Australian Water and Wastewater Association

SOUTH AUSTRALIAN BRANCH

SEMINAR ON

DOMESTIC WASTEWATER TREATMENT AND DISPOSAL

OPTIONS FOR UNSEWERED AREAS

ADELAIDE 24TH JUNE 1988

AUSTRALIAN WATER AND
WASTEWATER ASSOCIATION
S.A. BRANCH

PROCEEDINGS FROM A SEMINAR
ON

DOMESTIC WASTEWATER TREATMENT AND DISPOSAL

OPTIONS FOR UNSEWERED AREAS

STATE GOVERNMENT CONVENTION CENTRE,

ADELAIDE 24TH JUNE 1988

EDITED BY

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MEHLIKA KAYAALP

FOREWORD

Over a century ago, the Town Clerk of Adelaide, "the city of stenches", was moved to report that:

> "the fluid filth permeates the porous soil and (I doubt not) in many instances the very foundations of the homes suffer from such fluid of the vilest description draining under them that the occupiers of the premises are inhaling deadly gases resulting in certain death."

He was referring to the problems generated by on-site disposal of sewage and wastewater, topics which still remain problematic for many areas in this State.

This seminar on wastewater disposal provides a timely forum for review of the standards that have applied to domestic installations, and to examine the future for on-site disposal of sewage including alternatives to septic tanks.

During the last decade it has been clear, as a result of rapid urban growth, that a range of environmental considerations including the degradation of domestic water supplies, were not being adequately addressed by the community, land developers or local and state government agencies. This realisation prompted an extensive review of septic tanks and effluent disposal capacities in South Australia and new standards became operative on 1 June 1988.

The Association expresses its appreciation to the speakers at this seminar for their contributions and in making their papers available for publication.

A.S. CAMERON
President, SA Branch
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KPH/KE

SEMINAR

DOMESTIC WASTEWATER TREATMENT AND

DISPOSAL

The Australian Institute of Health Surveyors (S.A. Division) join with the Australian Water and Wastewater Association in welcoming you to their seminar.

The theme "The Treatment and Disposal of Domestic Waste Water in Unsewered Areas" coincides with the recently introduced guidelines for septic-tank installation in South Australia.

This seminar provides an opportunity for the legislators, designers and installation personnel to better appreciate the alternatives currently available for the disposal of waste water.

The Institute of Health Surveyors are proud to unite with the Australian Water and Wastewater Association in perceiving and implementing this seminar and we sincerely thank them, and the trading companies who have assembled their displays here today for our benefit and information.

Yours faithfully,

K P Hayley

K.P.HAYLEY
STATE PRESIDENT

CONTENTS

SEPTIC TANK SYSTEMS:
PRINCIPLES AND PROBLEMS

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SEPTIC TANK SYSTEMS : PRINCIPLES AND PROBLEMS

by

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1. INTRODUCTION

On-site treatment of domestic wastewater or sewage is a necessity in many areas of Australia, particularly in the rural areas and in the outskirts of cities and towns where sewerage systems do not exist.

This paper reviews the most common form of on-site treatment; the septic tank followed by a soil absorption system. Brief details of two alternative forms of septic tank effluent disposal are also presented.

Problems associated with the septic tank/soil absorption system are discussed and recent developments into alternative disposal methods are presented.

Finally, examples of the successful use of septic tanks in small community treatment plants are presented, showing that the septic tank is alive and well - its what we do with its effluent that still requires investigation.

2. NATURE OF DOMESTIC WASTEWATER

Domestic wastewater, or sewage, emanates from three sources in a household: excretion, washing and food preparation. Toilet waste is often referred to as 'black water' while the wastes from washing and food preparation are termed 'gray waters'.

The total volume of sewage produced per person per day depends on whether or not the household receives reticulated water and on the standard of living maintained by the occupants i.e. dishwashers etc. Typical values for daily per capita sewage flows in the major cities in Australia would be in the 250-300 L/d range, dropping to perhaps 100-140 L/d in unreticulated rural or semi-rural areas.

A typical domestic sewage contains some 99.9% water and only 0.1% dry solid matter, the make-up of which is varied and can cause severe environmental stress if not treated to an acceptable standard.

A sewage is a complex mixture of materials - not surprising when one considers the wastewaters from the three main sources; bathroom wastes contain soaps, oils and grease with small amounts of insoluble materials, kitchen wastes contain soap, food particles, fats etc while waste from the toilets contain faeces, urine and paper. In addition, there will also be a marked bacterial and possibly viral presence in the combined wastewaters.

The physical, chemical and bacteriological nature of a domestic sewage is generally gauged by parameters that are used throughout the wastewater industry. Table 1 summarieses various of the more salient parameters together with typical values that could be expected for a purely domestic wastewater.

TABLE 1 : TYPICAL DOMESTIC WASTEWATER

Biochemical Oxygen Demand (BOD)	:	250 mg/L
Chemical Oxygen Demand (COD)	:	500 mg/L
Suspended Solids (SS)	:	250 mg/L
Total Kjeldahl Nitrogen (TKN)	:	50 mg/L
Total Phosphorus (TP)	:	10 mg/L

3. ON-SITE TREATMENT

Domestic sewage is either collected and conveyed (via a sewerage system) to a centralised treatment plant for purification or it is treated on-site; the latter generally being the case in unsewered rural or city outskirt areas.

This paper is concerned primarily with on-site treatment and as such no further consideration will be given to centralised facilities.

The most common form of on-site treatment in Australia and indeed many other countries of the World is the septic tank and soil absorption system.

In most cases, the septic tank is designed to handle the total domestic sewage flow, (i.e. combined black and gray waters) in lieu of only the toilet or black waters).

The separate system (i.e. one that treats only black waters) has the advantage that it offers a safety factor in that the volume of faecally polluted effluent is much smaller than in the combined system, should a failure of the percolation system occur.

The combined system (both black and grey waters) has the following advantages over the separate system:

(i) The nutritional conditions are much more balanced than for the separate system, particularly as regards the decomposition of kitchen waste.

(ii) Kitchen waste is pretreated in the septic tank before discharge to the absorption system. The deleterious effect of raw kitchen waste on the absorptive capacity of the soil is thereby prevented.

(iii) If the grease-trap on the kitchen waste should be neglected, the combined system can still deal with the fats more efficiently than the absorption system of the separate system.

4. PRINCIPLES OF SEPTIC TANK SYSTEMS

A septic tank is essentially an enclosed unit through which the domestic sewage passes. Suspended solids settle out and depending upon the actual hydraulic retention time a degree of biological activity takes place.

Figure 1 shows details of a typical septic tank.

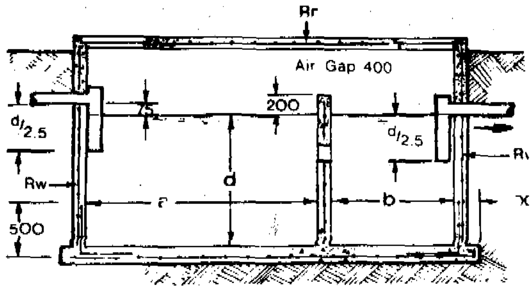


Figure 1 : Typical Septic Tank

The biological action within the septic tank is generally restricted to the scum and sludge layers that form in the tank and the rate of activity is temperature dependent. A reduction in BOD and suspended solids content through the septic tank could therefore be expected.

Experimental results from septic tanks in the USA and aqua privy tanks in Zambia respectively indicate that in tropical and sub-tropical regions the reduction in BOD can be roughly approximated by the empirical equation[1]:

$$P_p = \frac{P_o}{k_1 \left(\frac{P_p}{P_o}\right)^n R + 1}$$

where

P_p	=	Tank effluent BOD_5, 20°C (mg/l)
P_o	=	Influent BOD_5, 20°C (mg/l)
k_1	=	Degradation constant in day^{-1} units (base e logarithm)
R	=	Retention time for completely mixed system in days
n	=	exponent

For design purposes assuming $n = 4.8$, $k_1 = 6.0$, the percentage reduction according to the above equation is given in Table 2.

TABLE 2 : BOD IN SEPTIC TANKS

Retention time (days)	Percentage BOD remaining (%)
0.25	71
0.5	65
1.0	60
1.5	56
2.0	54
2.5	52
3.0	51
4.0	49
5.0	47
6.0	46

The values in Table 2 show that there is little advantage in having tank retention times longer than one day when 40% BOD reduction can be expected.

Septic tanks are generally sized for a minmum effective volume sufficient for a 24 hour retention. To this must be added allowances for scum and sludge storage, the magnitude of which is dependent upon the frequency of clean out. Table 3 summarises the rate of sludge and scum accumulation recorded in septic tanks in South Africa(2).

TABLE 3 : RATE OF SCUM AND SLUDGE BUILD UP

Years of Service	Accumulation (L/cap)
1	95
2	120
4	175
6	235
8	305
10	385

Sludge accumulation can vary significantly from country to country and indeed from area to area within a country, being heavily dependent upon diet and/or the use of in-sink garbage grinders. The figures presented in Table 3 should be viewed as being minimum values. For example, figures quoted from Canada indicate accumulation rates of twice those presented in the Table - perhaps temperature had an influence in this case(3).

It should nevertheless be noted that the rate of sludge accumulation or build-up in a septic tank should be monitored at least once a year and the unit cleaned out when the level of sludge is such that it could exit the unit. This is of extreme importance when the septic tank effluent is disposed of in absorption trenches as solids carry over could lead to premature blinding of the trench surfaces.

Codes of Practice or Regulations exist for both the sizing and design of septic tanks; the former making allowance for sludge and scum storage and the latter specifying tank proportions, baffling, inlet and outlet arrangements and materials and methods of construction.

4.1 Effluent Quality

The formula presented above indicates BOD removals of between 40 and 60% for 1 to 2 day hydraulic retention time. Experiences in the United Kingdom, Japan and South Korea all indicate BOD removals of between 40 and 60%.

It will be appreciated that the effluent from a septic tank still requires further treatment before it can be safely discharged to the environment, not only from an organic point of view but also from a bacteriological point of view, as there is very little coliform reduction achieved in the septic tank.

Great emphasis is placed, in compiling the design, on the ability of the septic tank to remove suspended solids - particularly if the effluent is to be disposed of by absorption trenches. Experience has indicated that removals of up to 80% can be achieved but that peak or surge inflows can adversely affect this figure - albeit over a short period.

5. EFFLUENT DISPOSAL

Septic tank effluent may be further treated by a variety of means, ranging from absorption trenches through oxidation ponds to trickling filters, rotating biological contactors and activated sludge systems.

All these forms of subsequent treatment have the aim of further purifying the septic tank effluent before it is released to the environment.

On-site treatment in unsewered areas has generally relied upon absorption trenches, transpiration beds and sand filters, with the latter two methods generally only being considered in those areas where absorption trenches are impracticable.

Australian Standard 1547-1973 covers the disposal of effluent from small septic tanks and most States and Territories have also produced Codes of Practice to cover disposal by the above three systems.

5.1 Absorption Trenches

A number of factors require consideration before an absorption system is constructed:

- area of land available for absorption area.
- identification of any likely adverse impacts arising from seepage from the area;
- permeability and depth of soil on the proposed site for the absorption area. Percolation tests should be carried out.
- Identification of seasonal changes in ground water level and absorptive capacity of the site.
- Effect of seepage and/or surface water from surrounding, higher level areas.

Unfortunatley, while everyone is aware of these factors, absorption systems are often installed, based on experience 'just down the road'.

Figure 2 indicates details of an absorption trench, proposed in the 'Code of Practice - Septic Tanks' published by the Health Commission of Victoria and not dissimilar to that produced in AS 1547-1973(4).

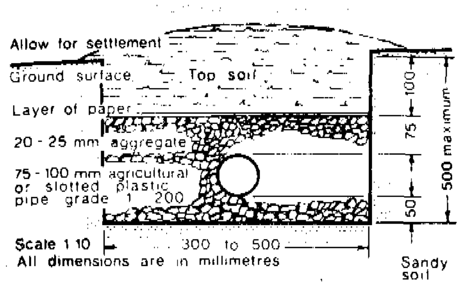


Figure 2 : Absorption Trench

It is of interest to note that this design utilises a side wall : base ratio approaching unity, i.e. the base contributes significantly to the overall area available for percolation, or absorption, into the soil.

This is in contrast to experience overseas where experience has shown that the base of any trench very quickly blinds and as such attempts should be made to maximise the side wall : base ratio. Depths of 1-2m with widths of 600mm are not uncommon.

It is appreciated that problems can arise with deep trenches in high ground water areas and either shallower, but longer, trenches should then be used or an alternative disposal system considered.

Guidelines for maintaining the infiltrative capacity of an absorption trench are as follows:

- o Continuous inundation of the infiltrative surface should be avoided - the required area should therefore be provided in two or more trenches, and their operation should be rotated.
- o The suspended solids content of the septic tank effluent should be minimised.
- o Deep narrow trenches should be considered wherever possible.
- o The infiltration surface should at the start be typical of a plane through undisturbed soil - avoid smearing the surfaces with digging equipment and keep the trench covered during rainstorms.
- o Ensure that the trench bottom is always above the highest expected ground water level.
- o Prevent surface water ingress into the trench.

5.2 Transpiration Beds

Transpiration beds can be used where absorption trenches are impracticable but their use does require low rainfall and high evaporation, so climatic factors require careful evaluation.

Disposal in this instance is achieved through evaporation and transpiration through grass or shrubs growing above the influent pipes. Figure 3 shows details of a typical bed[4].

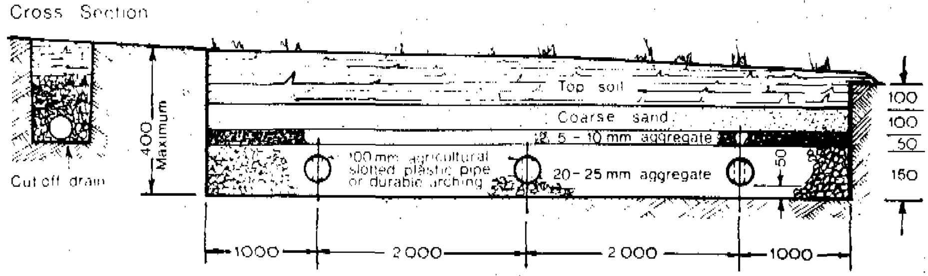


Figure 3 : Transpiration Bed

5.3 Sandfilter

Sandfilters are a suitable alternative for both the trench and transpiration bed and Figure 4 shows details of a typical sand filter, as outlined in the Health Commission of Victoria's Code of Practice[4].

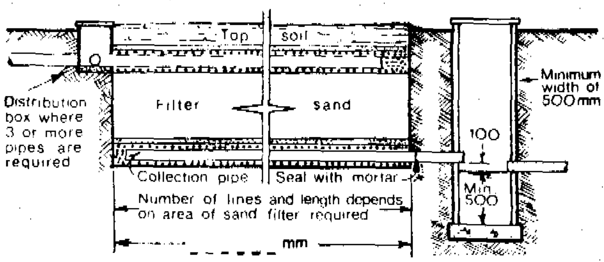


Figure 4 : Sandfilter

6. PROBLEMS PROBLEMS

It was estimated in 1984 that while nearly one third of the homes in the United States dispose of their wastewater via the septic tank/soil absorption system, less than half of these disposal systems performed satisfactorily over their design life of 15 to 20 years[5].

System failure occurs when the septic tank effluent surfaces above the soil absorption area, causing aesthetic and health problems. Causes of such failure can be attributed to:

- poor siting on soils with inadequate permeability or inadequate depth above limiting zones;
- organic clogging or hydraulic overload.

Water conservation within the household may often alleviate or correct such failures.

The siting of absorption areas should be considered in relation to the potential risk of polluting ground water and careful consideration should therefore be given to the variation in water table level as construction of absorption systems into the water table can lead to widespread contamination of groundwater supplies.

In rural zones the horizontal distance between absorption areas and wells or bores is of importance and yet recommendations for the minimum distances vary. AS1547-1973 ('Disposal of Effluent from Small Septic Tanks') states that absorption trenches should not be less than 15m from any underground source of water supply, but there is evidence that faecal bacteria are able to penetrate 30m in soil, and chemical pollution a further 65m[6] - such movement must, it is considered, be site and soil specific.

One should therefore always become aware of the local geology when planning soil absorption systems.

The above discussion relates more to the effluent disposal system, than to the septic tank itself. Problems can of course occur in these units if solid matter, cigarette butts, plasticware etc gain access to the septic and the use of disinfectants in the house should be controlled, as should the use of caustic soda for removing accumulations of grease in drains. It goes without saying that in-sink garbage grinders should be excluded or the rate of sludge build up within the septic will show a dramatic increase.

However, most problems do relate to the soil absorption system - a poorly functioning septic tank will only exacerbate the problem, or accelerate its appearance if it does not already exist. It is for this reason that the so-called 'aerated septic tank' systems are gaining acceptance in many areas of Australia. It is of interest to note that one Council in NSW has recently stopped approvals for absorption trenches and will only consider the aerated septic tanks on the grounds of less health risk - both at the surface and in groundwater.

These systems generally include a form of aerobic biological treatment - be it by biological filters or activated sludge - after a septic tank. The effluent from such systems is chlorinated prior to being irrigated on land adjoining the septic tank. Many proprietary systems are now available.

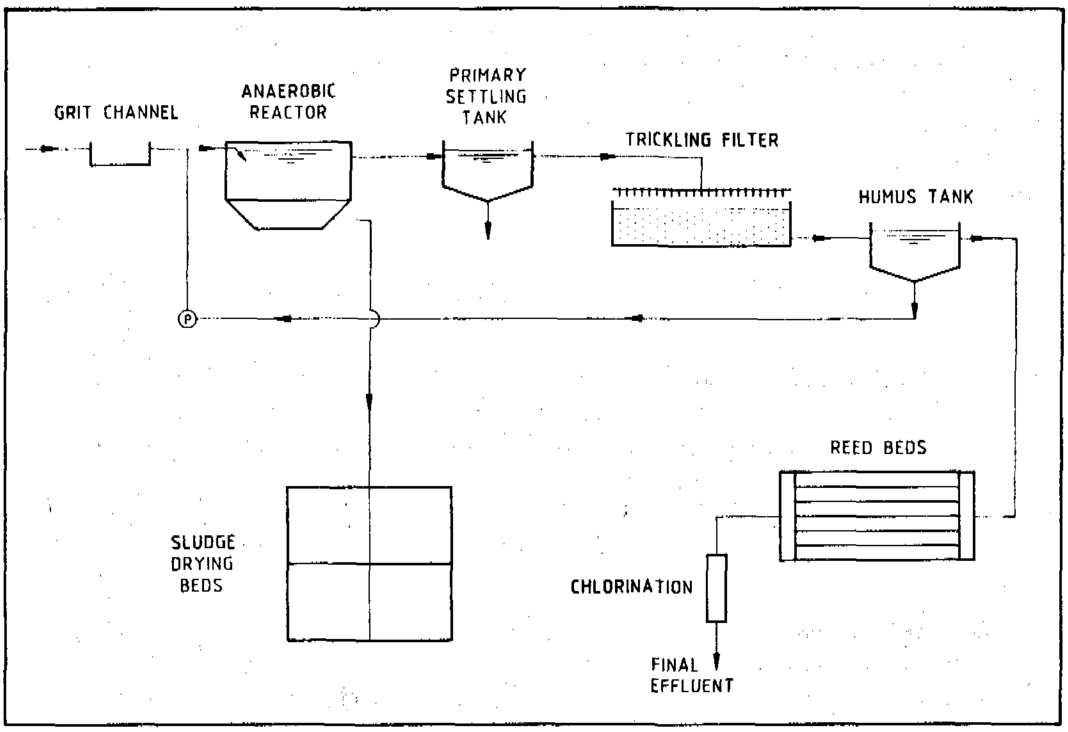
7. FUTURE OF THE SEPTIC TANK

The septic tank will be around for a good number of years to come - it is in the area of septic tank effluent treatment and disposal that we will see a lot of interest and development.

Anaerobic reactors, operating on exactly the same principle as the septic tanks and hence just another name for them, are finding wide application in low cost, simple and yet reliable, sewage treatment plants in many areas of the World.

They have been retrofitted as a means of reducing organic overload on oxidation ponds and have been used in conjunction with a number of subsequent aerobic processes such as rotating biological contactors, trickling filters and the activated sludge system to produce exceptionally good effluents.

Figure 5 shows the flow sheets of such combined systems that have found successful application in South Africa.



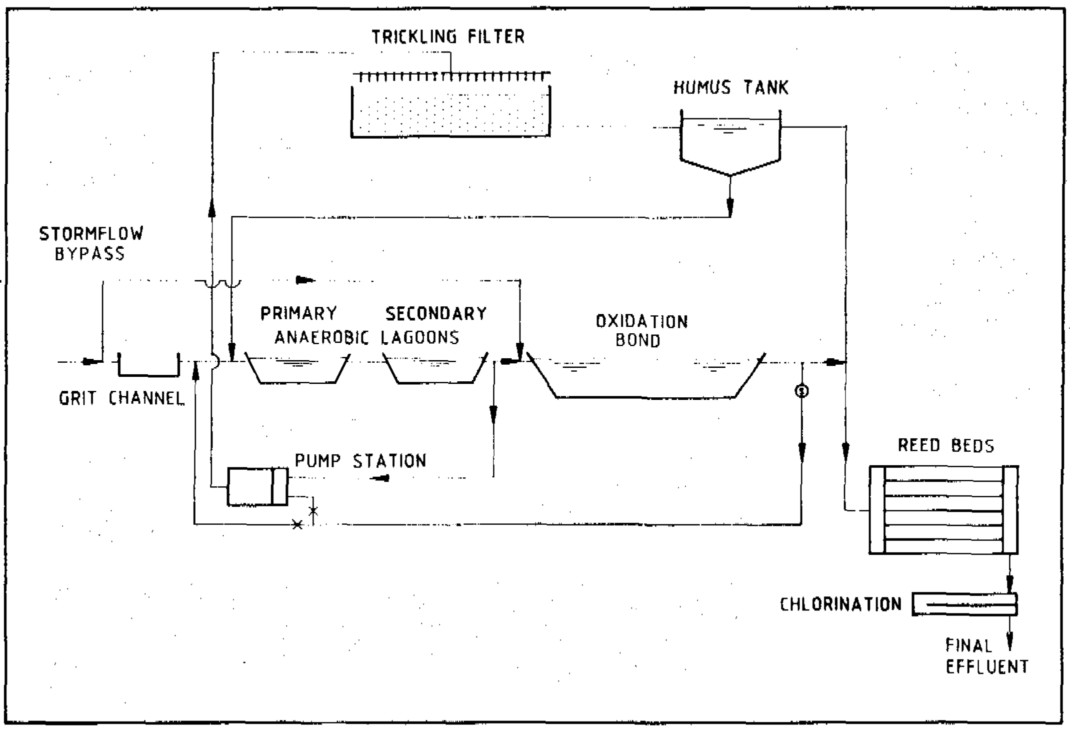


Figure 5 : Combined Treatment Systems

8. SUMMARY

This paper outlines the principles of the septic tank/soil absorption system for on-site treatment. It raises the problems that are often experienced with such systems and notes that most of the problems are associated with the effluent disposal system and not the septic tank.

These effluent disposal problems, and the requirement for added health and quality standards has spawned the aerated septic tank systems which are now gaining increasing acceptance in Australia.

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NEW SEPTIC TANK GUIDELINES
FOR SOUTH AUSTRALIA

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Health Commission

THE NEW SEPTIC TANK GUIDELINES FOR SOUTH AUSTRALIA

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INTRODUCTION

Throughout history major factors influencing health and well being of mankind has been the need to ensure the proper disposal of sewage, the protection of water supplies from human excremental pollution and the maintenance of an equilibrium between public health and the environment.

Without doubt the preferred method for treatment of excremental wastes to achieve healthful living is the provision of sewerage treatment facilities. Where a sewerage system is not available then the next most favourable option available is the installation of septic tank systems.

For a septic tank system to be effective it is important to ensure the system is designed and sized in accordance with the hydraulic load and prevailing site conditions.

It must be recognised that whilst a septic tank can be installed on any allotment the long term efficacy of operation of the onsite effluent system is controlled by a range of site conditions. Where the site assessment indicates conditions prejudicial to effective onsite disposal, then consideration needs to be given to collection of the effluent into an impervious sump for offsite disposal or alternatively other treatment options should be considered. This aspect will be further addressed in the paper to be presented on Segregated Waste Systems.

Recently a review of the requirements for septic tank systems was undertaken by a Joint Governmental Working Party. The working party brief provided for a review of the capacities for septic tank and effluent disposal systems and as appropriate make recommendations.

This paper outlines some of the various recommendations and provides discussion and or interpretation of the revised requirements for septic tank installations in South Australia.

LEGAL REQUIREMENTS

Legislation relating to installation of septic tanks are dealt with under the provisions of:-

- : Building Act Regulations
- : Health Act and Regulations
- : Local Government Act

In summary the provisions require:-

: Building Act Regulations

Reg. 45.2 Unsewered Sullage

That sullage wastes be disposed of in a manner to the satisfaction of the Central Board.

Reg. 55.4(1)

That sullage and sewage be connected to a septic tank system approved by the Central Board of Health.

Reg. 55.4(2)
That the sullage wastes system comply with Council requirements.

: Health Act
Sec. 123(1)
All buildings to have drains and sanitary requirements to satisfaction of Local Board.

Sec. 123(2)
Plans and specifications of drainage to be approved by Local Board.

Sec. 147 (h & h1)
Regulation making powers for septic tanks.

Sec. 171
Requires that precast septic tanks manufactured for sale to be constructed as approved by the Central Board.

: Health Act Regulations
Reg. 81 - Septic Tanks
Requires:
: submission and approval of plans prior to commencing work,
: a permit be issued prior to use,
: certain substances not permitted,
: tanks to be constructed of impervious materials,
: system to be ventilated,
: fittings to comply with certain standards,
: the disposal of tank contents in prescribed manner,
: effluent disposal to CBH requirements,
: a fee be charged for examination of plans,
: inspection of the system.

Local Government Act
Section 528 to 530(b)
Provides for compulsory installation of septic tank system, can be for sewage and or all purposes.

Generally it can be interpreted that the legislation provides for Local Government to require the installation of sullage and or sewage (septic tank) systems whereas the Central Board sets the standards for sewage (septic tank) and or sullage systems.

Under the provisions of the Public and Environmental Health Act, recently enacted and yet to be proclaimed, provisions exist for standard setting for septic tanks. Provisions do not exist for approval and inspection at the central level, therefore proposals under consideration provide for transferring these functions from State to Local Government. The issues are not yet finalised and in the meantime administration mechanisms will remain with the State Government.

Endorsement of Revised Requirements

The Central Board of Health at its 10 March 1988 meeting approved of the revised requirements for the installation of septic tank systems utilising subsurface effluent disposal methods and resolved that the provisions as approved be operative from 1 June 1988. Furthermore the Board resolved that approvals for systems approved and not substantially completed by 1 September 1988, would lapse and be subject to the increased requirements.

EXISTING GUIDELINES

The existing provision relating to the installation of septic tanks are addressed in the South Australian Health Commission, Public Health Service, Technical Bulletin (T.B.) No. 4 "Septic Tank Installations".

It is not appropriate to detail the content of T.B. No. 4, however the provisions therein only relate to the requirements for a septic tank system suited for a single occupancy residential dwelling of up to eight persons.

To enable an appreciation of the extent of change the capacity criteria for existing septic tank and soakage systems are provided.

Septic Tank Size Criteria

All Purpose
: 8 person minimum
: 90 litres per person
: base allowance of 900 litres
: minimum capacity
90 x 8 + 900 = 1620 litres

W.C. Only
: 8 person minimum
: 70 litres per person
: minimum capacity
70 x 8 = 560 litres

Soakage

Three methods of subsurface effluent disposal are utilised, these being:-

: Perforated Pipe (Soakage) Trench, minimum length - 18m
: Prefabricated Soakage Unit (Polytrench) Trench, minimum length - 9m
: Soakage Wells, minimum capacity - $3m^3$

The above capacities are for the all purpose system whereas a W.C. only system requires one third of the above capacity.

Water Catchment Area Requirements

In the Mount Lofty Watershed Area the soakage system capacity is increased by 100%. Additionally the soakage trench is to be protected by diversion of roof, surface and subsurface waters. A 450 litre pump sump is also required.

LAND CAPABILITY ASSESSMENT

It is well known that land characteristics can have a significant impact on the soil capability to absorb and treat septic tank effluent to a point where its identity as effluent is lost. Most land will possess positive characteristics favourable to effective on-site disposal whilst other features may severely limit effective on-site disposal.

Site investigations to determine capability for long term on-site effluent disposal should include:-

(1) Soil Classification

A number of test holes should be excavated to enable assessment of the soil characteristics. Such an assessment is critical to the determination of whether the soil and the site is suitable for the intended use.

Features of the soil profile requiring examination include:-

: Soil Colour - as mottling is always caused by a fluctuating water table or seasonal zones of saturation, it may be used as evidence of high ground water or poor drainage.

: Soil Texture - an examination of the depth and thickness of various horizons should be undertaken and any impervious layers noted. The assessment should include checking for silt, clay or sand compositions.

This work is generally undertaken in a geotechnical assessment of the land for building footings.

: Soil Structure - structure or the ability of the soil to form peds is important in assessing the porosity of the soil. Porosity or void space is very important as it relates to infiltration or percolation of the effluent through the soil.

(2) Land Slope

Sites having land slopes greater than 1 in 5 (20%) are not suited for long term on-site subsurface effluent disposal systems.

(3) Flooding

Sites subject to inundation or flooding more frequently than 1 in 10 years should not be used for long term on-site subsurface effluent disposal.

(4) Seasonal Water Table

Sites having seasonal high water tables less than 1.2m from the surface level are not suited for long term on-site subsurface effluent disposal.

(5) Bedrock

Where the depth to bedrock is less than 1.2m the site is not suitable for long term effluent disposal.

(6) Percolation

Where testing indicates the soil percolation rate is less than 15mm per hour or greater than 150mm per hour, the site is considered not to be suitable for long term effluent disposal.

Percolation rates greater than 150mm per hour needs to be assessed against the potential for contamination of underground and or stream water resources.

Following evaluation of the soil and site characteristics a determination should be made as to the suitability of the site for long term subsurface effluent disposal.

Where all of the above criteria and land characteristics are satisfied the minimum capacity of effluent disposal system could be approved for a 3 bedroom dwelling. Should the site not satisfy all of the land assessment criteria additional capacity of soakage may be required or consideration be given to alternative methods of treatment/disposal.

Percolation Testing

An indication of soil capability to absorb effluent can generally be demonstrated by determining the long term infiltration rate by carrying out the "Falling Head Percolation Test" or other recognised hydraulic conductivity tests.

The "Falling Head Percolation Test" will be described in the revised publication relating to the installation of septic tank systems.

The percolation rate is most frequently regarded during site assessment as an indication of soil permiability (hydraulic conductivity) which represents the potential rate of water movement through a soil and is the amount of water that can flow through a unit cross-section in the soil in unit time under standard conditions.

Whilst it should not be mandatory for all sites to be subject to percolation testing, it may be necessary for such tests to be undertaken to establish an area profile and also where concern exists as a consequence of unfavourable site conditions or geotechnical data indicates testing should occur.

Persons seeking approval to install a septic tank system should be able to demonstrate land capability for the proposed system. The approving authority may, as appropriate, seek confirmation of data supportive to the proposed system.

In most cases approval could be granted for the installation of the minimum capacity where the site characteristics and soil percolation criteria are satisfied. Where the percolation rate is marginally less than 15 mm per hour it may be possible to install soakage capacities greater than the minimum, providing the allotment is of adequate size to permit same.

Site evaluation and assessment include consideration of soil and site characteristics and percolation capabilities and must form part of any consideration to utilise on-site subsurface disposal for effluent dispsoal.

Whilst the percolation test is a guide as to the site suitability for subsurface effluent disposal it is not the only factor to be considered. Other factors can also have a significant influence on land capability for effluent disposal therefore reference should also be made to additional site assessment criteria.

Due to the potential for variation in percolation testing results and subsequent interpretation, it is recommended testing should be carried out by a geotechnical consultant or other suitably skilled persons.

ALLOTMENT SIZE

The Central Board of Health in 1985 endorsed a policy recommending a minimum area of 1200m^2 where it is intended that septic tank effluent be disposed of by means of subsurface soakage.

Many allotments throughout the State are considerably less than the 1200 m^2 area with some having areas around 700m^2.

Whilst it is possible to install systems of the increased capacity on a relatively flat block of 700m^2 the site is severely restricted and would not support the normal range of activities one could expect to enjoy on the block.

When considering land capability criteria many of the smaller sized allotments are unlikely to satisfy all of the parameters thus excluding the site as suitable for utilisation of onsite subsurface effluent disposal methods.

Several site layout drawings are provided to indicate some of the issues that need to be addressed in planning the proposed development. See figures 1 to 6.

THE SEPTIC TANK

The septic tank is constructed to provide sufficient capacity for 24 hour retention of the hydraulic loading and also provide capacity for accumulation of sludge and scum without reducing the retention period below 24 hours, see figure 7. The present 1,620 litre tank only provides a 12 hour retention.

1. Septic Tank Construction

A septic tank of up to 4,000 litre capacity is to be constructed in accord with the general construction requirements of Australian Standard 1546-1983 "Small Septic Tanks".

Other points applicable to the tank construction include:-

: provision of two 150mm diameter PVC access risers with screw caps and cover blocks terminated at ground level. The 150mm risers are to be positioned so as to provide visual observation of the inlet and outlet and also permit desludging of each compartment, see figure 8.

: all precast septic tanks are required to be approved by the Central Board of Health (CBH).

: all precast septic tanks are required to have the manufacturers name, address and effective capacity in litres permanently marked on the top of the tank at the inlet end.

: as an alternative to the provision of the 2 x 150mm PVC risers to surface level the tank can be constructed with the top terminating at surface level.

: access openings of at least 600mm diameter or 450 x 600mm are to be provided over each compartment. Alternatively one access opening not less than 900mm x 500mm can be positioned centrally over both compartments.

Requirements for Septic Tank Capacities over 4,000 litres:-

: name, address and litre capacity required

: application for CBH approval for precast septic tanks must be supported with engineering computations

: tanks constructed in situ with capacities from 3,000 to 10,000 litres must comply with requirements in South Australian Health Commission Code

: all septic tanks greater than 10,000 litre capacity require individual approval and must be supported with engineering computations

The terminology describing the septic as an "all purpose" or "WC" is to be discontinued with the tank capacity stated in "litres".

2. Septic Tank Capacity/Criteria

(a) Residential Dwelling

The minimum capacity for a septic tank, receiving discharges from all of the sanitary fixtures and serving a single occupancy residential building has been defined at 3,000 litres and is suited for a dwelling of up to 3 bedrooms and serving a maximum of 6 persons.

Where the number of bedrooms exceed 3 the septic tank capacity is to be increased by 1,000 litres for each additional bedroom.

(b) Design Criteria for a Residential Dwelling Septic Tank

: daily hydraulic loading of 150 litres per person per day

: 24 hour detention of daily hydraulic flow

: sludge and scum accumulation rate of 80 litres per person per year (scum 32 litres and sludge 48 litres)

: desludging frequency not greater than 4 yearly, provided the sludge/scum component does not reduce the detention period below 24 hours

(c) Non Residential Septic Tanks are sized in accord with the above criteria with adjustment to the hydraulic loading, sludge/scum and desludging frequencies on a time/use weighted basis.

Example

Hotel and/or Motel

Sludge/Scum Allowance

Accommodation: Total bed numbers (single equivalents) x 65 litres sludge/scum/person

Residential Staff: Number of persons x 80 litres sludge/scum/person

Non Resident Staff: Number of staff x number of shifts x 45 litres/person

Bar Trade: Average number of persons over 7 day period x 5 litres sludge/scum/person

Dining/Lounge Room: Average number of diners over 7 day period x 50 litres sludge/scum/person

Desludging Frequency: Where the sludge/scum calculation indicates that the capcity required for a 1 year period is between 5,000 and 10,000 litres the desludging period can be reduced to 2 years. Where the sludge/scum calculation for a 1 year period is greater than 10,000 litres then the desludging period can be reduced to 1 year.

Septic Tank Capacity for Sludge/Scum Component = (Accommodation + Residential Staff + Bar Trade + Dining/Lounge Room + Non Resident Staff) x Desludging Frequency

Accommodation, 50 beds x 65	=	3,250 litres
Residential, Staff 6 persons x 80	=	480 "
Bar Trade, $\frac{1500}{7}$ x 5	=	1,071 "
Dining/Lounge Room, $\frac{750}{7}$ x 50	=	5,357 "
Non Resident Staff, 10 x 2 x 45	=	900 "
	Total	11,058

= 11,058 litres sludge/scum capacity

Hydraulic Load Allowance

Accommodation: Total bed numbers (single equivalents) x 100 litres

Residential Staff: Number of persons x 150 litres

Non Residential Staff: Number of staff x number of shifts x 30 litres

Bar Trade: Highest daily number over 7 day period x 15 litres

Dining/Lounge Room: Highest daily number over 7 day period x 35 litres

Accommodation, 50 beds x 100	=	5,000 litres
Residential Staff, 6 x 150	=	900 "
Non Residential Staff, (no shower) 10 x 2 x 30	=	600 "
Bar Trade, 300 x 15	=	4,500 "
Dining/Lounge Room, 150 x 35	=	5,250 "
Hydraulic Flow	Total	16,250 litres

Septic Tank Capacity

Sludge/Scum 11,058 + Hydraulic Loading 16,250

27,308 litres

1 Year Desludging Frequency

(d) Where a food waste disposal unit is connected to the system the sludge/scum capacity needs to be increased by 50%.

EFFLUENT DISPOSAL

The capability of the soil to absorb effluent is controlled by biomass permeability and or soil infiltration rates. The maximum rate at which effluent can be disposed by absorption over a long period is the lesser of the two factors.

Organic suspended solids and micro-organisms remaining in the effluent discharged from the septic tank into the soakage system builds up as a layer of biomass on the surface of both the granular medium and the trench bottom and sides of the soakage system, see figure 9.

The biomass is subject to further anaerobic bacterial action and is further broken down. The ideal situation occurs when the rate of accumulation of biomass supplied from the septic tank reaches equilibrium with the rate of bacterial decomposition thus resulting in a zero growth of the biomass layer.

Extensive testing of various soil types in Western Australia (Caldwell Connell Engineers, Report 1986) and overseas confirm that when equilibrium is attained between the rate of accumulation of biological solids and their decomposition, then a biomass permeability rate in excess of 10mm per day can be expected. Should the biomass accumulation rate exceed the decomposition rate the optimum permeability rate will be reduced and resulting in system failure as a consequence of solids overload.

The Working Party concluded the infiltration rate of 10mm per day through the biomass is an appropriate rate for calculating capacities for septic tank effluent disposal systems.

Where the soil receiving the discharge from a septic system has a permeability rate of less than 10mm per day, then alternative systems should be considered, unless the allotment size is such that it will permit considerable increases in the capacity of the selected effluent disposal system.

<u>Sizing of Effluent Disposal Area</u>

Given that a soil permeability rate of 10mm/day converts to 10 litres per metre^2 the minimum surface area of the bottom and sides can be determined as follows:-

<u>Hydraulic loading per person per day</u>

Permeability rate per metre^2 per day

$$\text{Soakage system area} = \frac{150\ L/P/D}{10\ L/M^2D}$$

$= 15m^2$ per person per day

Therefore the minimum surface requirement for a 3 bedroom dwelling of up to 6 persons is:

$15m^2/p/d \times 6$ persons $= 90m^2$

Given that a soakage unit or polytrench disposal system has $2m^2$ surface area (side wall and bottom) for each lineal metre of trench the minimum length of soakage units is:-

$\frac{90m^2}{2m^2}$ = 45 lineal metres of soakage units

Whereas the length of soakage trench (perforated pipes) is:-

$$\frac{90m^2}{1.8m^2} = 50 \text{ lineal metres of perforated pipes}$$

Alternatively the lineal length of soakage trench can be determined as:-

: total hydraulic load x 10 litres/m^2 x factor for selected soakage system:-

- : soakage units (poly trench) 0.5
- : soakage trench (perforated pipe) 0.555

eg. : soakage units (poly trench)
900 litres x 0.1 x 0.5 = 45 lineal metres
: soakage trench (perforated pipe)
900 litres x 0.1 x 0.555 = (49.95) 50 lineal metres

Where soakage wells are to be utilised the potential for conflict with the land capability criteria is greater due to increased depth and depth limitations imposed under the Water Resources Act.

Assuming an outlet depth from the septic tank of 500mm, it would appear the maximum depth of the soakage well should not exceed 2.0 m.

Therefore a well diameter and liquid depth of 2m would require a number of soakage wells to achieve the required $90m^2$ surface area for a typical residential dwelling of 6 persons, see figure 5.

Example:-

$$\frac{90 \text{ m}^2}{2 \pi rh + 0.7854 \times d^2} = \text{No of wells}$$

$$\therefore \quad 2 \times 3.142 \times 1 \times 2 + 0.7854 \times 2^2$$

$$12.568 + 3.142$$

$$15.7m^2$$

$$\therefore \quad \frac{90}{15.7} = 6 \text{ soakage wells}$$

Effluent Disposal Methods

There are a range of soakage methods that can be utilised however the prevailing site conditions and amount of land available will dictate the method and type of system that can be installed. In all cases where soakage beds or trenches are utilised it is important to ensure they are installed on a level contour.

Methods utilised for subsurface effluent disposal include:-

- : soakage trench (perforated pipe)
- : prefabricated soakage units (poly trench)
- : soakage wells
- : soakage bed

See figures 10 to 13

The soakage bed is an additional method not previously utilised in South Australia. Configuration of the bed is dependant upon site conditions however they generally require relatively flat land for installation.

For example a soakage bed configuration utilising soakage units could be 8m x 9.5m or alternatively it could be installed in two separate areas and be subjected to alternating discharge.

Other options that could be utilised include variations of the soakage units and soakage trench, that is the trench width could be increased to reduce the length of the system whilst still providing the surface area requirements for the intended hydraulic loading.

Soakage beds can be utilised to obtain the required surface area however, they may be expensive to construct due to the large amount of aggregate required and the limiting side wall exposure factor. Narrow trenches are more effective in that the side wall surface area factor is maximised. Soakage trenches are expensive in land area when taking into consideration setback provisions.

Most sites will not permit soakage trenches to be constructed in one continuous length, however it is preferable to have multiple runs as they can permit maximising the system by working and resting trench lengths on an alternating basis, see figure 14.

It is very important that system requirements be considered in the planning and design phase to maximise site conditions. Failure to consider the septic tank system in the design stage could result in the site not being suitable for on-site subsurface effluent disposal.

The process of diverting flow is preferred to that of loading one trench and overflowing to the next trench. With flow diversion, see figure 15, one section of the system is charged until the biomass has developed to the point where flow is impeded. Effluent is then diverted to the other portion until the biomass in the first run has dried and decomposed. Under this method of operation research has indicated a higher overall degree of permeability will be achieved thus extending the life of the disposal system.

Allotment size ought to be sufficiently large enough to provide greater than the minimum requirement, see figures 1, 2 and 3, as in time it may be necessary to either rehabilitate or extend the system. This may arise from undersizing the system, increased hydraulic load, failure to maintain the system or environmental changes within or beyond the site.

Care needs to be taken during construction of the disposal system so as to not impair the soil absorption capabilities. Mechanical excavators can seal, smear or compact the soil during excavation thus seriously effecting the absorption capacity of the soil. Where this damage occurs the normal soil characteristics should be reinstated by removal of the damaged areas.

Ideally the disposal system should be located within 300mm of the natural surface level to assist the dissipation of the effluent by evapotranspiration.

Where the septic tank is installed at such a depth that the effluent would be discharged into a soil not having the required capability for long term effluent disposal, then the effluent should be lifted from a pump sump by means of an automatic motor operated pump to the disposal system located in soil having the desired capability.

Surface and Ground Water

Roof, surface and subsurface waters can have a significant deleterious effect on the operation of the effluent disposal area and therefore it is important that the disposal system be protected from these waters, see figure 16.

Roof and surface waters need to be redirected so as to not impact on the efficacy of the disposal system and preferably it should be discharged to the street water table, see figures 1 and 2.

Setback Distances

The following setback distances are applicable.

Septic Tank and Pump Sump
2.5 metres from buildings, allotment boundaries and soakage systems.

Effluent Disposal Systems
2.5 metres from septic tank and or pump sump, allotment boundaries, buildings, diversion trenches, between multiple runs of soakage runs or soakage wells.

3.0 metres down slope from a building or a swimming pool.

6.0 metres up slope from a building or a swimming pool.

50.0 metres from any well, bore, dam or water course used for domestic water supply.

100.0 metres from pool level for the River Murray and Lakes.

Refer also to figures 1 to 5.

CONCLUSION

In presenting this paper the intention has been to explain one of the why and how options available for the safe disposal of human excremental wastes to facilitate healthful living. The areas addressed, very briefly realted to the legislative framework, the existing provisions and the revised provisions with regard to land capability assessment, allotment size, the septic tank and effluent capacities and disposal methods.

The rationale for the changes have not been covered in this paper, however they are fully addressed in the publication "Review of Septic Tank Standards in South Australia", March 1988, which can be purchased from the South Australian Health Commission (SAHC), 158 Rundle Mall, Adelaide.

More details on the installation and maintenance of septic tank systems will shortly be available in Code form. When available, they also can be purchased from the South Australian Health Commission.

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: Various unprinted SAHC information.

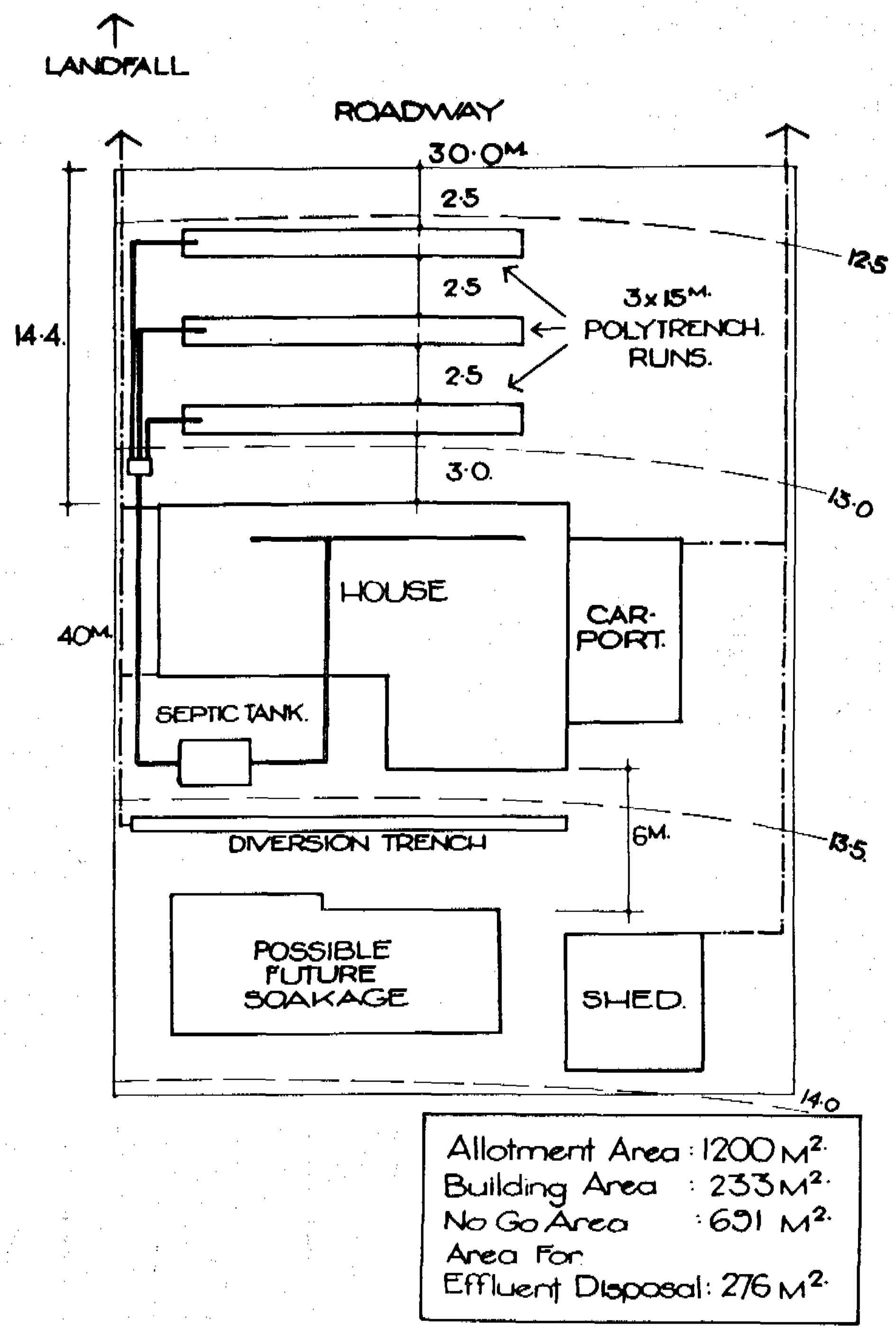


Figure 1. 1200m² Allottment. Landfall Back to Front. Building setback to enable soakage to be installed at the front of the house.

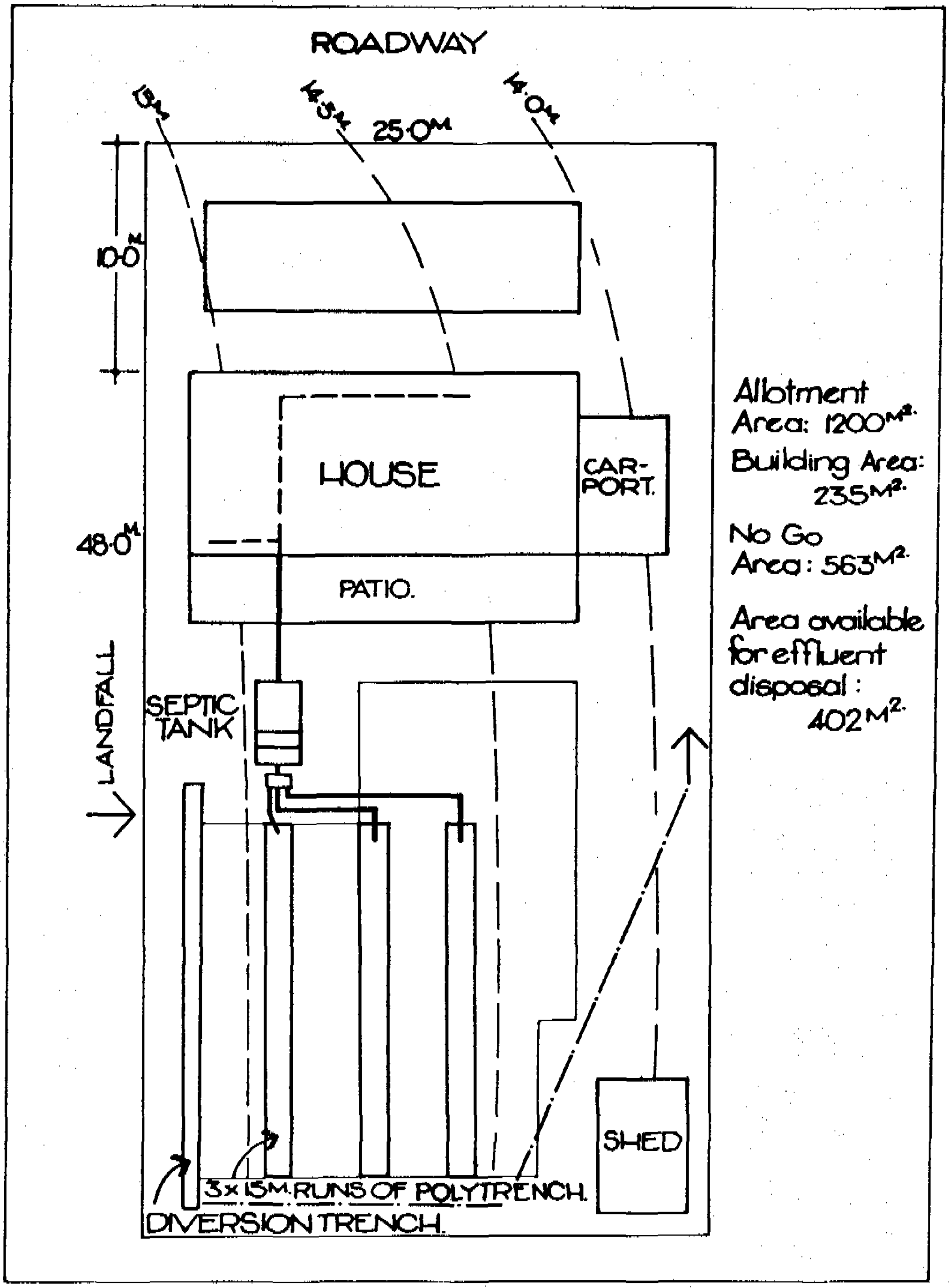


Figure 2. 1200m² Allotment. Landfall across site. Soakage located at the back of the house.

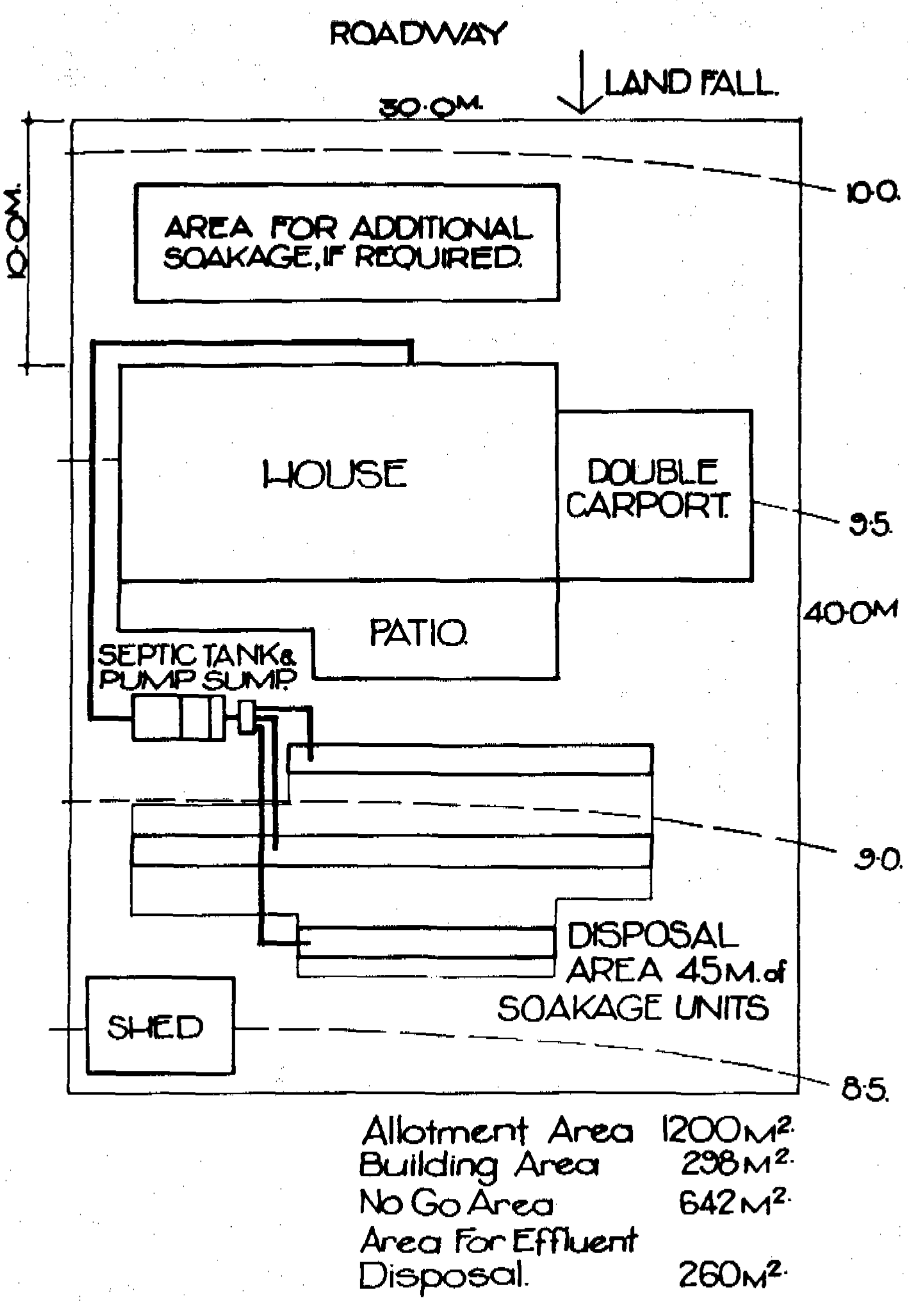


Figure 3. 1200m² Allotment Landfall from front to back. Soakage located at the back of the house.

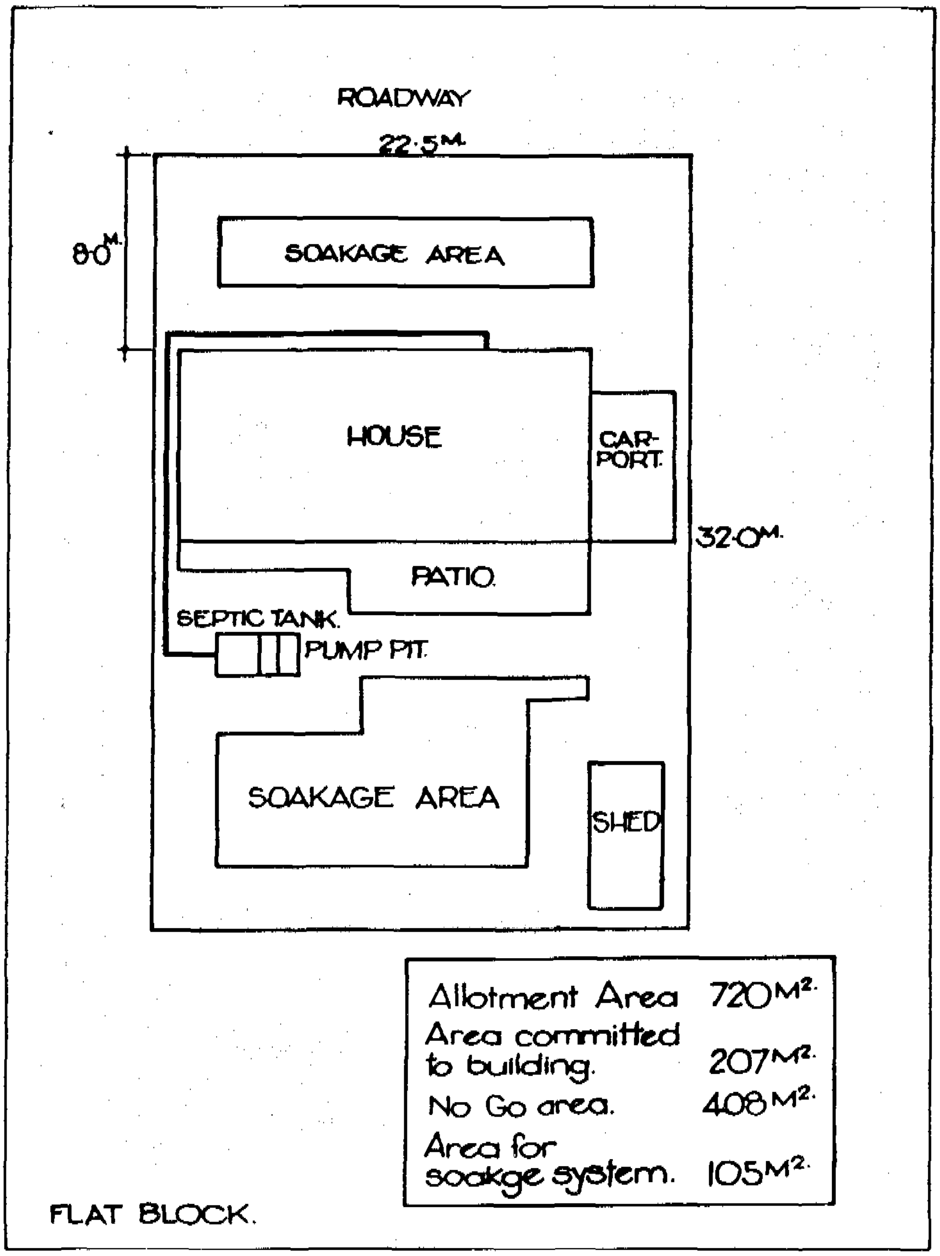


Figure 4. 700m² Flat Allotment. Soakage area required at the front and the back to enable minimum 90m².

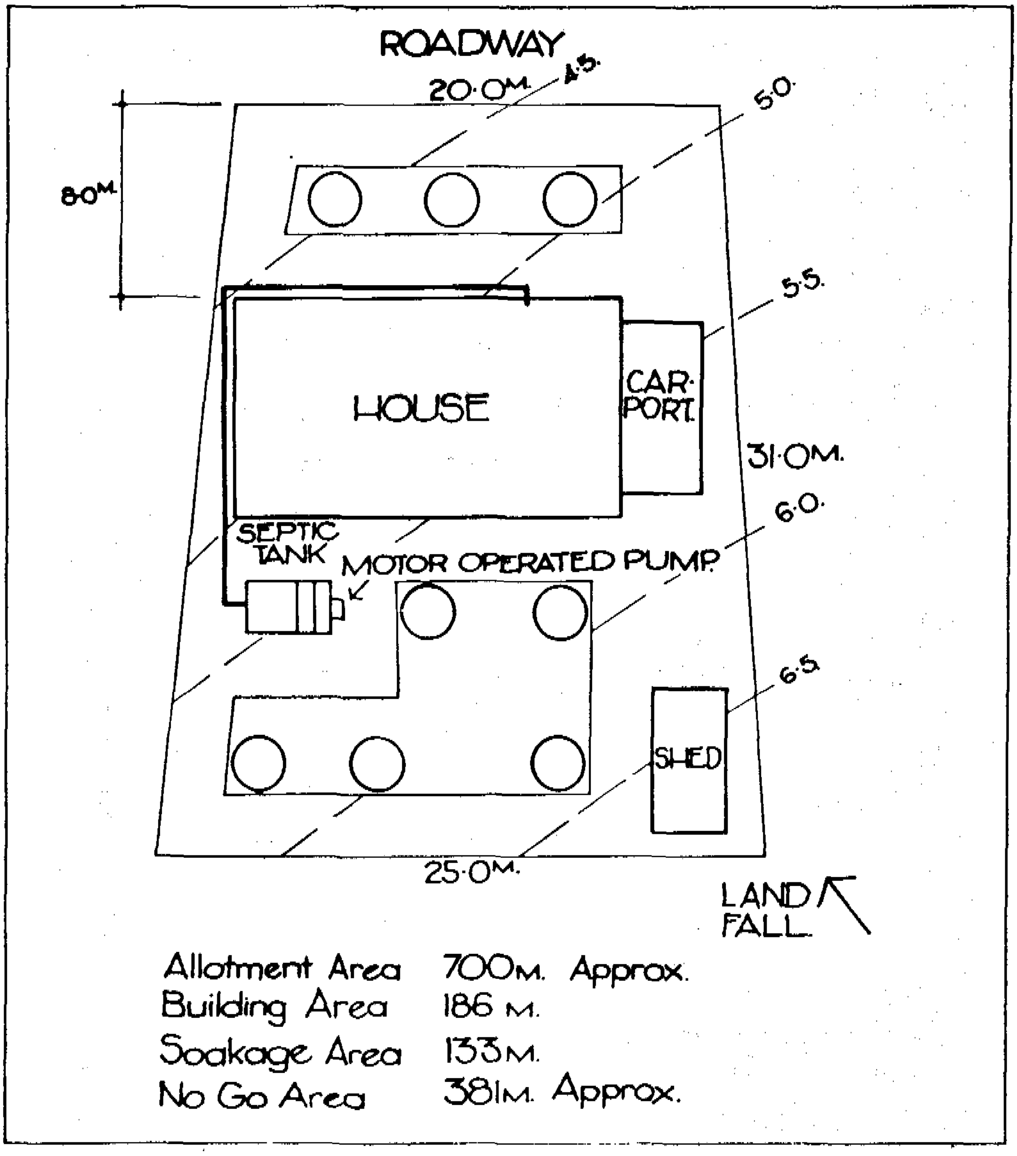
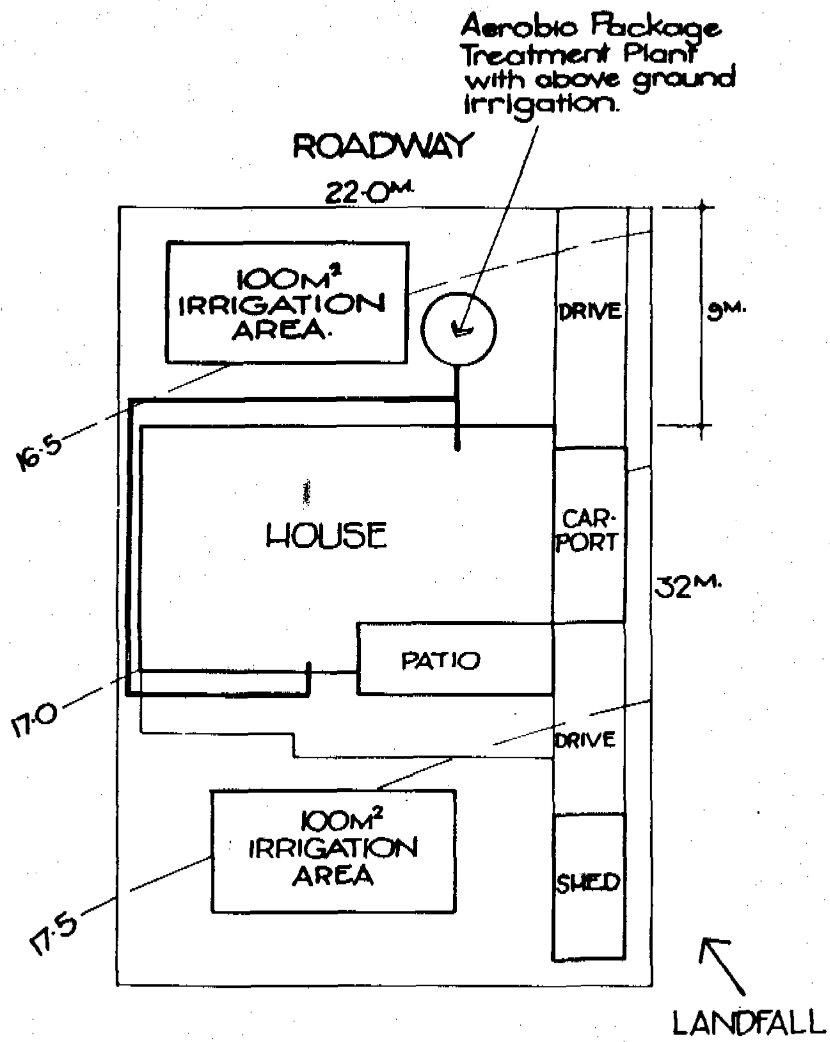


Figure 5. 700m² Allotment. Landfall across site, back to front, sufficient space to permit 8 soakage wells.



Allotment Area : 704 M²
Building Area : 217 M²
No Go Area : 147 M²
Irrigation Area : 200M²
Surplus for Irrigation or other uses : 136 M²

Figure 6. 700m² Allotment. Landfall across the site, back to front. Aerobic Package Plant with chlorinated effluent irrigated over the surface.

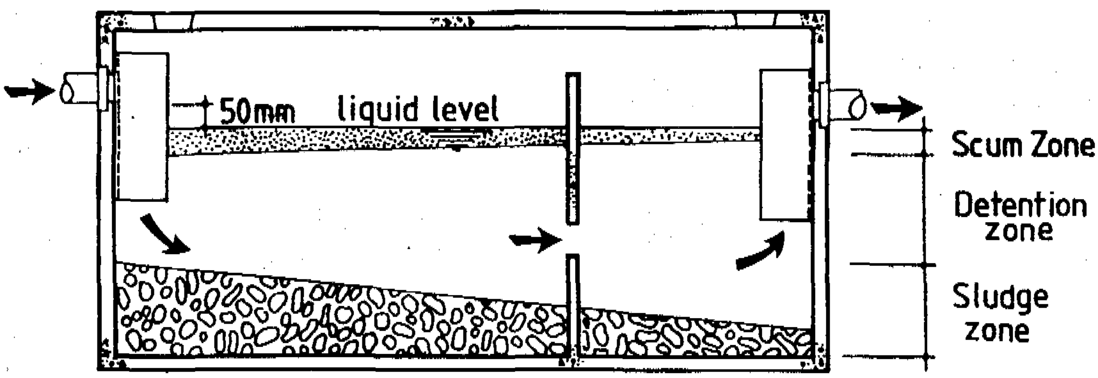


Figure 7. Septic Tank showing Scum, Detention and Sludge Zones.

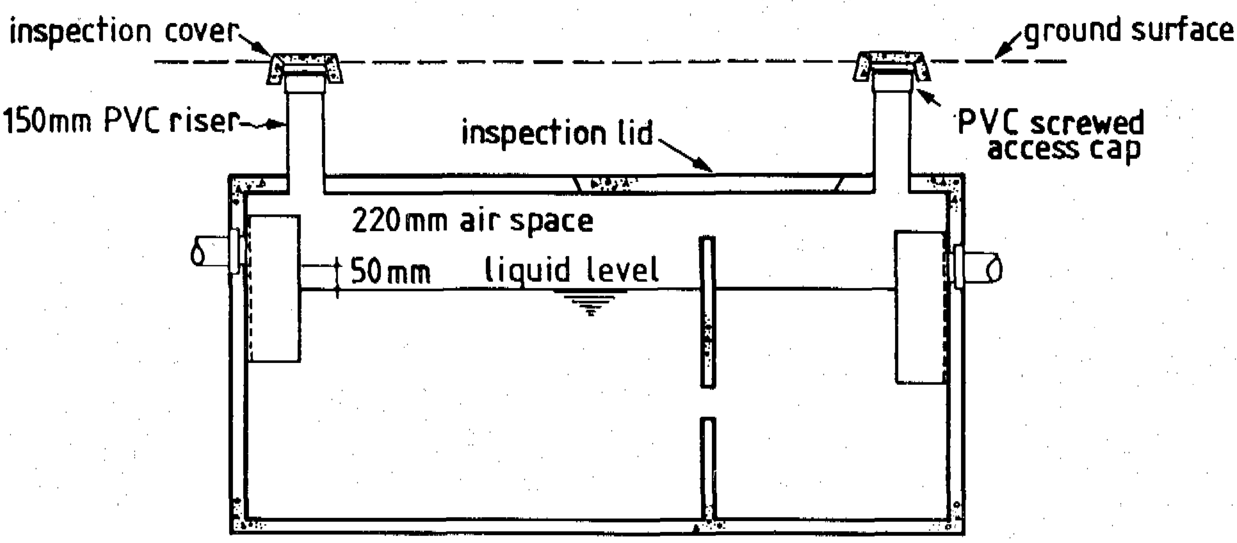


Figure 8. Schematic Section of Septic Tank showing PVC Risers, Inlet and Outlet and Air Space.

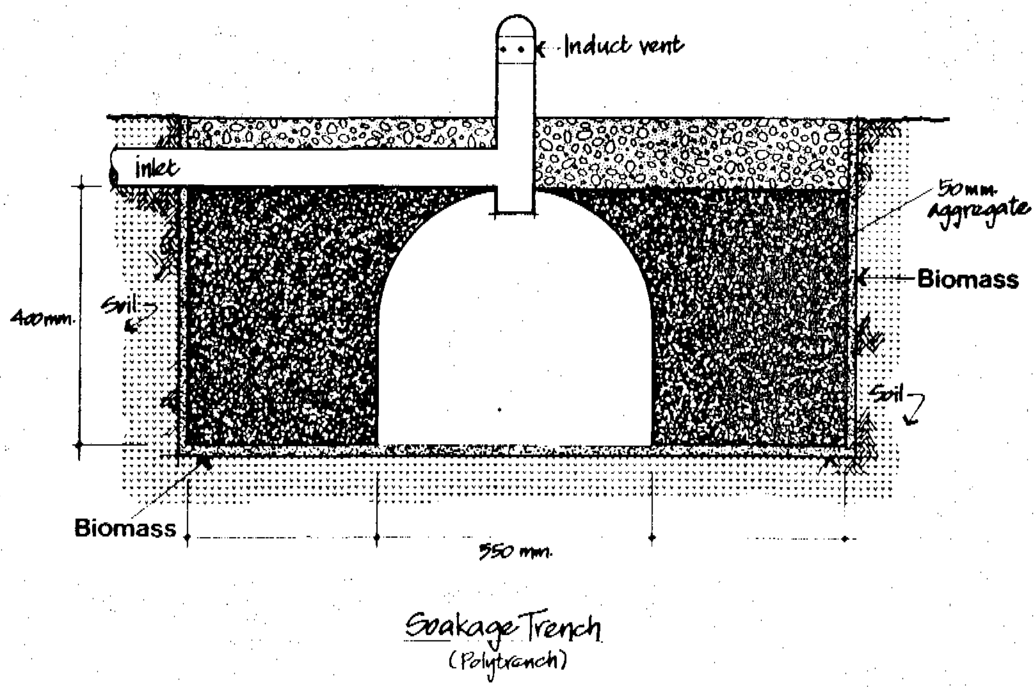


Figure 9. Biomass Layer

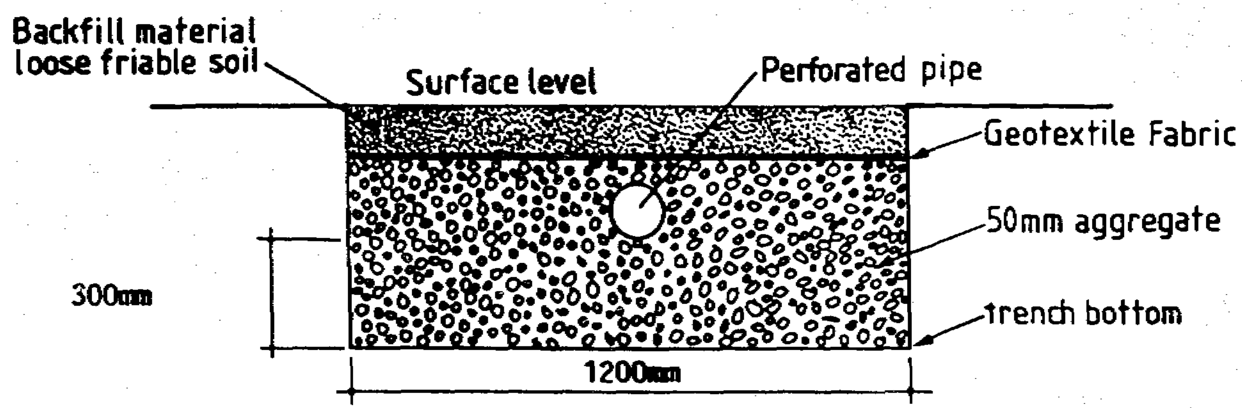


Figure 10. Soakage Trench (perforated pipe)

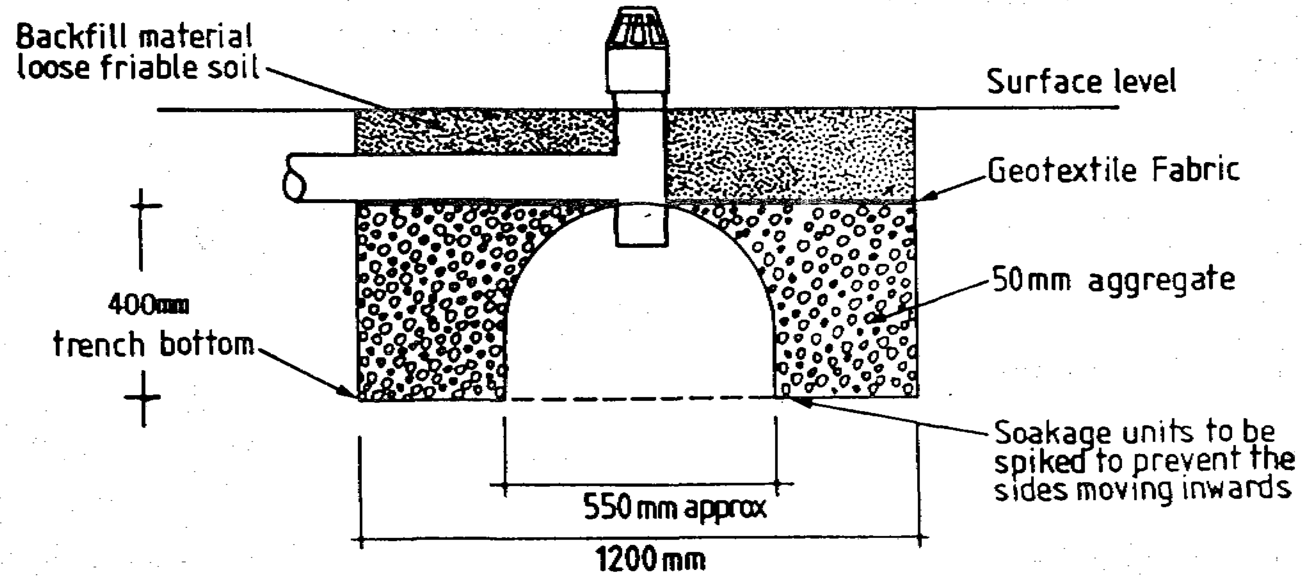


Figure 11. Prefabricated Soakage Units (polytrench)

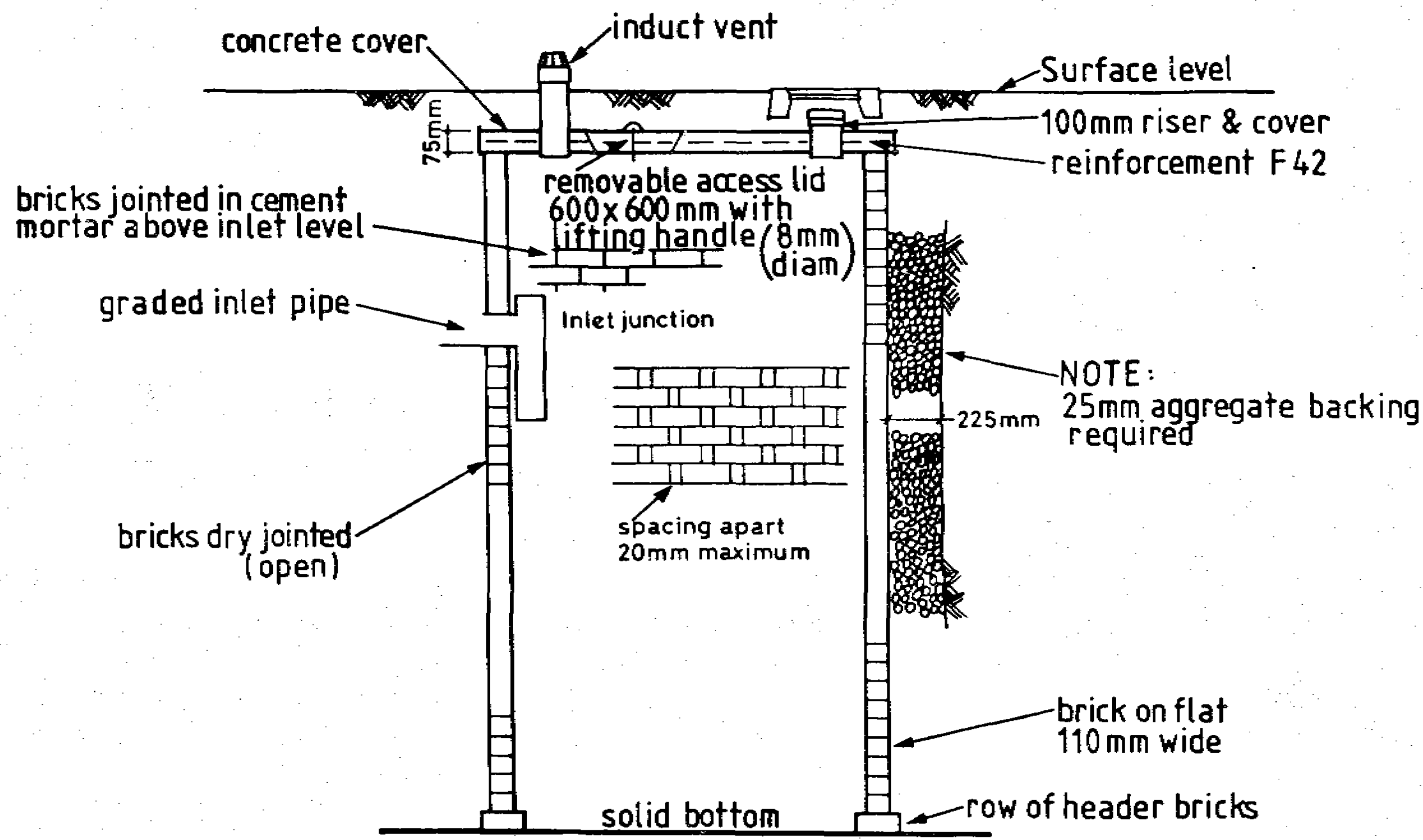


Figure 12. Soakage Well.

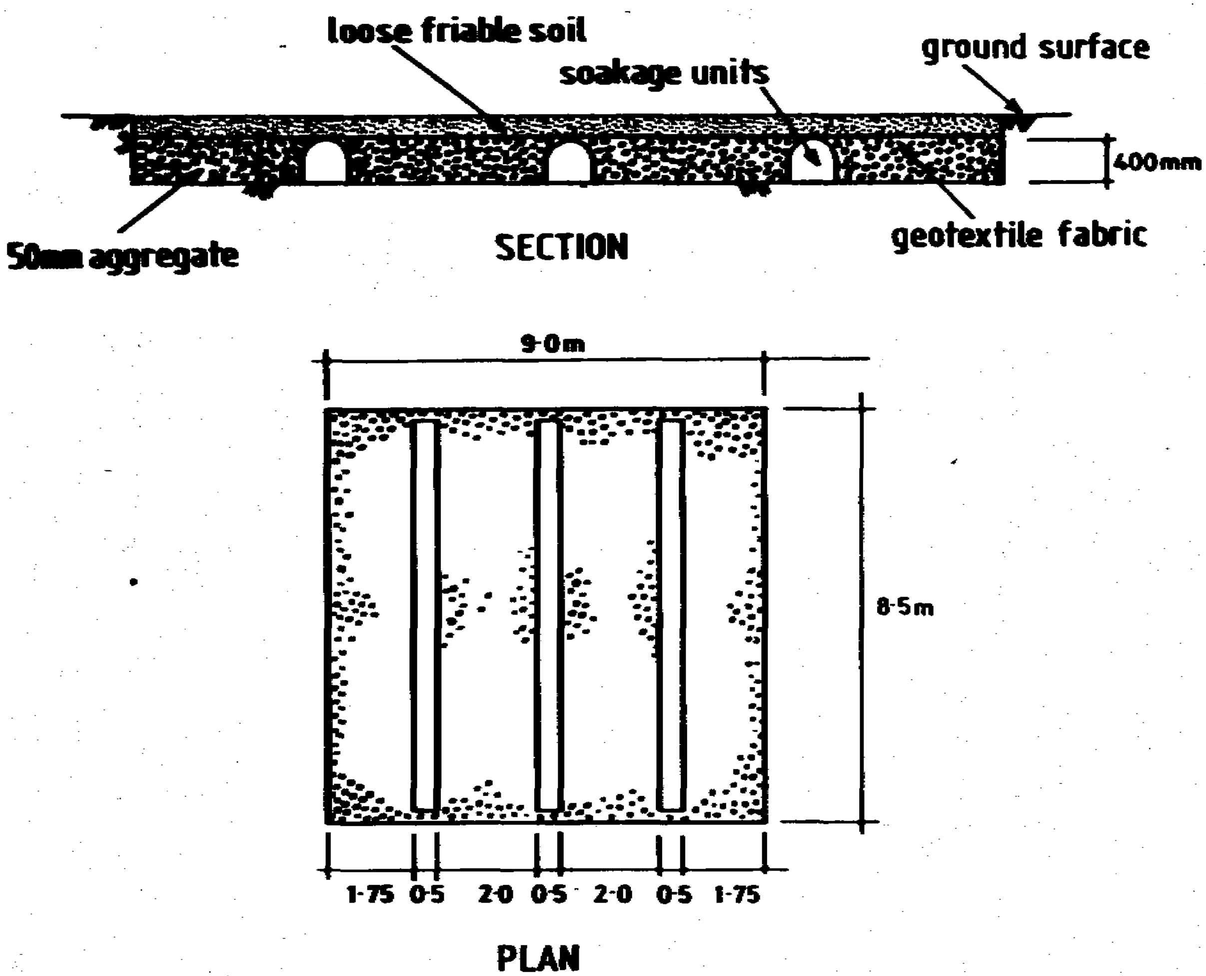


Figure 13. $90m^2$ Soakage Bed

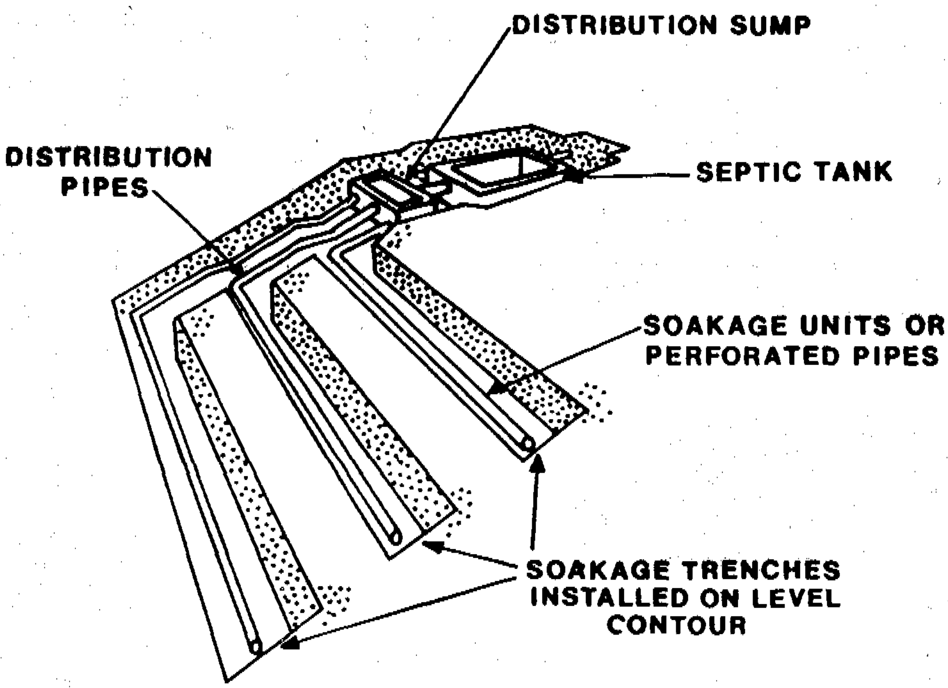


Figure 14. Multiple Soakage Trenches.

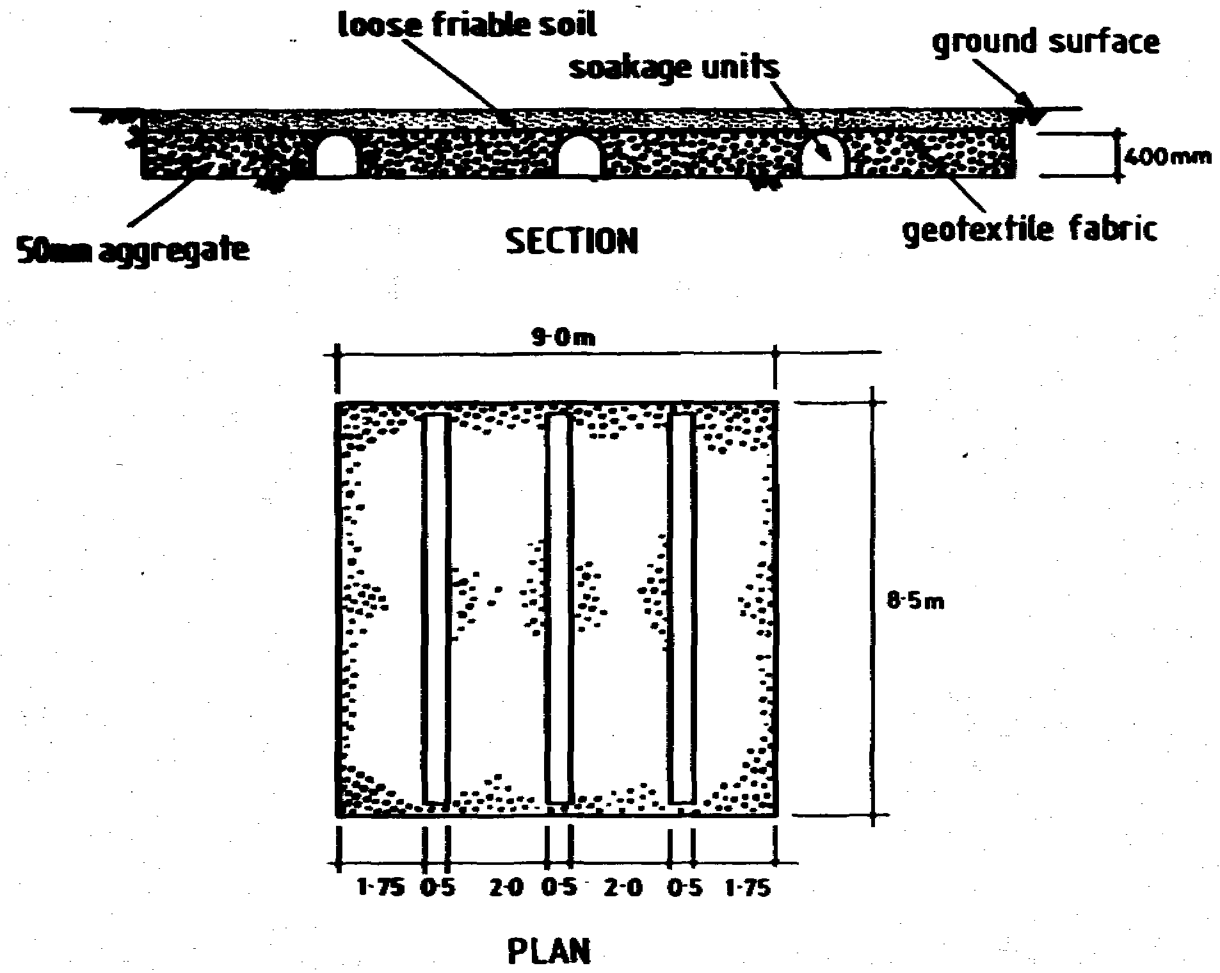


Figure 13. $90m^2$ Soakage Bed

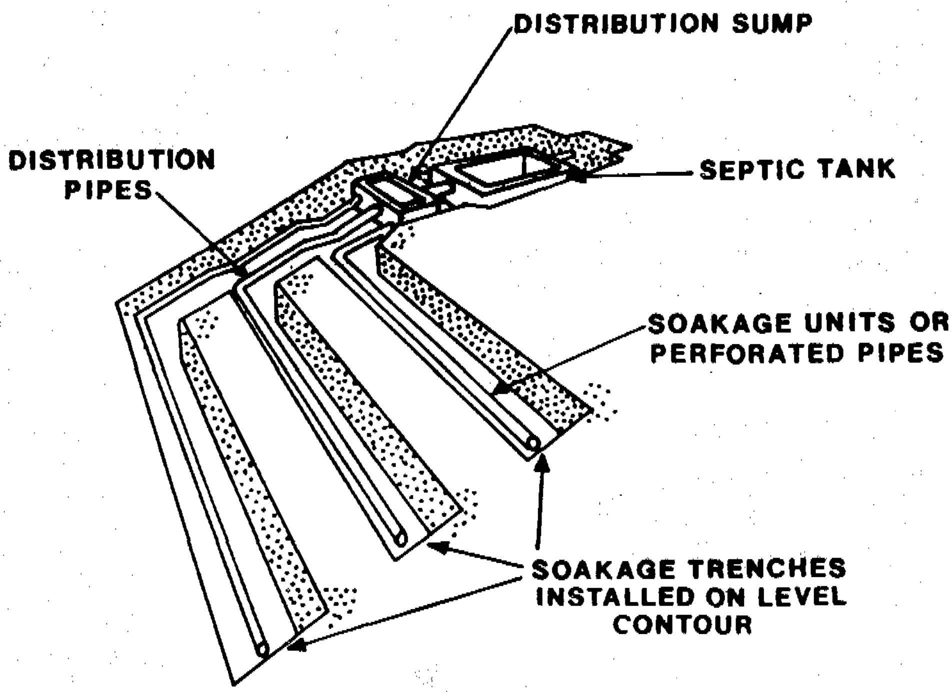


Figure 14. Multiple Soakage Trenches.

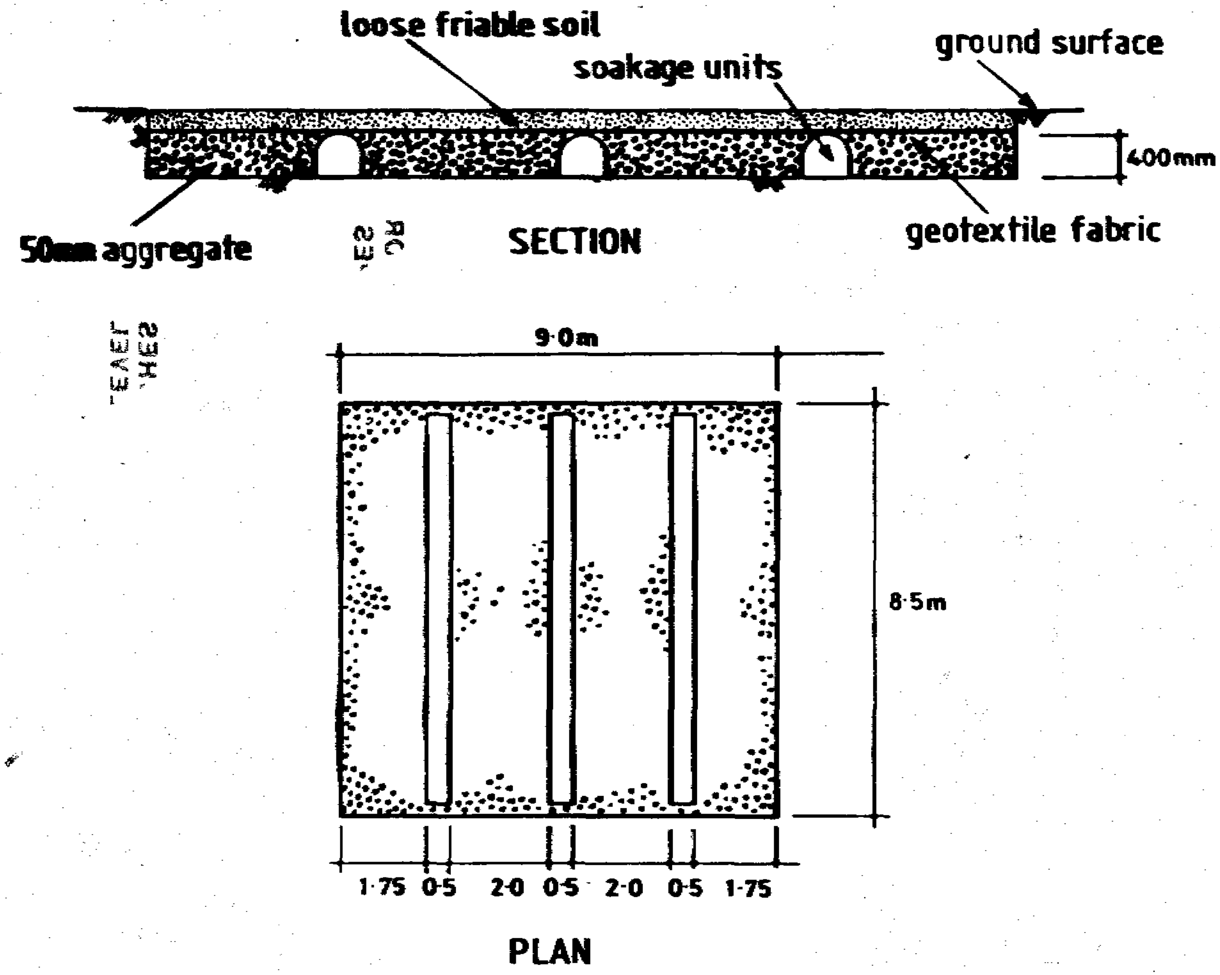


Figure 13. 90m² Soakage Bed

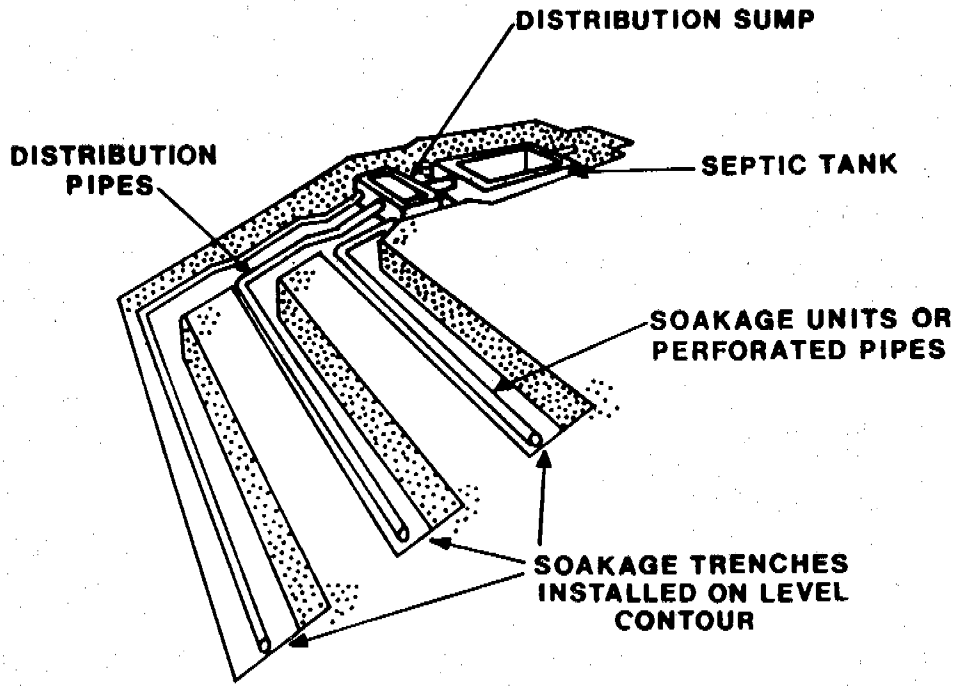


Figure 14. Multiple Soakage Trenches.

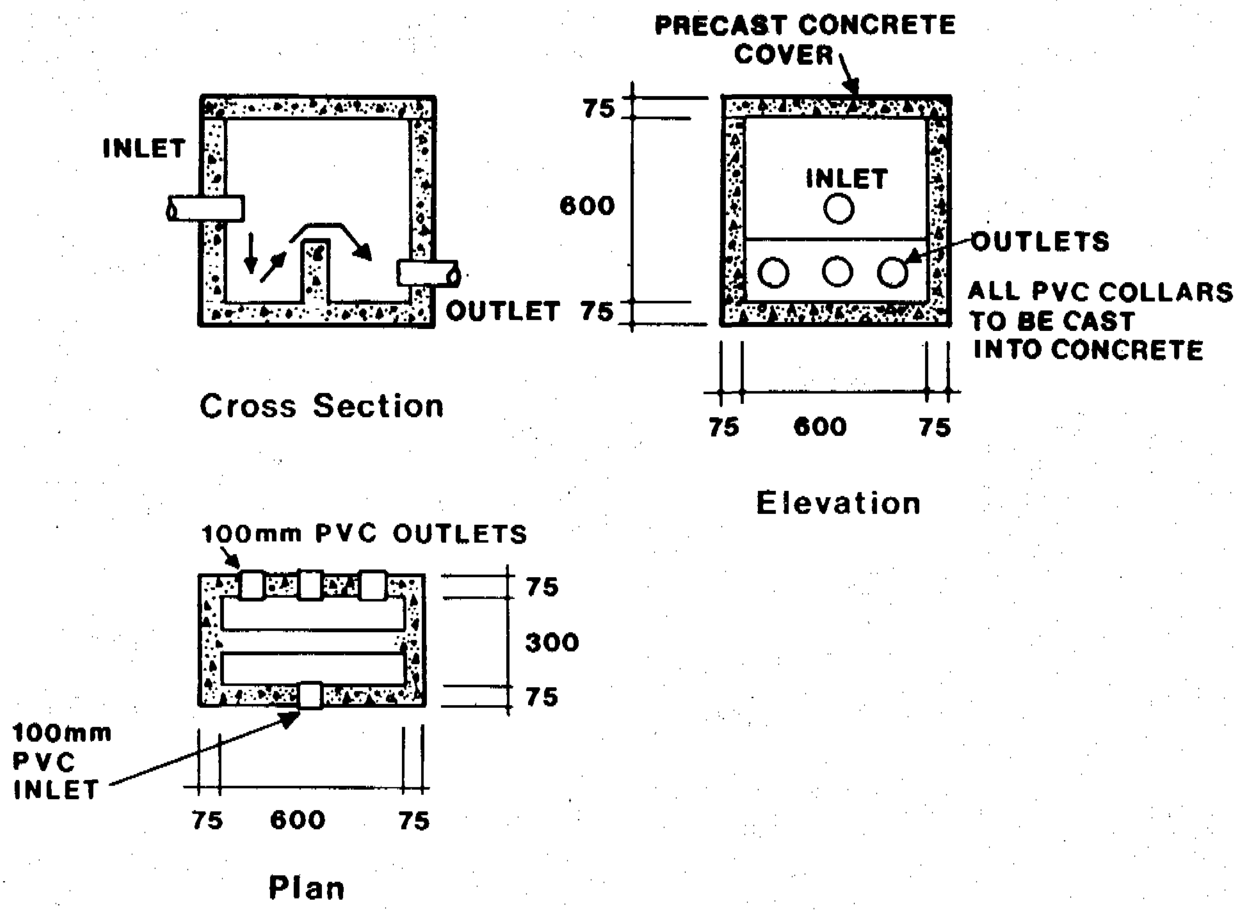


Figure 15. Flow Diversion Sump

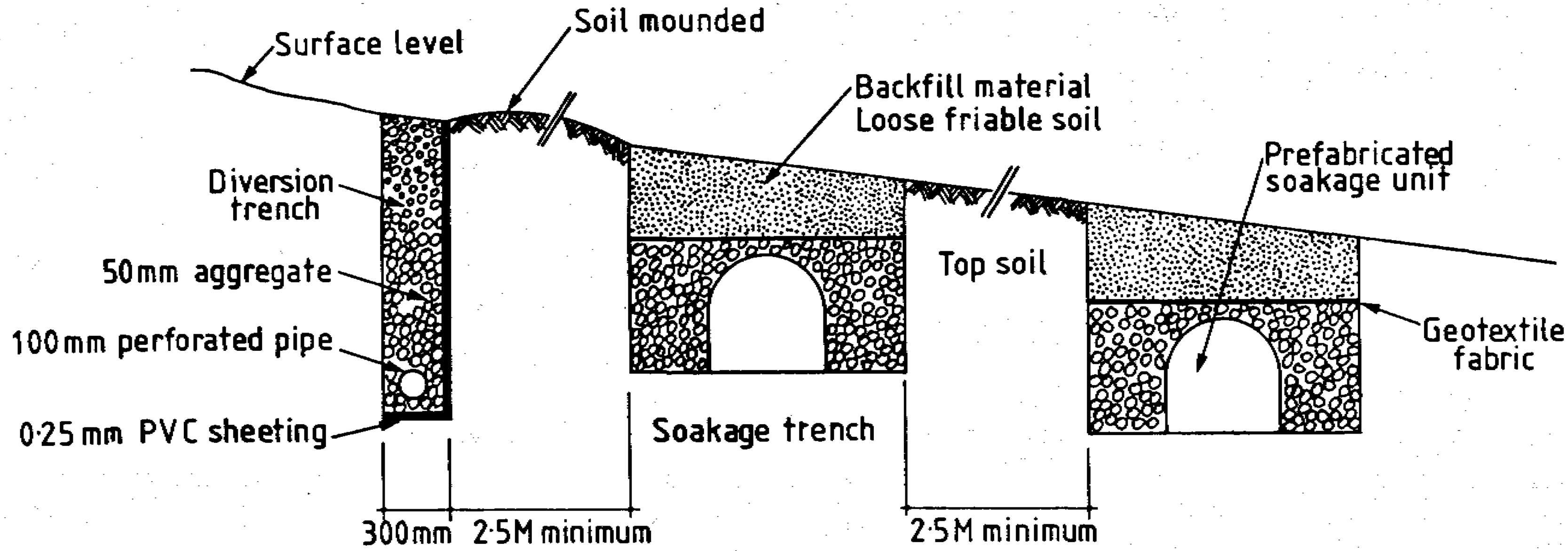


Figure 16. Surface and Ground Water Diversion Trench.

A VIEW FROM LOCAL GOVERNMENT

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DOMESTIC WASTEWATERS: A VIEW FROM LOCAL GOVERNMENT

Trevor Teakle
Senior Building Inspector and Health Surveyor
Onkaparinga District Council

1. INTRODUCTION

In 1967 I entered the industry of Local Government and came face to face with septic tanks, or more particularly with the problems resulting from their installation.

The educational training health surveyors received at that time was contained within the hygiene, sanitation, plumbing and public health engineering sections of the training course conducted for the Royal Society of Health Diploma for Public Health Inspectors.

All health surveyors, whether South Australian Health Commission or Local Government employed, received the same educational training, however some people did have a plumbing trade background.

Over the last twenty years a lot of water has run under the bridge, or should I say a lot of septic effluent has run into the water that runs under the bridge.

During this twenty years considerable concern has been expressed, many studies commissioned, and very little action taken to remove the effluent from entering the water running under the bridge. The exception to this is the gradual installation of sewer and common effluent drain facilities, although I understand that the Engineering & Water Supply Department still has problems with final treatment - in particular nutrients.

2. SOME HISTORICAL CONCERNS OVER POLLUTION

The pollution potential, particularly in the Adelaide hills water catchment, has been under discussion for a long time and septic tanks have been included in this scrutiny.

5th February, 1970 The Department of Public Health convened a meeting of Department of Public Health officers and local government executives and health surveyors working in the hills water catchment area to discuss general water pollution. Discussion revealed that all authorities were concerned and welcomed the proposal of an organised, comprehensive survey to cover all sources of pollution, including effluent. (To become known as the Environmental Survey of the Adelaide Hills Catchment Area - R.R. HENDERSON).

28th April, 1970 Department of Public Health & Local Board of Health officers met to discuss septic tanks and disposal of effluent in water catchment area.

1st May, 1970 Engineering & Water Supply Department proposed zoning policies aimed at curbing and controlling pollution in the water catchment area.

18th June, 1970 Department of Public Health convened a further meeting when agreement was given to:

(1) The inclusion of a third chamber on the septic tank to be used if necessary as a pumping chamber.

(2) Doubling the soakage trench requirements in water catchment area, with installation of diversion drains if necessary.

(3) Joint inspection by Central Board of Health and Local Board of Health Officers before any approval given.

(4) A permit to be issued following satisfactory completion of work.

(5) A follow up inspection to be undertaken 6-12 months later.

15th September, 1970 Department of Public Health and Local Board of Health officers from water catchment area met at Norwood to discuss the above proposals, and it was advised that the new requirements would be operative as from 1/1/71.

Throughout these discussion all approaches for the transfer of authority of septic tank approvals to Local Government authorities (at least those employing qualified health surveyors) met with negative response.

2nd December 1970 Engineering & Water Supply Department announced that the township of Chain of Ponds was to be purchased by the Government due to concerns over protection of water supplies.

In 1970 local authorities commenced notification of all development applications involving septic tanks, to the central health authority, to enable closer and more efficient surveillance of installations.

11th March, 1971 I reported to my local authority:

"A further report has been received from the Department of Public Health listing unsatisfactory conditions detected by R. HENDERSON during his Adelaide Hills Environmental Survey work. The majority of matters listed deal with inefficient disposal of septic tank effluent, and it is becoming apparent that in most cases this is due to faulty or inadequate installation of soakage facilities owing to lack of supervision. It is to be hoped that the new regulations and requirements for septic tanks and soakage trenches in the water catchment area will enable the Department of Public Health to require more efficient installations".

It is worth noting that in his report Henderson stated that it was apparent that one of the two most important sources of pollution was the inadequate disposal of human sewage and sullage wastes.

The question must be asked - why has it taken the Department of Public Health and subsequently the S.A. Health Commisssion (as the responsible authorities), sixteen years to respond to the findings of this report and to conduct a comprehensive review of septic tank standards?

3. THE CURRENT SYSTEM

The following comments have been made regarding the advantages and disadvantages of the current system of administration of septic tank applications and approvals-

(1) The keeping of records in one centralised location (i.e. the S.A. Health Commission) is inappropriate as records are usually requested at the local authority level following a system failure. This can be well after the seven year record retention period of the Commission. The local authority property file is considered more appropriate.

(2) The claim that centralised administration means uniform administration is countered by the inflexibility of decision making and adaption to local site conditions and knowledge that may exist to influence final design requirements of a system.

(3) Currently one authority sets the standards, receives the applications and issues approvals. No further responsibility is accepted upon failure of the system which in many cases occur due to lack of adequate or efficient site inspections and supervision of work in progress.

No follow up on failures or complaints means no learning by experience - a system which cannot adapt.

(4) Local Authorities have control of subdivision, planning and building aspects of any development (which can be expensive and extensive) however, septic tank installations, a minor part of the total development, require the approval of a central agency. It would seem entirely appropriate that such systems be considered and approved by one authority as part of a total development on any land.

(5) The current system results in duplications of manpower and financial resources. As earlier stated all health surveyors have the same qualification and the overlap of centrally employed and located officers into local authority areas, with obvious capital, administration, and salary costs is unwarranted.

(6) The stipulation of June, 1970 that joint inspections by central and local officers occur prior to any approvals being issued never eventuated. Although this may have extended the duplication of resources aspect, it was seen at the time to be important <u>interim</u> aspect to curb pollution.

(7) Over the years systems have been approved and installed with little or no knowledge or consideration of soil types by approving officers. There has also been a distinct lack of appreciation and consideration of the problems experienced by local authority officers with the inevitable failure of inefficient systems.

(8) A lack of co-ordination between planners approving the subdivision of land and departments responsible for further development of that land (including effluent disposal potential) have been obvious in the resultant irregular and impractical shapes and areas devised for residential and other allotments. A blanket policy that allotments involving septic tank installation should be 1,200 square metres in area does not guarantee successful effluent disposal. Factors such as gradient, soil type, <u>suitable</u> available area, water table etc., should be essential considerations.

(9) There appears to have been little or no use of powers by the S.A. Health Commission to refuse applications where the installation will obviously fail.

Approvals have been issued using the basic standard criteria and the inflexibility of the system has virtually eliminated the consideration of alternative installations.

(10) Many issues raised by health surveyors in the water catchment area over the years have not been taken up by the Health Commission or the E. & W.S. Department. e.g.:

- The installation of an additional holding tank on difficult or seasonally wet sites for emergency off site disposal of effluent.

- An increase in the capacity of septic tanks.

- Compulsory accessibility to tanks from surface level for inspection or pumping purposes.

- Analysis of effluent overflow to determine treatment efficiency and installations causing greatest pollution potential. The E. & W.S. Department considered this was not its role and no response was received from the S.A. Health Commission.

It is pleasing to see some of these aspects now in the new criteria but disappointing that it has taken so long to eventuate.

Despite the findings of the Environmental Survey of the Adelaide Hills conducted by Henderson (1972) that inadequate disposal of human sewage and sullage wastes was one of the two most important sources of pollution in the catchment area, the daily inspection areas serviced by the S.A. Health Commission still do not include all of the water catchment area.

4. THE WORKING PARTY REVIEW AND THE NEW CRITERIA

A few comments concerning the review and the new septic tank standards and installation criteria adopted by the Central Board of Health on 11th March, 1988 and to be operative as from 1st June, 1988:

(1) With the exception of minor changes introduced in 1971 for septic tank installations in the water catchment area, the new criteria is the only re-evaluation of design and efficiency for 40 years. It is difficult to reconcile this fact with findings exposed in previously mentioned reports on sources of pollution completed 16 years ago.

(2) The terms of reference for the Working Party were extremely limiting and allowed consideration of only part of the overall problems relating to septic tank installations - i.e. capacities and construction of tanks, capacities and methods of effluent disposal systems and allotment sizes. The problems of administration, supervision and installation, the incidence of failed systems and the use of alternative systems are surely an integral part of the whole process and should have been considered in conjunction with design criteria - i.e. theoretical aspects must be considered with aspects of practical application and enforcement.

(3) The final report of the Advisory Committee of Boards of Health in 1980 recommended the transfer of septic tank approvals to Local Government. This was supported by the Environmental Health Working Party reporting to the Health Minister.

Despite this the membership of the Working Party reviewing septic tank installation and operation did not include a representative of Local Government and only limited consultation was sought. No opportunity was available for comment on the final recommendations before adoption by the Central Board of Health.

(4) The Working Party report lists nine factors contributing to system malfunction: -

: improper system design,
: sloping sites,
: rainfall,
: soil conditions,
: site intervention (banking and filling),
: increased water usage,
: migrating roof, surface and subsurface waters,
: bedrock,
: nature and level of the water table and
: inundation.

The only aspect I consider to have been subject to reasonable change over the last 40 years is increased water usage due to changed residential standards of living - e.g. dish washers, multiple bathrooms, automatic washing machines and spa baths.

Why then, has it taken so long to recognise that septic tank standards are inadequate and the incidence of system failures too high.?

(5) Due to the restrictions placed on the Working Party by the terms of reference, it is considered that the new criteria and requirements could continue to highlight the problem of inflexibility in consideration and approval of systems. Administration proposals must address this issue.

(6) It has been suggested that consideration and emphasis on other aspects of system installation and operation may have increased efficiency and been more cost effective.

- e.g. water conservation measures, site modification, repair and maintenance programmes, increased frequency of tank pump out and on-site Management Districts.

These ideas are canvassed by P.M. GEARY in the report "On-site domestic wastewater disposal - options for the Mount Lofty Ranges Watershed". December, 1987.

(7) The introduction of new criteria for system installation is only one aspect required to be considered - without adequate and efficient on-site evaluation and supervision during installation, many systems are doomed to failure. Many existing systems are in this category - never a possibility of working due to inadequate consideration of site potential or maybe the complete indifference of the installer and plant operator.

(8) Certain aspects of the new criteria will have limited or difficult application - e.g.

(a) The installation of a food waste disposal unit will require a 50% increase in septic tank capacity. How will this be detected and enforced, particularly in the case of existing buildings or in new buildings when nothing is specified?

(b) The annual check for sludge/scum accumulation in septic tanks - who is responsible and how is it to be enforced?

(9) The Working Party report has resulted in dramatic increases in requirements for septic tank installations and on site subsurface effluent disposal. The possibility of alternative systems on difficult sites has been suggested by the report, but no recommendation made, presumably due to the restrictive nature of the terms of reference.

In fact the changes are so dramatic that sub surface effluent disposal <u>will not</u> be a possibility on a large percentage of existing building allotments.

(10) The subject of alternative systems, together with the practical administration and implementation of the new criteria, needs urgent and detailed consideration involving all parties currently, or likely to be, responsible in any way.

It has been suggested that as the pollution potential is so great from domestic effluent, the entire water cathcment area should be declared a compulsory biological disposal system area to eliminate the hassles of trying to achieve sub-surface soakage.

The demands of the new criteria applicable as of 1st June have certainly increased conventional sub surface installation costs dramatically and made the cost difference between systems a somewhat negligible factor.

The Working Party has spent considerable time in producing a report with recommendations based on the most recent information and technology available.

The report and recommendations, within the confines of the terms of reference, is comprehensive. The new criteria has been adopted by the Central Board of Health to be operative from 1st June and may well be considered to be a Rolls-Royce system. The question is - who is going to buy it, garage it, and service it and at what cost?

5. PROPOSALS FOR ADMINISTRATION

(1) Approvals for septic tank installations, supervision of their installation, and which authority should be responsible, has been a subject of debate, negotiation and some disagreement for at least the twenty years of my service in Local Government.

As previously stated the Advisory Committee on Boards of Health (after two years of intensive consultation) and more recently the Environmental Health Working Party both recommended the transfer of septic tank approvals to Local Government.

(2) I believe that the majority of local government personnel involved in any way agreed with the recommendation for transfer assuming that it would become another health responsibility administered by locally employed health surveyors with training and qualification in this field.

Somewhere in the system, this concept (recommended after extensive consultations by the above health orientated investigations) became lost and the following occurred:

(a) The drafting instructions on the structure and content of the proposed Public and Environmental Health Act recommended that the powers relating to construction and installation of septic tanks should be transferred in their entirety to the Building Act.

(b) The new health legislation however, retained the right of the Health Commission to determine design standards for septic tank installations and common effluent drainage schemes. It did not provide for Health Commission Officers to approve systems or collect fees for them. Instead it was proposed that Local Government should carry out this function under the provisions of the Building Act.

(3) It would appear that there was a distinct lack of consultation concerning this transfer of function from health legislation.

A quick reference to the preambles of the subject legislation provides the following:

(a) Public & Environmental Health Act - An Act dealing with public and environmental health.

It has provisions relating to sanitation and drainage and covers prevention of insanitary conditions on premises, discharge of wastes and provision of adequate sanitation.

(b) Building Act - An Act to regulate the construction, alteration, and demolition of buildings.

The only mention of unsewered sullage is in Regulation 45.2 which requires an installation to the satisfaction of a health authority - currently the Central Board of Health.

(4) Another question must be asked - why was a shift in the legislation base considered in the first place, particularly in light of the purpose and scope of each Act and -

(a) The historical involvement, training and qualification of health surveyors in the area of health and waste disposal.

(b) The lack of consultation to determine acceptance of the shift.

P. Geary in his report on on-site wastewater disposal states:

"The responsibility for septic tanks and all alternative systems should be in the hands of Local Government. As Local Government Health Inspectors currently have to deal with complaints caused by failing systems, the responsibility for approving systems should rest with them".

A recommendation made following consultation and preparation of an extensive report covering all aspects of standards and administration!

(5) One of the problems in the present administration system has been the split responsibility of what should be a total package concept - i.e. one authority setting standards and approving installations, another authority dealing with other development on the site, and yet a third authority required to deal with problems arising because of system failure.

The proposal to develop mechanisms under the Building Act to facilitate local approval, inspection and fee collection for an important and traditional environmental health function requires justification. If accepted this proposal will exacerbate the split responsibility problem, with building inspectors having the right to approve installations and health surveyors required to deal with problems arising.

I again quote GEARY -

"Appropriate institutional controls are a pre-requisite for effective on site management for on going water resources management programs in the watershed."

Domestic wastewater disposal and treatment is a health issue. I submit that the appropriate controls in this matter should be entirely within the scope of health legislation and under the control and supervision of qualified health surveyors.

SUMMARY

(1) There has been long standing concern over pollution potential from domestic wastewaters. This has been substantiated by HENDERSON and authors of subsequent reports.

(2) The response from all authorities to these findings has been inadequate.

(3) Deficencies in the current system have not been addressed and in most cases inadequate priority has been given to system approval, installation, operation and maintenance.

(4) The Working Party reviewing septic tank standards was not able to address all aspects of the problem. Urgent consideration must be given to administration and other aspects including the criteria for alternative systems (e.g. selection, responsibility, liability, and maintenance).

(5) Concerns have been expressed over the dramatic changes in installation criteria introduced by a central authority without adequate consultation and opportunity for comment - particularly in view of the imminent changes in administration responsibility.

(6) Local Government should be the authority to deal with all aspects of septic tank installation and waste water disposal as a total environmental health package, administered by qualified health surveyors - with standards of design and construction a state function.

In conclusion - I was asked to prepare a paper on the Local Government viewpoint. The contents of my presentation are a consolidation of many comments solicited from Local Government officers and may be interpreted as representing that viewpoint. The criticism of the existing system is made in a constructive attitude and reflects only on the system, not on individuals.

The problem is one of wide ranging environmental health importance - let us as individuals and authorities interested in and responsible for that discipline, combine resources to ensure the best possible solution.

TREVOR G. TEAKLE,

JUNE, 1988

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SEGREGATED WASTE SYSTEMS

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SEGREGATED WASTE SYSTEMS

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1. INTRODUCTION

Domestic wastewater disposal problems in many unsewered areas of South Australia are directly related to a reliance on soil absorption where unsuitable site soil conditions exist. Unsuitable conditions generally include low soil permeabilities and lack of sufficient soil depth. An alternative treatment option, which is not totally dependent on soil conditions, involves modifying the characteristics of typical household wastewaters.

The characteristics of domestic wastewaters may be modified by segregating the various individual waste streams into two major fractions: the toilet wastes, commonly referred to as the blackwater, and the other household wastes, commonly referred to as greywater or sullage (Figure 1).

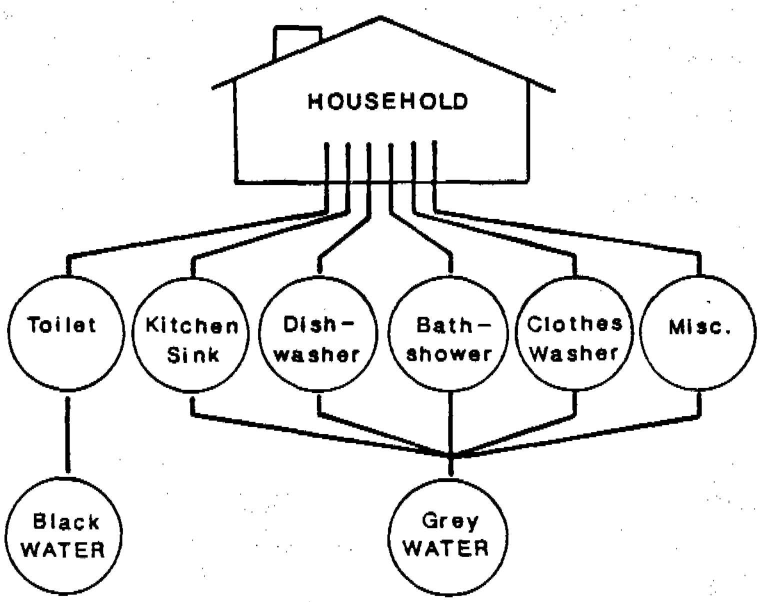

Figure 1 : Segregation of Household Wastes (Siegrist, 1977)

The in-house segregation of domestic wastewaters offers a means of enhancing the conventional methods of treatment and disposal, and of facilitating the development of alternative strategies for wastewater management. In this paper the characteristics of the wastewaters are discussed, and a number of management alternatives are presented for each waste fraction.

The use of a segregated waste treatment system becomes more attractive and cost-effective if its use results in,

i. a lower effluent pollutant concentration and mass,
ii. a reduced potential for pathogenic contamination if effluent is to be discharged,
iii. the conservation of water resources, and
iv. a potential for recycling valuable nutrients to the soil in a beneficial manner.

2. WASTEWATER CHARACTERISATION

Prior to the introduction of the all-purpose septic tank, greywater or sullage was often diverted untreated to the allotment. In many unsewered areas, sullage commonly entered the street water table where it was considered by many to be relatively innocuous. With the all-purpose septic tank, all wastewaters are treated in the same manner and the greywater is grossly contaminated by the toilet wastes.

The results of a number of domestic wastewater characterisation studies have been summarised by Siegrist (1977a). A typical distribution of the quality and quantity components of the blackwater and greywater streams is presented in Table 1.

TABLE 1

POLLUTANT DISTRIBUTION OF HOUSEHOLD WASTES

Greywater	Pollutant	Blackwater
65 %	Flow	35%
63%	BOD_5	37%
39%	Suspended Solids	61%
18%	Nitrogen	82%
70%	Phosphorus	30%
low	Pathogens	majority

The results of the characterisation studies have been used to predict the division of chemical/physical pollutants between the two waste streams. The greywater contributes about 65% of the flow, 70% of the phosphorus and 63% of the BOD_5, while the blackwater contributes about 61% of the suspended solids, 82% of the nitrogen and 37% of the BOD_5. The characterisation studies also demonstrated that a wide range of indicator organisms can be expected in raw bath and laundry wastewaters, which in turn indicated a potential for pathogenic greywater contamination. While the potential for pathogenic contamination appears to be substantially lower than that of either toilet wastes or combined household wastewater, greywater still requires adequate treatment and disposal.

The successful application of waste segregation and separate treatment requires the effective management of both the blackwater and greywater fractions. The management alternatives which are discussed in the following sections reflect the distinctly different characteristics of the greywater and blackwater components. While the treatment and disposal of blackwater through the use of alternative toilet systems has been well documented, there has only been limited experience and research regarding the treatment and disposal of greywater.

3. MANAGEMENT ALTERNATIVES

Domestic wastewaters in unsewered areas are commonly partially treated in a septic tank and disposed of by soil absorption using a soakage trench. The segregation of wastewaters and the utilisation of two trench systems, one for each fraction, often results in improved performance in absorptive soils.

The better performance of the conventional segregated system is usually ascribed to a reduction in wastewater hydraulic loadings and a reduction in the quantity and concentration of certain pollutants (refer to Table 1). The increased tank volume in using two septic tanks also means there is less chance of solids carry over into the soil absorption system, which is commonly a significant factor in the poor performance of soil disposal systems.

Manipulating the waste fractions in this manner may also mean that reduced-size soil absorption systems may perform successfully. Studies suggest that this may be primarily attributable to a reduced hydraulic loading (for example, in sizing a soil absorption field for greywater, only 65% of the normal wastewater load requires disposal).

The management alternatives listed below relate to the traditional separation of black and greywaters, although other combinations, such as the segregation of toilet and bathroom wastes from the kitchen and laundry wastes, have been able to be satisfactorily managed under certain conditions.

3.1 Blackwater Management

Various strategies have been proposed to enable segregation and separate management of domestic toilet wastes. Those strategies which appear most feasible for residential use at present are outlined in Figure 2.

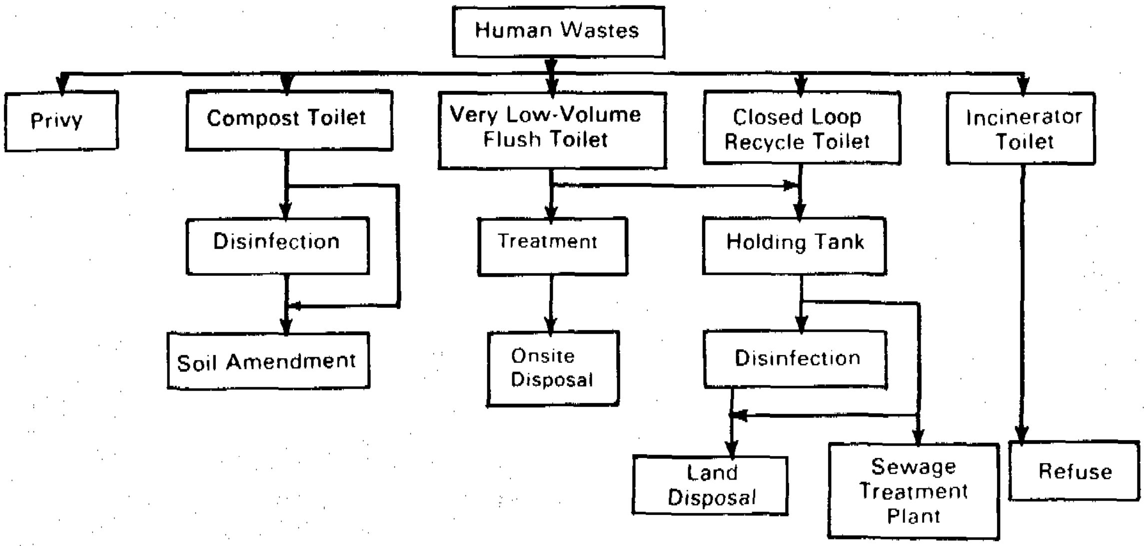

Figure 2 : Strategies for Blackwater Management (Environment Protection Authority, 1980).

A number of these alternatives have been briefly described by Geary (1987), although for more detail, reference should be made to Winter (1981) or Siegrist (1977). A brief description of alternative toilet systems follows:

i. **Composting Toilets -** these units accept toilet wastes (and sometimes garbage wastes) and utilise the natural process of composting to effect their decomposition. The heat from aerobic decomposition destroys pathogenic organisms, decomposes organic wastes into humus-like material and drives off the water content of the wastes. Two types of compositing toilets are available: those which have the point of use separated from the decomposition chamber (separated systems) and those which have the point of use directly attached to the chamber (non-separated systems). These latter systems often contain heater elements to accelerate the composting process. Commercial examples of compositing toilets include Clivus Multrum (segregated) and Bio Loo (non-segregated).

ii. **Incinerating Toilets** - these toilets are small self-contained units which utilise the process of incineration to burn the solid wastes and evaporate the liquids. The incineration is usually fuelled by propane/natural gas, electricity or a combination of the two and usually lasts for 10 or 15 minutes followed by a 5 minute cooling period. The incinerated waste materials are removed periodically and the unit cleaned. Incinerating toilets are not used frequently in permanent homes, and while there is merit in conserving water, problems with overloading, incomplete combustion and odours have frequently been reported. Commercial examples of incinerating toilets include Storburn and Destroilet.

iii. **Recycle Toilets** - these toilets utilise a flushing liquid in a closed loop to cleanse the toilet bowl and transport the waste materials. The process used to purify the flushing medium varies considerably between systems, but commonly includes separation, aeration, filtration or a combination thereof. Purification normally takes place in a treatment/storage tank installed outside the structure containing the toilet fixture. Chemical toilets, which use a water-chemical flush mixture to treat and sterilise wastes, are an example of a recycle toilet. Chem Loo is a popular proprietary brand.

iv. **Low Volume Flush Toilets** - these toilets use low volumes of water as a flushing medium with compressed air or a vacuum being used to assist in the flushing. Other devices used to minimise toilet flows include toilet tank inserts or dual flush cisterns. The smaller volume of wastes produced through using a low flush toilet can be directed to a retention tank for periodic pumping with either on or off site disposal.

In selecting an alternative toilet system for use, the following conditions should be provided for:

1. sanitary conditions at the point of use
2. safe ultimate disposal of toilet wastes
3. reasonably low maintenance and user attention
4. long-term user acceptance
5. reasonably low capital and operating costs.

A summary of the major features of the alternative toilet systems is provided in Table 2. The major advantage of segregating waste using an alternative toilet is that the use of often potable quality water as a transport medium is completely

TABLE 2 : REVIEW OF INDIVIDUAL ALTERNATIVE ON-SITE TREATMENT UNIT OPTIONS

TREATMENT STEP	MODIFICATIONS	TREATMENT METHOD	TYPICAL APPLICATION	ADVANTAGES	DISADVANTAGES	TECHNOLOGY STATUS FOR ON-SITE INSTALLATIONS, DATA BASE	COMMENTS
TOILET SYSTEMS:							
COMPOSTING TOILET	Storage Capacity: o large o small Heating: o heating element provided o unheated	Aerobic Decomposition	o Treatment of human excrements o Systems with segregated waste streams	o Elimination of water from the cycle o Approximate 35% reduction in water consumption o Significant reduction in wastewater value and pollutional load o Low energy requirements	o High capital cost o Significant O/M requirements o Possible fly, odour nuisance o Slight fire hazard o Continuous power supply required with most units o Incorrect, or lack of O/M and/or overloading leads to serious operational problems o Limited capacity o Power outage or equipment malfunction cause process upsets o Composted residue handled and disposed of by the user	o Well developed technology for on-site applications o Fair data base on field performance o Low-medium system complexity o Good commercial availability	o Alleviates disposal problems on difficult sites o Significant reduction in wastewater volumes and pollutional loads o Correct operation and adequate maintenance are crucial for performance o Large toilet has structural implications on the construction - suitable for new dwellings or outdoor installation o Owner's dedication necessary
INCINERATING TOILET	o Oil Fired o Gas Fired o Electrically operated	Waste Incineration	o Sytems with segregated waste streams o Premises used intermittently	o Waterless process o Water conservation of approx. 35% o Complete combustion produces minimal amount of ash residue for disposal	o Frequent residue removal o Rapid corrosion of metallic equipment o Short useful life o Air pollution, odours, untreated residue disposal problems during malfunctions o dependency on fuel o High capital and operating cost o Slight explosion or fire hazard	o On-site technology reasonably well developed o Data base on on-site field performance limited o Medium system complexity o Limited commercial availability	o Operational problems, high capital and operating cost preclude widespread use or continous domestic use
CHEMICAL TOILET	o Portable o Straight drop o Re-cycling o Fresh water flush	No treatment provided, waste decomposition inhibited prior to off-site disposal	o Premises used on intermittent basis o Sanitary facility for provisional conditions	o Waste contained under decomposition - inhibiting conditions o Decreased water usage for waste carriage o Substantial reductions of waste volume	o Substantial capital cost o High operating cost o Risk of illegal waste discharges o Untreated waste stored on the premises o Regular removal of waste for on-site disposal required o Regular chemical and flush water replenishment is required	o On-site technology for continous use limited o Low-medium system complexity	o Conditioned waste storage for subsequent off-site disposal does not substitute for permanent solution to waste disposal problems

TABLE 2 CONTINUED

TREATMENT STEP	MODIFICATIONS	TREATMENT METHOD	TYPICAL APPLICATION	ADVANTAGES	DISADVANTAGES	TECHNOLOGY STATUS FOR ON-SITE INSTALLATIONS, DATA BASE	COMMENTS
RECIRCULATING FLUSH TOILET	Biological Flushing Liquid o Synthetic liquid o Oil o Other	Waste liquification by enzymes and bacteria Treatment is limited to flushing liquid for recycling, waste stored for ultimate disposal	o Developed for special limitations: - On-site waste disposal not feasible or desirable - Water availability severely limited - Water volume to be kept to minimum	o Residue is reduced to liquid waste fraction o Sludge waste residue is eliminated during the process (Bilogical toilet) o Total waste volume generated drastically reduced o Requirement for water or sewer connection eliminated o High sanitary standard in difficult conditions o Water consumption decreased	o Operational problems arise due to process sensitivity (Biological Toilet) o Possible odour problems o Regular enzyme recharging required (Biological type) o High servicing needs o Heating element may be required (Biological Toilet) o Large on-site space requirements as compared to discharging units o Untreated waste stored on the premises o Waste removal for ultimate disposal is necessary o Health hazards and low aesthetic quality during incomplete waste-flushing liquid separation o Special disposal methods necessary for flushing liquid	o On-site technology developing o Poor data base on field performance o High system complexity o Low commercial availability	o Inherent process sensivity, relative complexity and operational problems limit technology development for on-site installations
PACKAGE TOILET		o No treatment provided o Waste is conditioned by packaging and freezing for subsequent disposal off-site					o Unsuitable
MICROWAVE TOILET		o Waste decomposition by microwave irradiation					o Research stage

(or partially) eliminated and that the volume of water is reduced for final disposal.

3.2 GREYWATER MANAGEMENT

When segregated systems have been used and toilet wastes have been managed by an alternative toilet system, greywater has typically been treated and disposed of through a septic tank/soil absorption system. Although greywater does contain pollutants and must be properly managed, greywater is simpler to manage than total residential wastewater, primarily due to a reduced flow volume.

A number of diverse management strategies for greywater have been proposed and these are shown in Figure 3. It should be noted that rigorous field evaluations have not been conducted in most cases.

If kitchen waste is incorporated into the household greywater, some form of pre-treatment is required prior to any further treatment and disposal. Greywater pre-treatment may be in the form of a double compartment grease trap and retention tank to permit waste separation of grease and scum. The use of a tank also allows for a period of settling and sedimentation prior to disposal. The septic tank also performs this function.

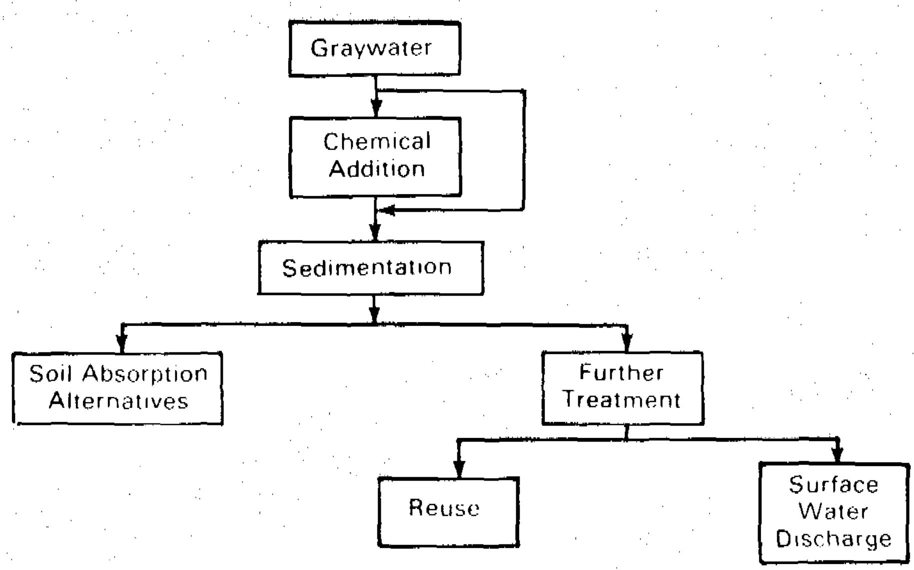

Figure 3 : Strategies for Greywater Management (Environment Protection Authority, 1980)

Greywater may be disposed of by a number of soil absorption alternatives adequately described in the literature. Design allowances should be made for the reductions in flow volume, as compared to typical residential wastewaters. It has been suggested that field size reductions of two thirds or one half of that typically required may be suitable. While the Further Treatment options of Figure 3 are also described in the literature, several strategies are outlined below:

i. **Sand Filters** - sand filters are a treatment alternative where pre-treated effluent is passed through a filter of fine sand. The basis of this treatment process is similar to that which occurs in a conventional biological trickling filter using aerobic disintegration. Sand filters consistently remove significant amounts of nitrogen and phosphorus and reduce concentrations of organic material and suspended solids to low levels. Sand filters have been studied in detail by Dymond (1981). Reference should also be made to the paper by Hawkins (in this volume) for a description of their suitability for residential areas and some of their performance characteristics. Effluent following this form of treatment may be discharged off-site or disposed of on-site by irrigation or soil absorption.

ii. **Wetland Filters** - in this system, greywater is piped to either a trench or bed where vegetation is grown specifically for the purpose of consuming wastewaters and nutrients. Effluent quality can be significantly improved by this form of treatment as high nitrogen and phosphorus removal rates have been recorded in small scale macrophyte trench systems studied. A typical example of the treatment effected by aquatic plants is shown in Table 3.

TABLE 3

GREYWATER TREATED BY MACROPHYTE TRENCH

	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
	31/7/87		13/10/87		15/12/87	
TDS (by EC) (mg/L)	320	110	330	320	370	350
Conductivity (uS/cm)	578	195	599	588	670	632
Tot. P (ug/L)	2100	410	1500	81	1000	10
TKN (mg/L)	11.5	3.11	13.7	2.50	11.9	0.24
NO_x (mg/L)	0.05	0.05	<0.01	<0.01	<0.01	0.02

Although vegetation reduces the wastewater volume through transpiration, and evaporation may also occur, there is usually a need to discharge from the site, particularly during wetter periods of the year. Wetland filters are a suitable management option where sufficient land exists, particularly for use in the urban fringe and for larger rural/residential allotments. The continued use of wetland plant systems to remove nutrients in wastewaters is being investigated in a number of locations interstate.

iii. **Disinfection/Irrigation** - provided that greywater is retained in a sedimentation or retention tank and adequately disinfected, it could be re-used above ground and spray irrigated. This re-use of treated and/or disinfected sullage conserves a valuable natural resource and returns nutrients to the land. However, it is necessary to determine whether the allotment is large enough to dispose of greywater on-site, and to design a retention tank of sufficient volume to hold greywater during wetter periods, if off-site discharge is not permitted.

iv. **Recycle Systems** - these systems are in-house wastewater treatment systems employed to remove specific pollutants from one or more wastewater streams in order to meet a specific water use objective. Although a number of household re-use schemes have been developed for both blackwater and greywater, the only re-use scheme which approaches potential cost-effectiveness is considered to be the re-use of greywaters for toilet flushing (Anderson **et al**, 1981). The costs of other re-use schemes are prohibitive because of the treatment required prior to re-use. A 39% reduction in wastewater flow has been projected from an average home in which recycled greywater is used for non-body contact functions, such as toilet flushing and lawn irrigation.

Based on the results of investigations described by Anderson **et al** (1981), greywater re-use has been shown to be technically feasible. Disinfection and routine system maintenance are essential for effective recycle system performance. Home recycle systems offer significant water savings and waste flow reductions, however, they are only economically attractive under extreme water cost or wastewater disposal conditions. If recycled water is to be used solely for toilet flushing, then simpler, more cost effective fixtures are available that provide similar flow reductions. At this stage of their development, the potential problems with the installation of available systems and the requirement for homeowner maintenance for proper functioning mitigate against their widespread use.

Other low technology-user contrived methods of treating and disposing of greywater, such as the coarse stone filter, are described by Van der Ryn (1978) and others. However, the types of systems involved are often of limited application and/or the experiences gained tend to fall far short of sufficiently delineating the operation and performance characteristics of the systems involved.

4. SUMMARY

There does appear merit in segregating domestic wastewaters into blackwater and greywater fractions and treating each accordingly for certain situations. In-house waste segregation also appears to be a possible method of enhancing conventional disposal methods using soil absorption. Treatment and disposal options are increased if waste segregation is adopted as the flow volume may be substantially reduced and the mass of wastewater pollutants may be altered.

In this paper, several alternative toilet systems have been described which can be used to provide for the segregation and separate handling of blackwater. The separate treatment of blackwater eliminates significant quantities of pollutants (particularly suspended solids, nitrogen and pathogenic organisms) from the wastewater stream and conserves water of potable quality for other domestic functions. The advantages and disadvantages of the various alternative toilet systems have also been presented.

Characterisation studies have demonstrated that the greywater fraction is not innocuous and must be properly managed, preferably on-site. Greywater contains sufficient quantities of organic materials, suspended solids and faecal bacteria to warrant treatment prior to disposal and/or re-use. A number of greywater management strategies have been presented in this paper, although further work is clearly needed in this area. There are definite advantages in certain situations in re-using treated greywater for irrigation, particularly as water is a valuable natural resource and as this procedure returns nutrients to the land.

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SAND FILTERS AS A TREATMENT MEDIUM

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SAND FILTERS AS A TREATMENT MEDIUM

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1. INTRODUCTION

My interest in individual waste water treatment began in 1964, when I was appointed as head of the Health Department of the City of Doncaster and Templestowe. The municipality, which is a suburb of Melbourne, is in the shape of a wedge with the long boundaries being formed by the Yarra River on one side and its tributory, the Koonung Creek on the other. Since 1966, the municipality has been mindful of the effect its subdivision and waste water treatment policies have on the Yarra and has implemented a number of positive controls to ensure its protection from pollution from domestic waste water.

To evaluate the effectiveness of its control measures, Council established a fully equipped laboratory in 1970. Discharges from individual systems are intermittently monitored and from 1973, the Yarra and its tributories have been monitored from 43 points for various pollution parameters, faecal coliforms, phosphorous, B.O.D. D.O., S.S., pH , and total coliforms depending on the site, and on frequencies varying from one to five times a month again depending on the site.

In planning terms, the municipality is divided into three major zones. The Residential "C" Zone comprising quarter acre allotments, Residential "D" Zone comprising one acre allotments and the rural zone. It was Council's policy in the Residential "C" Zone to ensure all properties were connected to reticulated sewerage and in one eighteen month period, Council was responsible for 10,000 premises being connected to sewerage.

In the one acre and rural zones, Council's initial policy was originally to contain all the wastes on the allotments. In the one acre areas, the policy was soon found to be impractical.

The majority of the soils in the municipality are described as moderately deep to deep generally mottled duplex soils of silts and clays derived from weathering of silurian mudstones. Where occurring in a natural state, they are strongly structured, have moderate permeability, and are generally suitable for effluent absorption.

However, a large percentage of the subdivisions have been located on old orchard sites with severely disturbed structureless soils due to years of cultivation. The permeability of these soils is very low. Other allotments are constrainted by steep slopes, (over 25%) and dense vegetation covers of mature eucalypts. Other major problems have been the overdevelopment of the allotments with large houses, swimming pools and tennis courts leaving insufficient room for absorption drains and the destruction of the natural contours and soils of the allotment with earthworks now inevitably carried out with house construction.

These constraints on disposing the effluent on-site forced Council to look for other options for treatment and disposal of effluent. To this end, I spent a week in South Australia studying the Common Effluent Drain Schemes and through a Churchill Fellowship, four months in U.S.A., Canada, the United Kingdom and Sweden studying alternative systems. From these studies and our own experimentation, a range of options was furmulated.

DOMESTIC WASTE WATER DISPOSAL OPTIONS

1. Convential Sewerage

2. Common Effluent Drains

3. Individual Systems

3.1. ONSITE EFFLUENT DISPOSAL

3.1.1. Septic → Absorption Trenches

3.1.2. Septic → Evapo-transpiration Trenches

3.1.3. Septic → Evapo-transpiration Beds

3.1.4. Septic → Sand Filter → Trenches

3.1.5. Septic → Mounds (flat site and permeable soils)

3.1.6. Mechanical Aeration → Trenches or Evapo-transpiration

3.2. ONSITE/OFFSITE DISPOSAL

	Onsite	Offsite
3.2.1.	W.C. Waste Septic→Drains	Sullage untreated →
3.2.2.	W.C. Septic → Drains	Sullage → 2000 l. Tank → Sand Filter →
3.2.3.	W.C./Kitchen Waste Septic	Sullage → 175 l. Tank → Sand Filter →

3.3. OFFSITE

3.3.1. Septic → Sand Filter →

3.3.2. Septic → Recirculating Sand Filter →

3.3.3. Septic → Superficial Sand Filter →

3.3.4. Mechanical Aeration → Sand Filter

3.3.5. Mechanical Aeration →

3.3.6. Mechanical Aeration or Septic/Sand Filter → Trenches → (seasonal overflows) →

The foregoing is not an exhaustive list of options. Except where otherwise stated septic means all-waste septic tank. All the individual systems, except mounds, have been tried in the municipality.

It is to be noted that the discharge of untreated sullage is only permitted in a limited area where sewerage will be available within three years.

After a number of variations, Council's policy is now simply to contain as much waste onsite as possible and ensure that any waste which is required to be discharged off site is adequately treated. Each allotment is evaluated individually at the time of house construction and the most appropriate option for site selected. Despite efforts by Council to preserve the allotments in their natural state, including letters to new owners and town planning requirements that earthmoving is not to take place without the health surveyors' permission, the bulldozer, overdevelopment of the site and natural constraints made onsite disposal increasing rare and all waste septic/sand filters, the most common installation on once acre allotments.

The municipality has an average annual rainfall of over 700 ml which contraindicates transpiration beds and the hilly terrain precludes mounds.

2. THE HISTORY OF SAND FILTERS IN VICTORIA

Mr. E.A. Hepburn, Chief Engineer of the Commissioner of Public Health first described and recommended the use of septic tank/sand filters in Victoria in 1944, his publication being based on American experience and data of the time. (HEPBURN, 1944). He noted that while the device was fairly widely used in America, it had only been used in a few instances in Victoria.

With rare exception, the system remained unused until the late 1960's when they became popular in Melbourne's eastern suburbs for W.C. waste only septics. It is of interest that one municipality which did not insist on an analysis of the sand suffered a very high failure rate of the filters. Subsequent tests found a very high content of silts and clays in the sands used.

In 1973, the City of Doncaster and Templestowe was faced with the problem of the gross pollution of Andersons Creek from an increasing number of large unsewered residential developments. As a a result of a Council report to the newly established Environment Protection Authority, the municipality was delegated as a Protection Agency for the Catchment and the discharge of untreated waste off the allotments was prohibited. Against the advice of Health Department Engineers of the time (there was a theory that phosphorous in the waste would cause clogging) all waste septic/sand filters were used exclusively on quarter acre allotments. A subsequent study by Melbourne Metropolitan Board of Works in 1978 reported -

> "Where wastes cannot be contained on the blocks, all waste septic tanks with sand filters are required. The requirements do not apply to houses built prior to 1973, which still discharge sullage waters directly into drains and watercourses. Although E.P.A. requirements have not reduced pollution along Andersons Creek, they have insured the water quality has not significantly deteriorated from 1973 levels, even though considerable residential development has taken place within the basin since that time."
>
> M.M.B.W. (1978)

There are currently about 1,700 all waste/septic sand filters in the municipality, the majority of which are permanent installations outside areas intended to be sewered. They are now used widely throughout the State.

3. THE FUNCTION OF SAND FILTERS

The use of specially selected and graded sand in the treatment water including water and potable water has been proven and utilised for many years throughout many coutries. The fact that sand filters used in the treatment of potable waters act purely as physical strainers of the suspended solids, and require frequent backwashing to alleviate clogging, falsely created a common notion that waste water sand filters would be subject to similar clogging.

Sand filters are in fact biological treatment plants which operate under aerobic conditions in a similar fashion to a biological filtration plant using aggregate as the filter medium. Sand filters replicate the natural biological treatment function of permeable soils. The septic tank 3000l, (dual (dual chamber) intercepts and removes the inert materials and the organic and nitrogenous waste fractions in suspension in the effluent are adsorbed onto the sand particles where they are oxidised by the zoogleal organisms which inhabit the slimes on the sand.

The passing of oxygen through the sand is critical to the function of the system. Under anaerobic conditions, the anaerobes are reponsible for the gelatinous precipitates which cause clogging.

In Doncaster and Templestowe malfunctions have been rare and with one exception. the malfunction has been caused by the intrusion of tree roots or anaerobic conditions created by burying the filter under clay fill. Fibrous roots from gum trees have caused the failure of about 5 filters in the past fifteen years and about the same number have failed because of oxygen deprivation. The one exception was a failure caused by a contractor mixing "brickie's sand" with a load of tested sand when the tested sand ran short.

4. DESIGN

The system is unique in that it uses no energy, there are no physical, mechanical or chemical aids (except where disinfection is used) or moving parts, all the treatment being carried out by natural processes.

There are four sand filter designs known to the author.

4.1 SUBSURFACE SAND FILTER: (Appendix "A")

These comprise the majority of installations in Victoria. The primary design factors are the hydraulic loading of not more than 50l. per M² and not less than 750 ml. of selected sand of an effective size between 0.25 mm and 0.6mm and a uniformity coeficient of not more than 4. (see Appendix "B"). This is a very conservative design and ensures longevity of the sand before clogging takes place. A typical sand filter in Victoria is 3m wide and from 6.75m to 9m long. A 3100 l. septic two chamber septic tank is adequate for the largest domestic unit.

The filters are normally gravity fed but on occasions a pump may be necessary to lift the effluent from the septic tank to the filter or on flat allotments, a pump will frequently be required to discharge to the stormwater system.

In the U.S.A., it is the common pracctice to intermittently dose the filter with a dosing siphon or pump in order to balance the load. In Victoria, the majority of systems are gravity fed. Victorian Effluent qualities are comparable to those in U.S.A. which indicates that there are no perceived advantages in the added expense of dosing.

4.2 SUPERFICIAL SAND FILTER

A superficial sand filter is an above the ground filter in which the sand is uncovered and accessible for maintenance. The filters are generally smaller and work on increased hydraulic loading which requires the surface to be raked regularly to prevent clogging. When clog to be raked regularly to prevent clogging. When clogging occurs the surface sand is removed and replaced with fresh sand. Superficial sand filters are usually dosed by pumps.

4.3 RECIRCULATING FILTER - U.S. DESIGN (Appendix "C")

The recirculating sand filter is an above the aground filter fed by a dosing pump regulated by a set recirculating factor of five times the average daily flow. The filter is above ground, and exposed, and requires regular maintenance to prohibit clogging. It is half the size of a gravity filter providing an advantage on small allotments.

The Illinois Department of Health reports high quality effluents and reliable performance (Hines Favriou, 1974).

4.4 RECIRCULATION FILTER - VICTORIAN DESIGN (Appendix "D")

This system uses a subsurface sand filter, half the size of a gravity filter, fed by a pump with the recirculation factor controlled by a gate valve. There have been a number of reports of the failure of these systems in Victoria and their use should be avoided until the cause has been isolated.

4.5 INNOVATIVE DESIGNS

Sand filters are often installed on sites too steep and/or too rocky for absorption drains. In these situations innovative designs can sometimes save the house owner considerable sums of money by obviating the need for expensive excavation of rock. On a number of occasions, when the gradients were found to be favourable, filters have been bricked up above ground level, rather than excavated and then surrounded with fill to form part of the landscaping.

4.6 SULLAGE FILTRATION

Where receiving waters need to be protected from pathogens and nutrients, the retention of the W.C. waste and kitchen waste on the site and filtration of the remainder of the sullage is an option where the allotment has room for small absorption fields. Where the absorption area is limited, the flow can be reduced by the use of dual flush or six pint cisterns.

TABLE 1. WASTEWATER FRACTIONS FROM TOILETS/KITCHEN AND LAUNDRY/BATHROOM (Percentage) *

	B.O.D.	S.S.	N.	P.
Toilet/Kitchen	65	65	85	45
Laundry/Bathroom	35	35	15	55

* Extracted from Bauer et al (1981)

Table 1 shows that the majority of the nitrogen, and a large percentage of the phosphorous can be retained on the site by using a W.C./Kitchen waste septic system. As the majority of the pathogens are also contained on the site, the filtration of the laundry/bathroom wastes produces an almost benign waste which can be discharged safely off the site, used on the site for watering or recycled back to the toilet.

The toilet/kitchen wastes are discharged to a 2000l. septic tank with the length of the disposal drains being determined by the loading and soil texture.

The sullage is discharge to 175 l. tanks with square junctions on the inlets and outlets and treated with a 2M by 4.5M filter. If the sullage includes kitchen waste, a 2000 l. septic tank should be used.

5. PERFORMANCE

Sand filters are not a new phonomena and for many years they have been subjected to evaluation by regulatory Authorities and other interested bodies.

A literature review indicates a universal finding of the very efficient treatment ability of sand filters. No adverse comments on the function or reliability was found. On the contrary, the literature confirms that reliabilty and the ability to deal with surge loads and intermittent loadings with virtually no maintenance is a strength of the system.

In 1955, a team from of the University of Florida concluded that experiments indicated that rates of eight times the maximum recommended (50 1/M^2) could be tolerated before clogging was induced and that effluent quality was not affected by a clogging layer. (Furman et al 1955).

The Ministry of Environment, Ontaria, reported that as result of a three and half year study of underdrained sand filters, that such filters are an effective alternative to tile fields/absorption drains and the produced effluents with B.O.D.'s and suspended solids in 85% of the samples equal to or less than 7.8 MG/L and 4.6 MG/L respectively. (Chowdhrey 1974).

The University of Wisconsin commented "sand filtration of wastewater has been practised for years to produce a very high quality effluent from septic tank wastes. Preliminary results from field installations indicate B.O.D.'s and T.S.S. concentrations of less than 10 MG/L and 50 MG/L. (Small Table Waste Management Project Team 1974).

In recent years, the U.S. Environment Protection Agency have conducted a great deal of research into domestic waste water treatment and disposal. A 1981 evaluation of all options gave top ranking for off site discharge systems to the covered intermittent or recirculating sand filter. (Bauer et al 1981). A fixed growth anaerobic reactor was recommended where nitrogen removal was indicated and sand/red mud filter where phosphorous removal was indicated. The evaluation reported that sand filters consistently reduced average B.O.D. and S.S. levels of combined wastewater to less than 10 MG/L and significantly reduced coliform levels by factors of 10^1 and 10^3.

TABLE 2 GRAVITY FILTRATION UNIT PERFORMANCE (BAUER et al 1981)

REFERENCE	BOWNE	HINES & FAVREAU	SAUER	SAUER	CHOWDHRY *	SIEGRIST	SIEGRIST
Filter Type	Recirculating	Recirculating	Intermittent	Intermittent	Intermittent	Intermittent	Intermittent
Pretreatment unit(s)	Septic Tank	Septic Tank	Septic Tank	Aerobic Unit	Septic Tank	Septic Tank	Septic Tank
Wastewater type	Combined	Combined	Combined	Combined	Combined	Greywater	Greywater
Type of study	Field	Field	Field	Field	Field	Laboratory	Laboratory
Average loading rate (m/day (gal/day/ft^2))	0.12(3)	0.12(3)	0.2(5)	0.15(3.8)	0.05-0.07 (1.2-1.8)	0.15(3.8)	0.29(7.3)
Constituents + (Average (Range))							
BOD influent	-	-	123	26	315	62(56-68)**	62(56-68)**
BOD effluent	4(1-11)	4(1-7)	9	2-4	4(2.2-9.3)	1(1-3)	1(1-3)
SS influent	-	-	48	48	285	46(41-51)	46(41-51)
SS effluent	3(1-6)	5(1-18)	6-9	9-11	6(4.8-9.8)	9(6-16)	13(9-19)
NH_3-N influent	-	-	19.2	0.4	37	2.1(1.7-2.5)	2.1(1.7-2.5)
NH_3-N effluent	-	-	0.8-1.1	0.3	0.5(0.2-1.4)	-	-
NO_3-N influent	-	-	0.3	33.8	0.3	-	-
NO_3-N effluent	-	-	19.6-20.4	36.8	35(19-42)	-	-
PO_4 influent	-	-	8.7	28.1	14	34(31-37)	34(31-37)
PO_4 effluent	-	-	6.7-7.1	22.6	6(1.8-9.8)	-	-
Fecal Coliform # (Average (Range)) influent	-	-	$5.9x10^5$	$1.9x10^5$	$3.5x10^6$	-	-
Fecal Coliform effluent	$6.7x10^5$ ($2.2x10^2$ - $5x10^6$)	$1x10^4$ ($8x10^2$ - $4.2x10^4$)	$0.5x10^3$ - $0.8x10^3$	$1.3x10^3$	<100-7500	-	-
Total Coliform # (Average (Range)) influent	-	-	$9.0x10^5$	$1.5x10^5$	$84x10^6$	-	-
Total Coliform effluent	-	-	$1.3x10^3$	$1.3x10^4$	$2x10^4$ ($1.2x10^3$ - $1.1x10^5$)	-	-

* Data presented for 9 filter beds. Values given are average values achieved 85 percent of the time.

\+ Value in mg/l except as indicated.

\# MPN/100ml.

** Log-normalized data.

Table 2 illustrates the results of a number of studies in North America. It is of interest to note the high quality effluents achieved by the filtration of grey water parallels the success of grey water treatment in Doncaster and Templestowe.

When comparing the effluent quality of a filter servicing a septic and a filter servicing an aerobic treatment plant, an Ohio study found a very high quality of effluent regardless of the type of pretreatment (Cashell et al 1987). It is to be noted that septic tanks have a far greater capacity to remove phosphorous than aerobic treatment plants.

A further study by the U.S., E.P.A. in Oregon found that sand filters consistently removed korganics and suspended solids to extremely low values of average of)4 MG/1 and 10 MG/1 respectively (Ronayne 1984).

The City of Doncaster and Templestowe has carried out over 1000 analysis of sand filter effluent. Unfortunately, not a great deal of the data has been collated, but hopefully in the near future, Council's computer can be utilised to compare the effluent quality with design parameters (eg. sand effective size) and loading characteristics (eg. household population, type of detergent used) to deduce optimal design criteria, and the factors which influence effluent quality.

In 1981, an average B.O.D. OF 9 MG/l and 17 MG/l suspended solids was found for some 550 determinations carried out over the preceeding years.

Recently, a limited amount of data was pulled out to construct the following tables. A total of 81 samples were used in their preparation. The validity of the conclusions needs to be weighed against the relatively small sample size in each category.

TABLE 3 DOMESTIC SAND FILTERS - B.O.D. AND S.S. VALUES BY AGE

YEARS OF USE	B.O.D.'s MG/l		SUSPENDED SOLIDS MG/l		
	Average	Median	Average	Median	No. Samples
0 - 1	8.1	5.5	12.8	10.0	9
1 - 3	8.0	5.8	22.8	15.0	22
3 - 6	8.0	6.3	13.3	10.0	18
6 - 10	5.4	5.8	13.7	13.5	20
10 +	13.0	9.0	18.4	11.0	12

Table 3 suggests that there is a gradual deterioration of effluent quality over time. However, even in the oldest filters, the median values indicate a good quality effluent.

The average of the 10+ Group was biased by a value of 40.5 MG/l B.O.D.'s from an effluent with a S.S. of 5 MG/l. An observation of laboratory records of that day found a similar discrepancy between S.S. and B.O.D.'s values from other samples implying that the laboratory error may have been responsible for the high B.O.D. value.

The municipality's clays display a dispersive characteristic and give false S.S. value to samples where clay clods fall into the sampling pit and surface and ground water intrude into effluent. For this reason, when B.O.D.'s values are low, high S.S. are ignored.

TABLE 4. RANGE - B.O.D. AVERAGE VALUES

B.O.D.'s	Number	Percentage
0 - 10	62	77
10 - 20	14	17
20 +	5	6
	81	100

Table 4 shows that 94% of samples were under the accepted limit of 20 MG/1. A significant number, 77% were under 10 MG/1 and although not shown in the Table, 38% were under 5 MG/1.

TABLE 5. EFFLUENT QUALITY BY EFFECTIVE SIZE (MG/1)

Effective Size	B.O.D.	S.S.	No. Samples
0.25 - 0.37	5.4	10.0	13
0.38 - 0.49	4.0	10.0	18
0.50 - 0.60	8.1	20.0	14

TABLE 6. EFFLUENT QUALITY BY UNIFORMITY COEFFICIENT (MG/L)

Unif. Coeffficient	B.O.D.	S.S.	No. Samples
1.00 - 3.00	8.7	18.0	8
3.00 - 3.49	6.5	12.0	17
3.50 - 4.00	4.3	10.0	20

TABLE 7. AVERAGE UNIFORMITY COEFFICIENT FOR EACH EFFECTIVE SIZE GROUP

Effective Size	Uniformity Coefficient
0.25 - 0.37	3.64
0.38 - 0.49	3.46
0.50 -0.60	2.99

Table 5. confirms overseas research that finer sands produce better effluent (Furman et al 1955, Chowdhrey 1974). Unless dosage rate are very low, less than 25 $1/M^2$, sands with an E.S. less 0.2 clog within a matter of months (Chowdhrey 1974).

Table 6. shows that effluent quality improves as the coefficient increases which appears to contradict a requirement for a limit of 4 on the coefficient.

However, as Table 7 shows, the finer sands have the larger coefficients so it is probable that the majority of sands in the 3.50 to 4.00 coefficient group were also in the 0.25 to 0.37 E.S. group.

According to Fair and Geyer, sands which have uniformity coefficients between 1 and 5 will have practicably the same hydraulic characteristics provided the effective size of the sands is the same (Chowdhrey 1974). The presumption from this information is that effective size is the most critical parameter in the sand specification. Fine sand should be avoided, as should sand with more than 5% silts and clay, but coarse sand still provides effective B.O.D. removal even if over the 0.6 limit set in Victoria. Chowdhrey reported a B.O.D.'s removal of over 95% in a sand of 0.1 effective size.

6. SUPERVISION

A rigorous inspection program is critical to the success of sand filter installations. In the first instance, site insecpections are essential before a permit to install is issued to ensure that the sand filter is to be placed in suitable area and that the required hydraulic gradients can be maintained through the system.

On flat allotments, the fall required on the sewer inlet can place the filter at a risky depth below the surface, thus encouraging anaerobic activity. This can be avoided by pumping to the filter or using large aggregate as backfill before the topsoil cover to encourage adequate ventilation.

At the permit stage, it is important that permit conditions are conveyed to the owner so that the maintenance requirements are known. The first and most critical requirement is for the sand to be sampled for analysis from the actual sand on the site. The sand should not be placed into the filter until the results are known. The sampling procedures are described in Appendix B. Compulsory construction inspections are required at -

1. the excavation stage to ensure that the dimensions and the underdrains comply with the design criteria.
2. the overdcrain stage; at this stage flow tests are carried out on the overdrains and probe tests are made with 25MM steel probes to ensure the correct depth of sand has been installed.
3. when the filter has been covered to ensure that impervious soils have not been used (NOTE: this usually carried out with the final plumbing inspection).

7. MAINTENANCE

Left in an undisturbed state, the sand filter will function satisfactory for many years. The U.S. E.P.A. in calculating operating costs placed a nominal 20 years life on the sand filter. Householders including new owners need to be educated not to fill or build over the sand filters.

The only maintenance required is the regular pumping of the Septic Tank on at least five year cycles.

Fifteen years of monitoring effluent quality in Doncaster and Templestowe, indicates that standards are rarely exceeded, hence regular sampling of each individual filter is unnecessary.

Monitoring of the sub catchment waters on a regular basis is a better tool to evaluate the continued performance of the filters of the therein.

8. RECORDS

Construction inspections are recorded on a works card carried into the field. (Appendix "E"). A copy of the application plan is made on the back of the works card.

After the issue of the permit to use, the system's inspections and sampling results are kept on a card with comprehensive data on the household including household appliances and detergents used. (Appendix "E") Effluentt analysis results are kept on the back of the card (Appendix "F").

In the near future, all records will be computerised enabling the data to be collated, cross tabulated, and used to elucidate the function and performance of sand filters. The computer will also bring forward these systems on a five year pump out.

9. SUMMARY

If installed in accordance with the approved design criteria sand filters provide reliable and effective treatment of domestic waste water. They can be used to treat effluents for direct discharges to surface waters, either from all waste septic systems, W.C. waste septic systems or sullage., Alternatively, they can be used to treat effluents for discharge to absorption fields in marginal soils so that overflows do not cause local nuisances or pollution to surface waters.

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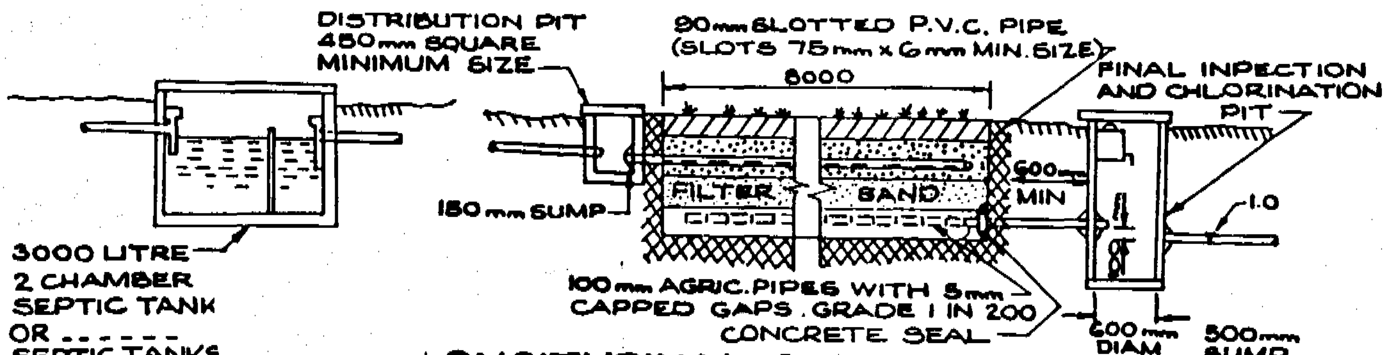
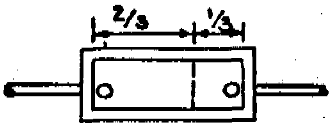
CITY OF DONCASTER AND TEMPLESTOWE

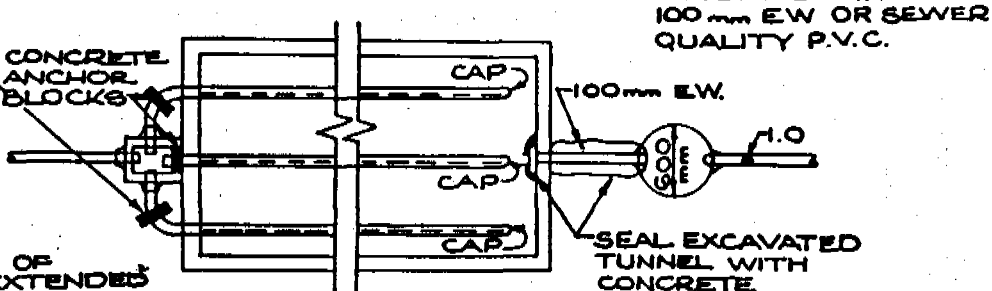
SUB-SURFACE SAND FILTER DESIGN BASIS: 50 Litres-Sq. Metre-Day Surface Area



LONGITUDINAL SECTION

OUTLET DRAIN
100 mm E.W. OR SEWER
QUALITY P.V.C.

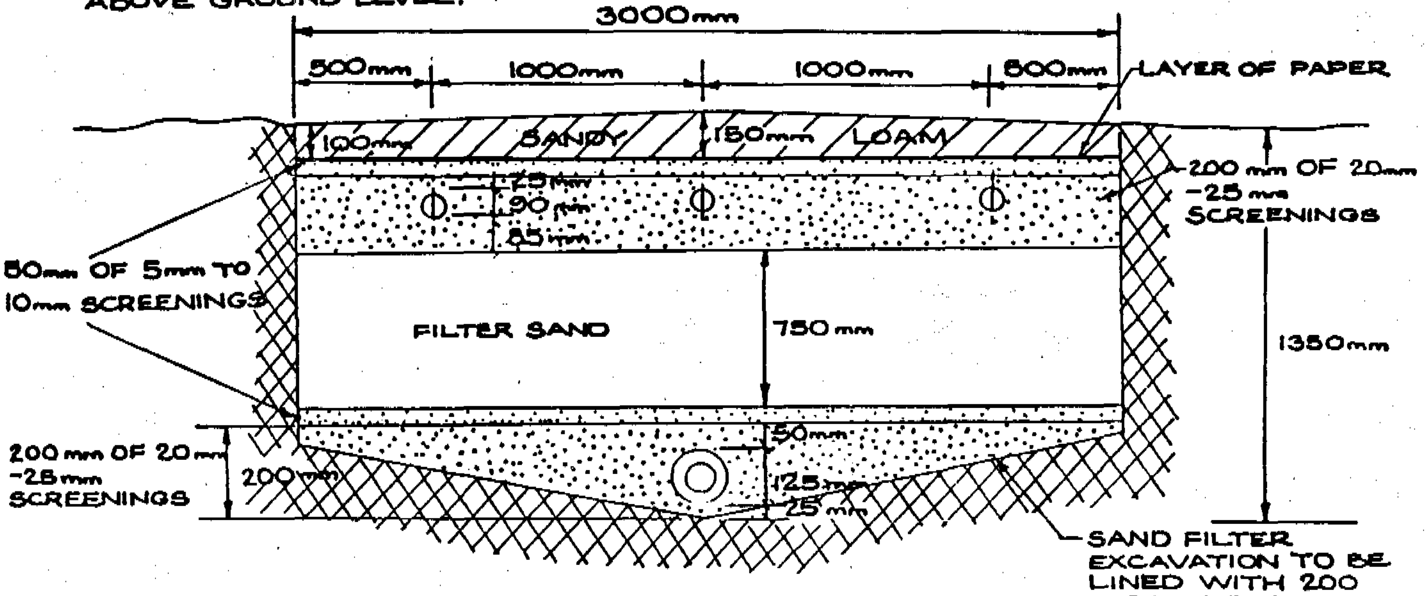




PLAN

NOTE:

1. INSPECTION OPENINGS OF SEPTIC TANK TO BE EXTENDED TO 75 mm ABOVE GROUND LEVEL.
2. DISTRIBUTION PIT AND CHLORINATION PIT TO BE EXTENDED TO 75mm ABOVE GROUND LEVEL.



SAND FILTER EXCAVATION TO BE LINED WITH 200 MICRON PLASTIC SHEET AND TAPED AT JOINTS

CROSS SECTION

SAND SPECIFICATION

Clean, washed sand only is to be used, all passing an 8mm sieve, and having an effective size of between 0.25 mm and 0.60 mm with a uniformity co-efficient not greater than 4 (four).

Sample of filter sand to be obtained from site by Health Surveyor.

Sink garbage disposal unit not to be installed.

Plumbing and sewerage drains to comply with M.M.B.W. By-Laws.

INSPECTIONS REQUIRED

1. When excavation completed with bottom A.G's, with 25 mm of screenings underneath only, outlet pipe, water proof liner and chlorination pit installed.
2. When all material installed prior to backfilling; top slotted P.V.C overdrains to be left exposed.
3. When overdrains are ready for flow test by Health Surveyor. Flow test of overdrains to be carried out by Drainer before inspection and flow test by Health Surveyor is called for.
4. Final when backfilled with sandy loam.
   Note : Only submersible pumps will be allowed, pumps to be installed 150 mm above floor of pit.

L.P.

HEALTH
COMMISSION
OF VICTORIA

9. Filter Sand Specification

9.1 General. The sand shall be either a silica or grantic sand as limestone material will gradually dissolve, or cement together, or both. The uniformity co-efficient should be low, as the gaps between the sand particles will be smaller with a sand having a high uniformity co-efficient than a sand with a low uniformity co-efficient.

Care must be taken in the selection of the filter sand as fine sand tends to clog quickly and very coarse sand will not achieve satisfactory oxidation of the effluent.

9.2 Sand Specification. Clean selected sand only is to be used, which conforms with the following requirements:

(*a*) Sand to have a particle size less than 6 mm.

(*b*) Effective size of between 0.25 and 0.60 mm.

(*c*) Uniformity co-efficient to be less than 4.

(*d*) Sand to contain less than 5 percent by volume of clay and fine silt as determined by the test method described in AS 1141, Section 33.

where,

Effective Size = maximum particle size of the smallest 10% of sample by mass

$$\text{Uniformity co-efficient} = \frac{\text{maximum particle size of the smallest 60\% of sample by mass}}{\text{maximum particle size of the smallest 10\% of sample by mass}}$$

9.3 Higher Dosage Rates. Where sand filters receive predominantly seasonal or intermittent use and the sand has an effective size of between 0.6 and 1.0 mm they may be expected to perform satisfactorily at dosage rates of 100 litres/m^2d. Under special circumstances sand filters having sand of this effective size may be loaded at higher rates than 50 l/m^2d provided that effluent is recirculated through the system at a ratio of at least 1 to 1.

9.4 Sieve Analysis. It is impossible to determine the effective size and uniformity co-efficient of sand by visual inspection, therefore it is essential that the sand samples should always be checked by mechanical analysis as follows:–

(*a*) A bulk sample of not less than 2000 g shall be collected by means of a 50mm diameter sampling tube from five (5) points around the sand deposit to obtain a epresentative sample;

(*b*) A test portion of 100–200 g dry mass shall be reduced from the bulk sample by means of a sample divider or by coning or quartering for sieve analysis;

(*c*) The sieve analysis shall be carried out in accordance with Australian Standard 1141 Methods for Sampling and Testing Aggregates.

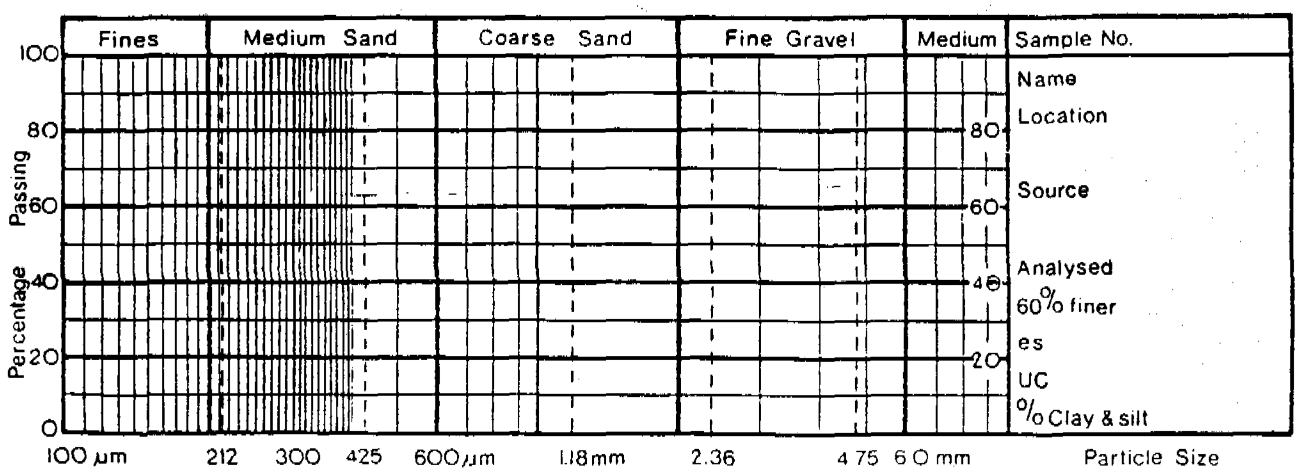
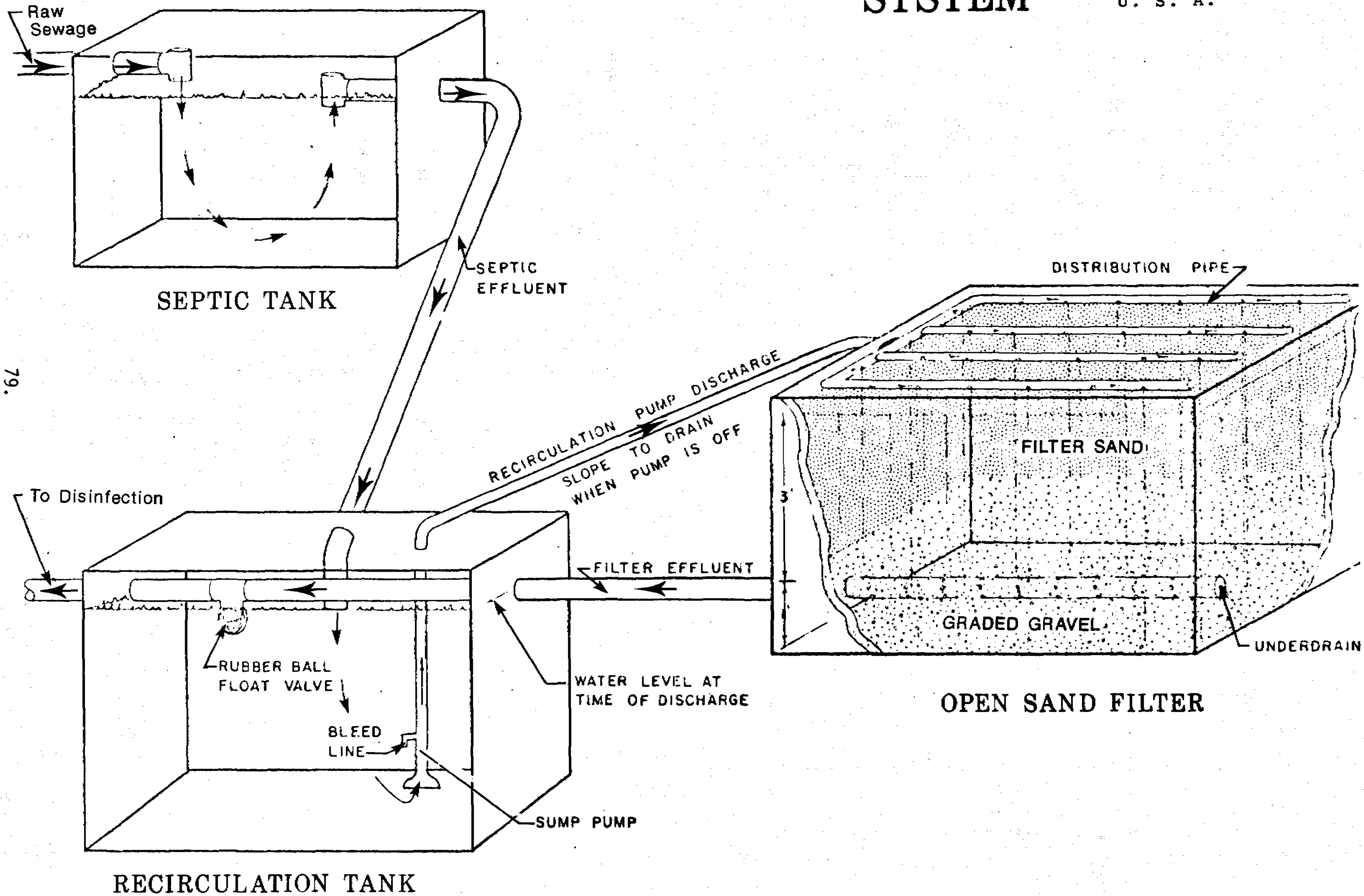


Figure 9.4 Mechanical Sand Analysis Chart

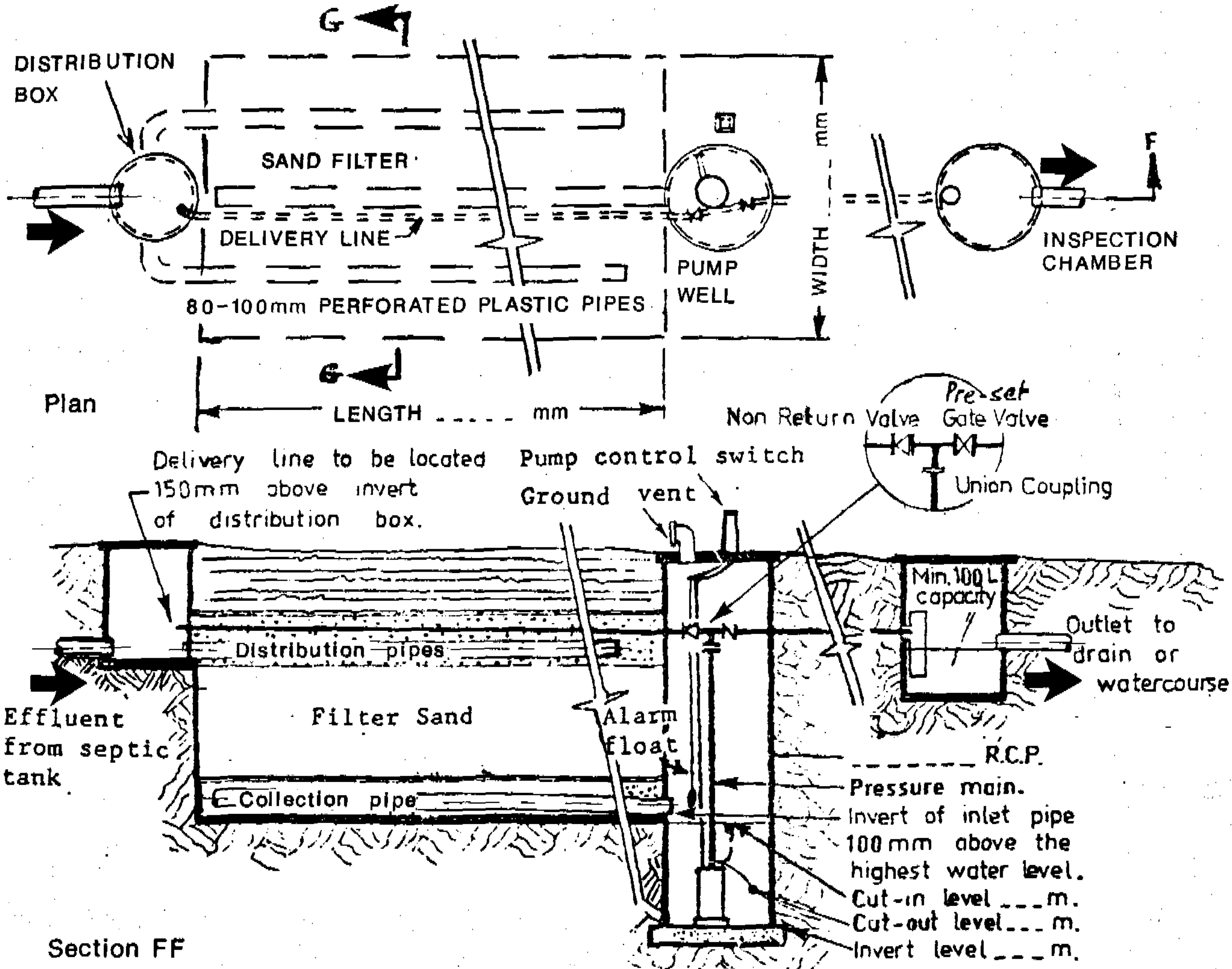
RECIRCULATING SAND FILTER SYSTEM

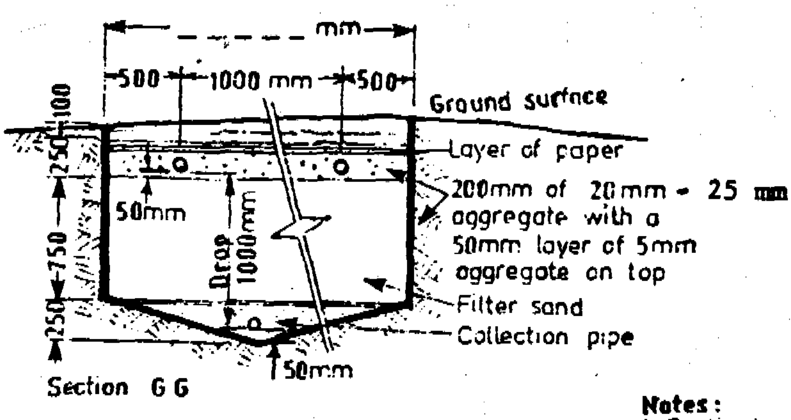
U. S. A.



APPENDIX "D"

RECIRCULATING SAND FILTER – VICTORIA





All Dimensions are in millimetres.

Notes:
1. Septic tank capacity equal to sludge storage plus daily flow.
2. Sand filter dosage rate up to 100 litres per square metre per day.
3. Pump well capacity between pump cut-in / out equal to 1/24 daily flow. (1h ≥ DWF).
4. Pump to be automatically controlled, self priming type with a minimum power rating of not less than 0·30kW.
5. Where daily flow exceeds 1000 L/d stand-by pump shall be installed.
6. Gate valve to be adjusted for equal distribution of effluent to distribution box and inspection chamber.

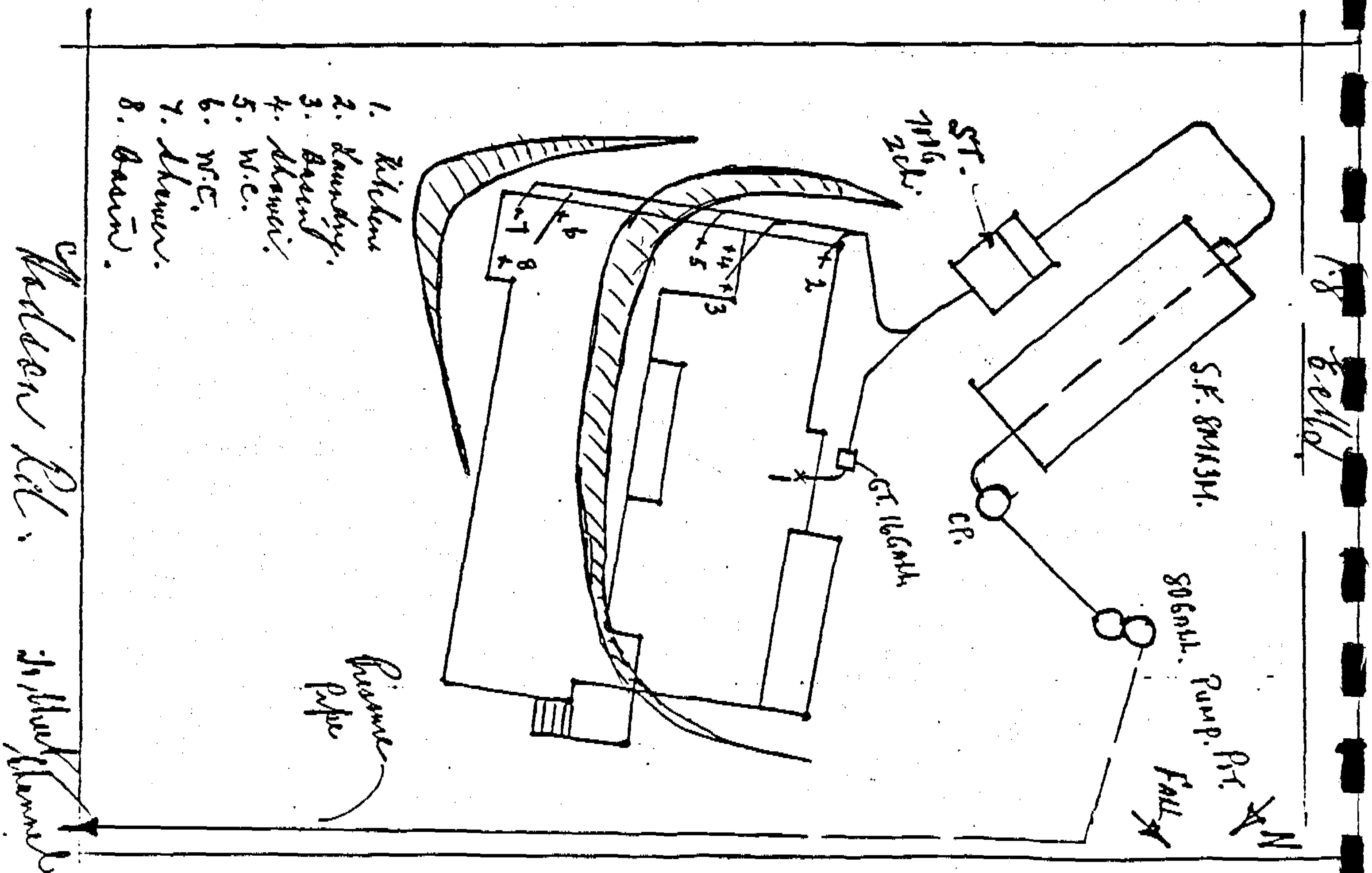
EPA. AWS.F. APPENDIX "E" WORKS RECORD CARD "PUMP." "750MM Sand

CITY OF DONCASTER AND TEMPLESTOWE

SEPTIC TANK REGULATION

Street Hodson Road.	Lot No. 27.	Unit 700G AWS.F.	
	House No. 18.	Permit to Use 25-1-80	
Owner	Applicant Larmer & Hill, Totara Rd, Mitcham.		
	Installer Greg Alexander.		
Fee paid $47.	Rec. No. 60496	Date 5/7/79	Permit No. 18011 Date 9-7-79
		Sand Results E.S. ·50 U.C. 286.	

Inspection	Remarks
9-7-79	Adm AW S.T.S 700G 2ch S.T. 8MX3M S/F. Inlet & to be installed in accordance with MMBW Sew. Regs & Pl. ea
22-10-79	S/F exc OK. Sewer - Grader test ok.
26-10-79	S/F + Flow test OK.
27-11-79	Plumbing OK. CP + Pump Pit oks. Pump in or yet installed. Pop up grate to be fitted to O.R.G.
25-1-80	Final ok.



APPENDIX "F"

CITY OF DONCASTER AND TEMPLESTOWE MONITORING RECORDS CARD SEPTIC TANK INSTRUCTIONS

Street BERRIMA RD Lot No. 24 House No. 9

Owner BAXTER Type Tank 3000 L.S.T. Sullage

= 0.41, UC = 368. Disposal Pump Installation Date 24-7-79

DISHWASHER: Yes GARBAGE GRINDER: NO CLOTHES WASHER: Yes

DESLUDGED NO Number Occupants M 1 F 4 Number Bedrooms 4

Date	Tank	Chlor.	D/Deterg.	L/Deterg.	Disinf.	Disposal	Sample	ACTION	COMMENTS
15-7-83			Finish	Coles Blue Label	Myno		Sampled ①		

CITY OF DONCASTER AND TEMPLESTOWE EFFLUENT ANALYSIS

Address: LOT 24 BERRIMA RD.

Date	B.O.D.	S.S.	Chl.	F/C	C.O.D.	M.L.S.S.	D.O.	Deter.	PO_4	pH
15-7-83	5.0	5.0	ND	–	–	–	–	–	4.90	7.5

MOUNDS - THE ABOVE GROUND ALTERNATIVE

Dr Joost Brouwer
Soil Scientist
Land Protection Division
Department of Conservation
Forests and Lands, Bendigo

Dr Robert van de Graaff
Consultant
Park Orchards, Victoria

Mounds - the above ground alternative

Joost Brouwer* and Robert H.M. van de Graaff**

* Land Protection Division, Dept. of Conservation, Forests and Lands, 21 Curtin Street, Bendigo 3550
** 80 Brucedale Crescent, Park Orchards 3114

1. Introduction

The two problems of soil treatment and soil disposal of septic tank effluent each have their own optimum solution. These solutions are in fact in conflict with each other: for optimum treatment a very clayey soil is best, for optimum disposal a very sandy soil. In very clayey soil disposal is very slow, even prohibitively so, as anyone familiar with on-site effluent disposal will readily testify. In very sandy soil treatment and purification of effluent is minimal, as the polluted groundwater under many suburbs of Perth demonstrates.

The best compromise then is a loamy soil. Such soils are obviously not found everywhere. There are of course also other soils on which both treatment and disposal of effluent can be satisfactorily achieved. Equally there are soils on which it is impossible to attain either a satisfactory disposal rate or a sufficient purification.

The general opinion in literature is that, by and large, for good chemical and microbiological purification 0.6 to 0.9 m of unsaturated soil is sufficient. The soil should however not be too coarse (too sandy). There should also not be any appreciable flow through macropores. The clogging layer that usually develops in absorption fields does not solve the problems of sandy soils, but it does see to it that flow through large pores does not take place.

The only purification problem that exists on all soils is with nitrate: where there is recharge of the watertable nitrate contamination of the groundwater is a virtual certainty and the degree of acceptable contamination needs to be assessed (USEPA 1978; Loudon and Fay 1982; Brouwer and Bugeja 1983; see also Section 6).

From the above it can be deduced that purification problems other than from nitrate occur on very sandy soils, on soils with high groundwater tables (seasonally or perched), and on shallow soils over fractured bedrock. Problems with effluent disposal also occur on soils with high groundwater tables, as well as on very slowly permeable soils.

Where one of these problem soils occurs there are several options in respect of septic tank effluent treatment and disposal:

a. In the case of slowly permeable soils it may be worthwhile trying to reduce effluent flow: with water saving devices (e.g toilet flush reducers, incinerating or composting toilets and sud savers on washing machines), and/or with wastewater recycle/reuse systems for in particular the grey water. Cf. Boyle and Otis (1979). It is also possible to increase infiltration rates using the principle of electro-osmosis, where an electrical potential is applied to the soil (NEHA 1979; USEPA 1980).

b. In the case of high groundwater tables, cut-off drains and subsurface drains may offer a solution. It must be kept in mind that, in the case of subsurface drains, the drains must, paradoxically, be positioned relatively close to the absorption field to ensure that the groundwater table under the field is drawn down sufficiently and there is adequate unsaturated flow. Cf. USEPA (1980); Loudon and Fay (1982).

c. In some situations it may be possible to dispose on-site by means of sealed evapo-transpiration beds, not using the soil at all. ET-beds need to be quite large though, to allow for full disposal during periods of low evaporation and/or high rainfall). Cf. e.g. USEPA (1977a, 1980); Day (1982).

d. It may be preferable not to dispose of effluent on-site, but to use sand filters for (partial) secondary treatment before discharge off-site (USEPA 1980), or to use a Common Effluent Drainage Scheme, perhaps with pressure sewers (USEPA 1977b).

But then: why not bring in the suitable soil to build up the absorption field and ensure adequate treatment as well as disposal? This is done in the case of fill systems: unsuitable soil is stripped away and replaced with suitable soil, in which an absorption field is constructed, (cf. USEPA 1980). It is also done in the case of mounded systems. Mounded systems have been functioning overseas very satisfactorily and are now also operating in Victoria. Their design, construction and maintenance are the subject of this paper.

2. Mounded effluent disposal systems - general principles

The principle of the mound system was developed in North Dakota in the USA in the late 1940's. Mound systems were hence first known as `Nodak' systems. A mound system basically consists of a mound of suitable soil (at first gravel, now medium sand to sandy loam), brought in from elsewhere, and adequately but not overly compacted. In this mound effluent disposal trenches or beds are constructed and effluent is distributed with a pressurised system to ensure even distribution and optimum infiltration and purification. (NEHA 1979; USEPA 1980). The main parts of a mound system are shown in Fig. 1.

The advantages of a mound system are that (USEPA 1978):

1. It provides additional soil material to purify the effluent before it reaches the groundwater at sites with shallow or excessively permeable soils.

2. At sites with slowly permeable soils, the purified effluent can infiltrate the more permeable topsoil over a large area and safely move away laterally until absorbed by the less permeable subsoil.

3. Clogging in the sandy fill is not as severe as it would be in the natural soil.

4. Smearing and compaction of the wet subsoil is avoided as excavation in the natural soil is not necessary.

3. Design principles

The hardware of a mound system consists of, in order: a septic tank: a sump box and pump: a mound with effluent absorption beds or trenches: a delivery pipe leading to a manifold in the mound: and a number of lateral pipes leading from the manifold into the beds or trenches. The laterals have orifices of varying specific diameters and at varying specific distances from each other to ensure even distribution of the effluent. When the pump operates the effluent squirts out of the orifices into the surrounding gravel or screenings, infiltrates into the body of the mound, and so on.

The design of the mound system is based on the design effluent loading and on the site characteristics. The system must of course still function under the worst conditions (mid-winter, high groundwater table), water should not rise into the material brought in, and the basal area must be sufficiently large to conduct the effluent into the underlying soil. Site requirements for three situations where mound systems might be constructed were formulated during a large research project on septic tank systems in Wisconsin in the USA in the 1970's. The requirements are shown in Table 1. It must be kept in mind that in Wisconsin evapotranspiration in winter is negligible and that for that reason the stated soil hydraulic conductivity or permeability requirements may be excessive for south-eastern Australia: in this part of the world evapo-transpiration can make a significant contribution to effluent disposal all year around (cf. Brouwer and Bugeja 1983).

Table 1. Site requirements for mound systems (after Boyle and Otis, 1979)

	Slowly permeable soils	Permeable shallow soils		Permeable soils with high water tables	
Slope	<6%	<12%	<6%	<12%	<6%
*(Percolation rate (min/in)	60–120	3–29	30–60	3–29	30–60)
*Hydraulic conduct. (m/d)	0.1–0.2	0.4–5	0.2–0.4	0.4–5	0.2–0.4
Depth to groundwater	>0.6m	>1.5m	>1.5m	>0.6m	>0.6
Depth to bedrock	>1.5m	>0.6m	>0.6m	>1.5m	>1.5

* Percolation rates should be treated with caution as they depend on testhole dimensions. Conductivities or permeabilities have been calculated from percolation rates assuming the use of 0.3 m diameter testholes initially containing 0.15 m of water (standard US Public Health Service test).

The USEPA (1980) gives a very comprehensive description of mound system design:

The location of the mound should preferably on a crest or high up on a slope.

It should also be on a convex rather than a concave slope. In this way there will be least problems with run-on and subsoil seepage from upslope. The mound should also be shaped to shed rainfall and run-on as much as possible. Even so it may be necessary to construct a cut-off trench upslope of the mound.

Fill material should preferably be selected from local materials to keep costs down. It should be permeable but not too permeable, as in the latter case problems with purification and lateral seepage over the less permeable natural soil will arise. Design infiltation rates vary from 50 mm/d for medium sand and sand/sandy loam mixtures to 25 mm/d for sandy loam (<15% clay). Other fill materials, e.g. cinders, have also been tested.

The geometry of the absorption area can vary. Trenches are preferred as they help achieve more even distribution of the effluent (USEPA 1978). However, for single homes, beds of varying design are usually used as they are easier to construct. In general a rectangular bed with the long axis parallel to the contour is preferred to minimise the risk of seepage from the base of the mound. If the natural conductivity of the soil is less than 0.2 m/d the bed should be narrow and extend along the contour as far as possible: this way there is least chance of effluent not infiltrating into the original soil and seepage coming out along the lower edge of the mound. In soils with a conductivity greater than 0.2 m/d the bed can be square if the (natural) water table is (at all times) more than 0.9 m below the natural surface: a square bed will give the highest groundwater mound underneath.

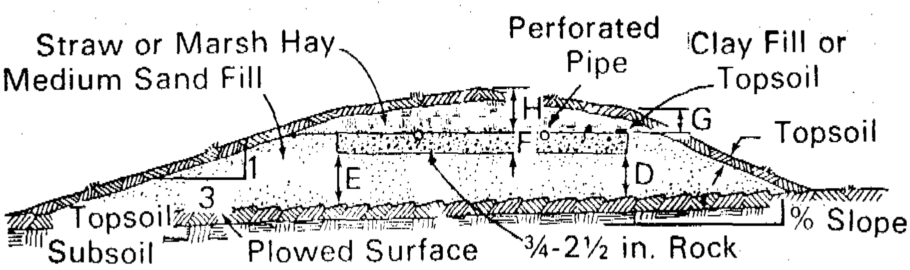
The size of the filled area and other dimensions of the mound are dependent on the size and shape of the absorption bed, on the conductivity of the soil, the slope of the site and the depth of fill below the bed (see Fig. 1). The dimension limits are presented in Table 2.

The downslope setback I in Fig. 1 is dependent on the conductivity of the natural soil. The basal area of the mound must be sufficient to absorb the effluent before it reaches the perimeter of the mound: otherwise surface seepage will result. On level areas the entire basal area (LxW) is used to determine I. On sloping areas only the area below and downslope of the absorption bed is considered [Bx(A+I)]. The infiltration rates used for the natural soil to determine the required basal area, and from that I, are given in Table 3.

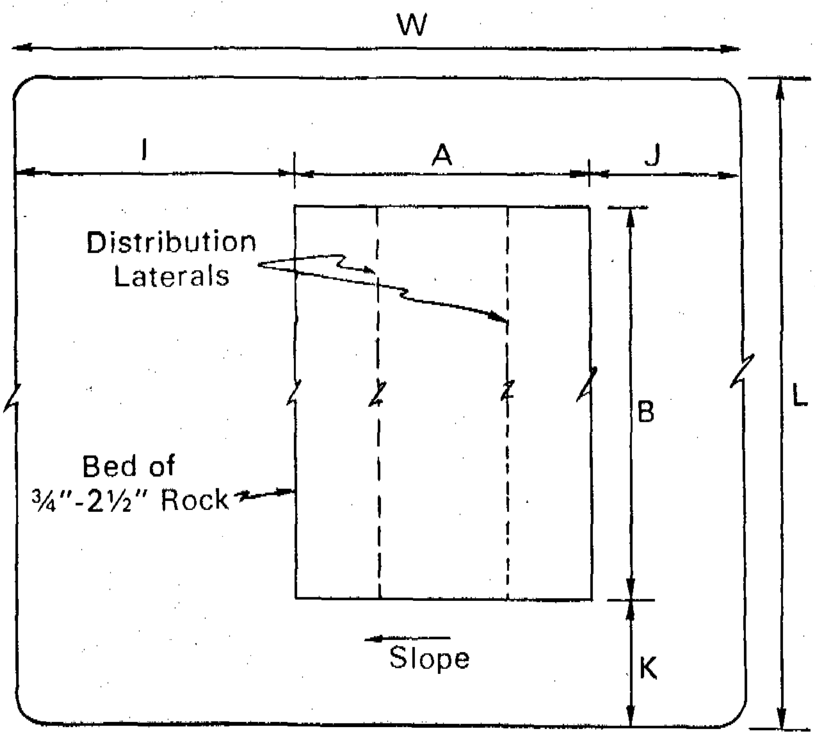
These rates are conservative as they are based on the assumption that a clogging layer will form at the fill-natural soil interface: this may not happen. As the effluent can and does move laterally through the subsoil calculated values of I are even more conservative. (Note: until more experience is gained with mound systems in Australia -including the effects of evapo-transpiration on disposal rates-, the dimensions should remain this conservative. Cf. Brouwer et al. 1982.)

On soils with a conductivity greater than 0.4 m/d it will in fact be the maximum allowed sideslope which determines the basal area.

Fig. 1. Mound dimensions (from USEPA 1980).



(A) Cross Section



(B) Plan View

Table 2. Dimensions for mound systems (after USEPA 1980)

Letters refer to dimensions in Fig. 1 and are in meters.

Mound height	
Fill depth D	0.3 (minimum) *
Absorption bed depth F	0.23 (minimum)
Cap at edge of bed G	0.25 **
Cap at centre of bed H	0.40 **
Mound perimeter	
Downslope setback I	Depends on soil conductivity
Upslope setback J	2.3 ***
Sideslope setback K	2.3
Side slopes	No steeper than 1:3

* On sloping sites this will increase downslope to maintain a level bed. In shallow soils where groundwater contamination is a concern the fill depth should be increased to 0.6 m.

** 0.10-0.15 m of quality topsoil is included. Add 0.15 m in areas with severe winters. Erosion after construction must be avoided.

*** Based on 3:1 sideslopes. On sloping sites J will be less if 3:1 side slope is maintained.

Table 3. Design infiltration rates into natural soil for determining mound basal area (after USEPA 1980)

N.B. The conductivity of the least permeable layer within 0.9 m of the natural surface is determining. Soil types are indicative only.

Natural soil type	Conductivity * (m/d)	Infiltration rate (mm/d or L/m2/d)
sand, sandy loam	>0.4	50
loam, silt loam	0.3-0.4	30
silt loam, silty clay loam	0.2-0.3	20
clay loam, clay	0.1-0.2	10
clay,	<0.1	5**

* Conductivities have been calculated from percolation rates assuming the use of 0.30 m diameter testholes initially containing 0.15 m of water (standard US Public Health Service test).

* The values on this line are not from USEPA (1980). They are based on experience in Victoria with conventional septic tank effluent absorption fields. Cf. Brouwer (1982): Brouwer and Bugeja (1983).

Effluent distribution systems should really be pressurised to ensure uniform distribution and associated good purification and absorption. Uniform distribution is achieved by balancing headlosses through proper sizing of pipe diameters, hole diameters and hole spacings. Approximately 75 to 85% of headloss is incurred across the hole in the lateral, the remaining 15 to 25% in the network delivering the effluent to each hole. Network laterals are usually spaced about 0.9 m apart and are 30 to 80 mm in diameter. The laterals have 6 to 13 mm diameter holes at 0.6 to 3.0 m spacing: hole diameter and spacing depend on position in the distribution system and diameter of the lateral. Pumps are used to pressurise the network, activated about 4 times per day to deliver each time a volume equal to about 10 times the total lateral pipe volume. Excellent tables and figures for designing pressure distribution systems and selecting appropriate pumps are contained in USEPA (1980). Some worked-out examples are also included there. Background details of the development of pressurised distribution systems are given by Otis et al. (1974). Otis (1982) also presents a simplified design procedure for such systems.

Inspection pipes are not necessary but can be useful for observing depth of ponding in the aborption field.

4. Construction

During construction the following list of points should be kept in mind (after USEPA 1980). Please note that this list is not exhaustive.

a. The area where the mound is to be constructed should be determined before any building activity takes place on the allotment. The area should subsequently roped off to prevent damage from traffic etc.

b. Excessive vegetation should be removed from the area of the proposed mound: trees should be cut at ground level and the stumps left in place.

c. The area within the mound perimeter should be plowed to 180-200 mm depth, parallel to the contour, when the soil is not to wet. All furrows should be thrown upslope. This will facilitate entry of the effluent into the natural soil and help prevent seepage at the lower edge of the mound. (On slowly permeable soils clay barriers may be constructed around the perimeter of the mound base to prevent lateral seepage. Such barriers can also be constructed underneath the mound, parallel to the contour, to help achieve more even infiltration into the natural soil. Cf. Bouma et al. (1972); USEPA (1978).)

d. Move the fill material from stacks upslope of the plowed area onto the plowed area with a small caterpillar tractor with a blade. Keep at least 150 mm of fill material between the tracks and the plowed surface to prevent compaction of the latter. In the formed mound excavate the absorption field with the blade, hand leveling to ensure proper forming.

e. Place a level layer of gravel or crushed rock, at least 150 mm thick, on the bottom of the field. The gravel should be approximately 20 and no more than 64 mm in diameter, and should not slake.

f. Assemble the distribution network on the gravel, making sure that the laterals are level and that the manifolds drain into the lateral or back into the pump chamber.

g. Place more gravel to at least 50 mm over the top of the pipes.

h. Put a suitable backfill barrier, e.g. old newspapers or straw, over the gravel.

i. Place at least 100 mm of finer textured soil (clay or silt loam) over the top of the bed and on top of this at least 150 mm of good topsoil.

j. Plant grasses adapted to local circumstances over the whole mound. Shrubs can be planted around the base and up the sideslopes. Shrubs should be somewhat moisture-tolerant as the downslope perimeter may become moist during winter. Plantings on top of the mound should be drought-tolerant as that area may be rather dry during summer.

5. Maintenance and rehabilitation

A properly designed and constructed mound system should operate satisfactorily with virtually no regular maintenance other than timely pumping out of the septic tank.

Severe clogging in the absorption field may be cleared with application of hydrogen peroxide or by reducing the strength and/or volume of effluent applied. It may also prove necessary to enlarge the mound, including the absorption field.

Seepage at the base of the mound points to the possibility of severe clogging of the fill-natural soil interface. This can sometimes be remedied by extending the mound downslope. If that does not help the site may have to be abandoned.

Partial plugging of the distribution laterals may be cleared by removing their end-caps and flushing them out, or by using a rod to clean them.

6. Possibility of groundwater contamination

As has been stated above, 0.6 to 0.9 m of unsaturated soil that is not too coarse is sufficient to adquately remove all septic tank effluent pollutants other than nitrates. Nearly complete removal of BOD5, Suspended Solids, and pathogenic bacteria, and complete removal of viruses is achieved within the sandfill of a mound (Boyle and Otis 1979). Removal of phosphorus and the rest of the other pollutants mentioned would most likely take place in the original soil if it is slowly permeable. Where there is little (<0.6 m) natural soil over fractured bedrock or above a shallow groundwater table phosphorus pollution may still be problem. This means that allowable and possible nitrate and phosphorus pollution should be assessed and compared and perhaps additional measures taken to limit such pollution.

As far as limiting phosphorus pollution is concerned, the use of a more loamy fill for the mound will greatly assist. The planting of shrubs around the mound will also increase phosphorus uptake. Should it be necessary to reduce phosphorus levels even further it is also possible to add crushed limestone or red subsoils with a high iron and/or aluminium content to the fill (Magdoff et al. 1974). For nitrate removal the addition of a carbon source such as straw to the fill may be considered (Magdoff et al. 1974). Alternatively there are denitrification systems which can remove most of the nitrogen from the septic effluent before it goes to the absorption field (Sikora and Keeney 1976; USEPA 1980; Laak et al. 1981).

With some idea of the size of the contribution of a single absorption field to nitrate and phosphorus pollution of the groundwater one can also calculate the minimum average lot size required to keep such pollution down to acceptable levels. Cf. Holzer (19); Yates (1985). It should be kept in mind, however, that pollution from a properly designed and constructed mound system will always be less than that from a conventional septic tank effluent absorption field in the same situation.

7. Australian vs. North American conditions

Before an account is given of experiences with mound systems in Victoria it must be emphasised that, as previously pointed out, the environmental conditions of most of Australia differ considerably from those of the northern USA were the mound systems were developed and tested. To begin with, soils in Australia generally have much lower conductivities than those in e.g. Wisconsin. This, however, is compensated by the fact that in most of Australia evapotranspiration can play a significant role in effluent disposal all year round (Brouwer 1982; Brouwer et al.1982; Brouwer and Bugeja 1983). Further more, low hydraulic conductivities of Australian soils are often relatively easily overcome by the application of gypsum.

Low soil hydraulic conductivity in Australia is commonly caused not just by high clay content but by relatively high proportions of sodium and magnesium ions adsorbed on clay particles, as compared to calcium and hydrogen ions. This brings about a tendency for the clay to disperse when in contact with relatively fresh water and results in clogging of soil pores with clay particles. In many cases the problem is easily overcome by applying gypsum at the rate of 1-2 kg per square meter of soil. Gypsum is so cheap that is advisable to use it as a matter of routine, applying it at the indicated rate to the natural soil surface after plowing and before constructing the mound itself. It can also be applied to the bottom of normal effluent absorption fields. It can not do any harm and in agricultural situations it frequently increases soil conductivity by a factor of 10.

8. Experiences in Victoria

The first mound systems in Victoria were installed in 1985/86 at the Sunnybank Estate near Langwarrin, in the Shire of Cranbourne, approximately 50 km south-east of Melbourne. This was followed by several systems at the Pivato Estate in the same Shire.

In the Sunnybank Estate use was made in some instances of naturally occuring small sand dunes to form a ready made mound over slowly permeable subsoil. In such cases the laterals were positioned in trenches parallel to the contours, one upslope (or downslope) of the other.

At the Sunnybank Estate the detailed construction guidelines were totally ignored. The engineering consultant, employed by the developer, in conjunction with the septic tank system installer used PVC pipe of the wrong diameter into which irregular slots had been cut more or less haphazardly with a thick circular saw. It is doubtful that the recommendation to prepare the underlying soil with gypsum was followed. All the systems at Sunnybank Estate have been causing problems.

Fortunately the owner and developer of the Pivato Estate was not so lacking in scruples and common sense. At this Estate the design guidelines have been and are being followed precisely, according to the Senior Health Surveyor of the Shire of Cranbourne. The systems are, however, not yet being used. Following are the design calculations for systems such as these. The calculations largely follow the guidelines of the USEPA (1980).

9. Design calculations for Pivato Estate, Shire of Cranbourne, Victoria

Pivato Estate lies near Westernport Bay, approximately 80 km south-east of Melbourne. It is situated on heavy clays of alluvial or marine origin, which during part of the year are saturated to relatively close to the surface. Some not very high dunes occur here and there on the Estate. After it was decided that the use of a reticulated sewerage system or conventional septic tank effluent absorption fields was out of the question, mounded effluent absorption systems were the logical option. On some allotments the natural dunes could be used as mounds. After the best locations for the mounds on the other allotments were selected, taking into account all the criteria mentioned in Section 3 above, the required dimensions of the mounds were calculated as follows. Tables and graphs used in the calculations, in US units of measurements, can be found in USEPA (1980).

Step 1. Selection of fill material. A locally available sand was selected as a suitable fill material. The design infiltration rate for such a sand is 50 mm/d.

Step 2. Estimation of design effluent flow. The standard design flow for all-waste septic tank systems in Victoria of 1000 L/d for a normal single family house with a reticulated water supply was used.

Step 3. Determine the size of the absorption area from the design infiltration rate of the fill material. As a medium sand was used that rate was 50 mm/d or 50 L/m2/d. The area of the absorption bed within the mound should therefore be

$$\{1000 \text{ L/d}\}:\{50 \text{ L/m2/d}\} = 20 \text{ m2} \quad .$$

Step 4. Determine absorption area dimensions As the site was flat any configuration of the absorption area would have been allowable, from sqquare to elongated. However, to ensure the most even distribution of effluent, it was decided to construct 2 parallel trenches each the

standard 0.5 m wide, 20 m long, 1.5 m apart, with the delivery pipe coming in in the middle, i.e. 10 m from either end. This makes for an absorption area (AxB) of 2.5 x 20 m.
Had the site been sloping, say at 5%, an elongated mound parallel to the contour would have been called for. Such a mound could have had a trench e.g. 0.5 m wide and 40 m long to make up the 20 m2.

Step 5. Calculate mound dimensions

Within the above boundaries the height of the mound and desirable slope gradients on the fill materials were considered, in order to obtain the overall mound dimensions.

a) Mound height was calculated from

Fill depth D = 0.3 m (see Fig. 1 and Table 2)

Fill depth E = D = 0.3 m as the area was flat (other wise it would have been equal to D + (slope x A)

Bed depth F = 0.23 m (minimum, see Table 2 and Section 4)

Cap at edge of bed G = 0.25 m (minimum, see Table 2)

Cap at centre of bed H = 0.40 m (minimum, see Table 2)

Total height at edge of absorption field: D or E + F + G =
0.3 + 0.23 + 0.25 = 0.78 m
Total height in the middle of the mound: D + F + H =
0.3 + 0.23 + 0.40 = 0.93 m

b) Mound perimeter was calculated from the total area of the absorption field (AxB), the height of the mound at the edge of the absorption field, the maximum allowed sideslope of the mound, total mound basal area required, and required setbacks.

As the mounds were to be constructed on a flat area, the downslope setback I and the upslope setback J could be the same. With the mound 0.78 m high at the edge of the absorption field, and maximum allowed sideslopes of 1:3, the setbacks would have to be at least (3 x 0.78) = 2.34 m. Sideslope setback K would be equal to 0.93 m (height at centre of field) x 3 = 2.79 m.

Coupled to the required absorption field dimensions, this gives minimum mound basal dimensions (WxL) of

{A + (2 x 2.34)} x {B + (2 x 2.79)} = (2.5 + 4.68) x (20 + 5.58) =
7.18 x 25.58 m

This is equal to 184 m2.

Total mound basal area required was calculated by dividing the design inflow by the design infiltration rate of the natural soil. As the natural soil was a rather slowly permeable clay, its design infiltration rate was taken to be 5 mm/d or 5 L/m2/d, hence a basal area was required of

(1000 L/d):(5 L/m2/d) = 200 m2 .

This is slightly larger than the area required to accommodate the minimum width and length required, so the width W was increased to 8 m and the length L to 26 m to give a total basal area of 208 m2.

Note that if the required basal area had been less than the area calculated as resulting from the setback requirements, the latter (larger) would have taken precedence.

Two comments:

1. Rather than estimate the design infiltration rate from the soil type it could also have been deduced from the results of hydraulic conductivity or permeability tests. Cf. Table 2.

2. If the site had been sloping, say at 6%, but otherwise the same, the calculations would have been somewhat more complicated. Let us assume the absorption field dimensions (AxB), for such a situation, of 0.5 x 40 m, mentioned in Step 4. Step 5 would have been as follows:

Fill depth D would have remained unchanged.

Fill depth E on the downslope edge of the absorption field would have had to be equal to (D + (slope x A)) = 0.30 + 0.025 = 0.325 m, an increase of 0.025 m.

Accordingly the height of the mound at the downslope edge of the absorption field would also have increased by 0.025 m, to 0.805 m.

Similarly the height of the centre of the bed, being halfway between D and E would have increased by half of 0.025 m, to 0.94 m.

Other heights would have remained unchanged.

The required upslope setback J would nominally still have been 2.34 m but because of the slope this would have come down to approximately 2.25 m.

Sideslope setback K would have become equal to (0.94 x 3) = 2.82 m.

The most important change would have been in downslope setback I. Because of the slope of the site, the requirement would have come into force that all effluent could be absorbed in the area of natural soil directly underneath and downslope of the absorption field, equal to (Bx(I+A)). As in this case the required area equals 200 m2, B = 40 m, and A = 0.5 m, this means that

(40 x (I + 0.5)) = 200 or I = ((200:40) - 0.5) = 4.5 m .

This is a considerable increase over the setback I required on the flat site at Pivato Estate of 2.34 m, and is partially reflected in the resulting total basal area (WxL) of

(A+I+J) x (B+2K) = 7.25 x 45.64 = 331 m2 .

It must be kept in mind, however, that the example of a 0.5 m wide trench parallel to the contour is the very safest and most extreme case: a less elongated trench may well be quite safe enough and will require less area. On the other hand, a conventional septic tank effluent absorption field such as is often necessary on the slowly permeable yellow clay soils of the eastern suburbs of Melbourne, consisting of 8 trenches, 0.5 m wide and with centres 3.0 m apart, would take up (((7 x 3) + 0.5) x 30) = 645 m2.

Step 6. Design effluent distribution network

It would go too far to reproduce here in detail the tables, graphs and calculations required in the design of the effluent distribution network. Suffice it to say that, as indicated above, it is a complicated procedure which has to be followed precisely for the mound system to function properly. Very detailed instructions and all the relevant tables and graphs can be found in USEPA (1980), pp. 278-296.

10. Summary.

In summary, mound systems can be excellent solutions for on-site septic tank effluent treatment and disposal in areas with slowly permeable subsoils, (seasonally) high ground water tables, very sandy soils or shallow soils over fractured bedrock, provided they are properly designed, constructed and maintained. There may on occasion be some problems with potential pollution of the groundwater which mound systems on their own can not solve, but at least on slowly permeable soils with a water table not too close (>0.6 m) to the surface these are likely to be minimal.

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AEROBIC TREATMENT SYSTEMS

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AEROBIC TREATMENT SYSTEMS

Paper to be presented by L. van Lien
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1. Introduction

The first domestic aerated waste water treatment system was approved for installation in NSW in 1983. Since then some eight more manufacturers joined the industry and more than 20 designs have been approved. It is estimated that there are now some two thousand installations in this state.

The majority are installed in unsewered areas unsuitable for conventional septic tanks with on-site effluent disposal into absorption trenches. These areas are traditionally serviced by effluent tanker removal services which are not only costly but can give rise to complaints. These are generally due to overflowing collection wells and illegal discharges of effluent into street water tables and stormwater drains.

The new aerated systems were seen as a solution to liquid waste disposal problems in difficult areas. Some defects have now, however, become obvious and the NSW Health Department together with selected Local Authories are now seeking to resolve the problems.

2. Early designs

A simple, non-mechanical double chamber septic tank with an aerobic stage was in use in NSW until some 30-40 years ago and until more recently in Queensland. In this design effluent from the septic tank gravitated into distribution channels over a one méter deep biological gravel filter. The resultant effluent was quite clear. The use of the aerobic stage was discontinued, however, as it was considered that the aerobic action took place in the absorption trench anyway the filter was superfluous.

3. Modern designs

The modern domestic aerated septic tanks are innovative, sophisticated, miniaturised sewage treatment plants which use long-established principles of biological treatment of sewage.

4. Standard of Effluent

In order to be suitable for irrigation the effluent must comply with the 20/30 standard which is as follows:

<u>BOD</u> not to exceed 20 mg/L

BOD = Biological oxygen demand consumed by a unit volume of liquid during biological oxidation over 5 days at 20°C with its suspended solids included, expressed in mg/L.

NFS not to exceed 30 mg/L

NFS = Non-filterable solids are solids which are suspended in sewage or effluent, expressed in mg/L.

Free residual chlorine not less than 0.5 ppm.

Faecal coliform not to exceed 30/100 ml.

5. Comparison of commercial with domestic units

Full size commercial sewage treatment plants are under constant supervision with regular monitoring of its operation. The domestic unit, however, is expected to function without any attention for three months. It is also a fact that the smaller systems are far more sensitive to changes in conditions than the larger ones.

All components and processes must at all times work at maximum efficiency or it could become a health hazard.

6. The processes

The domestic treatment systems come in many different configurations but all include the following treatments:

- Anaerobic liquefaction in the septic tank.
- Aeration to expedite biochemical oxidation and reduction of organic matter.
- Clarification and chlorination.
- Irrigation.

7. The septic tank stage

All of the new plants use a conventional septic tank for primary treatment of sewage.

The septic tank can be separate from the aeration stage or all processes can be fitted into one tank depending on the design configuration. An existing effluent collection well can be converted to house the aeration stage.

In NSW all tanks must comply with Department of Health guidelines which generally coincide with the Australian Standard 1546 (small septic tanks).

It is not the intention to describe the septic tank in this paper but it should be noted that the limitations that apply to the conventional septic tank also apply, perhaps even more so, to the new systems.

These limitations include:

- sensitivity to household chemicals such as disinfectants
- low temperatures
- changes in hydraulic loadings
- changes in organic loadings
- shock loadings

A baffle wall is also essential if the maximum liquefaction is to be achieved in the septic tank stage of the system. The size of the septic tank should be calculated as per normal formula.

8. The aeration stage

In the majority of designs the effluent gravitates from the septic tank to a tank of some 3000 - 4000 L. capacity. This tank is divided into a number of compartments.

They house the following processes:

- contact aeration
- settling and clarification
- disinfection

The aerobic action expedites the biochemical oxidation of organic wastes. Contact aeration takes place on a submerged medium which provides the base for the biofilm or zoogleal film formed by bacteria and algae. The medium is formed from a stable plastic material in honeycomb or egg-crate shape to provide a high surface area to volume ratio.

The media are fitted together in banks above air diffusers to which air is supplied by blowers or compressors. The quantity of air is critical and must be carefully calculated and regulated.

The zoogleal film sloughs off the medium from time to time as it grows. This air flow pattern is important and there is a self-cleansing action. Sludge will build up gradually.

9. Settling stage

Here any sludge and suspended matter that has been carried over into the clarification chamber will be allowed to settle. Most designs incorporate a quiescent period where the pumps and agitation are switched off to allow settling. The sludge is then returned by pump or airlift to the first aeration chamber or septic tank.

It was found that return of the sludge to the septic tank was preferable as it reduced the bulk of the sludge building up in the system.

In the activated sludge system to be mentioned later the sludge must be returned to the aeration stage to seed the incoming effluent.

Scum from the aeration chamber must also be removed frequently either by airlift pump for return to the septic tank or by physical cleaning. In the latter case the collected scum must be deposited into the septic tank.

10. <u>Chlorination stage</u>

All effluent must be chlorinated to give 0.5 ppm of residual chlorine. It was found that this was the minimum level to ensure adequate disinfection of effluent from a properly functioning aerated system.

Chlorination is usually by contact with chlorine tablets which are contained in a vertical P.V.C. tube through which the effluent passes. This system is rather primitive and a recent survey found most to be unreliable. A liquid chlorine dosing system has also been used with varying degrees of success.

The chlorine supply must be adequate to last the service period plus a reserve.

Too much chlorine in the effluent could affect vegetation in the irrigation area.

11. <u>Irrigation stage</u>

After chlorination the effluent is pumped to an irrigation system. There can be more than one area and areas can be alternated to prevent over-watering.

The NSW Health Department has set guidelines which were recently amended and are set out in the appendix.

Effluents from commercial treatment plants are not usually accepted for irrigation of areas accessible to people and animals unless it has been ponded for 30 days.

Effluent from the domestic plant which is supposed to be of a higher quality is accepted for irrigation of areas in close proximity to living and playing areas. The efficiency of the plant can, however, not be guaranteed and compliance with the guidelines is essential. This is to ensure a permanent safeguard against malfunction of any part of the aerated septic tank.

Unfortunately landscaping and preparation of irrigation areas is often left until last or even to be done by the owner. There are many instances of irrigation areas never having been completed and effluent was discharged over unprepared ground surface or even into the street water table. Children have been seen drinking or playing with effluent being irrigated.

12. Nutrients

The final effluent contains a high level of nutrients which promotes luscious growth of plants in the irrigation areas.

The nutrients are removed by absorption and transpiration but this highlights the need for the irrigated effluent to be contained within the property boundaries. There should be no run-off.

13. Planning and design of irrigation area

The irrigation system must be carefully designed for each individual site taking into consideration slope, levels, and aspect to ensure exposure to wind and sunlight.

Suitable existing natural areas can be utilised or areas may have to be prepared with native gardens and pine bark. The pumping arrangements facilitate the distribution of effluent in different areas. Recreational areas and areas attractive for children must not be used for irrigation.

Irrigation lines must be clearly identified and only non-domestic fittings used. Exposure of recreational areas to spray drift must be avoided. To this end buffer zones may be used.

14. Alarm system

The aerated septic tank should be provided with an audible alarm and mute switch that will sound in the house. Additionally the alarm should incorporate a warning lamp which may only be reset by the service contractor. The alarm should operate in the event of:

- blower or irrigation pump failure
- aeration or irrigation line blockage
- power failure to the unit from the distribution board (i.e. fuse failure)

The irrigation pump should be fitted with a device which automatically stops the pump whenever any of the mechanical components of the aerated septic tank cease to function. This automatic function should be combined with the alarm system.

15. Flow balancing

Shock loading is a sudden increase in hydraulic and/or organic loading e.g. laundering or large parties severely affects the efficiency of the plant. This results in a deterioration of the quality of the effluent. Some designs incorporate flow balancing systems which ensure that there is a constant flow of effluent into the treatment processes.

It is considered that all systems should incorporate flow balancing.

16. Other designs

There are a few designs that vary from the contact aeration type of treatment plant.

These include:

- A biological trickling filter. In this system effluent is pumped up to a distributor situated above a filter module. The effluent trickles through the filter media into the clarification stage.

- A rotating biological filter. In this system the effluent is contained in a horizontal trough in which the filter medium is rotated on a series of discs on a shaft. The medium is partly submerged in settled effluent and as the discs rotate slowly the organic matter is oxidised.

- Activated sludge system. In this system extended aeration results in the growth of purifying micro-organisms in the liquid itself rather than on a medium. In this configuration the sludge from the clarifying stage is returned to the aeration stage to seed the incoming effluent.

17. Advantages of domestic aerated systems

There are distinct advantages when comparing the new systems with effluent removal tanker services which give rise to overflows and illegal discharges and are quite costly.

The systems could initially be cheaper than reticulation sewerage. There are, of course, on-going costs of servicing and maintenance.

Rather than await the extension of the sewer in due course, an aerated system can be installed at any time.

A decrease in water results as water is re-cycled for watering the grounds.

Removal of nutrients by irrigation on-site prevents nutrification of streams and other bodies of water.

The unit lends itself to conversion of existing septic tanks and effluent removal systems.

18. Disadvantage of domestic systems

It is dangerous to consider the systems as an alternative to reticulated sewerage systems. There may be exceptions in very small isolated communities in areas with poor soil for absorption. No system is acceptable unless continued satisfactory service free from nuisance can be guaranteed.

Most units will require regular de-sludging every 1-3 years. There is also the on-going cost of servicing.

Failure to maintain the unit can cause turbid waste water, high faecal counts, irrigation chokes and pump failure. The unit can in fact become a health hazard.

The irrigation is easily interfered with by owners. There could be surface run-off and sprinklers and other irrigation equipment is easily damaged.

Waste water can easily be directed into stormwater drains or street water tables.

It is difficult to ensure proper construction of irrigation areas - the owner is keen to move in and the landscaping is always left until last.

It is difficult to legally enforce or even ensure regular servicing of the units in accordance with the specifications.

Units not fitted with flow balancing systems are adversely affected by shock loading.

19. Some problems with Domestic Aerated Septic Tanks and their performance and maintenance

Some units are not completed in a workman-like manner, i.e. some components are left out, mild steel brackets used inside the tank, poor makeshift fixing of components, no lifting handles for covers to service openings.

Failure of manufacturers to instruct client of principles of operation of the plant and their responsibility to keep it and the irrigation system working well.

Failure of installer to notify the Local Authority of the completion of the installation or the occupation of the premises before the work has been completed.

Quarterly services not properly carried out in accordance with the specifications or not carried out at all.

Failure of service contractor to submit quarterly service report to Council.

20. Some suggestions for ensuring better installation and performance

The application to the Local Authority/Health Department must contain complete specifications and plans showing location of the treatment plant, exact location and construction of irrigation system and full plans of landscaping.

To ensure that sufficient land remains available for irrigation the Certificate of Title or any other certificates in relation to the land might be noted to secure and reserve areas for irrigation e.g. the installation of a swimming pool could drastically affect the irrigation potential of the site.

The manufacturer/installer must notify the Local Authority of completion of each installation. The premises should not be occupied until all the work has been completed in accordance with the approved plans.

The Local Authority must be given a copy of the servicing report following each quarterly service. The householder must also be notified that the unit has been serviced. A metal tag system such as used on fire extinguishers has been suggested to prove date of service.

The Local Authority should have a copy of the service manual of each type of unit installed in its area.

The Local Authority should keep a register of all installations into which are noted the dates the units are serviced.

The Local Authority should hold a copy of each service agreement between manufacturer and the householder.

The Local Authority may adopt a Bond System whereby the installer pays a Bond only to be repaid when the installation is completed in accordance with the approved plans and specifications.

The Local Authority should carry out the servicing of the units itself or by its contractors. A service rate should be levied on the property together with sanitary service rates, water rates etc. This would ensure continuity of servicing. The service agreement might be for maintenance only or for maintenance and parts and labour.

The Local Authority may license each installation with an annual license fee to pay for an annual inspection of the unit. This inspection together with the quarterly service inspections, will reveal tampering with the irrigation equipment or other departures from the original approval.

21. Future plans concerning domestic treatment plants

Quality Control and sound construction of the units will be taken up with the Standards Association of Australia. The scheme that appears applicable is the Quality Assurance Scheme which ensures a durable serviceable treatment plant.

A working party has been established between officers of the Department, Local Authorities and representatives from the Industry to discuss problems and find resolutions.

Matters to be covered include:

- Quality Control of units
- Irrigation criteria and design
- Standards of irrigation and material
- Maintenance and Servicing
- Servicing agreements
- Legislation

Existing Units will be re-tested at random to evaluate current performance and efficiency of the treatment system. In particular, the chlorination system will receive attention and it is hoped that more reliable systems will be developed by the manufacturers.

It is pointed out that the manufacturers of the domestic treatment plants recognise the problems and most if not all are most supportive of efforts to improve the standard of installation, maintenance and servicing.

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May 1988

APPENDIX

DISPOSAL OF EFFLUENT FROM AERATED SEPTIC TANKS

The following guidelines have been set out for the design and operation of disposal areas provided for aerated septic tanks. Each site has, of course, to be considered on its own merits no hard and fast rules can be set. A thorough inspection needs to be made in each case.

It must be taken into consideration that aerated septic tanks depend on mechanical and chemical treatments to achieve an acceptable effluent. Total or part failure of any component of the installation will result in an effluent which is not acceptable and a possible health hazard.

Aerated septic tanks are not subject to constant monitoring such as a commercial sewage treatment system or even a domestic swimming pool. At the best, a quarterly inspection and maintenance of the plant can be expected. It must be assumed therefore that some part of the unit is going to perform at less than maximum efficiency and the effluent disposal area is the only part of the installation which can be designed to provide a permanent safeguard against malfunction of any part of the aerated septic tank.

The following guidelines are set out to design disposal areas for aerated septic tanks.

1. No spray irrigation is allowed unless the effluent from the aerated septic tank is in accordance with the Department's guidelines. Discharge or run-off into storm-water easements or other drainage channels is strictly prohibited. All effluent must be disposed of within the boundaries of the property.

2. A minimum total area of approximately 200m² of landscaped area should be provided for the specific purpose of receiving the effluent from the aerated septic tank. Full details of the proposed landscaping plan including: type and depth of soil; retaining and filling; grading; type of shrubs; depth of pinebark; and any other relevant information must be submitted to scale on the site plan. Details of the irrigation system including sizes and types of fittings must also be provided.

   Pedestrian traffic except for maintenance purpose shall be excluded from the disposal area. The area shall not be used for passive or active recreational purposes and shall not contain any paths, B.B.Q.'s, incinerators, patios or clotheslines.

   The irrigation area shall not be used for growing vegetables or fruit.

3. The disposal area may be divided into two or more areas, Additional secondary disposal not subject to the septic tank installation application may only be used with the written prior approval of Council.

4. The disposal area must be contained by basic landscaping and have a minimum depth of 100mm of good friable soil capable of retaining moisture. Where the disposal area is on rock or where there is danger of effluent escaping from the area, impermeable membranes or other earthworks to contain the effluent must be used.

5. Alternatively the disposal area may be covered with 100mm depth of pinebark or similar material and plants and shrubs with a known property for taking up water should be planted.

6. Should more than one disposal area be used, the owner/ occupier of the premises must be provided, by the installation firm, with an instruction sheet or manual, showing the position of delivery lines and the setting of valves necessary to allow the alternate use of areas. The system should include, where determined necessary, adjusted pressure limiting devices. The valve system shall be designed to ensure that at least one irrigation area is available for use at all times.

7. Effluent from Aerated Septic Tanks may be disposed of by the use of one or more of the following irrigation techniques:

   7.1 Drip irrigation,

   7.2 Trickle irrigation, or

   7.3 Spray irrigation provided that only low pressure/ low volume spray heads are used

      7.3.1 The spray head plume height shall be not more than 300mm.

      7.3.2 The spray head plume radius shall be not more than 500mm. The above spray head plume dimensions may be controlled by use of a pressure reducing valve or by increasing the number of spray heads on the irrigation line.

8. All irrigation equipment shall be installed in such a manner that it will not be readily subject to damage.

9. All feeder mains shall be buried to a minimum depth of 100mm.

10. Reinforced heavy duty type garden hoses may be used to convey effluent to the disposal area from the feeder line standpipe to the sprinkler/spray device provided:

10.1 Standard household hose fittings are not used.

10.2 The irrigation system is not capable of being connected to the mains water supply.

10.3 Any movable spray device shall be installed so as to limit the discharge of effluent to within the designated irrigation area only.

11. Soaker hoses and standard household sprinklers and attachments shall not be used for the irrigation of Aerated Septic Tank effluent.

12. The irrigation system shall be operated in such a manner as to prevent any run-off from the disposal area.

13. All effluent disposal areas are to be completely landscaped or prepared to the satisfaction of Council prior to:

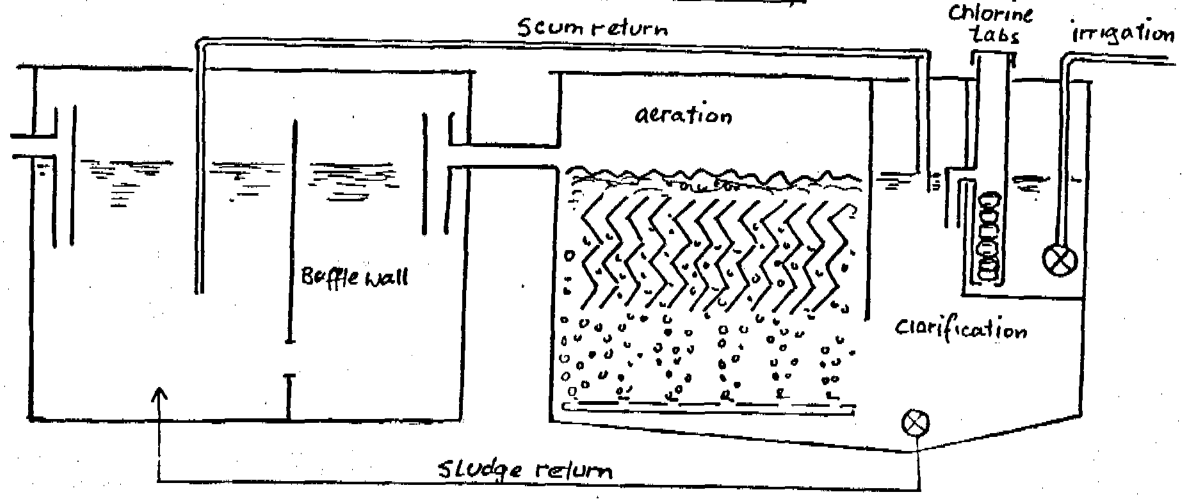
13.1 The occupation of the new dwelling.

13.2 The commissioning of the Aerated Septic Tank.

14. A suitable sign shall be affixed to the Aerated Septic Tank warning that irrigated effluent is unsuitable for drinking and that contact with the spray should be avoided.

15. The owner/occupier must maintain the irrigation area in regard to adequate cover, elimination of weeds, maintenance of plants and shrubs. The irrigation system and fittings must also be maintained in a serviceable condition at all times.

Domestic aerated sewage treatment
Schematic representation only!



REVIEW OF OTHER LOW COST SANITATION OPTIONS

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REVIEW OF OTHER LOW COST SANITATION OPTIONS

by

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This Seminar has concentrated so far on on-site wastewater treatment and disposal of domestic wastewater. The conventional septic tank/soil absorption trench is the most cost-effective option for on-site treatment and disposal, provided suitable site conditions exist. Several variations to the conventional trench have been developed to cope with difficult sites, including mound systems, alternating systems, and evapotranspiration systems. Segregated systems can be used to optimise the disposal methods. Sand filters and aerobic systems permit above ground discharge, but tend to be costly. The latter requires user skills to obtain consistently reliable operation.

On the other side of the range of options for disposal of domestic wastewaters is the conventional gravity reticulation system that most of us are served by. However, conventional sewerage systems are fairly expensive and more so for small towns and communities where it is not possible to obtain the economies of scale that are available to large cities. Costs of $4,000 to $6,000 and even higher for the off-site component of a sewerage system are not uncommon these days.

There are alternatives between on-site systems and conventional sewerage systems which are particularly suitable for the provision of a sewerage service to small towns and communities. This paper addresses six options which may be more economical than conventional sewerage but which nevertheless can provide adequate protection of public health and the environment. The systems are:

1. MODIFIED DRAINAGE.

   A system in which septic tank effluent (either all waste or sullage only) is discharged to a stormwater system. Includes treatment of combined stormwater and wastewater.

2. SEPTIC TANK EFFLUENT PUMPING.

A pump at each site pumps septic tank effluent into a pressure sewer system. Also referred to as pumped common effluent disposal in NSW.

3. VARIABLE GRADE GRAVITY SEWERS.

A small diameter gravity sewer which conveys septic tank effluent and can be laid at constant depth following terrain. Some sections of the sewer will remain full of wastewater at all times.

4. COMMON EFFLUENT DISPOSAL SYSTEMS.

Also known as small diameter gravity sewer (SDG) and septic tank effluent reticulation (STER). A system with septic tank effluent being collected and conveyed in a small bore gravity sewer.

5. GRINDER PUMPS.

A macerating pump at each house grinds domestic sewage and pumps it into a pressure sewer system.

6. VACUUM SEWERS.

A system in which all sewage is conveyed by a vacuum applied at the end of the collection system.

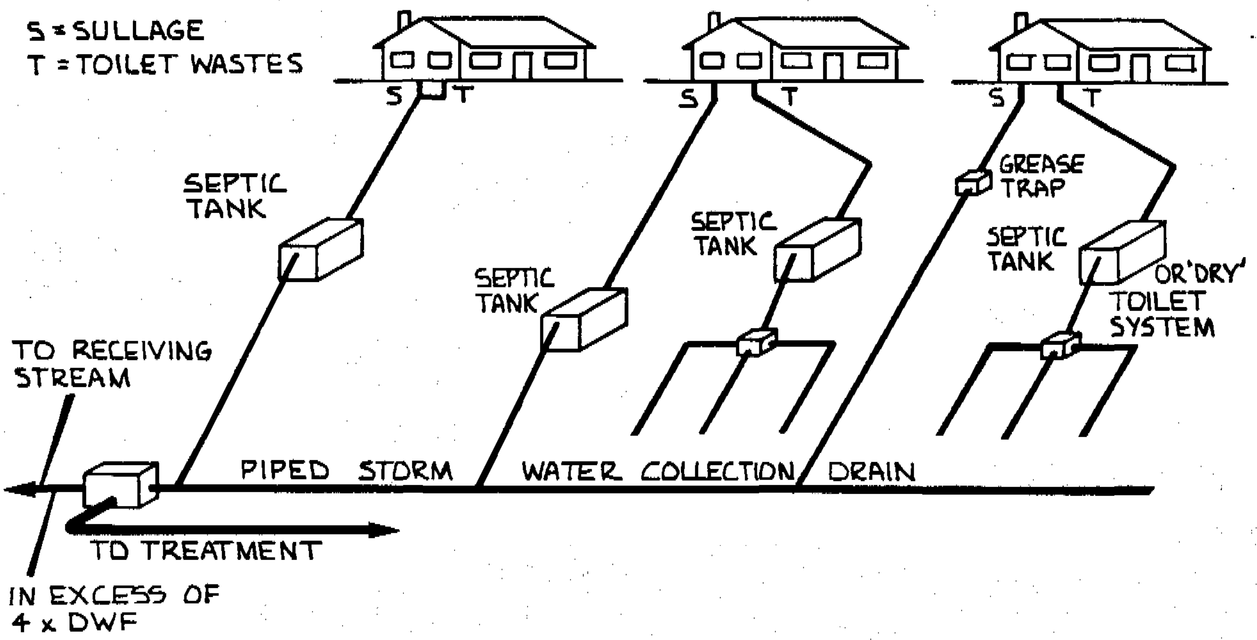
The basic characteristics of these options are presented in the attached Data Sheets. A summary of these characteristics, including those of on-site systems and of conventional sewerage is given in Table 1.

The selection of the most appropriate option for a town needs to address several factors including topography, geology, ground and groundwater conditions, availability of maintenance skills, population density, tourism, etc, and ideally should involve a community consultation phase.

TABLE 1 RELATIVE CHARACTERISTICS OF SEWERAGE OPTIONS

OPTION	MAIN ADVANTAGES	MAIN DISADVANTAGES	MORE SUITABLE FOR	LESS SUITABLE FOR	ORDER OF COST PER LOT (excluding treatment and connection)	COMMENTS
ON-SITE TREATMENT/ DISPOSAL	. No off-site requirement. . No power generally if septic tank used. . High quality effluent if sand filter/ aerobic plants used.	. Pump-outs reqd. . Large area reqd.	. Large lots. . Permeable soil for subsurface disposal.	. Small lots. . Poor soil. . Wet climates. . High density developments	$1,000 for new septic tank. $1,500 for new absorption trenches.	Attractive option if existing systems can be upgraded to new design criteria.
MODIFIED DRAINAGE	. Uses storm-water pipes as carrier. . Reduced organic loading at treatment plant. . No power generally required in reticulation system	. Pump-outs reqd. . Discharges dilute but untreated wastewater during high rainfalls. . Septic effluent.	. When piped stormwater system is available.	. When limited assimilative capacity of receiving waters exists.	$600-$1,000 for connection. $1,000 for new septic tank.	Inexpensive option but lower level of service. Preferable to take sullage only, with toilet wastes to septic system.
SEPTIC TANK EFFLUENT PUMPING	. Small pipes following terrain. . Reduced peaking factors. . Reduced organic loading at plant.	. Pump-outs reqd. . Power required. . Service of electro mechanical equip-ment required. . Septic effluent. . Septage facility required.	. Unstable soils . High groundwater. . Rocky terrain. . Flat and un-dulating terrain.		$1,500-$2,500. Assumes exist-ing septic tank.	Attractive option if majority of town already served by septic tanks. Limited use where seasonal loadings exist.
VARIABLE GRADE SEWER	. Reduced blockage frequency. . Smaller pipes. . No power generally reqd. . Reduced peaking factors. . Reduced organic loading at treatment plant.	. Pump-outs reqd. . Septic effluent. . Septage facility required.	. Flattish or gently un-dulating terrain. . Fair ground	. Rocky ground. . High ground-water. . Very hilly ground.	$1,500-$2,500. Assumes exist-ing septic tank.	Attractive option if majority of town already served by septic tanks.
COMMON EFFLUENT DISPOSAL	. Reduced blockage frequency. . No power generally reqd. . Reduce peaking factors. . Reduced organic loading at treatment plant. . Smaller pipes.	. Pump-out reqd. . Septic effluent. . Septage facility required.	. Flattish or constant slope. . Good ground.	. Rocky ground. . High ground-water. , Very hilly ground.	$1,500-$2,500. Assumes exist-ing septic tank.	Attractive option if majority of town already served by septic tanks.
GRINDER PUMPS	. Small pipes following terrain. . Septic tanks not reqd. . All sewage removed.	. Power required. . Servicing of electromechanical equipment reqd.	. Unstable soil. . High groundwater. . Rocky terrain. . Flat and undulating terrain.		$2,500-$3,500	Attractive option if town served by septic tanks. Limited use where seasonal loadings exist.
VACUUM SEWERS	. Small pipes following terrain. . Septic tank not reqd. . Aerobic effluent. . All sewage removed.	. Power required but centralised. . Servicing of electromechanical equipment reqd. but centralised.	. Flat terrain. . High groundwater. . Rocky terrain. . High population density.	. Hilly ground.	$3,000-$5,000	Attractive for new developments in flat high groundwater table areas where typical costs of conventional sewerage would no longer apply.
CONVENTIONAL GRAVITY SEWERS	. All sewage removed. . Generally aerobic effluent. . Septic tank not reqd.	. Cost	. Flattish or constant slope terrain. . Good ground.	. Rocky ground. . High ground-water table. . Very hilly ground.	$4,000-$6,000	Provides the highest level of service.

MODIFIED DRAINAGE SYSTEM (MD)



Description: Modified drainage is the combination of a portion of domestic wastewaters (septic tank effluent and/or sullage)and stormwater in the one piped system for conveyance to a treatment site. The treatment plant is designed to treat all waters up to (say) four times the design wastewater flow after which any extra is bypassed directly to the receiving stream. If sullage only is discharged, black waters are treated and disposed of on-site. Cannot be used with open stormwater drains.

Advantages:

1. Reduces pollution and health risks from backyards.
2. Inexpensive solution for areas with soil absorption problems and existing or proposed piped stormwater systems.
3. Stormwater, and particularly the "first flush", is treated.

Disadvantages:

1. Discharge of dilute, but untreated effluent during high rainfall periods may cause environmental problems and health risks.
2. Septic tank maintenance still required.
3. Possible corrosion of cement based pipes if septic effluent is collected.
4. Special facilities for dealing with silt, trash and oils may be required.
5. Some effluents may have to be pumped into the drains if not commanded.
6. Septage treatment facility is required.

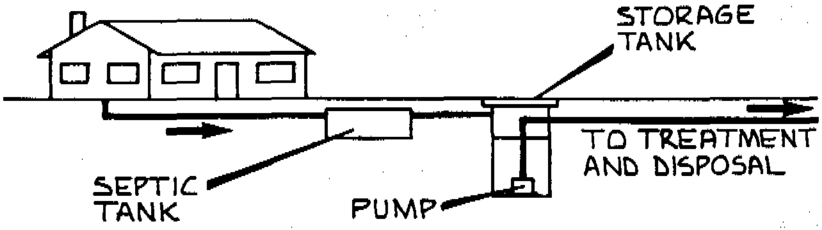
Indicative Costs:

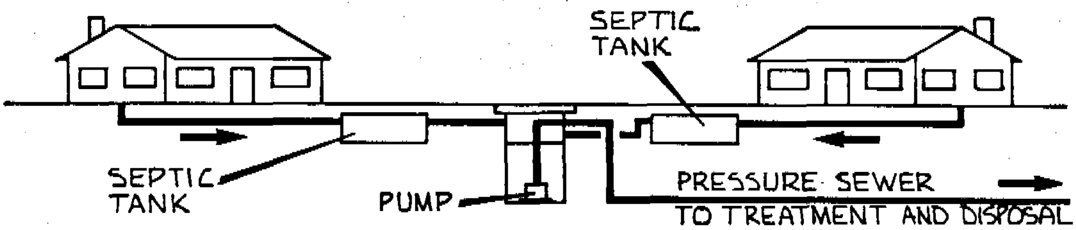
Assume stormwater system is existing, or if proposed, that it will be financed separately. Also assume existing septic tanks.

Construction Costs : $600 - $1000 per allotment (for connection of lot to drains). Allow additional $1000 if new septic tank is required. Excludes treatment costs.

Operating Costs : $80 - $100 every four years for septic tank pumpout.

SEPTIC TANK EFFLUENT PUMPING SYSTEM (STEP)





Description: Effluent from the septic tank(s) flows to a storage tank equipped with a pump (submersible or externally mounted and equipped with isolating and non-return valves) which discharges the wastewater into a small bore reticulated pressure sewer system. The storage tank has sufficient volume to cater for pump failures of up to 24 hours. The pressure sewer can serve several hundred homes. Wastewater is discharged to a centralised treatment plant. STEP systems can be used for individual dwellings or in a cluster of dwellings Septic tanks require periodic desludging.

Advantages:

1. Uses small bore pipes which can be laid at shallow depths following terrain, thus minimising construction costs. Particularly suitable for unstable soils, undulating terrain, high groundwater conditions, rock outcrops.
2. Infiltration/inflow is eliminated.
3. Low organic and solids loadings to treatment plants, which reduces treatment costs.
4. Peaking factors are reduced.

Disadvantages:

1. Effluent is septic and attention to odours and corrosion is necessary.
2. Relies on power supply for individual systems.
3. Septic tank needs periodic desludging.
4. Electromechanical equipment requires routine servicing.
5. Relatively high associated operation and maintenance costs.
6. Possible exfiltration from pressure sewer.
7. Septage treatment facility is required.

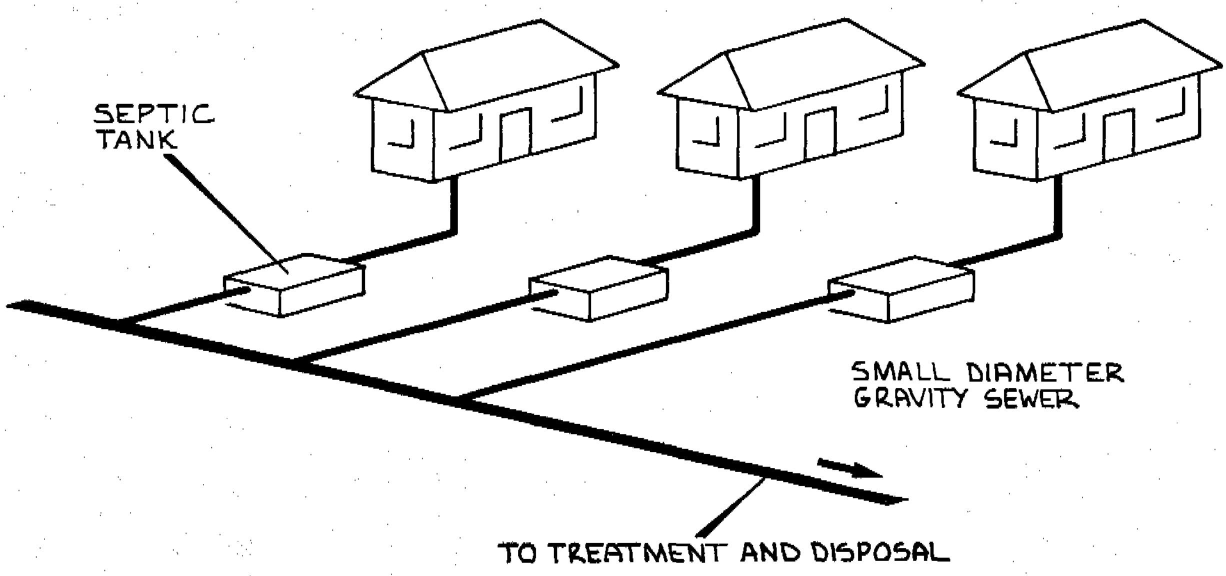
Indicative Costs:

Construction costs : \$1500 - \$2500 per lot including pump and excluding septic tank, connection to system and treatment facility,

Operating costs : - power \$5 - \$15 per annum
- desludging \$80 - \$100 every four years

Pump costs : \$600 - \$1000 installed (for replacement).

COMMON EFFLUENT DISPOSAL SYSTEM (CED)



Description: The common effluent disposal scheme is similar to a conventional full gravity reticulation system except that wastes are firstly treated in a septic tank prior to discharge. The lack of settleable solids enables smaller diameter sewers to be utilised, laid at flatter grades and with lower self cleansing velocities. A majority of the manholes can be replaced with inspection openings.

Advantages:

1. Reduced frequency of blockages resulting in reduced sewer maintenance.
2. Reduced capital costs due to smaller pipes, flatter grades, fewer manholes.
3. Organic and hydraulic peak loads are reduced in the septic tank.
4. Reduced treatment requirements at centralised plant.
5. No energy requirement in collection system.
6. Reduced infiltration because of smaller pipes and fewer manholes.

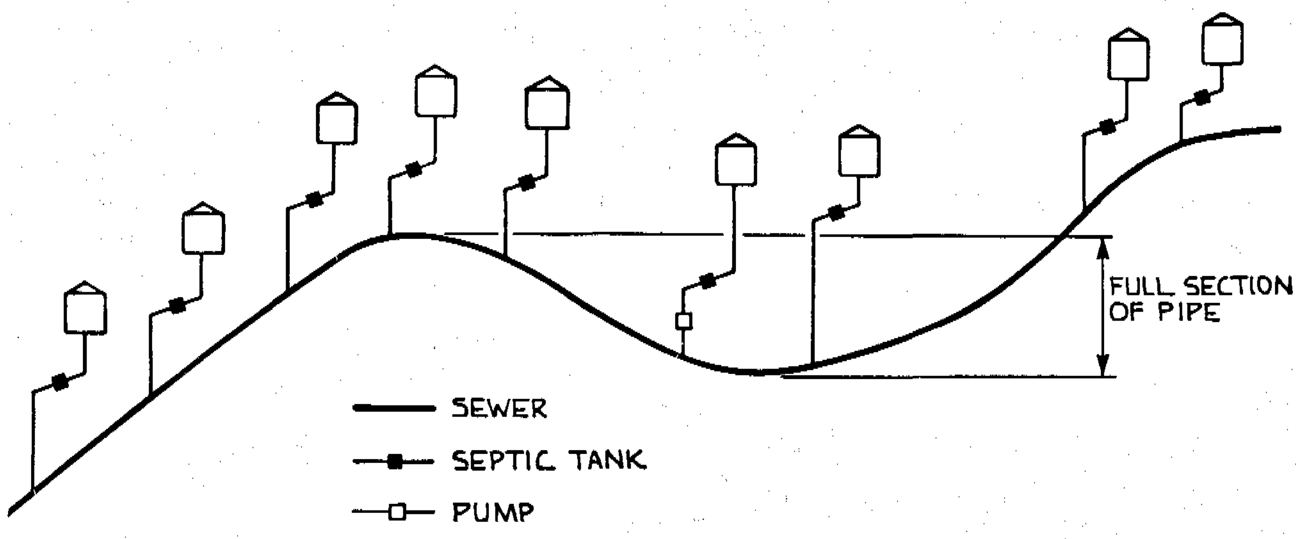
Disadvantages:

1. Periodic pump outs of the septic tanks are essential to ensure adequate removal of solids and scum to prevent blockages in the sewer lines.
2. Septic effluent can cause corrosion (particularly in manholes) and odour problems.
3. Septage treatment facility required.

Indicative Costs:

Construction Costs : $1500 - $2500 per lot, excluding septic tank, treatment facility and connection of lot to system. Allow $1000 if new septic tank is required.
Operating Costs : $80 - $100 every four years for septic tank pumpout

VARIABLE GRADE GRAVITY SEWERS (VGS)



Description: The system is similar to the Common Effluent Disposal scheme but it permits the collecting sewers to be laid at inflective grades, i.e., with a series of low points. The basic principle is the same as that of a sink trap. The complete system comprises a series of sink traps stretched out over a distance with net fall from inlet to outlet. The system can thus be laid at constant depth irrespective of grade. The system outlet must be located lower than the inlet of any house served by the sewer system. Some sections of the sewer will remain full at all times and this may cause maintenance problems. Premises in a valley section of the sewer which are below the sewer highpoint require pumps and valves similar to the STEP system, but overall the majority of houses discharge by gravity.

Advantages:

1. Reduced frequency of blockages resulting in reduced sewer maintenance.
2. Reduced capital costs due to smaller pipes, flatter grades, fewer manholes.
3. Organic and hydraulic peak loads are reduced in the septic tank.
4. Reduced treatment requirements at centralised plant.
5. Reduced energy requirement in collection system.
6. Reduced infiltration because of smaller pipes and fewer manholes.
7. Sewer can be laid at constant depth irrespective of slope.

Disadvantages:

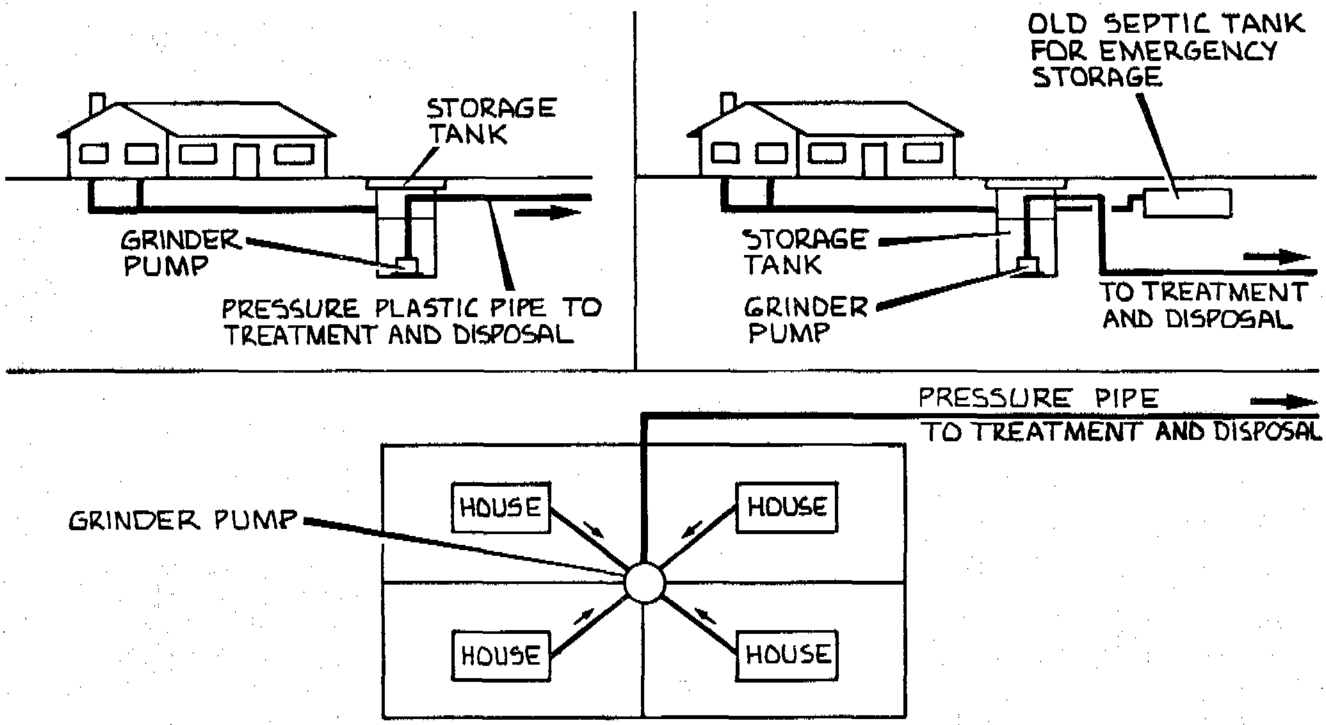
1. Periodic pump outs of the septic tanks are essential to ensure adequate removal of solids and scum to prevent blockages in the sewer lines.
2. Anaerobic effluent in sewer can cause corrosion and odour problems.
3. Low points remain full of wastewater.
4. Pumps and valves may be required at some premises.
5. Septage treatment facility required.

Indicative Costs:

Construction Costs : $1500 - $2500 per lot, excluding septic tank, treatment facility and connection of lot to system.

Operating Costs : $80 - $100 every four years for septic tank pumpouts.

GRINDER PUMP SYSTEMS (GP)



Description: Grinder Pump Systems consist of macerating pumps capable of grinding normal constituents of domestic wastewater into small pieces and then pumping the wastewater to a small diameter (usually 30-50 mm for small communities) pressure sewer system similar to the STEP system. A septic tank is not required. Instead, a small wet well complete with the pump isolating and non return valves and control equipment is installed. The wet well has one day's extra storage capacity to cater for pump failures. A single grinder pump can be used within a cluster arrangement for several homes to offset the installation costs.

Advantages:

1. Lower construction costs due to smaller piping and shallow narrow trenches. Also piping can be redirected around obstacles.
2. Septic tanks are not required.
3. Infiltration is eliminated.
4. Pressure sewers follow natural ground profiles.
5. All sewage is removed.

Disadvantages:

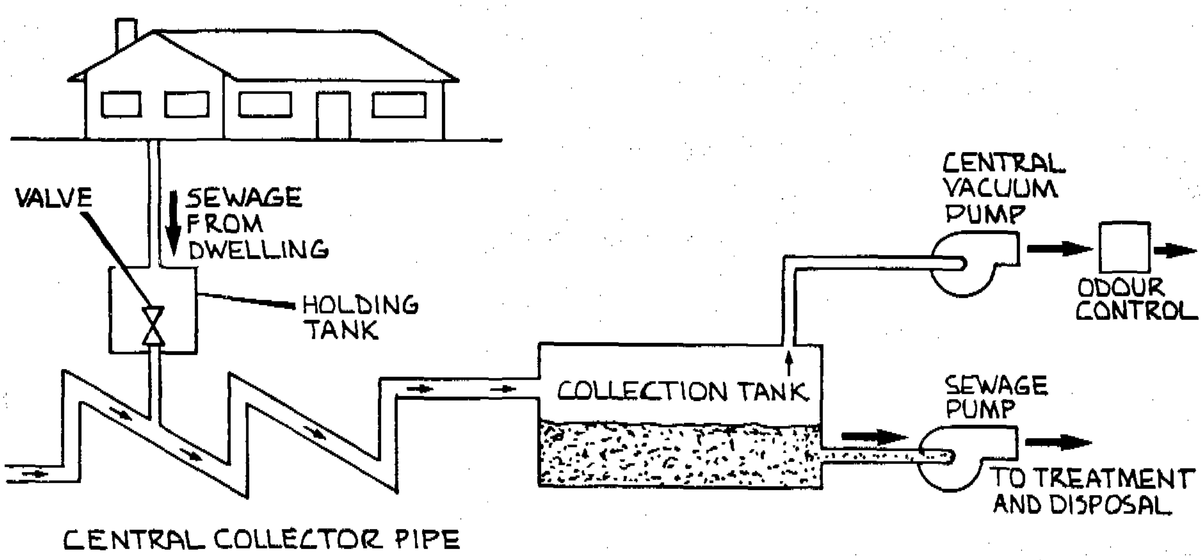
1. Higher operation and maintenance costs.
2. Relies on power supply to individual systems.
3. Grinder pumps are relatively expensive.
4. Possible exfiltration from pressure sewer.

Indicative Costs:

Construction Costs : $2500 to $3500 per lot, excluding treatment facility and connection to the system (Based on one pump per lot).

Operating Costs : $40 - $60 per year for power.
Pump Costs : $1500 - $2000 installed (for replacement).

VACUUM SEWER SYSTEMS (VS)



Description: A vacuum sewer system comprises a centrally located vacuum source which draws sewage through a sewer network to a collection tank from where it is conveyed to a treatment facility. Each allotment, or group of allotments, has a holding tank (fed by gravity) and an interface valve. When the level in the holding tank reaches an upper limit, the valve is actuated and the tank contents are drawn as a slug of liquid into a small bore sewer. A volume of atmospheric air follows the liquid slug. The slug soon disintegrates and gravitates to a low point (tranportation pocket) in the sewer where it re-establishes. Subsequent flows of atmospheric air then push the slug further downstream and this action continues until the slug eventually reaches a collection tank at the vacuum pump station.

Advantages:

1. Sewer can be shallow, can follow terrain and can be redirected around obstacles.
2. Aerobic effluent.
3. No exfiltration from system.
4. Centralised power utilisation.
5. Takes all waste.

Disadvantages:

1. Regular maintenance of vacuum valves is required.
2. Needs standby electrical power.
3. Need for precise construction.
4. Potential for high infiltration due to negative pressure.
5. Limit on lift due to vacuum limitation.
6. Less tolerance to flows exceeding design values.

Indicative Costs:

Construction Costs : $3000 to $5000 per allotment, excluding treatment and connection to the system.

Operating Costs : $5 to $10 per allotment for power.