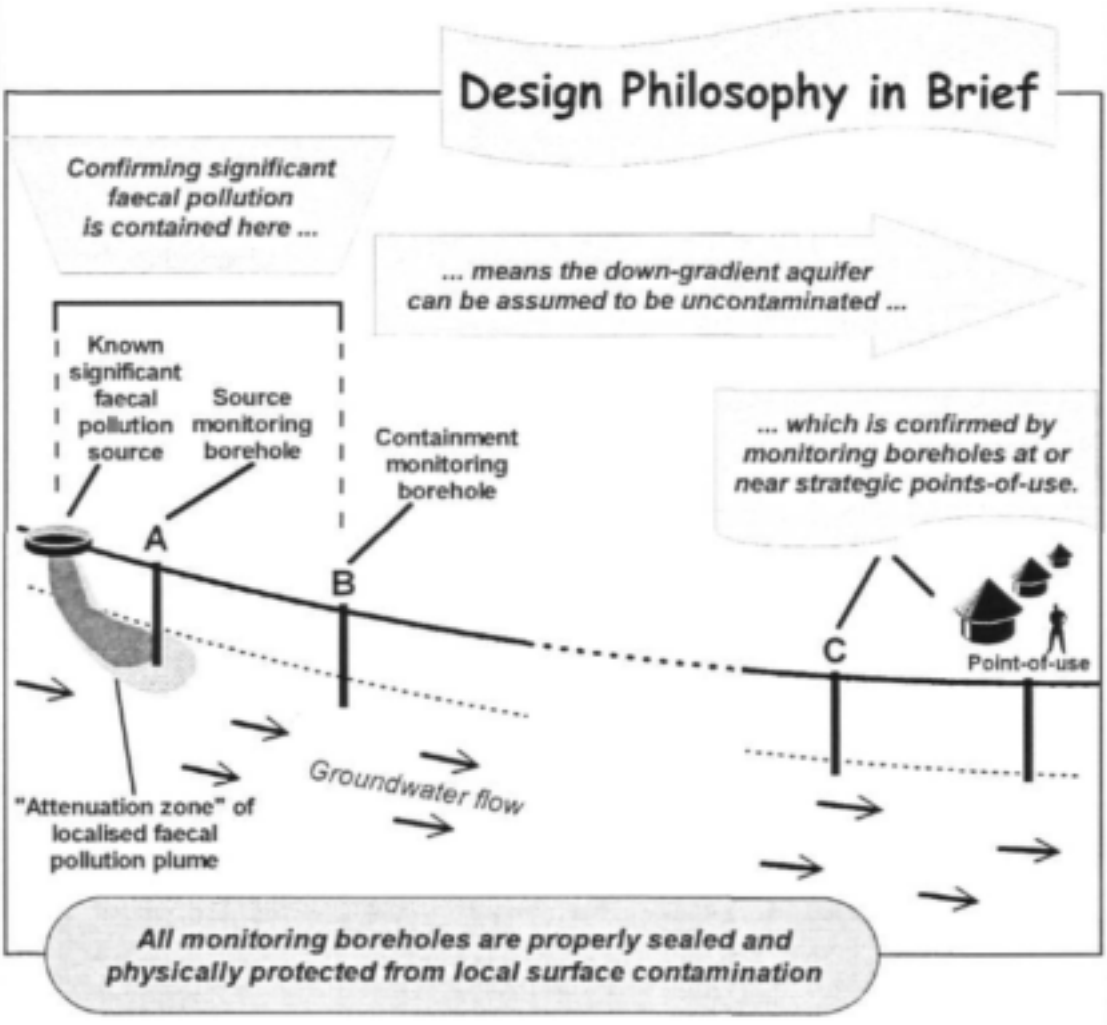
SUMMARY

Design Philosophy in Brief



Examples of typical analyses and associated assessments:

E. coli at ...			Assessment of ...		
A	B	C	... impact of source	... containment	... microbial quality down-gradient of B
Low or zero	*Zero*	*Zero*	Within expectations	Effective	Unlikely to be contaminated
Always high	*Zero*	*Zero*	Worsening	Effective	Unlikely to be contaminated
Always high	*Sometimes detected*	*Zero*	Worsening	Ineffective	Unlikely to be contaminated. Some concern over future contamination.

National Microbial Monitoring Programme for Groundwater
DWAF National Objectives

To measure, assess and report on a regular basis
the status and trends
of the microbial water quality
that reflects the degree of faecal pollution
(because of the associated human health risks)
of South African groundwater resources
in a manner that is
soundly scientific and
that will support strategic management decisions
in the context of sustainable fitness for use of those water resources.

This programme is one of a number of national "status and trends" monitoring programmes that address the requirement of the National Water Act (No. 36 of 1998) to establish national information systems on South African water resources. More specifically, it is aligned with the policy and strategy for groundwater quality management in South Africa. The Department of Water Affairs and Forestry (DWAF) as the custodian of the nations water resources has the mandate to establish monitoring programmes such as this one.

Microbial groundwater quality in South Africa, relating in particular to faecal pollution, is not well characterised at present. However, many potential faecal pollution sources exist, such as dense informal settlements with inadequate sanitation and large sewage treatment works. Groundwater is now seen as being of primary importance in supplying safe drinking water, especially to inhabitants of rural areas. However, groundwater studies in the past have generally not focussed on faecal pollution, although this is now changing. This may be due partly to the technical difficulties associated with obtaining representative and uncontaminated samples.

Groundwater monitoring on a national scale is carried out by the Department. This focusses on water quantity variables (such as water level) and chemical groundwater quality. The microbial monitoring programme described in this manual is intended to supplement the existing monitoring and should be regarded as a separate programme in its own right.

The behaviour of faecal microorganisms in groundwater is influenced by a wide variety of factors. Transport is facilitated primarily by the bulk movement of groundwater. However, although microscopic, faecal microorganisms are filtered to varying extents by the medium through which they are transported. The extent is dependent on the aquifer type and microorganism size. For example, bacteria are generally larger than

viruses so tend to be filtered more effectively. More importantly, most faecal microorganisms have very limited survival periods outside their optimum environment (namely, mammalian intestinal tracts). However, some can remain viable for very long periods (sometimes months) in the form of cysts or spores.

These factors, coupled with the generally relatively slow movement of groundwater, usually results in a localised impact. This is in contrast to conservative chemical pollutants that can be transported long distances in groundwater. This localisation concept is the basis of the philosophy of microbial monitoring of groundwater for which a design is presented in this manual.

In order to support strategic decisions in the context of fitness for use, general statements ideally need to be made about faecal contamination of aquifers as a whole. Because impacts are usually localised, monitoring a microorganism, like the indicator bacterium *E. coli* chosen for this programme, in a single monitoring borehole provides very little information about the likely distribution of that microorganism in the aquifer as a whole. This suggests that a finely-spaced network of monitoring boreholes throughout an aquifer might be necessary. However, this is prohibitively expensive and impractical in the context of a national monitoring programme.

Therefore the basic philosophy of this monitoring programme is to shift emphasis of the monitoring away from where the groundwater is used, or is likely to be used, to where it is known, or suspected, to be faecally contaminated. More specifically, the philosophy is to monitor the effectiveness with which faecal pollution from known significant faecal pollution sources is contained in a localised area. It is then assumed, albeit with caution, that the remainder of the aquifer is then likely to be of acceptable microbial quality. As a precautionary measure, monitoring is also done at strategic points of use. These include both current and potential future use.

Three types of boreholes are recommended, the purposes of which are summarised as follows (A, B and C refer to the figure on page (I)):

Borehole type	Purpose
Source (Borehole A)	Monitors behaviour of the source more confidently than the containment borehole, in particular detecting worsening trends at the source that can be used to invoke source directed controls.
Containment (Borehole B)	Confirms local faecal pollution plume effectively contained allowing reasonably confident statements to be made about likely microbial quality elsewhere down-gradient.
Point-of-use (Borehole C)	Provides backup monitoring near strategic points of groundwater use that confirm, or otherwise, that faecal pollution from known significant sources are indeed well contained. Also partly necessary because of uncertainties associated with defining the attenuation zone and down-gradient flow paths.

Of particular concern when establishing monitoring boreholes is that they are well protected from faecal contamination occurring in the immediate vicinity on the surface. This contamination can use the disturbed zone along the outside of the borehole casing as a conduit to reach the aquifer. Protection is achieved by equipping the borehole with a sanitary seal and by preventing unnecessary access to the borehole by animals and people. Extreme care also needs to be taken while sampling to ensure that the sample is not accidentally contaminated by unclean hands or other local contaminated objects. Purging of the borehole is also recommended, particularly in the case of infrequently-used boreholes, to ensure that the sample is adequately representative of the surrounding groundwater. Demanding logistical constraints also exist since samples need to reach the laboratory for analysis within 24 hours.

The monitoring data will be stored on the Department's Water Management System located near the Roodeplaat Dam, north of Pretoria. Annual assessments of the data should be carried out and reports prepared and sent to appropriate stakeholders. Particular care needs to be taken to ensure that reporting is accurate and unambiguous. A mechanism should also be in place that allows for interim *ad hoc* reports to be prepared and delivered to appropriate stakeholders when monitoring results indicate a worsening of a problem to the extent that some source directed intervention might be required.

A National Coordinator should be appointed within the Department to coordinate implementation of the programme. The overall national implementation process must focus on many issues that ensure the successful implementation of the programme in the initialisation phase and its sustainability thereafter. The process involves successively including Water Management Areas (WMAs) in a phased way until sufficient national coverage is attained. A Regional Monitoring Coordinator should be appointed in each WMA. Initial emphasis should be placed on establishing successful monitoring programmes that can be used to drive further interest and hence resource allocation. It is the responsibility of the Regional Monitoring Coordinator and the National Coordinator to ensure that local monitoring programmes are designed in a standard way within the framework described in this manual.

A multitude of role players with very specific responsibilities are required to successfully implement a national monitoring programme. These range from the samplers, analysts, local managers, regional coordinators, a national coordinator, the Minister of Water Affairs and Forestry and concerned parties at local, regional and national and international level. Different management models can be envisaged. These differ in the degree to which responsibilities are delegated. The most likely models involve delegation of responsibilities to Catchment Management Agencies who may in turn delegate local responsibilities to specific organisations (like water boards).

This prototype implementation manual is supplemented with a research report that provides the rationale behind the design and implementation plan presented here.