Guidelines for the Use of Septic Tank Systems in the South African Coastal Zone

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PREFACE

There exists a wealth of technical information on septic tank systems, yet little appears to have reached the local user along the South African coast line. This report hopes to rectify this problem.

Much of the information contained in the report has previously been published by other authors, who are listed in the Bibliography. The report draws heavily on the earlier CSIR research, but also includes research findings from the USA, United Kingdom and Australia.

It is well to remember

> *Septic tanks don't fail - it is rather a case of people who fail to design, locate, install and use them correctly*

1 INTRODUCTION

Septic tank systems were first installed in South Africa in 1898 by the British military authorities and have since become a widely used means of disposal for water-borne domestic wastes. Septic tank systems are especially popular along the South African coast line. The coastal area, with its many scattered towns, villages and resorts, serves as a popular holiday destination and as a result has a highly seasonal population. In most cases water-borne sewage is uneconomical and septic tank systems provide on-site sanitation.

Septic tank systems that are properly designed, constructed and maintained are efficient and economical alternatives to public sewage disposal systems. The technology is well established and a wealth of technical information exists on the subject. The CSIR, for example, produced a number of reports/guidelines on septic tanks in the 1970s and 1980s. It is thus disturbing to find that many people still consider a septic tank system as a low-technology, second-rate means of waste water disposal. A recent Water Research Commission study (Wright, 1995) investigating the current situation along the coast line found the following:

- ☐ The septic tank system is the most commonly used method of domestic waste water treatment in the coastal zone. The design and management of these systems vary greatly within the region. Differences even occur within single local authority areas.

- ☐ Waste water disposal by means of septic tank systems is a well-established technology and a wealth of technical information is available on design criteria. There is, however, a general lack of technical knowledge at the "user" level. This is reinforced by a lack of legislation pertaining specifically to septic tank systems.

- ☐ The majority of septic tank problems are caused by blocked or inadequate drainage fields and may be attributed to poor location, poor design and lack of maintenance. Greater emphasis should be placed on the land capability assessment and ongoing maintenance. Local hydrogeological conditions invariably play a major role in the regional variation of the same generic problem.

- ☐ Lack of a sufficiently thick, unsaturated zone is the greatest problem encountered in the coastal zone. This is due to:

    - relatively impermeable layers such as clay lenses and calcrete units causing perched water tables;
    - highly permeable layers such as gravel/pebble beds serving as preferential flow paths; and
    - shallow depths to bed rock.

    These invariably lead to horizontal flow at shallow depths, water-logged conditions and return flow.

- ☐ Pollutants of greatest concern in the coastal context are nutrients (nitrates and phosphates) and biological contaminants (bacteria, parasites and viruses). Field studies indicate that a correctly designed and constructed drainage field effectively retains these pollutants within a radius of 20 to 50 m of the discharge point. Nitrate does, however, have the potential to contaminate groundwater and should be regarded as a conservative constituent. Ideally the drainage field should be 5 m above any impermeable layer and/or water table and 30 m away from any surface water body. The distance from a groundwater supply point should be at least 50 m and ideally 100 m.

- ☐ There is an urgent need for greater control in the use of septic tank systems within the coastal zone. Greater attention must be given to the drainage field component of septic tank systems, as this currently receives minimal attention and is the cause of most pollution problems. Although the highly seasonal use of these systems results in peak loads, it also means that the systems have long periods in which to recover. This recovery period results in many systems, which would fail under normal circumstances, operating efficiently in the long term.

- ☐ The disposal of septic tank/conservancy tank effluent at communal sites, either by surface spreading or trench infiltration, must be closely monitored. Such operations should require a permit from the Department of Water Affairs and Forestry and routine groundwater quality should be maintained.

- ☐ The septic tank system remains the most cost efficient means of domestic waste water disposal for the coastal zone. The systems must, however, be correctly designed, constructed and maintained.

The study highlighted the need for a comprehensive set of guidelines for the use of septic tank systems in the sandy coastal areas of South Africa.

This report briefly describes how a septic tank system functions and the possible impact it may have on groundwater quality, before outlining in detail:

- the procedure for doing a land capability assessment; and
- the recommended septic tank system design.

2 SEPTIC TANK SYSTEMS AND THEIR EFFECTS ON GROUNDWATER QUALITY

2.1 The septic tank system

The basic septic tank system (Figure 1) consists of a buried tank and subsurface drainage field (soakaway/French drain). Waste water (toilet flushings; bath, hand-basin and shower water; kitchen water; and discharged water from washing machines and dishwashers) flows into the septic tank, where the oil and grease in the waste water rise up to form a scum layer, while the solids sink to form a sludge. Once the majority of solids have settled, the remaining water in the middle of the tank flows off into the drainage field where it percolates down into the soil. The percolating water is further purified as it passes through the soil before it reaches the groundwater table. The function of the septic tank is to condition raw sewage, which has a clogging effect on the soil, thereby reducing the effective absorption capacity of the subsoil. The function of the drainage field in turn is mainly to get rid of the effluent from the tank in a safe and inoffensive way.

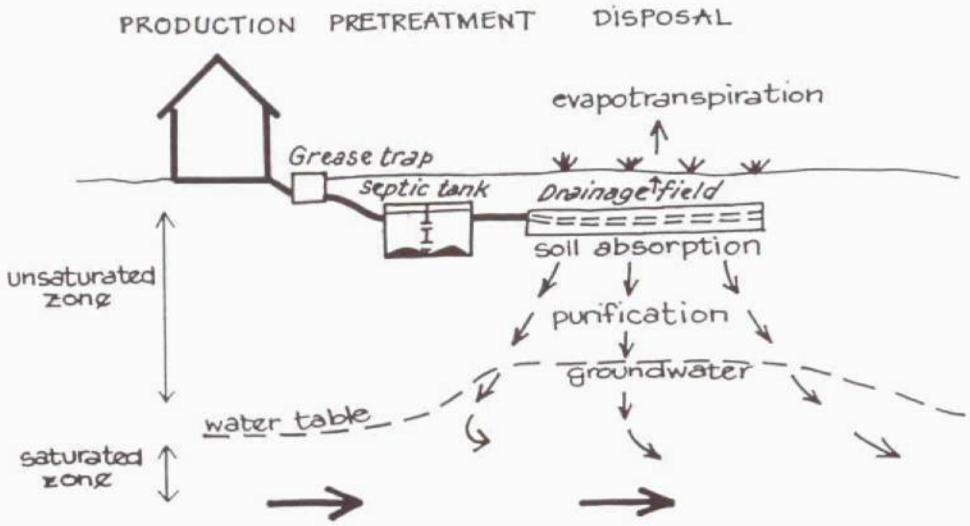


FIGURE 1: **Schematic cross-section through a conventional septic tank soil disposal system for on-site disposal and treatment of domestic liquid waste**

The processes taking place in the tank are complex and interact with each other. The separation and sedimentation of suspended solids are a mechanical process. Organic matter in the sludge and the scum is degraded by anaerobic bacteria. As a result of the bacterial action volatile acids are formed which are largely converted to carbon dioxide, methane and water. The sludge at the bottom of the tank becomes compacted owing to the weight of the liquid and the developing layers of sludge.

Many kinds of micro-organism grow, reproduce and die inside the tank. There is an overall reduction in micro-organisms, but a very large number of viruses, bacteria, protozoa and helminths can still be present in the effluent, scum and sludge. Further treatment is therefore necessary and takes place by natural microbiological processes in the drainage field. The drainage field typically consists of either a soakaway (trench, bed, seepage pit, mound or fill) or an artificially drained system, which allows the effluent from the tank to percolate into the surrounding soil. The soil filters out any remaining fine solids and bacterial contaminants. Trench and bed soakaway systems are the most common. Both absorption and transpiration processes take place concurrently, with effluent dispersing mainly through interflow during wet periods and through evapotranspiration during dry periods. The design and installation of the drainage field are at least as important as for the tank itself, but generally receive less attention.

An additional feature to the basic septic tank system is a fat and grease trap. These are located in the waste water outfall pipe prior to it entering the septic tank. Traps are generally not necessary for residential septic tanks, but rather those establishments where waste water is likely to contain above-average amounts of fat and grease (restaurants, hotels, service stations) or foreign materials (hospitals, laundromats, etc.)

Initially septic tank systems treated only black water (waste water from toilets), but with time were expected to treat all household waste water. As a direct result of this, septic tank systems soon became the leading contributor to the total volume of waste water discharged directly to the soils (Canter & Knox, 1986).

System performance is essentially a function of the design of the system components, construction techniques employed, characteristics of the wastes, rate of hydraulic loading, climate, areal geology and topography, physical and chemical composition of the soil mantle and care given to periodic maintenance.

2.2 Septic tank system effects on groundwater quality

One of the key concerns associated with septic tank systems is the potential for inadvertently polluting groundwater. Septic tank leachate is the most frequently reported cause of groundwater contamination in the USA (US EPA, 1977). It is estimated that in the USA only 40% of existing septic tank systems function correctly (Canter & Knox, 1986). Unfortunately no statistics are available for South Africa. Since the domestic waste water in septic tank systems contains many environmental contaminants, these systems have to be considered potential point sources for groundwater contamination. Contamination of the groundwater is of particular concern in the coastal area, as groundwater often serves as the local water supply. It is thus necessary to identify the constituents of potential concern in the effluents from septic tank systems and examine the main processes or mechanisms of groundwater contamination.

The current mode of operation is for septic tank systems to receive all the liquid-transported wastes produced by a household. This, for the average middle-class household, represents a discharge of approximately 160 litres per person per day. A substantially higher figure can be expected during the peak holiday period, as beachgoers are inclined to shower more than once a day. Typical sources of this waste water expressed on a percentage basis are:

toilet	22 - 45%
laundry	4 - 26%
bath and shower	18 - 37%
kitchen	6 - 13%
other	0 - 14%

These sources result in a waste water which contains a number of contaminants, namely:

- biological contaminants - bacteria, parasites, viruses;
- nutrients - nitrogen, phosphorus;
- inorganics - chlorides, potassium, calcium, sulphates, etc.;
- toxic inorganics - heavy metals;
- synthetic organics - surfactants, pesticides, cleaning solvents; and
- natural organics - trihalomethanes.

Of concern in terms of groundwater pollution is not so much what goes into the system, but what comes out, in other words the quality of the effluent from the septic tank portion of the system and the efficiency of constituent removal in the soil underlying the drainage field. The geochemical evolution of domestic waste water in a typical septic tank system is determined by the initial composition of the waste water, the physical arrangement of the septic tank system and the composition of the subsurface. It is also important to look beyond specific constituents and recognise that septic tank systems are true geochemical systems in which the waste water constituents react with each other and with the subsurface gases and porous medium.

TABLE 1: Septic tank effluent quality at three typical South African coastal facilities (a holiday home, caravan park and recreation complex)

Chemical and microbiological constituents		Holiday home (black and grey water)	Caravan park ablution block (black water)	Recreation centre swimming pool (black water)
K	(mg/L)	22.1	9.3	24.5
Na	(mg/L)	121.0	51.0	103.0
Ca	(mg/L)	18.0	18.1	45.3
Mg	(mg/L)	9.5	6.7	8.1
NH_4 - N	(mg/L)	87.0	27.0	81.0
SO_4	(mg/L)	20.0	33.0	11.0
Cl	(mg/L)	150.0	95.0	183.0
Alk($CaCO_3$)	(mg/L)	396.0	118.0	391.0
NO_x - N	(mg/L)	<0.1	<0.1	<0.1
PO_4 - P	(mg/L)	17.7	3.0	5,4
DOC	(mg/L)	47.7	31.0	33.0
EC	(mS/m)	145.0	66.0	142.0
pH		7.8	8.3	7.4
Faecal coliforms per 100 ml		5.5×10^6	4.0×10^6	1.2×10^5

The water quality data provided in Table 1 illustrate the variation in quality resulting from different activities. The data are for periods of peak use, i.e. mid-summer, and represent the water that is to be discharged into the drainage field and hence the subsurface environment. The effluent quality reflects the type of activity that takes place at each facility. For example, a residential unit can be expected to have higher concentrations of phosphate and refractory organics with occasional peaks in toxic metal. Both chemical and microbial contaminants occur in sufficient quantities to be potentially harmful to human health and the aquatic environment. The critical question is whether these contaminants are transported to the groundwater or surface water in sufficient concentrations to pose a pollution hazard.

Groundwater degradation does occur in the coastal area, especially in areas having high densities of septic tank systems (Wright, 1995). The degradation is exemplified by high concentrations of nitrates and bacteria in addition to potentially significant amounts of organic contaminants. One common reason for degradation is that the capacity of the soil to absorb effluent from the tank has been exceeded, and the waste added to the system moves to the soil surface above the lateral lines. Another reason of greater significance to groundwater is when pollutants move too rapidly through soils. Many soils with high hydraulic absorptive capacity (permeability) can be rapidly overloaded with organic and inorganic chemicals and micro-organisms, thus permitting rapid movement of contaminants from the lateral field to the groundwater zone. In considering groundwater contamination from septic tank systems, attention must be directed to the transport and fate of pollutants from the soil absorption system through underlying soils and into groundwater. Physical, chemical and biological removal mechanisms may occur in both the soil and groundwater systems. Transport and fate issues must be considered in terms of biological contaminants (bacteria and viruses), inorganic contaminants (phosphorus, nitrogen and metals), and organic contaminants (synthetic organics and pesticides). The biochemical changes that take place are not discussed in this report, as this has already been done in Wright (1995).

2.3 Recommended approach

Several hundred installations are thought to cause problems each year, the majority of which are avoidable. Problems occur with old and new installations because of poor location, poor drainage field design and lack of maintenance. It is essential, in order to avoid these problems, to undertake an initial proper land capability assessment. Only once this is complete can the design details be decided on and construction take place. The level at which these are done depends largely on the locality and guidance must be sought from the responsible local authority. The property owner must be given a copy of both the site assessment report and design plan.

3 LAND CAPABILITY ASSESSMENT

A proper site evaluation is fundamental to the design of a septic tank system.

Land capability is the ability of land to support a particular type of use without permanent damage. It refers to the evaluation of biophysical factors of land for a particular use. In assessing land capability, two aspects need to be considered:

- the effect of land on the proposed use; and
- the effect of that use on the land.

The first aspect relates directly to productivity or development costs, while the second relates to conservation requirements.

Assessment of the ability of land to support an on-site effluent disposal system involves consideration of five land qualities. These are:

- the ability of land to dispose of, or absorb effluent effectively;
- the ability to purify effluent effectively;
- the relative ease of excavation for installation of tanks and drainage fields;
- the risk of water pollution; and
- flood hazard.

The soil or land characteristics which need to be considered in relation to each land quality are shown below in Table 2 and are discussed in the following pages.

TABLE 2: Land characteristics used to assess qualities which affect effluent disposal capability

Absorption ability	Purification ability	Ease of excavation	Water pollution risk	Flood hazard
Site drainage/depth to seasonal water table	Permeability	Depth to rock Slope Stone content	(by over-land flow) Absorption ability Runoff	Landform/ topographic position
Permeability	Nature of soil: texture and coherence	Rock outcrop		Field observation of flood events
Depth to impermeable layer		Site drainage		
Stone content	Depth to impermeable layer Site drainage Slope		(by sub surface leaching) Nature of soil: texture and coherence	

[FROM: WELLS, 1987]

3.1 Absorption ability

This relates to the ability of soil to accept sufficient volumes and rates of applied effluent. It is determined from a consideration of soil permeability, site drainage, depth to an impermeable layer and the presence of stones within the soil profile (Table 3).

☐ Permeability is the characteristic of soil which governs the rate at which water moves through it. It influences aeration, water flow, water retention, biological activities and the filtration of parasites and pathogens. It is affected by texture, structure, degree of water saturation, degree of compaction, total pore space, fractions of total pore space occupied by large pores, continuity of large pores and spatial changes in any of the variables.

TABLE 3: Assessment of land quality - Absorption ability. The overall rating is determined by that of the most limiting land characteristics.

Land characteristic	Rating High	 Moderate	 Low	 Very low
Permeability class	Rapid	Moderate	Moderately slow	Slow
Drainage class	Well/ Rapid	Moderate	Poor	Very poor
Depth to impermeable layer	>2 m	1 m - 2 m	0.5 - 1 m	<0.5 m
Stone within profile	>90%	50 - 90%	20 - 50%	<20%

[AFTER: WELLS, 1987]

Permeability categories are essentially ranges of hydraulic conductivities (Figure 2). It should be noted that both extremes of the scale (slow and very rapid permeability) are problematic. The one leads to very poor filtration and the other inadequate purification of the effluent.

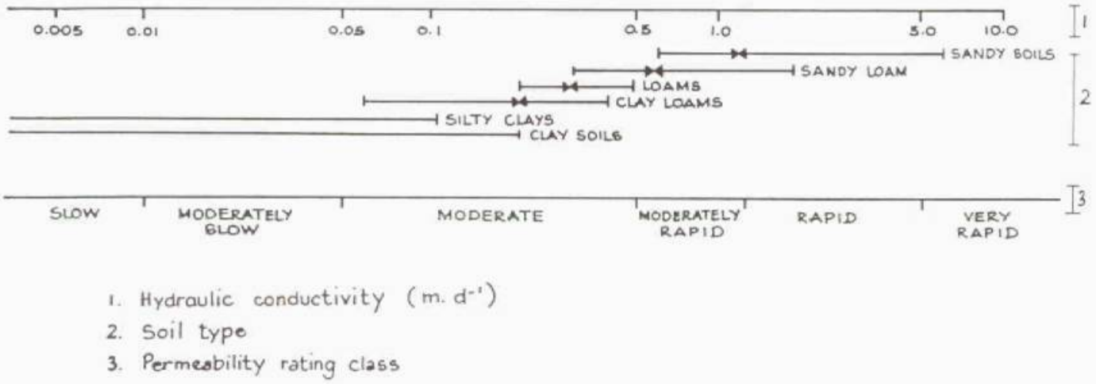


FIGURE 2: Comparison of permeability classes and hydraulic conductivities of various soils

For ease of use permeability classes are generally linked to soil texture as illustrated in Figure 2. Although most coastal sands fall within the sandy soils range they may contain horizons of more argillaceous material, which results in a "slower" permeability rating. It should, however, be remembered that a soil percolation chart evaluation is merely a tool for making decisions. Although texture is important it should be remembered that permeability is influenced by the extent of clogging mat development and that texture and permeability are equally weakly correlated.

Because it is a simpler test to conduct, percolation rate rather than saturated hydraulic conductivity is the parameter most frequently measured. The percolation test measures the rate at which clean water, under a constant or nearly constant hydraulic head, percolates into the surrounding soil, in both vertical and horizontal directions. The test is designed to quantify the rate of water movement into the soil and percolation rates will therefore change as soil moisture conditions change.

The Percolation Test

(i) Number of test holes

Four to six (depending on the size of the drainage field) percolation tests should be performed on the site of the proposed absorption field. The test holes should be placed uniformly throughout the area. More tests are required if soil conditions are highly variable.

(ii) Preparation of test holes

Each test hole should have a diameter of 150 mm or be 150 mm square. A spade or hand auger could be used for this purpose. Test holes, 400 mm deep, should be dug downwards from the bed of the proposed absorption system, and the sides and bottom of each hole should be thoroughly scarified with a sharp, pointed instrument to break up unnatural (such as smeared) soil surfaces. All loose material should be carefully removed from the test holes. Holes should be lined with a polyester filter fabric and the bottom of each covered with a 50 mm layer of pea-sized gravel to protect the soil surface from scouring when water is added.

(iii) Presoaking of test holes

The hole should be carefully filled to a depth of 300 mm above the gravel and this level maintained for at least 8 hours prior to percolation measurements. Automatic siphons or float valves may be employed for this purpose. Soaking should continue until a constant percolation rate is obtained. If in sandy soils, after filling the hole at least twice to a depth of 300 mm above the gravel, the water seeps away in less than 10 minutes, the percolation test can proceed immediately.

(iv) Percolation rate measurement

The measurement of percolation rates should immediately follow the presoaking phase. The water above the gravel should be allowed to drop to 180 mm above the gravel and, from this point, further drops in the water level should be measured, from a fixed reference point, to the nearest millimetre at constant intervals of between 5 and 60 minutes. Greater intervals should be chosen as the percolation rate decreases. If the depth of the water above the gravel decreases to 130 mm, water should be added to return its depth to 180 mm and measurements continued. Measurements should continue until water levels at two successive intervals do not vary by more than 10 percent. The level of the water above the gravel in the test hole should at no time be allowed to drop below 130 mm, or rise above 180 mm.

Calculation of percolation rate

The percolation rate is calculated for each of the test holes by dividing the magnitude of the last drop in the water level by the time taken and this rate is expressed in millimetres per hour (mm/h). The rates obtained for all the test holes should be averaged to determine the overall percolation rate for the proposed absorption system. The average percolation rate should be calculated by the geometric mean method (the n-th root of the product of n measurements), because high values have less influence on the geometric mean than on the arithmetic mean. If individual percolation test values on a site vary by more than 10 percent, a variation in soil type is indicated and therefore the number of test holes should be increased so that a more reliable average rate can be determined.

- Site drainage/depth to water table - The setting and land-form of a site indicate surface and subsurface drainage patterns. For example, hill tops and upper slopes can be expected to have better drainage than depressions and slopes. This may appear rather obvious, but it is amazing how many septic tank systems are located in low-lying areas that become bogs during the wet season.

- Depth to the seasonal water table (be it a superficial aquifer or perched) is the depth of soil available to receive the purified effluent. The thickness of the unsaturated zone can have a great effect on the rate of flow of effluent from the drainage field, particularly on the vertical flow. The effect is most marked where a shallow groundwater table exists in a relatively flat area. It is thus necessary to determine the depth to the highest seasonal groundwater table. Soil mottling is a good indicator of the seasonal high groundwater table. Unfortunately organic matter can mask the soil colours or make it appear mottled. Real soil mottling is caused by stages of oxidation of the iron in the soil. In coastal sands the presence of a thin calcareous horizon may indicate the seasonal high groundwater table. In duplex soils where sandy top soils overlie a more argillaceous (clayey) substrate, a perched water table may exist for several days or even months. It is therefore preferable to define the effect of the seasonal water table in terms of site drainage status which indicates the length of periods of saturated conditions. The site drainage classes given in Table 4, though rather qualitative, should be used as an indicator or substitute for "depth to seasonal water table".

TABLE 4: Drainage classes

Drainage class	Approximate period of saturation
Very poor	Water table remains at or near the surface for most of the year
Poor	All soil horizons remain wet for periods of several months
Imperfect	Some soil horizons are wet for periods of several weeks
Moderately well	Some soil horizons may remain wet for as long as one week after water addition
Well	Some site horizons may remain wet for several days after water addition
Rapid	No soil horizon is normally wet for more than several hours after water addition

[AFTER: WELLS, 1987]

☐ Depth to impermeable layer often influences the depth to the groundwater table. An impermeable layer may be bed rock, but in many cases may be a thin layer or lens of clay, calcrete, or ferricrete. These layers can retard flow in a vertical direction to such an extent that a perched water table develops or that the general flow direction changes from a vertical direction to a more horizontal direction at very shallow depths.

☐ Stone within profile refers to the percentage of stone (pebbles and boulders) within the soil profile. The presence of boulder beds can result in preferential flow and thus affect the flow of the effluent. This may be of particular relevance in those areas along the coast where screen material constitutes the overburden.

3.2 Purification ability

This relates to the ability of the soil to remove microbes effectively which may be detrimental to public health, and to provide suitable conditions for oxidation or breakdown of organic and some inorganic material within effluent.

TABLE 5: Assessment of land quality - Soil purification ability

Permeability	Nature of soil	Depth to impermeable layer	Rating
Moderately rapid - Very rapid	Leached sands with little coherence	< 5 m	Very low
		> 5 m	Low
	Earthy sands with slight to moderate coherence	> 2 m	High
		1 - 2 m	Moderate
		< 1 m	Low
Moderate - Slow	Soils with loamy textures or heavier	> 1 m	High
		0.5-1 m	Moderate
		< 0.5 m	Low

[AFTER: WELLS, 1987]

- Permeability has already been discussed under absorption ability. It should, however, be noted that in this category highly permeable soils are problematic, as excessive percolation can result in inadequate purification of effluent in the soils. This is particularly relevant in the coastal zone with the clean, well-sorted sands of the beach environment. Although texture is important it should be remembered that permeability is influenced by the extent of clogging mat development and that texture and permeability are generally weakly correlated (Kaplan, 1991). In the past great significance was placed on soil texture. A virgin soil may have an initial high absorption rate but with time, as the clogging layer develops, so this decreases.

- The nature of soil not only influences the rate at which the water infiltrates, but also plays a vital role in the physical and chemical purification processes. A good soil should provide a high level of treatment before the effluent reaches the groundwater. In general, finely textured soils immobilise pollutants more effectively than more coarsely textured soils. This is not only related to the soil's ability to filter out pollutants (physical process), but also to its cation exchange capacity (chemical processes).

  The nature of soil capacity is not that important within the South African coastal zone, as the majority of those areas where development is taking place consists of recently deposited sands. A further factor is that developers are inclined to alter the original landscape completely. The area immediately inland of the high-water mark is often completely reworked by mechanical means, creating a uniform, structureless sand profile. In those areas where the sands have not been disturbed the profile often contains thin layers of highly permeable material such as shell beds/gravel lenses. These act as "conduits" and result in preferential, accelerated flow with reduced purification.

☐ Depth to impermeable layer invariably constitutes the depth to the seasonal groundwater table. It thus directly influences the effluent travel time available for removal of microbes, and for organic and some inorganic materials to be oxidised or broken down. In the past the accepted standard depth of soil required for proper microbe removal was 1.2 m irrespective of soil type. This, however, is not adequate in coarse sands and here a depth of 5 m is more appropriate. Any clay present in the sand will obviously aid the purification process. The high calcium content commonly found in coastal calcareous sands does not, however, affect the sand's purifying ability significantly.

☐ Two further related factors not included in the purification ability table (Table 5) are site drainage and slope. If site drainage is very poor, soils will be insufficiently aerated for bacterial breakdown of effluent components. Rating is automatically very low.

On steep slopes where permeability is moderate to low, lateral seepage may intercept the surface, resulting in ineffective purification. Therefore under such permeability conditions, if slope is 20 to 30%, rating is automatically low, and if greater than 30%, rating is very low.

3.3 Ease of excavation

This relates to the relative ease of installation for septic tank units and for construction of drainage fields/soakaways. Table 6 summarises this category.

TABLE 6: Assessment of land quality - Ease of trench excavation ratings[*]

Land characteristic	Rating - High	Rating - Moderate	Rating - Low
Depth to rock	> 2 m	0.5 m - 2 m	< 0.5 m
Slope	0 - 10%	10 - 20%	> 20%
Stone within profile	< 20%	20 - 90%	90%
Rock outcrop	Very few	Few	Common
Site drainage[1]	Rapid	Moderate-poor	Very poor

[*] Rating determined by that of the most limiting land characteristic

[1] See Table 4

High slopes may create construction difficulties, as due to colluviation there is a good chance that bed rock will be encountered at shallow depths. Hence ineffectively purified effluent may come to the surface as it flows downslope. Due to interaction of slope with characteristics such as soil texture and depth, there is room for argument about when high slopes begin to hinder construction and when lateral flow of effluent and subsequent seepage become a problem. A cut-off of 20 degrees is now generally accepted.

3.4 Water pollution risk

The risk of water pollution from on-site effluent disposal relates to excess microbial and/or nutrient contamination and is generally an on-site problem. This aspect is particularly important in the coastal zone where developers attempt to build as close to rivers, lagoons, estuaries and the beach as possible. The pollution can either be on the surface by means of overland flow or the subsurface. Water pollution risk from overland flow is determined from soil absorption ability and surface runoff rates with a modifying factor for flood hazard areas (Table 7). The absorption ability rating is obtained from Table 3. If the site is subject to high flood hazard, the risk rating is automatically very high.

The surfacing of partly treated effluent usually occurs because of one or more of the following:

- sites that have a shallow restricting layer (such as a high groundwater table) or an impermeable soil layer;
- sites that have very steep slopes, especially when underlain by a relatively impermeable soil layer;
- poor construction (such as caved-in trenches or where ingress of fine materials into trenches takes place); and
- drainage fields where infiltrative surfaces have become badly clogged due to factors such as effluent application rates that are too high, or poor maintenance of the septic tank.

Pollution by subsurface leaching is based very much on a purification ability and in particular the subsoil texture and coherence characteristics. This type of pollution is the more common in the coastal area. Drainage fields immediately upgradient of stormwater drainage systems (channels or subsurface pipes) often contribute pollutants to the stormwater runoff, this being particularly serious during baseflow conditions.

Generally, the susceptibility of a water source to pollution decreases quite sharply with increasing distance from the drainage field, and with increasing source depth, except in areas with fissured rock, limestone or very coarse soil.

TABLE 7: Assessment of land quality - Water pollution risk

	Absorption ability*	Runoff rate	Risk rating			
			Very high	High	Moderate	Low
Surface flow	High					✓
	Moderate	Slow				✓
		Rapid			✓	
	Low	Slow			✓	
		Rapid		✓		
	Soil texture	Nature of soil				
Subsurface flow	Sand	Leached with little coherence	✓			
		Earthy with slight coherence		✓		
	Sandy loam/loam	Moderate to good coherence			✓	
	Clay loam/clay	Good coherence				✓

* Obtain using Table 3

In areas where groundwater is used for household purposes, the following criteria apply:

- Drainage fields should, if possible, be located downgradient of the water source.
- Where an upgradient location cannot be avoided, the drainage field should be located at least 30 m from the water source, preferably 50 m. This distance should be 100 m for the "very high risk" areas. These figures are based on field studies at two different hydrogeological sites along the southern Cape coast.

3.5 Flood hazard

Flooding is the temporary covering of land by water from overflowing streams and, to a lesser extent, surplus runoff from adjacent slopes. Hazard ratings (Table 8) are determined both by inference from landform and soil data and published flood level contours.

TABLE 8: Assessment of land quality - Flood hazard

Flood hazard	Description
High	- Lowest terraces and margins of major rivers and streams; - active floodways as defined by structure plans
Moderate	- Intermediate level terraces of major rivers and streams, incised drainage lines, and minor valley floors; - area within the 1:50 year flood level
Low	- Higher terraces of major rivers and streams non-incised, illdefined drainage pathways associated with minor creeks and streams; - land occurring outside active floodway areas but within the 1:1 000 year flood level

3.6 Land capability rating

The values determined from the quality assessment tables (Tables 3 - 8) in turn fit into the final capability rating tables (Table 9).

TABLE 9: Land capability rating table for on-site effluent disposal in the coastal zone

	Degree of limitation				
Land qualities	None	Slight	Moderate	High	Severe
Absorption ability	High	Moderate	Low	Very low	-
Purification ability	High	Moderate	Low	Very low	-
Water pollution risk	Very low	Low	Moderate	High	Very high
Ease of excavation	High	Moderate	Low	Very low	-
Flood hazard	-	-	Low	Moderate	High

[AFTER: WELLS, 1987]

The degree of limitation is defined as follows:

- *None to very slight*: Very high capability for the proposed system. Very few physical limitations present, which are easily overcome. Risk of land degradation is negligible.
- *Slight*: High capability. Some physical limitations affecting the risk of land degradation. Limitations overcome by careful design.
- *Moderate*: Fair capability. Moderate physical limitations significantly affecting risk of land degradation. Careful design and conservation measures required.
- *High*: Low capability. High degree of physical limitations not easily overcome by standard development techniques and/or resulting in a high risk of land degradation. Extensive conservation requirements.
- *Severe*: Very poor capability. Severity of physical limitations is such that its use is usually prohibitive in terms of either development costs or the associated risk of land degradation.

4 DESIGN CRITERIA

A septic tank system usually comprises two major components: the septic tank itself; and an effluent disposal system in the form of a subsurface soil absorption system (drainage system). Each component has a specific function and should be designed accordingly. Design considerations related to the septic tank component include determination of the appropriate volume, a choice between single or multiple compartments, selection of the construction material and placement of the site. Placement of the tank on the site basically involves consideration of the site slope and minimum setback distances from various natural features or built structures. Design consideration of the subsurface soil absorption system relate largely to the soil's ability to treat and dispose of effluent. As such the site evaluation (land capability assessment as described in section 3) plays a crucial role. The design criteria established by the old National Building Research Institute (Boutek) of the CSIR remain the most definitive set of guidelines for South African conditions. As a result this chapter includes much of the material contained in these earlier CSIR reports (Malan, 1964; Drews, 1986; De Villiers, 1987 a/b).

4.1 The septic tank

The most important factor in the performance of a septic tank is the rate at which sewage moves through the tank. Other factors affecting the retention time and thus the performance of the tank include its geometry, the loading pattern, the inlet and outlet arrangement, the number of compartments and the way in which it is maintained.

A septic tank should be designed to meet the following criteria:

- a theoretical liquid retention time of at least 24 hours at maximum sludge depth and scum accumulation;

- sufficient sludge and scum storage space to prevent their discharge to the liquid disposal system and to ensure a reasonable period of time before desludging becomes necessary;
- tank layout configuration that minimises the disturbance of sludge and scum; and
- ventilation to allow the accumulated methane and hydrogen sulphide gases to escape.

4.1.1 Compartmentation of the septic tank

The inflow from residential and from non-residential buildings can vary greatly. During peak flow, higher concentrations of solids are likely to be discharged from the septic tank and this can have a detrimental effect on the drainage field. Well-designed double-compartment septic tanks reduce the effect of such peak flows. Therefore, although single-compartment septic tanks can perform acceptably under average conditions, it is better to use double-compartment tanks. Any further advantage derived from dividing septic tanks into more than two tanks is usually insignificant.

4.1.2 Geometry of the septic tank

The geometry of the septic tank has an influence on the velocity at which the sewage flows through it, on the sludge accumulation and on the possible presence of stagnant pockets of liquid inside the tank. When the tank is too deep in relation to its surface area, the other dimensions will be too small and a direct flow of sewage (short-circuiting) can take place between its inlet and outlet, resulting in a reduced retention time for the liquid. Where the septic tank has too large a liquid surface area in relation to its volume, the clear space between sludge and scum will become small, resulting in too high a liquid flow rate for sedimentation and flotation. This is an important factor in the coastal area, as often, in areas that have a high groundwater table, contractors build rather shallow/flat rectangular tanks. The contractor incorrectly believes that it is acceptable so long as the tank has the required volume, irrespective of the dimensions of the tank.

Research indicates that rectangular tanks, in general, perform better than either square or cylindrical tanks, although all may provide satisfactory treatment. It is recommended that septic tanks be designed to have (see Figure 3):

- a liquid depth (L) of between 1 and 1.8 m;
- a rectangular shape with the length of the septic three times its width (W);
- a first compartment twice as large as the second; and
- the width calculated using the formula

$$width\ (W) = \left[\frac{Required\ capacity\ (m^3)}{3 \times selected\ depth}\right]^{1/2}$$

4.1.3 Inlet and outlet arrangements

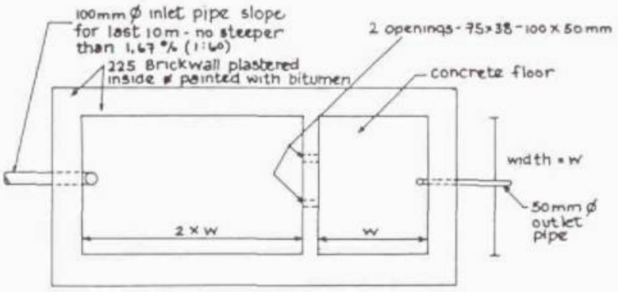
The inlet should introduce waste water to the septic tank with the least disturbance of settled matter. Therefore, it should dissipate the energy of the incoming flow. In addition, it should prevent short-circuiting of the incoming and the outgoing flows as far as possible.

(a) INLET TO FIRST COMPARTMENT

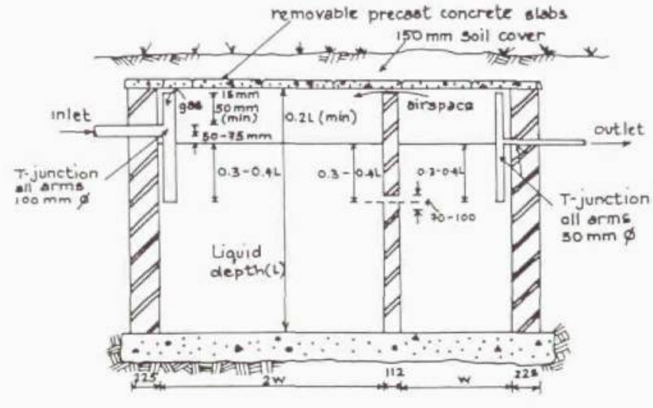
The inlet should preferably be a sanitary T-piece. The vertical portion of the T (see Figure 3) should extend below the surface of the liquid to minimise incoming turbulence. The lower vertical arm of the inlet should be submerged to between 30 and 40% of the liquid depth. The vertical upper arm should extend at least 50 mm above the surface of the liquid and 15 mm below the cover of the septic tank. The invert of the inlet pipe should be between 50 mm and 75 mm above the surface of the liquid.

The following criteria apply to the incoming drain pipe:

- It should have an outside diameter of at least 100 mm.
- The diameter of the vertical arms of the inlet T should not be less than that of the incoming drain pipe.
- The incoming drain pipe should be laid at a gradient of no steeper than 1.67% (1 in 60) for the 10 m before the tank.



PLAN



CROSS SECTION

FIGURE 3: Recommended septic tank design [FROM: DE VILLIERS, 1987]

(b) OPENING BETWEEN COMPARTMENTS

Flow of liquid between compartments is best through vertical slots. Two or more slots, 75 mm to 100 mm deep and half as wide, should be provided between 30 and 40% of the way down from the theoretical surface of the liquid.

(c) OUTLET FROM SECOND COMPARTMENT

The outlet should preferably also be a sanitary T-piece. The vertical lower arm of the T should also be submerged to between 30 and 40% of the liquid depth. The vertical upper arm of the T should project above the layer of floating scum. Both arms of the outlet piece, and the horizontal section, should have an inside diameter half to three-quarters that of the inlet pipe. Reducing the size of the outlet has the advantage of damping peak flows through the septic tank. The invert of the outlet pipe should be 50 mm to 755 mm below that of the inlet pipe.

4.1.4 Materials

Septic tanks may be constructed of brick, concrete, fibre-cement, glass-reinforced plastic or any other material not subject to excessive corrosion.

4.1.5 Access, inspection and ventilation

All compartments and fittings should be readily accessible for inspection and cleaning. If manholes are to be provided, they should give access to both inlet and outlet pipes (where blockages can occur). Alternatively, access can be provided through removable cover slabs.

The inlet drain pipe should be served by a ventilation pipe which may be situated against the wall of the building for which the septic tank is provided.

4.1.6 Location

The septic tank should be located so as not to endanger the structure of any buildings or other services on the site. The following criteria apply:

- The tank should not be closer to building foundations or site boundaries than twice its depth.
- It should be near a road or driveway for easy access for maintenance purposes (such as desludging).
- Its site should facilitate the eventual connection of the building drain pipe or the tank outlet pipe to sewerage reticulation.

From a health point of view it is sufficient to have a soil cover of 150 mm to 200 mm over the whole tank.

4.1.7 *Septic tank capacity*

The capacity of the septic tank should be adequate to store sludge and scum as well as to retain liquid for at least 24 hours. For this reason it is necessary to determine the expected sewage flow, as well as the rate of accumulation of sludge and scum, before a septic tank can be designed.

(a) RESIDENTIAL INSTALLATIONS

Residential sewage flow in low-income areas is often directly related to the level of water supply in the area. Table 10 gives guidance in this regard. In the higher-income areas there is often a relationship between the number of occupants in a house and the number of bedrooms. Table 11 gives an indication of the waste water flow that could be expected from houses with full in-house water reticulation.

TABLE 10: Estimated sewage/waste water flow for lower-income areas where water is obtained from standpipes

Level of water supply	Litres per person per day
Public street standpipes	12 to 15
Single on-site standpipe with dry sanitation system	20 to 25
Single on-site standpipe with WC connected to water supply	45 to 55
Single in-house tap with WC connected to water supply	50 to 70

[FROM: DE VILLIERS, 1987]

TABLE 11: Sewage flow that could be expected from dwellings with full in-house water reticulation

Description	Litres per stand per day
Lower-income area (2 - 3 bedroomed houses) :	
Houses with unmetered water supply	1000
Houses with metered water supply	840
Middle- to high-income area :	
House with 2 bedrooms	700
House with 3 bedrooms	900
House with 4 bedrooms	1100
House with 5 bedrooms	1400
House with 6 bedrooms	1600

[FROM: DE VILLIERS, 1987]

The rate of accumulation of sludge and scum will depend on various factors such as ambient temperature and living standard of occupants, diet, health, occupations and working conditions. Accumulation rates are therefore very variable. Tables 12 and 13 give an indication of the accumulation rates that may be expected.

TABLE 12: Rate of sludge and scum accumulation for low-income areas

Materials used for anal cleansing	L/Person/year
Sand, stone etc.	
Toilet wastes only	55
Additional household sullage	70
Hard paper, leaves and grass	
Toilet wastes only	40
Additional household sullage	50
Water and soft paper	
Toilet wastes only	25
Additional household sullage	40

[FROM: DE VILLIERS, 1987]

TABLE 13: Rate of sludge and scum accumulation in litres per person for middle to high-income areas (multiple sanitary fittings)

Years of service	Sludge	Scum	Total
1	65	20	85
2	105	35	140
3	125	60	185
4	145	57	220
5	170	85	255
6	195	95	290
8	240	120	360
10	295	145	440

[FROM: DE VILLIERS, 1987]

Two methods exist by which to calculate the capacity of a septic tank:

The first method relates the capacity of a septic tank to the number of persons served by the system. This method should be used when materials other than water or paper have been used for anal cleansing or for dwellings without multiple sanitary fittings. The total capacity (A) of the septic tank is determined as follows:

$A = Q + P$ (A not to be less than 3Q or 1.5 m^3);

where $Q =$ the estimated daily sewage flow, and
$P =$ the capacity required to store sludge and scum between septic tank cleanings.

The second method, in which the capacity of the septic tank is related to the number of bedrooms, is applicable mainly to middle and high-income areas. However, this method may also be used for lower-income areas if each room in the house is regarded as a bedroom. The main advantage of relating septic tank capacities to the number of (bed)rooms per house is that this method recognises the fact that the number of occupants at any particular time may vary. When using this method, each servant's room should count as an additional bedroom. Figure 4 should be used to determine the size of the septic tank needed. The figure is based on a 24 hour liquid retention time and the septic tank capacities indicated should prevent any appreciable discharge of sludge and scum.

(b) MULTI-HOME SEPTIC TANKS

These tanks should be able to handle variable sewage flow because approximately 45% of the total sewage flow takes place within a peak of 4 hours. Multi-compartment septic tanks are therefore a necessity. A multi-compartment effect could also be accomplished by using two or more septic tanks in series. Design features for these tanks are generally the same as for those serving single dwellings.

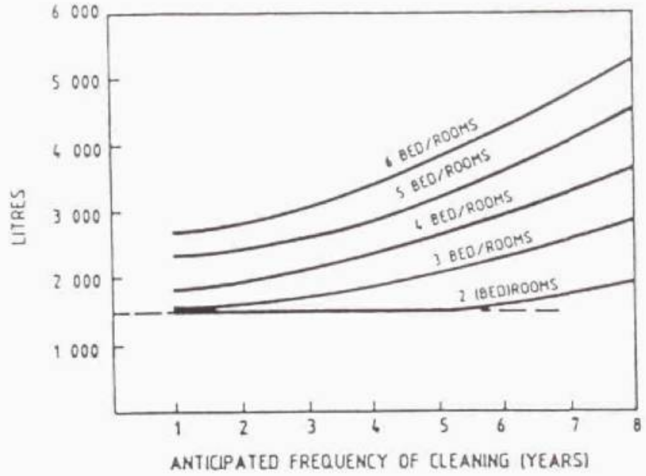


FIGURE 4: Septic tank capacity related to size of dwelling

[FROM: DE VILLIERS, 1987]

(c) NON-RESIDENTIAL ESTABLISHMENTS

Sewage flow from non-residential establishments fluctuates widely. Peak flows can be estimated by fixture-unit methods based on probability studies. This subject is fully covered in the National Building Regulations of 1985.

It is very difficult to provide "typical" sewage flows for non-residential establishments, since they are affected by many intangible factors. The values in Table 14 are meant to serve as a guide and should be applied cautiously.

It is extremely difficult to predict sludge and scum accumulation rates for non-residential establishments, as they will depend to a great extent on the quality of the incoming sewage. Qualities can vary significantly, since different establishments have different waste-generating sources.

In addition, effluents can contain many problem constituents, such as excessive grease or lint. For example, the quality of the effluent from a laundromat can be expected to differ from that of a cafeteria.

It is recommended that septic tanks for non-residential establishments be designed to have a capacity of at least three times the estimated average daily flow. Sludge and scum accumulation should be measured once yearly to establish the accumulation rate and, once known, these inspection intervals could be adjusted accordingly.

TABLE 14: Typical daily waste water flows from various non-residential establishments (US EPA, 1980)

Type of establishment	Unit	Litres/unit
Airport	Passenger	10
Bar	Customer	8
Boarding house	Person	140
Cafeteria	Customer	7
	Employee	40
Caravan park with central ablution block	Person	90
Cinema	Seat	10
Coffee shop	Customer	20
	Employee	40
Country club	Visitor	370
	Employee	50
Departmental store	Toilet	1 850
	Employee	40
	Meal served	30
	Person	140
Factory	Person/shift	140
Hotel with private bathrooms	Person	140
Hotel without private bathrooms	Person	110
	Bed	650
Hospital	Employee	40
Laundromat	Machine	2 000
Laundry (self-service)	Wash	180
Motel	Bed	90
Office building	Shift worker	90
Prison	Inmate	450
	Employee	40
Restaurant	Meal served	10
School	Student	40
Swimming pool	Person	10
Service station	Vehicle served	10
Visitor centre	Visitor	20

4.2 Fat and grease traps

Fat and grease traps are usually not needed for residential septic tanks, but should be provided for non-residential establishments such as restaurants, communal cooking facilities, hotels and service stations, where waste water is likely to contain above-average amounts of fat and grease. Special traps are also needed to remove foreign materials emanating from establishments such as hospitals, laundromats and public laundries. The effluent from any non-residential establishment needs to be investigated in order to establish whether it needs pre-treatment before discharge into the septic tank, particularly if its quality differs greatly from ordinary residential effluent. Typical grease traps are illustrated in Figure 5.

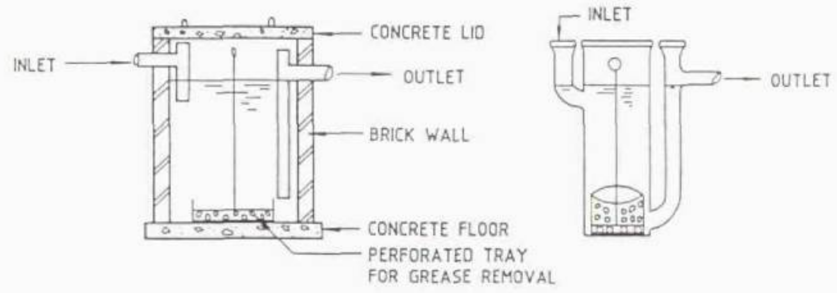


FIGURE 5: Typical grease traps

4.3 The drainage field

A proper site evaluation is fundamental to the design of a drainage field. It is unfortunately not easy to determine a soil's suitability for a long-term drainage field. There are several basic designs to choose from, namely trenches, beds, seepage pits, mounds, fills and artificially drained systems. Several factors should be considered when choosing which design to use.

- The objective of a drainage field design should be to maximise the surface expected to have the highest infiltration rate. This raises the side-wall versus bottom-surface infiltration issue. Research has shown that, in relatively permeable and homogeneous soils and in humid regions where percolating rainwater reduces the matrix potential along the side wall, the bottom surface is usually the main infiltrative surface. In the less humid areas and on sloping sites or sites with shallow restrictive horizons (such as a high groundwater table and bed rock), the side-wall area becomes the main absorption surface. Treating drainage fields as if all flow is either through the bottom or the side-wall surfaces may result in oversizing.

- The design should allow for a stress period of some specified frequency. This is particularly relevant along the southern Cape coast where highly seasonal rains result in raised groundwater levels and possible failure of the drainage field. Rutledge *et al.* (1982) suggest that a drainage field be designed to provide flow through the clogging layer from its lower portion during stress periods.

- The practice of alternating between drainage fields can extend the life of the system. The original absorptive capacity of a system can be restored by allowing it to rest for between 6 to 12 months. This consideration is not that important along the coast line, as many dwellings are occupied on a seasonal basis, resulting in long periods of minimal flow into the drainage field.

- ☐ Evapotranspiration is an important consideration in South Africa and drainage fields should be as shallow as possible. Evapotranspiration plays an important role, as in the coastal areas the periods of high effluent discharge coincide with peak evaporation and vegetation growth.

Two types of drainage field are recommended for the coastal zone:

(a) DRAINAGE TRENCHES/BEDS

Trench dimensions should be selected to suit soil and climatic conditions. In the wetter parts of South Africa shallower, wider trenches should be used, sized on the basis of trench-bed infiltration area while in the drier parts narrower, deeper trenches sized on the basis of the side-wall infiltration should be used.

Drainage beds are rather shallow but wide trenches. Although beds encourage evapotranspiration they are also most susceptible to the development of a clogging layer. Trenches are generally more desirable than beds because:

- trenches can provide up to five times more side wall surface area than beds for identical bottom-surface areas;
- less soil damage occurs during construction; and
- trenches can follow the contours of sloping sites.

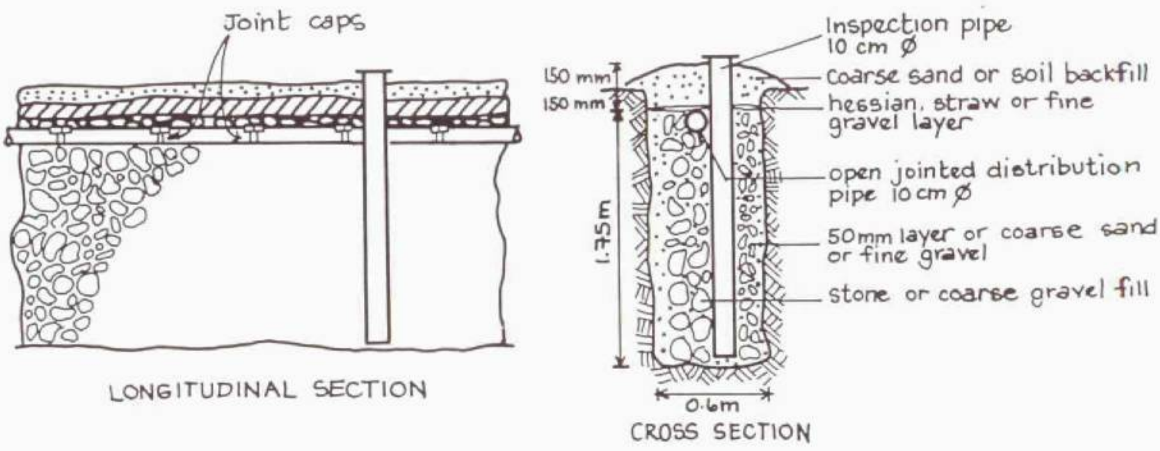


FIGURE 6: Detail of trench construction [FROM: DREWS, 1986]

The following aspects should be considered in trench construction (see Figure 6):

- Trenches should be constructed along the contour of the soil surface. Average trench widths are usually between 300 mm and 450 mm, while average depths are about 600 mm.
- After excavation, trench surfaces should be roughened to restore a natural infiltration surface.
- The side walls of the trenches should be lined with a suitable polyester filter fabric, or alternatively have a layer of fine gravel or coarse sand against the infiltrative surface to protect it.
- Filling material should be clean and from 20 mm to 100 mm in diameter. Builders' rubble is not acceptable.
- Effluent should be distributed by means of a suitable pipe laid near the top of the gravel fill. Prior to backfilling, a layer of polyester filter fabric should be placed on top of the bed to prevent soil from entering the trench. A topsoil cover of between 100 mm and 150 mm should be placed on top of the bed.
- Since the sizing of a drainage field depends on approximations, it is advisable to provide for possible extensions at a later stage.

This is the most popular design currently in use and takes full advantage of the high evapotranspiration rates experienced in South Africa. It has the added advantage that it can be extended relatively easily. A trench or bed design must, however, be used in the correct setting. There is no point, for example, in opting for a "bed" design (which is based on bottom-surface infiltration), when an impervious layer exists at depths of 2 to 3 m.

Mounded absorption systems represent a derivation of the conventional trench/bed system. They are suitable for areas with marginal soils, high groundwater tables or insufficient soil depth, all of which preclude the use of conventional drainage fields. A mound system is basically a drainage field elevated above the natural soil surface, consisting of suitable fill material. In essence, its purpose is to treat and distribute the septic tank effluent prior to its introduction into the natural soil (see Figure 7).

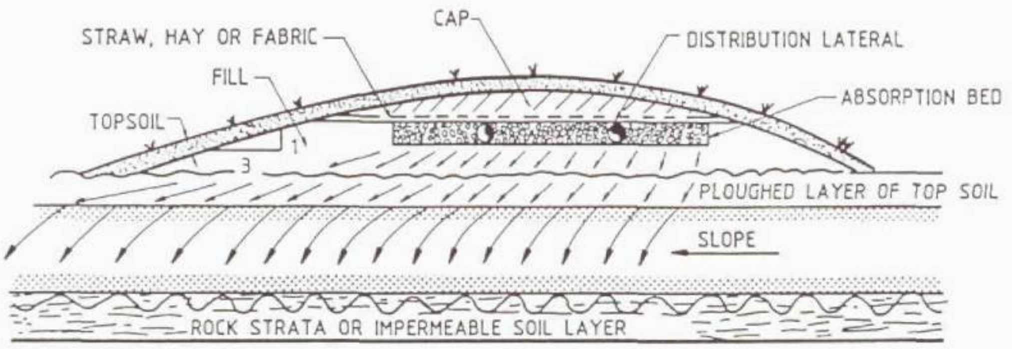


FIGURE 7(a): **Cross-section of a mound system for slowly permeable soil on a sloping site** (US EPA, 1980)

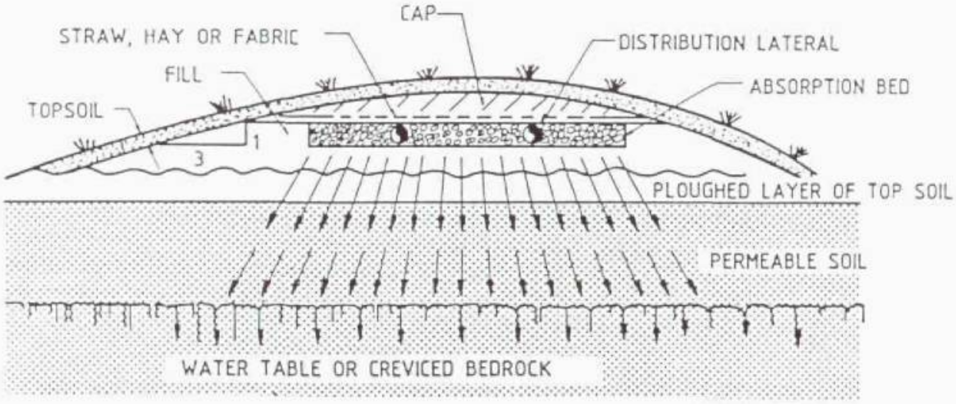


FIGURE 7(b): **Cross-section of a mound system for a permeable soil with high groundwater or shallow creviced bed rock**

(US EPA, 1980)

The two most important aspects of site selection are perhaps the permeability of the natural soil and the depth of the groundwater table. The site criteria for domestic mound systems have been summarised in Table 15. Very permeable material should be avoided when considering fill materials, because of its smaller capacity for treatment and the increased risk of surface seepage from the base of the mound, especially when used over less permeable soils. Commonly used fill materials in the USA and their design infiltration rates are presented in Table 16.

TABLE 15: Site criteria for domestic mound systems

Item	Criteria
Landscape position	Well-drained areas, level or sloping. Crests of slopes or convex slopes most desirable. Avoid depressions, bases of slopes and concave slopes unless suitable drainage is provided.
Slope	0 - 6% gradient for slowly permeable soils; 0 - 12% gradient for highly permeable soils such as coarse sand, gravel or pervious or creviced bedrock.
Suitable/recommended horizontal separation distances, from edge of basal area :	
Potable water sources:	15 to 30 m
Escarpments:	3 to 6 m
Site boundaries:	1.5 to 3 m
Building foundations:	3 to 6 m (9 m when located upslope from buildings in slowly permeable soils)
Soil profile	Soils with well-developed and relatively undisturbed topsoil are preferable.
Groundwater depth	0.5 to 0.6 m of unsaturated soil should exist between the original soil surface and seasonally saturated zones or pervious or creviced bedrock.
Depth to impermeable barrier	1 to 1.5 m (acceptable depth depends on the site)
Percolation rate	0 to 430 mm/hour measured at 0.3 to 0.5 m. (Tests are run at 0.5 m unless the water table is at 0.5 m, in which case it is run at 0.4 metres. In shallow soils over pervious or creviced bedrock, tests are run at 0.3 m.)

(FROM: US EPA, 1980)

TABLE 16: Commonly used (USA) fill materials and their design infiltration rates

Fill material	Design characteristics (percent by weight)	Infiltration (mm/day)
Medium sand	> 25% of 0.250 - 2.0 mm <30 - 35% of 0.050 - 0.25 mm < 5 - 10% of 0.002 - 0.05 mm	60
Sandy loam	Clay content of 5 - 15%	30
Sand/sandy loam mixture	88 - 93% sand, and 7 - 12% finer grained material	60

(AFTER: US EPA 1980)

The shape, size and layout of the mound are largely dictated by the characteristics of the site, such as permeability of the natural soil, the slope of the site and the depth of the saturated zone. The mound should be built in such a way as to ensure that the zone of saturation does not rise into the fill during stress periods. On level sites, the entire fill/natural soil interface can be used in calculating the required land area, but on sloping sites only the area below and downslope from the absorption field.

In general, drainage trenches are preferred to beds because they perform better. Trenches should be oriented with their long axis perpendicular to the natural ground slope and they should be no wider than indicated in Table 17. The mound should be oriented relative to the contours of the bed rock rather than to those of the ground surface.

Installation practices can have a great influence on the long-term performance of a mound system. Sandy fills in particular should be handled with care to minimise the segregation of particles. The recommendations listed below apply:

- Long narrow mounds, oriented parallel to the contour, should be constructed.
- Vegetation should be mown and hand-raked off the soil surface. Tree stumps should be cut flush with the soil surface and left in place.
- The soil surface should not be compacted, only chisel-ploughed. No heavy construction equipment should be permitted on the mound area, the fill, or directly downslope of the mound.
- Vegetation should be established on the mound surface.

Mound systems are considered to be expensive, often because of the sand fill. Furthermore, they cannot be built on small residential sites because of the large space requirements and the need to control the use of the land downslope of and immediately adjacent to the mound.

TABLE 17: Trench widths in relation to site characteristics

Site characteristics	Trench width
Depth to groundwater table between 300 and 600 mm	between 3 and 4.5 m respectively
Natural soil slowly permeable (<25 mm/hour)	less than 1.5 m
Presence of soil layers that may impede vertical movement of effluent	less than 1 m

[FROM: DE VILLIERS, 1987]

(b) DRAINAGE PITS

A drainage pit is basically a deep, covered excavation (Figure 8) and is ideal for situations where impervious soils (an impervious layer) are underlain by porous soils. Effluent enters the chamber, where it is stored until it seeps out through the base and side walls. Pits should have a diameter of between 1.8 m and 3.6 m and a depth of up to 6 m. When more than one pit is needed, the distance between one pit's side wall and the next side should be three times the diameter of the largest pit.

This design has a number of practical advantages. It is ideal for sites with limited available space for soakaways. It is also cheaper to construct and easier to check and maintain than the conventional trench system. It should be noted that the drainage field depicted in Figure 9 is not a drainage pit. This design, which was found to be popular along the south Cape coast, is not recommended. The drianage field design is hopelessly inadequate when the system is placed under stress, as is generally the case during holiday periods.

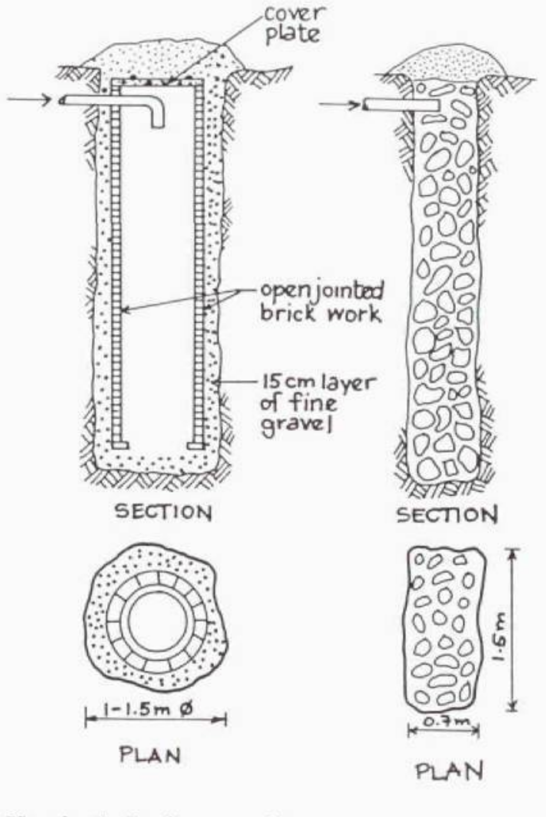
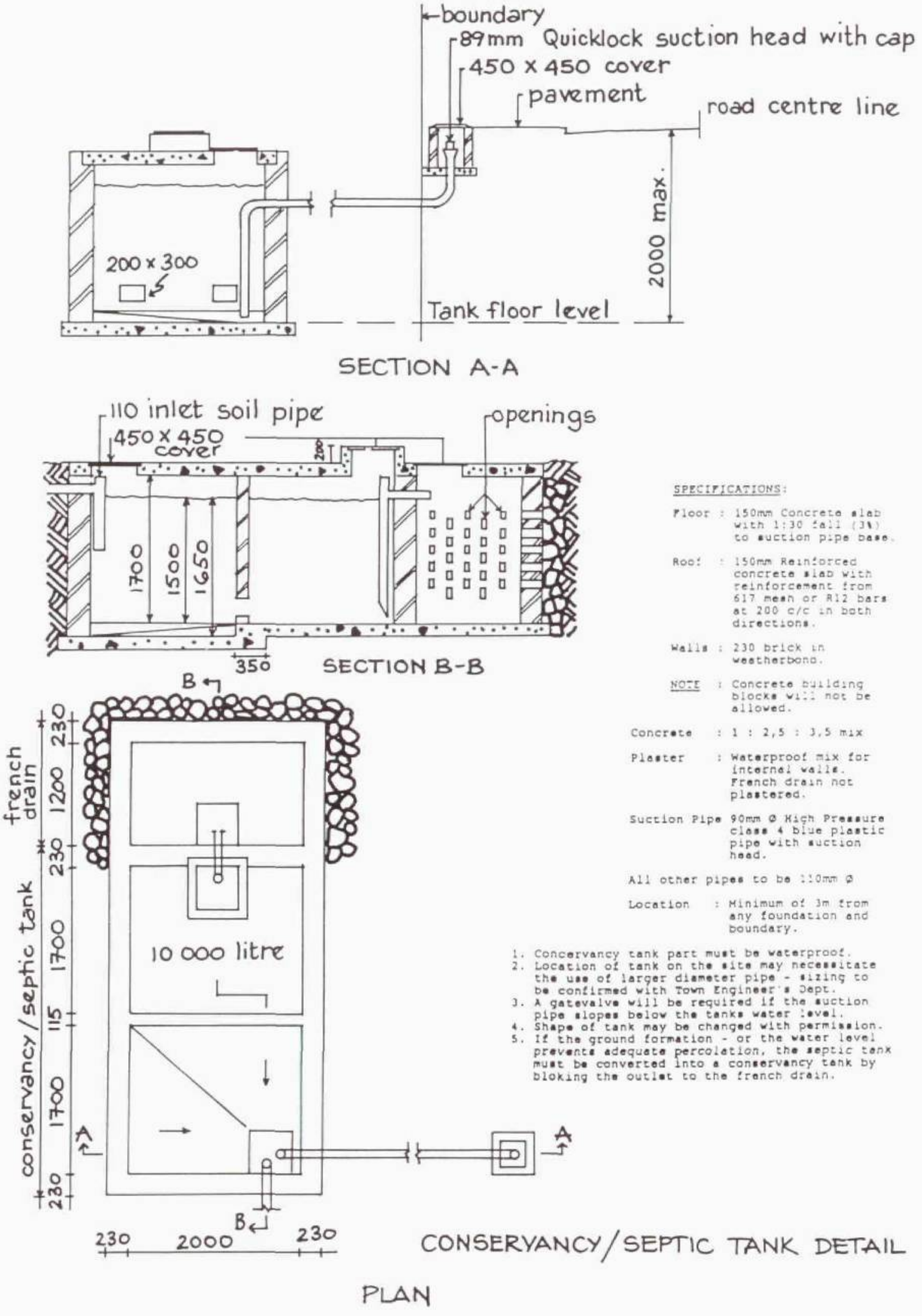


FIGURE 8: Typical drainage pits [FROM: DREWS, 1986]



SPECIFICATIONS:

Floor : 150mm Concrete slab with 1:30 fall (3%) to suction pipe base.

Roof : 150mm Reinforced concrete slab with reinforcement from 617 mesh or R12 bars at 200 c/c in both directions.

Walls : 230 brick in weatherbond.

NOTE : Concrete building blocks will not be allowed.

Concrete : 1 : 2,5 : 3,5 mix

Plaster : Waterproof mix for internal walls. French drain not plastered.

Suction Pipe 90mm Ø High Pressure class 4 blue plastic pipe with suction head.

All other pipes to be 110mm Ø

Location : Minimum of 3m from any foundation and boundary.

1. Concervancy tank part must be waterproof.
2. Location of tank on the site may necessitate the use of larger diameter pipe - sizing to be confirmed with Town Engineer's Dept.
3. A gatevalve will be required if the suction pipe slopes below the tanks water level.
4. Shape of tank may be changed with permission.
5. If the ground formation - or the water level prevents adequate percolation, the septic tank must be converted into a conservancy tank by bloking the outlet to the french drain.

FIGURE 9: Typical example of a septic tank system design as specified by a south coast local authority

BIBLIOGRAPHY

Canter, L.W. & Knox, R.C. (1986) *Septic tank system effects on groundwater quality.* Lewis Publ., Michigan, USA.

De Villiers, D.C. (1987a) *Septic tank subsurface absorption systems - a literature review.* NBRI Special Report BOU 78, CSIR, Pretoria, South Africa.

De Villiers, D.C. (1987b) *Septic tank systems.* NBRI Report BOU 93, CSIR, Pretoria, South Africa.

Drews, R.J.L.C. (1986) *A guide to the use of septic tanks systems in South Africa.* NIWR, Tech. Guide K86, CSIR, Pretoria, South Africa.

Kaplan, O.B. (1991) *Septic systems handbook.* Lewis Publ., Michigan, USA.

Malan, W.M. (1964) *A guide to the use of septic tank systems in South Africa.* CSIR Report 219, CSIR, Pretoria, South Africa.

Rutledge, E.M., Mote, C.R., Stafford, P.S., Mitchell, D.T. & Scott, D.D. (1982) *Designing septic tank filter fields in soils with hydraulically limiting surface horizons.* Proceedings of the Third National Symposium on Individual and Small Community Sewage Treatment. ASAE Report 1 - 82 American Society of Agricultural Engineers, Michigan, USA.

US EPA (1977) Report to Congress: *Waste disposal practices and their effects on groundwater.* Report No. EPA 570/9 - 77 - 001, Washington, USA.

US EPA (1980) Design manual: *On-site wastewater treatment and disposal systems.* Report No. EPA 625/1 - 80 - 012, Cincinnati, USA.

Wells, M. (1987) *Assessment of land capability for on-site septic tank effluent disposal.* Division of Resource Management Tech Report No. 63, Western Australian Department of Agriculture, Australia.

Wright, A. (1995) *The use of septic tank systems in the South African coastal zone.* WRC Report 597/1/95, Water Research Commission, Pretoria.