REPUBLIC OF SOUTH AFRICA

Water Quality Management Series

Managing the Water Quality Effects of Settlements: -

THE NATIONAL COSTS OF POLLUTION FROM SETTLEMENTS

Department of Water Affairs and Forestry

OCTOBER 2001

Water Quality
Management Series

MANAGING THE WATER QUALITY EFFECTS OF SETTLEMENTS:-

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FROM SETTLEMENTS

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DOCUMENT INDEX

This document forms part of the Department of Water Affairs and Forestry's National Strategy for Managing the Water Quality Effects of Settlements. It represents one of the outputs of a project that was jointly funded by the Department of Water Affairs and Forestry and the Danish Government via their DANCED program.

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Managing the Water Quality Effects of Settlements.
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Managing the Water Quality Effects of Settlements
Considerations for the Sustainable Management of Pollution from Settlements. Policy Document U 1.4

Managing the Water Quality Effects of Settlements
The National Strategy. Edition 2, Policy Document U 1.3

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PREFACE

Pollution from densely populated and poorly serviced settlements is perhaps one of South Africa's most *important*, but most *complex* water quality problems.

Important, because pollution in and from these settlements not only affects downstream users, but has its most significant impacts on the communities living in these settlements. Failing sanitation and waste removal systems create appalling living conditions in many settlements, and contribute to serious health problems in these communities. Pollution in and from these settlements is, therefore, not only a water quality issue, but has much wider implications for government's aims to provide a better life for all

Complex , because pollution in settlements is rooted in the socio-economic, political and institutional conditions in the settlement. The use, or misuse, of services together with the way in which the services are maintained by Local Authorities lies at the heart of the pollution problem in many settlements. This is further complicated by the legacy of South Africa's apartheid history. Solutions, therefore, lie in changing the way in which the services are supplied and used.

However, *sustainable* solutions to the problem lie not only in our ability to supply and use waste and sanitation services to best effect, but also in the longer-term capacity of local government to maintain these services. This is likely to be the biggest stumbling block to sustainable management of pollution from settlements. Local government in South Africa clearly has significant capacity problems, and misuse of services, for a variety of reasons, is endemic in many settlements across the country. More importantly, failing waste services contribute to poor living conditions, and hence to the misuse of the services. Non-payment for services also limits the capacity of the Local Authority to effectively maintain the services, which then leads to further failure of the services.

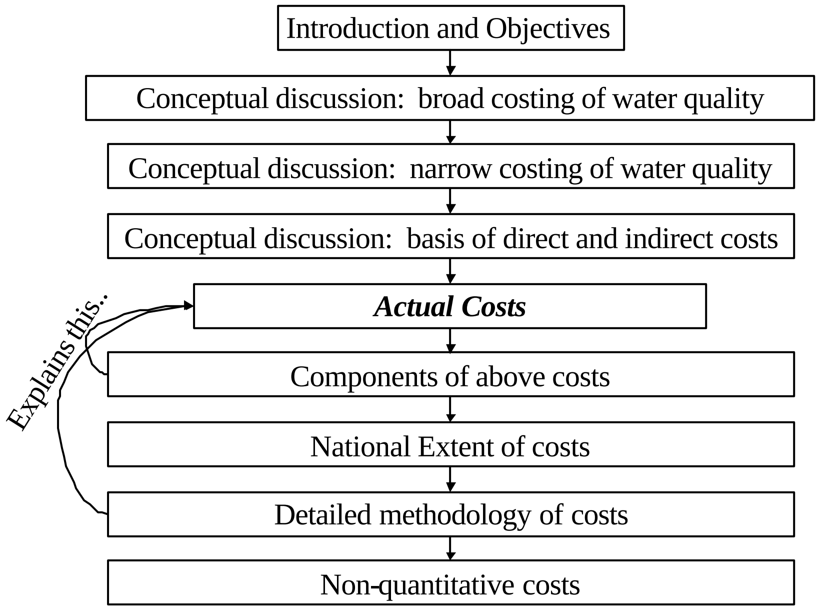
Strategies to manage pollution in settlements must take a broader view of both Local Authority capacity, and the socio-economic and political dynamics of the community in order to arrest this downward spiral. The Department of Water Affairs and Forestry, therefore, initiated a study of the links between pollution, community perceptions and local government capacity, to run in parallel with the Test Cases. A number of reports have been produced to support this study.

It is hoped that these reports provide compelling arguments to address this problem both by ensuring better planned and run services, but also by active intervention and assistance where there are clear and immediate threats to community health and the environment. This report forms part of this process.

Table of Contents

1. *How to read this report…*

This report follows the plan laid out below. The report provides an initial discussion of the objectives of the report, and a conceptual discussion what "costs" are associated with pollution in and from settlements. After this, the actual costs of this pollution are presented. The report then outlines the details of how these costs were calculated. The reader should therefore step through the document for increasing detail on the "costs" of pollution in settlements, and how these were calculated. This is illustrated in the following diagram.



Please also note that it is not possible to quantify the direct costs of pollution from settlements. However, there is a link between diarrhoea and pollution in settlements. Where there are significant pollution problems, both with solid waste and failing sanitation systems, the incidence of diarrhoea is significantly higher. This is due to an increased exposure to faecal material, and an increase in the numbers of insect vectors. While, the Project Team recognises that diarrhoea can be caused by many factors, including poor sanitation and health practices in the home, we feel that risks are significantly higher in a polluted environment.

Previous studies in South Africa have estimated the incidence rates for diarrhoea in settlements with different service levels. These incidence rates can be used to calculate the likely number of incidences of diarrhoea on a national basis using the Census data.

2. Introduction

This report forms part of a wider DWAF project aimed at the development of a strategy to manage the water quality effects of densely populated settlements. This project was initiated by DWAF along with DANCED in June 1997 with the development of a draft National Strategy and was followed by a Bridging Phase, which allowed for stakeholder involvement.

Phase 2 of the study began in January 1999 and was aimed at testing the National Strategy. A decision was made to investigate how Local Authorities engage and implement the strategy and this part of the study is referred to as the National Strategic Process. On 15 and 16 July 1999 a workshop was held at Mabula Lodge near Warmbaths to develop a Terms of Reference for this process.

From this workshop, a number of tasks and outputs were assigned to various resources for further analysis and investigating. These tasks were designed to further assist with the overall National Strategic Process.

This report addresses one of the tasks (output 5.2.3), which is an analysis of the costs of poor water quality effects in densely populated settlements. These costs are the economic costs (quantified) and the health and environmental impacts.

3. Objectives

Poor water quality in dense settlements has a wide range of highly significant impacts on human health, social development, environment and down-stream use values. All of these carry with them large economic costs and wider development implications. This study addresses the potential costs to the SA economy on a qualitative and quantitative basis.

We discuss the social and environmental costs on a qualitative basis. We analyse the following two quantitative scenarios:

- The cost of not managing water quality in densely populated areas with low incomes and poor service levels – also referred to as Low Service Levels in Dense areas;
- The cost of a potential capacity gap where densely populated settlements with high service levels and low incomes are unable to continually fund such service levels – referred to as High Service Levels.

The next section outlines our approach to the broader costing of the effects of poor water quality and sanitation.

4. *Broad costing of poor water quality*

We outline below our overall conceptual thinking to costing the effects of poor water quality.

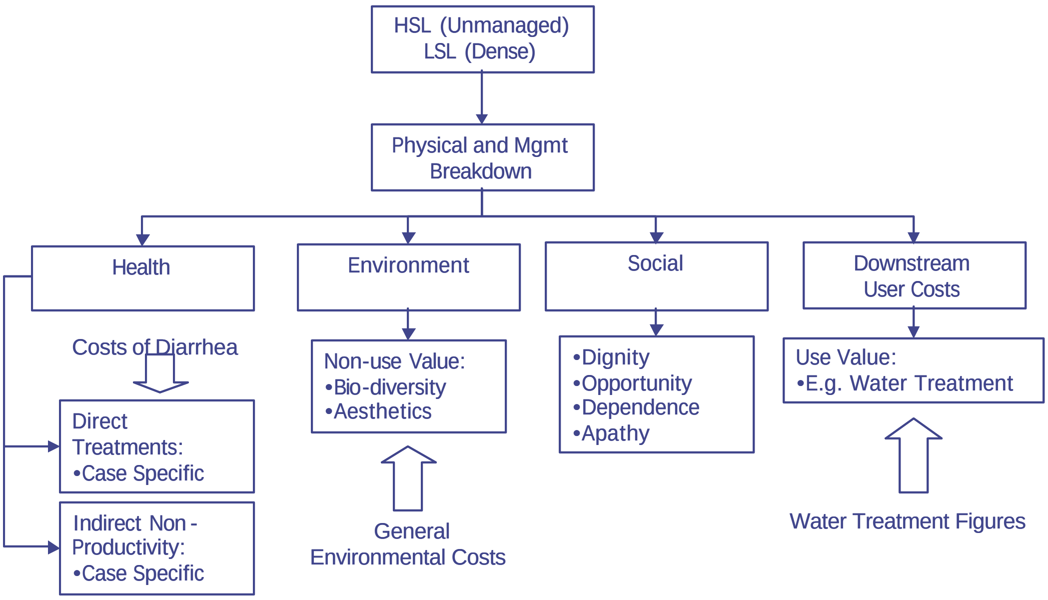


Figure 1: Broader costs of poor water quality

From the above, our overall argument is that the potential costs of poor quality water would be as a result of physical, social and institutional factors. The National Strategy document outlines how these cause pollution problems in more detail. The physical breakdown would result in poor water quality and thus costs in terms of health, environment, social and down-stream user costs. Of these costs, we were able to only quantify treating diarrhoea and down-stream water treatment costs. The cost to the environment would clearly also be significant in terms of non-use values such as bio-diversity and aesthetic degradation. In addition to this, the social costs such as loss of dignity are not quantifiable.

We now continue to present the economic costs and thereafter we follow this up with a qualitative discussion on the environment and social costs.

5. *Narrow economic cost of poor water quality*

The figure below gives an outline of the approach we took in making the narrow economic cost estimates.

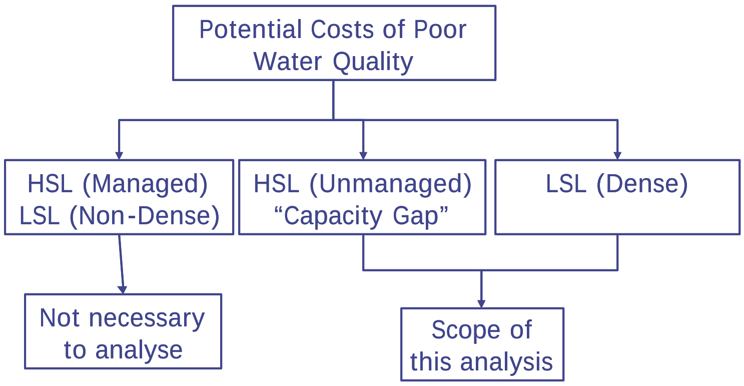


Figure 2: Economic model for costing poor quality water

We approached the question of the potential cost of poor quality water by using the following primary drivers, namely:

a. Population density;
b. Water service levels;
c. Income levels; and
d. Cost of treating diarrhoea.

Population density is simply divided into dense and non-dense areas. We concentrated our study on the densely populated areas, as these are where the obvious costs are likely to arise.

Service levels were divided in low service levels areas and high service level areas.

Income levels were based on income per month and a household earning less than R1000 pm were considered as low.

We limited our study to the costs of treating diarrhoea, as this was the only disease that we could obtain reasonably verifiable statistics for.

From this, we decided to cost the effects of diarrhoea in those areas where the income is low and the population dense. This is regardless of the service levels, as our assumption was, based on other studies for this project, that both low and high service levels, in densely populated areas with low income households, would lead to pollution and hence to increased incidence of diarrhoea. (See the reports on the Capacity Gap, The Financial Gap, and the Economic Gap.)

Throughout this report, Low Service Levels in Dense areas refers to households with low incomes, low service levels and living in dense settlements. High Service Levels refers to households living in high dense areas with high service levels, but low incomes. Research is indicating, *mutatis mutandis*, that where 30% of the population has high service levels and low incomes and they reside in a densely populated area, there is a likelihood of a capacity gap. This is due to local government possibly not being able to recover their cost for providing such services. (See the report on the Financial Gap.)

6. Basis for direct and indirect costs calculations

This section deals with the direct and indirect costs of the effects of diarrhoea for Low Service Levels in Dense areas and High Service Levels. We first outline our methodologies and then present the cost calculations.

6.1 Direct health costs

The table below outlines our methodology in calculating the total direct cost of diarrhoea.

Table 1: Illustration of calculation for total direct health costs

	Total Direct Costs
=	RSA Population
x	% LSL(D) and % HSL(U)
x	% Diarrhoea Incidences
x	Actual Diarrhoea Treatment Cases
x	(% Visits to Health Practitioner/Clinic)
	(% Hospital Out Patient)
	(% General Wards)
	(% Intensive Care)
	(% Diarrhoea Medicine)
	(% Self Medicated Diarrhoea Medicine)
	(% Transport Costs)
=	Direct Health Costs

6.2 Indirect costs

We then factored in the indirect costs and this was done as illustrated by the table below:

Table 2: Illustration of calculation of indirect health cost

	Total Indirect Costs
=	Actual Diarrhoea Incidences
x	Non-Productive Patient Time
x	Non-Productive Carer Time
x	Average Daily Income
=	Indirect Health Costs

7. Costs of poor water quality

The table below summarises our overall costs calculations. Of note is the fact that we calculate that the potential costs of poor water quality in densely populated areas are around R2,9 billion for South Africa per annum.

Table 3: Annual costs of poor water quality in the year 2000

Million	***LSL(D)***	***HSL(U)***	***Total***
Health Direct	R2,070	R154	R2,224
Health Indirect	R647	R53	R700
Water Treatment	R64		R64
Sub-Total	R2,781	R207	R2,988
Environment	x	x	
Social	x	x	

The calculation of these figures is outlined in more detail in the following sections.

The bulk of the costs emanate from densely populated areas with low service levels, Low Service Levels in Dense areas, given that 35% of the South African population find themselves in these circumstances, as opposed to 22% of the population living in areas with low income and high service levels, High Service Levels. (The other 43% of the population has a household income greater than R 1000/m).

As can be seen from the diagram above, the costs are broken down into direct costs (thus treatment costs), indirect productivity losses and additional down-stream treatment costs. As we have mentioned the medical treatment costs are for diarrhoea only.

8. *How we arrived at the above costs*

This section explores in more depth how we arrived at the above costs.

8.1 Direct health costs (based on diarrhoea only)

The actual diarrhoea incidences are an estimate based on fieldwork done by Dr Pegram and then extrapolated to SA as a whole. (Pegram *et al.* 1996)

The diarrhoea incidences were broken down into age groups of under 5 years, between 5 and 16; and over 16 years of age.

The treatment costs took into account the severity of the disease, e.g. mild, moderate or severe and the costs for medicine, doctors, clinics and hospitals. The costs of transportation to and from medical centres were also considered.

8.1.1 For Low Service Levels in Dense areas

Table 4: Incidences and Treatment Costs

Estimated incidences (Million)	***14.2***
Case Treated (Million)	1.1
Average Treatment Cost	R1,904
Total Direct Health Cost (Million)	R2,070

See Table 5 for an explanation of the calculation of the estimated incidences.

The total direct health costs of Low Service Levels in Dense areas is R2.07 billion and this is the product of an estimated 1.1 million cases treated in SA at an average of R1904 per treatment.

Around 8% of people who had diarrhoea, are estimated to have gone for treatment in SA.

The relatively high cost of treatment is a function of the fact that most cases treated were of a moderate or severe nature. In the case of a severe nature, the costs included hospitalisation.

Table 5 below shows how we derived the 14,1 million actual diarrhoea cases.
Of the total amount of people in SA (being 40 million), 14,1 million is estimated to be living in areas with Low Service Levels in Dense and on average, one person would have diarrhoea due to poor water quality at least once per year.

See Section 10 for a more detailed analysis of the incidence rates and numbers of people affected.

Table 5: Estimated diarrhoea cases in LSL(D)

	RSA Population	# of People LSL Dense	Diarrhoea cases per 1000	Actual Diarrhoea Incidences
< 5 Years	4,443,621	1,551,720	2,515	3,902,576
> 5 < 16 Years	9,322,822	3,255,545	1,001	3,257,173
> 16 Years	26,817,129	9,364,587	750	7,024,845
Total	40,583,572	14,171,852	1,001	14,184,594

See Section 10 for a more detailed analysis of the incidence rates and numbers of people affected.

8.1.2 For High Service Levels

Table 6: Direct health costs HSL(U)

Estimated incidences (Million)	1.6
Cases treated (Thousand)	91.0
Average Treatment Cost	R1,692
Total Direct Health Cost (Million)	R154

See Table 7 for an explanation of how the estimated incidences were calculated.

The total direct health costs for High Service Levels is calculated in a similar fashion as that of Low Service Levels in Dense areas.

The number of cases treated is a function of the number of incidences of diarrhoea. We estimate that 5% of the number of people who contracted diarrhoea, would eventually be treated.

As these would be the moderate or severe cases, treatment costs would typically include some form of hospitalisation and thus treatment costs are high.

Table 7: Actual diarrhoea incidences

	RSA Population	# of People HSL (U)	Diarrhoea cases per 1000	Actual Diarrhoea Incidences
< 5 Years	4,443,621	958,020	501	479,489
> 5 < 16 Years	9,322,822	2,009,949	250	502,537
> 16 Years	26,817,129	5,781,624	104	601,318
Total	40,583,572	8,749,593	181	1,583,344

See Section 10 for a more detailed analysis of the incidence rates and numbers of people affected.

The actual diarrhoea incidences for High Service Levels are on average 181 people per thousand. Just below 20% of this population group contract diarrhoea.

8.2 Indirect health costs

The indirect costs, thus productivity lost, is a function of the employee days lost as a result of the incidences of diarrhoea and the daily income.

We took the number of people who would contract diarrhoea and then calculated the average time that each patient might be sick.

We then calculated the employee equivalent time (thus the days an adult would be out of work, either through care giving or the actual adult patient).

8.2.1 For Low Service Levels in Dense areas

Table 8: LSL (D) Non-productive cost

	Actual Diarrhoea Incidences (Million)	*Patient Time Days*	*Equivalent Employee Days*	*Average Daily Income*	*Total Non-Productive Costs (Million)*
< 5 Years	3.9	1.43	3.25	32.10	R407
> 5 < 16 Years	3.3	0.52	0.37	32.10	R39
> 16 Years	7.0	0.52	0.89	32.10	R201
Total	14.2				R647

The product of the employee time and income loss are regarded as the indirect costs. Daily income of R32.10c is low as the average income in areas with Low Service Levels in Densely populated areas are on the subsistence level. Thus for the year, R647million is considered to be the cost of poor water quality in indirect costs.

See Section 10 for a more detailed analysis of the incidence rates and numbers of people affected.

8.2.2 For High Service Levels

Table 9: Basis for indirect cost calculations

	Actual Diarrhoea Incidences (Million)	Patient Time	Equivalent Employee Days	Average Daily Income	Total Non-Productive Costs (Million)
< 5 Years	479	1.43	1.96	32.10	R30,133
> 5 < 16 Years	503	0.52	0.13	32.10	R2,151
> 16 Years	601	0.52	1.08	32.10	R20,778
Total	1,583				R53,062

See Section 10 for a more detailed analysis of the incidence rates and numbers of people affected.

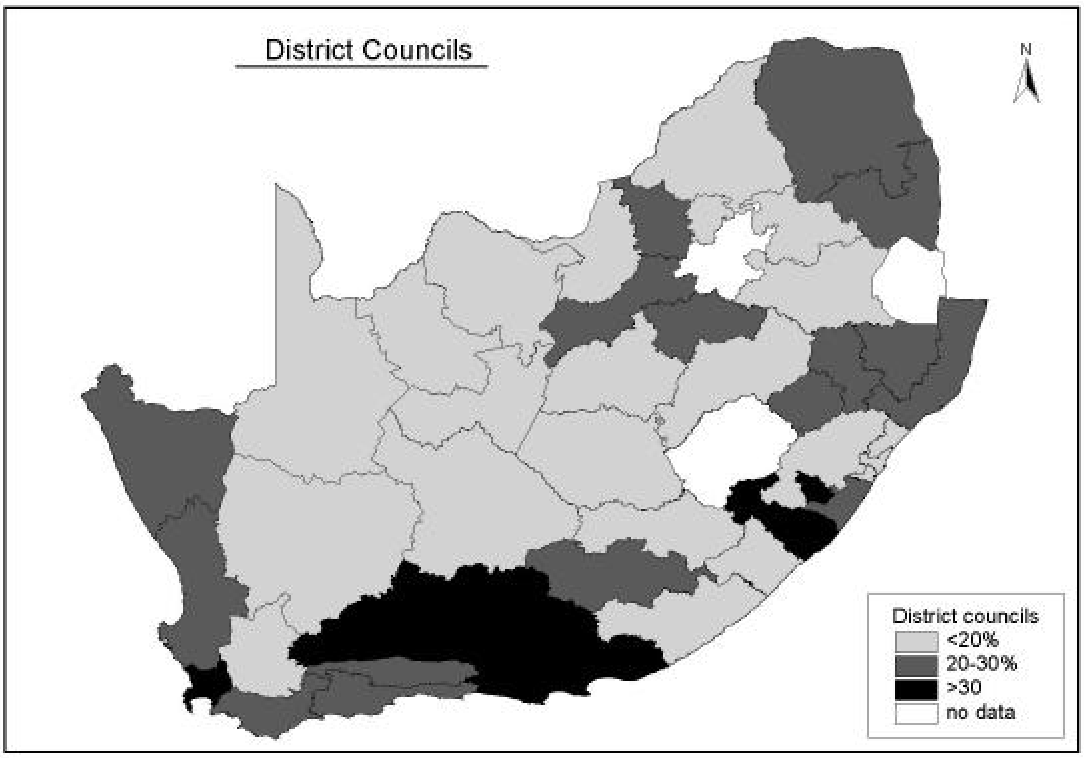
9. National Extent of the capacity gap

Our next section is a discussion on the national extent of the capacity gap, or extent of the problem of poor households on High Service Levels. (See the National Strategy document for an explanation of why this may lead to pollution problems) We estimate that there are 46 local authorities where 30% or more of its population has low incomes and high service levels. This makes up 6% of the total local authorities. These are the local authorities where there is a likelihood of economic costs emanating due to the lack of funding to provide high levels of services.

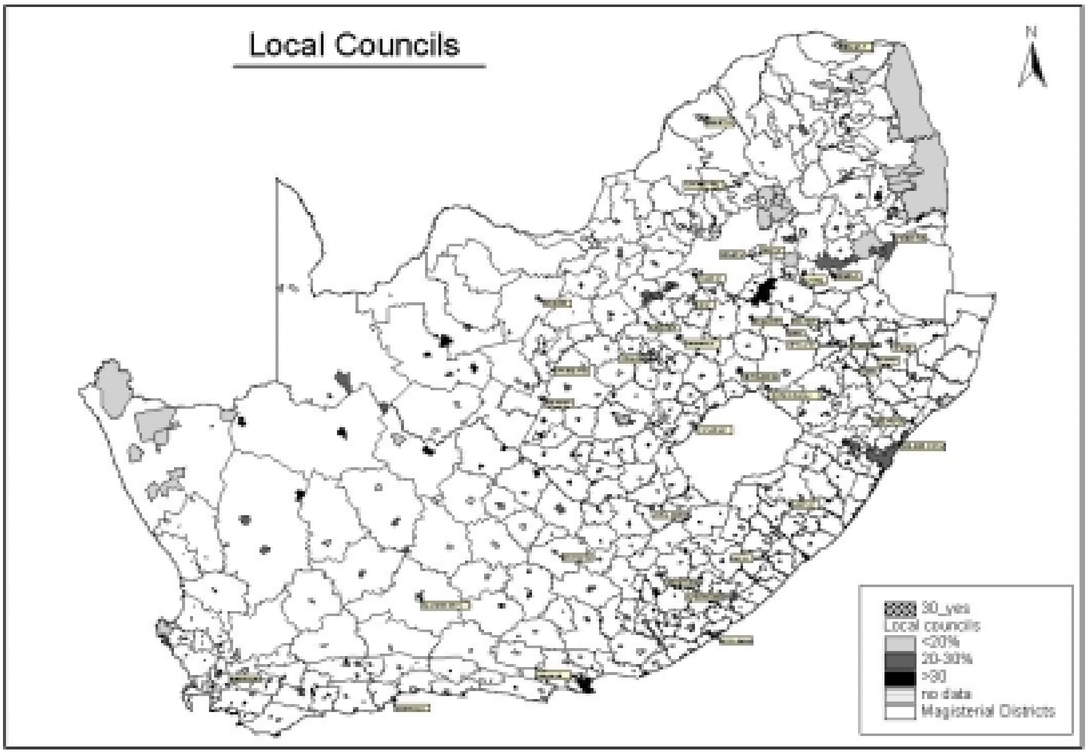
Table 10: National Extent by Province

Count of Capacity Gap	Capacity Gap
Province	Y
Free State	10
Eastern Cape	8
Mpumalanga	7
Kwa-Zulu Natal	6
Western Cape	5
North West	3
Northern Province	3
Gauteng	2
Northern Cape	2
Grand Total	46

Map 1: National Extent by District Council



Map 2: National Extent by Local Councils



9.1 Conclusion

- The potential economic costs of the effects of poor water quality are estimated at nearly R3 billion.
- This amount is significant as it would typically be around 10% of the SA Health budget for 2000/1.
- 35% of SA's population is at risk to the effects of poor quality water in Low Service Levels in Dense areas, with a further potential 22% in High Service Levels .
- These costs do not take into consideration the qualitative environmental and social costs.
- A large economic cost such as R3bn per annum, would translate to a once-off annuity cost of R20 billion, which amount could assist greatly in implementing strategies to combat the effects of poor water quality.

10. Detailed methodology of costs calculations

In this section, we give a detailed explanation of how we arrived at the direct health and indirect economic costs.

10.1 Concentrating on diarrhoea

We estimated the costs of the effects of one of the many diseases, namely diarrhoea. A case of diarrhoea carries with it two categories of costs or damages. The first category consists of morbidity and mortality costs, which are made up productivity losses through lost time and in the case of death, lost future earnings. The second category consists of the costs associated with taking action to avert and to treat the illness. This study will attempt to measure each of these categories of costs in order to arrive at an estimate of the economic costs of diarrhoea associated with dense settlement pollution.

The costs components analysed were:

- Direct costs of medical resources used in the treatment of the disease, including costs of self-treatment to individuals (or households) and government expenditure;
- Indirect costs for households associated with lost economic opportunities caused by illness or death, due to reduced productivity of the victim or family care-providers, in both the short and long term;
- Other direct costs, such as transportation to health services and household costs to accommodate the needs of the affected person;

(Paul and Mauskopf, 1991 – quoted in Pegram, G.C., Rollins, N., Espey, Q. 1998)

Diarrhoea is not a notifiable disease and therefore estimates of the number of cases have to be taken from morbidity estimates, which provide the approximate number of cases per age group. The incidence of diarrhoea is higher for populations with lower levels of water and sanitation service. This study is primarily concerned with those populations with high levels of service and low income as this is considered to be at high risk. Demographic data from the 1996 census are used in order to obtain accurate information on the size and age groups of the populations living with high standards of water and sanitation services and low incomes. For illustrative purposes, the economic costs of diarrhoea for populations at all service levels are also calculated.

Data on wage levels for individuals living in areas with poor water services and sanitation are used in order to obtain accurate estimates of the lost productivity associated with diarrhoea. Although the highest incidence of diarrhoea is among children, who are not economically active, the disease requires an adult caregiver to remain with the patient, which incurs economic costs in terms of lost productivity.

It is important to note that the estimates of economic costs associated with diarrhoea do not account for the future lost earnings of children due to time lost at school. It also does not take account of the losses in dignity and the psychological effects of the illness, which in many cases will be very significant.

The economic costs that are calculated therefore should be viewed as very conservative estimates of the full economic costs as it will only account for the financial direct costs associated with treating the disease and the economic costs in terms of lost productivity. The educational losses and the costs to society due to the fact that communities with inadequate water supply and sanitation have reduced abilities to develop economically are not taken account of.

10.2 Demographic Data

The 1996 South African Census estimates that the total population of South Africa is 40 583 573, with 4 443 621 below the age of 5, 9 322 822 between the age 5 and 15 and 26 817 129 older than 15. The age distribution is reproduced in the table below.

Table 11: Age Distribution in five-year intervals, South Africa

Age Group	South Africa	Cumulative Total	% of Total
0 – 4	4 443 621	4 443 621	11
5 – 9	4 668 722		
10 – 14	4 654 100	9 322 822	23
15 – 19	4 180 716		
20 – 24	3 982 353		
25 – 29	3 455 728		
30 – 34	3 074 201		
35 – 39	2 653 755		
40 – 44	2 138 626		
45 – 49	1 677 525		
50 – 54	1 268 895		
55 – 59	1 069 936		
60 – 64	890 536		
65 – 69	758 887		
70 – 74	482 163		
75 – 79	377 428		
80 – 84	178 902		
85 +	137 284		
Unspecified	490 194	26 817 129	66
Total	40 583 573	40 583 573	100

Source: Statistics South Africa Census 1996

The service levels, as detailed in Table 12, are grouped so as to approximate the morbidity rate classifications.

Table 12: Main Water Supply and Sanitation Type

Service Level	Households	Individuals	% Individuals
Water Supply			
Piped water in dwelling	3 976 855	16 282 671	40
Piped water on site or in yard	1 491 228	6 508 259	16
Public tap	1 765 945	7 974 484	20
Water-carrier/tank	111 204	483 615	1
Borehole/rain-water tank/well	441 884	2 154 561	5
Dam/river/stream/spring	1 116 484	6 315 455	16
Unspecified/other	155 970	864 528	2
TOTAL	**9 059 571**	**40 583 573**	**100**
Toilet Facilities			
Flush toilet or chemical toilet	4 552 854	18 406 506	45
Pit latrine	2 919 594	14 496 062	36
Bucket latrine	420 185	1 809 725	4
None of the above	1 118 132	5 453 026	13
Unspecified/Other	48 807	418 254	1
TOTAL	**9 059 571**	**40 583 573**	**100**

Based on the above analysis of service levels, it is assumed that 22% of individuals live with lower than RDP standards of water supply and sanitation, that 28% live with intermediate standards of water supply and sanitation and that 50% live with on site water supply and sanitation. This is based on the assumption that water carriers, tanks, boreholes, rain water, wells, dams, rivers, streams and springs are all below RDP standards for water supply. It is further assumed that bucket latrines and no provision of toilet facilities are below RDP standards. It is also assumed that a pit latrine and public tap represent RDP standards and that flush or chemical toilets, with piped water in the dwelling or yard is on site water supply and sanitation.

The overall proportions of individuals living with less than RDP levels of water supply and sanitation are arrived at by combining those living with less than RDP water supply and those with less than RDP toilet facilities. These percentages are given in greater detail below.

Table 3 (a) Percentage of Individuals at various service levels

Service Levels	Individuals	%
< RDP Water and Sanitation	8 749 593	22
Intermediate	11 235 268	28
ON Site (formal)	22 790 930	50
TOTAL	**40 583 573**	**100**

10.3 Diarrhoea Incidence

The morbidity and mortality rates of diarrhoea for different levels of water services and age groups are given below. These are published incidence rates (Pegram et al. 1996) and should be considered as conservative estimates. Because of the fact that diarrhoea is not a notifiable disease there are very limited data on the actual number of cases, estimates of incidence have to be used. Due to variations in the quality of incidence rates, it is considered prudent to use conservative incidence rates, especially as these rates are critical to the calculation of economic costs.

Diarrhoea has been classified into three types of illness depending on severity, namely mild, moderate and severe. Clearly the more severe the illness, the greater the economic costs in terms of treating the disease and in lost productivity due to time away from work. The clinical symptoms of the three classifications are as follows:

- Mild: cases have loose stools and vomiting;
- Moderate: cases are indicated by dehydration and require oral rehydration therapy;
- Severe: cases present with complications requiring case-specific treatment. (Pegram et. al. 1996)

The incidence rates are used together with the demographic data presented above in order to arrive at the annual number of diarrhoea cases.

Table 13: Diarrhoeal Morbidity Severity and Mortality Incidence Rates for Different Levels of Water and Sanitation Services

Water Supply and Sanitation Infrastructure	Age	Diarrhoea (incidence per 1000 people)			
		Morbidity			Death
		Mild	Moderate	Severe	
< RDP Water and Sanitation	<5	2000	375	125	15
	5 – 16	900	80	20	0.5
	> 16	675	60	15	0.15
> RDP Water and Sanitation	< 5	1275	165	60	3
	5 – 16	450	42.5	7.5	0.1
	> 16	225	21	4	0.025
On Site Water and Sanitation	< 5	450	40	10	0.5
	5 – 16	238	11	1	0.025
	> 16	95	4.5	0.5	0.005

(Pegram et al. 1996)

Table 14: Number of Diarrhoeal Cases and Deaths among Populations with various different service levels.

Age Group	Mild	Moderate	Severe	Deaths	TOTAL
< RDP Water and Sanitation					
< 5	1 916 040	359 258	119 753	14 370	
5 – 16	1 808 954	160 796	40 199	1 005	
> 16	3 902 596	346 897	86 724	1 005	
TOTAL	7 627 590	866 897	246 676	16 242	**8 757 460**
Intermediate Levels of Water and Sanitation					
< 5	1 221 476	158 073	57 481	2 874	
5 – 16	904 477	85 423	15 075	201	
> 16	1 300 865	121 414	23 126	145	
TOTAL	3 426 818	364 910	95 682	3 220	**3 890 630**
On Site Water and Sanitation					
< 5	431 109	38 321	9 580	479	
5 – 16	478 368	22 109	2 010	50	
> 16	549 254	26 017	2 891	29	
TOTAL	1 458 731	86 447	14 481	558	**1 560 217**

10.4 Health Service Requirements

Only a small proportion of the diarrhoea cases require formal treatment as the majority are mild cases with limited impacts and can usually be treated at home. Those mild cases that do require formal treatment (approximately 10%) at a clinic or hospital are all among the under 5 year old age group. As is detailed in table 6 below, only 50% of the mild cases that require formal treatment actually seek treatment, while 70% of the moderate cases seek treatment and 90% of the severe cases seek treatment.

Table 15: Diarrhoeal Health Service Impacts and Transport Impacts at Different Levels of Morbidity, Severity and Victim Age

	Age	Mild	Moderate	Severe
Require formal treatment (% of incidents)	< 5 > 5	10% 0%	70% 50%	100% 100%
Obtain formal treatment (% of requiring)	< 5 > 5	50% 50%	70% 70%	90% 90%
Health practitioner only (# of visits)	< 5 > 5	0.2 -	1 0.5	- -
Clinic/Health practitioner (# of visits)	< 5 > 5	0.7 0.1	1 0.5	1.5 1
Hospital out-patients (# of visits)	< 5 > 5	0.3 0	1 0.5	1.5 1
General ward (d)	< 5 > 5	0 0	2 1	7 3
High care (d)	< 5 > 5	0 0	0 0	0.2 0.04
Local transport (# trips)	< 5 > 5	0.7 0.1	1 0.5	1.5 1
Hospital transport (# trips)	< 5 > 5	0.3 0	1.5 0.5	2.5 2

Source: (Pegram et al. 1996)

The health service costs relate to drug costs, ward costs (which include bedding, food and miscellaneous items) and time costs for physicians, nursing staff and clinicians. In addition to the above costs, patients incur transport costs in getting to health practitioners or to treatment centres.

Health service impacts have been separated into the following:

- Health practitioner only: This indicates the average number of visits a patient requiring formal clinic or hospital treatment, but not obtaining it, would make to their local health practitioner (including doctors, community health workers and traditional healers)
- Clinic/Health practitioner: This indicates the number of visits a patient requiring formal clinic or hospital treatment would make to their local clinic or health practitioner.
- Hospital out-patient: This indicates the average number of visits to a hospital out-patient facility.
- General ward: This represents the average number of days that a patient requiring formal treatment would spend in a general hospital ward.
- High care: This represents the number of days that a patient requiring treatment would spend in a high care ward or intensive care unit (ICU)
  (Pegram et al. 1996)

Local transport costs refer to the costs incurred by patients in getting to health practitioners. It is assumed that only 50% of those requiring formal treatment incur local transport costs, with the remainder walking to the health practitioner. Hospital transport costs refer to the costs that a patient incurs in getting to a hospital or treatment centre. In this case it is assumed that 70% of cases incur these transport costs.

The direct unit costs associated with each diarrhoea case are given in the table below.

Table 17: Health Service and Transport Costs at Different Levels of Morbidity Severity

	Mild	**Moderate**	**Severe**
Health practitioner and clinic	R20/visit	R20/visit	R20/visit
Hospital out-patient	R90/visit	**R180/VISIT**	R270/visit
General ward (clinic or hospital)	R375/d	R375/d	R357/d
High care (or ICU)	R1200/d	R1200/d	R1200/d
Diarrhoea medicine: Health care Self-treatment	 R10/incident R10/incident	 R50/incident R20/incident	 R400/incident R50/incident
Local transport (return trip)	R8/trip	R8/trip	R8/trip
Hospital transport (return trip)	R20/trip	R20/trip	R20trip

10.5 Productivity Costs

A large proportion of the total economic cost associated with diarrhoea is in lost productive time. Each adult patient is likely to lose formal employment or if he/she is unemployed will lose productive time in the home. Most childhood diarrhoea cases require a care-giver to remain with the patient and therefore the estimates of lost productivity will consist of two elements, adult patient lost productive time and care-giver lost productive time. As explained above, due to a lack of data and reliable information, no attempt will be made to estimate the impact of lost future earnings as a result of lost school days from bouts of diarrhoea.

The Table below details the average period of illness for diarrhoea and also the degree of incapacitation, which determines the extent of lost productivity. Because of the similarity in impacts, the age groups have been divided into those below the age of 5, and those above the age of 5.

Table 18: Average period of Illness Impacts (days) for Victim and Care-giver at Different Levels of Severity and Victim Age

	Age	Mild	Moderate	Severe
Total period of episode	< 5 > 5	4 2	7 5	11 8
Little impact (no impairment)	< 5 > 5	1.5 1	2 1	2 1.5
Discomfort (25% impact)	< 5 > 5	2 1	2.5 2	2 2.5
Restricted activity (75% impact)	< 5 > 5	0.5 0	2 1.5	5 2
Incapacitation (100% impact)	< 5 > 5	0 0	0.5 0.5	2 2
Total non-productive patient time	< 5 > 5	0.9 0.3	2.6 2.1	6.3 4.1
Total non-productive care-giver time	< 5 > 5	1 0	2.5 1	5 2.5

Source: (Pegram et al. 1996)

The value of lost productive time is measured according to daily wage rates for the populations living with less than RDP standards of water service and sanitation.

According to Statistics South Africa, the average annual wage rates for individuals living with less than RDP levels of water supply and sanitation is R2 064. This wage data however is based on the 1996 census and therefore the average wage rate is assumed to have increased by 5% per annum since then. The average wage rate used in this analysis for individuals living with less than RDP levels of service is R2 389 per annum. This translates to a daily wage rate of R10.38 assuming an average of 230 working days per annum. The table below summarises the wage data and numbers of individuals living with below than RDP service levels.

Table 18 (a): Average Incomes for < RDP Water and Sanitation Standards

Year	< RDP facilities (R/annum)	Intermediate	High Service Levels
1996	2 014	2 351	6 073
1997	2 115	2 469	6 377
1998	2 220	2 592	6 696
1999	2 331	2 722	7 030
2000	2 448	2 858	7 382

11. Non-quantitative health impacts

This section provides a more detailed view of the relationship between water supply and health impacts. It in particular describes the various types of water-borne diseases.

11.1 Health, Sanitation and Water Supply

Low standards of water supply and poor sanitation are a feature of almost all developing countries. The diseases that arise as a result of inadequate water services contribute to a large proportion of infant and child death and to many of the diseases in adults. Gastrointestinal infections in young children may reduce the absorption of nutrients by as much as 30% which in turn affect the body's immune system and could lead to other diseases and complications. Poor sanitation is directly responsible for the fact that excreta related diseases account for between 10 and 25 per cent of childhood illnesses that reach health care services. (von Schirnding, Yach, Mathee, 1993)

Many areas, particularly urban centres, are in need of adequate sanitation facilities so as to avoid the contamination of food, soil and water and therefore reduce the contact of residents with disease causing organisms. As urban areas become more dense and heavily populated, the pollutant loads are likely to increase, thereby increasing the risk of disease and the provisions for the removal of waste need to be comprehensive and less simple. More importantly, these services must be operated effectively in order to ensure that they do not fail.

Most waterborne diseases are caused by germs typically transmitted by the faecal-oral route. In dense settlement areas, the spread of disease can occur through direct contact with faeces, for example children transferring germs from contaminated fingers to their mouths, or indirectly when organisms are transferred to food and water by insects, rodents or fomites.

A wide variety of pathogenic viruses, protozoa, and bacteria may be transmitted by water. These micro-organisms cause such diseases as gastroenteritis, giardiasis, hepatitis, typhoid fever, cholera, salmonellosis, dysentery and eye, ear, nose and skin infections. These have been associated with polluted water throughout the world. Infections are generally contracted by (i) drinking contaminated water, (ii) recreational exposure to contaminated water, (iii) inhaling contaminated aerosols or (iv) the consumption of raw food exposed to polluted water. (Domestic Water Use, Second Edition, 1996 (1st Issue).

11.2 Health Impacts

A waterborne disease is defined as an illness that is transmitted through contaminated water. Disease causing germs normally multiply in water sources that are not properly managed and treated for healthy consumption. There are a number of water borne diseases, some of which, such as hepatitis and cholera are noticeable. By far the greatest cause of death from water borne disease for the whole South African population are intestinal infections, causing 2.87%

of all deaths[1]. This rises to 19.51% when only the 1 to 5 year old age group is considered. (WRC, 1996)

A summary of the main excreta-related infections in South Africa is given below. More detailed descriptions of some of the major illnesses then follows.

Table 19: The Impact of Excreta-Related Infections in South Africa

Category	Infection	Data source	Cases/Deaths/Year
Faecal-oral (non-bacterial)	Poliomyelitis Hepatitis A Rotavirus diarrhoea Amoebic dysentery Giardiasis	Morb/Not* Morb/Not* Survey Survey Surveys	4 cases (1990) 1162 cases (1990) Not quantified Infections in 10-33% Variable
Faecal-oral (bacterial)	**Diarrhoeas/dysenteries** Campylobacter Cholera E.coli Shigellosis **Enteric fevers** Typhoid Paratyphoid	Mort Survey Morb/Not* Survey Outbreak (1991) Mort Morb/Not Not available	10450 deaths (1990) Included in 10450 deaths, 2015 cases (1990)
Soil transmitted helminths	Ascariasis Trichuriasis Hookworms Strongyloidiasis	Survey Survey Survey Survey	Variable
Pork Tapeworm	Taeniasis	Surveys/hospital	2 million infected, approx. 10% diseased
Water-based helminths	Schistosomiasis	Surveys/hospital	8-20% infected in rural areas
Morb/Not* = Morbidity from a notifiable disease. Mort = Mortality from broad categories. The 9th revision of the International Classification of Diseases codes 000-009 are used. The average number of deaths for 1980 – 1985 are given (latest available)			

Source: von Schirnding, Yach, Mathee, 1993

11.3 Cholera

Cholera is an acute bacterial infection of the small intestine by *Vibrio cholerae* that characteristically results in water diarrhoea. Severe disease manifests with profuse painless watery stools, some vomiting, rapid dehydration, acidosis and circulatory collapse.

Prevention of the disease, particularly at the community level should concentrate on ensuring the safe disposal of faeces and a safe water supply. Communities should also be informed of the importance of correct food preparation and of boiling drinking water.

[1] Including deaths from non-water borne diseases, such as diseases of the circulatory system, malignant neoplasms and accidental deaths.

In South Africa a cholera epidemic lasted between 1980 and 1987 and resulted in approximately 25 251 cases. The communities most affected by the epidemic were black rural communities living with poor water supply and sanitation and with high levels of rainfall. The presence of endemic cholera in neighbouring Mozambique reinforces the need to ensure primary prevention and surveillance of the condition. (WRC, 1996)

11.4 Diarrhoeal Disease

Diarrhoea is a clinical syndrome characterised by acute onset of more than three loose or watery stools per day and is often accompanied by vomiting and fever. It is therefore a symptom complex of infection by any one (or combination) of a variety of enteric pathogens.

Diarrhoea transmission is by ingestion of faecal organisms and is encouraged by conditions where there is faecal contact and spread. In infections such as *Salmonella*, *E.coli* and *Campylobacter*, with a wide range of reservoirs (including animals) and where higher inocula are required, food and water contamination is of greater importance. (WRC, 1996)

The primary prevention of diarrhoea is based on the interruption of the faecal-oral transmission of causative agents and requires behavioural and environmental interventions, such as sanitary waste disposal, adequate and clean domestic water supplies, refuse removal and improved personal hygiene (including hand washing) and food hygiene. (WRC, 1996). For this reason, reducing dense settlement pollution has a direct positive impact on the number of diarrhoea cases. Among others, risk indicators include the lack of an inside full flush toilet, overcrowding and non-functioning sewage systems.

Oral rehydration therapy is one of the most frequently used and effective treatments for diarrhoea. This sugar-salt solution offsets the effects of acute diarrhoea, such as loss of fluid and electrolytes and reduced nutrient intake.

Diarrhoea is a major cause of morbidity and mortality in South Africa with more than a quarter of all deaths in children under the age of 5 being due to the disease. The highest risk groups are black and coloured living with poor sanitation and water supply. Because of the importance of the disease, full economic cost calculations of the disease are performed in section 6 below.

11.5 Viral Hepatitis A and E

The hepatitis A virus (classified as Entervirus type 72) infection results in acute onset of fever and malaise, followed by jaundice. In children the disease if often mild or asymptomatic and there is no known chronic form of the disease. Man is the only reservoir of the virus and transmission is by person-to-person via the faecal-oral route. The virus is excreted in the faeces of the infected individual and can contaminate food and water sources, which provides the link to uninfected persons.

Prevention is frequently achieved through the provision of safe potable water supplies and the safe disposal of faeces.

Hepatitis is a notifiable condition in South Africa and cases are reported in most parts of the country. On a national level, the incidence of the disease increased from 4 per 100 000 in 1986 to 5 per 100 000 in 1990. The younger age groups (5 – 9 years) have the highest rate at 8 per 100 000, compared to young adults with 4 per 100 000 and people over the age of 40 with 1 per 100 000. (WRC, 1996)

11.6 Intestinal Helminthiasis

Gastrointestinal helminthiases (parasitic worms) are among the most prevalent and widespread of chronic human infections. It is estimated that more than 25% of mankind is currently infected with one or more species of gut parasitic worm. (WRC, 1996) Only a small proportion of these infections result in any serious disease and the most prevalent genera that are important from a water based disease viewpoint are *Ascaris lumbricoides*, *Trichuis trichiura* and *Hymenolepis nana*.

Infections are most frequently found in the 5 to 9 year old age group, with pre-school and young school children being most frequently infected because of their exposure in contaminated soil and hand-mouth actions during play. Low-income urban and rural populations are most afflicted due to poor hygienic conditions and inadequate access to clean safe water or proper sanitation services.

Although the disease is not directly transferred by infected water, the lack of clean water or the ability to maintain hygienic conditions in the home is important in the transmission of the parasitic worms. Because of this, action to reduce infections should include:

- Sanitary disposal of human faeces
- Improving family hygiene by making adequate safe water available for hand washing (particularly before meals and after defecation); and
- Washing and scalding of uncooked vegetables where night soil is used for fertiliser. (WRC, 1996)

11.7 Typhoid Fever

Typhoid fever is a systemic bacterial disease caused by the bacillus *Salmonella typhi*, of which there are over 106 different types. The *S. typhi* bacillus is a natural pathogen only of human and patients who have recovered from the disease can continue to be asymptomatic carriers for many months or even years. Carriers excrete *S. typhi* in their stools or urine and serve as a reservoir for future infection. Transmission is by means of food and water that has been contaminated by the urine or faeces of patients or carriers and as *S. typhi* is able to survive in water and sewage for weeks or months, transmission is often highly effective.

Antimicrobial therapy is considered to be an effective method of treating the disease, however there are some reports of resistance to antibiotics in South Africa. Most of the cases in South Africa however continue to be treated with ampicillin/amoxycillin and chloramphenicol. Prevention of the disease is achieved most effectively through the provision of safe, clean drinking water, water to maintain personal hygiene and the proper disposal of human faeces and urine. In addition, prevention measures should ensure high standards of food preparation and the pasteurisation of milk and dairy products.

In South Africa the vast majority of typhoid fever cases are in the black population group, with 60% of the cases in the 5 to 19 year old age group. The rate of infection for the whole of South Africa was 7 per 100 000 in 1989, the rate of infection in the former homelands of Venda, Lebowa and Gazankulu is higher. During the period of 1976 to 1970, the rate of infection in these three areas, where there is generally inadequate water supply and sanitation, varied between 16 and 110 per 100 000.

12. Environmental Impacts

12.1 Introduction

The purpose of this section is to highlight, and where possible quantify the economic cost of environmental damage. Such environmental externalities occur on a wide scale and have numerous impacts, as will be explained below. It is outside the scope of this report to undertake a detailed economic costing study in order to provide specific economic costs of dense settlement pollution. The study will however give an indication of the economic costs associated with pollution from dense settlements and the consequences of this form of pollution on downstream users and eco-systems.

This section first describes the sources and types of pollution from dense settlements, then continues to detail the impacts on eco-systems and the economy of such pollution. Impacts to be dealt with range from agricultural water quality to impaired recreational value of water sources. The report will then, where possible, approximate the economic cost of such pollution and also provide qualitative descriptions of the impacts.

12.2 Water Quality, Environmental Externalities and Economic Valuation

This report attempts to examine the economic costs that dense settlement pollution imposes on South Africa. As will be explained below, this study does not attempt to estimate the full economic costs associated with the degradation of an environmental resource. Rather, it identifies the kinds of environmental externalities that arise as a result of dense settlement pollution and discusses some of the economic impacts that this has on the environment and on downstream users. This however is far from the full economic costs as it only accounts for some of the use values of the resource and does not account for the non-use values.

Total Economic Value (TEV) is made up of use values and non-use values, as detailed in Table 19 below. Use values are likely to include direct use values, where individuals or enterprises use the resource for commercial or recreational purposes, such as irrigation, agriculture or swimming. Indirect use values will include the services that the environmental resource provides that do not have a direct financial value, yet provides economic benefits, such as watershed protection or flood control. Non-use values will be made up of option values, where individuals are willing to pay for the option of using the resource in the future or existence values, which reflect the fact that people value resources for 'moral' or 'altruistic' reasons. Non-use values can also include bequest values, which measures peoples' willingness to pay to ensure that their heirs could use the resource in the future.

There are numerous economic methods available to determine the wider economic costs of resource degradation that will take into account the use and non-use values. Where applicable, the quantitative valuation of resource degradation will be done by using the averting behaviour technique. Averting behaviour technique is fundamentally a revealed preference technique, as it infers economic values by observing actual behaviour, such as the amount of money spent on ensuring clean water, as the value individuals place on clean water.

Table 20: Economic Taxonomy for Environmental Resource Evaluation

Use Values		Non-Use Values		
Direct Use	**Indirect Use**	**Option Value**	**Bequest Value**	**Existence Value**
Outputs directly consumable	Functional benefits	Future direct and indirect values	Use and non-use value of environmental legacy	Value from knowledge of continued existence
• Food • Biomass • Recreation • Health	• Flood control • Storm protection • Nutrient cycles	• Biodiversity • Conserved habitats	• Habitats • Prevention of irreversible change	• Habitats • Species • Genetic • ecosystem

Expenditure that is made to mitigate the environmental effects of an externality, such as pollution from dense settlements, is used as a proxy for the value of the resource in its pristine state. The advantage of such a method is that it requires relatively modest amounts of data, however provides sound estimates of actual expenditures. The method however will underestimate the value of the resource, as it relies on discrete choices by individuals - either the water is purified or it is not - and will not account for all the non-use values.

Given the difficulties associated with environmental valuations, the task is further complicated by the cost estimation required for the whole of South Africa and not for a particular region. The size and nature of environmental costs depends on the state of the existing environment, the assimilative capacity of the resource, the nature and number of downstream users and the opportunity costs associated with those costs.

The economic costs associated with dense settlement pollution will be lower where there are fewer downstream users who are impacted on, as compared to their being many downstream users. Most pollution from dense settlements occurs where the demand for the resource is greatest. The assimilative capacity of rivers, watercourses, dams and lakes varies widely and will therefore greatly affect the economic cost of pollution from dense settlements. The lost opportunities associated with environmental degradation are likely to vary widely depending on the economic, climatic and developmental state of the resource. The opportunity costs, or the cost of not being able to undertake a certain economic activity in the future associated with the environmental degradation, is likely to vary widely between and within different watercourses.

There is no data available regarding the extent to which dense settlement pollution affects South Africa's watercourses. Data and information is available on the types and amounts of pollutants found in watercourses, however these come from many different sources, such as industry, agriculture and water treatment works. Without any clear relationship between the amount of pollution attributable to dense settlements and then the impact that the pollution has on economic activities and the environmental resource, it is not possible to determine accurately the economic cost.

For the above reasons, it is not possible within the scope of this project to arrive at an accurate estimate of the economic costs associated with environmental degradation due to dense settlement pollution in South Africa. What is given below is a description of the kinds of pollutants arising from dense settlement pollution and the impacts that these have on aquatic ecosystems, irrigated agriculture and livestock farming. We will then examine averting behaviour undertaken by water service providers and economic agents, such as irrigation farmers. This should give the reader an idea of the types of economic costs associated with dense settlement pollution and how this impacts on economic activities.

12.3 Impacts

The typical types of environmental impact arising from dense settlement pollution are sedimentation, faecal pollution and eutrophication.

The impacts of sedimentation, faecal pollution and eutrophication on the economic activities of downstream users can be dramatic. Irrigated agriculture for example is frequently confronted with lower plant yields because the pollution in the water settles on leaves and reduces photosynthesis. The presence of nutrients such as nitrogen and phosphorous can also stimulate plant growth, even if unwanted, for example, during a fruit development period. Pollution from dense settlements also causes blockages in irrigation equipment that not only affects production but can be costly to remove and to control. Irrigation with contaminated water reduces the market value of a number of irrigated crops, such as vegetables and fruits that are not cooked before they are consumed.

The economic impact of pollution from dense settlements on aquatic environments will be felt most through the reduction in amenity value and the value of the resource as a tourist destination. As South Africa's tourism and leisure industry is set to grow and is proffered as a vehicle for future economic growth, these impacts will be increasingly severe.

Livestock farmers also suffer economic costs when pollution from dense settlements is inadvertently consumed by their stock. Apart from the palatability effects, there are a number of diseases that can be spread though contaminated water. Apart from the impacts on stock production, the market value of livestock is greatly reduced due to the presence of pollution from dense settlements.

Human consumption of contaminated water is highly costly in terms of disease costs, lost productivity costs and mortality costs. Water service providers therefore are particularly vigilant about treating water to acceptable portable standards. The cost of treatment increases dramatically with the presence of pollution from dense settlements. This is dealt with in Table 21.

12.3.1 Treatment Costs

This section will examine the costs of treating water, with particular reference to dense settlement pollution and the measures available to water users to mitigate the impacts of dense settlement pollution. Although these costs do not equate to the total economic costs associated with environmental externalities, they do go some way in describing the costs imposed on downstream users.

According to Rand Water, blue-green algae has been prolific in seven out of the past ten years (although blue-green algae has been known to have occurred as far back as 1938). Under normal operating conditions, water that is recovered from filter back washing and the de-sludging of sedimentation in dams, is recovered and returned for purification. The presence however of the odour producing algae prohibits this practice as it concentrates the algae in the water works.

The additional treatment costs arising from these pollution problems (taste, odour, filter clogging, greater chemical usage, sludge disposal, filter backwash etc.) are significant and frequently requires additional capital investment. Rand Water estimates that the increased running treatment costs as a result of non-point source pollution, much of it from dense settlement areas and resulting in algal and sediment disposal, to be R 4.5 million per month. Apart from the increase in running costs, the presence of blue-green algae and sedimentation requires substantial capital investment in additional plant and machinery. Rand Water estimates that over two years, the required capital investment due to increased algal and sediment treatment problems is R 111 million. The table below details the additional expenditure required by Rand Water to treat water to acceptable standards.

Table 21: Running and Capital Cost Estimates Due to Algal and Sediment Treatment Problems (Rand Water)

	Cost Millions
Running (per month)	
Filter backwash water	3.0
Geosmin[2]	1.3
Sludge disposal	0.15
Supernatant	0.054
TOTAL R/month	**4.5**
Capital (over 2 years)	
Filter backwash plant (1)	64
Filter backwash plant (2)	26
PAC dosing plant[3]	14
Supernatant recovery	7
TOTAL	**111**

The relationship between lake water quality and water treatment costs has been examined for the water impoundments, or lakes, in the Umgeni Water operational area. The Umgeni Water study analyses the water quality and treatment costs of five different water treatment systems, namely the Hazelmere system, the Durban Heights system, the DV Harris system and the Wiggins system. Each of these systems suffers in varying degrees from turbidity, suspended solids, coliforms, eutrophication and many other forms of pollution.

The average cost of treating water at the Durban Heights waterworks is R28/Ml, while it is lower, at R20/Ml at the Wiggins waterworks. The range of costs at the Wiggins waterworks however ranged from a low of R3/Ml and R75/Ml, depending on the changes in water quality. This wide range in treatment costs is likely to be caused in large part by pollution from dense settlements and as much as R40 of the variation could be attributed to this form of pollution. While the mean values for the water quality indicators may be fairly low, the high maximum values means that investment in capital equipment to deal with the problems is essential.

[2] Geosmin is a tertiary alcohol and metabolite produced in trace concentrations by certain Cyanobacteria (blue-green algae), algae and bacteria. It is released into water and soil, where it imparts a typical earthy/muddy odour and taste. The odour and taste threshold for humans is extremely low (in the order of ng/l) DWAF, 1996b.

[3] Powdered Activated Carbon (PAC) dosing plant removes at least 60% of geosmin.

Table 22: Descriptive Statistics showing the characteristics of raw water treated at Wiggins Waterworks (January 1990 – March 1997)

Water quality indicators	**UNITS**	**Minimum**	**Mean**	**Maximum**
Treatment cost	R/Ml	3.06	20.84	75.32

There are many factors that influence the cost of treating water and therefore it is difficult to obtain accurate figures on costs to water treatment plants that can be directly attributable to dense settlement pollution. Some figures however are available from various water service providers and they indicate the scale of the problem. Western Transvaal Regional Water Company (WTRW), for example, extracts water from the middle Vaal River and is downstream from the major Witwatersrand and Vereeniging urban centres. As a result of algal growth (of which dense settlement pollution is likely to be a major contributor), WTRW was obliged to install a dissolved air flotation plant in 1996 at a cost of R26 million. The company further estimates that on average it spends between R30 000 and R50 000 per day between the months of February and May in order to control algal growth. If dense settlement pollution is only responsible for 50% of the algal growth, this increases the annual running costs of the treatment plant by R2.5 million (not including interest payments on new capital investments).

Among those water treatment plants surveyed that are downstream of dense settlement areas, this could increase annual treatment running costs by around R47 million. Table 23 below summarises the estimated additional capital investment required by water service providers and the additional running costs, which is largely made up of costs of additional activated carbon (powdered or granulated).

Table 23: ***Additional Capital and Running Costs by Water Service Providers as a result of Dense Settlement Pollution.***

Treatment Plant	Additional Capital Investment (R million)	Increase in Running Costs (R million/annum)
Umgeni Water	27	13.1
Rand Water	111	27.0
Goudveld Water	-	2.7
Western Transvaal	26	2.5
East London	-	1.6
Bloem Water	-	
Magalies Water	-	0.5
TOTAL ANNUALISED COSTS	**16.4**	**47.4**

Clearly industry, agriculture and sewage treatment works contribute significantly to the pollution problems, but as urban centres increase and local councils struggle to deal with water supply and sanitation, dense settlement pollution is likely to be responsible for an increasing proportion of treatment costs.

12.3.2 Mitigation Measures

The DWAF describes a number of mitigation measures that can be undertaken by water users in order to minimise the damage to crops, livestock or the aquatic environment. While these averting activities do not capture the full economic cost associated with the environmental damage, it does go some way to describing the value that individuals attach to the state of the environment.

The cost of mitigation will vary according to the type and severity of the pollution and the type of productive activity that is affected. Actual costs would need to be calculated for individual cases, based on the degree of pollution, the assimilative capacity of the receiving environment and the amount of damage to production.

Certain mitigation measures, such as changing to different types of irrigation equipment, can be extremely costly and could reduce the efficiency of water use. For example, DWAF recommends that irrigation farmers change from drip irrigation systems to microjet systems should the drip system become clogged as a result of sedimentation.

Irrigation equipment is normally a major capital investment for most farming enterprises and therefore replacing is likely to be a substantial financial commitment. Changing irrigation systems could also impact on the efficiency of water use. For example changing from a drip irrigation system, where evaporation losses are low to a microjet of spray system will increase water use and will probably not result in any significant increase in yield.

In order to mitigate the impacts of clogged irrigation equipment, DWAF suggests that apart from changing irrigation system types, farmers could apply copper sulphate to the irrigation equipment so as to reduce algal growth. Screens and filters can also be installed to irrigation equipment so that algae does not clog up irrigation equipment.

In order to mitigate the impacts of faecal coliforms, DWAF suggests only irrigating crops that will be boiled before they are cooked. Farmers would not be able to grow any fresh crops such as lettuce, tomatoes, berries and so on and this could severely impact their profitability. Livestock farmers are required to disinfect their water supplies so as to avoid the spread of disease throughout their stock. This could be a costly exercise for livestock farmers, especially for those whose profit margins are continually being reduced.

While there are several mitigation procedures available to the economic users of polluted water, these are all likely to be highly costly and also reduce the number of productive crops and options available to the farmers.

12.4 Conclusion on environmental impacts

While there is very limited research on the extent of dense settlement pollution in South Africa and the degree to which this particular form of pollution affects the waterways, it should be clear from the information that the impacts are likely to be highly significant. Dense settlement pollution can severely impact aquatic ecosystems that in turn affects the economic value of those ecosystems, reducing the potential for tourism and impacting on the number of ecological services the ecosystem provides.

Large users of water, such as agriculture, particularly irrigated agriculture are likely to be severely affected by dense settlement pollution as the various impacts, such as increased suspended solids, higher levels of nitrogen and phosphorous and faecal coliforms reduce the market value of agricultural products and increases farming costs. In an already water stressed country, some of the mitigation procedures proposed by DWAF in the case of pollution, such as suspended solids, is to use higher amounts of water so as prevent leaching of salts. This not only increases agricultural costs, but further damages ecosystems and downstream users.

Due to a lack of data, no full economic costs of dense settlement pollution to the environment have been calculated, however the costs are likely to be large. This is particularly true when one considers the wide range of economic costs, such as use costs, non-use costs, option values, bequest values and existence values. The costs associated with such pollution to water treatment plants is however quantifiable and looks set to increase. According to Rand Water (pers. comm. Ralph Heath) the impact of dense settlement pollution on water treatment plants have been rising in recent years and with the projected growth of cities and the demand for services is likely to continue to increase.

Increased levels of pollution, some of which originates from dense settlement, results in increased running costs to the order of R 47 million per annum and requires capital expenditure of over R160 million (R16.4m per year if depreciated over 10 years). These are significant costs, particularly when one considers that these will be passed on to water users, many of whom have very low affordability levels.

13. Annexure: Bibliography

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