Combining sludge removal and hut provisioning makes for very efficient use of the helicopter and saves dollars.

Operational Procedure for Sludge Removal

1. A team of one or two fly onto site with empty tanks and pumping equipment. With some sites equipment may have to be long stropped into the vicinity of the septic tanks. The helicopter can either shut down or do another job while waiting for completion of the operation.
2. Remove septic tank lid and break up crusty sludge so that it is liquid that can be sucked up. This mixing may carry on throughout the operation depending on thickness of the sludge layer.
3. Set up tanks, pump equipment and hose.
4. Get a bucket of water with disinfectant for rinsing hands during operation. Gloves are an option but a good operator should be able to undertake the operation without getting a drop of hazardous waste on their person. Care must be taken not to expose fresh cuts or abrasions to any sludge.
5. Fill flying tanks.
6. Clean hose and associated equipment. There is a need to ensure that back flow of contaminated water from cleaning (bucketed water not a problem) does not enter the water supply.
7. Fly out tanks to road access deposit site. This can be done after all the tanks are full or throughout the filling operation.
8. Arrange to get tanks emptied. All the flyable sludge tanks are flown to the nearest road end and the septic tank cleaning contractor is notified to come and remove the contents. Contents removed from the flying tanks by a commercial septic tank cleaner are dumped into the local sewage ponds for secondary treatment.

Operational Considerations

To clean the onsite septic/sludge tanks for effective future operation they need to be cleaned out completely. Removing the top scum layer applies only temporary relief. If the lower sludge layer present in the tank is not removed it may be carried over into the next tank or land treatment field. A multiple tank system allows some sludge overflow from the primary tank to the secondary tank without major adverse effects to the land treatment field.

The flying sludge system is most cost effective for us when cleaning out sewage systems that have dual small (2-30001) multiple tanks. This gives the ability to let the primary tank get very full of sludge and the tank to he completely cleaned out. Dual primary tanks can he alternately cleaned on a biennial basis depending on system design and loading.
Current hut use levels allow the numbers of flyable sludge tanks to be flown out to be kept to around four per hut per season.

**Health and Safety Issues.**

Occupational health and safety aspects specific to this operation include:

- Helicopter loading and unloading-staff have to be familiar with movement and operations involving helicopters.
- Helicopter long stropping through trees. Falling dead and loose branches. Tree material may break off with helicopter down draft or through flying tanks dislodging branches.
- Hard Hat and high visibility vests are worn.
- Restriction of public access or health warning signage when tanks are stored at hut site or road accessible collection point. This is generally away from general public access areas.
- Personal hygiene is of major importance. Either disposable cotton overalls or waterproof bib/over trousers should be more than adequate. Keeping things clean is the critical part of the operation. The bucket of water with disinfectant is essential, with the operator rinsing hands, and exposed skin, regularly throughout the operation.

**Hut Site Case Studies**

On average from each of the eight Great Walks huts within Fiordland National Park four 600-litre tanks of sludge are removed annually, approximately 19 200 litres in total. The following examples provide an indication of the costs associated with waste removal by helicopter at two hut sites of differing locations.

**Example 1. Mintaro Hut**

Mintaro Hut, the middle of three DOC huts on the Milford Track, has a very high toilet use loading (both Independent and guided walkers). The primary tank holds around 8000L of sludge and is emptied annually.

Mintaro is one of our remotest Great Walks huts, having a 15 to 20 minute helicopter turnaround. The road end at Milford Sound, the closest road accessible site, is 120km from Te Anau, the nearest town. Careful management of the flying operation is required to ensure that unnecessary flying time is not clocked up in flying out the nine sludge tanks. The cost per litre to fly out sludge from this hut is around $1.00/litre if back flights are not utilised. Through the utilisation of back flights the additional cost, above standard back flight time, is around 10 cents/litre (for extra helicopter time to fly the tank out over an alpine pass). A further 10 cents/litre can be added onto this for removal back to Te Anau for final treatment. Also the cost of flying empty tanks and pump in adds 12 cents/litre. $T22 /litre without back loading or 22cents / litre with back loading.
PROFILE
Peter Quirk Jemby-Rinjah Lodge
Peter and his wife Margaret own and operate Jemby-Rinjah Lodge, an ecotourism facility at Blackheath in the Blue Mountains. They can accommodate over eighty resident guests, have a public restaurant and are involved heavily with educational conferences, school groups and day visitors for luncheons. Commencing with training at RMIT Peter spent seventeen years in service with the Air Force and the Department of the Navy before becoming an elected Alderman of the City of Blue Mountains.

He served nearly twenty years with the Council including seven as the longest serving Mayor and as an elected official with a commitment to conservation issues. During this time, after the UN Year of the Tree, Peter became the first National Director of Greening Australia, leaving this position to enter private enterprise, firstly with a vegetarian restaurant and then the holiday lodge and conference centre.

Jemby-Rinjah Lodge has won numerous Tourism Industry and construction awards, the most notable being the National 1996 Banksia Foundation Award, in the Built Environment Division.
Abstract
This paper is an anecdotal coverage of the experiences of an ecotourism operator and his practical involvement with dry-composting toilets over the past fifteen years. It outlines the use of these toilets in both small holiday cabins and a larger ecolodge facility with full dining capability that necessitated major on-site grey water disposal. The paper suggests management practices that are necessary to adapt dry-toilets to alpine regions and covers technical evaluation of his Lodge's facility and the development of an Environmental Management Plan providing a proscribed structure for maintenance and Council reporting. In conclusion the paper recommends greater involvement of natural area managers in promoting dry-toleting community education regarding the environmental benefits of dry toilets and government advocacy of alternatives to water based disposal systems.

Introduction
The introduction of what I will refer to as modem, dry composting toilets to a group such as are present for this workshop, should be an easy task.

Hopefully by this point in your careers you will all have sat and contemplated on either a Clivus Multrum, Rotaloo or Dowmus suite, determined firstly – yes, there is a breeze here somewhere, thought for a moment that someone is blowing on your nether regions and quickly realised that it better not be blowing, more likely sucking the air downhill – or otherwise the little room that you were occupying would have a terrible aroma instead of smelling as it should — as sweet as a rose as they say.

All of the new toilets, when installed and operating properly, arc capable of providing an odour and steam free environment within a bathroom as well as facilitating an environmentally friendly first stage in the disposal of human waste.

I take dry-toileting very seriously. In 1985 I was the first accommodation developer to commit to using firstly domestic Clivus Multrum's and then Rotaloo's in our new Cabins in the Blue Mountains and later used the larger commercial units in our Ecolodge accommodations units and the restaurant and Foyer area of our small-scale ecotourism facility.

I am spoken about and have been introduced on numerous occasions as the person who owns the largest group of dry toilets in a single installation in the Country. I have been laughed at, sitting on stage at a Conference and dropping my trousers to reveal multistriped undies ... and all with the simple purpose of getting people thinking .... thinking about composting human waste, composting their own body waste and the waste of others .... Of protecting the natural environment from water borne bugs and pollution and of educating users. young and old, that we can be responsible for managing our own waste disposal.

Jemby-Rinjah Lodge
Let me firstly brief you on Jemby-Rinjah Lodge — we call ourselves an Ecolodge now and before we started the project we adopted a “tread softly, live lightly” philosophy that underpins everything that we do and have done. A simple proposition and one that surely fits
the objective of your desire to manage and dispose of human waste at high altitude, cold
temperature locations.
Our Lodge is immediately adjacent to the Greater Blue Mountains National Park, the land is
typical sandstone country with medium height dry schlerophyl cover, located right on the 1000
metre line; at least partially on the way to being alpine. We see a bit of snow each year, lots of
frosts and have had to do battle with theories about evaporation in such climates before settling
down with the techniques we now use.
Yes, the majority of our guests tend to be interested and committed natural thinkers, but most are
still surprised to find that we integrate our dry loos into fully tiled en-suite situations and don't
treat them as out the hack" type facilities.
We have also, for instance, recently completed our `top-of-the-line' Treetops Retreat unit that we
sell as our `luxury' ... dry toilet unit and which also has the worlds smallest spa working in
conjunction with a grey water disposal system that operates perfectly on two, alternatively used
15 metre nimmi trenches.
Our land parcel was one of those lucky purchases, flat over much of it's nearly seven hectares,
home to a miriad of small birds, much bigger Lyre birds, a family of Tiger Quolls — plus a
Worm Farm and T Herb Garden. All in all the perfect location for passionate dry toilet folks like
us.
We obtained our Development Approval in 1985 with permission to use traditional Septic Tanks
and establish a cleared "Disposal Area" ... this would or could have become over time, one of
those smelly stagnant, black water bogs that are part and parcel of many Caravan Park and
Camping site developments all round Australia.
Our first Blue Mountains home however was in Blaxland, it accessed a creek which was for my
children a pristine swimming experience, but which became a tainted soap scum dribble where
the bubbles came to life as the water trickled between the boulders. The years of so called
disposal of septic black water into the sandstone ridges above, had left otherwise magical creeks
as long term pollution problems with `No-Swimming' signs to warn off the generation of young
people who came to live (here, later than ours.
I am no expert. Yes H have a tertiary education, but it was in electronics and missile technology.
I spent a major part of my working life in Air Force bases here and overseas, experiencing plenty
of smelly toilets at Mount Isa, Woomera, Singapore, Penang, Surabuya and Kuching. What
impacted most on my practical but unlearned mind was that much of the problems, the smells
and the surrounding environmental pollution ... came from the use of water.
I am told that it all started with Queen Victoria, she demanded the development of the
'Thunderbox' .... a basic water closet that would remove, by flushing it away with water, her
waste products. The fact that somebody else then had to deal with it was obviously not of her
concern.
Things really haven't got much better since then if you ask me, so called civilised humans in the
main expect to be able to press a button, sense the flushing of fresh water and all that poop and
paper goes down the drain .... crossing fingers for good luck that some equally
finger crossing engineer will have constructed a so called Water Treatment Plant down stream. This so-called treatment plant will take the water which has been deliberately polluted, hoping to treat it so that it can be returned to the natural environment without poisoning someone, but usually without success.

What did earlier communities do?, what does nature itself do?. what in fact. is the natural thing to do with our waste?.

I understand that, as humans, over 90 percent of what we excrete is water. A bit of wind and gaseous product otherwise known as smell, a very small volume of good and bad bacteria and viruses. internally produced hulking agents that generally provide the dark brown nature of the stuff .... and all of this is usually mixed with an externally provided hulking agent that varies from location to location with names such as Safe, given to the guaranteed recycled and brown coloured paper to the triple layered and very white Bowscott Ultrasoft, torn pages of the Sydney- Morning herald .... or often in the Alps. Gum I caves.

Blow away the smell, evaporate the water, let the good bacteria eat the had bacteria, encourage the warmed bulking agents to initiate a composting process and what is left? — very little. And what is left of course is itself excellent feeding and breeding fodder for composting Tiger Worms who prepare the resultant humus for safe re-introduction to the earth from which, of course, it originally came.

Have you noticed for instance that we, the human race do not pollute the earth with our bodies when we die. We let the natural biological action of nature take its course and like the dog poop on the lawn, or the body in the grave, dust to dust earth to earth, be it in a rainforest, a beach, desert or alpine heath the humus and re-cycling action of nature leads the way in environmental protection. But to be honest, a good way to compete with nature is to take a little bit of shit and mix it with a lot of water and then mess up a lot of the world in trying to dispose of it without a public health problem.

The toilets that we use don't smell, they are not hard to maintain, they are cheaper than all of the flushing alternatives, they work perfectly and can he modified or adapted to cuter for extremes in cold or hot climatic conditions.

An effective dry toilet needs to draw in air at a higher than ambient temperature. In our case we preheat the summer air in a glass topped box and in winter suck air from the guest fire-pit to achieve high levels of evaporation aided by the simple expedient of painting the flue pipes black. proven in a university experiment to warm the air within the tube and assist it to rise.

Excess urine that does not evaporate can be easily disposed of effectively and efficiently in grey water disposal systems — remember the old advice to World War One Diggers to wash wounds with urine to clean out the bugs — or in sawdust filled pits and nimmi trenches. one technique alone or in combinations of say transpiration beds and artificial wetlands.

Grey water handling is not, of course, for the amateur or naive handyman but with a few simple rules, low voltage technology that has developed primarily for the pleasure boating industry, improvisation is not difficult. We have found that with polypipe and the like together with containers such as grease traps one can easily develop switching and carrying systems for grey water and urine from reasonably large numbers of people on small areas of land.
I say small areas of land not to just prove a point but because even if one is then in close proximity to waterways or water tables you can prove dispersal and disposal within defined limits and without contamination of adjoining critical areas. Remember, our grey water does not contain the cellulose and other paper waste that clogs black water trenching and our use of water is greatly reduced on the norm with the removal of the wasteful flush.

It is my experience that both State and Local Government Officials require assistance so that they can adequately understand the simplicities of dry toileting that I have outlined in these few words to you. Such people seem to require in their nature a feeling of control and power over people and so we recently prepared a protective Environmental Management Plan that would proscribe the performance of our dry toilets and grey water disposal.

This Plan, as a concise document, became a feature of our Development Consent when it was last altered to allow full public access to our dining room which had become a matter of contention to a number of our Councillors still horrified with the thought of dry toilets and even though we have now had the Lodge open for 15 years.

They felt this necessity to place limits and controls on us and thankfully technical design features and parameters exist for the new generation of commercially available dry toilets and for grey water system. Thus our Plan contains sections dealing with the programmed testing of both our dry toilets and the grey water's impact on the surrounding soil and vegetation, along with scheduled maintenance and emergency procedures in case of failure.

As I outlined earlier our toilet output gets a secondary treatment, so to speak, in our Worm Farm after, in the usual cycle of things, a full year of composting within the unit. We see no problem in leaving the worms unhindered to work over this material until they withdraw and seek better food sources adjacent.

Our grey water volume and dispersal calculations have always had the support of committed consultants, in our case Terry Lustig and Michelle Maher of Environmental Management from Sydney who have just been appointed to a major study of the Myall Lakes, an area greatly under threat from water borne pollution and after recently completing a proposal for the Illawong Ski Club here in the Alps.

The standards used by Environmental Management are those developed by Standards Australia and Standards New Zealand firstly as AS/ANZS 1547 for Domestic On-Site Waste Water Management and the Draft AS/NZS Standard for Waterless Composting Toilets, in other words, the standards are in place, the results required by natural area managers are achievable .... What "we" the committed developers of product require are more innovative projects and public education so that the mystique of dry-composting can be allowed to dissipate.

In our case tests are done, the reports submitted to Council and evaluated by their Waste Water Management personnel who are now required to be on staff following the Mc Clelland Enquiry into the pollution of Sydney's Water supply.

As well, our major grey water disposal system is available to students of the University of NSW under a program initiated by Nick Ashbolt, Associate Professor in the University of NSW's Department of Water Engineering.
Piezometers have been installed both above and directly below the Nimmi "Trenching system and also in the National Park adjoining where an existing swamp feeds a small but delightful waterfall into the Grose Valley. This system is now in its seventh year of operation and was recently the subject of study for a PHD paper, let me read you some of his comments just about the Microbiology side of things as the Chemical findings regarding reductions in Nitrogen and Phosphorous were described in the paper as `remarkable'.

Total Coliform count as a test is only subsidiary to E.coli detection and readings did not confirm presence of any faecal contamination in the ground water. E.coli was detected in the source water from the settling tanks, but none detected in the piezometers along the trenches nor downhill in the piezometer adjacent to the swamp. Enterococci was detected in the swamp piezometer from one early sampling only whereas none was present adjacent to the disposal area, thus indicating the likely source to be the macropods resident is the swamp area.

Thermo-tolerant Coliform — the number of thermo tolerant coliform reduced significantly from 16000 (MPN) at the source down to 3 (MPN) at the adjacent piezometer. No thermo tolerant coliform was observed further down towards the swamp. Clostridium perfringens was detected at minimum levels in an early source test but none was detected in the adjacent piezometers and only on a very low level in the swamp piezometer.

In his summary of the overall performance of the system, our student described its removal efficiency as extremely high primarily because the grey water at the source contained concentrations between 1 to 10% of typical raw wastewater. Coupling this low input of contaminants with high removal features of 3 to 4 log, gave outstanding results. He also noted that RNA bacteriophage (a human specific virus) was tested for, in all water samples. It was detected once in the source water but was absent from all other test points.

All of this sounds typically technical and scientific but surely it is this balance of good scientific outcome from common sense practice that we need both in mv ecotourism industry and in the broader natural area management profession.

The words of warning though, come from those who have studied a broader sample of installations than mine. and done where results here not been so positive.

Some few years ago there was a paper done by a doctorate student from Tasmania which criticised all of the composting systems she visited except ours. The inference being and probably a quite correct assumption — that one needs to be passionate about poop to dispose of it adequately - ie. Human intervention in the process must be committed, sensible, trained and ongoing.

Our maintenance is supervised by a retired Westpac Bank Manager. a person who gains some pride in achieving trouble free operation of the system. Yes, he is given protective clothing and always wears disposable rubber gloves. We do have an occasionally messy job to do when dates are marked incorrectly on reports or the like and once when a transfer pump and sump became totally blocked with blowfly lavae.
We take the view that we must learn from each of these problems, not let them recur and gain the knowledge so that we can continually improve our performance.

The benefits, in turn, are enormous. As an ecotourism venture we have an educational input to about 6000 people per annum who make use of our toilets for our 15000 guest nights, quite an annual sample you might say of dry toilet users.

We have seen the perceptions and understanding of these guests change over time .... from a near fear of sitting over a dry toilet to a complaint if a guest, keen to use a dry toilet, is placed in one of the earlier cabins that contain a full flush septic system.

The words often spoken in 1986 — 87 of "I don't want one of those funny toilets I need a real toilet please" has changed to a full acceptance of both the need for and benefits of drytoileting. Some direct benefits of dry toilets have also worked to convince people of the advantages of not flushing everything away with a press of the button.

Our regular guest who had an expensive gold chain slip off her wrist and down the loo firstly said she never wanted to see it again .... but we simply waited for the eighteen months till the compost was removed, retrieved and washed it — and returned it to her, as good as new.

A more rapid response was needed recently when a woman guest wrapped an orthodontal device in a tissue for protection to then have her husband dispose of it down the hole. Urgent action saw access made with a jigsaw through the top of the fibreglass Rotaloo. The item was easily retrieved safely wrapped in the tissue and the expensive gadget returned .... Gaining another thankful guest.

In this example also the hole we cut for the emergency use became a major aid in the cleaning of the early model Rotaloos, so much so that we then modified all of the similar units to take advantage of the feature discovered in solving a crisis.

These are the good stories .... some other examples lead to problems, such as with young kids where I decided to treat the process of composting as a joke and developed a brief patter that described the "compost man" who worked down in the loo chomping up all the waste to turn it into good humus. I gave many young guests the story of how _, if they studied the blackness down the hole they would sec the little lights built into the eyes of the compost chomper while he went about his work.

I had to stop this action however as the parents of young girls especially reported that their children were having nightmares and talking for days about these terrible toilets with little people working in them. Just goes to prove, the best intentions can easily go astray can't they?

Our best intentions, though, must win out. Dry composting of human waste can be made to work effectively in very many locations and installations where it was previously thought water borne systems would suffice and were environmentally appropriate.

Black Water pollution of natural areas is not appropriate at a time when the products and the expertise are available to do it better.
"Do it naturally" as they say, but don't just take this to mean using the outdoors to please the persona .... compost your solid waste .... assess the suitability of available soils, and have a good grey water system designed and installed .... Then you, like I, can be proud of the results that are achievable.
THE
CLIVUS MULTRUM
EXPERIENCE
The Clivus Multrum Experience
Tony Rapson — Clivus Multrum
Abstract
Clivus Multrum composting toilets have been operating in all climatic conditions for over 50 years. Clivus Multrum Australia has been in operation for over 20 years.

Overseas experience in Alpine and cold climate conditions has demonstrated that with the correct initial specification and maintenance, the continuous process of the Clivus Multrum system is well suited for operations in these conditions. The continuous process and associated large composting tank mean that Clivus Multrum toilets can efficiently handle peak loads and climatic variations. Because Clivus Multrum toilets use no water and produce only innocuous solid waste and very little liquid discharge they are the ideal choice for human waste disposal in areas where conservation of water and the environment is important.

Clivus Multrum toilets are Australian made and supported by extensive experience both in Australia and overseas.

Introduction
In Australia, Clivus Multrum composting toilets are manufactured and marketed by Clivus Multrum Australia based in Brisbane. The Clivus Multrum concept for composting toilets was developed in Sweden over 50 years ago and since then these toilets have been installed in many countries in many different climatic conditions.

Clivus Multrum Australia has been successfully operating in Australia for over 20 years and as is the case overseas, Clivus Multrum composting toilets are installed all over Australia and currently operate in widely varying climatic conditions.

Clivus Multrum is probably the largest selling public facility composting toilet in the world and has over 50 years experience on which to draw.

Clivus Multrum is a proven performer in cold climate areas in North America and Europe and will perform equally well in Alpine areas of Australia.

The Clivus Multrum Design
As with other true composting toilets (as opposed to dehydrating or wet systems) the Clivus Multrum system works by the composting of waste by the bacteria present in nature that breakdown animal and vegetable waste.

The Clivus Multrum system takes advantage of this natural and simple process and refines it into a very efficient composting toilet that decomposes human waste.
The System is Continuous

This means that fresh waste enters at one end of the composting tank and over time moves forward to the other end of the tank where it is removed as fully decomposed and innocuous waste or compost.

The main components of the system are:
1. The tank which is made of UV resistant rotationally moulded polyethylene.
2. The toilet pedestal and waste chute.
3. The ventilation system with a small 12 volt fan to provide forced air flow.
4. The small liquid drain to dispose of any excess liquid.

Excreta accumulates in the tank and along with added carbon rich bulking material, such as wood shavings, garden clippings and leaves, decomposes in the oxygen rich atmosphere in the tank.

Baffles and air channels control the air flow to aerate the pile and accelerate the decomposition. The air flow also promotes evaporation of the liquid waste.

The small fan in the vent system draws off odour continuously and keeps the toilet cubicle odour free at all times. The fan can be powered by mains power if available via a transformer (as in many domestic situations) or by solar power or any other source of 12 volt power if mains power is not available. The vent system is designed so that odours will not enter the cubicle even on a still day.
Over a period of time, decomposed wastes will be typically reduced by 95% of their original volume and can be easily disposed of, usually by shallow burial. Under normal operation only a very little liquid waste is produced because the composting process and forced ventilation combine to reduce the liquid volume to insignificant levels.
The Advantages of the Clivus Multrum System

1. It uses NO WATER.
2. It produces reusable composted material that is a source of nutrients and can be used as a fertiliser if desired.
3. It eliminates odour from the toilet cubicle.
4. It is very easy to operate, maintain and clean.
5. Multiple pedestals can be accommodated by the larger commercial units.
6. It is a continuous process eliminating the need to frequently change bins.
7. The large composting tank size of the Clivus Multrum system means that waste has ample time to properly decompose and it is best placed to handle the effects of peak loads and climate variation.

Clivus Multrum units come in a number of sizes to cater for small domestic use through to large commercial units ideally suited for public installations.

<table>
<thead>
<tr>
<th>Model</th>
<th>Uses/year</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM8</td>
<td>8 000</td>
<td>Small domestic situations, walking trails, remote work stations.</td>
</tr>
<tr>
<td>CM14</td>
<td>13 000</td>
<td>Larger domestic situations, small public installations.</td>
</tr>
<tr>
<td>CM20</td>
<td>20 000</td>
<td>Large domestic situations, medium sized public facilities.</td>
</tr>
<tr>
<td>CM40</td>
<td>40 000</td>
<td>Large public and commercial installations</td>
</tr>
<tr>
<td>CM60</td>
<td>60 000</td>
<td>Very high usage areas.</td>
</tr>
</tbody>
</table>

Clivus Multrum Performance

The composting process utilised in the Clivus Multrum system successfully improves on the natural process. The liquid product is successfully treated as it percolates through the compost bed in the toilet. It undergoes a partial nitrification process and accumulates as hydroxide and nitrate. This kills most pathogens and renders it odour free and safe to handle. The resultant liquid discharge is not only innocuous but is a desirable source of nutrients. Overseas experience notes that the liquid waste treatment is extremely important and has shown that the liquid stabilisation is largely independent of temperature. It will drain off the pile and be odour free and treated even in cold weather.

Although in Australia we usually aim to dispose of the treated liquid waste; in Europe it has been recognised that it is an excellent organic fertiliser and emphasis is being placed on ways to re-utilise the liquid. Typical analysis of the end products of a Clivus Multrum system shows that there is no evidence of Faecal Coliforms, E Coli or Salmonella in the compost product. The liquid effluent typically shows Faecal Coliforms in the range 0-2 per 100ml.

Site Requirements

Because the Clivus system does not require water to operates and also produces very little liquid waste, it is ideal when siting in sensitive areas is required, or when water conservation is of prime concern.
Because there is no flushing the toilet pedestal needs to be positioned above the composting tank, this means that the tank has to be accommodated under the cubicle.

This can be achieved on any terrain, however, if a natural grade can be utilised, installation is simpler.

On a flat site the composting tank can be set into the ground up to the level of the compost removal hatch to minimise the required height of the building.

Environmental Factors
With the Clivus system there is minimal risk of environmental damage.

Treated solid waste is innocuous and will typically have no pathogens present. It can be reused as a fertiliser and is best buried about 100mm under the surface.

There is little liquid discharge under normal circumstances and the liquid that does discharge can be easily handled in a small absorption trench. For liquid loadings that are higher than normal, additional trenching can be utilised. If this is not possible or if liquid loadings are expected to be continuously abnormally high, a holding tank for future disposal can easily be installed.

Clivus Multrum units are designed to eliminate the effects of insect infestation. Attention to sealing of the tank and vent system ensures that any insect incursion will only be through carelessness or poor management. If somehow insects accidentally do enter the unit the composting process produces an atmosphere that inhibits reproduction and so will make any major infestation unlikely.

Operation and Maintenance
After installation, the unit would be used for a short time. Some seed bacteria are then added. This serves to accelerate the composting process and helps to establish equilibrium in the system. As the toilet is used, a carbon rich bulking agent is added regularly. The bulking agent is needed in the composting process as a source of carbon, but also acts to keep the pile loose, absorb the liquid waste, and help to reduce the odour.

The pile needs to be inspected, levelled, loosened and raked about every month but this will depend entirely on the amount of usage the toilet receives. This process is carried out via the specially designed inspection hatch. The task is not physically taxing or time consuming.

Again, depending on usage the decomposed waste needs to be removed via the compost removal hatch. Typically this would be done 12-18 months after commissioning and probably about every 6 months thereafter. In alpine situations where units are not heated, the composting process may be dormant for part of the year and the above schedule may vary. The decomposed waste is safe to handle and typically not offensive at all.
The only other maintenance required is periodic inspection of the 12 volt fan to ensure that the ventilation system is working as designed. If the fan does not function for a short time the composting process will still continue. (The fan will run for years without external influences). As with any toilet routine maintenance of the cubicle is needed. Because the Clivus system has easily accessible inspection and compost hatches, any misuse or vandalism can be addressed easily.

**Safety**

We have had no reported accidents with the Clivus Multrum toilet system. However, to minimise any potential risk, the toilet waste chute and pedestal on the Clivus system have been designed in a unique oval cross sectional shape which provides both the necessary area to minimise fouling while restricting the ability of a large object to enter the tank. In the event that an object entered the tank via the pedestal it could easily be recovered via the inspection hatch.

**Australian Applications**

Thousands of Clivus Multrum units have been installed and are operating successfully in Australia in all climatic conditions. Toilets are used for both domestic and commercial applications. In the commercial area, Clivus units have been specified by various National Parks and Wildlife services, local Councils State Government Departments, Road and Traffic authorities, Department of Defence and various private commercial operators. Where correctly specified and maintained Clivus systems always operate as expected and problems will be few.

As with any other system, problems will arise if the initial specification of the unit size does not correctly take into account the expected normal and peak loadings. Because Clivus Multrum composting toilets have a large tank capacity, it is a fairly simple matter to ensure that enough capacity is installed.

We are aware of a small number of cases in the past where not enough attention was paid to correct initial specification. This resulted in overloading and less than efficient operation. In these cases it was usually assumed that the unit was inappropriate for the application, when in actual fact, the problem did not lie with system design but was related directly to incorrect sizing in the first instance.
Similarly, operation of Clivus Multrum toilets is simple and maintenance requirements are minimal, however, when the recommended procedures are neglected or trivialised the opportunity for the system to operate sub optimally is created. This is usually the reason for user complaint and not the design of the system. It is essential with all public facilities that they are correctly operated and maintained.

**Alpine Applications**

Clivus Multrum has a wealth of alpine experience in Australia and particularly overseas in North America and Europe.

It has been found that both the solids composting and liquid stabilising processes are resilient and require little service and maintenance.

The process will be dormant during periods of non-use and will become active as use increases. Similarly in an unheated situation the composting process will be dormant in the cold months and will reactivate when the temperature rises again.

The Clivus Multrum utilises a large composting chamber which allows the accumulation of the waste during dormant periods which will become active as the temperature increases. Composting is not a linear process and the rate of decomposition will be determined by many environmental factors. Our systems are typically dimensioned to provide a large retention time which is why periodic freezing is acceptable. It is important therefore to initially specify a model of Clivus Multrum toilet that adequately caters for expected temperature fluctuations. The smaller bin sizes of other units will not allow this to happen and so they may need artificial heating to keep up with the input. The consequence of under sizing is that the unit will not cope with the required load resulting in a "soupy" pile texture. Clivus systems can be artificially heated if considered appropriate. This would reduce the unit size required for a given application. Heating can be provided in many ways and should be the subject of a separate examination to ensure that the optimum configuration is determined for each different situation.

**Summary**

- Clivus Multrum composting toilet systems have been operating worldwide for over 50 years and in Australia for more than 20 years. Clivus Multrum therefore has data and experience in relation to thousands of installations.
- When correctly specified and maintained Clivus Multrum toilets will operate exceptionally well in all climates.
- In relation to alpine applications Clivus Multrum has extensive overseas experience on which to draw that could be translated to Australian operations.
- Clivus Multrum is an approved toilet system in all Australian states.
- Clivus Multrum toilets utilise a continuous process with large tank size. This means:
  - Greater flexibility to handle climatic variations and peak loads.
  - More efficient composting.
  - Easy Operation.
  - Low Maintenance.
  - Low operating costs.
- Clivus Multrum toilets are manufactured from all Australian components and are designed for durability
- Clivus Multrum provides a waste disposal solution which has minimal ecological impact.
• Clivus Multrum systems are designed with safety in mind. For further information you can contact Clivus Multrum in Brisbane on (07) 3889-6144.
Colin Salter is a graduate Environmental Engineer from the University of Wollongong. His undergraduate thesis was based on research analysing the major barriers to successful decomposition in composting toilets. He is currently working on a toilet options report for the Myall Rakes National Park with Environmental Management Pty. Ltd.
SITE SELECTION AND FACILITIES DESIGN:
FUNDAMENTAL TO COMPOSTING TOILET SUCCESS

Colin Salter - University of Wollongong

The successful decomposition of human manure to a stable end product is vital to ensure minimal environmental impacts. The increase in attempts to achieve this in recent years, with a move away from the use of pit toilets (often described as composting toilets) in National Parks, State Forests, and other areas, has experienced a number of problems. These problems are not inherent to composting toilets, but can be a result of the following: poor site selection, inappropriate installation, inadequate toilet selection/design, or incorrect maintenance. These problems are often exacerbated by local climatic conditions, in the majority of cases cold climate areas.

The composting process, whether occurring on the forest floor or in a composting toilet, exists in a slate of dynamic equilibrium. Indicative of this is the inter-dependency of each parameter. As a result, any event that impacts on one composting parameter can have significant effects on a number of the other parameters. Of most significance in relation to cold climate areas are the effects of lower temperatures on moisture removal and the composting process in general. Moisture is essential for composting to occur. It provides the means of nutrient transport both to microbes present and through cell walls for decomposition. It can be, however, a multi-edged sword. Low moisture content can lead to a retardation of the composting process, whilst high moisture content can lead to anaerobic conditions, odour generation, and a significant decrease in volume reduction. "The latter being of more consequence in cold climate areas.

The last step in ensuring a composting toilet installation will operate effectively is to select an appropriate site. The importance of this to cold climate areas cannot be underestimated. Whilst site selection is often constrained due to a number of factors, an area that has an open northerly aspect is almost essential. The area should be free of shade for as long as possible during the day, especially in the winter months, should be protected from prevailing winds, and should not be placed in a valley. These considerations are the first steps required to ensure maximum solar benefits and minimum heat losses to the environment.

The next considerations are what materials are to be used to construct the housing for the facilities. Wood is often the most appropriate material in relation to availability and case of construction, but is not ideal due to its low thermal mass and poor insulating qualities. If wood is the material used, insulation is often required to prevent heat loss. This is more important in the floor, especially around the edges, due to typical soil temperatures in cold climate areas.
The basement of the facilities, or the room that contains the composting chamber/s, should be designed to be as small as practical to reduce both its volume and surface area to volume ratio. Larger volumes will require more energy for a similar temperature rise, and a higher volume to surface area ratio will increase the amount of heat lost to the surrounding environment. The design of an effective direct gain passive solar heating system is fundamental. The glazing on this room should be exposed to as much winter sun as possible from 9am to 3pm (as close to true north as possible), with the level of glazing determined by site requirements. The actual area of glazing should be up to 30% of the rooms floor space. This system can harness as much as 75% of the sun's energy.

To compliment a north facing direct gain system, east facing windows, with or without a thermal storage wall, can be installed to collect early morning sun, and west facing windows afternoon sun. These can in some cases, however, create overheating problems in summer.

High thermal mass materials retain the sun's energy and release it throughout the night, or at times of low solar energy, and can be used to compliment a direct gain system. Modifications can also be made to accommodate for some site-specific constraints, but these become limiting in cold climate areas.

To boost the effectiveness of a direct gain passive solar heating system, it can be coupled with an electric space heating system. "This system can be regulated by a thermostat to maintain a constant temperature. A temperature of 20°C has been proved to be sufficient at an existing installation in Govett's Lap National Park. At temperatures below this value, the onset of decomposition can be slowed. To increase the initial rate of decomposition, adding (or leaving) previously decomposed material to the composting chamber will introduce beneficial microorganisms already suited to the material. Increased pile temperatures also facilitate a corresponding increase in the rate of decomposition, with the rate generally doubling with every 10°C increase. Increasing the ambient air temperature, will also increase the capacity of air for moisture removal.

The major barrier to pile temperature increase in cold climate areas is the heat lost to evaporative cooling, with as much as 90% potentially being lost. Thus, the method of excess moisture removal/drainage is the next most important consideration. In a composting mass, a liquid film accumulates around particles providing a means for nutrient and microbial transport. As moisture content increase, so does the thickness of this film. The rate of diffusion of oxygen through water is 10,000 times slower then through air. Thus, with an increasing liquid film thickness, the level of oxygen transfer significantly decreases. Oxygen becomes limiting, reducing microbial activity, heat evolution, and can lead to anaerobic conditions. Adequate drainage of the composting chamber is essential to ensure these conditions do not develop.

To facilitate improved drainage, the installation of a false wall inside the composting chamber, with the cavity filled with a porous media, can compliment the typical drainage provisions present in the chambers base. This can also facilitate an increase in natural ventilation (diffusion), shortening the air-flow path and increasing interstitial oxygen concentrations. Source separation, including mo-flush ' male urinals or urine separating pedestals, can also be used to reduce the liquid entering the composting chamber.
The use of amendments, typically sawdust, to increase the carbon/nitrogen ratio can also improve drainage and reduce the overall moisture content. The use of sawdust, when added by users in excess, can lead to high carbon/nitrogen ratios and affect the composting process. A High carbon/nitrogen ratio (above approximately 30:1) leads to a reduced rate of decomposition, slowing the composting process. The carbon nitrogen ratio of human manure is significantly lower than 30:1, but values in this range do not affect the rate of decomposition, but can affect the level of ammonia gas volatilisation. The addition of fruit/vegetable matter (which can be promoted through signage) increases the carbon/nitrogen ratio closer to the optimum value, significantly increasing the level of energy released through decomposition, and can be significantly beneficial in cold climate areas.

Moisture content also has a significant impact on heat retention and loss. Water has a high capacity to store heat (specific heat) and subsequently requires a significant amount of energy for evaporation. This can amount to 90% of the total heat lost and lead to prolonged periods of low composting temperatures, retarding the composting process, especially in cold climate areas. When considering composting toilet design and installation, it needs to be noted that water is also produced during decomposition.

The current methods of treating/Removing this liquid include sub surface discharge to sand filters, transpiration mounds/trenches, evaporation, or a combination of these. If evaporation is to be used either as the primary means, or to complement sub surface discharge, it needs to be included in the design of the facilities from the outset. A number of methods are currently in use for the evaporation of excess liquid, including immersion heaters and space heating. Immersion heaters tend to super-saturate the air and can cause a significant increase in ammonia gas released. Irrespective of which method of evaporation is used, the air leaving the evaporation chamber should not pass through the composting mass. A back-up system should also be included in the design to reduce the impacts any potential problems may have.

Another problem associated with the evaporation of excess liquid, especially in cold climate areas, is the build-up of condensation in the exhaust vent/s. This liquid can then re-enter the composting chamber and reduce its temperature, affecting the composting process. This can be a significant problem, and can lead to a cessation of the composting process, especially in cold climate areas. One method of overcoming this problem is the inclusion of an s-bend or drop down section in the exhaust vent to catch this condensation.

One other issue, often overlooked in the site selection of a facility, is the reuse of the composted material. This is something that can require a significant amount of consideration. The sensitivity of some sites makes reuse inappropriate, whilst the potential for removal from remote sites can also be non-existent. This can significantly affect, and often force a change, on the criteria for site selection.
Oliver Vaughan
Technical Officer
Parks and Wildlife Service, Tasmania
Oliver hails from Tasmania where some 25% of the land area is reserved for conservation, and public interest in parks and conservation is strong.

Oliver's training is trade-technical and civil engineering. He has been with the Parks and Wildlife Service for 27 years - first as a field ranger and later as a technical officer working on the provision and maintenance of small-scale infrastructure projects.
OBSERVATIONS ON THE TASMANIAN EXPERIENCE IN HUMAN WASTE MANAGEMENT IN TEMPERATE NATURAL AREAS.

Oliver Vaughn - Technical Officer, Southern Region, Parks and Wildlife Service, Tasmania

Introduction

Bushwalking (backpacking/trekking/tramping) in Tasmania is a popular activity for locals as well as interstate and overseas visitors. Our bushwalking tracks (trails/paths/routes) are a significant destination for the State's tourist industry. The major overnight walking tracks are situated in the temperate, mountainous western and south-western sectors of the State. It's the job of the Tasmanian Parks and Wildlife Service (PWS) to manage the tracks and provide facilities for visitors, at the same time as safeguarding the natural features through which the tracks pass. Toilets are one of the facilities the PWS provides.

Pit toilets (long drop/earthen pit/privy/latrine) have been the traditional waste treatment system used in such sites. At road-head sites accessible by vehicle, septic tanks with French drains have been used. However, with increasing numbers of visitors, changing visitor expectations, greater public and scientific awareness and understanding of the environment, and the availability of alternatives, pit toilets and septic systems are no longer as acceptable. About twenty years ago, PWS began looking at and testing improved waste treatment systems.

The relevance of our experience to this Workshop lies in the similarity between the highlands of the Tasmanian west and southwest and the Australian Alps. The similarity includes climate, natural physical and biological features, visitor types and expectations, and management aspirations.

The focus of this paper is small, on-site waste-treatment systems. They are characterised as follows:

- isolation – remote from reticulated electric power and/or sewerage
- low annual usage <5,000
- seasonal usage
- limited or no vehicle access
- tight capital and operating funding

The trials and investigations have led us towards waterless, composting systems. Other types have been installed, including vault, haul-out, pump-out, various water-borne and package units. I'll focus on waterless systems, as they are the types I know best and that best suit the applications I design for. The performance of the other types is less effected by environmental and usage factors, and thus their suitability or otherwise is less site-dependent. Our larger treatment plants servicing major road-heads and visitor centres are designed by engineering consultants, and effluent quality must comply with discharge standards set by relevant authorities. Until about five years ago our preferred treatment-type for such plants was lagoon systems. In recent years we've moved towards multi-stage, intermittent cycle, extended aeration activated sludge systems.
Tasmania

Physical
The alpine and sub-alpine zones of the Tasmanian Central Plateau and western and south-western highlands are similar to those of the Australian Alps. Tasmania has 6,400 square kilometres of alpine and sub-alpine terrain (not all in National Parks) and the Australian Alps includes 5,200 square kilometres. The elevation of the Tasmanian zone is approximately 900 metres lower than the Alps, but is offset by the more southerly latitude and the oceanic influence of the 'Roaring Forties'. The shared characteristics of the two zones are: frequent, year-round frosts, low winter temperatures, high rainfall with no significant summer dry period, persistent winter snow cover of at least one month, and restricted biological productivity. There are differences, however, that are relevant to the performance of waterless waste treatment systems.

Climate
- rainfall - whilst totals are similar, the Australian Alps has a dryer summer and wetter winter
- wind - more constant in Tasmania
- sunshine - the Alps have twice the number of clear days in summer and three times as many in winter
- temperature - similar at equivalent altitudes (the Alps are significantly warmer in summer at the same altitude)
- Tasmania has higher summer humidity due to the oceanic influence

Vegetation
Whilst similar in form and distribution, in the Alps the areas above the tree line, and the ground-cover below it, are more commonly grassland and herb-fields, whilst the same areas in Tasmania tend more to heath-land and scrub. In Tasmania closed-canopy rainforest commonly occurs right to the edge of the tree line, which rarely occurs in the Alps.
Nutrient levels

Low nutrient levels are a distinctive characteristic of the terrestrial and aquatic ecosystems of pristine areas in the Tasmanian highlands and southwest. The selective advantage of highly-adapted native plants is effected adversely by small variations in background nutrient levels, leading to eventual displacement by exotic species if the variation is ongoing. Dominant species are known to have died-off in two locations due to changes to nutrient levels caused by sewerage systems.

National Parks

Tasmania has 18 national parks, covering close to 25% of the State. The four largest parks lie in the west and south-western highlands and together make up an integral region that has been listed as a World Heritage Area (WHA) for its distinctive natural and cultural features and largely intact ecosystem. The WHA, and the nearby Mount Field National Park, contain almost all the States major walking tracks and overnight bush-walking destinations. The walking tracks traverse terrain that is remote, mountainous, temperate and wet. It's on these tracks, and at the associated road-heads, that the PWS has done most work on waste treatment development.

Who are the users, and how many?

The total number of multi-day walkers using the WHA and adjoining highland regions of Tasmania is estimated to be 18,000 per year. The average trip-length is 4 days, giving a visitor-night figure of 54,000 p.a. The number of visitors at each overnight camp or hut site during the peak summer period averages 60 on the Overland Track in Cradle Mountain Lake St Clair National Park, our best known and most popular multi-day track. The average for the other tracks is much lower at 9, although there is wide variation.

The following graphs give a picture of seasonal variations, visitation trends and social characteristics of track visitors. (Data extrapolated from statistics collected for major tracks and visitor surveys.)

Walker registrations for Overland Track - Cradle Mt.-Lake St Clair Nat'l Park

Note: The Overland Track is the most well known and popular day and multi-day track in Tasmania. The steady growth trend shown above (average 5.7% p.a.) is not repeated on similar but less well known tracks in the WHA.
Statutory obligations

Under Tasmanian health legislation overnight camping and hut sites are "places of public assembly". As such they must be kept in "a sanitary condition", including the provision of a toilet "within 50 metres". A single toilet is acceptable for up to 100 males and/or 25 females. Under local government legislation the hardware components used in waste treatment systems must be "authorised", and the waste treatment systems must be "accredited". The legislation also regulates the construction and operation of waste treatment facilities, the plumbing trade, and the handling and transport of toilet waste material. Residues from waste treatment operations are classified as hazardous waste, and the handling, removal, transport and disposal is permitted only by licensed operators. An exception is humus from composting toilets which have been accredited within Tasmania, which is not classified as hazardous.

Water quality objectives set by Tasmanian legislation

Direct discharge of effluent to ground waters is totally banned. Quality standards for discharge of effluent to surface-waters are determined on a case-by-case basis by local government Environmental Health Officers. The relevant, broad objectives of such determinations include:

- Effluent must be matched to receiving surface water.
- Surface waters are classified as: - pristine, recreational, drinking, agricultural, industrial.
- Pristine waters (most remote walking areas) require zero bacteriological and nutrient readings. The guidelines acknowledge the difficulty of achieving that standard, and recommended that no wastewater be discharges into such waters.

Management objectives

The World Heritage Area Convention requires for WHA sites that the managing authority provide "protection", "conservation" and "presentation" of "natural heritage". The translation of that requirement into on-ground criteria for waste treatment systems, means: (a) achieving minimal and acceptable environment impact, and (b) meeting the reasonable social expectations and health needs of visitors. 'Environmental impact' includes any site disturbance involved in: (a) the initial construction of the facility; and (b) the ongoing discharge or otherwise of waste and/or effluent into the site.

In addition, PWS internal management criteria include:

- must meet statutory requirements
- minimal and acceptable health risk to users and to servicing staff
- attractive and pleasing to users.
- minimal and acceptable servicing and maintenance
- affordable capital and operating costs
- visually in harmony with location
Finding A Replacement for Pit-Toilets and Septic Tanks

**Traditional systems**
The traditional waste treatment system used in Tasmanian parks, and in Tasmania generally, in isolated sites which lack sewerage, but are accessible by vehicle, has been the in-ground septic tank feeding to a French drain. Trickling filters were sometimes installed between the two in sites of high-conservation-value to reduce effluent nutrient levels. In more remote, or less-used sites, and at sites inaccessible to vehicles, including most bushwalking tracks, the traditional vented pit toilet was used. Beyond those areas on less frequented walking tracks and in untracked walking country within national parks, a Minimal Impact Bushwalking Code has been promulgated. It encourages walkers to shallow-bury (150mm deep) their faeces away from campsites and at least 100 metres from surface water.

**Why change?**

**Septic Tanks**
The good:
1. known to users, plumbers, regulators
2. components readily available and every plumber knows how to install them
3. familiar to, and generally preferred by visitors
4. untreated waste is securely protected from vectors, animals, and visitors.

The bad:
(a) requires a reliable, nearby water supply, unless local piped supply available — roof collection is seldom adequate
(b) may need a long supply pipeline, and always a cistern, both of which are vulnerable to blockage and malfunction – hence require regular maintenance
(c) significant site disturbance during construction
(d) regular, costly pump-outs
(e) use of water to transport and separate waste significantly increases volume of effluent
(f) quality of effluent released to soil is poor

**Pit toilets**
The good:
(a) cheap to build – can be improvised from left-over or recycled materials on-hand if necessary
(b) simple, easy to understand. familiar to staff and most Visitors
(c) cheap to operate — nothing to break, jam or block

The bad:
(a) directs untreated waste directly into sub-soil and possibly into groundwater
(b) in poorly draining soils pit can fill with liquid — risk of splashing and flooding
(c) new hole required every year or so that cause significant site disturbance; labour-intensive to dig new hole, move toilet, seal and protect filled hole
(d) emit foul odours, especially if liquid level is high.
(e) attract flies and mosquitoes
(f) no longer acceptable to the majority of visitors — dark, flies. smell, often ramshackle, last user's waste visible, splashing, spiders, snakes!

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What do we want?
A system without the bad features of septic tanks, French drains and pit toilets, but retaining as far as possible the good points.
In summary:
(a) Must meet the reasonable expectation of users, and exceed them if possible: in particular the toilet cubicle must look, smell and 'feel' clean, it must not attract flies, and waste shouldn't be readily visible through pedestal.
(b) The components and treatment-system must be approved; effluent quality and disposal method must meet relevant legislation/regulations; PWS environmental protection objectives and public/staff safety and health codes must be met
(c) The amount of site disturbance during construction should be minimal; the toilet should not require periodic removal to a new site; and the toilet structure should be visually compatible with typical park settings
(d) Water requirement should be low enough to be met by roof collection — preferably for hand washing only.
(e) The design, construction and operation of the system must be understood and supported by staff

Systems Tried and Conclusions Reached
Some 40 toilet units, excluding fly-outs, have been built in the 20 years or so since we began looking for a better toilet system. The systems can be classified into the following types:
(a) Modified pits - lined and drained pits
   - drained vault
   - vault
(b) Composting - single chamber in-house designs
   - commercial — Clivus Multrum — Rota-too
(c) Batch compost- in-house/consultants
(d) Fly-outs - in-house
Modified pit toilet trials were the first to be tried, and are still being built in some places, mainly outside the WHA. In the WIIA they were succeeded by enthusiastic adoption of commercial compost units not long after they became available. The commercial units performed well, initially, and more were built.
Over time, however, performance declined and proved unsatisfactory. Negotiations with manufacturers led to modification of installed units, and a trial installation of a newer model. Concurrently the disparate field-staff involved in the trials were brought together, and, with the assistance of a consultant, decided to try an in-house, batch-composting design. A trial unit was installed under an existing toilet building, replacing a failed commercial unit. The trial led to modifications and a second, stand-alone installation. After several years in use the second trial unit was accepted by field staff as a satisfactory system. An engineer was engaged to prepare drawings for a final, 'standard' version, incorporating some minor changes. Other designs using the same concept have been built, mainly in coastal sites.
Thanks to...

The following PWS staff provided helpful advice and assistance in preparing this paper: Skye Jackson, Adrian Pyrke, Jayne Balmer, Trevor Westren, Sue Rundle, Jen Fry, Roger Ling and Peter Grant. Invaluable reference was made to the paper "Too Much of a Good Thing - The effect of high-nutrient effluent on Tasmania's natural environment' by Steven Smith (PWS Tasmania, 11/08/1990, 13p's). It is recommended to anyone interested in the effect of effluent on terrestrial and aquatic ecosystems in pristine natural environments.
PROFILE
Trevor Westren
Parks and Wildlife Service, Tasmania
Trevor Westren is a long-standing officer with the Parks and Wildlife Service in Tasmania. During his many years of service, Trevor has contributed to the management of a large number of the National Parks throughout the State.

Trevor joined the agency in 1972 as a field based Ranger, after having spent some years in a similar role in the New Zealand National Park Service. In 1985, Trevor transferred to the agency head office in Hobart, to contribute to the management of the State National Parks and Reserves and the newly proclaimed Tasmanian Wilderness World Heritage Area.

In his current role as a Special Works Advisor, Trevor is one of a number of specialist officers who are called upon to provide solutions to the many complex issues, which form part of contemporary National Park and World Heritage Area Management.

Trevor's commitment in this area, is to provide technical and policy advice for major Park infrastructure projects in accordance with the environmental and statutory regulation that are required by the Tasmanian Government.

Trevor is a member of a Standards Australia/New Zealand Committee given the task to develop an Australian/New Zealand Standard for Waterless Composting Toilets. He is also a member of a Tasmanian group who reviews plumbing product applications prior to authorization for use in the State.

Trevor is a Tasmanian branch committee member of the Australian Water Association (formally AW WA).
OCCUPATIONAL HEALTH & SAFETY POLICY & SAFE WORKING PRACTICE FOR HANDLING WASTE FROM REMOTE AREA COMPOSTING TOILETS

Trevor Westren - Parks & Wildlife Service, Department of Primary Industries Water & Environment

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Dr Martin Bicevskis, Department of Health and Human Services Tasmania, Adviser on Parks and Wildlife Service Occupational Health and Safety Policy and Safe Working Practice for handling waste from remote area composting toilets

Introduction

The Tasmanian Parks and Wildlife Service in consultation with the Tasmanian Department of Health and Human Services has developed a set of policy guidelines to be adopted by employees involved in the management and removal of waste from waterless composting toilets. The major issues involved include, providing adequate personal protection during the waste removal process, ensuring that personal hygiene requirements are not compromised and that secondary contamination of plant and equipment including helicopters does not occur.

The department has also adopted a general practice of making immunisation vaccines i.e. I hepatitis A & 13 available to staff involved in this type of work,

NB Contractors who are engaged to remove waste from composting toilets are required to either comply with the PWS Policy Guidelines, or ensure that the same level of compliance is met.

This policy is in line with the Legislative Requirements of the Workplace Health and Safety Act 1995.
Parks & Wildlife Service Tasmania Policy

Occupational Health & Safety, Safe Working Practice Field Work in Remote Areas Handling Waste From Composting Toilets

This policy and the attached safe operating procedures have been developed for handling waste from composting toilets. Any stall member who will be involved in this task should be provided with a copy of this document and directed to read it and to use the specified clothing and equipment in accordance with these guidelines. This document is to be included in the Safe Working Practices Manual.

To reduce and remove as many of the health risks associated with the process of emptying waste from remote area compost toilets and other handling of raw sewage the following policy is to be observed:

- the process of emptying the composting toilets is to be undertaken on fine days only
- the process is to be organised on a fly-in/fly-out basis using helicopters on a single day basis so that no-one stays overnight at the site (that is, that they are taken to a base with showers/cleaning facilities)
- the Department will provide protective equipment aiming for total body coverage, and
- the Department will provide the necessary equipment and cleaning solutions in accordance with the procedures

The other documents, which are relevant to this policy and extend from it, are:

- Health Risks, Personal Equipment and Use.
- Removing and Decontaminating Equipment On-Site.
- Disposal and Decontamination Procedures at Base.

In planning this work the efficient use of helicopters should also be considered. Legislative Requirements

Part 3 of the Workplace Health and Safety Act 1995 identifies the duties and obligations relating to Workplace Health and Safety. Of particular relevance to this policy are sections 9(1)(a), 14(1)(a) and 16, which discuss the obligations of employers, designers and employees respectively. These sections are reproduced below:

Section 9-(1) An employer must, in respect of each employee employed by the employer, ensure so far as is reasonably practicable that the employee is, while at work, safe from injury and risks to health, and in particular must-

(a) provide and maintain so far as is reasonably practicable
(b) a safe working environment, and
(c) safe systems of work, and
(d) plant and substance in safe condition
Section 14-(1) A person who designs, manufacturers, imports or supplies any plant for use at a workplace must so far as is reasonably practicable-

(a) ensure that the design and construction of the plant is such that persons who use the plant properly are not, in doing so, exposed to risks to their health and safety; and
(b) when the plant is supplied, ensure that adequate information is supplied in respect of;
(c) any dangers associated with the plant; and
(d) the conditions necessary to ensure that persons using the plant are not, in doing so, exposed to risks to their health and safety

Section 16- While at work, an employee must-

(a) take reasonable care for the employee’s own health and safety and for the health and safety of other persons, including persons working under the direction or supervision of the employee, who may be affected by the employee's acts or omissions at the workplace, and
(b) comply with any direction given to the employee by an employer or responsible officer with respect to any matter relating to health and safety under this Act.

Chairperson. H H & S PWS State Committee–Director Parks & Wildlife Service

Health Risks
The health risks listed below have been identified as associated with coming into contact with human waste:

- Potentially there are many types of bacteria in human waste. These can cause an untold number of diseases from typhoid to diarrhoea and giardia. Contact with contaminated material can be either direct or indirect.
- There are also non-bacterial health risks such as parasites and viruses including hepatitis A & B.
- Methane build-up includes risks such as explosion if someone lights a match nearby or ruptures the tank, as well as headaches and dizziness from the fumes.
- Postural risks to neck, back and knees from bending and working in the confined space while wearing protective equipment lifting waste from within the chamber to ground level. An additional postural risk exists in lifting heavy containers of waste to boats or helicopters.

It is important to note that while equipment is visibly clean it may not be sterile, therefore the precautions detailed in the following guidelines should be observed.

It is recommended that wherever possible that food and drink is not consumed, and cigarettes are not smoked once the process of emptying toilets has started. This will also help reduce the risk of ingesting any waste particles from hand to mouth contact.
Personal Equipment

The complete protective equipment kit is as follows:

Full face mask (personal choice of "Survivair" series 400 full face piece air purifying respirator. "Sari" full face mask. Spray Painters Hood with filter or full-face mask, code RFF 90, with filter code RC 220).

- Disposable overalls ("Tyvec" type)
- Industrial Gloves (PVC 475mm with extended cuff and elasticised)
- Rubber latex gloves ("Astra" vinyl or equivalent)
- Gum boots or walking boots

When Should Equipment Be Worn

The full kit as listed above must be worn at all times when handling waste.

Both pairs of gloves and overalls must he worn when handling containers of waste.

Gloves should be worn when handling any tools which may come into contact with waste matter.

How To Use the Protective Equipment.

The rubber latex gloves are to he worn inside the industrial gloves in case any waste gets inside the industrial gloves or there is a need to remove the industrial gloves during the procedure (e.g. to handle tools).

Ensure before leaving the base that the facemask has been decontaminated from previous use.

Removing and Decontaminating Equipment On-Site

Prepare a bowl/bucket and nail brush with clean water and one capful of hibiclens solution at the site for each person involved, before commencing the process of emptying the toilet.

The process of removing the equipment as described below will be demonstrated where ever possible to staff whom will be involved in emptying the toilets.

Step 1 Remove industrial gloves:

Step 2 Remove the latex glove that has come into contact with the second industrial glove during its removal. Remove by peeling the glove over itself from the wrist towards the fingers.

Step 3 Remove the mask using the gloved hand.

Step 4 Remove the second latex glove.

Step 5 Put on a fresh clean pair of latex gloves.

Step 6 Remove overalls.
The next steps involve packaging the equipment for removal still wearing the latex gloves put on in step 6 above. Place the mask inside the first plastic bag and tie it off (to be decontaminated back at the base).

Using a second plastic bag place any contaminated tools that will be removed from the site (e.g. spanners etc) and tie the bag off

Place used industrial gloves, overalls and latex gloves inside the bag inside the third plastic bag (the containers of waste should be placed in the helicopter nets prior to this stage). Note: because of the difficulties in decontaminating these gloves and removing the waste to make them safe for re-use, the industrial gloves will be disposed of.

Remove the latex gloves using the techniques described in step 2 above and place in same bag as the other equipment to be disposed of. Tie off the third bag (this bag should not be re-opened).

Scrub hands following the instruction sheets for this procedure (laminated posters by hibiclens will be provided with the kit).

**Disposal & Decontamination Procedures at Base**

The bag containing the disposable equipment should be stored in an animal proof place to avoid destruction of the bag by possum's etc and staff when rehandling the bag of contaminated material. Dispose the bag to an authorised land fill site as per regulatory requirements.

Prepare two sinks/buckets with warm water. Add a mild disinfectant to one bowl for decontaminating the masks, the other bowl will be used for decontaminating the tools.

Put on a clean pair of latex gloves before opening the bags and coming into contact with the mask and tools. Place one of the bags inside the other for disposal of the latex gloves.

Place the mask and tools in the respective bowls prepared for soaking. Soak these for one hour.

Remove the latex gloves and place in the garbage bag

When soaking time has been completed put on a fresh pair of latex gloves. Remove the masks from the bowl and wipe off with hibiclens solution using gauze pads. Leave the masks to dry in a clean place. Remove the tools from the bowl, rinse, wipe with spirit and allow to dry.

Empty sinks and bowls and clean with Ajax.

Remove gloves and place in garbage bag and tie off bag. Dispose of this bag with the other rubbish.

Wash hands thoroughly with hibiclens following the instructions on the poster.
NON FLUSHING ALTERNATING BATCH WATERLESS COMPOSTING TOILET SYSTEM FOR REMOTE AREA PUBLIC USE

Trevor Westren - Parks & Wildlife Service, Department of Primary Industries Water & Environment
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Dr John Todd, Department of Environmental Studies, University of Tasmania for student assistance with the project.

Leone Crennan, Honors Student Environmental Studies University of Tasmania. Composting Toilet Reports 1-10. Contribution to the design and trial of prototype alternating cage, batch, waterless composting toilets at Pelion Plains and Pine Valley.


1. Product Application
The product consists of an alternating batch waterless composting toilet system, which has been developed by the Tasmanian Parks and Wildlife Service in collaboration with the Department of Environmental Studies, University of Tasmania. The toilet system is for use in remote areas of the state, primarily by bushwalkers and other remote area users.

This public use toilet system has been designed to meet the variable loadings and climatic conditions common to remote areas of Tasmania, such as the Overland Track in the Cradle Mountain Lake St Clair National Park, where unit use may exceed 6,000 persons pa or approx. 15,000 individual uses.

- The toilet system has been designed to provide for:
- Public toilet facilities for use in remote areas
- Variable loadings up to 15,000 uses pa
- Effective operation within Tasmanian cold & wet climatic conditions
- Minimum maintenance and manipulation of waste matter during treatment
- Maximum aeration of the composting chamber and pile
- A minimum 12 month isolation maturation period to maximise composting and pathogen die off prior to end product removal
- Easy access for maintenance and the safe removal of treated/composted end product
- Solid & liquid treatment removal and disposal to statutory requirements

2. Concept Background
The Parks and Wildlife Service has developed this alternating batch waterless composting toilet system to meet the environmental requirements and sanitation needs of the increasing numbers of bushwalkers etc to Tasmania's World Heritage Area, (WHA) National Parks and State Reserves.
For many years Parks and Wildlife Service relied on the use of simple pit toilet technology in remote areas. However since the proclamation of the Tasmanian Wilderness World Heritage Area in 1982, the numbers of bushwalkers frequenting the States remote Wilderness areas has significantly increased. The World Heritage Area Management Plan 1992 sets out policies for the management of camping, Ref Policies for Management of Camping. 7.8.1 Toilets will be provided at all major campsites along popular walking tracks, and, Actions for Management of Camping 7.8.2 Construct toilet facilities at all major campsites along the Overland, Frenchman's Cap, South Coast and Port Davey Tracks and to serve the Walls of Jerusalem area.

In order to implement the requirements of the WHA Plan, the Service commenced a program of installing proprietary brand waterless composting toilets along the most popular and heavily used walking tracks. The Service held an expectation that the commercially available composting toilets would achieve a high environmental and health standard. To this end, a number of proprietary brand composting toilets were installed on the Overland Track in the Cradle Mt Lake St Clair National Park, Frenchman's Cap Track and in Hartz Mountains National Park.

Within the first few years of operation it was found that the installed composting toilets were useful in containing waste matter but generally proved to be unsatisfactory in actually treating the waste matter. In reviewing the conditions under which the toilets were expected to function, a number of operational factors were noted i.e. variable user numbers, shock loading during summer, infrequent management by Park Staff and cold and wet climatic conditions.

The inability of the toilets to compost the waste matter created major occupational and health safety problems for the Service and personnel involved in the management and disposal of the untreated waste from the units. Untreated waste in the toilets quickly turns putrid (anaerobic) and becomes extremely hazardous to manage and remove. The stinking odours emanating from the putrid waste are a discouragement to bushwalkers and they avoid using the facility. This in turn leads to hazardous toilet waste being spread to surrounding bush areas.

Personnel removing waste from the toilets are required to comply with a strict set of occupational health and safety procedures. However due to the remote locations of the toilets, compliance with the safety and decontamination procedures becomes a complicated task.
Given these less than satisfactory toilet systems and associated management problems, the Service undertook a review of the composting toilets which had been installed and a decision was taken to develop a composting toilet system which would be suitable for use in remote areas. This required designing a composting toilet system which:

- would be suitable for the purpose
- would meet environmental standards
- would meet statutory requirements
- be safe for users
- less hazardous and easier for staff to manage.

With this goal in mind, Parks and Wildlife in collaboration with the University of Tasmania, Department of Environmental Studies, developed and installed the first of two prototype batch waterless composting toilets at Pelion Plains on the Overland Track in 1992.

The first prototype system was installed at Pelion Plains in a toilet that had previously housed a proprietary brand composting system. Samples were taken for testing from the first prototype following 14 months maturation period and the results were encouraging i.e. less than 10 E coli/g in samples taken from the surface, core and base of the pile.

(liven the encouraging results from the Pelion Plains prototype toilet system. the Service decided to build and trial a second prototype batch toilet system in a purpose built structure at Pine Valley. This second prototype toilet was installed in 1995.

**Official Trial**

The prototype alternating batch waterless composting toilet, which was constructed at Pine Valley in 1995, has been used to trial the toilet system for the purpose of system accreditation.

3. Description—Alternating Batch Composting Toilet

The alternating batch waterless composting toilet, developed for remote area use, comprises two toilet cubicles, which sit over two alternating batch composting cage systems. The composting cages consist of large rectangular expanded galvanized steel bins. Each cage is fitted with three doors, one full width half door at the top, and two split doors on the lower section. The doors are opened for pile management and end product disposal. One toilet pedestal sits over each chamber. Only one batch composting cage/chamber and one toilet is used at any one time. When the composting bin in use is full, the batch is closed and the corresponding toilet above locked off. The second batch and corresponding toilet is then placed into use. The closed batch is left to continue composting for a further 12-month period. Following the 12-month additional composting/maturation period, the contents of the first batch are removed for off site disposal.

Each cage is enclosed/isolated in a separate basement chamber. The basement chambers also form the lower structural section/component of the building. Each chamber is fully lined and is fitted with a fibreglass liquid collection tray, which is
located under the composting cage. The liquid collection tray is supported on structural joists and forms the floor of the chamber. The basement chamber has been designed to exclude entry by insects, native animals and vermin.

Each chamber is fitted with a large external lockable door. The doors are clad with Lexon Thermoclear. The buildings are orientated so that the basement doors face North to permit maximum thermal gain through the Lexon Thermoclear to assist the composting process.

The main airflow to the basement chamber is through an insect proof ventilation grill at the bottom of the Thermoclear door. Air is drawn through the system by thermal action on the doors and chimney and through wind (vermin) action on the chimney. Air is drawn through the door vent, across the exposed surfaces of the waste pile within the composting cage and out the 300mm black poly pipe chimney, which extends 1000mm above the roofline.

The positive airflow pressure through the basement chamber allows air to be drawn through the toilet pedestal when the toilet seat lid is opened. This reduces odour transfer from the pile into the toilet cubicle. When the toilet seat lid is closed, the incomplete seal, i.e. small gap between lid & seat, permits a small volume of air to enter the compost chamber.

The toilet pedestals have been specifically designed for the toilets. Each toilet cubicle is fitted with insect proof ventilation at the base of doors and at the apex of walls. Roof skylight panels are fitted over each toilet cubicle.

4. Prototype Trial—Pine Valley Alternating Batch Toilet

- Design development commenced May 1994
- Pine Valley Prototype was constructed late in 1994 and the trial operation commenced in January 1995
- Batch 1 Trial Commencement January 1995
- Batch I filled and closed for maturation on 11 March 1997
- Minimum maturation period after closure is 12 months (to allow additional composting of pile and pathogen die off)
- Batch 2 commenced 11 March 1997
- Batch I emptied 9 December 1998. (18 months after date of batch closure, allowing 6 months additional time to undertake testing program)
- Batch 2 closed 9 December 1998 for a 12-month maturation period. Waste to be removed December 1999
- Batch I restarted (after being emptied) on 9 December 1998

5. Trial—Testing & Test Results

Testing of the closed batch commenced in April 1998, following a twelve-month maturation period to allow additional composting activity and pathogen die off within the pile.
Parks and Wildlife field officers collected composite samples of approx. 500 grams from three locations in the pile, i.e. base, middle and top. The samples were placed in new clean zip lock plastic bags and delivered to the Water Biological Laboratory DPIWE Mt Pleasant for microbiological analysis and for determining the carbon/nitrogen ratio.

Three series of test samples were taken at approximately three monthly intervals i.e.: -

Sample 1 taken from Batch 1 on 1/4/98
Test Results Sample No 1.

<table>
<thead>
<tr>
<th>Coliforms/gm</th>
<th>E.coli/gm</th>
<th>Faecal Strep/gm</th>
<th>Salmonella</th>
<th>N&amp;C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>Not Detected</td>
<td>Sampled 17/6/98</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3-34</td>
</tr>
</tbody>
</table>

Sample 2 taken from Batch 1 on 28/7/98.
Test Results Sample No 2 (three samples taken)

<table>
<thead>
<tr>
<th>Coliforms/gm</th>
<th>E.coli/gm</th>
<th>Faecal Strep/gm</th>
<th>Salmonella</th>
<th>N&amp;C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>&lt;5</td>
<td>240</td>
<td>Not Detected</td>
<td>Not Tested</td>
</tr>
<tr>
<td>&lt;5</td>
<td>&lt;5</td>
<td>250</td>
<td>Not Detected</td>
<td></td>
</tr>
<tr>
<td>130</td>
<td>190</td>
<td>250</td>
<td>Not Detected</td>
<td></td>
</tr>
</tbody>
</table>

Sample 3 taken from Batch 1 on 20/10/98
Test Results Sample No 3

<table>
<thead>
<tr>
<th>Coliforms/gm</th>
<th>E.coli/gm</th>
<th>Faecal Strep/gm</th>
<th>Salmonella</th>
<th>N&amp;C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>&lt;5</td>
<td>25</td>
<td>Not Detected</td>
<td>Not Tested</td>
</tr>
</tbody>
</table>

6. Compliance
The trial of the prototype toilet was undertaken in a remote field location. The trial location is representative of sites where this type of toilet system is to be installed, i.e. remote locations, infrequent access for management, unpredictable and seasonal user patterns and severe climatic conditions including high rainfall, humidity and low temperatures.

6.1 Design & Materials
Compliance is in accordance with: -
- Draft Australian/New Zealand Standard Waterless Composting Toilets DR96086
- Building code of Australia, Clause F2.102
- Australian Standard 3500.2 Sanitary Plumbing and Sanitary Drainage
6.2 Performance requirements
Compliance is in accordance with:
- Draft Australian/New Zealand Standard Waterless Composting Toilets 1996 DR96086. (Interim Accreditation pending test results from batch No 2)

6.3 End product sampling and performance criteria
Compliance is in accordance with:
- Draft Australian/New Zealand Standard Waterless Composting Toilets 1996 DR96086
All composted end product samples tested were in compliance with the Test Criteria for E coli and Salmonella.

6.4 Toilet user numbers
Toilet usage numbers were recorded for the first three-months of the Pine Valley prototype trial. Due to the remote location of the site it was not possible to use the door counter and record user numbers over an extended period.

During the period 3 January to 11 April 1995 the toilet door had been opened 7,333 times. This represented 3,665 usages, assuming that the door was opened and closed twice for each use.

During 1995, the number of bushwalkers who registered to walk the Overland Track totalled 5,197. Bushwalker registration figures for the period January - March 1995 totalled 2,863.

A direct correlation cannot be made between the Overland Track registration figures and the Pine Valley Toilet usage figures as there are no statistics available to show overnight stay numbers, and daily usage numbers for the Pine Valley hut and toilet. However, Parks and Wildlife observations of bushwalker usage patterns on the Overland Track indicate that bushwalker numbers to the Pine Valley Hut area are equal to, if not higher than other individual sites on the Overland Track.

Therefore, using the Overland Track registration figures as a general guide, and assuming bushwalkers stay a maximum of one night only and use the toilet twice during their stay, usage numbers for the Pine Valley toilet for 1995 would be in the order of 10,394. Add to this total, a non-registration rate of 10% (survey undertaken of non registered bushwalkers) total usage would be approx. 11,433.

These figures are regarded as conservative and therefore represent the minimum number of times the toilet is used. An additional percentage needs to be added to allow for bushwalkers who stay more than one night and for persons using the toilet more than twice during an overnight stay. Given the above range of variables, the toilet usage figure for Pine Valley for 1995 has been estimated to be between 12,000 to 13,000 uses.

NB. The toilet treatment chamber has been designed to treat waste deposits accumulated over a minimum period of one year, or until the batch is full.
The batch is then closed to allow a 12-month maturation period before the contents are removed.

Additional toilets will be installed in high use areas where the minimum twelve-month maturation period cannot be maintained.

Product Design
The design for the Alternating Batch Waterless Composting Toilet is based on the prototype trial toilet system which has been tested at Pine Valley. The final design and layout for the toilet and treatment system has been developed by a joint working group consisting of Parks and Wildlife Field and Technical Officers plus input from a Consulting Engineer.

7.1 Final design—treatment
The final design for the treatment chamber and batch cage incorporates the same elements, general layout and dimensions as were used in the prototype system. However a number of minor design changes have been made to improve the ventilation system, liquid collection tray and liquid collection and drainage arrangement.

7.2 Final design—toilet layout
The final design incorporates two cubicles/pan over each batch system. The prototype system used one cubicle/pan over each batch system. This design change has been made in order to make more efficient use of the batch cage, and to double the number of toilets available to users at any one time. This design change will also permit waste matter to be more evenly distributed in the batch cage, thus reducing the amount of pile manipulation work by management personnel.

7.3 Foundations
Foundations for the toilets are site specific and will be addressed during individual site assessments. A qualified engineer will design toilet foundations in accordance with the Building Code of Australia and will verify completed work.

7.4 Structural & hydraulic loadings
The treatment chamber sits on foundations above ground level and forms the lower basement structure and walls of the building. The treatment chamber is not subjected to hydrostatic or hydraulic lateral loads. An engineer has designed the building and structural components in accordance with the Building Code of Australia.

System Management
8.1 Composting chamber
The toilet and toilet system has been designed for use in remote locations where daily management is not possible. The toilet requires periodic inspection and cleaning, and bulking agent (rice husks) additive by toilet users. From time to time it may be necessary to remove any carried over rice husks from around the dome strainer in the liquid collection tray or from the collection basket in the
solids collection trap. The compost waste pile may require periodic leveling (when greater than half full).

NB. It has been found that rice husks provide a good carbon supplement to the composting process. They also assist in the aeration of the pile as they do not compress easily under the weight of the waste matter.

8.2 Toilet cubicle
The toilet pedestal/pan is constructed from fibreglass and is finished to a smooth gloss surface. All pedestal surfaces can be easily cleaned, as the gloss finish inhibits solid matter from adhering to the bowl. Interior surfaces within the toilet cubicle are finished in waterproof or water resistance materials.

Toilet cleaning/maintenance duties are carried out every two weeks (minimum) during summer, and monthly during the remainder of the year. Each toilet cubicle is supplied with a container for rice husks (carbon supplement), a dispenser and appropriate signage explaining toilet usage procedures.

8.3 Composting cage start-up
The procedure for starting a composting cage is simple. A layer of cardboard is placed on the floor of the cage to prevent waste matter and rice husks from falling through the mesh onto the liquid collection tray. When the waste matter has started to build up and the composting process commenced, the (taste pile stabilises in the chamber and the cardboard is quickly broken down. When emptying the composting cage, a small amount of composted end product is left on the floor of the cage as starter material for the new batch.

The waste treatment chamber has been designed to provide easy access and good ventilation for persons managing the compost cage and liquid collection tray. Each compost cage has been fitted with three doors, one full width half door at the top of the cage and two split doors on the lower section. This allows easy access to the composed waste matter during the waste removal process.

Solid waste disposal in the form of composted end product is removed and disposed of in the following way:

9.1 Composted end product removal & disposal
A heavy-duty plastic sheet (poly weave or equivalent) is placed on the ground at the opening end of the treatment chamber to collect any composed material which may be spilt during the removal process. The upper cage door is opened and waste is removed (shovel/fork) and placed into heavy duty double plastic bags. The bags are then tied off and placed into heavy duty poly weave fishmeal bags. The lower doors are opened as the waste level in the cage reduces.

When the waste removal process has been completed, the ground sheet and any split waste is doubled bagged and placed in the fish meal bag for disposal. The full fish meal bags are sealed and then airlifted by helicopter onto a truck (at a convenient road head) for transferal to an authorised waste disposal site.
The Parks and Wildlife Service has adopted a general practice of using Professional Contractors when ever possible for the removal of waste composted end product from Waterless Composting Toilets.

In situations where employees are required to carry out this work, they are required to comply with PWS Occupational Health and Safety Guidelines.

These Guidelines have also been provided to the Professional Contracting Company as a minimum requirement for use by their staff when undertaking this work for the Parks and Wildlife Service.

9.2 Liquid waste disposal
Liquid disposal requirements may vary with each toilet installation. An evaluation of site characteristics will be undertaken for each location by an Environmental Health Officer to establish the "Protected Environmental Values" and to authorize an appropriate in ground liquid disposal method in accordance with contemporary applicable regulatory requirements. On sites where in ground disposal/treatment is found to be inappropriate, an alternative method of liquid disposal will be adopted.
1. Product Application

Much work has been undertaken in the development of toilets for high use sites, however the fragile nature of much of Tasmania's alpine country has lead to the Parks & Wildlife Service developing a fly out, human waste receptacle for use in remote walking areas.

The need for this product has arisen as a result of the increasing numbers of bushwalkers to remote alpine areas within the Tasmanian World Heritage Area, National Parks and other Crown Lands.

The increasing numbers of people wishing to visit and camp in these areas has placed additional impact on the sensitive alpine environments. Campsites in high alpine areas are invariably limited in size, and due to the rocky nature of the soils the safe burying/disposal of toilets wastes is limited. The process of burying human waste in alpine areas usually damages or destroys the sensitive vegetation. Alpine vegetation is extremely slow growing, is easily destroyed, and can be impacted upon by root disturbance and the elevated levels of phosphorus and nitrogen present in human waste.

In addition to environmental considerations, the Parks and Wildlife Service has a duty of care commitment, to minimise the health risks associated with the management and disposal of human waste in these sensitive areas.

The development of these units is consistent with one of the Key Desired Outcomes of the Tasmanian World Heritage Area Management Plan, which states in relation to toilets:-

- Review whether the present remote area toilets meet relevant statutory requirements including human and environmental health standards. Where toilets are not functioning adequately undertake appropriate measures to resolve the problem. Assess the need for waste disposal at high use campsites currently without toilets.

- Manage toilets that are not connected to sewage treatment facilities in such a way' that adjacent water bodies are protected

the units are used where conventional toilets and associated infrastructure has been deemed to be inappropriate. These areas are remote from roads and usually served by helicopter on a seasonal basis.

Two trial transportable toilet units have been in use in the Western & Eastern Arthurs for the past two years. Both units have proven to be successful as toilet facilities, and an effective means of preventing further damage to vegetation and the spread of human waste throughout the campsites. Parks and Wildlife personnel have found the units easy to manage and bushwalker users have given them favourable comment.
**Product Description**

The product is nothing fancy, simply a fibreglass tank designed to hold waste products and be easily placed and recovered from remote sites.

The product is to be regarded as a transportable toilet/sewage collection facility. The units are not intended to undertake any form of composting or drying of the waste material. The receptacle when full is airlifted by helicopter to a convenient road head for discharge to a waste tanker. The waste is then transferred to an authorised wastewater treatment plant. Authorised waste removal personnel pump the units out.

The receptacle is fitted with a waterproof hatch/lid which when removed allows the unit to be used as a squat toilet. The concept of providing a squat facility rather than a conventional toilet pedestal reduces the need for users to come into physical contact with the unit. This is an important factor, as regular cleaning of the toilets is not possible due to the remoteness of the sites where the units are to be located.

The receptacles are regarded as stand alone units and can be placed on the ground or small timber pads, discretely out of direct line of sight of the main camp area if possible, and easily accessible for lifting by helicopter. The cost of the units is such that multiple units are often flown to the same location to allow bi annual recovery and cleaning rather than expensive annual operations. This also provides economies of scale for hiring waste removal operators in a remote area to empty and clean a series of units on the same day.

A fly proof pressure-equalizing vent is fitted in the lid to prevent pressure build up when the lid is closed.

The receptacles are fitted with four lugs to allow lifting by helicopter. Full receptacles weigh approximately 500kg.

The receptacles are clearly marked with the manufacturers name and date of construction.

The manufacturer has advised that the receptacles should be visually field inspected every two years for defects and that the minimum design life of undamaged units is ten years.

Since development the receptacles have also been utilized as the collectors for liquid waste from more conventional composting toilets.

**Compliance**

The units have been designed and constructed to exceed the Australian Standard 2634-83 Chemical Plant Equipment Made From Glass Fibre Reinforced Plastic and the Australian Standard 1546.1:98 for Fibre Glass Septic Tanks.

A structural engineer has certified adequacy of the receptacles for airlifting when full.

The units have been granted accreditation for use in Tasmania under the requirements of Part 132 of the Tasmanian Plumbing Code.
4. Occupational Health & Safety
5. Drawings
PROFILE
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Zhihang Chen graduated from the Department of Geochemistry of Beijing University in 1970. She majored environmental chemistry and environmental analysis.

Nature conservation is her favor pursuit.

She has been working for WCPA-EA /IUCN East Asia Nature Conservation Research, Monitoring and Training Center since 1993.

Zhihang Chen is a lecturer and has several publications.