Septic Tank Systems in the South African Coastal Zone

A Wright

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SEPTIC TANK SYSTEMS IN THE SOUTH AFRICAN COASTAL ZONE

Compiled for

Water Research Commission

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PREFACE

The septic tank system is the most commonly used method of domestic waste water treatment in the coastal zone. The technology is well established and a wealth of technical information exists on the subject. The perception, however, exists that this method of on-site sanitation is both second rate and ineffective. In order to understand the issue better the Water Research Commission provided funds for a project to:

define the issues related to septic tank systems in the coastal zone and
develop documents for the transfer of existing technical knowledge to the user level.

The full title of the project was:

"Technology adaptation for successful application of septic tank systems in the coastal zone".

The project, carried out by the Groundwater Programme of Watertek, CSIR, resulted in three technology transfer documents:

(a) "Septic tank systems in the South African coastal zone";
(b) "Guidelines for the use of septic tank systems in the South African coastal zone"; and
(c) "SEPTIC TANKS - how do they work & what can go wrong?" (a double-sided leaflet).

The project commenced in January 1994 and was completed in July 1995.

ACKNOWLEDGEMENTS

The research in this report emanated from a project funded by the Water Research Commission (WRC) entitled:

"Technology adaptation for successful application of septic tank systems in the coastal zone".

The Steering Committee responsible for the project consisted of the following persons:

Mr H C Chapman	WRC (Chairman)
Dr S A Mitchell	WRC
Mr F P Marais	WRC
Prof. G C Bate	UPE
Prof. D Baird	UPE
Prof. I Rust	UPE
Mr G Norris	CSIR
Ms P Rathbone	CSIR
Mr B Taylor	CSIR
Ms B Genthe	CSIR

The financing of the project by the WRC and the contributions of the members of the Steering Committee are gratefully acknowledged.

The CSIR is thanked for co-sponsoring the case study undertaken in the South-Western Cape during this project. Finally I would like to thank all my colleagues in the Groundwater Programme for their encouragement and assistance, in particular Ivan Williams, Alan Hön, Roger Parsons and Pannie Engelbrecht.

EXECUTIVE SUMMARY

Septic tank and soakaway systems are the most widely used system of waste water disposal in the South African coastal area. In view of the highly variable loadings linked to holiday seasons, few resorts have water-borne sewerage and even many of the newer developments rely on conservancy tanks and a centralized waste water soakaway system. The design and management of these systems vary from area to area and even within single municipalities, as different design criteria have been applied over the years. This *ad hoc* approach, coupled with rather limited local technical expertise, has led to septic tank systems being the single most important pollution hazard in the region. Not only does it involve contamination of groundwater, but also stormwater runoff and ultimately the local lagoon, estuary or bay. Bacteria, viruses, nitrate and synthetic organic chemicals have been identified as the major pollutants (Canter & Knox, 1986).

The potential for serious pollution from septic tank systems is increased due to the fact that:

(a) many of the resorts/towns/settlements are located on unconfined sandy aquifers;

(b) shallow groundwater levels and poor storm drainage during the wet winter season cause serious water logging in the Southern Cape;

(c) many existing waste water disposal systems were not designed for the higher population densities now found in the coastal area, especially with the peak loads experienced during holiday periods;

(d) groundwater is often abstracted via wellpoints in close proximity to soakaways;

(e) the more affluent nature of the people making use of the area is resulting in an increase in the use of modern household cleaning agents, which contribute an ever-increasing number of synthetic organics and other chemicals; and

(f) there is no standard set of guidelines applicable to South African conditions.

The subject of septic tank systems and possible groundwater contamination has received extensive coverage in the developed world. A wealth of technical information therefore exists and, if correctly installed and designed, septic tank systems are highly effective means of waste water treatment and disposal.

Initial indications, however, showed that the average property owner, and even local authorities, have a very rudimentary understanding of septic tank systems. Many of the holiday homes are owned by city dwellers, who are accustomed to water-borne sewage and have therefore never had to ponder about what happens to waste water beyond the toilet bowl and kitchen sink. This, combined with the lack of specific national legislation on the use of septic tank systems, has led to the general misuse of this technology, with often disastrous effects. The major issue therefore appeared to be the adaptation of existing information to the South African situation and the transfer of technology and provision of decision support to local administrators/managers/town engineers.

In order to address this situation the Water Research Commission provided funds for the CSIR to undertake an 18 month study to:

- define the issues related to septic tank systems in the coastal zone and
- develop documents for the transfer of existing technical knowledge to the user level.

The study was divided into three components: the collection of information, field verification and technology transfer.

Methodology

A comprehensive literature search was undertaken using WATERLIT of the South African Water Information Centre. In addition personal contact was made with a number of researchers in South Africa, North America, Australia and the United Kingdom. Two different questionnaires were sent out: one to all regional and local authorities along the Cape coastline and one to all consulting civil engineers operating in the coastal zone.

Field verification involved visits to those towns/settlements between the Berg and Great Kei River mouths. Past CSIR pollution assessment investigations which took place within the coastal zone were revisited. Five of these were found to have relevance to the present study and this information could be incorporated in the project. A brief case study was undertaken in the South-Western Cape to obtain a better understanding of the effectiveness of these systems in coastal sands. Groundwater quality monitoring was done at three different septic tank systems. These were considered representative of the most common categories of usage along the coastline.

During the course of the project it became clear that there were three target groups for the technology transfer: those responsible for designing and constructing septic tank systems, the local and regional authorities responsible for administration/management and the individual user/property owner. Their different needs were met by means of three technology transfer documents:

(a) "Septic tank systems in the South African coastal zone";
(b) "Guidelines for the use of septic tank systems in the South African coastal zone"; and
(c) "SEPTIC TANKS - how do they work & what can go wrong?".

Study results

(a) 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.

(b) 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.

(c) 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.

(d) 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;
- shallow depths to bedrock.

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

(e) Pollutants of greatest concern in the coastal context are nutrients (nitrates and phosphates) and biological contaminants (bacteria, parasites and viruses). Field studies indicated that a correctly designed and constructed drainage field effectively retains these pollutants within a radius of 15 to 20 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 100m.

(f) 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 system has long periods in which to recover. This recovery period results in many systems that would fail under normal circumstances operating efficiently in the long term.

(g) 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 maintenance.

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

Conclusion

The study achieved its overall objective in that a better understanding was obtained of the status of septic tank technology in the coastal zone, user groups were identified and technology transfer documents were developed.

Recommendations

(a) The use of septic tank systems should continue and be actively promoted as a cost-efficient means of domestic waste water disposal.

(b) Regional and local authorities need to develop their technical capabilities further in order to manage septic tank system usage effectively. The usage of septic tank systems should be based firstly on land capability maps and secondly on site-specific assessments.

(c) Communal/municipal effluent disposal sites (in whichever form these may occur) should comply with the Water Act. This must be actively enforced by the DWA&F and receive the same priority rating as landfill sites.

(d) Any further research/investigations relating to septic tank systems in the coastal sands should be site-specific and problem-related.

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1 INTRODUCTION

Septic tank systems are widely used in the South African coastal zone. Serving as a popular holiday destination the area experiences a marked seasonal influx of visitors, which, combined with the sandy conditions, makes septic tanks the most cost-effective means of on-site sanitation. Only in the larger towns and cities is it really economically feasible to make use of water-borne sewage and treatment works. Unfortunately many of the septic tank systems appear to have failed or are problematic at some stage during the year. For this reason local and regional authorities tend to consider on-site sanitation as a temporary solution and strive to install water-borne sewage wherever possible. A recent trend has been to restrict the use of drainage fields/soakaways and insist on conservancy tanks, with effluent pumped out and removed by tanker. The effluent is then either trucked to a waste water treatment plant at the nearest large town or disposed of at a communal site.

It is of great concern that the use of septic tank systems is often frowned upon and generally considered a "low-tech", second-rate means of waste water disposal. Septic tank systems that have been properly designed, constructed and maintained are efficient and economical alternatives to public sewage disposal systems. The current situation basically results from a poor understanding of on-site sanitation technology and lack of clear guidance from central and regional government. Unfortunately the average property owner, and even local authorities, often have a very rudimentary understanding of septic tank systems. Many of the holiday homes are owned by city dwellers, who are accustomed to water-borne sewage and have therefore never had to ponder about what happens to waste water beyond the toilet bowl or kitchen sink. This, combined with the lack of specific national legislation on the use of septic tank systems, has led to the general misuse of this technology, with often disastrous effects.

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 functions correctly (Canter & Knox, 1986). 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. The potential for serious pollution in the coastal area is increased due to the fact that:

(a) many of the resorts/towns/settlements are located on unconfined aquifers;

(b) shallow groundwater levels and poor storm drainage during the wet winter season cause serious water logging in the Southern Cape;

(c) many existing waste water disposal systems were not designed for the higher population densities now found in the coastal area, especially with the peak loads experienced during holiday periods;

(d) groundwater is often extracted via wellpoints in close proximity to soakaways;

(e) the more affluent nature of the people making use of the area is resulting in an increase in the use of modern household cleaning agents, which contribute an ever-increasing number of synthetic organics and other chemicals; and

(f) there is no standard set of guidelines applicable to South African conditions.

For this reason the Water Research Commission (WRC) provided funds for an 18 month study by the CSIR to define the issues related to septic tank systems in the coastal zone and develop documents for the transfer of existing technical knowledge to the user level. The study was undertaken in three phases: the collection of information, field verification and technology transfer.

A comprehensive literature search was undertaken using WATERLIT of the South African Water Information Centre. In addition personal contact was made with a number of researchers in South Africa, Australia, North America and the United Kingdom by means of mail, E-mail and the telephone. The most useful information was obtained from:

CSIRO, Western Australia
Geological Survey, Western Australia
CIRIA, United Kingdom
EPA, USA
Boutek, CSIR

Two different questionnaires were sent out: one to all regional and local authorities in the Cape coastal zone and one to all consulting civil engineers operating in the coastal zone. A total of 198 letters and questionnaires was sent. Examples of the letter and questionnaire are provided in Appendix A. A full list of all the organizations approached is not included, but is available on request.

Field verification involved both a case study at a selected site in the South-Western Cape and field visits to selected areas along the coast. Past CSIR pollution assessment investigations which took place within the coastal zone were revisited. Five of these were found to have relevance to the present study and the information was incorporated into the project.

During the course of the project it became clear that the technology transfer should be aimed at:

(a) those responsible for designing and constructing septic tank systems; and

(b) the local and regional authorities responsible for administrating/managing those areas using septic tank systems.

This report is meant specifically for the second target group. The second report, "Guidelines for the use of septic tank systems in the South African coastal zone" (WRC 597/2/95), although specifically for the first target group, should also be acquired by the administrator/manager group. A third product, a double-sided information leaflet entitled "SEPTIC TANKS - how do they work & what can go wrong?" is specifically for the general user/property owner.

2 SEPTIC TANK SYSTEMS

The basic septic tank system (Figure 1) consists of a buried tank and subsurface drainage field (Soakaway/French drain). Waste water (toilet flushing; 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 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.

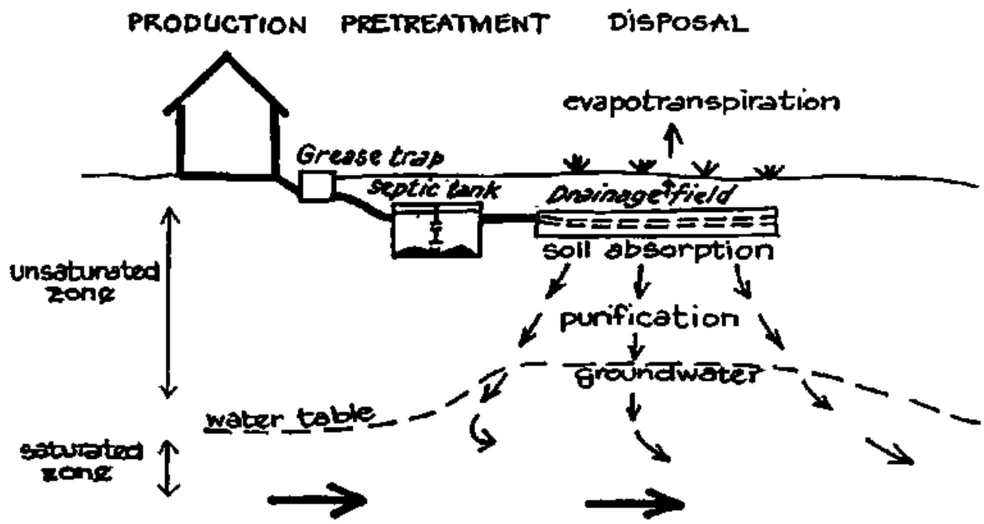


Figure 1: **Schematic cross-section through a conventional septic tank soil disposal system for on-site disposal and treatment of domestic liquid waste**

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. This is 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).

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 discharge 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 core given to periodic maintenance.

3 CURRENT PRACTICE AND COMMON PROBLEMS

3.1 Current practice

No authoritative figures are yet available on the numbers of septic tank systems currently in use along the coast. Research (Swart, 1995) at the Department of Botany, University of Port Elizabeth, should, in the very near future, provide greater insight into the subject. It is, however, clear that septic tank systems are used throughout the coastal zone. Even the larger towns and metropolitan areas still make use of septic tanks, even if only on a very limited scale.

No specific regulations/legal requirements exist on a national level with regard to septic tank systems. The Water Act contains no legislation dealing specifically with design criteria or the placement of septic tanks and soakaways. Section 21(1) of the Water Act requires that any person who is using water for industrial purposes (including water used for or in connection with a sewerage system) shall purify such water to a laid-down standard and then return it to the public stream where the water was originally abstracted (if it originally came from a public stream).

Section 21(2)(a) of the Water Act exempts water in a septic tank or French drain sewerage system from the requirements laid down in sections 21(1)(a) and (b) (i.e. that the effluent should be treated and returned to source), unless the Minister directs otherwise, as would be necessary in the circumstances indicated below.

From the point of view of the Department of Water Affairs and Forestry (DWA&F), septic tanks and soakaways are only suited for domestic-type effluent and must not lead to the pollution of ground or surface water. Should pollution occur it would be regarded as an infringement of sections 22 and 23 of the Water Act and would have to be curtailed. Septic tank systems are not acceptable for the treatment of industrial effluent under any circumstances.

Where septic tank effluent is disposed of by means other than French drains (soakaways) it is subject to Sections 21 and 23 of the Water Act. Section 23 of the Water Act states that any persons who, willingly or negligently, carry out any act (e.g. the placement of septic tank systems too near a river (sea) or on top of an underground water source) which could pollute public or private water, including underground water, or sea water in such a way as to render it less fit for the purpose it could ordinarily be used, shall be guilty of an offence. The approach of the Department is thus very much reactive with regard to septic tank systems. No design or construction criteria are laid down in order to minimize the risk of problems occurring. What it does provide is standards against which identified problems may be measured. There is no direct requirement for monitoring or policing of the situation in order to identify problems at an early stage.

Although Section 38 of the Health Act,1977 (Act 63 of 1977), enables the Minister of Health to make regulations relating to the regulation, control, restriction or prohibition of septic tank-related matters, no such regulations have yet been promulgated (Van Rooyen, Dept of Health, pers. com., 1995). Section 20 of the Act does, however, regulate for certain duties and powers of local authorities in this regard. The relevant part of this section is given below (the key words are italicized):

Duties and powers of local authorities

20. (1) Every local authority shall take all lawful, necessary and reasonably practicable measures-

(a) to maintain its district at all times in a hygienic and clean condition;

(b) to prevent the occurrence within its district of -

(i) *any nuisance*;

(ii) any unhygienic condition;

(iii) any offensive condition, or

(iv) any *other condition which will* or could be harmful or dangerous to the health of any person within its district or the district of any other local authority,

or, where a nuisance or condition referred to in subparagraphs (i) to (iv), inclusive, has so occurred, to abate, or cause to be abated, such nuisance, or remedy, or cause to be remedied, such condition, as the case may be;

(c) *to prevent the pollution of any water* intended for the use of the inhabitants of its district, irrespective of whether such water is obtained from sources within or outside its district, or to purify such water which has become so polluted;

(d) to render in its district, subject to the provisions of this Act or any other law, services approved by the Minister for -

- (i) the prevention of communicable diseases;
- (ii) the promotion of the health of persons; and
- (iii) the rehabilitation in the community of persons cured of any medical condition,

and to co-ordinate such services with due regard to similar services rendered by the Department of Health and Welfare or the provincial administration of the province in which its district is situated.

The term "nuisance" is further defined as:

(a) any stream, pool, marsh, ditch, gutter, watercourse, cistern, watercloset, earthcloset, urinal, *cesspool, cesspit, drain, sewer,* dung pit, slop tank, ash heap or dung heap so foul or in such a state or so *situated or constructed as to be offensive or to be injurious or* dangerous to health;

(b)-(i)................

The effective control of septic tank system usage therefore rests with local authorities. The responsibility lies specifically with the local health official and/or building inspector. Each municipality has its own design and construction criteria, normally summarized on a single A4 sheet. Figures 2 to 5 show examples of these sheets for various areas along the coast. The level of technical expertise, with regard to septic tank systems, held by these local officials varies dramatically. Surprisingly few officials have any authoritative guidelines or reference literature on the subject and decisions are often based on "this is how we've always done it in the past" thinking. Individual building plans and a formal application for constructing a septic tank system are not required by most local authorities. The local builder is, in reality, the person who advises private individuals and developers as to what type of septic tank system can be installed. This is based on (a) the local municipal regulations (the single information sheet), and (b) the builder's experience and knowledge of local conditions. There is no formal requirement for a land capability assessment. The only formal check is a site visit by the building inspector during or on completion of construction. Thereafter there is no contact between the property owner (user) and the local authority, unless a complaint is lodged concerning the malfunction of the system.

In the case of public amenities such as caravan parks, recreation centres and public ablution facilities, the design is normally done by consulting engineers. In this case, design plans are produced and some type of site assessment is carried out. The site assessment may include the excavation of shallow pits for soil profiles and laboratory tests, which include particle size analysis, California Bearing Ratio and consolidometer tests on "heaving" clays. A dropweight cone penetrometer (DCP) test may also be included in the geotechnical investigation. The extent of the investigation depends largely on the professional integrity of the consulting engineer, who generally makes use of the existing CSIR documents (de Villiers, 1987), SABS standards and local authority specifications. All consultants claim to consider the environmental impact of the system before finalizing the design. It would, however, appear that very few bother with a percolation test.

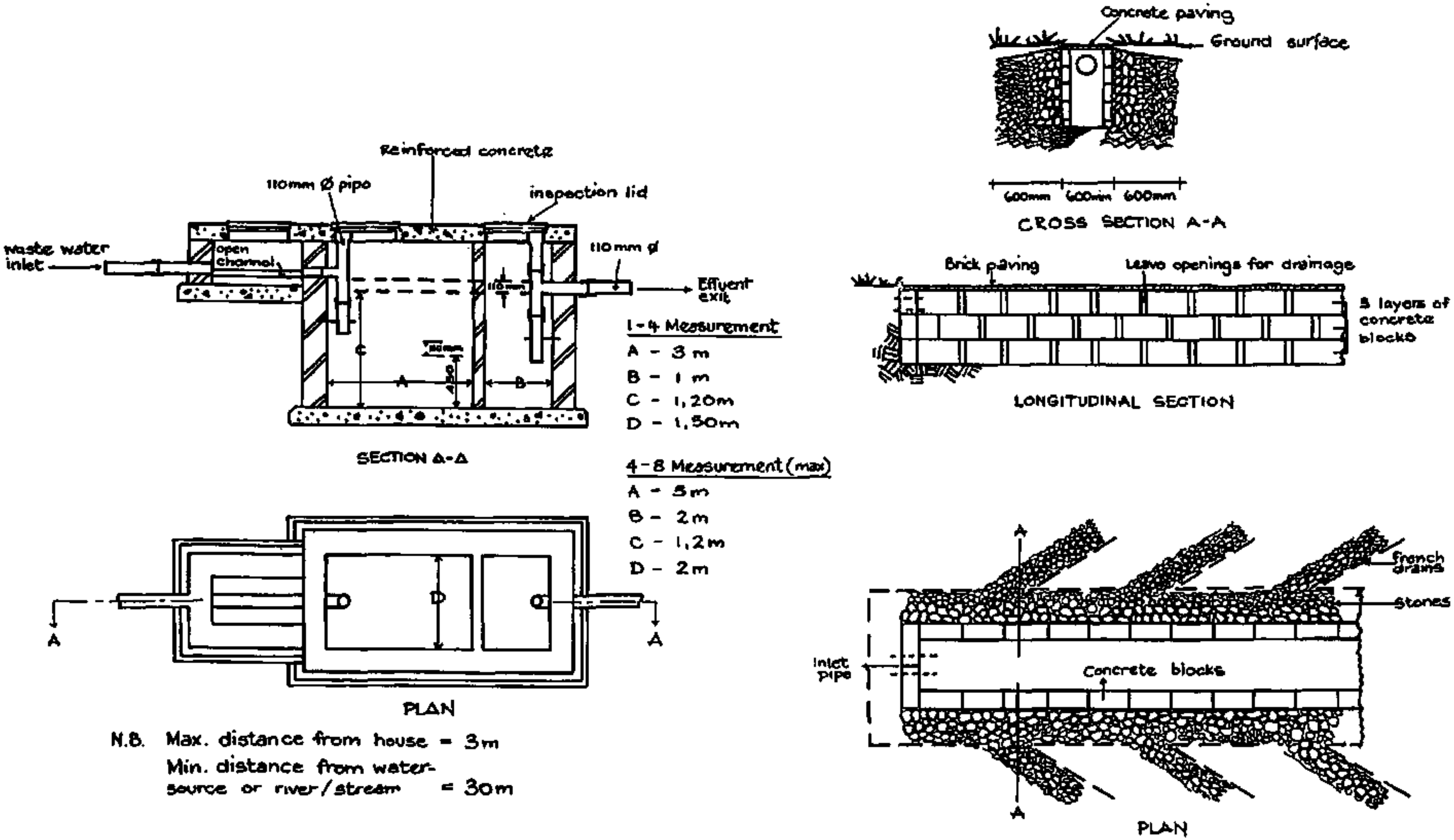


Figure 2: A typical example of a septic tank system designed as specified by a West Coast local authority

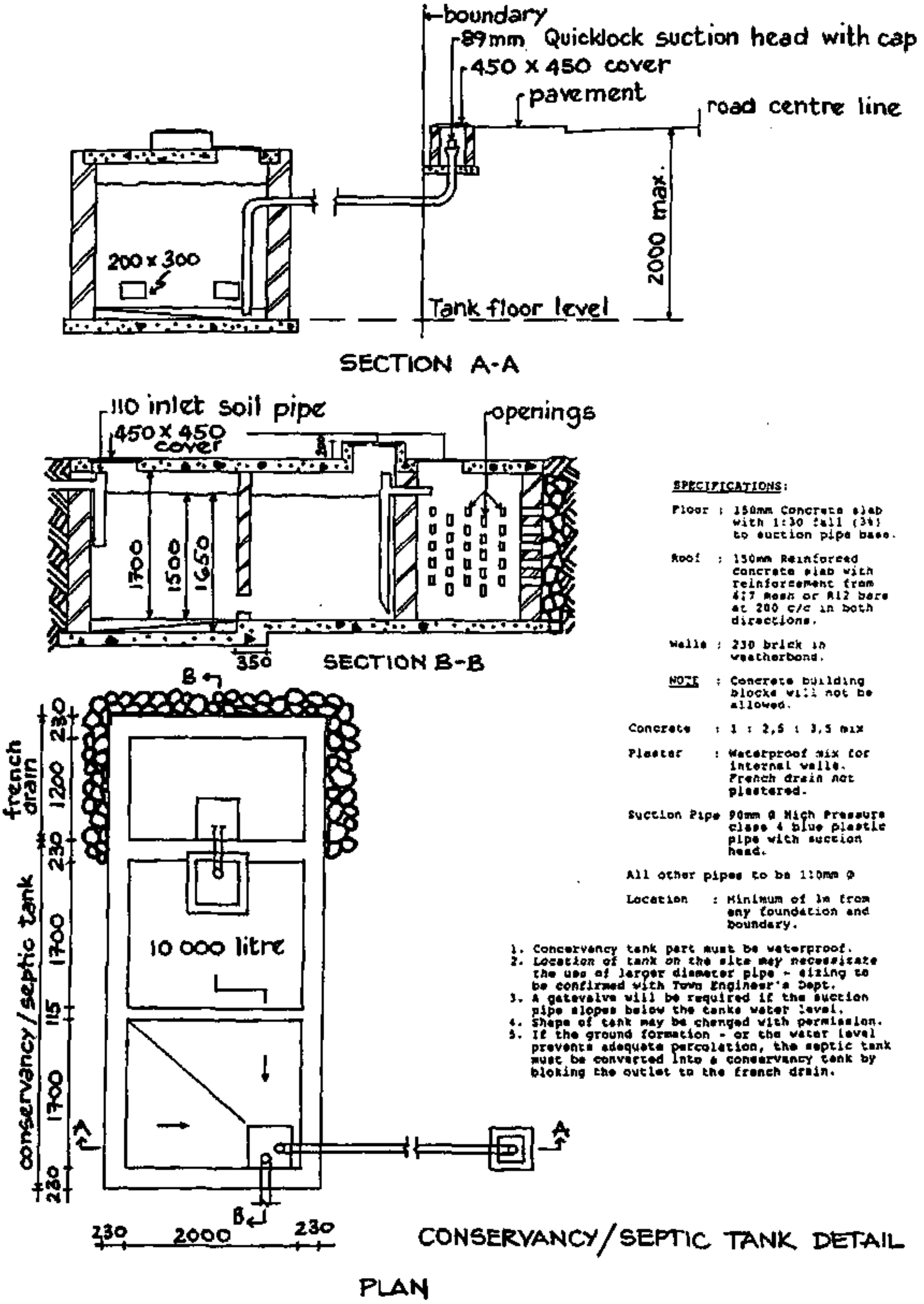


Figure 3: **A typical example of a septic tank system designed as specified by a South Coast local authority**

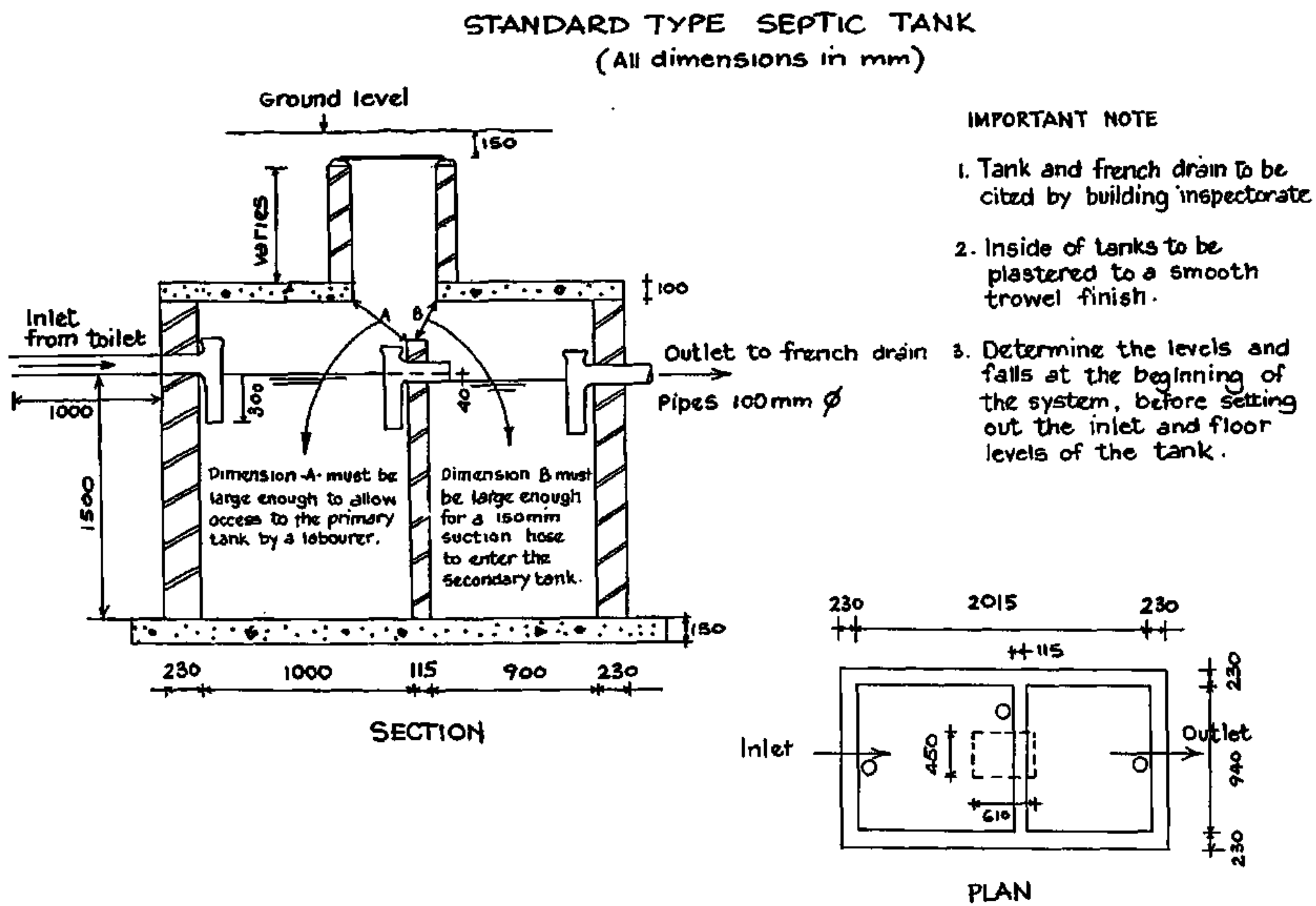


Figure 4: **A typical example of a septic tank system designed as specified by an Eastern Cape local authority**

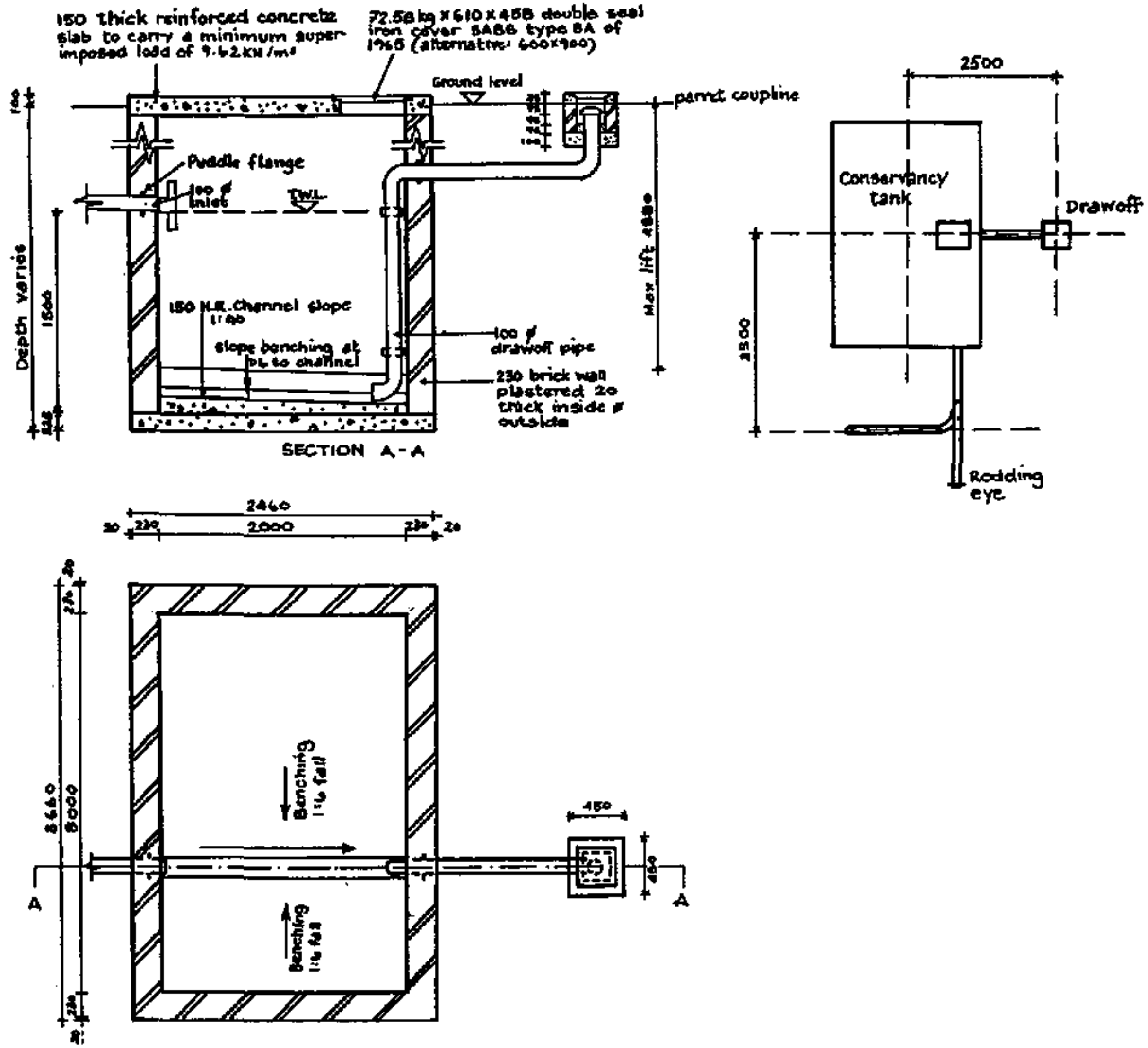


Figure 5: Typical design criteria for a conservancy tank

A common problem with these larger (communal) septic tank systems is that the final system differs somewhat from that which was planned. The original design plans produced by the consulting engineer are approved by the local authority, after which the construction is undertaken by a local builder. At this stage, deviations start to occur: the construction period is clearly often not supervised by the consultant; cutbacks in the budget force changes; and builders take short-cuts or use inferior materials to save money (boost profits). This is particularly relevant with regard to drainage fields and is a major cause of failure. In the case of drainage beds, a confining layer/horizon is often intersected at shallow depths. If difficulties are encountered in getting through this layer the plans are ignored/altered and the drainage bed is constructed above the layer. The principle of having an adequate depth to the impermeable layer/seasonal water table is thus ignored. The end result is failure of drainage field and surface seepage from the system. In the case of trenches a common problem is that the trench is (a) filled with builder's rubble and (b) does not have a distributor pipe the full length of the trench. This effectively restricts seepage to the first part of the trench and for all practical purposes the remainder of the trench serves no purpose whatsoever.

The highly seasonal use of septic tank systems is an important characteristic of the coastal zone. Many of the systems are only used during holiday periods or over weekends. However, when used, they often have to cope with peak loads. This results in temporary problems; drainage fields prove inadequate and result in surface seepage or flooded septic tanks. The periods of non-use, however, allow the drainage field to recuperate and in the long term the system operates efficiently.

Several municipalities now no longer allow the construction of drainage fields due to past problems. In these areas the outlets from the old septic tanks have been blocked and the tanks act as conservancy tanks. The effluent is pumped out by the municipality and disposed of at a central point, either at one of the larger neighbouring towns that has a waste water treatment works or locally by means of surface spreading or infiltration in open trenches. The conservancy tank principle is now generally accepted as the standard approach for those facilities tnat cater for large numbers of people (e.g. caravan parks, hotels, commercial concerns). The danger of this method is that it is assumed that the conservancy tank is constructed correctly (Figure 5) and therefore no local pollution can take place. This is not in reality necessarily true, as most of the old septic tanks now leak and there is no monitoring to check for this potential pollution. The biggest danger revolves around the local disposal of effluent at a communal site. From the many such sites visited it was clear that no proper land capability assessment had been carried out prior to commissioning and no monitoring takes place to assess the resultant impact on the environment. There is no doubt that many of the sites contravene the Water Act and require urgent attention.

The higher population densities along the Kwazulu/Natal stretch of coastline, especially the South Coast, have resulted in local and regional authorities assuming greater control than elsewhere with regard to the use of septic tank systems. The approach taken in most municipalities follows that accepted by Kloof. The Town Planning Regulations for Kloof were developed by the consultants Drennan, Maud & Partners and are now widely used by other consulting engineers. Their approach is very much that which is prescribed in WRC report 597/2/95 "Guidelines for the use of septic tank systems in the South African coastal zone". Special attention is, however, given to the evapotranspiration area. In contrast to the septic tank and drainage field components, the evapotranspiration area is not constructed and can therefore not really be designed to meet the requirements of a specific site. At best the extent of the evapotranspiration area can be controlled and the evapotranspiration characteristics can be modified slightly by the expediency of installing subsoil drainage to divert natural seepage around it, and by planting suitable vegetation to achieve optimum evapotranspiration.

Inherent in the function of the evapotranspiration area is the fact that the effectiveness of this function is dependent upon seasonal fluctuations, poor function being associated with periods of prolonged rainfall and dormant vegetal activity in the cooler winter months. In addition, function can be severely impaired by casual, indiscriminate site development which may occur subsequent to design and installation of the disposal system. Such impairment can result from subdivision, landscaping, driveway construction, paving, swimming pool construction or indiscreet location of new stormwater soakpits. This problem becomes particularly acute on small steep sites with a shallow soil cover.

3.2 Common problems

The symptoms of common septic tank system problems are relatively few and often occur simultaneously. They are:

(a) odour nuisance;
(b) backing up of waste water;
(c) surface flooding or seepage;
(d) local watercourse pollution; and
(e) groundwater pollution.

These symptoms may occur inside the dwelling, outside the dwelling or in the surrounding area. Table 1 lists the immediate causes of these symptoms, which are discussed in more detail below. Most of the problems described can be traced back to poor location or lack of maintenance.

The septic tank

Literature places great emphasis on the need for desludging septic tanks. The accumulation of sludge in the septic tank is reported as a major cause of odour, sewage back-up and overflow problems. This was not, however, found to be true in the field. Very few septic tanks, in fact, have to be desludged as such.

What does happen is that the system is incorrectly used and blockages occur that result in the tank filling with effluent. The blockage is generally caused by the disposal of coarse, non-degradable solids such as cigarette butts, facial tissues, sanitary pads, rags, bottle tops and disposable nappies. The local authority then has to be called in to empty the tank.

TABLE 1: Symptoms and immediate causes of septic tank system problems

SYMPTOM	CAUSE
INSIDE THE DWELLING	
* Waste water drains slowly or not at all from bath, shower, hand basin, etc. Rising waterlevel in toilet bowel.	* Blocked septic tank due to incorrect use. Sagging or blocked drains.
OUTSIDE THE DWELLING	
* Odours around septic tank.	* Blocked septic tank due to incorrect use. Malfunction of septic tank due to excessive use of detergents, disinfectants and chemical cleansers. Blocked grease trap/fouling grid.
* Sewage overflow from septic tank.	* Blocked septic tank due to incorrect use. Sagging or blocked drains. Flooded tank due to blocked drainage field.
* Septic tank lifts/fills with water.	* High groundwater table.
* Surface seepage around drainage field. * Exceptional vegetation growth. * Marshy/water-logged conditions. * Surface runoff.	* Blocked drainage field. Drainage field capacity inadequate. Inadequate infiltration. Inappropriate topography.
LOCAL AREA	
* Pollution of local groundwater.	* Poor location of drainage field. Proliferation of tanks in sensitive area.
* Eutrophication of nearby surface water bodies.	* Deliberate, illegal overflow connection. Proliferation of tanks. Poor location of drainage field.

Malodorous odours may initially be produced with a new septic tank. These may persist for a few weeks until the system has stabilized, after which it should be almost odourless. The practice of throwing dead cats, fowls or fish into a new tank to "kick start" the bacterial activity has no merit and only leads to blockages in the outlet pipes. The only "starter" which is likely to bring about stabilization of the digestion process is a few buckets of sludge from an operating septic tank (Drews, 1986). A handful of slaked lime helps remove the initial odours.

The use of most commercially available synthetic detergents, soaps, disinfectants and chemical cleansers has no significant adverse effect on the septic tank. There are one or two that are harmful, but these are clearly marked "not suitable for use in septic tanks". **Excessive use** of detergents, disinfectants and chemical cleansers will, however, inhibit the natural bacterial activity that needs to take place in the septic tank. This will result in poorer quality effluent leaving the tank and entering the drainage basin, where it can either result in clogging or ultimately contamination of the subsurface environment. Many of the cleaners sold for septic tank systems contain sodium or potassium hydroxide (caustic soda or caustic potash), which can result in belching of the sludge in the septic tank and excessive discharge of sludge to the drainage field (Drews, 1986).

Sagging inlet drains are a result of poor design and construction. This is not, however, a common problem and recurrent blockages are more likely to be due to improper use. Undersizing of the tank is usually associated with a change of use, leading to overloading of an existing tank. When houses served by septic tanks change hands, the new owners are often not aware of the septic tank system. Change of ownership is often also accompanied by a change in water use patterns, which can render a tank which has functioned without problems for many years inadequate.

Septic tanks installed in areas where there is a high water table may fill due to groundwater seepage. In the case of prefabricated tanks these may even become dislodged. Many local authorities allow septic tank systems to be installed in areas prone to seasonal flooding/high water tables. It is also still common practice for septic tank systems to be installed in the flood plain adjacent to lagoons, estuaries and lakes, dewatering being necessary in order for the builder to install the septic tank. There is no doubt that pollution takes place in these situations, although this is often difficult to prove, as the adjacent surface water body dominates the hydrological regime.

The drainage field

Blockage of the drainage field is a very common problem which occurs either because the ground conditions are unsuitable or because of solids carryover from the tank. Most blockages occur either within 18 months of installation (where the conditions are unsuitable) or long after installation because the tanks have not been emptied (see below). Blockages most frequently occur when the ground is saturated and effluent cannot drain away quickly. This commonly occurs in the winter rainfall area as a direct result of a perched groundwater table. In these circumstances a pit-type drainage field is more appropriate. The pit must, however, penetrate to well below the impervious layer. An unacceptable variation of the pit drainage field is currently in use at many of the coastal resorts/towns. These drainage fields, as designed, are literally an extension of the drainage tank (Figure 3) and merely represent a third chamber. The design would be acceptable if the depth was greater than 3 m, rather than the 1.5m maximum which is currently the norm.

A drainage field which fails as a result of the development of a clogging layer at the infiltrative surface should be rested for a minimum of one year, but, alternatively, can be rejuvenated by treating it with hydrogen peroxide (H_2O_2), which is a strong oxidizing agent. Extreme safety precautions are necessary when it is used. Sandy soils require lower concentrations of H_2O_2 than silty soils, and can be successfully rejuvenated with solutions of 7.5 and 15% at application rates of 0.5 and 1.25 litres respectively per square metre. For silty soils an application of at least 2.44 litres per square metre is needed. Unfortunately, hydrogen peroxide treatment can be expensive. The decision whether to construct a new drainage field or to use hydrogen peroxide is purely a balance between economics and convenience. It must, however, be remembered that any form of treatment only provides temporary relieve.

The drainage field can be inadequate for several reasons, the most common being that it has not been properly designed and constructed. In extreme cases there may be no drainage at all. This usually applies to old tanks, which may have been designed to a watercourse, but can also apply in cases where the owner of a large plot has either sold part of the land containing the drains to a neighbour for development or developed the land him/herself.

Subsurface irrigation systems and soakaways are constructed without first conducting a percolation test, and may then be too small to dispose of the effluent. Where percolation tests are carried out, if they are not properly supervised they can give misleading results. Even with good supervision it is a crude test. Errors can also occur because of local or seasonal variations in ground conditions.

It is also common for the length of drain determined by the percolation test to be too great for the size of the plot which has to accommodate it, but this rarely results in an alternative means of sewage disposal being sought. A common practice in the construction of trench-type drainage fields is not to install a distributor pipe the full length of the trench. This effectively restricts seepage to the first part of the trench.

Another circumstance under which the drainage field can become inadequate is where a septic tank is upgraded because a dwelling is extended without any modification to the existing drains.

Pollution of both surface and groundwater

In some areas there is a proliferation of tanks discharging to land which quickly drains to a watercourse, causing noticeable pollution of surface water. This problem occurs at several localities in the Southern Cape. In several villages/towns the sand unit wedges out towards the coastline and the bedrock outcrops on or near the beach. Any subsurface flow within the sands is forced to the surface, either into surface streams or as springs above the high-tide mark. The flow is also often intersected by stormwater drains, which in turn empty into lagoons/rivers/the sea. The problem is exacerbated by the highly seasonal nature of the rain and the resultant high water tables.

Groundwater pollution can be detected if there is a proliferation of tanks in a sensitive area, or if the tanks are too close to borehole supplies. This type of problem is most likely to occur at resorts or towns within the Lake District of the Southern Cape. The Sedgefield area for example receives approximately 25 000 holiday makers at its many timeshare chalets, caravan parks, resorts and hotels. Many of these resorts rely on groundwater resources for their water supply and exploit the shallow coastal aquifers. Unfortunately very few of the resorts/towns have water-borne sewage, with the result that most waste water passes directly into the subsurface by means of soakaways. During peak periods many of the soakaways are placed under exceptional loads and cannot possibly function efficiently.

Each situation must, however, be examined within its own regional context. A brief investigation of one resort showed that, hydraulically, it was possible to dispose of some 140 m^3/day in a properly designed drainage field and extract 190 m^3 /day of groundwater from the same shallow aquifer some 80 m away. Good transmissivity properties ensured adequate groundwater flow and the presence of clay and a 5 m unsaturated zone ensured adequate treatment. Although the extracted water included a component of the recharge effluent, it was not a health risk, as only the conservative chemical constituents could be identified. Nitrate, phosphate and the biological contaminants had been removed from the soil. Such schemes must, however, be continuously monitored to ensure their long-term efficiency.

In two areas, Great Brak and Knysna, islands within the lagoon/estuary are inhabited and considered potential sources of pollution by virtue of their use of septic tank systems. In both cases the underlying lens of "fresh" groundwater is at times contaminated. This contamination is relatively insignificant, as the local hydrological regime is dominated by the regional fluvial or marine environment. The highly seasonal nature of occupancy at The Island, Great Brak, also helps to ensure that the pollution plume caused during peak holiday times is effectively absorbed by the environment during the remainder of the year. Leisure Isle at Knysna in turn is surrounded by a dynamic marine environment which daily flushes the system and so ensures that no build-up of pollutants can occur.

4 CASE STUDY

4.1 Introduction

A brief case study was undertaken in the South-Western Cape to obtain a better understanding of the effectiveness of drainage fields in South African coastal sands. Three different types of septic tank systems were selected as representing the most common usage along the coastline.

4.2 Site description

The Onrus-Hawston area near Hermanus on the South Coast was selected as the study area. This area is:

(a) totally dependent on septic tank systems for the disposal of domestic waste waters;
(b) typical of the average coastal town, consisting mainly of holiday homes, a small permanent population of retired people, a few basic shops, a filling station, caravan parks, and public recreational facilities;
(c) underlain by coastal sands, which constitute a shallow aquifer that is exploited locally by private landowners;
(d) problematic during the rainy season (winter), since problems occur with many of the drainage fields, which results in return flow and contamination of the stormwater runoff; and
(e) subject to municipal use of communal trenches to dispose of septic tank effluent.

Three different types of septic tank systems were selected for study.

(a) Onrus - domestic septic tank system

This represented a typical domestic tank system serving a single household that is occupied throughout the year. Such a household can be expected to discharge approximately 160 litres per person per day. The greatest loads occur during the summer holiday season. The source of the waste water can be expressed on a percentage basis:

toilet	20 - 45%
bath/shower	20 - 40%
kitchen	5 - 15%
laundry	10 - 20%
other	0 - 10%

The system consisted of a standard (10 000 L) septic tank with a 10 m^3 bed drainage field (soakaway). The system had in the past experienced problems during the winter months when water logging occurred and caused effluent to reach the surface and become return flow.

Figure 6 illustrates the groundwater monitoring network that was installed. Wellpoint 10 was established as the reference (background) point. The monitoring points were installed during late summer and no groundwater table was intersected, although there was evidence of a seasonal perched water table at 1.2 m. The wellpointing equipment could unfortunately not penetrate below 3 m.

(b) Hawston - public amenity septic tank system

The site consisted of a septic tank and trench soakaway that served the new ablution block in the caravan park. The septic tank only received black waste water, as the shower water drained into a separate soakaway system some distance away. The layout of the system is illustrated in Figure 7. The soakaway trench was 1 m x 1 m x 37 m and did not contain a central open-jointed distribution pipe. As a result the effluent never reached the final soakaway pit. The system received minimal flow during the wet winter months, and peak loads during the summer months, especially over the Christmas/New Year and Easter periods. A fairly extensive network was installed (Figure 7). Wellpoints were sunk to varying depths near the septic tank to monitor the different horizons. Wellpoint 25 represented the reference (background) point.

(c) Hawston - public amenity septic tank system

This septic tank system received all the black waste water from the swimming pool complex, which during the peak season received more than 1 000 people/day. The soakaway consisted of a 0.5 m x 0.5 m x 22 m trench which did not contain a central open-jointed distribution pipe. Unlike the other two systems this was built on reworked dune sand and thus had no impeding layers/horizons. The monitoring network is illustrated in Figure 8, and did not include a reference point. Access was somewhat restricted, hence the linear nature of the monitoring network.

4.3 Methodology

At each site the monitoring network consisted of a series of wellpoints. These were established by hand-auguring to the groundwater table after which the wellpoint was jetted to the required depth using mains water. Each wellpoint had a 1 m length of screen (0.3 mm slot size). The monitoring points were all developed prior to sampling and sampling was done as specified in the Groundwater Sampling Manual (Weaver, 1992). The samples were all analysed by the CSIR laboratories in Stellenbosch. Table 2 lists the parameters analysed for and Table 3 summarizes the sampling programme. The brief nature of the study meant that only a few sample runs could be done. Difficulties were experienced when sampling the domestic house site at Onrus, as water samples could not always be obtained from all of the wellpoints. This was as a direct result of the seasonal water table.

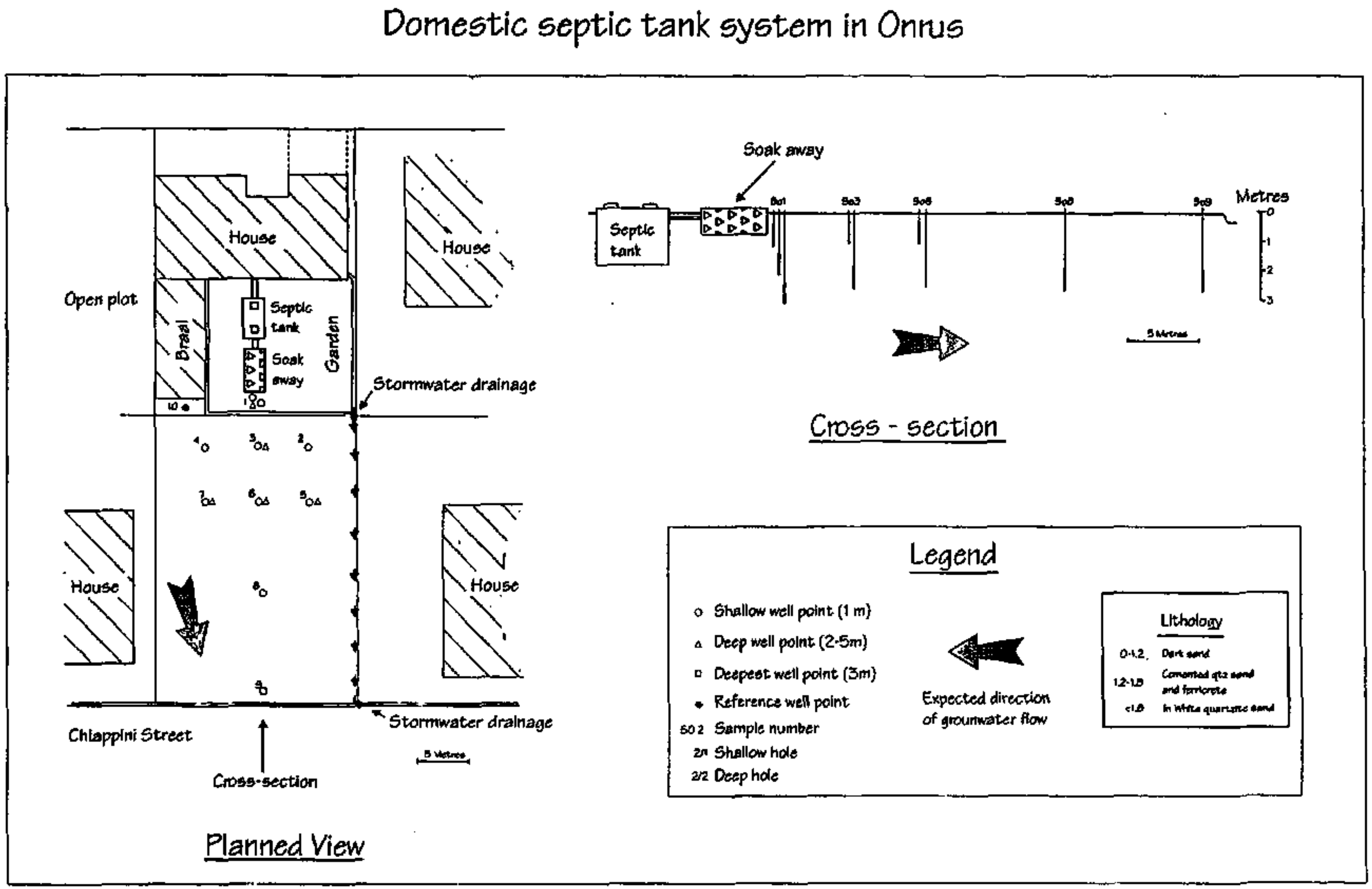


Figure 6: Groundwater Monitoring Network

For a public amenity septic tank system (with trench soakaway) caravan park at Hawston

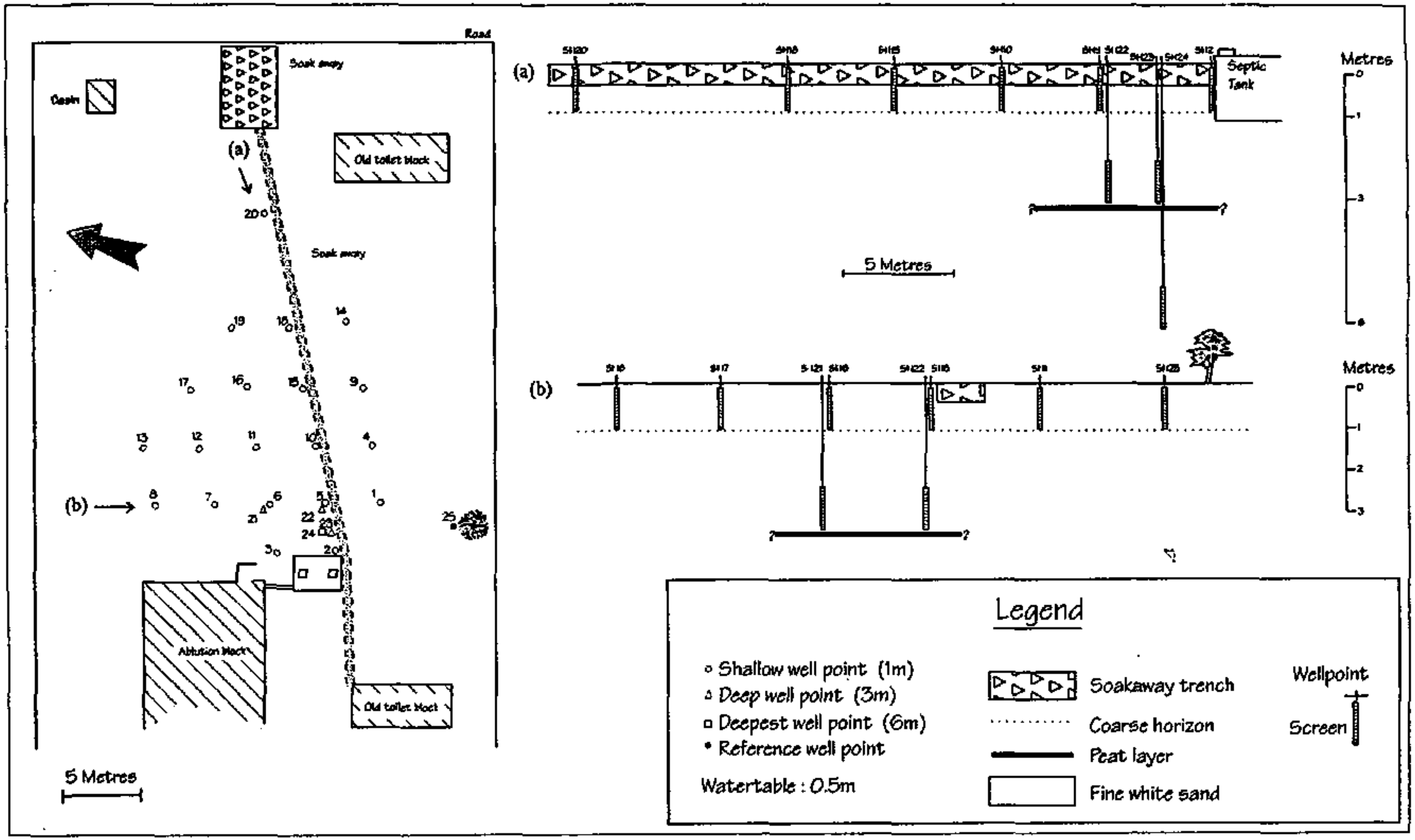


Figure 7: Groundwater Monitoring Network

For a public amenity septic tank system (with trench soakaway)
Public pool complex at Hawston

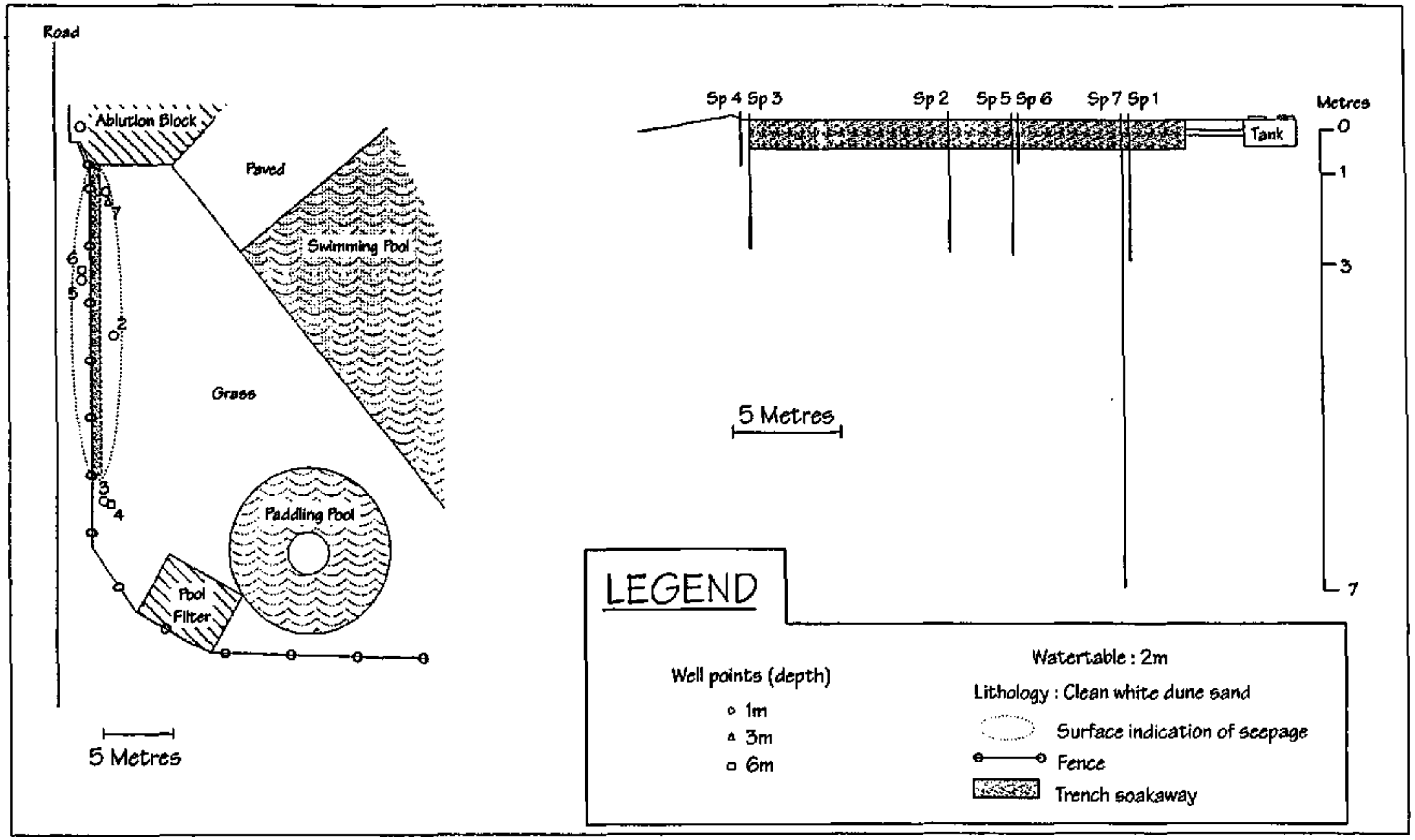


Figure 8: Groundwater Monitoring Network

TABLE 2: *Parameters analysed for in the case study*

PARAMETERS	FULL	PARTIAL	INDICATOR
pH	x	x	x
EC	x	x	x
DOC	x	x	x
Ammonia as N	x	x	x
Nitrate as N	x	x	x
Orthophosphate as P	x	x	x
Potassium	x	x	
Sodium	x	x	
Calcium	x	x	
Magnesium	x	x	
Sulphate	x	x	x
Chloride	x	x	x
Total alkalinity as $CaCO_3$	x	x	
Copper	x		
Iron	x		
Manganese	x		
Zinc	x		
Faecal coliform	x	x	x
Faecal streptococci	x		

TABLE 3: The sampling programme

		TYPE OF ANALYSIS[1]		
SITE	TIME AND RATIONALE	F	P	I
Domestic house	May - Start of wet season		5	11
	Sept - End of wet season	6		8
	Jan - Peak loads & dry season		8	11
Caravan park ablution block	Jan - Peak loads	11	15	
	March - End of holiday season		16	
	April - Prior to wet season	1	25	
	Sept - End of wet season	11		15
Swimming pool complex	Jan - Peak loads	6		
	March - End of holiday season		6	
	April - Prior to wet season	1	5	
	Sept - End of wet season			4

[1] number of samples

4.4 Discussion of results

The sampling programme provided some interesting results. Unfortunately the limited nature of the programme meant that the results were statistically inconclusive, but did provide valuable insight.

Table 4 summarizes the effluent quality entering the drainage fields at different sites. The values generally confirm what could be expected from the different activities/facilities. The domestic effluent for example contains grey water, hence the higher concentration of phosphate. The results from the two resorts clearly reflect the seasonal usage of these facilities. This was not as marked at the public pool site, as a limited amount of black water entered the system through the year (reflected in the ammonia and faecal coliform concentrations). The source of this was casual visitors to the adjacent beach and shop.

It is interesting to note the marked similarity between the quality of the public pool peak season and that of the domestic house.

The generally better-quality effluent from the caravan park ablution block is thought to be as a result of mains water constantly being added from the automatically flushing urinals and leaking cisterns. From the effluent quality it was clear that the main pollution indicators when looking at the groundwater would be K, NH_4-N, NO_x-N, PO_4, DOC, and faecal coliforms.

TABLE 4: Septic tank effluent quality resulting from different activities

Determinant	Normal domestic (Black and grey water)		Caravan park/resort ablution block (Black water)		Resort/public pool - day visitor (Black water)		Mains water
	Normal	Holiday time	Low season	Peak season	Low season	Peak season	
K	23.9	22.1	3.5	9.3	11.5	24.5	2.6
Na	101.0	121.0	37.0	51.0	67.0	103.0	50.0
Ca	18.5	18.2	14.6	18.1	50.6	45.3	18.8
Mg	7.9	9.5	4.9	6.7	8.0	8.1	6.8
NH_4-N	8.2	87.0	5.0	27.0	28.0	81.0	<0.1
SO_4	2.8	20.0	29.0	33.0	23.0	11.0	27.0
Cl	141.0	150.0	63.0	95.0	116.0	183.0	95.0
Alk ($CaCO_3$)	363.0	396.0	41.0	118.0	238.0	391.0	26.0
NO_x-N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.23
PO_4-P	14.2	17.7	0.2	3.0	2.3	5.4	<0.1
Cu			<0.05	<0.05		<0.05	0.05
Fe			0.10	<0.05		1.73	0.09
Mn			<0.05	<0.05		<0.05	0.05
Zn			<0.05	<0.05		0.30	0.05
DOC	26.0	47.0	4.0	31.0	17.0	33.0	0.4
EC	126.0	145.0	37.0	66.0	92.0	142.0	44.0
pH	6.8	7.8	8.8	8.3	7.5	7.4	8.9
Faecal coliforms per 100 ml	3.6×10^6	5.5×10^6	2.9×10^3	4.0×10^6	8.3×10^5	1.2×10^5	0

Units mg/L, except EC = mS/m

Tables 5 and 6 illustrate the impact which the respective effluents had on the groundwater quality immediately downgradient of the drainage field. The results clearly indicate how effective the coastal sands are in purifying the effluent.

TABLE 5: Water quality at different depths immediately below a soakaway (sandy terrain)

Determinant (mg/L)	Black and grey water (domestic)				Black water (public amenity)				Black water (public amenity)		
	Impeding layer at 1.5 m Perch water table				Impeding layers at 1 m and 3 m Groundwater table 0.5 m.				No impeding layers Groundwater table 2 m.		
	E[1]	<1 m	1-2 m	2-3 m	E	<1 m	2-3 m	5-6 m	E	2-3 m	6-7 m
K	22.1	26.7	11.5	5.7	9.3	18.8	11.7	11.1	24.5	10.3	8.5
NH_4-N	87.0	96.0	31.0	6.1	27.0	4.1	<0.1	<0.1	81.0	<0.1	0.27
NO_x-N	<0.1	0.12	4.54	0.1	<0.1	<0.1	4.87	<0.1	<0.1	0.32	0.57
PO_4-P	17.7	16.9	1.48	28.2	2.99	0.24	<0.1	<0.1	5.4	<0.1	<0.1
FC[2]	10^6	35	2	1	10^6	10^3	0	0	10^5	0	0

[1] E = effluent
[2] Faecal coliforms per 100 ml

TABLE 6: The impact on groundwater quality immediately downgradient of the drainage field (caravan park ablution block)

Determinant (mg/L)	Effluent	Resident groundwater	Distance downgradient from drainage field: 0.5 m	5 m	10 m	15 m
K	9.3	13.0	16.3	14.8	8.3	9.6
NH_4-N	27.00	<0.10	6.90	4.50	0.76	0.12
NO_x-N	<0.10	6.02	<0.10	<0.10	<0.10	0.73
PO_4-P	2.99	<0.10	0.50	0.22	0.15	<0.10
DOC	31.0	3.6	16.8	8.6	6.0	5.3
EC (ms/m)	66	250	260	270	250	160
Faecal coliforms (per 100 ml)	4.1×10^6	3	5.4×10^5	38	3	3

Figures B1 to B5 in Appendix B provide a summary of the most important results obtained at the Onrus domestic house site and the following observations may be made for the different constituents shown:

NH_4-N: Influence of effluent was seen throughout the year but peaked over the Christmas period when discharge volumes were greatest. The background levels for the site were less than 0.2 mg per litre. The size of the contaminant plume remained fairly constant throughout the year, although the intensity (concentrations) increased during the holiday period. The plume orientation changed during the wet winter period as a result of the increased regional groundwater flow. Ammonia was effectively reduced with both depth and distance (10 - 15 m).

NO_x-N: The nitrate levels suggest that the nitrification process was effective at this site. Concentrations were highest at the end of the dry season when the ammonia input was lowest. It was unfortunately not possible to follow the downgradient movement of the plume. It is suspected that limited denitrification took place and that nitrate acted as a conservative constituent. The background levels for nitrate ranged from < 0.1 mg/L to 4 mg/L during the wet season. These levels are what could be expected for an urban area.

PO_4-P: The trends are very similar for ammonia and phosphate serves as an excellent pollution indicator for septic tank systems receiving domestic grey water. The impeding layer at 1.5 m resulted in far greater horizontal movement at shallow depths than normally expected and highlights the impact that a perched water table has.

EC: The resident groundwater had a conductivity of 130 ms/m. This decreased with depth, as the quartzitic bedrock has very low values. The trends observed indicate that during winter the area receives considerable natural recharge, whereas by late summer/early autumn the major influence comes from the septic tank system.

Faecal coliforms: Unfortunately no samples could be obtained during the May sample run, but it would appear that the greatest impact occurs during the dry summer season, which coincides with the peak holiday period. No distinct plume could be detected at the end of the wet season, which suggests that natural recharge dilutes the plume in winter. The higher counts measured at wellpoint 7, during January, appear anomalous and do not persist with depth, suggesting a highly localized pollution source. The subsurface environment appeared highly efficient in removing biological contaminants, as the organisms remain at very shallow levels (< 1 m) and die off very rapidly (5 - 10 m) downgradient of the drainage field.

Figures B6 to B15 provide a summary of the most important results obtained at the caravan park ablution block site. The following observations may be made for the different constituents:

NH_4-N: The contoured plan (Figure B6) clearly indicates that effluent was only really discharged in significant volumes during the holiday periods (Christmas/New Year and Easter). Wellpoint SH 25 represents the background levels and remains at <0.01 mg/L throughout the year. The ammonia plume never extended further than 10 m from the trench and did not penetrate below the coarse horizon. The coarse horizon appeared to act as a zone of preferred flow. The bimodal nature of the plume in January (also reflected by the other constituents) indicates that effluent was not infiltrating uniformly down the length of the trench. In April all the effluent discharged into the trench infiltrated immediately, i.e. where the feeder pipe entered the trench. In January, however, a considerable volume moved down the trench and infiltrated some 10 m beyond the feeder pipe, larger volumes of waste water being generated during the Christmas/New Year period than earlier (April).

No_x-N: The nitrate concentrations should be studied in conjunction with those of ammonia, as the patterns (Figures B6 and B8) illustrate the inter-relationship between the two, nitrification being responsible for the removal of ammonia. There would, however, appear to be an external source of nitrate upgradient of the drainage field, as the resident groundwater had higher concentrations than downgradient of the trench.

Nitrification occurred with depth as expected, but was then contained by the peat layer at 3 m. The lack of nitrate below this probably indicates horizontal movement rather than denitrification.

PO_4-P: The low concentrations found in the effluent meant that very little groundwater contamination could be expected. The sampling confirmed this and phosphate was effectively removed at very shallow depths within 5 m of the trench. The bimodal nature of the infiltration is depicted very neatly by phosphate.

Faecal coliform: In April (Easter period) the effluent never really moved more than 10 m down the trench, with the majority of effluent infiltrating in the first 5 m. During the Christmas/New Year period, however, there was far more movement down the trench; it could be traced as far as 20 m from the discharge pipe. The greatest infiltration, however, occurred between 15 to 20 m, suggesting a degree of clogging in the first 10 m of the trench.

EC and K: Salinity did not serve as a very good indicator of the contaminated plume. The resident groundwater had higher than average salinity values and, as the effluent was less saline, it formed a lens of better-quality water, the differences being rather subtle. In a similar fashion, potassium was not a very good indicator.

4.5 Conclusions

(a) Peak loads experienced during holiday periods cause distinct pollution plumes in the groundwater. Pollutants are nevertheless effectively contained and, with time, removed from the groundwater within a radius of 15 to 20 m of the effluent discharge point. Pollutants seldom penetrated more than 3 m vertically.

(b) The presence of either a more or a less permeable layer within the sands altered the pattern of flow. An impervious or semi-pervious layer such as clay or calcrete restricted flow and invariably resulted in a perched water table. A more permeable layer such as a gravel lens or a pebble bed in turn acted as a conduit and resulted in preferential horizontal flow. In both cases it restricted the pollutants to rather shallow depths. It also meant that denitrification never occurred and nitrate acted as a conservative constituent and therefore had the potential to become a regional problem.

(c) Purification of the effluent took place in even the most structureless sand, the swimming pool drainage field being constructed on reworked dune sand. It is unlikely, however, that many areas will be found with such uniform sand.

(d) Bed-type drainage fields, probably the most popular type along the coast, are more likely to result in pollution than trenches or pits. The coastal sands invariably have some sort of barrier zone at shallow depths (<5 m) and, by virtue of the drainage bed design, the pollutants are discharged above this layer. The pollution plume thus moves horizontally and has the potential to become return flow.

(e) The greatest threat of pollution is therefore directed at surface water bodies and not the deeper groundwater aquifers. The practice of discharging effluent from faulty septic tanks and conservancy tanks into communal trenches is a far more serious threat to the groundwater environment. These trenches are normally dug with a back-actor and are thus deeper than the average drainage bed. The effluent from conservancy tanks (these cater for hotels, commercial concerns, etc.) is also more likely to contain toxic inorganics and synthetic organics.

(f) A trench drainage field must be correctly designed and constructed. The trench must have a distributor pipe running along its full length. The infill material should not be builders' rubble. It is recommended that if possible a small pit be constructed at the end of the trench to handle the extreme peak discharges.

(g) Many property owners also allow stormwater runoff either to enter the drainage field or to infiltrate the evapotranspiration area downgradient of the drainage field. This causes unnecessary water logging and drainage field failure.

(h) The findings from the case study, although site specific, are relevant for much of the coastline, the exception being those areas with shallow loamy soils overlying hard rock formations and the Lake District (Wilderness-Sedgefield-Knysna).

(i) In general, property owners have very limited knowledge about septic tank systems and seldom know the dimensions and construction details of their own systems.

5 CONCLUSIONS

(a) 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.

(b) 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.

(c) 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.

(d) 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;
- ❑ shallow depths to bedrock.

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

(e) 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 15 to 20 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.

(f) 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 system has long periods in which to recover. This recovery period results in many systems that would fail under normal circumstances operating efficiently in the long term.

(g) 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 maintenance.

(h) The communal effluent disposal sites constitute by far the greatest pollution threat to the coastal environment.

(i) 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.

6 MANAGEMENT RECOMMENDATIONS

The use of septic tank systems should continue and be promoted as a cost-efficient means of domestic waste water disposal. The systems must, however, be correctly designed, constructed and maintained. Problems currently occur because of poor location, poor drainage field design and lack of maintenance.

(a) No one set of criteria or regulations can apply to the entire coastal zone. It is, however, possible to establish broad guidelines on a regional basis as defined by hydrogeological and climatic conditions. The coast may be divided into 5 regions as illustrated in Figure 9. Fairly similar conditions prevail within each region, although a further categorization can be made into areas characterized by primary aquifers, secondary aquifers and lakes or estuaries. A set of broad guidelines should be developed for each region. This would be the responsibility of the regional authority in consultation with the Directorates Geohydrology and Water Quality Management of the DWA&F. WRC Report

597/2/95 should form the basis of these guidelines, with specific advice with regard to local conditions and administrative requirements. The regional authority should be in a position to provide technical advice or guidance to local authorities, which often do not have the financial base required to employ technically qualified staff. This follows the current trend of co-ordinating water supply, waste water treatment and waste disposal on a regional basis.

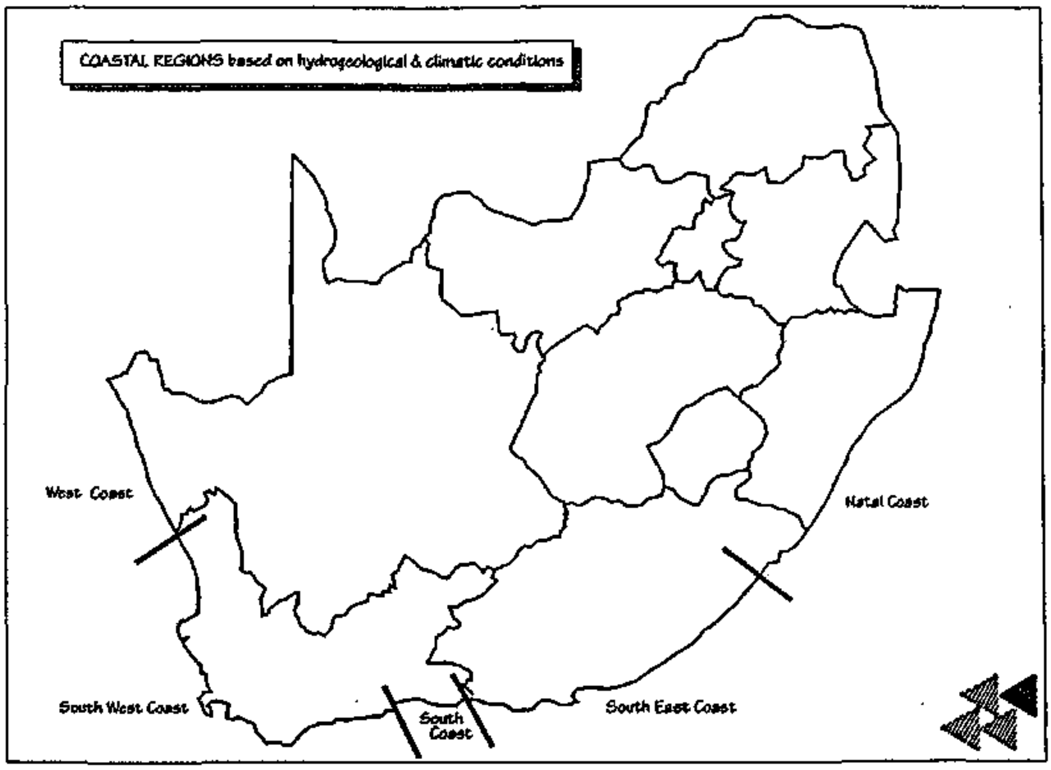


Figure 9: The different hydrogeological regions into which the coast may be divided with respect to use of septic tank systems

(b) At a local level authorities should have a land resource plan (map) indicating which areas have the ability to treat and dispose of domestic liquid waste effectively by means of a soil absorption system. This plan should be based on a regional land capability rating as described in WRC Report 597/2/95 and serve as an urban planning tool. Any proposed development would then first be evaluated using this plan. The next stage should involve a preliminary, site-specific assessment and would be of a qualitative nature. The final stage would be a detailed site evaluation and include the logging of soil profiles and a percolation test. Only once this has been completed can the detail design be undertaken. This design plan should be included in the normal building plans submitted before any construction may take place. The amount of detail required in the design plan will depend on the locality of and guidance, which should be forthcoming, from the regional technical authority. It is crucial that the responsible local official physically checks that construction is as specified in the design plan. This should even be done in the case where consulting engineers are responsible for both the design and construction phases.

(c) A further responsibility of the local authority is an ongoing maintenance programme. All septic tanks should be inspected at least once a year by an official from the local authority. The septic tank should be checked to ensure timely desludging and the drainage field/evapotranspiration area for efficiency. Regular groundwater quality monitoring should be done at those localities where septic tank systems could contaminate an aquifer, especially if it serves a water supply. Stormwater systems should be periodically sampled in those areas that experience seasonally high water tables/perched water tables. Monitoring should be mandatory wherever septic tank/conservancy tank effluent is disposed of at a communal site, irrespective of the technique employed. This should be actively enforced by the DWA&F, which should also ensure that the Water Act is adhered to.

(d) It should be recognized that drainage field failure is a common problem in the coastal zone and is generally a temporary problem resulting from peak loads. Little action is required unless it results in obvious pollution of surface water or a groundwater resource. The long periods between holiday seasons allow the system to recuperate, with no permanent damage.

(e) Although the effluent entering the drainage field may contain a number of contaminants, namely:

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

it is not necessary to do a full chemical and microbiological analysis during routine sampling. A number of key/indicator parameters, as summarized in Table 7, should be checked for. Sampling should be done as prescribed in the Groundwater Sampling Manual (WRC Report TT54/92 by Weaver, 1992). A more comprehensive analysis is only required once a pollution problem is identified or suspected.

TABLE 7: Recommended list of constituents to be analysed for during routine groundwater sampling at septic tank disposal sites

K	potassium
NH_4-N	ammonia as N
NO_x-N	nitrate (plus nitrite)
PO_4-P	ortho phosphate
Cl	chloride
pH	
EC	electrical conductivity
DOC	dissolved organic carbon
Faecal coliform	

REFERENCES

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.

Swart, M.C. (1995) *Sewage disposal by means of septic tanks in the East and Southern Cape coastal dunes.* Unpubl. MSc thesis (in Afrikaans), Faculty of Natural Sciences, UPE, Port Elizabeth, South Africa.

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

Weaver, J.M.C. (1992) *Groundwater sampling. A comprehensive guide for sampling methods*. WRC Report TT54/92, Pretoria.

OTHER RELATED REPORTS FROM THIS STUDY

Wright, A (1995). *Guidelines for the use of septic tank systems in the South African coastal zone.* WRC Report 597/2/95.

APPENDIX A

PROJECT QUESTIONNAIRES

a. Examples of covering letters

b. Example of questionnaires

c. Summary of questionnaire responses

d. List of towns/settlements using septic tank systems

Division of Water Technology
Western Cape Branch
PO Box 320, Stellenbosch, 7599 South Africa
Telephone : (021) 887-5101
Telefax : (021) 883-3086
Telex : 5-27126 SA

CONSULTING ENGINEERS

WF023/1

Water Technology

CSIR

Your technology partner

The Managing Director
company ~
address1 ~
address2 ~
pcode ~

Dear Sir/Madam

DESIGN CRITERIA FOR SEPTIC TANK SYSTEMS

The Groundwater Programme of the CSIR have been commissioned by the Water Research Commission to undertake research into the use of Septic Tank Systems along the South African coastline. The ultimate objective is to develop a brief set of guidelines for local authorities on the approach to be taken when installing and using such systems. Special emphasis is placed on possible ground and surface water contamination.

Consulting Engineers obviously play a key role in this process and this needs to be clearly highlighted in the guidelines. It is thus necessary to obtain a picture of the current involvement of consulting engineers and the attached questionnaire is the first step in this process. If your company is involved in this line of work, it would be greatly appreciated if this form could be completed and returned to the CSIR in Stellenbosch.

Your time and cooperation are greatly appreciated. Should you have any enquiries or concerns with regard to the questionnaire, please do not hesitate to contact Alan Wright (Tel. 021 - 8875101).

Yours sincerely

ALAN WRIGHT
Geohydrologist

Project Leader (CSIR):	A Wright
Project Manager (WRC):	H C Chapmann
WRC Project No:	K5/597

Division of Water Technology
Western Cape Branch
PO Box 320, Stellenbosch, 7599 South Africa
Telephone : (021) 887-5101
Telefax : (021) 883-3086
Telex : 5-27126 SA

LOCAL AUTHORITIES

WF023/1

Water Technology

CSIR

Your technology partner

to whom ~
municipality ~
address1 ~
address2 ~
pcode ~

Dear Sir/Madam

DESIGN CRITERIA FOR SEPTIC TANK SYSTEMS

The Groundwater Programme of the CSIR have been commissioned by the Water Research Commission to undertake research into the use of Septic Tank Systems along the South African coastline. The ultimate objective is to develop a brief, user-friendly, set of guidelines for local authorities on the design and management of septic tank systems. Special emphasis is placed on possible ground and surface water contamination.

Your cooperation in filling in the attached questionnaire would be greatly appreciated. Should you have any enquiries or concerns with regard to the questionnaire please do not hesitate to contact Alan Wright (Tel. 021 - 8875101). The project team would welcome the opportunity of visiting your area to discuss any specific problem/issue that you would like to highlight with regard to septic tanks and soakaways.

Thank you for your time.

Yours faithfully

ALAN WRIGHT
Geohydrologist

Project Leader (CSIR):	A Wright
Project Manager (WRC):	H C Chapmann
WRC Project No:	K5/597

Division of Water Technology
Western Cape Branch
PO Box 320, Stellenbosch, 7599 South Africa
Telephone : (021) 887-5101
Telefax : (021) 883-3086
Telex : 5-27126 SA

REGIONAL AUTHORITIES

WF023/1

Water Technology

CSIR

Your technology partner

to whom ~
rsc ~
address1 ~
address2 ~
pcode ~

Dear Sir/Madam

DESIGN CRITERIA FOR SEPTIC TANK SYSTEMS

The Groundwater Programme of the CSIR have been commissioned by the Water Research Commission to undertake research into the use of Septic Tank Systems along the South African coastline. The ultimate objective is to develop a brief, user-friendly, set of guidelines for local authorities on the design and management of septic tank systems. Special emphasis is placed on possible ground and surface water contamination.

It would be greatly appreciated if you could distribute the attached questionnaires to those RSC officials responsible for coastal settlements/resorts within your region. The project team would welcome the opportunity to visit any specific area in which you may be experiencing problems or would like to highlight specific issues related to septic tank systems. Should you have any enquiries or concerns with regard to the questionnaire, please do not hesitate to contact Alan Wright (Tel. 021 - 8875101).

Thank you for your time and cooperation

Yours faithfully

ALAN WRIGHT
Geohydrologist

Project Leader (CSIR):	A Wright
Project Manager (WRC):	H C Chapmann
WRC Project No:	K5/597

QUESTIONNAIRE

CSIR

Should you have any enquiries with regard to the questionnaire, please contact Alan Wright (CSIR 021-8875101)

1. NAME OF TOWN ....

2. APPROXIMATE POPULATION............ (PERMANENT) .... (SEASONAL)

3. SANITATION SYSTEM IN USE (and % of population using each)

	✓	%
Waterborne sewage		
Septic tanks		
Conservancy tanks		
Buckets		
VIP & Pit latrine		
Other (e.g. LOFLOS)		

4. IF CONSERVANCY TANKS ARE USED, IS THE EFFLUENT DISPOSED OF IN

surface spreading	
a central soakaway (dams or trenches)	
wastewater treatment plant (ponds)	
wastewater treatment plant (conventional)	

5. ARE PROBLEMS EXPERIENCED WITH THE EXISTING
(a) Septic tanks (b) Soak aways (c) Sewers

YES	NO

If YES, what problems?

....
....
....
....
....

6. ARE SPECIFIC DESIGN GUIDELINES ADHERED TO IN THE CONSTRUCTION OF SEPTIC TANKS AND SOAKAWAYS?

YES	NO

If YES, what are these? (If possible, please attach a copy)

....
....
....
....
....

7. IS GROUNDWATER USED (EITHER PARTIALLY OR WHOLLY) FOR TOWN SUPPLY?

YES	NO

8. IS GROUNDWATER UTILISED BY PRIVATE INDIVIDUALS/INSTITUTIONS WITHIN THE TOWN LIMITS?

YES	NO	NOT SURE

9. HAS ANY GROUNDWATER CONTAMINATION OCCURRED AS A RESULT OF SEPTIC TANKS/SOAKAWAYS?

YES	NO	NOT SURE

10. IS ANY GROUNDWATER QUALITY MONITORING DONE?

YES	NO

11. ARE THERE ANY SPECIFIC ASPECTS REGARDING SEPTIC TANKS/SOAKAWAYS THAT YOU MAY REQUIRE INFORMATION ON OR CONSIDER FURTHER RESEARCH SHOULD BE DONE ON?

....
....
....
....
....
....
....
....
....
....

12. NAME AND ADDRESS OF RESPONDENT Tel. ( ) ....
Fax ( ) ....

....
....
....

DESIGNATION: ....

DATE:.....................

PLEASE RETURN COMPLETED FORM TO:

ALAN WRIGHT
Division of Water Technology
CSIR
P O Box 320
7599 STELLENBOSCH

VRAELYS

WNNR

Indien u enige navrae het betreffende die vraelys, kontak asseblief vir
Alan Wright (021 - 8875101)

1. NAAM VAN DORP ....

2. BENADERDE BEVOLKINGSTAL .... (PERMANENT) .... (SEISOENAAL)

3. SANITêRE SISTEEM IN GEBRUIK (en % van inwoners wat elk gebruik)

	✓	%
Spoelriolering		
Septiese tenks		
Emmerstelsel		
"VIP" en putlatriene en/of		
Ander (bv LOFLOS)		

4. INDIEN SUIGTENKS GEBRUIK WORD, GESKIED WEGDOENING VAN UITVLOEISEL DEUR:

oppervlakspreiding	
sentrale wegsyfering (damme of slote)	
oksidasiedamme/verouderingsdamme	
afvalwaterbehandelingsaanleg (konvensioneel)	

5. WORD PROBLEME ONDERVIND MET BESTAANDE
(a) septiese tenks (b) wegsyferings (c) rioolstelsels

JA	NEE

Indien JA, watter probleme?

....
....
....
....
....

6. WORD SPESIFIEKE ONTWERPSRIGLYNE NAGEVOLG MET DIE KONSTRUKSIE VAN SEPTIESE TENKS EN WEGSYFERINGS?

JA	NEE

Indien JA, spesifiseer. (Indien moontlik, heg 'n voorbeeld aan)

....
....
....
....
....

7. WORD GRONDWATER GEBRUIK (BEIDE GEDEELTELIK OF TEN VOLLE) VIR DORSVOORSIENING?

JA	NEE

8. WORD GRONDWATER BENUT DEUR PRIVAAT INDIVIDUE/INSTANSIES BINNE DIE DORPSGRENSE?

JA	NEE	ONSEKER

9. HET ENIGE GRONDWATERBESOEDELING PLAASGEVIND AS GEVOLG VAN SEPTIESE TENKS/WEGSYFERINGS?

JA	NEE	ONSEKER

10. WORD ENIGE MONITERING VAN GRONDWATERKWALITEIT GEDOEN?

JA	NEE

11. IS DAAR ENIGE SPESIFIEKE ASPEKTE RAKENDE SEPTIESE TENKS/WEGSYFERINGS WAAROOR U MEER INLIGTING SOU VERLANG OF VAN MENING IS DAT VERDERE NAVORSING GEDOEN MOET WORD?

....
....
....
....
....
....
....
....
....
....

12. NAAM EN ADRES VAN RESPONDENT

Tel. ( ) ....
Faks ( ) ....

....
....
....

HOEDANIGHEID: ....

DATUM: ....

STUUR ASB VOLTOOIDE VORM AAN:

ALAN WRIGHT
Divisie vir Watertegnologie
WNNR
Posbus 320
7599 STELLENBOSCH

QUESTIONNAIRE

CSIR

Should you have any queries with regard to the questionnaire, please contact Alan Wright (CSIR 021-8875101)

1. NAME OF FIRM

....

2. ADDRESS

....
....
....

Tel. .... Fax: ....

3. HAS YOUR FIRM DESIGNED AND/OR CONSTRUCTED ANY SEPTIC TANK SYSTEMS IN THE SOUTH AFRICAN COASTAL ZONE?

YES	NO

4. IF YES, IN WHICH MUNICIPALITIES/TOWNS?

....
....
....
....
....
....
....
....
....
....
....

5. WAS THE SEPTIC TANK SYSTEM DESIGNED USING

In-house guidelines	
South African based guidelines	
Internationally based guidelines	

6. IF BASED ON ANY PUBLISHED GUIDELINES, WOULD IT BE POSSIBLE TO LIST THESE REFERENCE(S)

....
....
....
....
....

7. DO CLIENTS REQUIRE ANY FORM OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA) (no matter how brief) PRIOR TO THE INSTALLATION OF SEPTIC TANK SYSTEMS?

YES	NO

8. IF SOME FORM OF EIA IS REQUIRED, DOES IT CONSIDER GROUNDWATER ASPECTS?

YES	NO

9. ARE THERE ANY SPECIFIC ASPECTS RELATING TO SEPTIC TANK/SOAKAWAYS WHICH YOU CONSIDER TO REQUIRE FURTHER RESEARCH?

YES	NO

....
....
....
....
....
....
....
....
....
....
....
....
....
....

FORM COMPLETED BY: ....

DESIGNATION: ....

DATE: ....

PLEASE RETURN COMPLETED FORM TO:

ALAN WRIGHT
Division of Water Technology
CSIR
P O Box 320
7599 STELLENBOSCH

VRAELYS

WNN

Indien u enige navrae het betreffende die vraelys, kontak asseblief vir Alan Wright (021 - 8875101)

1. NAAM VAN FIRMA ....

2. ADRES ....
....
....
Tel.. .... Faks: ....

3. HET U FIRMA VOORHEEN ENIGE SEPTIESE TENK SISTEME IN THE SUID-AFRIKAANSE KUSSTREEK ONTWERP EN/OF OPGERIG?

JA	NEE

4. INDIEN JA, VIR WATTER MUNISIPALITEITE/DORPE?
....

5. WAS DIE SEPTIESE TENK SISTEEM ONTWERP DEUR GEBRUIK TE MAAK VAN

Interne riglyne	
Suid-Afrikaans gebasseerde riglyne	
Internasionaal gebasseerde riglyne	

6. INDIEN GEBASSEER OP ENIGE GEPUBLISEERDE RIGLYNE, IS DIT MOONTLIK OM ASSEBLIEF DIE TOEPASLIKE VERWYSINGS TE LYS:
....

7. BENODIG KLIENTE ENIGE VORM VAN OMGEWINGIMPAKSTUDIE (EIA) (hoe gering ookal) ALVORENS DIE INSTALLASIE VAN SODANIGE SEPTIESE TENK SISTEME?

JA	NEE

8. INDIEN ENIGE VORM VAN OMGEWINGIMPAKSTUDIE (EIA) BENODIG WORD, SLUIT DIT GRONDWATER-ASPEKTE IN?

JA	NEE

9. IS DAAR ENIGE SPESIFIEKE ASPEKTE WAT BETREKKING HET OP SEPTIESE TENK SISTEME / WEGSYFERINGS WAT VOLGENS U MENING VIR VERDERE NAVORSING IN AANMERKING GENEEM BEHOORT TE WORD?

JA	NEE

....

10. NAAM EN ADRES VAN RESPONDENT

Tel. ( ) ....
Faks ( ) ....
....

HOEDANIGHEID: ....

DATUM: ....

STUUR ASB VOLTOOIDE VORM AAN:

ALAN WRIGHT
Divisie vir Watertegnologie
WNNR
Posbus 320
7599 STELLENBOSCH

SUMMARY OF QUESTIONNAIRE RESPONSES

DESIGN CRITERIA GUIDELINES USED BY CONSULTING ENGINEERS

CSIR - Boutek	Publications:	BOU 93	(De Viliers	1987)
		BOU 78	(De Villiers	1987)
		X/BOU 2-14	(Info sheet	1972)
		Report 219	(Malan	1964)

SABS 0 0400
Borough of Kloof Guidelines by Drennan, Maud & Partners
National Building regulations (Part P)
The Red Book
WISA Green Book
In-house documents

MAIN PROBLEMS EXPERIENCED BY LOCAL AUTHORITIES

- Poor construction cause drainage fields to block and collapse
- Steep slopes and high seasonal water tables cause systems to overflow
- Stormwater gets into drainage fields
- Septic tanks leak at inlet pipe and roof
- Oxidation ponds are overgrown with grass and reeds

GENERAL COMMENTS BY CONSULTING ENGINEERS

- Any set of guidelines should be available to all engineers at a reasonable cost. Don't follow the Red Book approach
- The "Minimum Requirements for Waste disposal at Landfills" - Should be applicable to communal effluent disposal sites
- Every situation should initially undergo a land capability assessment

INFORMATION REQUIREMENTS

- Extent of the pollution plume around dry and wet on-site sanitation area
- Maximum allowable density of soak-aways
- What distance is required between the bottom of the drainage basin and the groundwater?
- What is the relationship between evapotranspiration and rainfall?
- What size evapotranspiration area is required for low flush systems?
- Provide actual field results from tests done on systems
- Design criteria for both septic tanks and drainage fields
- Positioning of soakaways in relation to cut and fill embankments on steeply sloping sites
- Percolation rates in sandy soils
- What bacteria & viruses are present during the various stages of water treatment?
- How long a retention time should there be in the septic tank?
- Methods of extending the life time of septic tanks
- The effect of bio-enzymes on septic tanks
- Capacity requirements - septic tanks and drainage fields

GENERAL COMMENTS

- Consulting engineers *claim* to always do some sort of EIA
- Local authorities generally have a very sketchy idea of if and where groundwater is used in their areas
- No groundwater quality monitoring is done

TABLE 1: SUMMARY STATISTICS OF RESPONSE TO QUESTIONNAIRE

SURVEY TYPE	REGION	No OF QUESTIONNAIRES			RESPONSE PERIOD (MONTHS)*					
		SENT	RETURNED		1	2	3	4	5	6
Civil Engineering Consultants	Cape Town	47	11	23%	54	18	9	9	9	
	George/Mossel Bay	12	0	0%						
	PE / EL	35	11	31%	54	18	9		9	9
	Durban	63	20	32%	75	15			5	5
Local & Regional Authorities	South western Cape	19	14	74%	14	58	21	7		
	Southern Cape	11	6	60%	17	50	17	16		
	Eastern Cape	10	5	50%	20	60	20			

* Given as a percentage of those that responded

The following areas (towns/villages) use septic tank systems:

Lamberts Bay
Elandsbaai
Dwarskersbos
St Helena Bay
Paternoster
Yzerfontein
Hout Bay
Scarborough
Pringle Bay
Rooiels
Hawston
Vermont
Kleinmond
Betty's Bay
Onrus
Hermanus
Stanford
Gansbaai
Franskraalstrand
Uilenkraalsmond
Pearly Beach
Agulhas
Struisbaai
Arneston
Witsand
Stilbaai
Gouritsmond
Vleesbaai
Grootbrak
Mossel Bay
Hartenbos

Wilderness
Sedgefield
Buffelsbaai
Knysna
Plettenberg Bay
Natures's Valley
Cape St Frances
Humansdorp
Jeffrey's Bay
Cannon Rocks
Kenton on Sea
Kasuka Road
Port Alfred
Kleinemonde
Wesley
Hamburg
Kidds Beach
Christmas Rock
Kayser's Beach
Birah
Fish River Mouth

APPENDIX B

SUMMARY OF ANALYTICAL RESULTS FROM THE CASE STUDY

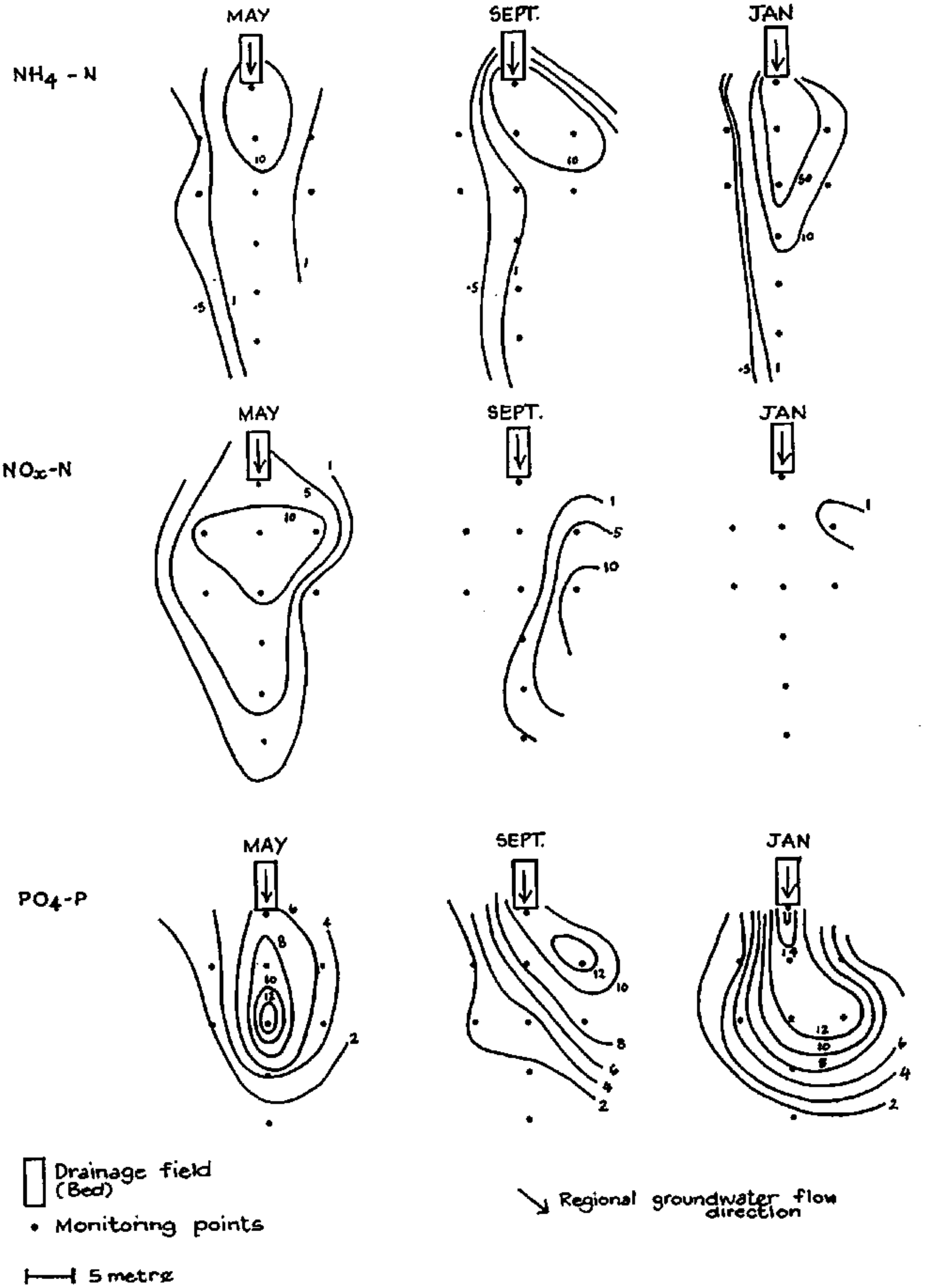


Figure B1 Selected contaminant plumes as observed at the domestic septic tank system in Onrus

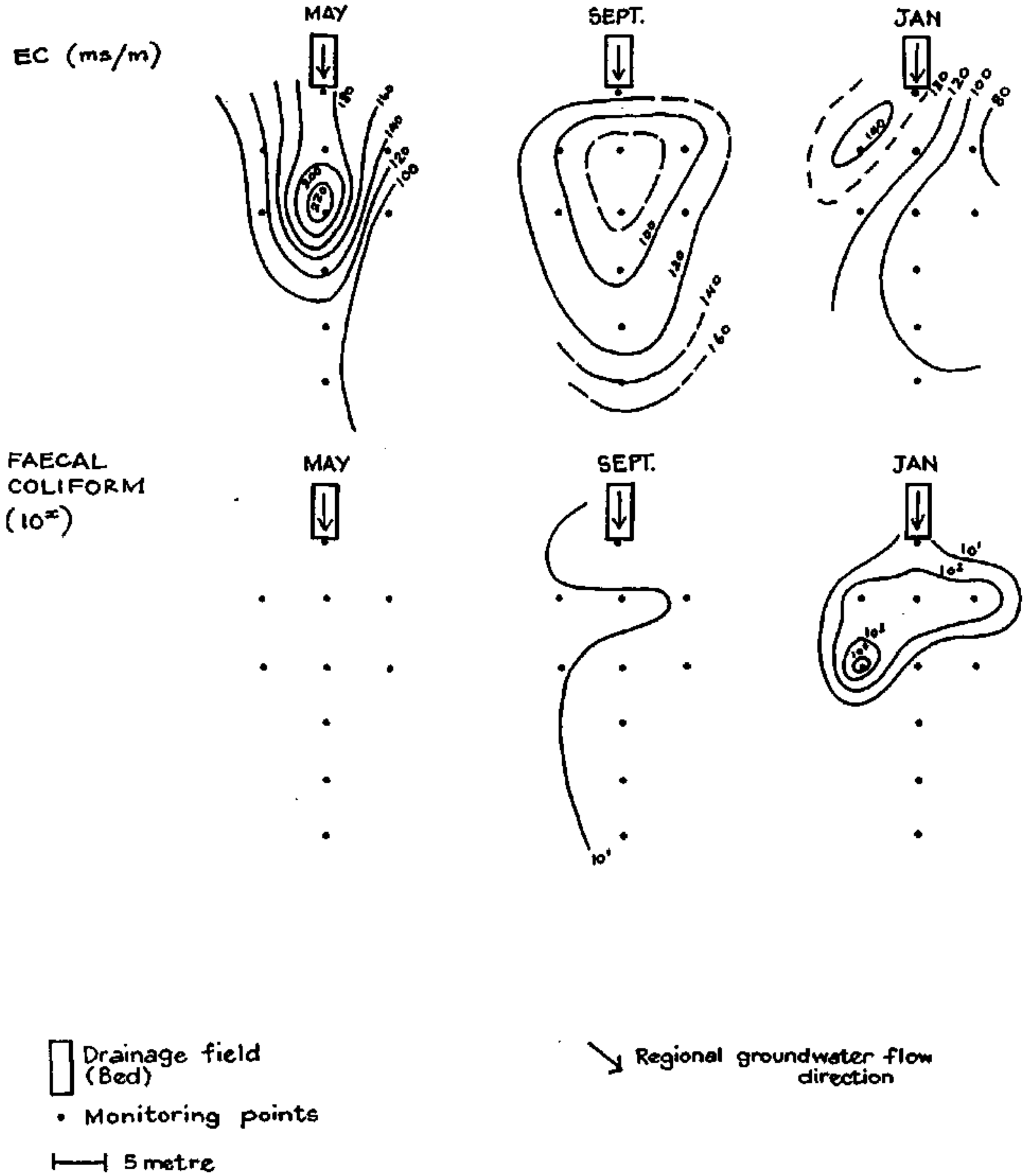
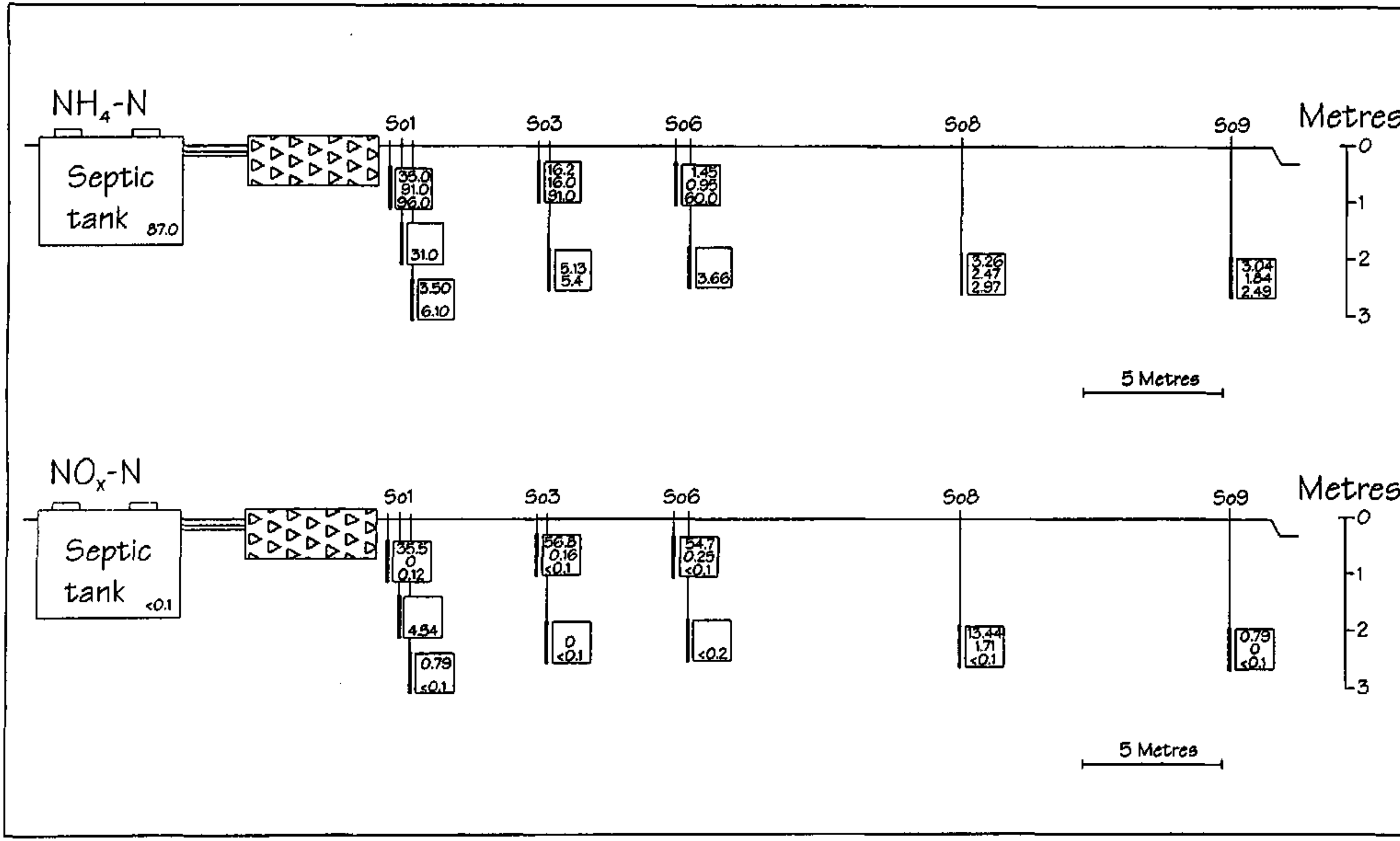


Figure B2 Selected contaminant plumes as observed at the domestic septic tank system in Onrus



GROUNDWATER MONITORING NETWORK

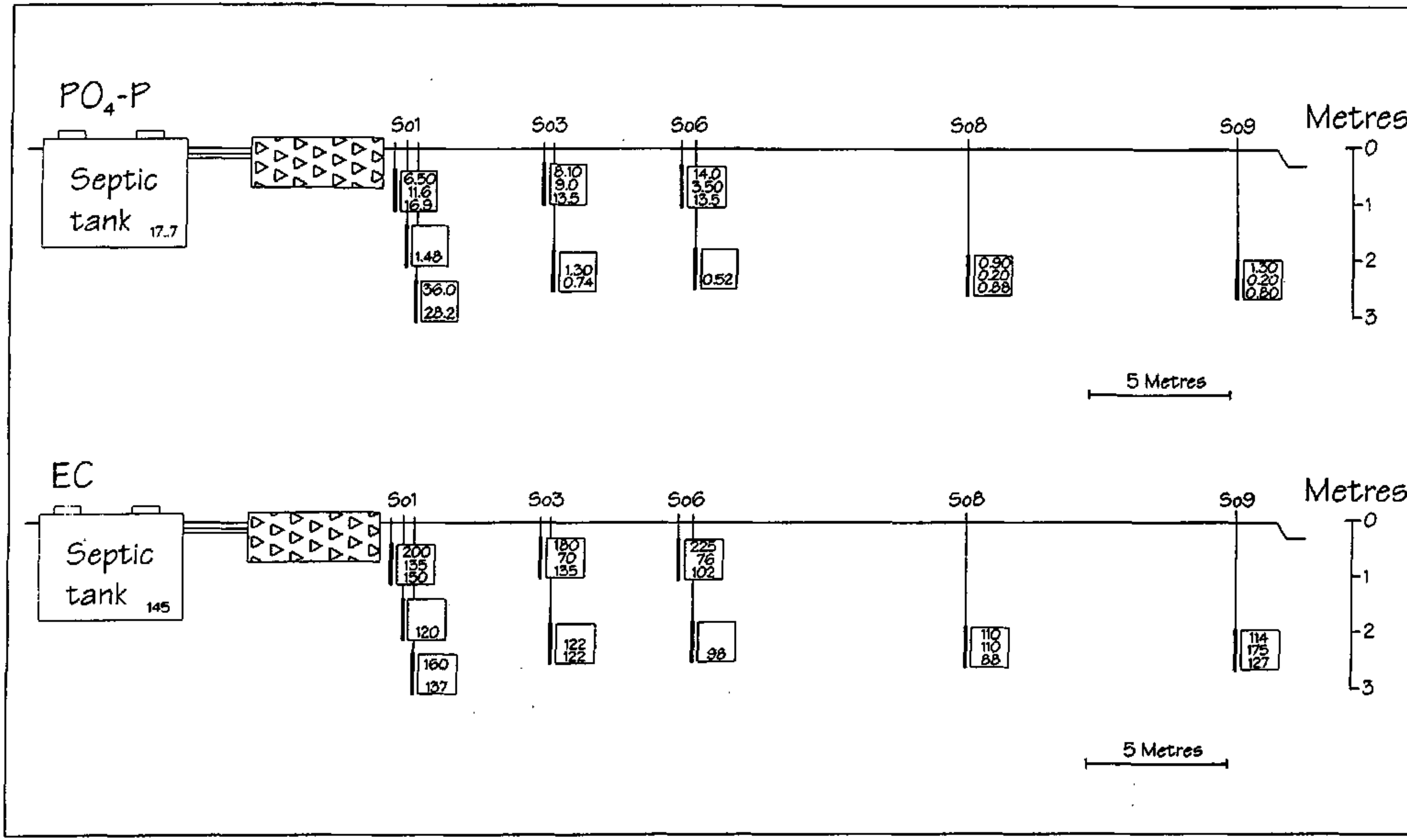
Domestic septic tank system in Onrus

NH_4-N and NO_x-N

10.0	Autumn
15.8	Spring
16.3	Summer

Soakaway trench

Figure B3-



GROUNDWATER MONITORING NETWORK

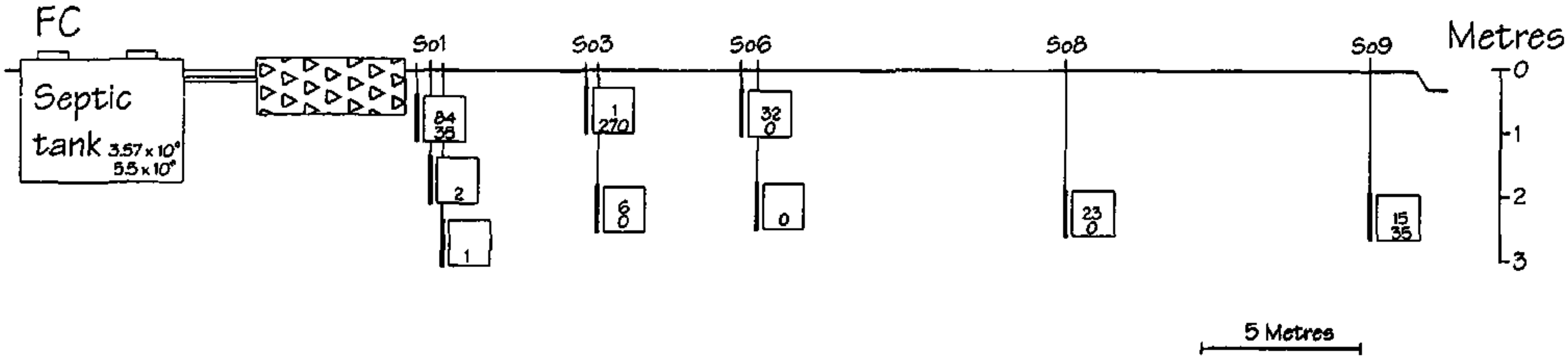
Domestic septic tank system in Onrus

PO_4-P and Electrical conductivety

10.0	Autumn
15.8	Spring
16.3	Summer

Soakaway trench

Figure B4



GROUNDWATER MONITORING NETWORK

Domestic septic tank system in Onrus

Faecal coliforms

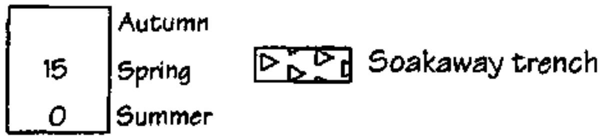


Figure B5

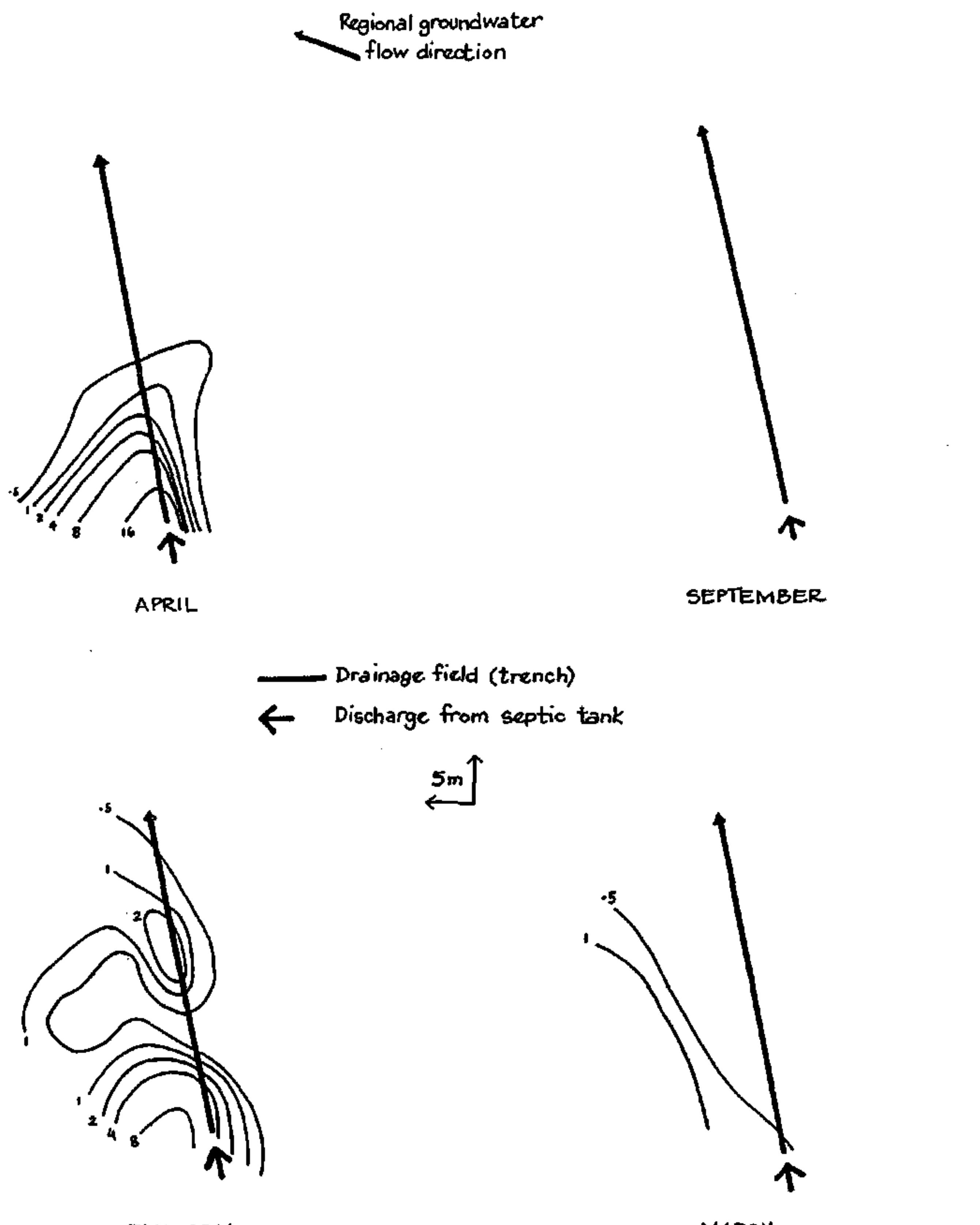
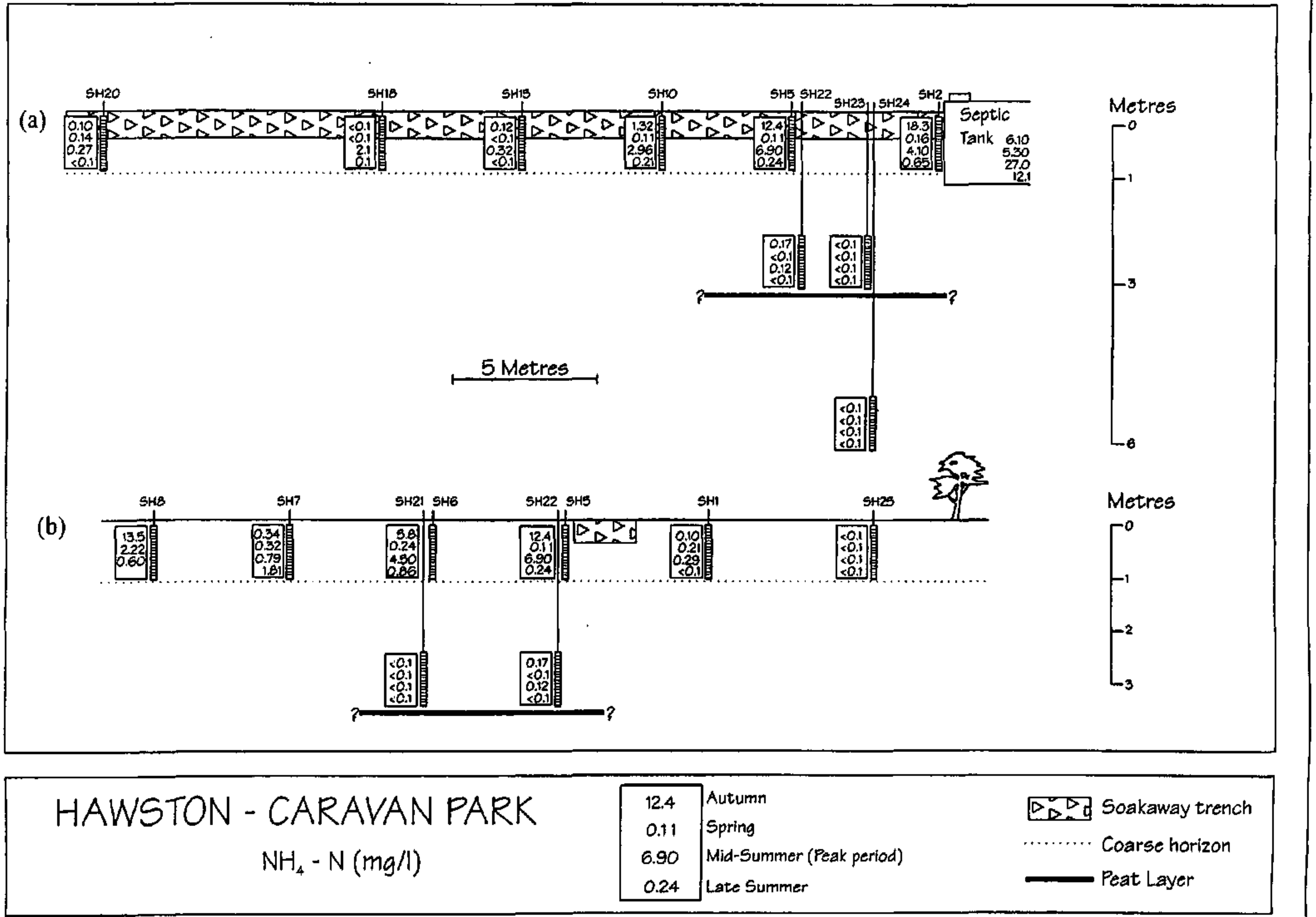


Figure B 6 The ammonia plume as observed at the caravan park ablution block site



(a)
SH20
SH18
SH15
SH10
SH5
SH22
SH23
SH24
SH2
Septic Tank
6.10
5.30
27.0
12.1
0.10 0.14 0.27 <0.1
<0.1 <0.1 2.1 0.1
0.12 <0.1 0.32 <0.1
1.32 0.11 2.96 0.21
12.4 0.11 6.90 0.24
18.3 0.16 4.10 0.65
0.17 <0.1 0.12 <0.1
<0.1 <0.1 <0.1 <0.1
<0.1 <0.1 <0.1 <0.1
5 Metres
Metres
0
1
3
6
(b)
SH8
SH7
SH21
SH6
SH22
SH5
SH1
SH25
13.5 2.22 0.60
0.34 0.32 0.79 1.81
5.8 0.24 4.50 0.86
12.4 0.11 6.90 0.24
0.10 0.21 0.29 <0.1
<0.1 <0.1 <0.1 <0.1
<0.1 <0.1 <0.1 <0.1
0.17 <0.1 0.12 <0.1
Metres
0
1
2
3
HAWSTON - CARAVAN PARK
NH4 - N (mg/l)
12.4 Autumn
0.11 Spring
6.90 Mid-Summer (Peak period)
0.24 Late Summer
Soakaway trench
Coarse horizon
Peat Layer

Figure B7-

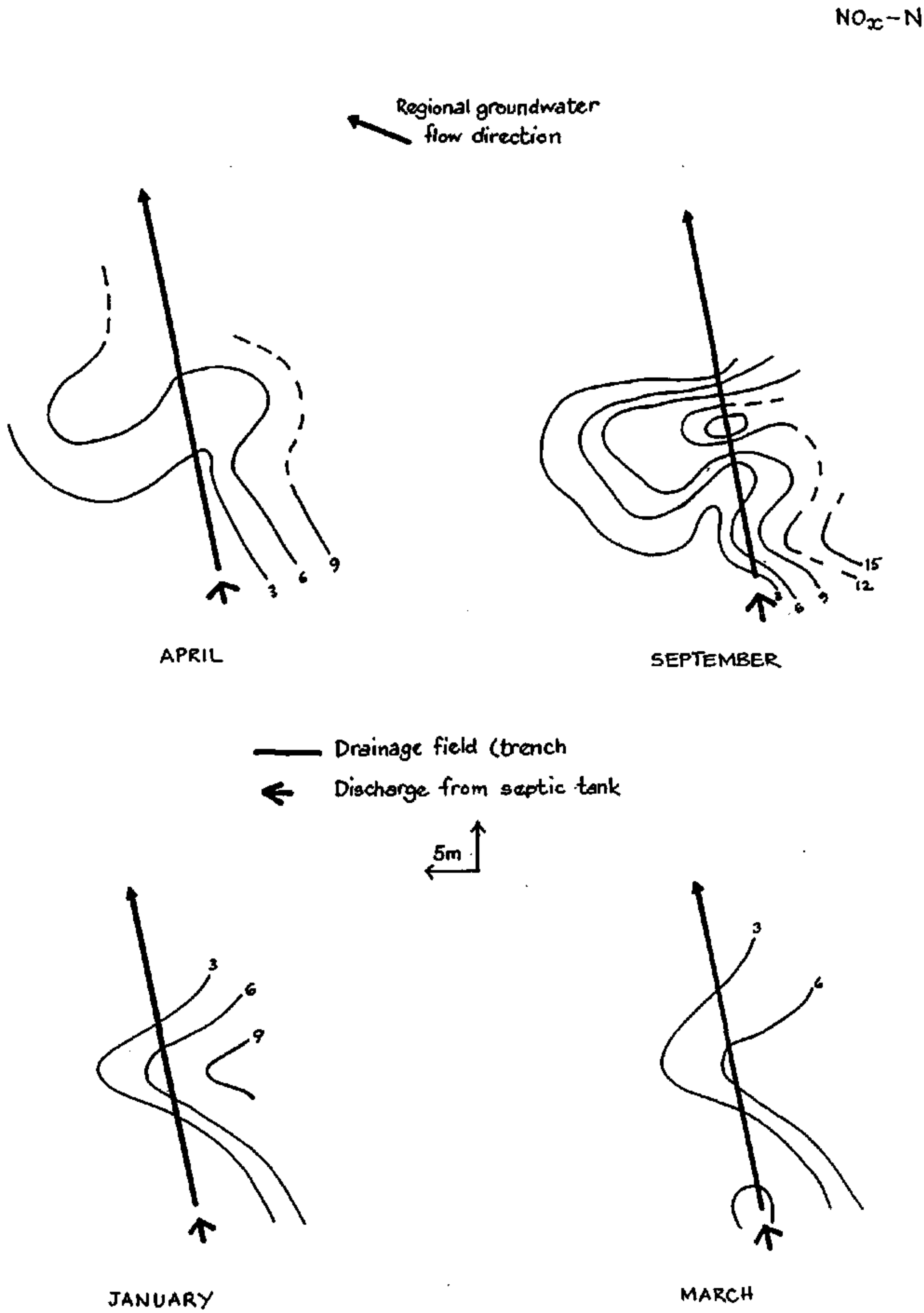


Figure B 8 The nitrate plume as observed at the caravan park ablution block site

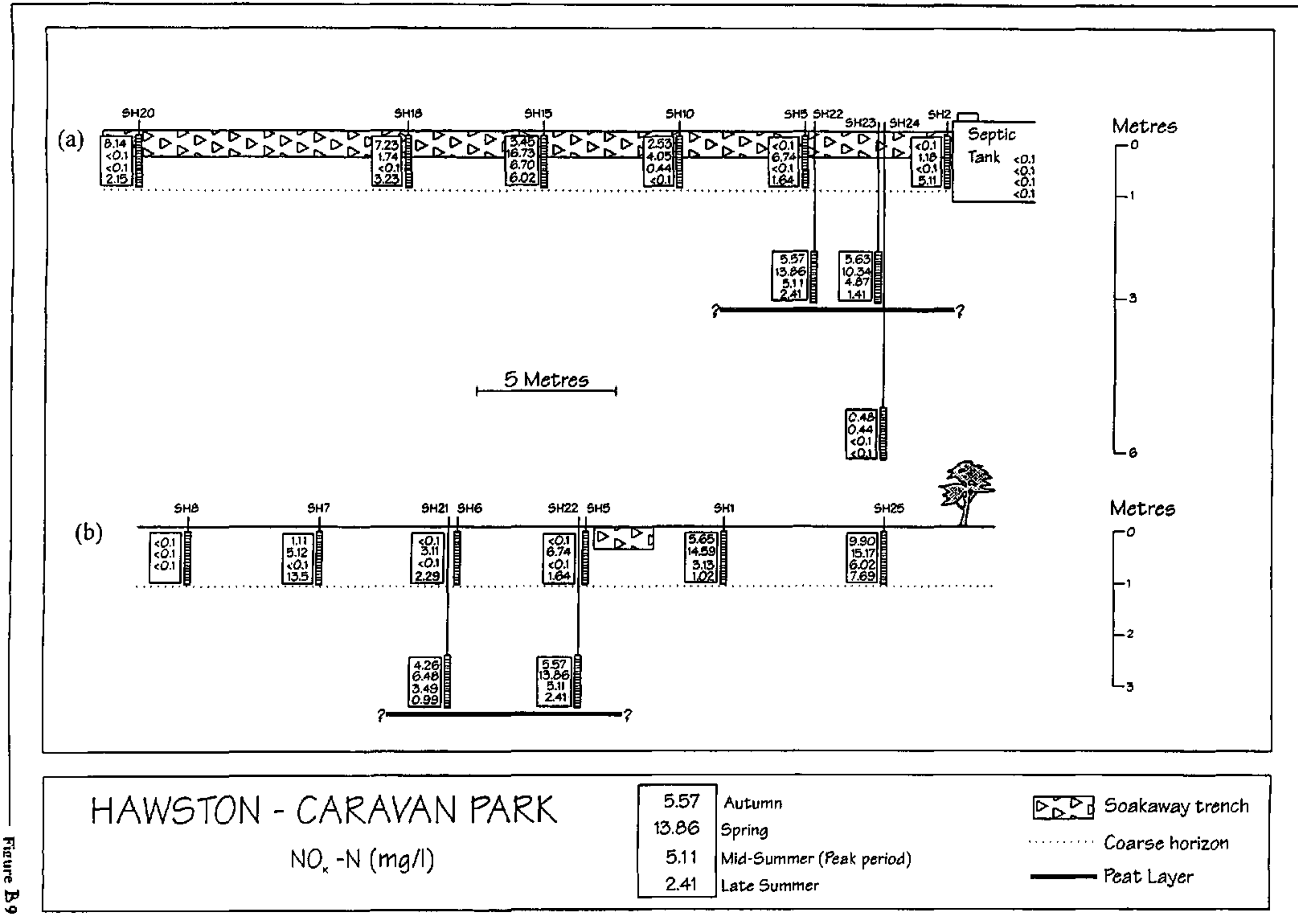

(a)
SH20
SH18
SH15
SH10
SH5
SH22
SH23
SH24
SH2
Septic Tank
8.14
<0.1
<0.1
2.15
7.23
1.74
<0.1
3.23
3.45
16.73
8.70
6.02
2.53
4.05
0.44
<0.1
<0.1
6.74
<0.1
1.64
<0.1
1.18
<0.1
5.11
<0.1
<0.1
<0.1
<0.1
5.57
13.86
5.11
2.41
5.63
10.34
4.87
1.41
0.48
0.44
<0.1
<0.1
5 Metres
Metres
0
1
3
6
(b)
SH8
SH7
SH21
SH6
SH22
SH5
SH1
SH25
<0.1
<0.1
<0.1
1.11
5.12
<0.1
13.5
<0.1
3.11
<0.1
2.29
<0.1
6.74
<0.1
1.64
5.65
14.59
3.13
1.02
9.90
15.17
6.02
7.69
4.26
6.48
3.49
0.99
5.57
13.86
5.11
2.41
Metres
0
1
2
3
HAWSTON - CARAVAN PARK
NOx -N (mg/l)
5.57 Autumn
13.86 Spring
5.11 Mid-Summer (Peak period)
2.41 Late Summer
Soakaway trench
Coarse horizon
Peat Layer

Figure B9 .

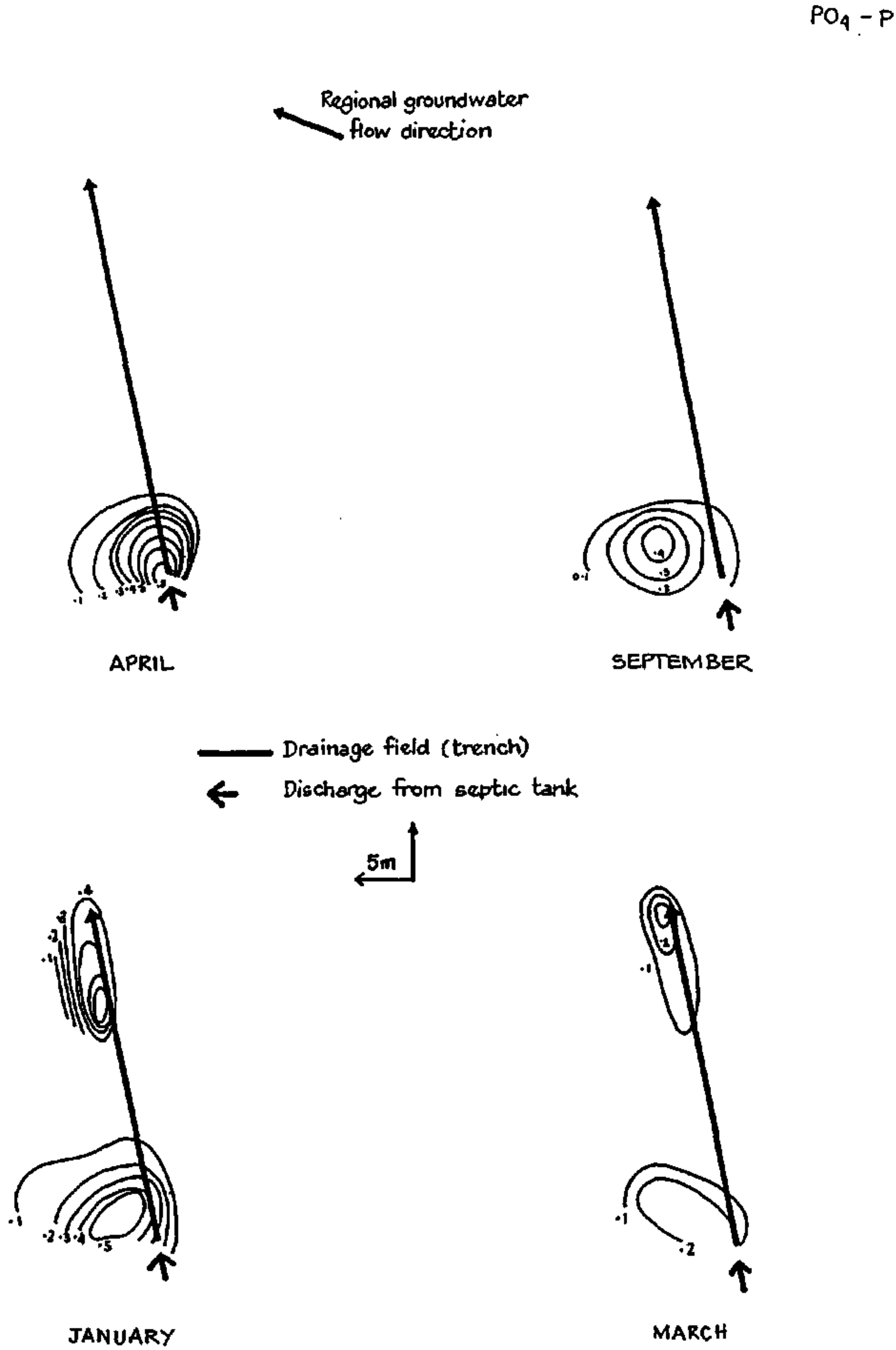
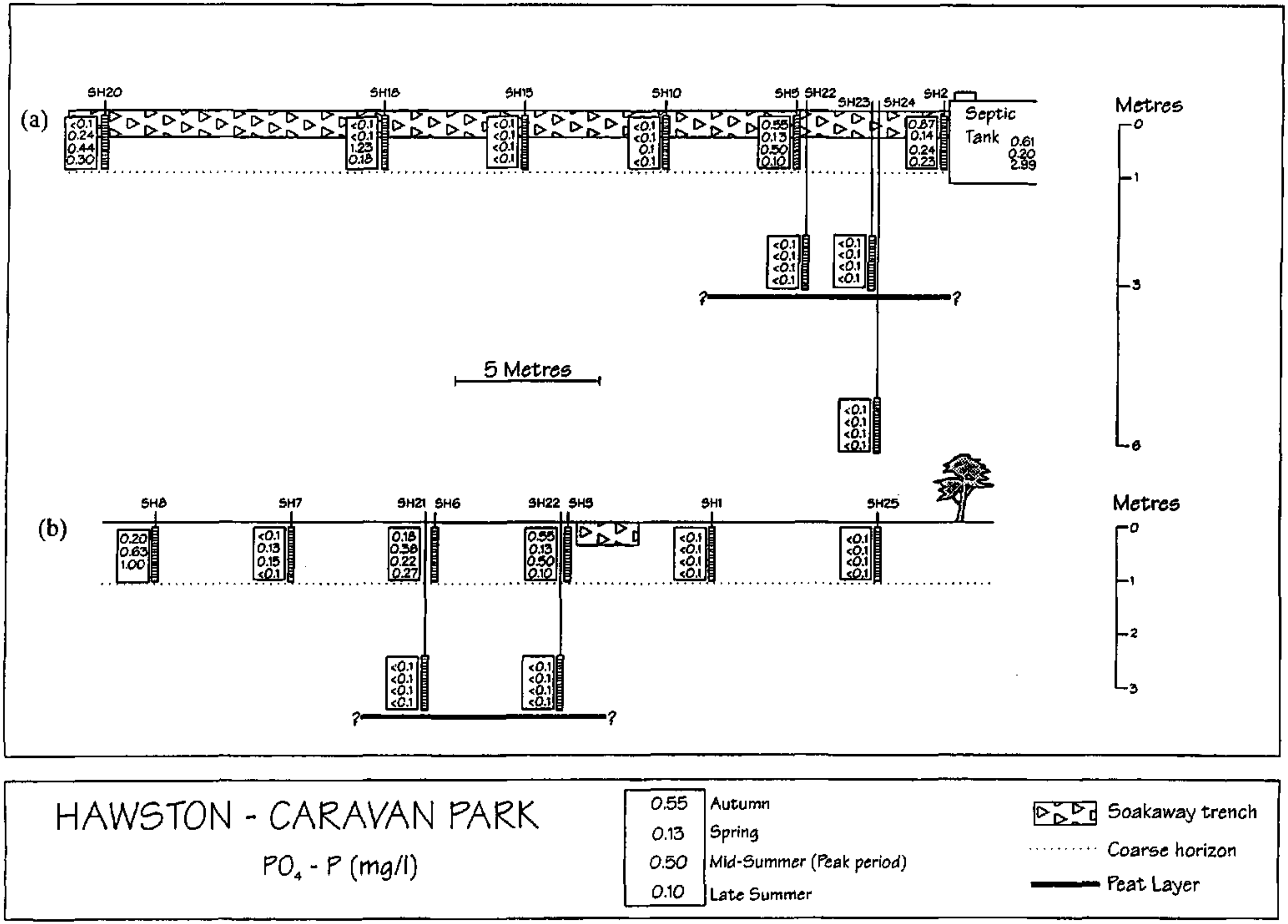


Figure B10 The orthophosphate plume as observed at the caravan park ablution block site



(a)
SH20
SH18
SH15
SH10
SH5
SH22
SH23
SH24
SH2
Septic Tank
0.61
0.20
2.99
<0.1 0.24 0.44 0.30
<0.1 <0.1 1.23 0.18
<0.1 <0.1 <0.1 <0.1
<0.1 <0.1 0.1 <0.1
0.55 0.13 0.50 0.10
0.87 0.14 0.24 0.23
<0.1 <0.1 <0.1 <0.1
<0.1 <0.1 <0.1 <0.1
<0.1 <0.1 <0.1 <0.1
5 Metres
Metres
0
1
3
6
(b)
SH8
SH7
SH21
SH6
SH22
SH5
SH1
SH25
0.20 0.63 1.00
<0.1 0.13 0.15 <0.1
0.18 0.38 0.22 0.27
0.55 0.13 0.50 0.10
<0.1 <0.1 <0.1 <0.1
<0.1 <0.1 <0.1 <0.1
<0.1 <0.1 <0.1 <0.1
<0.1 <0.1 <0.1 <0.1
Metres
0
1
2
3
HAWSTON - CARAVAN PARK
PO4 - P (mg/l)
0.55 Autumn
0.13 Spring
0.50 Mid-Summer (Peak period)
0.10 Late Summer
Soakaway trench
Coarse horizon
Peat Layer

Figure B11 -

FC

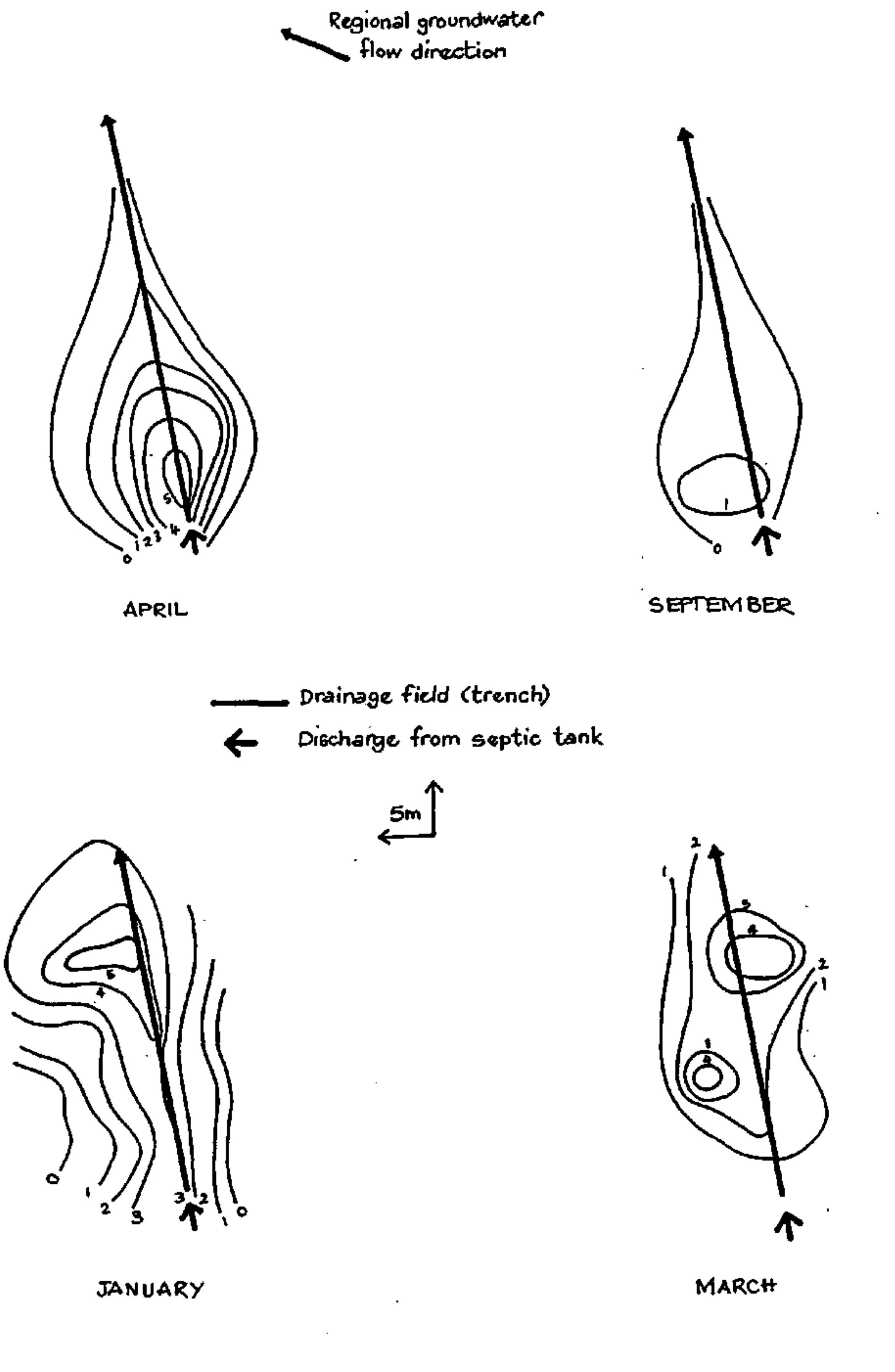
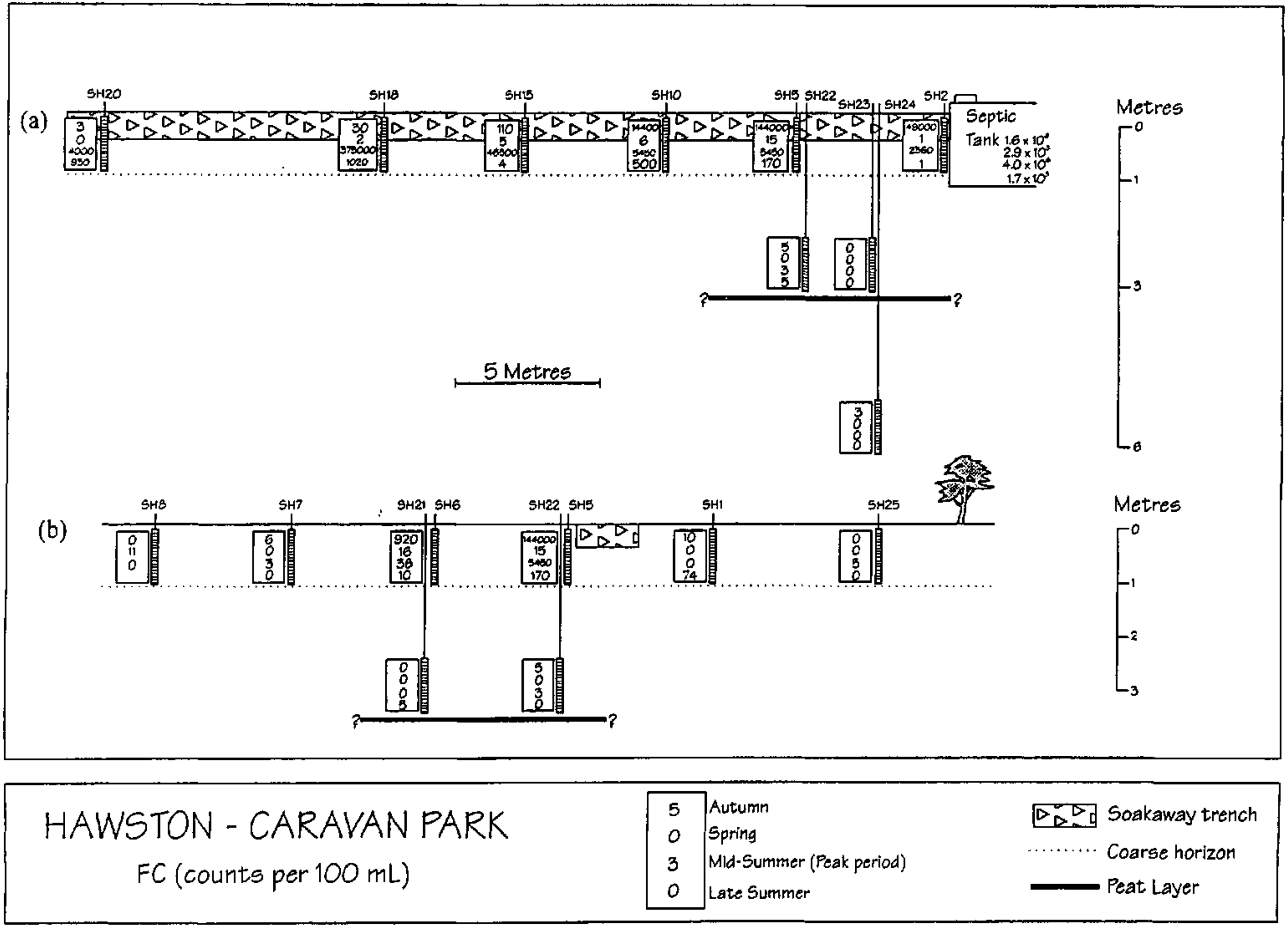


Figure B12 The faecal coliform plume as observed at the caravan park ablution block site



(a)
SH20
SH18
SH15
SH10
SH5
SH22
SH23
SH24
SH2
Septic Tank 1.6 x 10⁶ 2.9 x 10⁵ 4.0 x 10⁶ 1.7 x 10⁵
3 0 4000 930
30 2 375000 1020
110 5 46500 4
14400 6 5450 500
144000 15 5450 170
49000 1 2360 1
5 0 3 5
0 0 0 0
3 0 0 0
5 Metres
Metres
0
1
3
6
(b)
SH8
SH7
SH21
SH6
SH22
SH5
SH1
SH25
0 11 0
6 0 3 0
920 16 38 10
144000 15 5450 170
10 0 0 74
0 0 5 0
0 0 0 5
5 0 3 0
Metres
0
1
2
3
HAWSTON - CARAVAN PARK
FC (counts per 100 mL)
5 Autumn
0 Spring
3 Mid-Summer (Peak period)
0 Late Summer
Soakaway trench
Coarse horizon
Peat Layer

Figure B13—

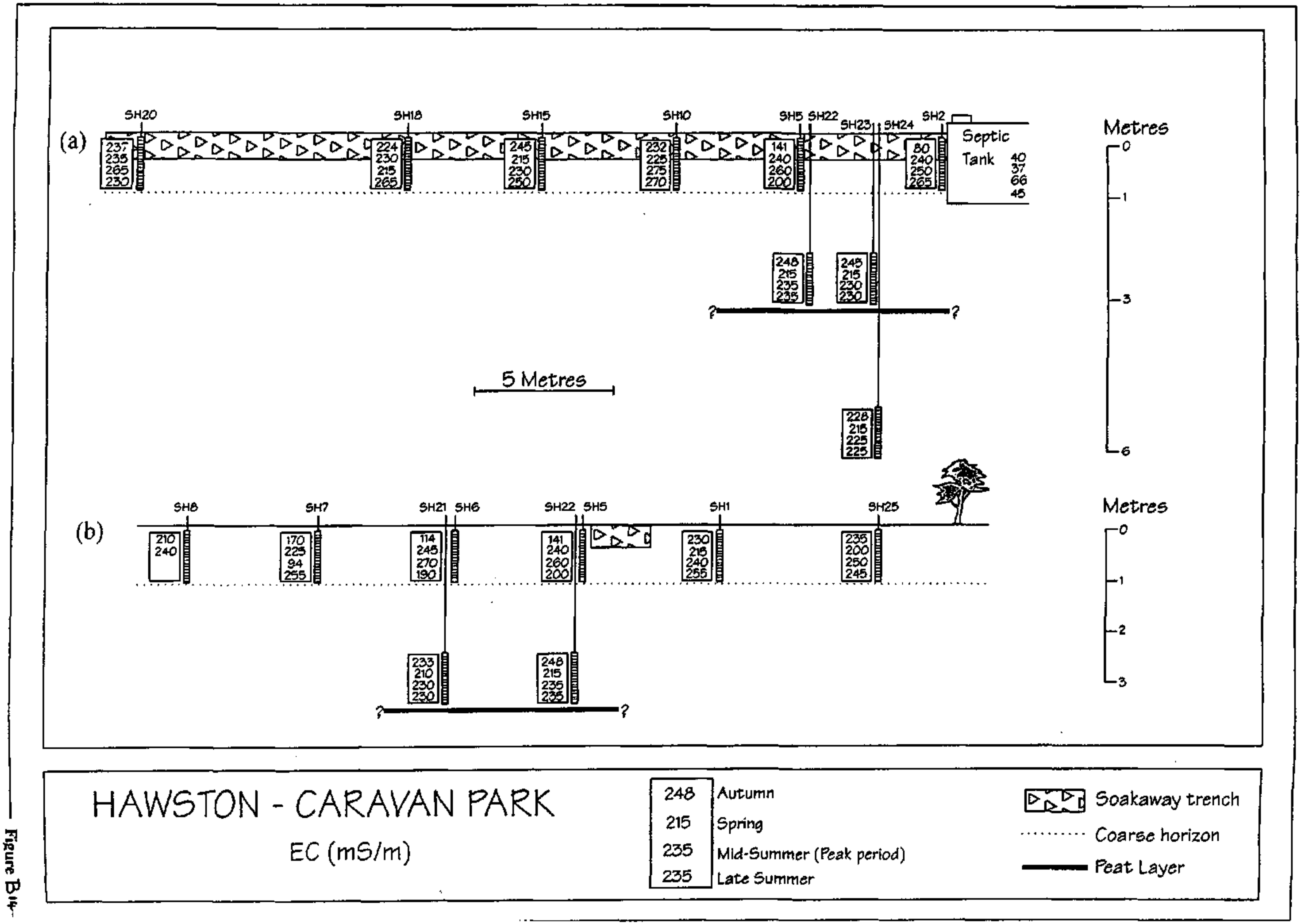
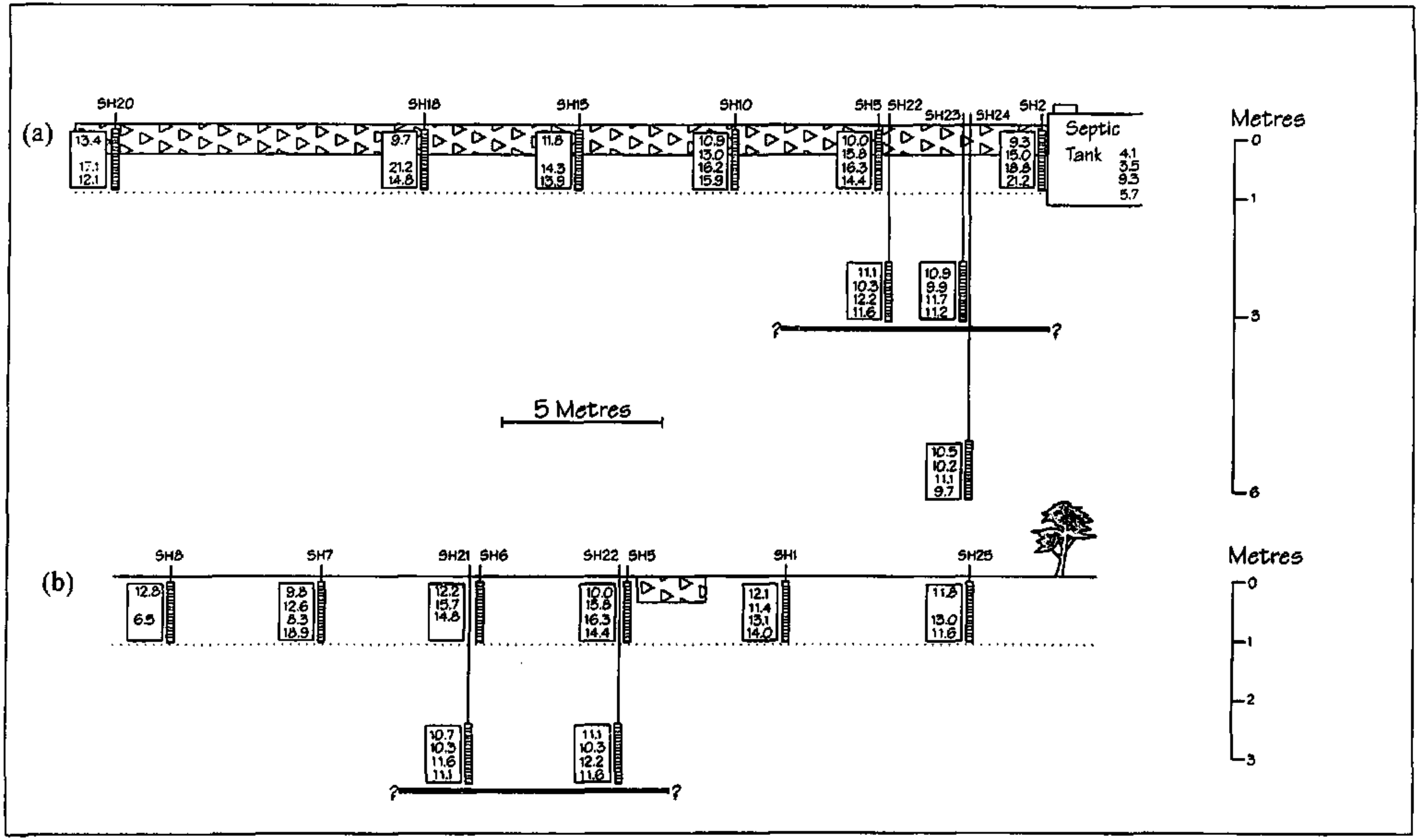

(a)
SH20
SH18
SH15
SH10
SH5
SH22
SH23
SH24
SH2
Septic Tank
40
37
66
45
Metres
0
1
3
6
5 Metres
(b)
SH8
SH7
SH21
SH6
SH22
SH5
SH1
SH25
Metres
0
1
2
3
HAWSTON - CARAVAN PARK
EC (mS/m)
248 Autumn
215 Spring
235 Mid-Summer (Peak period)
235 Late Summer
Soakaway trench
Coarse horizon
Peat Layer

Figure B14



HAWSTON - CARAVAN PARK

K (mg/L)

10.0	Autumn
15.8	Spring
16.3	Mid-Summer (Peak period)
14.4	Late Summer

Soakaway trench

Coarse horizon

Peat Layer

Figure B15