# Sustainable options for community-level management of greywater in settlements without on-site waterborne sanitation

Report to the
**Water Research Commission**

by

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**WRC Report No. 1654/1/11**
**ISBN No. 978-1-4312-0107-5**

**APRIL 2011**

# Executive Summary

## Introduction

Poor management of greywater in informal settlements in South Africa (RSA) poses a daily threat to human and environmental health. In non-sewered, informal and low-income settlements water-related services are frequently dysfunctional and the disposal of greywater creates an unpleasant environment and becomes hazardous when mixed with blackwater and solid waste. Greywater is produced from household processes (e.g. washing dishes, laundry and bathing) without input from toilets, and is generally perceived by residents of informal settlements as being wastewater or unwanted water that is dirty and must be discarded (Carden *et al.,* 2007).

A previous WRC study (K5/1524) provided a general overview of conditions in non-sewered settlements in RSA, and highlighted the implications for greywater management in these settlements, where settlement density was found to be one of the most challenging obstacles (Carden *et al.,* 2007). One of the recommendations from the study highlighted a need to conduct a longer-term study in which communities without on-site waterborne sanitation could consider various options for managing greywater including re-use and disposal. It was with this in mind that the present study was undertaken, with the hypothesis that sustainable options for the management of greywater in non-sewered settlements are more likely to be achieved when local residents are involved in managing greywater themselves rather than following a traditional or conventional approach in which the provision of rudimentary engineered services occurs with minimal consultation and involvement of residents who are the end users of these services. The overarching aim of this study was therefore to explore how greywater could be managed by 'community-level' initiatives, meaning that local residents themselves might collectively offer plans and appropriate small-scale solutions to manage the problem in the absence of any formal drainage in the settlement.

It was acknowledged that tensions exist between what local authorities are prepared to do and what local residents expect. The research question therefore sought to understand how 'bottom up', community-led initiatives could contribute to managing greywater. For this reason a Participatory Action Research (PAR) approach was adopted, which meant that the researchers attempted to work with local people in a collaborative study at selected settlements – to establish the capacity for, and interest in managing greywater; and to test low-cost greywater management options and means of disposal.

## Literature review

Current literature on service delivery approaches frequently emphasizes collaboration and co-operation between inhabitants and local authority officials as prerequisites both for improving accountability and for effective control in service delivery and operations. In part this suggests that a failure to achieve a measure of trust and co-operation between service providers and users contributes to inefficient, unsustainable services. The literature review attempted to test this assumption in the context of informal settlements to see how or whether users of services in these circumstances are prepared to become involved in service delivery agreements and are willing to establish co-operation and partnerships with local authorities.

It is not possible to make generalisations about the composition of greywater, as it depends on the sources from where the water is drawn, as well as the use to which this water is put. Studies aimed at determining the characteristics of greywater being generated from non-sewered communities in South Africa all show that the quality varies significantly, and when most concentrated, should be considered hazardous and therefore managed as a sanitation issue to be incorporated into the suite of services offered by local authorities (Carden *et al.*, 2007).

Solutions to water supply, sanitation and drainage problems depend on the integration of political, social, technical and institutional approaches, and on changing established practices so as to achieve interventions which are socially acceptable and which attempt to establish a `genuine commitment to partnership and empowerment' (DfID, 1998). In 2000 the Bellagio Principles emphasized the household level and its neighbourhood as being central to planning processes for sanitation interventions (WSSCC / Sandec, 2000). The overall goal of the Household Centred Environmental Sanitation (HCES) approach (and other similar approaches, such as 'Slum networking') is to contribute to the achievement of the Millennium Development Goals by promoting sanitation that is sustainable and reaches the poorest communities in urban and peri-urban settings.

The socio-political context in South Africa has led to polarized positions in which many urban dwellers remain frustrated by poor service delivery, while local authorities and national government are unable to meet the demand in addressing backlogs, especially in larger cities. There is general agreement that development that includes civil society leads to the empowerment of citizens and that this raises the potential for citizens to participate (Carmody, 2007). The approach taken by the current study was built on the premise that the governance of urban services is best served by efforts to decentralize planning and incorporate participation and partnerships within civil society. This is problematic however when there is limited institutional support and where government is largely unprepared to engage with civil society as the critical agent for transformation of services.

The study design was informed largely by the Adaptive Decision-Making Process (ADMP) to structure Participatory Action Research (PAR) as this approach provides a procedure for formulating and implementing a course of action that could explicitly take into account social, political, economic and institutional factors (Lal *et al.,* 2001). An ADMP approach acknowledges the need for discursive and iterative decision-making and recognises

that multiple stakeholders have different values and knowledge systems. It also recognises that decisions need to be achieved through collaboration, co-operation and consensus.

## Research methods

In order to explore the hypothesis of community-level management of greywater, an in-depth analysis of the existing conditions and levels of service in selected study sites was required to identify current practices and to consider appropriate interventions for greywater management. Local inhabitants, stakeholders and interest groups, including local authority officials and councillors were consulted to obtain their input, plans and support. The intention of this study was to identify and strengthen local level greywater management strategies and implement and evaluate low-cost, appropriate interventions. The research design therefore needed to emphasize participation, collaboration and consensus decision-making among stakeholders to ensure the long term sustainability of social and technological interventions and solutions; it was for this reason that the research method chosen was the ADMP, in conjunction with a PAR process.

Two settlements – Langrug, near Franschhoek, and Waterworks in Grabouw – were chosen for the ADMP. There are four operational phases required in the implementation of any ADMP: identification and assessment (settlements, services, stakeholders); reflection and establishing of shared goals (identification of problems associated with existing greywater management practices); action (implementation of management strategies); and adaptive learning (adaptation of intervention strategies).

A third settlement, Hangberg, in Hout Bay, was selected for a separate assessment because community-led solutions, facilitated by an NGO, were already relatively advanced. The intention of this survey was merely to observe the process whereby residents worked together with the NGO and the local authority towards an incremental upgrade process.

Three further settlements in Paarl, which were recently provided with basic services by Drakenstein Municipality, with limited public participation, were investigated for the purposes of comparing this ‘top-down’ strategy with efforts to encourage a more participatory one advocated by the study hypothesis (a ‘bottom-up’ approach). The final site, Simondium, near Paarl, was chosen as an interesting example of what can happen when settlements are largely neglected. Information for these last four settlements was captured using open-ended qualitative ethnographic observation and discussion, with interviews being conducted with local authority officials, consultants, and other service providers who helped develop the interventions that were in place.

## Study settlement description

Langrug is an informal settlement situated 5 km from the town centre of Franschhoek. The first shack dwellings were erected in 1993 and by 2006 the population had reached approximately 5,000. Water services in the settlement comprise two communal ablution blocks and five publicly accessible tapstands, with stormwater channelled along a shallow concrete-lined ditch to the Franschhoek River.

Waterworks lies three kilometres from the town centre of Grabouw, and comprises about 1,000 shacks with approximately 3,000 residents. Water is supplied by way of tapstands, with only one having a formal drain for overflow. Sanitation facilities are limited and in a poor state, comprising ten flush toilets and twelve Ventilated-Improved Pit (VIP) latrines.

The informal settlement at Hangberg is located on the south-west side of the village of Hout Bay at the base of the Sentinel Mountain. By the early 1970s, the formal residential flats in the Hangberg formal settlement had become overcrowded, and land was invaded south of the area. By 2007 some 400 shacks were built on steep mountain slopes adjacent to the formal structures. Residents living in shack dwellings were provided with access to limited basic services, namely 39 flush toilets and 37 water standpipes; but many individuals have also managed to install water and sanitation services in or next to their own homes by cutting into the municipal lines. In 2006 an NGO, the Development Action Group (DAG), partnered by the City of Cape Town and the Hangberg in situ Development Association (HiDA), began a participatory process toward an *in-situ* upgrade of 302 households, which entailed formal provision of basic services and improved tenure security to enable house owners to upgrade their dwellings incrementally.

The three sites located in Paarl in the Drakenstein Municipal district included: Oliver Tambo (about 3,500 people living in 670 structures); Drommedaris (3,200 people), Fairyland (2,900 people. In mid-2004 the Municipality introduced its ‘Provisions of basic services project to informal settlements’ programme. Consulting engineers conducted investigations to determine solutions for sanitation and greywater management, and recommended communal waterborne sanitation in all informal settlements. Installation commenced in December 2007; the upgrades were accompanied by management and operational plans to ensure that services were maintained.

The final site Simondium, situated just outside Paarl, comprised just 21 households, with about 84 people.

## Greywater management

Various low-cost greywater management interventions were identified at the outset of the research, with three actually implemented (a shallow crate and trench soakaway, a drum filter, and a wash basin connected to a soakaway) in the settlements where the ADMP was undertaken, i.e. Langrug and Waterworks. An account of these efforts, as well as a discussion on the contrasting approaches in both Hangberg and the Drakenstein settlements follows.

### Langrug, Franschhoek

Greywater emanating from Langrug includes greywater and blackwater – the latter flowing from constantly leaking, dysfunctional toilets – which is channelled towards a stormwater system ultimately discharging into the Franschhoek River. Surface water monitoring in and around Langrug as well as in the Franschhoek River itself indicated high levels of pollution as a result of the inadequate water services.

One intention of this project was to develop and test the efficacy of greywater management options through workshops to be held in settlements with groups of residents brought together by street or block committees. No social structures of this kind were identified in Langrug, so the fieldworkers chose rather to work with willing residents, to discuss options with them, and then to install the chosen greywater management devices (a shallow crate and trench soakaway, and a wash basin connected to a soakaway) at some 12 households throughout the settlement. Most of the time, the fieldworkers themselves completed the installations and there was little evidence of the sort of behavioural change that might have led to the active engagement of residents in the development of alternative methods of greywater management that might have been more appropriate. Eventually all the soakaways failed and were removed and the experimentation was discontinued.

### Waterworks, Grabouw

Sanitation and drainage facilities in Waterworks were limited and in a poor state; residents disposed of their greywater simply by tossing it into the nearest roads or pathways, or into the uninhabited areas alongside the settlement where they also discarded garbage and where many defecated. The risk to health and environment was raised considerably by a sewer pipe that regularly discharged raw sewage between the houses. A household level survey was conducted to describe the conditions and experiences of residents living in Waterworks, particularly focused on the residents' experience of the environmental conditions and health risks. The responses provided a vivid description of the state of health and environment at the settlement. Residents were clearly aware of the risks caused by contaminated water, litter and unhealthy facilities. Moreover, it appeared that residents took calculated decisions to address the problems but were overwhelmed by the circumstances in which they live. The respondents were emphatic in expressing their disgust about the poor state of the environment, the conditions in which they live, and the health risks, particularly as it affects the children.

The research team met with the street committee on several occasions and it was eventually agreed to explore the possibility of experimenting with a crude drum filter as a

means of managing greywater. The first filter was installed in public space between a number of shacks, followed by two more in individual yards. All of these filters were subsequently removed when they proved to be ineffective and after complaints from residents. In the case of the communal filter, it soon became apparent that an installation with uncontrolled access would not work and that any provision of a public place for disposing waste was likely to be used for disposal of items not suited for that system.

**Hangberg, Hout Bay**

Unlike in Langrug and Waterworks, the fieldworkers did not attempt to propose any greywater management systems in Hangberg, choosing rather to observe the process whereby the residents worked together with the HiDA committee in consultation with the Development Action Group (DAG) and the City of Cape Town (CoCT) towards an *in situ* upgrade of the settlement. Two surveys were conducted with the involvement of community leaders; the first captured the socio-economic information of each household and the second focused on service-based infrastructure.

Cape Town Municipality had provided 39 flush toilets and 37 water standpipes for the 400 households in the settlement during 2001. Many of the home-owners then decided to install toilets in their homes by way of connecting to the shallow sewer network that had become exposed through erosion of the topsoil. By 2007, 37% of households had installed indoor toilets in their homes and 79% had their own water supply to the home. Greywater is either disposed onto the ground or flows downhill into the stormwater system, with associated negative impacts on surface water quality. The HiDA committee therefore requested that greywater should be included in the City of Cape Town (CoCT) *in situ* upgrade of the settlement, planned for 2009. The proposal was that all wastewater, including greywater, should be discharged into the municipal sewage system. The tender was awarded in June 2009, but when the contractors attempted to commence with the work the HiDA raised concerns about the lack of consultation, uncertainties about the layout of the settlement and the type of tenure that was envisaged, all of which resulted in delays to the project. This case study served to emphasise the necessity of mechanisms to manage a process in which stakeholders co-operate in decision-making. The support from DAG and the Municipality appear to be an essential element in taking the process forward.

**Paarl informal settlements**

In 2003 the Drakenstein Municipality began responding to numerous complaints from the Department of Water Affairs and the Irrigation Board in connection with the discharge of polluted stormwater originating from informal settlements in the municipal area. By mid 2004 the Municipality had launched the ‘Provision of basic services project to informal settlements’ programme to determine the best solutions for water, sanitation and greywater operations and management. It was decided that waterborne sanitation in the form of communal toilet facilities, and tapstands with drainage should be installed at all informal settlements. The Municipality began by installing pump stations at informal settlements situated close to the Berg River in order to intercept polluted runoff, particularly during low flow periods, and thereby largely prevent this water from entering the river. Work in the

settlements themselves commenced with the installation of communal toilet blocks, each cubicle being locked and its key allocated to a group of households; with tapstands comprising a standpipe discharging into a drain within a standard pre-cast concrete ring. At the same time workshops were conducted to teach people how to use the facilities correctly and also to raise awareness about how contaminated water might affect the general health of residents.

To investigate a 'top-down' approach to managing greywater such as this, four sites were selected out of a possible 24 settlements in the area for in-depth surveys. Structured interviews focused on gathering information about access to water, disposal of greywater, interventions in support of greywater management, and the role played by the municipality. In all four settlements were surveyed: Oliver Tambo, Drommedaris, Fairyland and Simondium.

*Oliver Tambo*

Oliver Tambo comprises two pieces of land, one belonging to the municipality and the other to Spoornet. Thirteen Absolute Ablutions Container Toilets (AACT) and standpipes equipped with a catchpit to drain water to the sewage system have been installed on the municipal land, but only limited service infrastructure was provided for those living on the Spoornet land. The communal tapstands provide access to water, but inadequate maintenance and a lack of suitable places to wash laundry and household utensils has resulted in excess greywater runoff and unpleasant conditions. Furthermore, whilst the pump station has clearly reduced flows of polluted water into the Berg River, frequent blockages continue to create hazardous conditions.

*Drommedaris*

As in the case of Oliver Tambo, an asphalt road splits the settlement of Drommedaris into two camps, one located on Spoornet and the other on municipal land. In order to address the problem of indiscriminate greywater disposal residents were advised by the Ward Committee to make use of the kerbsides in Drommedaris Road from where it could be channelled into the stormwater system. The open stormwater conduits often become blocked with solid waste however, and polluted water is frequently observed flowing into the Berg River, especially on the Spoornet-owned land. Residents now tend to wash laundry and household utensils at the communal tapstands alongside the AACT units although excess runoff at these tapstands creates unpleasant conditions.

*Fairyland*

The physical layout of Fairyland was planned and constructed well before the first shacks were built on site. It is the only informal settlement in the municipal area that has communal washing areas and an open drainage system alongside the streets, intended to direct all wastewater to sewer. The washing facilities and standpipes along the gravel streets in this settlement are connected to these open channels. Municipal officials offered minimal consultation with Fairyland residents prior to installing this service infrastructure; nevertheless the survey revealed that residents felt that the overall standard of living and

conditions in Fairyland are an improvement on the other informal settlements in the area, owing to the actions taken by the Drakenstein Municipality. Most residents were happy to use the standpipes, toilets and refuse facilities that had been provided.

*Simondium*

Greywater management in Simondium appears to be failing largely because of regular blockages at the communal tapstands and/or because the septic tank often overflows. With communal facilities limited to a single washing area with just two standpipes and six toilets, residents near the facilities used them as washing areas, even though there was almost constant flooding, which created unpleasant conditions. Those living toward the back of the settlement carried water to their homes and discarded wastewater either on the ground around their homes or by tossing it over a wall on three sides of the settlement. One reason for the general neglect is explained by the fact that Simondium was not always a part of the Drakenstein municipal area and therefore had not been included in previous policy and interventions plans.

## Discussion

The study's intention of developing a participatory action research (PAR) process which could assist residents in informal settlements improve management of their greywater was realised with only very limited success. In two of the settlements where PAR was attempted (Langrug and Waterworks), the fieldwork team failed to find local social structures that were prepared to become involved in dealing with greywater problems. This meant that efforts to encourage residents to participate in the creation and evaluation of various alternative greywater management options were largely fruitless. Ultimately, the experiments with simple greywater management technologies failed because of the limited interest and participation by both key actors: the residents themselves and the local authority officials. Impoverished residents of informal settlements have neither the capacity nor the resources to install or maintain greywater management systems – nor indeed the motivation to do so when other priorities predominate. Without authentic participation, it appears that any attempt to promote exclusively local collective management of greywater is likely doomed, no matter how good the technology: local government management appears to be crucial.

It was thus concluded that the study's starting hypothesis, that a 'bottom-up' approach to managing greywater offers a more sustainable approach than a 'top down' one, is not supported by the evidence obtained. Indeed, it is arguable that such an approach is misplaced in informal settlement contexts, and is possible only when a series of specific conditions have been met. In particular, the local authority must take full responsibility for service provision and, even where an NGO or outside agency intervenes (as in Hangberg), it can only be to mediate between residents and local authority officials. The Hangberg case also showed that setting up a neat dichotomy between 'bottom-up' and 'top-down' is counterproductive; continuing collaboration between 'top' and 'bottom' is necessary for achieving some degree of success – in that instance 'top-down' intervention was needed to ensure that those in positions of power (at the 'top') would develop the capacity (and the will) to 'listen to and hear' what the needs and priorities are of those at the 'bottom'. The Groot Drakenstein cases

provide further evidence of precisely that – even though, in those instances, the greywater management system installed there had been implemented through a process that was driven primarily from the 'top' and down towards its beneficiaries on the ground.

One of the most salient factors emerging from the case studies is the gap in understanding between local authority officials and settlement residents, symptomatic of weak collaboration and co-operation between stakeholders. Social engagement in the implementation of solutions is critical; interventions must be socially acceptable and should attempt to establish a 'genuine commitment to partnership and empowerment' (DfID, 1998). To realise such a vision requires an integrated framework consisting of multi-sector planning (accounting for water supply, sanitation, drainage and solid waste management) and multi-actor participation (participation of all stakeholders, beginning at the household and neighbourhood scale) for successful implementation of sustainable environmental sanitation components (EAWAG, 2005).

The issue of governance became one of the more important facets of this study –largely because the 'state of governance' in the municipal areas in which the study took place greatly influenced its outcome. Local authority officials did very little at three of the study sites to support residents to resolve their greywater management problems. Putnam (1993) emphasises the importance of local authorities building capacity at a local level, and the fact that social capital is regarded as essential for citizen action that can lead to local-level management, participation in and control over civic affairs.

The study went a long way towards bringing about an understanding of what is going wrong with service delivery – and not just greywater management – in informal settlements, and reveals some of the aspects that need to be addressed if there is to be a reasonable likelihood of success. In summary, whilst consultation with local residents would almost certainly lead to more sustainable service delivery, engagement by the local authority is the most critical aspect, without which there can be little expectation of success.

## Conclusions

The municipalities of Stellenbosch and Theewaterskloof have been incapacitated by a funding allocation that has prioritised formal housing over the immediate needs in informal settlements. The result, in regard to greywater management, is a toxic mix of polluted water creating severe public health threats and environmental degradation that has the potential to threaten commercial export agriculture. By contrast Drakenstein Municipality has taken a proactive approach to managing the crisis, particularly in terms of reducing the volume of contaminated water entering the Berg River.

South African policy calls for development projects to utilise participatory processes in their planning and implementation. Yet, while lip-service is widely made to public participation in government decision-making processes, in practice the tensions between electoral processes, political party demands and the structures of municipal government are such that real participation is unlikely (Kruger, 2009). Such tensions reveal in turn the extent to which power relations are biased in favour of those who sit in offices and conduct high

level decision-making for, and often also against, those who must live with and utilise the products that derive from their decisions.

One of the main objectives of this study was to deliver low-cost, environmentally friendly greywater technologies, and to ensure that in so doing there was collaboration and genuine co-operation at all phases including reflexive learning and modification of these options. The process and results were disappointing, attributed to the fact that the devices installed became dysfunctional in a matter of weeks, and also, that 'on the ground' social structures in both the primary research sites were weak. It appears that a PAR methodology is not going to deliver solutions without adequate commitment from the local authorities and also that intense attention and effort is needed for developing the capacity of the users of greywater and sanitation technologies to manage both their use of those technologies and their relationships with local authority officials. Local authorities remain critical agents of local level social change, and should increasingly be positioned and resourced so that they can build their own capacity alongside that which inheres in well-functioning, truly representative local social structures such as street and block committees. At present it appears that neither the scope for alternative service approaches nor the opportunities for community-based participation in technical options for greywater management currently exist in informal settlements.

An important conclusion of the present study, based as it was on an intention to use its research exercise, through PAR, to develop such capacity, is that such research exercises are inappropriate vehicles for affecting that kind of capacity building. At most they can be structured to collaborate with NGOs and/or local authorities who have initiated such a process and can report on its efficacy. These processes need to be supported over a very long period of time however, precisely because the socio-political constraints that have created the poverty that characterises informal settlements undermine their residents' livelihoods and capacity in a wide range of ways.

## Guidance for greywater management

- Greywater management in areas without on-site waterborne sanitation must be directed at disposal only, rather than considering it a resource that could be used productively.
- Greywater emanating from non-sewered settlements should be treated as a health hazard to be removed off-site as quickly and effectively as possible. If there are opportunities for treatment, e.g. in a wetland, these should be investigated for their potential contribution to environmental protection.
- Initiatives to manage greywater and the interventions that follow must be undertaken by local authorities as the primary agent of change, but in collaboration and co-operation with other stakeholders, including users (recipients), NGOs and researchers, so as to achieve socially acceptable solutions.
- Information exchange between, and capacity building of officials and informal settlement residents remain one of the strongest instruments of social change in the development of effective, long-term service delivery.

- Investment in the short- to medium term must focus attention on improving the health of residents of low-income urban settlements and the receiving environment.
- The development of definitive health regulations / guidelines for the disposal of greywater in South Africa is critical in view of the negative impacts resulting from indiscriminate greywater disposal practices in poorly-serviced settlements throughout the country.
- Whilst the study itself did not provide direct evidence of the institutional 'blockages' responsible for the inattention and lack of services to the poor who live in conditions that extend barely beyond basic human survival, it appeared that there might well be a need for institutional transformation, without which service implementation will remain limited.
- There are various drivers (environmental, financial, technical and social) which could potentially force greywater management interventions in settlements without on-site waterborne sanitation through behavioural and institutional / organisational changes at local authority level.
- Greywater is a sanitation issue – successful management interventions are more likely to occur when they are part of an integrated service delivery package, including water supply, sanitation, drainage, solid waste disposal and hygiene.

## Recommendations for further study

- What are the institutional factors that undermine effective water, sanitation, solid waste disposal and related service delivery in South African informal settlements?
- What are the social dynamics in informal settlements that contribute to low levels of participation in, and high levels of resistance to, community-level engagement with respect to service delivery planning and implementation? How does this relate to issues such as land entitlement and/or land tenure?
- How is the behaviour of residents of informal settlements regarding water and sanitation services conditioned by circumstances within their respective settlements and how does it relate to (and how might it be mobilised for) extending the provision of communal basic services so that they might be incrementally upgraded as resources permit?
- Under what conditions and how might informal settlement residents develop a sense of ownership of, and willingness and to take responsibility for, those parts of the service infrastructure in their settlements that are conventionally privately maintained by suburban residential site owners?
- What combinations of social, financial and technical (including environmental) requirements are necessary to implement, operate and maintain functional basic water, sanitation and related services in informal settlements, and how do changes in those combinations affect service provision and especially maintenance outcomes?

- Is it feasible to capacitate municipal officials to include, as part of their roles, a requirement that they develop governance capacity amongst residents of informal settlements and, if so, how might that be effected?
- Further assess / qualify what influences changes in the quality of greywater over time within settlements as well as differences in the quality of greywater from settlement to settlement.
- Are there Southern African examples of communal sanitation that are proving successful and, if so, under what conditions and how might these be rolled out elsewhere?
- If greywater management is necessarily a component of more general programmes to improve basic service delivery to informal settlements, what is required institutionally to ensure its integration into such programmes, and how might such programmes be structured to ensure that integration?

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# Abbreviations

| | |
|---|---|
| ADMP | Adaptive Decision Making Process |
| BOD | Biochemical Oxygen Demand |
| CBO | Community Based Organisation |
| CMA | Cape Metropolitan Area |
| CoCT | City of Cape Town |
| COD | Chemical Oxygen Demand |
| DA | Democratic Alliance |
| DAG | Development Action Group |
| DfID | Department for International Development |
| DSS | Decision Support System |
| DWAF | Department of Water Affairs and Forestry |
| ESWG | Environmental Sanitation Working Group |
| HCES | Household-Centred Environmental Sanitation |
| HiDA | Hangberg in-situ Association |
| KAP | Knowledge Attitude and Practices |
| MDG | Millennium Development Goal |
| NGO | Non Governmental Organisation |
| PAR | Participatory Action Research |
| RSA | Republic of South Africa |
| SAR | Sodium Adsorption Ratio |
| SPI | Specific Pollution Index |
| UES | Urban Environmental Sanitation |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| VIP | Ventilated Improved Pit |
| WELL | Water and Environmental Health at London and Loughborough |
| WHO | World Health Organisation |
| WRC | Water Research Commission |

# Acknowledgments

The following people contributed substantially to the study:

**University of Cape Town field researchers**

| | | |
|---|---|---|
| Ratidzo Dlembeu | : | Environmental and Geographical Science Department |
| Thyane Dodo | : | Social Anthropology Department |
| Ntobeko Dyani | : | Environmental and Geographical Science Department |
| Festus Kapembe | : | Environmental and Geographical Science Department |
| Lizzie Kruger | : | Social Anthropology Department |
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| Rory Liedeman | : | Social Anthropology Department |
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| Prof A Spiegel | : | University of Cape Town, UCT |
| Mr F Stevens | : | eThekwini Water and Sanitation |
| Dr M van Ryneveld | : | University of Johannesburg, UJ |
| Dr K Winter | : | University of Cape Town, UCT |

**The researchers are indebted to the following contributors:**

- Municipal officials (Town Managers and Engineers) of the City of Cape Town; Drakenstein; Theewaterskloof and Stellenbosch municipalities;
- Street and project committee members at Hangberg, Waterworks and Grabouw.
- Local residents of Hangberg, Hout Bay; Langrug, Franschhoek; Waterworks, Grabouw; and various informal settlements of Paarl, who gave freely and willingly of their time during interviews and group discussions.
- Members of the WRC Reference group who directed this study through discussions, debate, and written comment.

# 1. Introduction

Poor management of greywater in the informal settlements in the Republic of South Africa (RSA) poses a daily threat to human and environmental health. In non-sewered informal settlements, including those where water-based services are dysfunctional, the disposal of greywater creates an unpleasant environment and becomes hazardous when this disposal mixes with blackwater and solid waste. This deplorable situation is partly because drainage and greywater management in informal settlements countrywide are often not treated as a priority in the provision of basic and improved services (Carden *et al.,* 2007). Thus, informal disposal of greywater in these settlements contributes to unsafe, unhealthy and unacceptable conditions. Moreover, informal settlements are unlikely to be eradicated from the RSA urban landscape in the short to medium term. The backlog in the delivery of formal housing continues to grow despite the provision of 2,355 million government-subsidised houses that was achieved between 1994 and 2007 countrywide (Department of Human Settlements, 2009). The greatest demand for housing is in the larger cities. Since 2001 the population of Cape Town and Gauteng grew by an average of 3.0% and 2.3% per annum respectively, with much of this growth being absorbed into informal settlements. Progress toward full service provision through the national housing programmes remains slow and an ongoing challenge. In the interim, a lethal cocktail of toxins is being released from informal settlements with the potential to compromise human health and the environment.

Greywater in informal settlements was highlighted in a study by the South African Water Research Commission (WRC) in Report No. 1524/1/07 entitled "Understanding the use and disposal of greywater in the non-sewered areas in South Africa" (Carden *et al.,* 2007). This study provided a general overview of conditions in non-sewered settlements in RSA, and highlighted the implications for greywater management in non-sewered, informal settlements in which settlement density was found to be one of the most challenging obstacles in dealing with greywater management. Of the many findings, at least four of these are pertinent to the present study: (a) no attention was given to the resultant longer-term impacts on environmental health in non-sewered areas once increasing volumes of water were supplied to these settlements; (b) social dynamics and behavioural patterns have a significant impact on the way that communities deal with water supply and wastewater management issues, including greywater disposal; (c) the quality of greywater in non-sewered areas varies significantly, and when most concentrated, should be considered hazardous and therefore should be managed as a sanitation issue rather than a drainage one; and (d) people living in non-sewered settlements are generally not prepared to use greywater for growing vegetables. In addition, one recommendation from the study highlighted a need to conduct a longer-term study in which communities without on-site waterborne sanitation could consider various options for managing greywater including re-use and disposal (Carden *et al.,* 2007).

Greywater is produced from household processes (e.g. washing dishes, laundry and bathing) without input from toilets, and is generally perceived by those living in informal settlements as being wastewater or unwanted water that is dirty and must be discarded (Carden *et al.,* 2007). In non-sewered, informal shack settlements in RSA, including those with limited waterborne services and drainage, greywater often merges with toilet water and

other effluent flows resulting in a toxic mix of contaminated water that poses a threat to human health and the environment. Although the per capita volume of greywater disposed on the ground is relatively low in volume, the dangers are multiplied since greywater runoff often carries solid and liquid waste contaminants that accumulate in ponds in and around settlements and are then discharged via stormwater systems into surrounding surface water systems (Carden *et al.,* 2007). In dense urban settlements, greywater disposal is likely to result in significant health and environmental impacts where large volumes are being generated and discharged along formal and informal drainage corridors. Polluted surface runoff can become a health risk for children who frequently play in these pools of water.

Carden *et al,* (2007) highlighted a number of general concerns about the potential to manage greywater in informal settlements and as a result the following considerations and recommendations were extracted from the study and applied to this one:

- Greywater is generally unsuitable for re-use except under controlled conditions.
- In low-income, high-density areas, where initiatives to use greywater are generally not feasible (or affordable), interventions should focus on treatment / disposal systems which ensure that greywater does not have negative impacts on health and the environment.
- Most people believe that the solution to their water supply and wastewater management problems rests with local authorities and government alone and therefore will only consider alternative water provision and wastewater management options as temporary measures.
- Greywater management initiatives are unlikely to be successful unless the recipient communities are involved in the decision-making process, as well as in the implementation and operation of such systems.
- Based on the quality of greywater generated in low-income, densely-settled urban areas, greywater should be treated as a sanitation issue rather than drainage in these settlements.
- Education and training in greywater management is vital, together with the provision of 'material possibilities' in the form of money, infrastructure, service availability etc., to encourage people to get involved in helping to create healthy environments.
- Simple technological solutions should be explored further.

## 1.1 Study aims

In this study it was hypothesized that sustainable options for the management of greywater in non-sewered settlements were more likely to be achieved when local residents were involved in managing greywater themselves rather than follow a traditional or conventional approach in which the provision of rudimentary engineered services occurs with minimal consultation and involvement of residents who are the end users of these services. The overarching aim of this study was therefore to explore how greywater could be managed by 'community-level'

initiatives, meaning that local residents themselves might collectively offer plans and appropriate small-scale solutions to manage the problem in the absence of any formal drainage in the settlement. This situation has arisen because local authorities are generally reluctant to invest adequate funds to install service infrastructure (water, sanitation and drainage) in informal settlements, or to give sufficient support to those operations that already exist. It was therefore pertinent to explore the role a 'community' might be prepared to offer to resolve greywater problems either as individuals or as a collective group of interested and affected residents. For this reason the original objectives of the study were focused on the interface between social / environmental impacts and technology options for greywater management at community level, and were as follows:

1. Identification of the social challenges to effective greywater management in non-sewered areas and the reasons why previous initiatives to implement management systems have not been sustainable in the long term.
2. Identification of specific environmental impacts resulting from greywater management practices in non-sewered areas.
3. Identification of ways of overcoming social and related obstacles in order to create sustainable management options relevant to the local communities and in particular identify solutions to the inability of communities to continue with existing management systems or implement new systems.
4. Identification of ways of mitigating environmental impacts.
5. Testing the social and environmental interventions in selected communities in the Western Cape Province.
6. Developing best practices (scientific and sociological) and guidelines for greywater management.

From the outset the research team acknowledged that tensions exist between what local authorities are prepared to do and what local residents expect. The research question therefore sought to understand how 'bottom up', community-led initiatives could contribute to managing greywater. As a partial means to answering this question, it was felt that issues of governance required further understanding with respect to: the commitment of the local authority to implementing service delivery and maintaining operations; and the extent to which local social structures on the ground were willing to support and involve themselves in interim solutions. For this reason a Participatory Action Research (PAR) approach was adopted, which meant that the researchers attempted to work with local people (residents, leaders and local representative committees including local government officials and representatives) in a collaborative study at selected settlements – to establish the capacity for, and interest in managing greywater; and to test low-cost greywater management options and means of disposal. The research team decided that the following amended objectives would lend support to the overall aim of the study:

**Objective 1**

To identify the social challenges that could inform efforts to manage greywater and establish the reasons why previous initiatives to implement management systems were not sustainable in the long term. In part, this objective was expected to be achieved by examining local and international academic research on social theory so as to explain how and why local residents manage natural resources and services in developing countries.

**Objective 2**

To identify specific socially salient environmental impacts resulting from greywater management practices in non-sewered areas. This was to be achieved by, *inter alia*, analysing water samples collected from greywater generated from discarded water found either in ponds or flowing as streams in and around settlements. In addition, impacts were to be observed, described and explained based on regular field visits and from non-structured interviews with local residents, stakeholders and local authority officials.

**Objective 3**

To establish specific links between the greywater quality (particularly in respect of the detergents used) and the potential for its beneficial use. This was to be achieved partly through an examination of local and international literature, but largely by conducting focus group discussions with stakeholders to determine how greywater could be reused in non-sewered settlements.

**Objective 4**

To identify ways of overcoming social and related obstacles in order to create sustainable management options relevant to local residents. This was to be done by conducting workshops with stakeholders in order to identify possible options for greywater reuse and to determine sustainable solutions for the reuse of greywater in each settlement.

**Objective 5**

To identify ways of mitigating environmental impacts that had social purchase amongst settlement residents. Again it was envisaged that workshops would be conducted with local residents and stakeholders with the intention of finding agreement on what was problematic and then to identify ways in which each settlement could mitigate these environmental impacts.

**Objective 6**

To trial selected interventions by conducting *in-situ* field experiments, and then to understand the preparedness of residents to manage greywater.

**Objective 7**

To consult with individuals who had installed the various greywater management options, and modify the various options where necessary based on the new learning and experience. This would be achieved by using focus group discussions and workshops with interested individuals who were in the best position to provide feedback.

The researchers were well aware that the broad aims and objectives would prove challenging because the study was being conducted in complex social and economic settings that have had a long history of poor service delivery and general neglect. It was also recognised that any study that focused on greywater alone, rather than other more pressing service issues such as water, sanitation and housing, would receive a lukewarm reception from local residents, and perhaps local authority officials too.

## 1.2 Study methodology

To explore the hypothesis described in Section 1.1, an in-depth analysis of existing conditions and levels of service in selected study sites was required in order to identify current practices and to consider appropriate interventions for greywater management. The research design was also required to emphasize participation, collaboration and consensus decision-making among stakeholders, and to involve local residents in particular, so as to examine the potential for low-cost, interim strategies and solutions for managing greywater. In addition, the intention of this study was to identify existing local-level greywater management strategies, and limitations. It was vital that the research was undertaken with local residents, and where possible, to extend this to other stakeholders and interest groups such as Non-Government Organisations (NGOs) and Community-Based Organisations (CBOs). Participatory Action Research (PAR), described further in Chapter 2, was thus chosen as an approach that the research team hoped would establish opportunities for participation by focusing on the development of relationships between stakeholders, and in negotiating roles and responsibilities through the research process (Aimers, 1999). PAR, in this instance, necessitated that the field researchers spend a considerable amount of time observing how residents conducted daily activities such as laundry washing, the use of public tapstands, and disposal of water, and by holding interviews, discussions and meetings with stakeholders.

Various study sites were selected to explore community-led solutions, while a further study area, comprising four informal settlement sites in the Drakenstein Municipality, was chosen because the local authority had already provided some engineering solutions to the problem of greywater management in these informal settlements. In the case of the latter there was limited consultation regarding the choice of greywater management options, including water and sanitation services. The selected study sites were used to compare and contrast the variety of strategies that were being used to manage greywater from a so called ‘bottom-up’, community-led approach to that of a ‘top-down’ local authority level intervention.

## 1.3 Selected settlements

Two of the selected sites were considered for the PAR approach and for possible experimentation and implementation of low cost greywater management options. These sites were situated outside the City of Cape Town Municipality. Two further sites were chosen, one within the City, where a detailed population survey was conducted as part of a

community registration exercise, while the remaining sites comprised four informal settlements within the Drakenstein Municipality. The sites listed below will be described in detail in Chapter 4 and are shown on the map in Figure 4.1:

- Waterworks, Grabouw (Theewaterskloof Municipality)
- Langrug, Franschhoek (Stellenbosch Municipality)
- Hangberg (City of Cape Town)
- Four informal settlements in and around Paarl (Drakenstein Municipality)

## 1.4 Study Limitations

Participatory Action Research (PAR) methods typically involve close engagement with the participants in a study, in which researchers experience a social setting as a trustworthy and accepted 'insider'. This approach is an ideal, but proved difficult to realise in the present study as far longer timeframes are required for researchers, as outsiders, to establish a rich, collaborative and trustworthy relationship with local residents. The researchers attempted to visit the selected settlements regularly, but these were usually confined to short day-long visits. For a period of four weeks the researchers secured accommodation in the neighbourhood nearby to enable them to establish a daily presence in one settlement and to observe behaviours with respect to greywater management each day and at different times of the day. Despite these efforts, the researchers were inevitably perceived as 'outsiders' looking in on their study subjects. The intention to secure co-operative, collaborative and participatory decision-making processes in order to establish community-led initiatives to manage greywater remained largely an ideal. Arguably PAR methods are entirely suitable to address the chosen aims of the study, but were limited in this case by the study timeframe, budget and the challenge of working with the urban poor in circumstances where there are myriad other priorities and issues that clamour for attention over and above concerns about greywater and drainage. A further challenge was working with students who had coursework commitments.

## 1.5 Report structure

A brief review of the literature follows in **Chapter 2** commencing with an assertion that greywater should be regarded as a sanitation issue to be incorporated into the suite of services offered by local authorities. The discussion then explores contemporary themes in the literature dealing with concepts such as Household Centred Environmental Sanitation (HCES) and Slum Networking. These themes emphasise capacity building at the household-level so that local groups and individuals can take greater responsibility for monitoring and managing services; they also recognise the need for capacity building and accountability to be extended to local authorities. The literature review continues with a discussion on the realities of service delivery in South Africa and suggests that the challenge of engaging community and households in service delivery and maintenance is problematic. Finally, the

literature review describes and explains the PAR approach as a precursor to the chapter on research methods.

**Chapter 3** introduces the study design and methodology. Building on the theory and practice of PAR discussed in the previous section, the discussion turns to the design and application of PAR, its potential and limitations. Each phase of the study design is discussed.

**Chapter 4** introduces each of the selected settlements in the study and describes these in some detail. This is followed in **Chapter 5**, which describes the researchers' various efforts to intervene with 'community-led' initiatives to manage greywater. This part of the study is informed largely by qualitative information that was gathered from a range of primary and secondary sources including field observations, descriptions of various encounters with stakeholders, minutes of meetings, interviews and reports. This information is synthesised and used to compare and contrast similarities and differences within and between each of the selected settlement. Chapter 5 also provides an account of the efforts to install some greywater management options in two of the settlements. The potential to use these greywater options is highlighted as are their limitations.

**Chapter 6** discusses the main points to come out of the study; raising such issues as the inadequate support from government and local authorities; limitations of community-led initiatives; and the argument about the perceived successes of 'bottom up' or 'top down' approaches in the delivery and maintenance of services. **Chapter 7** draws conclusions from the study findings and also highlights the urgent need to manage greywater. **Chapter 8** gives some interim guidance for the management of greywater in informal settlements, while **Chapter 9** lists some recommendations for further study.

# 2. Literature review

Current literature on service delivery approaches frequently emphasizes collaboration and co-operation between local inhabitants and local authority officials as prerequisites for improving accountability and effective control in service delivery and operations. In part this thinking suggests that a failure to achieve a measure of trust and co-operation between service providers and users contributes to inefficient, unsustainable services. This assumption needed to be tested in the context of an informal settlement to see how or whether users of services living in these circumstances and conditions are even prepared to become involved in service delivery agreements and are willing to establish co-operation and partnerships with the local authority. The literature review begins by discussing the characteristics of greywater in informal settlements. This is followed by a discussion on new developments and thinking on the governance and management of services. Finally PAR theory and research methods are described.

## 2.1 Greywater management: SA policy and legislation

The health, legal and economic considerations as well as the determination of the National Strategy for managing pollution from settlements have been described in the Department of Water Affairs and Forestry (DWAF) reports on "Managing the water quality effects of settlements". They include: "The National Strategy" (DWAF, 2001a), "Legal considerations for managing pollution from settlements" (DWAF, 2001b) and "The national costs of pollution from settlements" (DWAF, 2001c). These reports include references to the Water Services Act No. 108 of 1997 (RSA, 1997), which has as its primary focus the regulatory framework pertaining to the provision of water services, including sanitation services, by local authorities. It is worth noting that the Water Services Act defines water services as 'water supply services and sanitation services', and sanitation services as 'the collection, removal, disposal, or purification of human excreta, domestic wastewater, sewage and effluent resulting from the use of water' – i.e. this implies that greywater management is included as part of the Water Services Act.

There is no specific reference to greywater in the National Water Act (NWA) No. 36 of 1998 (RSA, 1998) although sections concerning water resource management do apply. According to the "White paper on a national water policy for South Africa" (DWAF, 1997), South Africa's water is defined as a 'common resource' and its use has to be balanced with the protection of the resource in such a way that resources are not degraded beyond recovery, i.e. 'environmentally sustainable use'. The requirements for ensuring long-term utilisation in terms of the policy necessitate implementing resource and source-directed measures – the source-directed controls focusing on impacts from both point and non-point sources. These measures (which include standards, management practices, guidelines, procedures, etc.) are directed at managing and controlling the generation of wastewater at source and are aimed at provincial governments and municipalities. Currently there appears to be no objection in principle to the use of household greywater for individual property irrigation in South Africa but this is subject to the different wastewater regulations and by-laws of the relevant local

authorities (Murphy, 2006). None of these regulations relate directly to greywater disposal however, and most refer only to normal precautions with respect to nuisances resulting from irrigation with any wastewater (such as using sub-surface or drip irrigation only) – either in terms of common law, the Health Act, or the NWA. Nuisances are defined *inter alia* as fly / mosquito breeding, objectionable odours, surface ponding of water, and entry of polluted water onto neighbouring properties (Alcock, 2002).

## 2.2 A darker shade of grey: quality

Despite considerable research internationally that has addressed the chemical and microbiological composition of greywater in both industrialized and developing countries, it is not possible to make any generalizations about the composition of greywater found in the non-sewered, informal settlements of South Africa (Carden *et al.,* 2007). The composition of greywater depends on the sources whence the water is drawn, as well as the use to which water has been put. Typical composition of greywater generated in developed countries differs from that generated in developing countries, and in non-sewered settlements in particular. In a literature review by Eriksson *et al.,* (2002) it was claimed that most research in developed countries has tended to focus on the analysis of the content of oxygen consuming compounds, i.e. Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD), nutrients and some microorganisms. Most of the COD derives from household chemicals like dishwashing and laundry detergents, which are also the primary source of phosphates ($PO_4$) and sodium (Na) in the greywater. The total nitrogen (N) content of greywater is lower than in domestic sewage as urine is generally not present. In general greywater also contains lower levels of organic matter and nutrients compared with ordinary domestic wastewater but heavy metals appear to be in the same concentration range. Microorganisms can appear in greywater from laundry and kitchen wash waters. They can include pathogenic viruses, bacteria, protozoa and helminths (parasites in the body, e.g. worms) in variable numbers.

Lindstrom (2000) reported that the most significant difference between blackwater and greywater lies in the rate of decay of the pollutants in each, with greywater generally decomposing much faster than blackwater. This means that greywater that is discharged directly into surface water will have a more immediate effect on the recipient water body than blackwater. The impact of greywater on groundwater is less than with blackwater, however, owing to the rapid decomposition rate of greywater once it infiltrates into soil.

Other pollutants that could occur in greywater include heavy metals and xenobiotic organic compounds (XOCs). XOCs constitute a heterogeneous group of compounds that originate from the chemical products used in households, such as detergents, soaps, perfumes etc. Information about the presence and levels of XOCs is scarce and it has been recommended that further research be conducted in this regard if greywater is to be used for irrigation or infiltration as they may potentially be toxic to plants and could pollute groundwater (Eriksson *et al.,* 2002).

In research on greywater use for sustainable water management in the sewered areas of Jordan, Al-Jayyousi (2003) noted that the greywater collected from clothes washers, bathtubs,

showers and basins is relatively low in suspended solids (SS) and turbidity, indicating that most of the contaminants are dissolved. Greywater generally has high COD (up to 5,000 mg/l) with a high COD:BOD ratio (4:1) and a deficiency in macronutrients (typically COD:$NH_3$:P of 1,030:2.7:1 compared to typical domestic wastewater of 100:5:1). It can also contain up to $10^5$/100 ml bacteria which increases with storage, making the key to successful treatment being that of the immediate handling of greywater before it reaches an anaerobic state.

A study in Malaysia by Idris *et al.,* (2005) reported that a significant portion of the water in urban streams in that country comes from untreated greywater from residential settlements and that this is a major contributor of pollution with high concentrations of BOD, COD, Ammonia Nitrogen ($NH_3$), $PO_4$ and Total Kjeldahl Nitrogen (TKN), and resulting in low levels of Dissolved Oxygen (DO).

The South African literature indicates an absence of any research on the chemical and microbiological composition of greywater until the study by Alcock (2002) which considered the typical inputs as well as the chemical composition of domestic greywater from middle-income, sewered households in Stellenbosch. Such household greywater was found to have high concentrations of chlorine (Cl), sodium (Na) and potassium (K) with variable levels of nitrogen (N) and phosphorous (P). The greywater was generally alkaline and had a reasonably high sodium adsorption ratio (SAR). As with the international research, it was noted that storage of such greywater can lead to changes in its chemical and microbiological composition, which may increase the pollutant load.

The characteristics of greywater being generated from non-sewered, lower-income communities in SA have been assessed by various researchers over the last few years. Källerfelt & Nordberg (2004) evaluated local greywater treatment in the Moshoeshoe Eco-village and Hull Street housing estates in Kimberley, Northern Cape; the Pollution Research Group of the University of KwaZulu-Natal (UKZN, 2005) conducted plant trials with household greywater from the Cato Manor area in Durban; and Stephenson, *et al*., (2006) monitored the greywater from seven different households in Kwamathukuza township in Newcastle, KwaZulu-Natal. Greywater quality sampling was also undertaken in 39 settlements in six provinces by Carden *et al.* (2007) to quantify the potential risks to human and environmental health associated with greywater use and disposal. Table 2.1 summarises the greywater quality results from these studies. In general the results indicate high levels of pollution emanating from the use of household chemicals and detergents, and suggest that greywater is generally unfit for use except under controlled conditions (Carden *et al.*, 2007). Phosphate ($PO_4$) and Phosphorus (P), together with Chemical Oxygen Demand (COD) values were found to be particularly high.

On the whole, relatively little information is available on the microbiological composition of greywater in South Africa and that which does exist focuses mainly on total bacterial counts. An important defining factor in the measurement of the type and concentration of microorganisms in greywater is the general health of the population and the ability of infectious agents to survive outside of their hosts. Bacterial counts are likely to be higher in kitchen wastewater compared with bathroom and laundry wastewater, although this depends on whether there are babies in the family (there are higher bacterial loads from

washing nappies) and the levels of personal hygiene. Consideration should be given in this regard to the role of greywater disposal in the transmission of pathogens, particularly if the method of disposal is not managed properly.

**Table 2.1: Comparison of greywater quality measurements – SA research**

| Variable | Källerfelt & Nordberg (2004) | Pollution Research Group (2005) | Stephenson *et al.* (2006) | Carden *et al.* (2007) |
|---|---|---|---|---|
| pH | 6.1-7.0 | 5.8-6.3 | - | 3.3-10.9 |
| Conductivity (mS/m) | 83-132 | 144-148 | - | 28-1,763 |
| $PO_4$-P (mg/l) | 14.8-56.2 | 11 | 0.3-18.9 | 0.7-769 |
| COD (mg/l) | 530-3,520 | 1,135 | 999-1,625 | 32-11,451 |
| Suspended solids (mg/l) | 69.0-1,420 | - | 265.2-1,261 | - |
| Oil & Grease (mg/l) | - | - | - | 8-4,650 |
| TKN (mg/l) | - | 24-30 | - | 0.6-488.0 |
| Ammonia nitrogen (mg/l) | - | 20 | - | 0.2-44.7 |
| Sodium (mg/l) | - | - | - | 96-1,700 |

Recognition of the relationship between increasing phosphorous inputs to surface waters and the subsequent increase in eutrophication of water bodies resulted in efforts being made by the USA, Japan and some EU member states to reduce these phosphorous loads by decreasing the amount of sodium tripolyphosphate (STPP) used in detergents, and switching to alternative non-phosphate based additives, such as Zeolite A (European Commission, 2002). Recommendations on 'Phosphates and alternative detergent builders' included a general ban on all EU member states on the use of STTP as a builder for household detergents, and improving wastewater treatment through implementation of the Urban Wastewater Treatment Directive (UWWTD).

In SA it appears that STTPs are still used to some degree in household detergents. Alcock (2002) reported that the water from hand washing laundry solutions typically contains between 0.62 and 1.22g/*l* of STTP. An investigation of the costs and benefits of eliminating detergent phosphorous altogether indicated that the costs outweighed the benefits, but Pillay (2001) concluded that the cost of other systems which use reduced amounts of phosphorous should be investigated as they may still provide some benefit to the environment whilst being affordable.

## 2.3 Generating greywater: quantity

The generation of greywater is directly related to the consumption of water in a household and is dependent on a number of factors including the level of service provision, tolerance of residents to pollution, and levels of awareness of health and environmental risks. Greywater accounts for virtually all water usage in non-sewered areas except for that which is used for drinking purposes, that which is used consumptively in cooking, and the water that remains on the surfaces of washed articles. Wood *et al.,* (2001) noted that there is a general absence of data on the quantification of greywater in dense informal settlements owing to the fact that

often there is no proper measurement of services in these areas, and assumptions are based largely on population estimates. During the on-site surveys that were conducted by Carden *et al.,* (2007), residents of non-sewered settlements reported water consumption figures ranging from 4.7 *l* to 28 *l* per capita per day (*l*/c.d) although, in the general absence of metering, these figures do not accurately reflect the total water drawn from the system (i.e. leaks, under-reporting etc.).

Källerfelt & Nordberg (2004) studied two settlements in Kimberley that had an on-site, metered water supply with dry (ecological) sanitation in the form of urine-diverting toilets and greywater treatment facilities. The average water consumption for the two areas during the period of study was found to be 37 *l*/c.d and the mean greywater flow into the treatment facility was calculated as 25 *l*/c.d (i.e. 68%). This figure does not however take into consideration the fraction of greywater from households that is tossed onto the ground, and not discarded into the treatment system.

Alcock (2002) reported that water consumption in households without waterborne sewage is markedly less than in Western-style households and is primarily dependent on the availability of a standpipe on the plot. Similarly, multiple-tap households use substantially more water than those with access to only one tap. Alcock examined several water consumption surveys with reference to South African urban, peri-urban and rural areas in order to determine trends, and estimated that water consumption for households with a standpipe in the yard is of the order of 30-80 *l*/c.d. Where water has to be carried from an external source (250 m-3 km to the source), a mean consumption of 9-50 *l*/c.d can be expected. Alcock's study also refers to research conducted by van Schalkwyk (1996), who estimated that the water used for dish-washing, cleaning the house, clothes washing, and personal hygiene varies from approximately 12 to 50 *l*/c/d. Under such circumstances van Schalkwyk concluded that a greywater volume of 150 *l* per household per day is possible, assuming a mean household size of 6, and the fact that up to half of the water used for washing could be retained on surfaces.

Consumptive water use coefficients were determined for various urban water use categories by Stephenson & Barta (2005) so that return flows to receiving river ecosystems could be determined. The figures that were given for RDP and informal houses with water connections (in-house or communal) but without waterborne sanitation ranged from 0 to 20%, i.e. 0 to 20% of the total water use was used consumptively and not disposed in any manner. However this does not necessarily give an indication of the amount of wastewater that is discharged onto the ground.

The ranges of typical domestic water consumption and greywater generation figures for the different levels of service (LOS) as quoted in the "Red Book" – "Guidelines for human settlement planning and design" (CSIR, 2001) are shown in Table 2.2.

Similar figures have also been determined in non-sewered areas in other parts of the world, e.g. Idris *et al.,* (2005) who investigated the disposal of greywater (sullage) from an urban residential area in Selangor, Malaysia, where the sullage from all houses was discharged via a detention pond into the Kuyoh River, and sewage was conveyed by a

separate sewer line to an oxidation pond. The study concluded that approximately 83% of the total water consumption in the study area was released as greywater.

**Table 2.2: Typical domestic water consumption and greywater generation**
(CSIR Red Book, 2001)

| Type of water supply | Typical consumption (*l*/c.d) | Range (*l*/c.d) | Greywater generation (*l*/c.d) |
|---|---|---|---|
| Communal water point | | | |
| Well or standpipe at > 1000 m distance | 7 | 5-10 | - |
| Well or standpipe at distance 250-1000 m | 12 | 10-15 | - |
| Well or standpipe nearby, <250 m | 20 | 15-25 | - |
| Domestic water consumption | | | |
| Standpipe within 200 m | 25 | 10-50 | 20-30* |
| Yard connection | 55 | 50-100 | 30-60* |
| Yard connection with dry sanitation | 55 | 30-60 | - |
| Yard connection with LOFLOS | 55 | 45-75 | - |
| Yard connection with full-flush sanitation | 55 | 60-100 | - |

* Sanitation type – pit toilets

## 2.4 Greywater: a health and environmental issue

The World Health Organisation (WHO, 1996) estimates that diarrhoea is responsible for over a quarter of the deaths of children in the world, and that 80% of these deaths are as a result of a lack of sanitation and water (Esrey, 1998). In SA, about 43,000 people, mainly children under the age of 5 years, reportedly die from diarrhoea-related diseases each year (Mara, 2001). Water-related transmission routes are typically found in under-serviced settlements where poor drainage fails to carry the pathogens away, and where diseases are spread by insects that breed in standing bodies of foul water. McGranahan *et al.,* (2001) concur with WHO (1996), suggesting that preventative strategies should include increasing the quantity of available water whilst simultaneously improving the management of surface water.

Apart from overwhelming sociological arguments for the management of greywater, there are powerful economic and environmental reasons for improving water and sanitation services to poor people. The discharge of surface water containing human waste contributes to pollution of rivers and groundwater resources and, in the absence of suitable conveyance systems, poor control of *in-situ* greywater disposal results in an increase in the total pollution load with the potential to create a host of environmental and health impacts all of which will have economic implications.

As mentioned earlier, there are currently no definitive health regulations or guidelines for the disposal and / or use of greywater in SA's non-sewered areas. The City of Cape Town has however published draft "Greywater Guidelines" (City of Cape Town, 2005) specifically

concerned with the disposal of greywater in high-density, informal settlements, while the eThekwini Municipality (Durban and surrounds) has included greywater disposal and drainage issues in its "Business plan for the delivery of basic sanitation services in the eThekwini Municipal area" (eThekwini, 2003). Neither of these reports offers guidance though on the management of health issues which are associated with low-income settlements, e.g. gastro-intestinal disease, HIV/AIDS and TB management. While the beneficial use of greywater in a water scarce country is obvious, the associated risks implore strong institutional support, monitoring and control.

By 2015 it is expected that in SA 66.3% of the rural population and 79.4% of the urban population will have access to basic sanitation (UNDP, 2006), but not all of it is likely to be waterborne. In the interim absence of suitable sanitation systems for millions living in low-income housing and shacks, options for the disposal of greywater remain limited to that which is most convenient, which generally means simply tossing wastewater onto the ground alongside one's dwelling. Accumulation of this water can form ponds in and around shacks in poorly drained settlements resulting in impacts on health and on the environment downstream. Effective management of greywater must be included in the simultaneous management of water, sanitation, drainage and hygiene (Evans, 2005). A logical approach to managing greywater thus involves investments in drainage and disposal / reuse / recycling infrastructure and especially in building capacity amongst various stakeholders to manage the waste disposal.

## 2.5 Sustainable greywater management: lessons learnt

One of the lessons learnt from the Department for International Development (DfID) projects is that it is no longer possible to solve water supply and sanitation problems with pipes alone. Solutions, DfID (1998) argues, depend on the integration of political, social, technical and institutional approaches, and in changing established practices.

A further lesson emerging from the DfID (1998) projects is that prior to the 1980s water and sanitation provision seldom involved users in decision-making and management. Until this stage, projects were implemented largely on the administrators and technicians' perceptions of users and their needs rather than through consultation and participation. As a consequence, services often did not reflect user preferences, were not maintained, and were used inappropriately or not at all. Experience from these programmes and projects has now resulted in a collective wisdom that seeks to achieve interventions which are socially acceptable and which attempt to establish a 'genuine commitment to partnership and empowerment' (DfID, 1998). The Water and Environmental Health at London and Loughborough (WELL) resource centre has formulated four guiding principles that give particular attention to the recipients of water and sanitation services (cited in DfID, 1998). These four principles are quoted verbatim as follows:

*i) People matter more than science – failures in environmental health in developing countries are usually human problems of conflicting interests, inadequate human resource development, and an inaccurate interpretation of the needs and priorities of various stakeholders. The demand for services from women, men and children across*

*all social groups must be understood before selecting suitable approaches and technologies.*

ii) *Software and hardware must go hand in hand – many public health engineering projects fail because the hardware has been provided but the means to sustain the intervention beyond construction have not been developed. An integrated approach is required to develop suitable infrastructure by integrating the social, health, technical, economic, financial, institutional, and environmental aspects and planning for sustainable management, operation and maintenance. The many demands on the time of both female and male residents severely constrain what is sometimes naively viewed as the limitless potential of community management.*

iii) *Both public and private aspects of environmental health count – environmental health services often require both centralised (e.g. water treatment works) and distributed resources (e.g. public taps, drains, pit latrines, street level solid waste collection).*

iv) *Environmental infrastructure is about more than health – operational evaluations of facility functioning and consumer use, combined with studies of hygiene behaviour, are far more useful than time-consuming, often wasteful epidemiological studies. Such studies can also illustrate other benefits of water and sanitation that are valued highly by users, such as saved time, convenience, cost and dignity, which are all too lightly dismissed in a narrow medical framework. These principles express the need for measured interventions that are informed by research involving a deep level of understanding of the social and technical issues at stake.*

A further set of overlapping principles typically used in the sanitation discourse is that of the Bellagio Principles. In 2000 a group of senior sector experts met in Bellagio, Italy, and proposed that an environmental sanitation system should be based on a set of four basic principles, known formally as the "Bellagio Principles for Sustainable Sanitation". These principles were subsequently endorsed by the members of the Water Supply and Sanitation Collaborative Council during the 5th Global Forum in November 2000 (WSSCC / Sandec 2000):

i) *Human dignity, quality of life and environmental security at household level should be at the centre of the new approach, which should be responsive and accountable to needs and demands in the local and national setting.*

ii) *In line with good governance principles, decision-making should involve participation of all stakeholders, especially the consumers and providers of services.*

iii) *Waste should be considered a resource, and its management should be holistic and form part of integrated water resources, nutrient flows and waste management processes.*

iv) *The domain in which environmental sanitation problems are resolved should be kept to the minimum practicable size (household, community, town, district, catchment, or city) and wastes diluted as little as possible.*

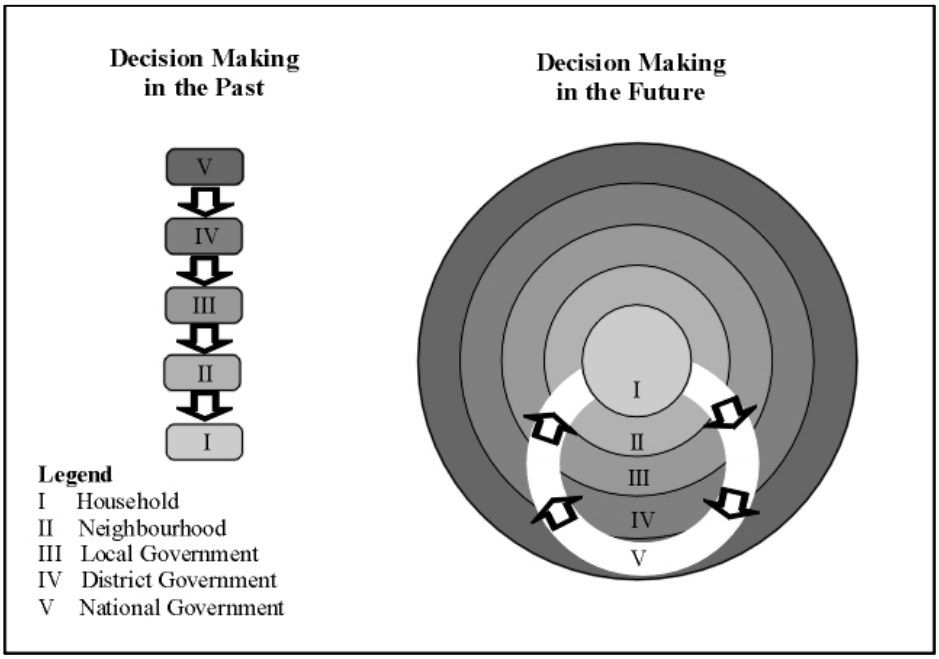



**Figure 2.1: Contrasting decision making**: **the Household Centred Environmental Sanitation (HCES) model** (EAWAG, 2005)

The Household Centred Environmental Sanitation (HCES) model emphasises three important elements. First, the household, as the consumer, is the effective basic unit for securing demands for better services and for achieving sustainable progress; second, the zones illustrated in Figure 2.1 are populated by the actors best able to address the problems close to where they originate at the various scales; and third, it is a circular model that seeks to reduce wastage and conserve resources within the system of planning and implementation of sanitation (EAWAG, 2005). The overall goal of the HCES approach is to contribute to the achievement of the MDGs by promoting sanitation that is sustainable and reaches the poorest communities in urban and peri-urban settings.

The HCES approach is consistent with the principles and the approach used in India's Slum Networking projects (Parikh, 1998; Davidson, 1998; Shah, 1999; Parikh, 2008), but here the scale of the project goes beyond HCES and indeed beyond the scope of the current study. 'Slum Networking' provides a comprehensive range of physical improvements such as access roads, water supply, storm drainage, sewerage, earthworks, electricity and soft landscaping. It seeks to establish quality solutions in preference to substandard measures conventionally generated by a 'poverty mindset'. Furthermore the approach explicitly seeks to integrate all elements of physical infrastructure responding to the reality that water, sanitation and drainage infrastructure are all interconnected.

During the course of this study it was often suggested that consideration should be given to the same principles applied by India's Slum Networking projects (Parikh, 1998; Davidson, 1998; Shah, 1999; Parikh, 2008). Yet those principles require an integrated

approach, and not one that focuses on greywater alone. The study's focus on greywater management in particular has made any attempt to go beyond a relatively closed brief extremely difficult. The research team has therefore not been able properly to consider and incorporate grassroots-popular assessments of general local development needs, or to direct attention more akin to the HCES approach. Effectively the project has focused largely on on-the-ground experimentation giving consideration to low-cost technologies at the household level to do only with greywater disposal management.

## 2.6 Improving governance

Without it having been intended, the issue of governance became one of the more important facets of this study largely because the 'state of governance' in the municipal areas in which this study took place greatly influenced the outcome of the study. Local government did little, at least at two of the study sites, in helping the local residents solve their own problems; and at a third it simply imposed systems from the top down. This is contrary to recommendations found in the international literature since the 1980s in which considerable attention has been given to building capacity and where the development of social capital is given particular attention so as to encourage citizen action. Putnam (1993) concurs with this approach in suggesting that dense networks of civic engagement produce a capacity for trust, reciprocity and co-operation, which in turn produces a healthy democracy. In his argument, he refers to social capital as a key attribute of social organization and one that is best identified in the form of social networks, norms, and trust that together become instrumental in the facilitation of co-ordination and co-operation. In the context of this study, it might suggest how citizens could use such attributes to establish and further partnerships and agreements that could be exercised in addressing service requirements.

Putnam has however been criticized for giving too much attention to citizens, whilst under valuing the state as an agency (Lowndes & Wilson, 2001). These authors argue that governments are in the best position to shape the development of social capital and have the greatest potential to influence democratic performance. This observation is not a reason to reject Putnam's argument but it does imply that he neglected to emphasize the state as a critical agency. Lowndes & Wilson (2001) argue that social capital should be used to facilitate a two-way relationship between civil society and government in which government seems likely not only to establish social capital but to effect its mobilization. In essence, the underlying institutional framework of government is a crucial factor in determining the long-term prospects for social capital in any community since government inevitably plays an instrumental role in framing civil society, for better or for worse.

The implications of this discussion are well illustrated in Parikh's thesis (2008) on the "Impact of integrated water and environmental sanitation infrastructure on poverty alleviation". Parikh explored an alternative philosophy that water and environmental sanitation infrastructure can be a catalyst for change through alleviating poverty effectively and at affordable costs. Her research aimed to evaluate the impacts of water and sanitation on health, education, income, housing and human development indices; and to assess the potential of communities to invest in improving their housing stock, including access to water

and sanitation. The research was conducted in five informal settlements of which three were in India and two in South Africa. The main findings pertinent to this study were that:

- Water and sanitation have a positive impact on health, education, income and housing, as demonstrated in both the Indian and South African settlements.
- Apart from physical comforts there is a significant impact on other factors such as freeing people's time and improving their social standing and safety.
- Community members have highlighted the benefits of individual services in the home.
- Communities may be able and willing to contribute to capital and maintenance costs of infrastructure.
- The research demonstrates the 'multiplier effect' of water and sanitation in that the communities were found to invest further in infrastructure and housing between 5 to 85 times more than the initial government contribution.
- There is an improvement in Human Development and City Development Indices after the provision of services.

In short, Parikh's findings indicate that water and sanitation provision contributes to the alleviation of poverty, improves human health, and raises educational and income levels in the community. In addition, the research demonstrated the ease with which the community and other partners mobilised the initial capital investments without recourse to aid. Even more striking were the huge investments subsequently made by slum dwellers themselves in rebuilding their shelters and acquiring luxury items.

It is significant that Parikh's study not only identified the improvement in health and education as a positive outcome of improved service infrastructure, but that households found the necessary capital to upgrade the physical structures and living conditions. In informal settlements in India, this was reportedly achieved through a combination of institutional support, private / public partnerships, micro-loan schemes and support to enable the development of social capital. In South Africa, Parikh's findings showed that multiplier effects from initial investments were considerably lower than those found in India, but nevertheless SA householders did perceive that improved services had reduced their risks associated with an unhealthy environment.

A recently published Water Research Commission (WRC) study on the use of contingent valuation methods to assess people's attitudes and perceptions towards sanitation demand (Martin & Pansegrouw, 2008) supports Parikh's findings. In this study, a model was used to determine the effective demand for services according to the affordability of all services to residents living in dense settlements. The conclusion was that residents were able to make relatively well informed choices about sanitation and other service options based on their valuation of the various options. It was found that many people were prepared to compromise in some way, for example, by accepting smaller houses or lower levels of service in exchange for perceived higher levels of other services.

Public and private sector partnerships are an important component of sustainable service delivery. It is argued that 'partnerships' are helpful in overcoming the challenges of

providing viable, affordable sanitation services to the urban poor since they have the potential to leverage the combined strengths of government, civil society and non-government organisations (service providers) (Eales, 2008). It was acknowledged at the World Summit on Sustainable Development in Johannesburg (UN, 2002) that partnership arrangements could complement the work of governments in meeting the goals of sustainable development, and specifically the water and sanitation targets of the MDGs. Whilst there has been substantial success in regard to water supply schemes, the use of partnerships in urban sanitation schemes has proved far more challenging mainly due to issues around settlement density and tenure insecurity. Since sanitation provision and operation require a multi-disciplinary and cross-sectoral approach, effective partnerships require extraordinary commitment to examine areas where needs are evident but responsibilities and accountability are not defined. Local accountability mechanisms, mediated through CBOs and NGOs, are more likely to be effective in this regard. In all cases, there is a need for partnerships which build understanding and communication in helping to close the gap between people and government – often the most valuable are non-formal and unstructured, built around recognition of common interests (Eales, 2008).

## 2.7 Participation in greywater management: social challenges

Perspectives on access to services for the majority in SA are rooted in the history of struggle for social justice on the one hand, and, in the post-apartheid period, on effective governance on the other. Current tensions remain largely polarized between those who see the need for vociferous advocacy directed towards social justice as the only means to redress the problem of slow service delivery to the poor, and those who assert that the provision of better services is best achieved through participation and partnerships between civil society and local government. It is in the context of these largely polarized positions that the present study's researchers have had to operate. Social and political challenges abound and are no more evident in SA than in the context of the urban poor.

South Africa's transition from apartheid to democracy represents a paradigm shift in social and political transformation, yet uncertainty remains among theorists and practitioners about the role of civil society (Oldfield & Stokke, 2006; Kruger, 2009). There is general agreement that development must include civil society, broadly defined as the dominion of organized or unorganised social and / or public life that is voluntary, self-generating, sustaining, and autonomous from governmental structures (Carmody, 2007). This suggests that involvement of civil society leads to the empowerment of citizens and that this raises the potential for citizens to participate in development. Yet the question must be asked: can poverty stricken poor people be expected to establish a cogent movement (an organised social structure) that will be powerful enough to demand the attention of the state and ultimately improved delivery of services that is also sustainable?

The approach taken by the current study was built on the premise that the governance of urban services is best served by efforts to decentralize planning and incorporate participation and partnerships within civil society. Implicit in this approach is an assumption and expectation that members of civil society, as represented by inhabitants living in the

settlements investigated in this study, are prepared to accept this approach and to demonstrate a willingness to co-operate with other stakeholders in a project to improve greywater management. Such assumptions might be unworkable, particularly when there is limited institutional support and where government is largely unprepared to engage with civil society as the critical agent for transformation of services.

The foregoing serves to highlight social challenges confronting the research design and methodology of this study. The discussion raises the point that civil society in the context of social deprivation, injustice and general deprivation is unlikely to operate in a normative, idealized sense (Oldfield & Stokke, 2006). More likely, local social movements will operate with power of their own choosing which might not be 'civil', or 'virtuous'. As Bayat (1997) argues, poor people are likely to focus energy on the range of activities that might secure opportunities where their need is greatest, for example land tenure, housing, services and especially their livelihoods.

## 2.8 Participatory action research

The study design was informed largely by an Adaptive Decision-Making Process (ADMP) to structure Participatory Action Research (PAR). That was because this approach suggested a procedure for formulating and implementing a course of action that could explicitly take into account social, political, economic and institutional factors (Lal *et al.,* 2001) (Figure 2.2). An ADMP approach requires a problem-focused, action-oriented participatory process aimed at producing management strategies in which all stakeholders reach agreement because they accept some degree of propriety over the process. More importantly, as a research approach, ADMP acknowledges the need for discursive and iterative decision-making and recognises that multiple stakeholders have different values and knowledge systems. It also recognises that decisions need to be achieved through collaboration, co-operation and consensus.

### 2.8.1 The ADMP framework

The ADMP framework has three underlying themes, namely (a) Participatory Action Research, (b) the use of a Decision Support System (DSS), and (c) dialectic, stakeholder-based decision making. These themes are described prior to commencing with a discussion in Chapter 3 on how the research team adapted this approach to the current study.

#### 2.8.1.1 Participatory Action Research (PAR)

PAR requires the active involvement of all stakeholders in the entire research extension / development process. In general, as distinct from the particularities of its implementation in this project, the key characteristics of this process include (Lal *et al.,* 2001):

- A problem-focused research concern that responds to local priorities
- A methodology with an interdisciplinary focus that includes every stakeholder's knowledge system

- The use of more than one methodology
- Data collected jointly by researchers and stakeholders
- An analysis carried out by researchers from different disciplines using their own theoretical constructs, paradigms and disciplinary tools
- Results and information that are interpreted through a dialectic process
- Actions integral to the process
- Results that are shared and owned by all the stakeholders

#### 2.8.1.2 Decision Support System (DSS)

In the context of ADMP, the DSS is an integrative analytical tool that describes the key processes and the spatial and temporal connections within and between the human and biophysical subsystems. Typical characteristics of DSS are data sets, key analytical models, and user interface, all of which are considered central to a dialectic decision-making process (Lal *et al.,* 2001).

#### 2.8.1.3 Dialectic decision-making process

Dialectic decision making assumes that there are many different interpretations based on different scientific paradigms, experiences and value systems that cannot easily be reconciled. No one interpretation may be complete and, as a result, many realities are possible. Decisions are based on the knowledge systems of all the stakeholders and on sound judgments supported by rigorous analysis. These decisions are achieved through interactions between stakeholders (Lal *et al.,* 2001).

#### 2.8.1.4 Operational phases of ADMP

The process of implementing ADMP consists, in principle, of four phases: (1) subsystem identification, (2) reflection, (3) action, and (4) adaptive learning. Although a four-phase ADMP is recommended, the boundary between one phase and the next is flexible, and more than one phase may be undertaken at the same time. In Figure 2.2 four phases of such a research framework are illustrated, beginning with an initial assessment of the settlement in context, followed by a phase in which the problem is to be clearly defined, collectively understood and from which a shared vision is ideally articulated. Phase Three is meant to include a combination of DSS and active interventions; while Phase Four is, in principle, where actions are (re-)assessed, adapted and then re-introduced.

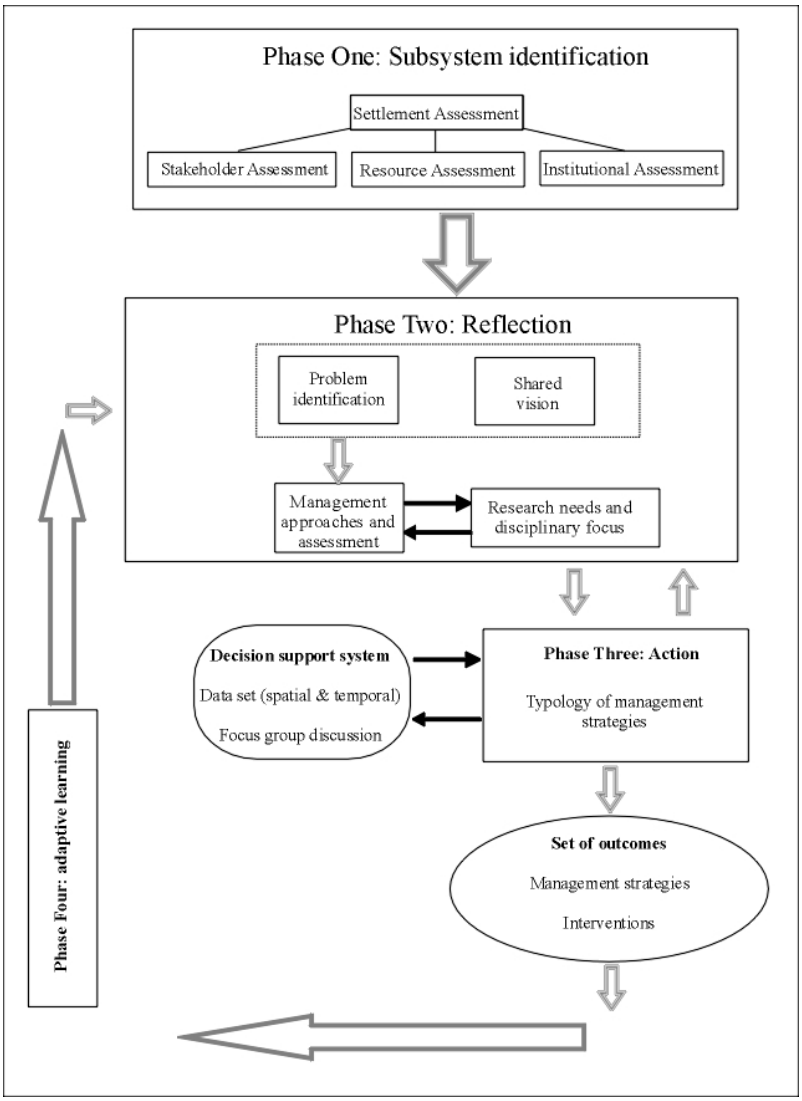



**Figure 2.2: Research design framework** (Adapted from Lal *et al.*, 2001)

## 2.9 Relevance of the literature review to this study

Ultimately, this study attempted to use a PAR approach in conjunction with the ADMP process as a structured framework that could guide the research process whilst also allowing for sufficient flexibility without determining the course of action and outcomes that might compromise action research. From the outset, attention was to be focused on assessments of the various resources at each settlement and on engaging with local communities and individuals. While the researchers were hopeful that they might be able to encourage a measure of community-led decision making, in line with the thinking and approach expressed in the Bellagio principles and Household Centred Environmental Sanitation (HCES) concept, they were careful not to raise expectations or to impose solutions. Chapter 3 describes the research method in more detail.

# 3. Research methods

## 3.1 Introduction

The study hypothesis was that sustainable options for the management of greywater in non-sewered settlements were more likely to be achieved when local residents were involved in managing greywater themselves rather than through following a traditional or more typical approach in which the provision of rudimentary engineered services occurs with minimal consultation with residents as the end users. An appropriate research design was therefore required that emphasized participation, collaboration and consensus decision-making among stakeholders to ensure the long term sustainability of social and technological interventions and solutions. An Adaptive Decision Making Process (ADMP), as described in Chapter 2, was thus initially chosen for the study.

For logistical reasons, it was necessary to identify a limited number of suitable study sites. After examining a number of candidate settlements (the site selection process is described in Chapter 4), two – Langrug and Waterworks – were chosen for the ADMP. An additional settlement – Hangberg – was selected for a separate assessment because community-led solutions, facilitated by an NGO, were already quite far advanced. Three additional settlements – Oliver Tambo, Drommedaris and Fairyland – which had recently been provided with basic services by Drakenstein Municipality, including greywater management and employing limited public participation, were investigated for the purposes of comparing this 'top-down' strategy with efforts to encourage a more participatory one advocated by the study hypothesis (which could perhaps be called a 'bottom-up' approach). Finally Simondium, another settlement falling under the auspices of Drakenstein Municipality, was investigated as the residents there had not been included in the programme that had led to the upgrade of the other three – thereby providing an interesting example of what can happen when settlements are largely neglected.

This chapter explores the adaptation of ADMP to make it suitable for use in Langrug and Waterworks. This is followed by a description of the surveys that was carried out in Hangberg. Finally the open-ended qualitative ethnographic observations employed in the Drakenstein settlements are discussed.

## 3.2 Adapting the ADMP to the study

### 3.2.1 The need for adaptation

ADMP was the research method that was used for Langrug and Waterworks. The engine of ADMP is Participatory Action Research (PAR) which seeks to involve all stakeholders in the research process. This includes developing and/or strengthening relationships between stakeholders and negotiating roles and responsibilities (Aimers, 1999). The immediate challenge in attempting to adopt a PAR approach was the need to recognize the inherent problems faced by residents living in what could largely be described as inhumane conditions. These include disillusionment as a consequence of: job insecurity; uncertainties about land tenure and/or the prospects for secure housing; the collapse of rudimentary service

infrastructure such as tapstands and toilets; and a lack of clarity regarding exactly who is responsible for the various services. The four operational phases that are required in the implementation of ADMP had thus to be adapted to these conditions.

## 3.2.2 The operational phases

### 3.2.2.1 Phase 1: Identification and assessment

Settlement selection was achieved through consultation with local authorities, field visits and, in some cases, an evaluation of previous studies. Local authorities were consulted in order to establish the level of service in the identified settlements and future prospects for development in each. In addition, efforts were made to identify other stakeholders such as non-governmental and community-based organizations which might have had an interest or involvement in the settlement. A five-fold purpose summarizes this initial phase of the project:

- To introduce the research project to the multiple stakeholders.
- To assess the level and extent of support from the local authority and identify the major obstacles that might hinder such support. Obstacles might have included contradictory perceptions existing between local authorities and residents regarding the issue of support, and possible areas of disconnect and communication failure between various key personnel within local authorities.
- To establish estimates of the numbers of housing structures in each area.
- To obtain data about existing and proposed water and sanitation services.
- To identify social linkages, working structures and communication channels within each settlement and between its residents and the local authority responsible for it.

### 3.2.2.2 Phase 2: Reflection and establishing of shared goals

The aim of this phase was to identify problems associated with existing greywater management practices with an emphasis on how such practices (or their absence) have the potential to, or currently do, influence health and the environment. A clear understanding of the underlying management issues and general agreement as regards desired outcomes was thought to be critical to any decisions that might lead to interventions and ultimately to sustainable solutions. Stakeholders were to be encouraged collaboratively to prioritise greywater disposal and management issues in order to reach a shared understanding of what might be the best desired outcome for all concerned and to identify appropriate management strategies. It was intended that once agreement had been reached with respect to the scope and extent of the problem, the researchers would attempt to facilitate discussions with the intention of establishing a shared vision for greywater management.

#### 3.2.2.3 Phase 3: Action

In this phase, the stakeholders, having agreed on various greywater management options in Phase 2, would begin implementing management strategies and possible technical interventions that had been identified.

#### 3.2.2.4 Phase 4: Adaptive Learning

This final critical phase was meant to provide assurance of the long-term sustainability of the study outcomes. It was intended to treat the prospective management strategies as a series of management policy experiments. The management strategies and possible technical interventions selected in Phase 3 were then to have been monitored iteratively in an attempt to assess the possibility of success.

Regardless of how the results might be interpreted, Phase 4 was meant to have been one of adaptive (or experimental) learning in which feedback assists in promoting reflection and adaptation of intervention strategies. This phase was also intended to support capacity building and empowerment of residents. Central to the intended success of the study was the establishment of representative resident groups (street or block committees) whose members might be willing to engage in a process to implement changes in conjunction with the support of local authorities and elected ward councillors. As experienced in the study, however, this proved problematic as there was considerable disagreement, even outright antagonism, between the various stakeholders.

### 3.2.3 ADMP and the original study objectives

This section explains how each of the original research objectives was adapted to conform to the four phases of ADMP in this study.

#### 3.2.3.1 Phase 1: Identification and assessment

Objective 1: Identify the social challenges to effective greywater management in non-sewered areas and the reasons why previous initiatives to implement such management systems might not have been sustainable.

Method: Literature survey of local and international academic research in an attempt to develop an understanding of how local residents manage natural resources and services in developing countries.

Objective 2: Identify specific socially salient environmental impacts resulting from greywater management practices in non-sewered areas.

Method: (a) Sample water quality from various containers used in generating greywater and from discarded water found either in ponds or flowing as streams in and around the settlements as runoff. Compare results of these tests in relation to known activities within a

settlement, between settlements and in relation to South African Guidelines for Water Quality; (b) observe, describe and explain the environmental impacts based on field visits and non-structured interviews with local residents, stakeholders and local authority officials.

Objective 3: Establish the specific links between greywater quality (particularly in respect of detergents used) and the potential for its reuse.

Method: (a) Draw on local and international literature to determine how or whether greywater is being reused elsewhere and under what conditions; (b) conduct a number of focus group discussions with stakeholders to determine how greywater is or could be reused in each settlement.

#### 3.2.3.2 Phase 2: Reflection and establishment of shared goals

Objective 4: Identify ways of overcoming social and related obstacles in order to create sustainable management options relevant to the local resident populations and, in particular, to identify possible means to overcome such people's inability to continue with existing management systems or implement new systems.

Method: Conduct workshops with stakeholders to identify possible options for greywater reuse and to determine sustainable solutions for the reuse of greywater in each settlement.

#### 3.2.3.3 Phase 3: Action

Objective 5: Identify possible ways of mitigating environmental impacts that have social purchase amongst residents.

Method: (a) Conduct workshops with stakeholders to identify possible ways in which each settlement to consider how to mitigate environmental impacts that local stakeholders (residents and/or local authorities) agree are problematic; (b) facilitate field visits for community leaders to experience best practice determined at sites elsewhere.

Objective 6: Trial social and environmental interventions in selected settlements.

Method: If agreements established in Phase 2 on shared goals and strategies, then *in-situ* field experiments could be conducted to improve knowledge and understanding.

#### 3.2.3.4 Phase 4: Adaptive Learning

Objective 7: Consult with individuals who have installed the various greywater management options, and consider modifications based on social learning and experience if necessary.

Method: Use focus group discussions and workshops with interested individuals to monitor and adapt strategies and options, and feed this learning back into adapting existing options and social learning.

The intended research method and likely success of the study depended largely on the co-operation and willing collaboration of local residents. The assumption was that sustainable solutions and strategies for greywater management are more likely to be achieved if research and the resulting implementation strategies are driven by all stakeholders and by the users in particular, and not simply by local authorities alone. The research methods therefore focused on participation and consensus decision making in keeping with PAR principles. The study was, however, more than just a 'bottom-up' approach since any implementation, with respect to this study, had to be achieved by a combination of all the actors including researchers, local authority and local residents.

In the course of the work in Langrug and Waterworks, it became evident that the conditions for the success of an ADMP were not fully present – for reasons which will be described in Chapter 5. Valuable lessons were, however, learnt. The decision was thus made to continue as far as possible in these two settlements, whilst concurrently investigating alternative models.

## 3.3 Surveys in Hangberg

Unlike those at Langrug and Waterworks, the approach to the study of Hangberg was guided largely by the Hangberg in-situ Development Association (HiDA) in consultation with an NGO, the Development Action Group (DAG), which had agreed to facilitate an *in situ* upgrade. The researchers attended three meetings (16 May 2007, 30 May 2007 and 26 June 2007) with civic committee members to enlist their support and to develop a *modus operandi*. The researchers also attended a block-level (cluster of houses) workshop on 31 May 2007. The meetings with community leaders and residents helped the researchers understand what was needed in terms of preliminary surveys and to refine the details. Two distinct surveys were planned; the first with the purpose of establishing a community register of socio-economic data about each household and its rights to its current site for the *in-situ* upgrade; the second to identify existing services. The surveys were followed by a focus group discussion with four members of the HiDA committee to clarify various issues. Concerns about the impact on the settlement of the wastewater disposal practices raised by the HiDA led to the collection and analysis of water samples in and around the settlement.

Unlike in Langrug and Waterworks, the fieldworkers did not attempt to propose any greywater management systems in Hangberg, choosing rather to observe the process whereby the residents worked together with DAG and the City of Cape Town (CoCT) to an attempt to reach their stated goals.

## 3.4 Ethnographic observations in the Drakenstein settlements

Whilst the main aim of the study was to explore local, community-led solutions to greywater management, the study team also investigated the implementation of various relatively low-cost schemes in Oliver Tambo, Drakenstein and Fairyland by Drakenstein Municipality in order to contrast so called 'bottom-up' and 'top-down' approaches. Some public participation had been used in these interventions but in general there was limited consultation regarding

the choice of different services as well as in their location. Simondium, another settlement under the auspices of Drakenstein Municipality provided an example of a settlement that had not yet been 'upgraded' by the municipality.

The four informal settlements were investigated during March and April 2008 with a view to investigating the success, limitations and failures of the various interventions including, *inter alia*, greywater management, instigated by Drakenstein Municipality. Meetings were first held with representatives of the Municipal Engineering and Housing Departments and with their consultants. A researcher then spent a minimum of five days each in Oliver Tambo, Drommedaris, Fairyland and Simondium conducting semi-structured and structured interviews and focus group discussions, as well as gathering additional data from informal conversations and general observations. The structured interviews were mostly carried out in English or Afrikaans, with occasional help from isiXhosa speaking interpreters. Most were conducted with individual residents. They focused on residents' access to water, their disposal of greywater, municipal interventions for greywater management, and perceptions of the municipality's role. Residents were specifically asked about:

- Length of residence in the settlement
- Water and toilet accessibility and utilization, including processes of fetching fresh water and disposing greywater
- Major greywater problems experienced (if any), including problems experienced at facilities such as standpipes, toilets and washing areas
- Accessibility and utilization of solid waste disposal facilities
- Information about what the municipality might have 'promised' to do to enhance service delivery, management of greywater problems, etc.
- Technologies / interventions implemented by the municipality
- Interventions and other actions currently being conducted
- Perspectives on what the municipality should be doing in the settlement
- Perspectives on what individual residents do (or did) to address water disposal and related concerns in the settlement, i.e. exercise individual agency
- Reflections on group and / or 'community' action
- Reasons why municipally provided facilities might have become inoperable.

Once sufficient information was gathered, the researcher asked local leaders, such as street committee members, to invite willing residents to participate in focus group discussions.

## 3.5 Summary

Initially the investigation was to focus entirely on the use of an ADMP in a bid to substantiate the hypothesis that sustainable options for the management of greywater in non-sewered

settlements were more likely to be achieved when local residents were involved in managing greywater themselves rather than through following a traditional or more typical approach in which the provision of rudimentary engineered services occurs with minimal consultation with residents as the end users. In spite of taking considerable care in the selection of suitable study sites, it soon become apparent that there were substantial obstacles to the likely success of this approach. The decision was thus made to expand the investigation to look at two other models: facilitation by an NGO as illustrated in Hangberg; and a more conventional 'top-down' approach with limited public participation as illustrated in Drakenstein Municipality.

Chapter 4 looks at the selection of the study sites.

# 4. Study settlement description

## 4.1 Introduction

This chapter outlines the criteria for settlement selection and then briefly describes the settlements that were chosen.

## 4.2 Settlement selection

Initially eleven settlements in the Western Cape were visited by the research team and evaluated against a set of pre-determined criteria for the purposes of investigating their potential for community-level greywater management. Three settlements were finally selected from three municipalities namely: City of Cape Town (CoCT), Stellenbosch and Theewaterskloof. In addition, three settlements from Drakenstein Municipality were chosen to compare the impact of the so-called 'top-down' initiatives that had been taken by that local authority to implement greywater management along with a suite of other basic and improved services. A fourth settlement, also under the auspices of Drakenstein Municipality, but that had been largely neglected, was also chosen for the purposes of comparison.

### 4.2.1 Settlement selection criteria

The initial choice of settlements was based in part on prior knowledge of the settlements that were investigated in the previous study (Carden *et al*., 2007), while others had been the subject of research by other academics from UCT. In one instance, a site was visited on the recommendation of the local authority. The team deliberately tried to select a similar number of sites inside and outside of the CoCT. Of particular concern was the need to identify some form of social structure, for example a street or project committee within each settlement, which might become the principal partner in the participatory approach envisaged by the study team. In summary, the initial site selection criteria were as follows:

- A formal water supply with either no formal sanitation or dry sanitation systems at each dwelling
- Greywater disposal posed a potential health and/or environmental risk
- Evidence of some form of community or social structures
- Accessible and 'safe' for researchers
- Opportunities for greywater reuse, e.g. for irrigation, or where existing greywater treatment systems were in place
- A range of housing densities across the various settlements
- Within reasonable travelling distance from UCT

### 4.2.2 Settlements considered

In total more than eleven informal settlements in the Western Cape were inspected for possible inclusion in this project. The site visits were typically of two to three hours duration. The settlements were: Doornbach, Melkbosstrand; Hangberg, Hout Bay; Imizamo Yethu, Hout Bay; Masiphumelele, Noordhoek; Sweet Home Farm, Philippi; Khayelitsha RR Section; Kanana, Gugulethu (all CoCT); Waterworks, Grabouw; Rooidakke, Grabouw (both Theewaterskloof Municipality); Langrug, Franschhoek (Stellenbosch Municipality); and a number of settlements in and around Paarl (Drakenstein Municipality).

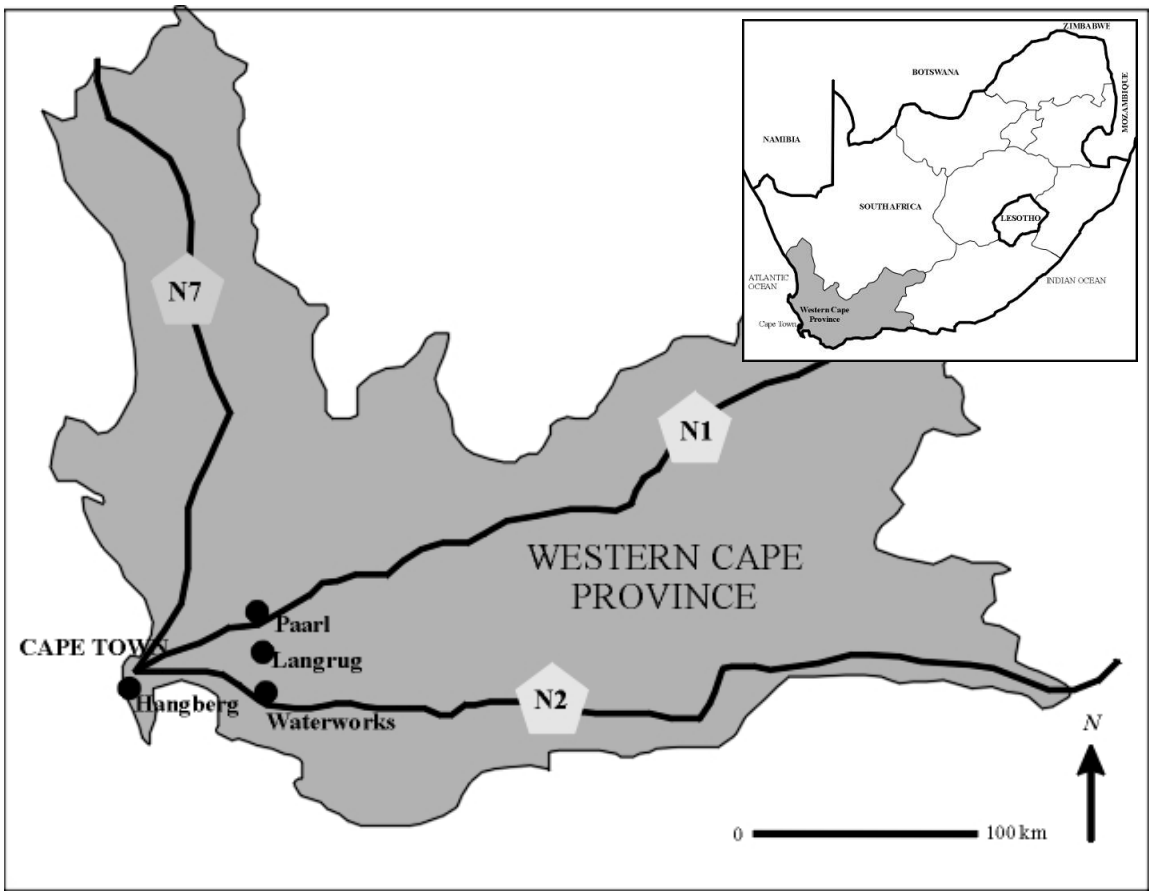



**Figure 4.1: Location map showing selected study settlements**

Seven settlements were eventually selected for the research (Figure 4.1):

- Waterworks, Grabouw (Theewaterskloof Municipality)
- Langrug, Franschhoek (Stellenbosch Municipality)
- Hangberg (CoCT)
- Oliver Tambo, Drommedaris, Fairyland and Simondium – all in the vicinity of Paarl (Drakenstein Municipality)

The settlements fell into four categories:

1. Langrug and Waterworks seemed to be suitable for the ADMP proposed by the research team.
2. Hangberg was an example of greywater management initiatives already taken by the residents with the aid of an NGO.
3. Three settlements (Oliver Tambo, Drommedaris and Fairyland) in Paarl offered examples of initiatives taken by Drakenstein Municipality and provided an alternative (so-called "top down") approach to that originally advocated by this study.
4. Simondium (just outside Paarl) was an example of a settlement that had been largely neglected by the local authorities.

## 4.3 Overview of the selected sites

### 4.3.1 Langrug, Franschhoek

Langrug lies on a steep slope about 5 km north-west of the centre of Franschhoek which is a small tourist town in mountainous terrain about 50 km straight line distance north-east of Cape Town (Figure 4.1). The town also serves as a centre for a commercial vine and deciduous fruit-growing area. Agricultural production in the Franschhoek Valley relies heavily on freshwater from the Franschhoek and Berg Rivers for crop irrigation, but, as will be discussed later, the quality of this water is being compromised by various sources of pollution including surface water runoff from Langrug informal settlement. Langrug settlement is situated along the foothills of the Franschhoek Mountains, separated from the main road (R45) to the south by a low cost formal housing scheme (Groendal). The Franschhoek River is situated a further 500 m to the south. Surface runoff from Langrug and surroundings is discharged directly via a stormwater pipe into the river (Figure 4.2).

Langrug's first shack dwellings were erected in 1993. By 2006 the population had reached approximately 5,000, nearly 90 percent of whom were recent migrants from the Eastern Cape. At the time of this study, unemployment was widespread and limited to short-term employment opportunities in the local construction industry or seasonal agricultural work (Barnes, 2006; Adams, *et al.,* 2007). Shack dwellings were constructed of corrugated iron, wood, plastic sheeting and a variety of other scrap materials including old fruit-packing cases (Kruger, 2009).

At the time of this study, there was only a single central gravel road running directly up the hillside with a number of narrower parallel gravel roads on either side linked together by various paths. There was no formal stormwater drainage system other than a shallow open concrete-lined ditch approximately 1 m wide running down the hill parallel to the central road. This ditch was designed to collect runoff from the road but also picked up wastewater from the surrounding area. All potable water supplies were communal and were accessed at two ablution blocks (including both flush toilets and washbasins), five publicly accessible tapstands and two other tapstands incorporated into private yards. The tapstands were located on a drainage structure comprising piped outlets surmounted by a small grid cast in a

concrete slab and surrounded by a low brick wall. The pipes were linked through a limited sewage network to the Stiebeuel Wastewater Treatment Works (WWTW) situated south of the settlement along the banks of the Franschhoek River which handles sewage from the entire Franschhoek area. Apart from the ablution blocks, a few double cubicle flush toilets were scattered around the settlement.

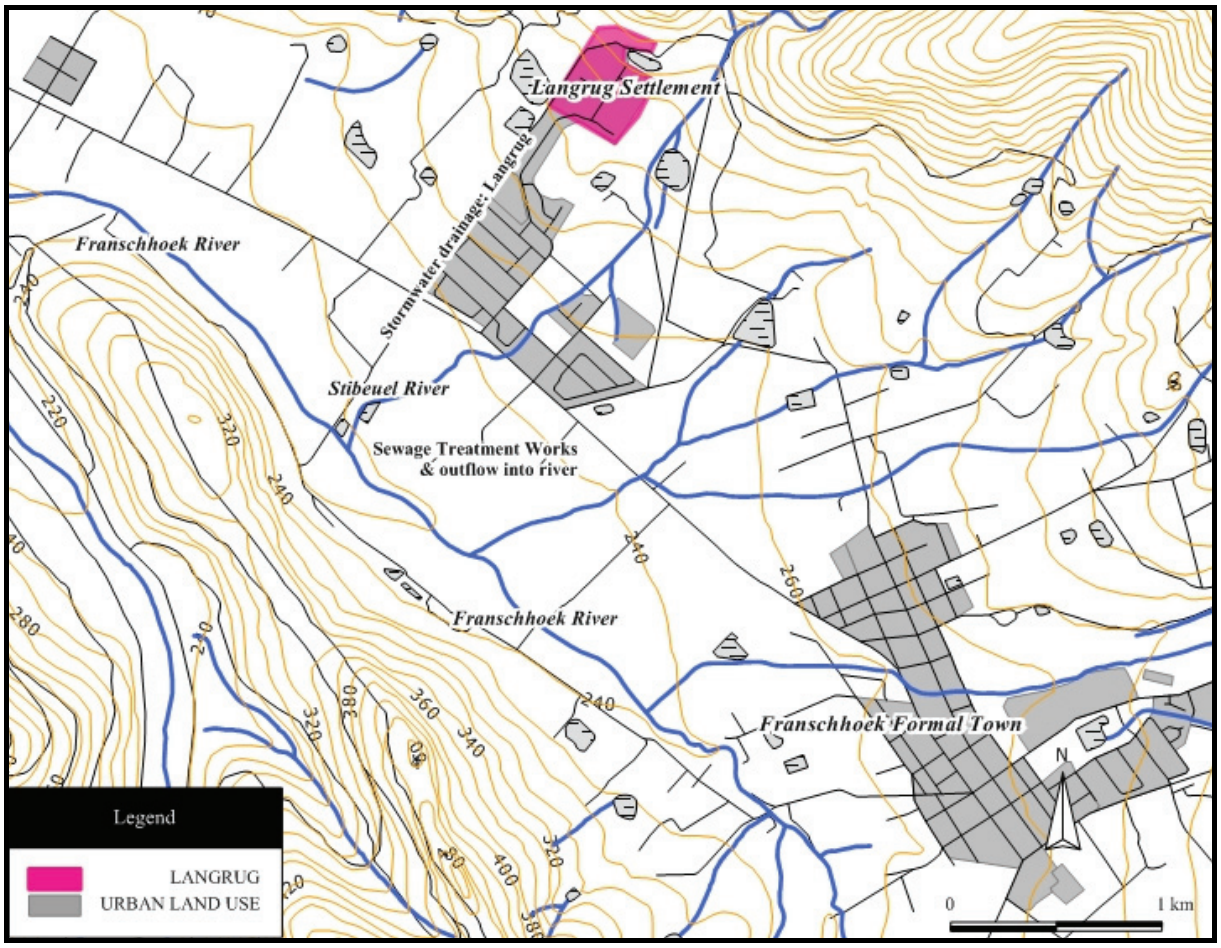



**Figure 4.2: Location of Langrug** (Note the stormwater drainage pipe that leads surface water from Langrug and surrounding areas to a discharge point in the Franschhoek River)

### 4.3.2 Waterworks, Grabouw

Grabouw is a small town approximately 100 km straight line distance east of Cape Town providing infrastructure and support for commercial deciduous fruit farms and the pine forestry industry. The informal settlement of Waterworks lies on a hill-side some 3 km from the town centre, alongside a small municipal water reservoir – hence the name (Figure 4.3). It also lies adjacent to a middle income residential housing area, separated from it by a narrow asphalt urban road and wire fence. Invasion of the land by migrants, most from the Eastern Cape Province, commenced in the mid-1980s, being exacerbated in the 1990s by farm worker evictions following farm mechanisation (Kruger, 2009). At the time of the study, there were

over 800 shacks constructed from wood, plastics, corrugated iron as well as from other scrap materials – prominently timber from old fruit-packing cases. Many adults amongst the settlement's approximately 3,000 residents were seasonal workers on nearby farms and, as was the case in Langrug, many were un- or underemployed.

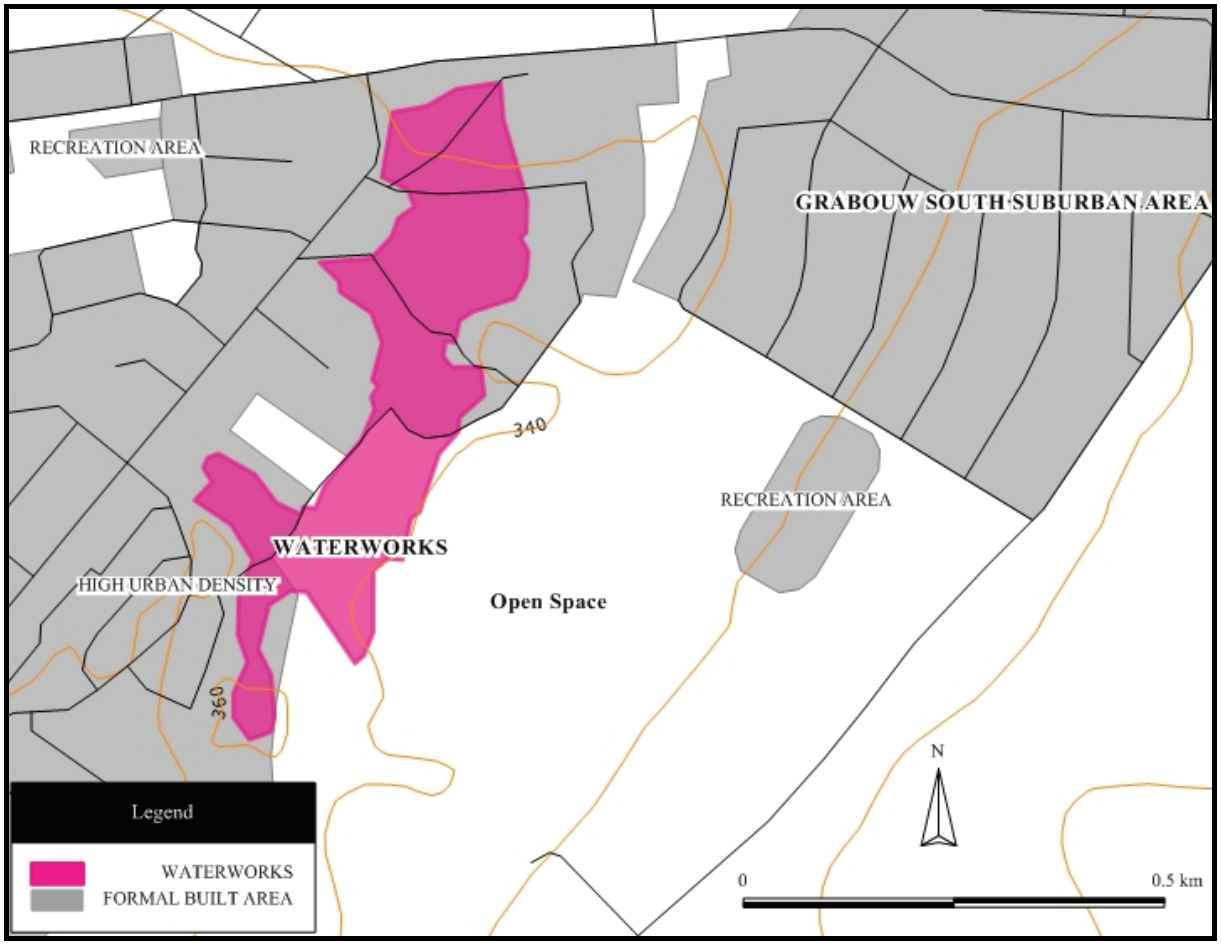



**Figure 4.3: Location of Waterworks**

The Grabouw Town Management claimed to have provided one tapstand per 25 families and one pit latrine per five families but fewer than this were found on the ground. Only one tapstand had a formal drain for overflow. Sanitation facilities were also limited and in a poor state. According to residents, they comprised ten flush toilets and twelve Ventilated-Improved Pit (VIP) latrines.

### 4.3.3 Hangberg, Hout Bay

The informal settlement at Hangberg, Hout Bay is a stark contrast to the two settlements just described, largely because the socio-political history of the settlement is very different to the others. Hout Bay is situated in the Disa Valley of the southern Cape Peninsula, abutting Table Mountain National Park and the Atlantic Ocean. The informal settlement of Hangberg is located on the south-west side of the village at the base of the Sentinel Mountain with its

upper boundary adjoining Table Mountain National Park, and both private land and provincial land. It has spectacular views over the bay (Figure 4.4).

**Figure 4.4: View from Hangberg (Hout Bay)**

According to Omari (2006), the Group Areas Act (No. 41 of 1950) designated Hout Bay as a 'white' settlement area in 1956, but allocated two percent of the total land area for 'coloureds' i.e. those of mixed ethnic descent (Gawith, 1996). Black (i.e. Bantu) South Africans living in Hout Bay at the time were forced to re-settle elsewhere (Omari, 2006). By the early 1970s, however, fishing activities in Hout Bay had intensified, attracting additional coloured fishers and their families to the area for whom the City Council built formal residential flats. The facilities soon became overcrowded however and, as a consequence, the open ground immediately south of Hangberg formal settlement on the slopes of the Sentinel was invaded and transformed into an informal settlement (Figure 4.5).

Since 2001, residents living in Hangberg's shack dwellings have had access to limited basic services, namely 39 flush toilets and 37 water standpipes, installed by the Cape Town Municipality and intended to service about 400 households. Many individual residents have however managed to install taps and flush toilets in or next to their own homes, cutting into the municipal lines to do so. In 2006 the Development Action Group (DAG) – an NGO – partnered by the City Cape Town and the Hangberg in-situ Development Association (HiDA), began a participatory process toward an *in-situ* upgrade of 302 households (DAG, 2006). The project entailed formal provision of basic services and improved tenure security to enable house owners to incrementally upgrade their dwellings (DAG, 2007). The settlement was divided into a number of neighbourhood blocks, each with representatives elected onto

the HiDA (MacGregor, 2007). The Committee's role was to communicate with the rest of the residents; facilitate their participation in upgrade planning; deal with queries and report problems; and liaise with relevant government departments (DAG, 2007).

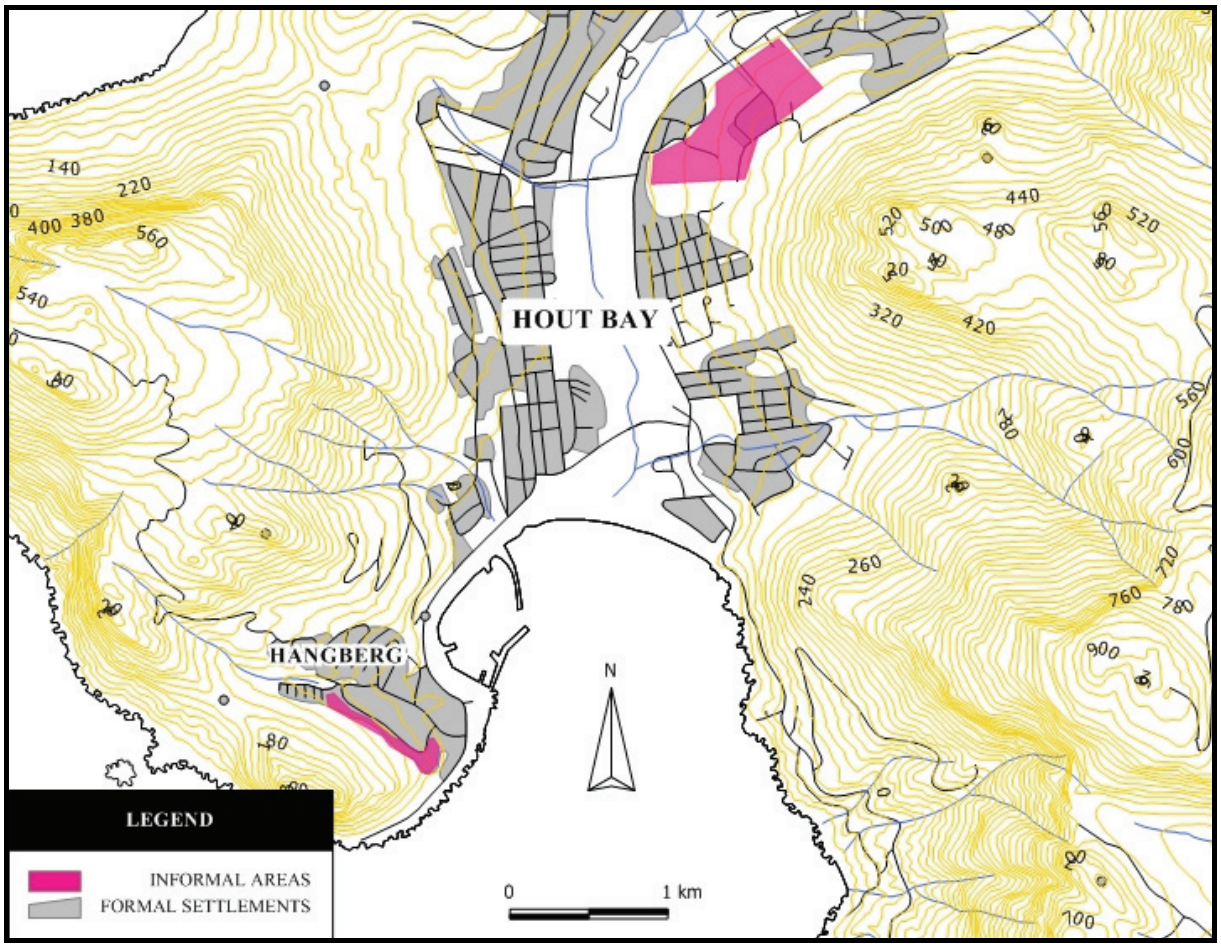



**Figure 4.5: Location of Hangberg informal settlement**

## 4.3.4 Paarl settlements, Drakenstein Municipality

Housing in the Drakenstein Municipal area includes approximately 4,200 shacks in approximately 24 informal settlements accommodating some 21,000 people (Van Wyk, 2008). In 2003 the municipality faced numerous complaints from the Department of Water Affairs and the Irrigation Board about polluted stormwater flowing into the Berg River from many of these informal settlements.

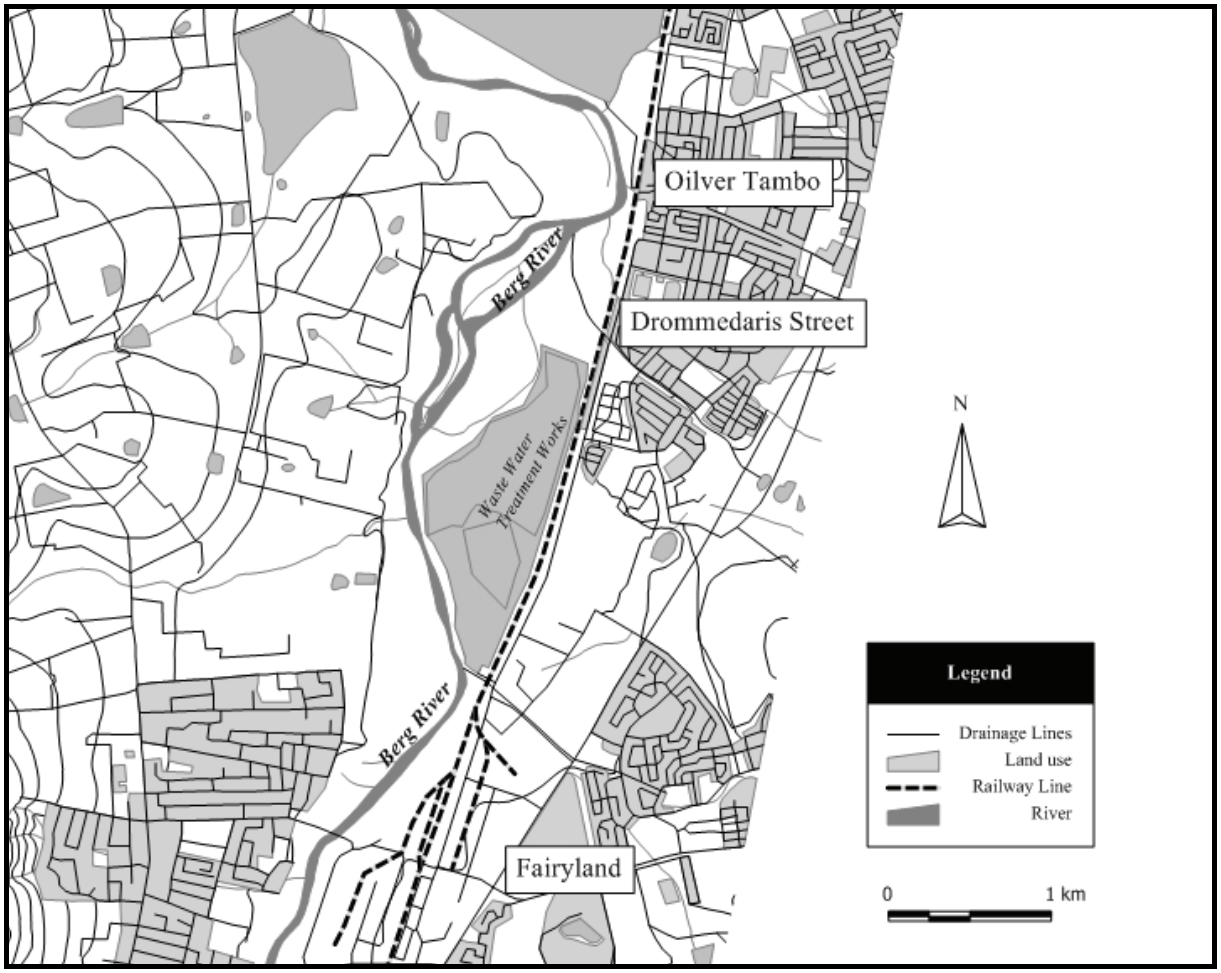



**Figure 4.6: Location of Drakenstein study sites** (Simondium off the map to the south)

In mid-2004 the Municipality introduced its 'Provisions of Basic Services Project to Informal Settlements' programme. Consulting Engineers conducted investigations to determine solutions for sanitation and greywater management and recommended that the best option was to install communal waterborne sanitation in all informal settlements. Installation commenced in December 2007 and each settlement site was raised to a 'point of satisfaction' agreed by the Municipality prior to handover. The upgrades were accompanied by management and operational plans to ensure that the services were maintained.

Oliver Tambo, Drommedaris and Fairyland (Figure 4.6) were selected for the study to illustrate how a more conventional approach to the provision of basic services in informal settlements works and to use as a benchmark against which to test the study hypothesis. Simondium, situated some 15 km due south of the centre of Paarl was selected as a settlement that had had very little outside influence.

#### 4.3.4.1 Oliver Tambo

At the time of the study approximately 3,500 people lived in 670 structures in the Oliver Tambo settlement (van Wyk, 2008). Some residents had settled on municipal land between the Mbekwini formal settlement and a road running parallel to the railway line, while others had occupied Spoornet-owned land across that road. In 2008, 13 'Absolute Ablutions Container Toilets' (AACT) and tapstands were installed on the municipality's side of the road, but only limited service infrastructure was provided for those living on the Spoornet land.

#### 4.3.4.2 Drommedaris

With 546 structures housing 3,200 people at the time of the study, Drommedaris was the second largest informal settlement in the Drakenstein municipal area (van Wyk, 2008). As in Oliver Tambo, Drommedaris was split into two, 70% of households being located on land alongside the railway line and 30% on municipal land abutting a sports ground. The settlement had been supplied with conventional waterborne sanitation systems servicing communal ablution blocks, most of them located on municipal land.

#### 4.3.4.3 Fairyland

Fairyland informal settlement was established in 1993. At the time of the study it comprised approximately 573 structures and 2,865 residents (van Wyk, 2008). The settlement was designed initially as an 'emergency camp' to provide temporary lodging for rural-urban migrants awaiting housing. It was thus somewhat different from Drakenstein's other informal settlements in that it was planned and supplied with basic infrastructure from the outset before any settlement had occurred. It was the only informal settlement in the area with communal washing areas, and an open drainage system had been laid alongside the streets to direct wastewater, including stormwater, to the local sewer.

#### 4.3.4.4 Simondium

At the time of the study, Simondium comprised 21 households with 84 inhabitants on 4,500 $m^2$ land (van Wyk, 2008). It abutted a graveyard and was surrounded on three sides by pre-cast walls built by the municipality. Six pit latrines were situated near the roadside entrance to the settlement alongside two standpipes supplying water to a washing-up area. These facilities were filthy during the course of field visits in March 2008. The washing-up area, being constantly blocked, appeared to pose a significant greywater problem.

## 4.4 Summary

This chapter has described the settlement selection process and gave an overview of the settlements for the research. Chapter 5 describes the various greywater management initiatives – irrespective of their initiators – and documents their relative success.

# 5. Greywater management

## 5.1 Introduction

This chapter commences with an overview of various low-cost greywater management options that were identified by the researchers at the outset of the research. It then describes greywater management interventions at, and findings from, each of the research sites. Since greywater management in poorly serviced settlements is inseparable from other services such as water supply, sanitation, stormwater drainage and solid waste removal, these are also described where appropriate. The chapter gives details of the water quality at Langrug. It gives an account of efforts to install low-cost greywater management devices at both Langrug and Waterworks and of residents' responses to them. It considers the contrasting path followed in Hangberg. Finally, it shows some outcomes of a more conventional approach to basic service delivery – including greywater management – by Drakenstein Municipality.

## 5.2 Low-cost greywater management options

It had been hoped that the ADMP would lead to the development of greywater management options that were appropriate to the particular circumstances of the settlement. As will be discussed shortly, this did not really materialise. In an attempt to 'kick-start' the research, the research team had, however, put together a list of potential low-cost greywater management options. They included:

1. 'French drains' i.e. utilizing a stone-filled trench to drain the greywater into the ground – with or without some pre-treatment
2. Filtration and drainage into the ground without utilizing a French drain (for confined areas)
3. Open drainage channels lined with low-grade concrete where necessary to reduce erosion
4. Improving the communal washing areas to better manage greywater disposal
5. Irrigating flowerbeds and/or fruit trees with the greywater (the greywater is too polluted to safely use for food production)
6. Treating the greywater in constructed wetlands

Owing to the various limitations of the study, only Options 1 and 2 were implemented by the research team. Various attempts had been made by the four municipalities covered by the study to provide greywater management solutions utilizing Options 3 and 4 – with varying degrees of success. Options 5 had been taken up by various individuals in the settlements but will not be discussed further as it seemed to have limited appeal owing to the crowded situation of many residents living in the informal settlements. Option 6 was theoretically possible, but given the challenges of time and space – as well as the issue of ongoing management – was not considered further.

Some of the variations on Options 1 and 2 that were developed and constructed by the research team are described below.

### 5.2.1 Crate and trench soakaway

The "crate and trench soakaway" (Figure 5.1), a type of French drain, was designed for locations where the soil was permeable and there was sufficient space between houses for their installation, e.g. a corridor of at least 4 m x 1 m. They were deliberately designed to be constructed of low cost materials. An upturned plastic milk crate with perforated sides and bottom was the greywater disposal point. It was covered with "shade-cloth" (i.e. the porous plastic cloth commonly used in plant nurseries) to prevent entry of food matter. The shade-cloth was held in place with stones laid flush with the surrounding ground level. The crate was located at one end of a trench of nominal dimensions; 3.5 m long by 0.75 m wide by 0.75 m deep. In most cases where these soakaways were installed in Langrug, the trench was lined along the bottom and sides with a polyethylene sheet secured to the crate using string or thin wire. The other end was left open. The trench was then filled with small stones (e.g. 19 mm crushed stone such as that used for road construction) and covered with infill from the hole. Reeds, ornamental flowers or rooted crops such as fruit trees or vegetables could be planted over the soakaway to aid in nutrient removal and promote evapotranspiration – although rough calculations showed that, at most, greywater loss through this mechanism would not exceed 10ℓ/day, dropping to a potential net gain on rainy days.

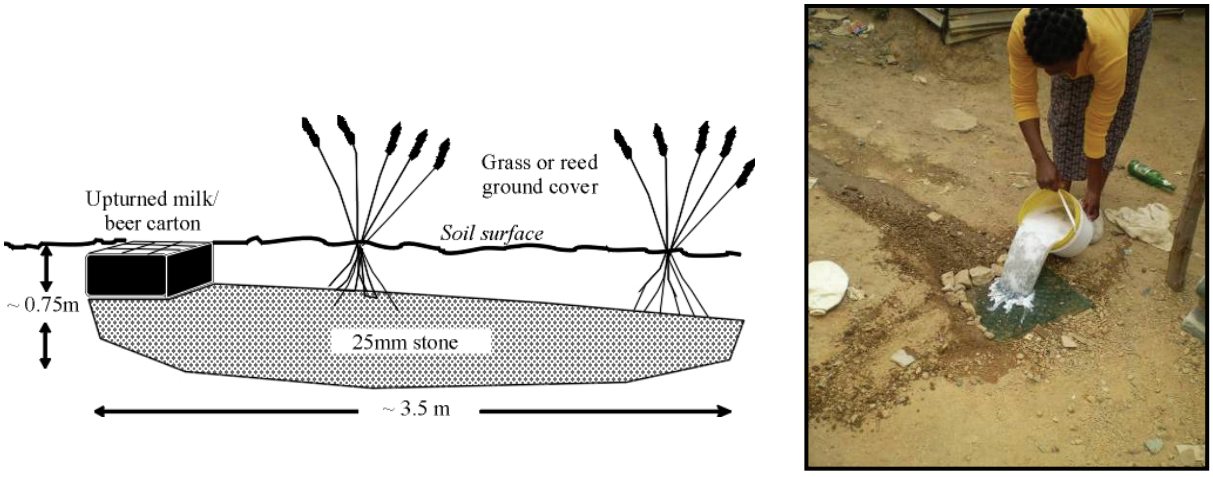



**Figure 5.1: Crate and trench soakaway** showing a long-section (left) and an example in Langrug (right) – without vegetation. Note the dry surface to the right (downstream) of the soakaway. The damp section on the left is from greywater disposal from higher up.

Introducing the lining reflected an attempt to reduce the impact of poor quality greywater on groundwater by providing an opportunity for some primary treatment through the stone and root matrix. The lining also acted as a geomembrane to reduce the migration of fines into the trench material. The porosity of the soakaway should have provided a detention period of

roughly two weeks of greywater generated by a typical dwelling. After this temporary storage, surplus greywater seeped out of the exit into the surrounding substrate.

The research team had anticipated at least four limitations to this greywater disposal option that would require further evaluation and modification:

- Clogging of the porous shade-cloth material by grease and fats
- Spillage resulting from the too rapid pouring of greywater into the grate-like entrance
- Plants being unable to grow in the high nutrient, alkaline conditions caused by the greywater
- Space between shacks being too limited for this type of device.

The fieldworkers soon discovered a further limitation; neighbours making use of the device and thereby overwhelming its capacity.

On one occasion, a washbasin replaced the crate inlet, but once again, the capacity of the drain was inadequate.

### 5.2.2 Drum filter

The drum filter was designed for situations where there was limited room between shacks and the soil was highly permeable. It comprised a 90ℓ plastic ‘drum” (a bin of the type commonly used for storing domestic refuse) sunk into the ground with only its lip above the surface (Figure 5.2). The bottom portion of the drum was filled with coarse sand, the central three-quarters was filled with coarse stone, whilst the top portion was left empty for the temporary storage of greywater. The bottom and sides of the lower portion of the drum were perforated so that filtered water could drain into the surrounding soil. The drum lid was also perforated before being turned upside down and fixed to the top of the drum to form a crude sieve that excluded gross solids whilst allowing the flow of greywater. The relatively small diameter of the holes was also intended to limit the escape of smells from decomposing organics and to reduce the likelihood of the drum becoming a breeding place for flies and mosquitoes. In some instances, the inverted lid was covered with shade-cloth to help remove oils, fats, grease and sludge and thereby to prevent them entering the drum. In one installation, a short length of PVC piping directed some filtered water into a small sealed bucket fitted with a single vertical pipe, for sampling purposes (Figure 5.3).

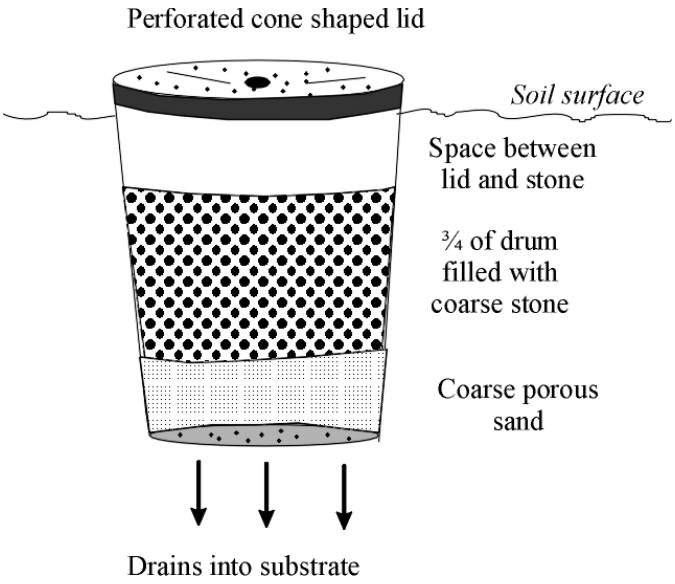



**Figure 5.2: Cross-section through a drum filter**

**Figure 5.3: Preparation of a drum filter with a sampling bucket**

## 5.3 Langrug, Franschhoek

### 5.3.1 Service levels in Langrug

During a visit in April 2008, researchers noted that of the 34 communal washbasins with taps, only 21 taps were working; similarly, of 74 flush toilets, only 31 were working. The areas surrounding the tapstands were constantly blocked for the duration of the study so unused water spilled over into the roads and pathways alongside, while some entered into the concrete-lined ditch to be discharged directly into the Franschhoek River. Water was provided free of charge by the municipality at these communal points. Residents generally collected water in buckets or 25 litre plastic containers, and then either carried it back to their homes (women and girls generally carried buckets on their heads) or it was loaded onto wheel barrows. Field observations revealed that many of the tapstands were persistently dysfunctional (Figure 5.4). In some places the standpipes had been broken wasting a constant flow of fresh water. Drains at public tapstands were generally blocked, forcing residents to collect water from perpetually flooded and overflowing areas. There being no formal provision for disposal of household water other than at communal facilities, most domestic wastewater was either tossed onto the roads or pathways, or directed through short lengths of pipe from dwellings onto the roadside or nearby pathways, and there formed informal furrows. Since solid waste collection skips (hoppers) were provided at only three locations in the settlement and often overflowed – they were supposedly cleared three times weekly, but frequent observation showed that did not occur (Figure 5.5) – much rubbish was strewn throughout the settlement and blocked the informal furrows causing local ponding. Making matters worse, dysfunctional toilets forced residents to urinate and/or defecate on any available open ground in or near the settlement. A consequence was that, even during extended dry periods, a mixture of black and greywater ran continuously down the streets,

between shacks, into residents' homes and, in one instance, through the playground of a local crèche. When it rained, stormwater exacerbated the problem.

**Figure 5.4: Women and young girls collect water at a public tapstand in Langrug** (Note the drainage structure is filled with water)

**Figure 5.5: Wastewater flowing down the central access road past a waste disposal skip**

### 5.3.2 Water quality measurements

As mentioned, severely contaminated surface water was observed to flow continuously down the main thoroughfares of Langrug. The runoff was a mixture of stormwater, greywater and blackwater, the latter emanating from leaking dysfunctional flush toilets (Figure 5.6) or from faecal matter from "bush toileting" conveyed by other types of flow. Large quantities of solid waste were also evident.

**Figure 5.6: Greywater and blackwater are discharged onto the bare ground in Langrug**

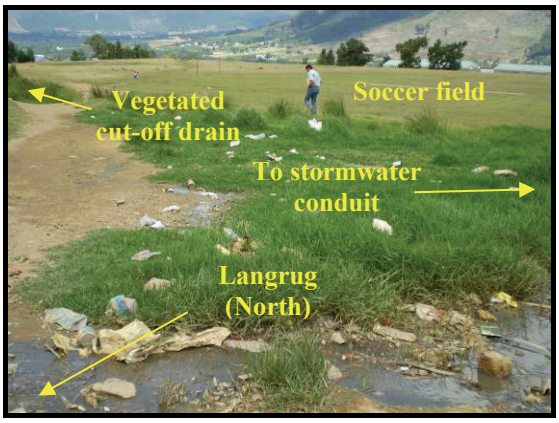


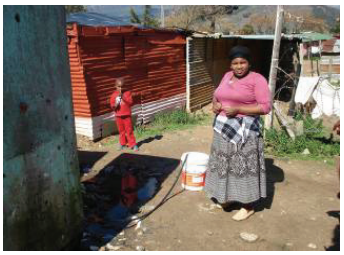

**Figure 5.7: Runoff paths around the soccer field at Langrug** (cut-off drain to the left, conduit to the right)

Much of this polluted water ended up in a vegetated cut-off drain situated along the northern (uphill) side of a soccer field to the south of the settlement. The lush green appearance of the grass on the field closest to the drain bore testimony to the continuous supply of nutrient rich water. The balance flowed into a stormwater conduit situated to the west of the field (Figure 5.7). This conduit forms part of the regional drainage system which ultimately discharges into the Franschhoek River, a tributary of the Berg River, thus contributing to the pollution of this important regional water resource.

Surface water samples collected from various points at Langrug on 6 September 2007 indicated high levels of pollution, with Sampling Point 3 having the highest loading of N, $PO_4$ and oils and grease (Table 5.1). Sampling Point 3 was approximately 80 m downhill from a dysfunctional ablution block comprising ten flush toilets and two laundry basins and, at the time, strewn with faeces and litter and partially inundated by water leaking from broken taps (Figure 5.8). All samples had *E. coli* values in excess of 1000 counts / 100 mℓ. According to the South African Water Quality Guidelines (DWAF, 1996), gastro-intestinal and other illnesses can be expected to rise when people are in contact with *E. coli* counts above 400 counts / 100 mℓ. The population of Langrug, including small children, are exposed to this level of pollution on a daily basis.

**Figure 5.8: Scenes from a dysfunctional communal wash and toilet centre in Langrug**

**Table 5.1: Water quality measurements at five Langrug collection points (samples collected Thursday 6 September 2007)**

| Sampling point | Water quality variable | | | | Photograph taken at collection point |
|---|---|---|---|---|---|
| | Total Kjeldahl Nitrogen (TKN) | Total Phosphorous (P) | Boron (B) | Oil and Grease | |
| **1** | 8.3 | 1.9 | <1.0 | 4 |  |
| **2** | 15.1 | 4.0 | <1.0 | <1 |  |
| **3** | 164 | 19.3 | <1.0 | 556 |  |
| **4** | 133 | 17.7 | <1.0 | 56 |  |
| **5** | 20.2 | 14.4 | <1.0 | 44 |  |

**Notes**: 1. Units are mg/ℓ throughout
2. All measurements of *E. coli* showed greater than 1000 counts per 100 mℓ

Between January 2005 and April 2008, DWAF (now the Department of Water and Environmental Affairs, DWEA) collected water samples bi-monthly from the Franschhoek River at a point approximately 15 m downstream of the outlet of the stormwater system and 50 m downstream of the confluence with the Stiebeuel River. Of the 57 *E. coli* samples collected during this period, most of them far exceeded the recommended levels for human contact – with only two less than 1000 counts / 100 mℓ. Admittedly, there were two pollution sources; apart from the stormwater outlet, there was also effluent from the Stiebeuel Wastewater Treatment Works (WWTW) that discharges into the Stiebeuel River. A biological assessment attempted to establish the impact of the two point sources of pollution. The findings concluded that there was a deterioration of the ecosystem, but the bigger impact might well have been the WWTW (Appendix A).

### 5.3.3 Greywater management interventions

At the outset, an intention of this project was to develop and test the efficacy of greywater management options through workshops to be held in the settlements with groups of residents brought together by street or block committees. It soon became evident however that this was naïve because the residents formed far less coherent groups than had been anticipated. At Langrug attempts were initially made to work through the local municipal councillor in an attempt to assemble people for such workshops, but these efforts proved unsuccessful; perhaps because the councillor seemed concerned that such meetings might, if not very carefully managed: *'contribute to an existing element of mistrust among residents towards the municipality'*. The councillor gave numerous reasons for postponing or cancelling various scheduled meetings with community members; usually on the eve of the agreed date.

**Figure 5.9: Problems with greywater initiatives at Langrug. Self-installed drainage pipe across road** with the inlet blocked by rubble pushed there by a municipal grader (left). Note broken pipes in background. Crate grid broken by municipal grader (right)

Some residents had made various attempts to manage their own greywater disposal. In one instance, a resident had installed plastic piping over a distance of approximately 50 m and had linked it to a self-installed wash basin in his yard. This drained greywater from his site to a nearby pathway. He seemed unaware of – or disinterested in – the consequences of such action. In another instance, neighbours had done something similar; sections of plastic piping linked to small metal grates were installed in each yard to channel wastewater into an informal furrow running alongside a nearby road. This simply transferred the greywater problem to a nearby public space and increased the rate of erosion of the furrow. When local government officials decided to re-grade that road, the furrow was closed up and some of the piping was broken (Figure 5.9). In yet another instance, a householder, who ran a small *shebeen* and planned to sell meat from his home, redirected wastewater that had been flowing toward his home by creating a small sump and laying some piping from there, under an adjacent road, to a point further downhill where it emptied into a roadside erosion furrow. This too did not last and broken sections of pipe had, from time to time, to be replaced.

Given that it proved very difficult to assemble groups of residents at Langrug and to offer them what would in any case probably have ended up being fairly abstract workshops about technical options, the fieldworkers chose rather to work with a small number of volunteers from the settlement. Various technological options were initially considered by the research team, and those that seemed most appropriate and viable in the particular context were discussed with the volunteers by the fieldworkers. The fieldworkers then helped install the chosen alternative.

Ideally the residents themselves should have undertaken the installation of the greywater management devices with the assistance of the fieldworkers. In practice, the fieldworkers did most of the work themselves with minimal assistance from the local residents – who largely chose simply to watch and ask questions. To a certain extent then the installation of the various devices became informal workshops in the form of practical demonstrations by the fieldworkers. The research team also took responsibility for the procurement of the materials with some assistance from a local government official from the Stellenbosch Municipality who provided a small truck load of stone on three occasions.

Two alternative options were chosen and installed at ten households throughout Langrug. The crate and trench soakaway option was the one initially selected by Langrug residents and seemed to be an immediate success, although in some instances the installations required minor modifications. All the installations were installed during the dry summer months without the complicating factor of rainfall to contend with.

The first resident to install a crate and trench soakaway was the *shebeen* owner, whose previous efforts to control greywater are described above. Since there was a concrete slab over most of his site, he chose a spot for the soakaway across the road running past his shack. The fieldworkers gathered stone from a nearby construction area, purchased building sand (that had to be sifted because of the proportion of fine material), and constructed the soakaway in a downhill orientation parallel to the road. A small perforated bucket with a short vertical sample pipe sticking out of it was placed at the exit of the soakaway to store water for testing purposes. Subsequently the *shebeen* owner planted grass over the trench. He

also suggested casting a concrete lip around the crate and a fashioned a lid to keep out stormwater, but this was not, however, implemented.

While the *shebeen* owner and his wife expressed satisfaction with the trench soakaway as an alternative to throwing greywater onto the ground surface (which they had complained was a health hazard), they also repeatedly insisted that the only real solution would be for each household to be linked to a sewerage system with its own tap and toilet, for which it could take responsibility. They nonetheless used the trench soakaway diligently for a couple of months. Over time, however, it took longer and longer to drain and eventually began both to stink and to overflow into the nearby roadside furrow. The fieldworkers therefore suggested building a second soakaway to which the owner agreed. This time, the fieldworkers constructed an unlined soakaway – assisted by some local children – along a contour. A perforated plastic pipe was laid from the inlet along the length of the trench through the stone to assist with the distribution of the greywater. It was linked to the crate by means of a funnel formed out of plastic sheeting. The further end was sealed off with a plastic bottle. Unlike with the previous installation, the goal this time was to encourage infiltration of the greywater into the surrounding soil over as large an area as possible.

This second installation thus provided the *shebeen* owner and his wife with two soakaways which the residents said they would use alternately; if one blocked up they would use the other. Soon thereafter, however, a municipal grader came in to "repair" the road and in the process destroyed both soakaways and filled in the erosion furrows alongside the road – resulting in greywater ponding on the road itself.

The *shebeen* owner also introduced the fieldwork team to various other residents who might be interested in installing soakaways, three of whom agreed. In each case, however, the installation was undertaken almost exclusively by the fieldworkers. In one instance there was insufficient space around the house site so it was installed, down-slope, on the edge of a public pathway alongside (Figure 5.1 right). This proved problematic: firstly because, being situated on public space, it soon came to be used by neighbours and overflowed, and secondly because the crate was damaged by people repeatedly stepping on it until it eventually collapsed into the ground. In this condition the soakaway was soon blocked by a mixture of sand and water from the pathway.

Another soakaway was installed outside the home of a nearby resident who wanted one for his own use. This soakaway was constructed along a contour. Unusually, in this instance, the fieldworkers were given some assistance by the resident. Unfortunately the soakaway soon began to overflow and was removed.

As with the *shebeen* owner, the resident insisted that the only real way to resolve the problems in the settlement relating to wastewater and sanitation was for a fully sewered flush toilet and a tap to be provided at each home where the residents could take direct responsibility. Nevertheless, the construction of the various soakaways attracted the attention of others, some of whom requested something similar for themselves. In one instance a resident sought and obtained permission from his neighbour living further up the hill to install a soakaway on her site because the greywater from her home and another alongside it had created a half-metre deep furrow alongside his site. Unfortunately, the plan soon came to

nought when the neighbour extended her house over the space where the soakaway would have been installed – an act suggesting that the drive to increase living space was greater than the perceived need to manage greywater runoff though means other than through regular sewers. In another instance, when a resident showed interest in installing a soakaway, it was agreed that the fieldworkers would obtain the materials and would demonstrate to him how to construct it whilst building another one elsewhere, but that he would have to build it himself. This resulted in an informal workshop when a group of people – mostly men – gathered around to see what the fieldwork team was doing whilst the two Xhosa-speaking fieldworkers answered questions and explained what and why the fieldworkers were doing.

In the course of research, the researchers discovered a small diameter pipe that was regularly discharging foul water onto a gravel road from a house some 50 m away. The occupant had installed the pipe, coupled it to an old wash basin and was using it as a makeshift drain. On being informed of the harm caused further downstream, the occupant readily agreed to alterations; opting to have the wash basin connected to a soakaway to be constructed parallel to the contours and adjacent to the basin (Figure 5.10). The soakaway's construction served as an informal workshop attended by a few neighbours who observed a trench being excavated and filled with stone. In an attempt to limit potential seepage into neighbouring properties, the trench was partially lined with 4 mm polyethylene sheeting onto which was laid 100 mm of 25 mm diameter coarse stone. A 50 mm diameter perforated pipe was placed onto the stone bed and more stone was placed around the pipe and over it to a depth of a further 100 mm. Finally, a thin sheet of porous polythene from an old fertilizer bag was placed over the stones to act as a geomembrane and covered in turn with some *in-situ* material. Initially the system met with some success, but the rate of greywater exfiltration proved inadequate and, after just six weeks, the occupant called the fieldworkers to inform them that the trench was full and smelt bad. Ultimately the installation was abandoned as there was insufficient space to enlarge it sufficiently to cater for the volumes that were being discarded into it.

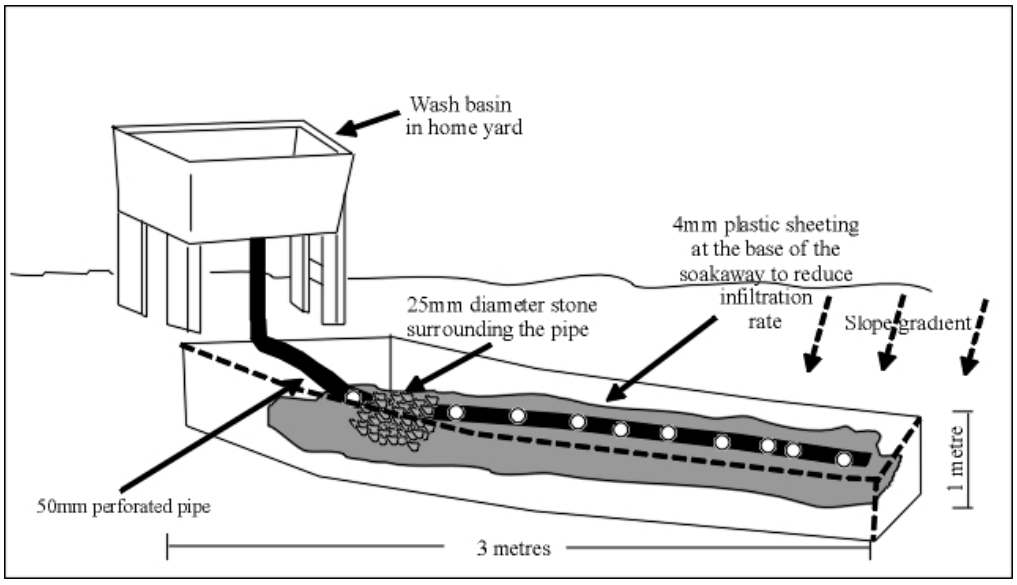



**Figure 5.10: Sketch of the washbasin connected to a soakaway**

### 5.3.4 Evaluation of the interventions

Although a few residents volunteered to have soakaways installed outside their homes, and some others showed sufficient interest in the research to leave their contact details with the fieldworkers, it proved impossible to arrange a formal workshop and no residents took the initiative to construct their own soakaways. The absence of any identifiable social structure in Langrug that the fieldworkers could work with was disconcerting. It meant that the researchers could only work with those individuals who expressed some interest. Most of the time, the fieldworkers did all the hard work whilst the beneficiaries did little more than watch and engage in some discussion. There was little evidence of the sort of behavioural change that might have led to the success of the soakaways – or the active engagement of the residents in the development of alternative methods of greywater management that might have been more appropriate. Eventually all the soakaways failed and were removed – three within a few weeks – and the experimentation was discontinued.

## 5.4 Waterworks, Grabouw

### 5.4.1 Service levels in Waterworks

As previously mentioned, the Grabouw Town Management claimed to have provided one tapstand per 25 families and one pit latrine per five families but, as in Langrug, they were poorly maintained, and fewer were found on the ground (Figure 5.11). In April 2008, fieldworkers observed only 7 functional tapstands; the rest were broken, leaking substantial quantities of water to create erosion channels and flooding through the settlement. The water to some of the tapstands was reticulated through 25 mm piping lying either on the ground or in very shallow trenches making them vulnerable to breakage or illegal connections. Only one tapstand had a formal drain for overflow.

Sanitation facilities were also limited and in a poor state. According to residents, they comprised ten flush toilets (in locked cubicles near the access road), and twelve Ventilated-Improved Pit (VIP) latrines elsewhere (two cubicles were locked, eight wired closed). Keys for locked cubicles were held by a limited number of households who thereby controlled access – despite the municipality regarding their actions as ‘illegal’. Whilst the flush toilets appeared in relatively good working order, their water supply and exterior sewage pipes tended to be poorly maintained or to have been repaired in an *ad hoc* manner. Municipal workers cleaned the flush toilets weekly, a keyholder opening the cubicle for them. During the fieldwork team’s numerous site visits, fewer than five VIPs were ever found operable at one time; most were filthy and blocked – filled with faeces and paper. Moreover, a sewer pipe conveying sewage from a neighbouring formal residential area higher up the hill frequently discharged raw sewage through the settlement via the lid of an inspection cover (Figure 5.12) and added to the general unsanitary and unhygienic conditions caused, as in Langrug, by streams and ponding of greywater and blackwater and by scattered litter.

**Figure 5.11: A typical tapstand in Waterworks with chemical toilets in the background**

**Figure 5.12: Raw sewage flowing through the settlement as a result of a blocked sewer**

### 5.4.2 Environmental concerns

At the time of the study, Waterworks residents generally disposed of their greywater by tossing it onto the nearest road or pathway, or onto the uninhabited areas alongside the settlement – which also served as informal rubbish dumps and/or toilets. Fortunately there were no water bodies in the vicinity of the settlement that might have been placed at immediate risk as a result of such practices. Polluted water either soaked away into the predominantly coarse sandy soil where it was discarded, or it flowed via erosion gulleys to pond at various low points throughout the settlement, there eventually to infiltrate into the soil. Much of it ended up in a large pool of highly contaminated water just outside the settlement. Only one attempt appeared to have been made by a resident to create their own drainage system. In this instance the resident had erected a concrete basin in the yard outside his shack and connected it to a drainage pipe, the other end being buried in the sand close by.

The generally unsanitary conditions were hugely exacerbated by the overflows from the sewer line. The sewage would flow through it for a distance of some 500 m before reaching the large contaminated pool previously described. When this was reported to the municipal engineer, he claimed to be unaware of the situation but agreed to look into the matter. Nevertheless, researchers continued to observe sewer overflows on at least three separate occasions.

Further details of the state of the settlement as at 18 January 2008 are to be found in Appendix B.

A household level survey was carried out in a bid to understand the conditions and experiences of residents. Adults from 57 households, fairly evenly distributed throughout Waterworks, were selected – sampling being based largely on the availability and willingness of adults to engage in a semi-structured interview. The gathered data included information such as: time spent by the respondent living in Waterworks; the number of people living in the household; employment, and an indication of income. Four open-ended questions focused attention on residents' experience of environmental conditions and health risks, namely; *'what problems do you have with wastewater?'; 'what do you do with wastewater?'; what problems do you have with litter?';* and *'what do you do for a toilet?'*. The questions were designed to encourage conversation between fieldworkers and respondents. It was conducted in the vernacular. Further details on the process and results of the survey have been published as part of a MA dissertation at the University of Cape Town (Kruger, 2009).

The survey revealed: a 4-year median residence in the settlement, with one person claiming to have lived there for 16 years; a median household occupancy of 3 with a maximum of 13; an average of 10 minutes (maximum of one hour) to fetch between 5 and 145 litres of water per day from a communal tap; and the main sources of income being child grants and agricultural seasonal work.

Responses to questions exploring environmental and health experiences and perceptions warrant greater discussion. Questions about problems of wastewater in the settlement generated responses that showed that over 50% of the 57 respondents were concerned that it poses a health threat, especially to children. Typical comments recorded by the fieldworkers included:

> *"Illness: coughing, asthma, runny tummies, children's rashes, genital infections".*
>
> *"Illness: tummy aches, rash, runny tummies, TB, asthma, sores. No place to dump wastewater so people get sick".*
>
> *"Bad odours with heat, children much more affected: throw up when they eat because of the offensive smells".*
>
> *"Everything gets thrown into the sink including vomit, pooh, night soil, porridge. Grease and oils collect in the sink. Difficult to control common facilities. It is smelly when it's hot and people urinate in the street – it's revolting".*
>
> *"The area where it is discarded is also used as a toilet and as a rubbish disposal site. This attracts foul odour and flies".*

People deliberately selected particular areas to discard wastewater, choosing spaces away from their shacks such as patches of open grass, roadsides, drains or on existing piles of refuse – thus demonstrating that they made strategic choices based on health and environmental concerns, out of concern for immediate neighbours, and to avoid social conflict. The following comments illustrate some of the strategies used by the residents:

*"Onto the ground"*. Reason: *"If onto street it can lead to conflict"*.

*"Alongside the house"*. Reason: *"No other place, onto street people complain about walking over dirty water"*.

*"By tap or near rubbish heap behind shop, not around houses"*. Reason: *"Municipality has disallowed throwing water around houses due to flies, also people complain"*.

*"Into pit latrines"*. Reason: *"People must walk on the ground and children play in the water"*.

*"On hillside 20-40 m from house"*. Reason: *"Can't just throw it between houses, especially where it is steep because it runs into other people's homes"*.

*"Bathing water just below house; kitchen water beyond fence 40-50 m away"*. Reason: *"To avoid smells, flies and mosquitoes"*.

*"About 30 m away at fence line"*. Reason: *"Anywhere else will attract flies which will cause tummy problems"*.

*"Roadside"*. Reason: *"It pools and is dirty if by the house. To avoid mosquitoes, for children's health"*.

*"Rocks behind house and in front of house"*. Reason: *"If it goes into the trench the children play in it and get sick"*.

Responses to a question about places people relieved themselves, were that over 70% used nearby bush or open space (100 m or more from the fence line of the settlement) whereas only 14% used one of the municipally maintained flush toilets (those who had keys to access these facilities) and the rest used the communal pit latrines. Some comments serve to indicate the severity of the situation:

*"Bush (flush toilets get locked)"*.

*"Bush but sometimes use flush toilets because sister has a key"*.

*"Over the hill or across the road, 100-200 m*".

*"Where rubbish is thrown, opposite house"*.

When asked about problems of litter and its management, people mostly offered one of three responses: 24% complained that litter was thrown indiscriminately around the settlement; 20% said that litter caused ill health affecting children in particular because they tended to play in it; and 18% complained that windblown litter created unpleasant conditions and a health hazard since human faeces were often on it. Selected responses outlined below suggest that residents attempted what they could to manage their solid waste and litter, but expressed concern that the local authority had failed to provide adequate services:

*"Thrown between houses: dirty, smelly and mosquitoes breeding. The tip is too far away and it gets full quickly"*. Action: *"Behind shops due to proximity"*.

*"Major issue: nowhere to throw it, decided in street committee to dispose of it in bush and not between houses".* Action: *"In the bushes".*

*"Wind blows the rubbish all over the place and into homes, some of which has human pooh on it. Nobody cleans the settlement".* Action: *"Collected in plastic bag and dumped in bush".*

*"The municipality neglects to clear the tip so people throw it all over the place. Dogs rip open bags and knock over bins so it goes everywhere".* Action: *"At tip".*

*"Tip no longer gets cleared by municipality. Kids play in and eat the rubbish and get sick with tummy problems".* Action: *"Takes it to tip in a bucket even though it is full".*

*"Causes germs, there is pooh where the rubbish is dumped right near the houses, bringing flies into the homes and onto the food".* Action: *"Collected in small can which is dumped behind the house".*

The various quoted responses vividly describe the state of health and environment at Waterworks at the time of the study. Moreover, they suggest that respondents did make some attempt to address their problems, albeit in the face of overwhelming circumstances. Residents were clearly aware of, and informed about, the risks associated with contaminated water, litter and unhealthy facilities, and many emphatically expressed disgust about the poor state of the environment, the conditions in which they lived, and the health risks, particularly as it affected children.

### 5.4.3 Greywater management interventions

As indicated earlier, the fieldworkers observed only one example of a locally constructed formal greywater disposal system prior to their arrival; that despite the household survey indicating that residents were aware of wastewater problems and had developed some limited coping mechanisms. It is also possible that the generally coarse sandy soils at Waterworks enabled relatively rapid wastewater infiltration so that it seemingly created a lesser problem than in Langrug with its finer grained soils. The research team nonetheless did meet with a street committee on several occasions and eventually gained agreement to explore the possibility of experimenting with a crude greywater filter.

Drum filters (Figure 5.2) were initially selected by the street committee as an appropriate option, having been told that such a filter might be useful in a dense settlement such as Waterworks where there is limited space between houses and where water passed through a simple filter can drain into sandy porous soils. One drum filter was installed in a public space between some shacks with the assistance of members of a local street committee, while two others were installed in the yards of two residents who volunteered to have their own.

As indicated, the first installation was in a public space, street committee members regarding such an arrangement as one that would provide a facility for a number of nearby

households. The fieldworkers purchased the drum, piping and shade cloth, gathered the sand and stone and carried out the installation while some local residents watched and commented. Unfortunately none offered any assistance. It was clear however, from a field visit soon thereafter, that the filter was being used. Then, two months later after Christmas, the fieldworkers visited and reported (January 2008):

> *"an unholy stench in the vicinity of the drum filter. Nearby the filter was a bag of guts which had been left there, the source of fetid smell… the filter we had put on the lid had deteriorated, and there were chicken feathers clogging it… a member of the street committee ... seemed very upset about the state of the filter, and said that her neighbours too were upset about it… people had been pouring their offal waste liquids into the communal drum filter ... [something] that would previously have been thrown in the veld, but 'it's far, so people are just throwing it in the filter. It's bringing many flies, and had been the source of many squabbles between people".*

Evidence of the failure of the installation combined with fact that residents and members of the street committee were unhappy with it, resulted in its removal by the fieldworkers. The clear lesson was that an installation with uncontrolled access was liable to abuse through the disposal of items unsuited for it. The street committee had also suggested another public space for installation of a drum filter but, in this instance, nearby residents resisted a public-access facility near their homes. As one said:

> *"if the bin were by a house, anybody would use it and put all sorts of things in it, and they could come in the night and put faeces in it, and then the nearby resident would be left with the problem. The stink and flies would come into your house, and it would be your problem".*

The resistance led to a street committee member and a resident insisting that the fieldworkers and street committee should together call a community meeting, so that all community members could contribute and have their say. The resident said that he thought most people would like the idea, but that it would not work if it were communal. He added that, were he to have it in a demarcated place near his home, he would call on five trusted friends to use and take responsibility for it. Such an installation could, he said, be closed at night to prevent others discarding things in it to avoid flies and smells at their own homes. Plans to install another public drum filter were therefore abandoned.

After the failure of the public installation, only two more drum filters were installed – this time for the intended exclusive use of individual households. The first was for a group of residents who, having seen the fieldworkers in the settlement and found out what they were doing there, volunteered to have a drum filter installed in a space alongside their shacks. Once again, all the work of acquiring the materials and constructing the system was undertaken by the fieldworkers. This time the perforations in the bottom and lower sides of the drum were made somewhat larger than those that had been drilled in the first drum in a bid to improve the exfiltration rate into the surrounding soil. Even with limited access,

however, the drainage capacity of the drum filter soon proved inadequate and within a month the drum was almost continually full. It too was consequently removed by the fieldworkers.

In the third installation, a drum filter was installed on the site of a local man living close to the site just described; although his first preference had been a trench soakaway of the Langrug design. In this case the inverted bin lid was not adequately perforated causing repeated splashing. The installation was thus used only briefly and, given the problems with the other two, the fieldworkers removed it rather than attempting to repair it.

The experiences with drum filters suggested their inappropriateness for the kinds of conditions in which they were installed. Most significantly, the experience showed that any kind of publicly accessible waste disposal system in the kinds of shack area that Waterworks exemplifies is liable to be overwhelmed by the number of people likely to use it, and to be used for waste other than the greywater for which was designed, as a consequence of the inadequate provision for waste disposal in general.

## 5.5 Hangberg, Hout Bay

### 5.5.1 Service levels in Hangberg

Unlike in Langrug and Waterworks, the fieldworkers did not attempt to install any greywater management systems in Hangberg, choosing rather to observe the process whereby the residents worked together with DAG and the City of Cape Town (CoCT) to an attempt to reach their stated goals.

In 2001 the then Cape Town Municipality installed 39 free standing communal flush toilets and 37 water standpipes, intending to service the approximately 400 households. By 2007 remarkably almost 37% of households surveyed had installed toilets for themselves inside their homes – illicitly connecting them to the limited simplified sewerage pipes serving the communal facilities. Most households (87%) claimed to have access to a flush toilet either within their own homes or belonging to friends, relatives or neighbours, although some used the communal toilets. About 10% of households used their own bucket toilets which they emptied at the edge of the settlement, whilst 1.5% used informal pit latrines.

A survey carried out as part of the study found that the mean adult period of residence in Hangberg Extension (the local description of the informal settlement alongside Hangberg itself) was 28.2 years with half the residents having lived there for more than 29 years and over 75% for more than 4 years. One respondent claimed to have lived there for 35 years. It also showed that the initiative to install waterborne toilets in individual homes (called bungalows in Hangberg) came largely from the residents themselves, and was generally accomplished with the help of neighbours, relatives or friends. Most (73%) reported that the toilet that they were using was in working condition. Some had informally connected individual houses to the settlement's water reticulation system: nearly 80% reported that their bungalows had a water connection, and most indicated that their household tap was in working order.

A total of 203 householders responded to a question about where they discharged their wastewater: 28% reported that they did so from the home via “a pipe”; 24% claimed to use it to irrigate the garden or grass; 10% flushed it down the toilet; 5% discarded it in “a channel”; and 25% said they threw it on open ground outside their home – three quarters of them explaining they did so because they had nowhere else to discard it. Other interesting responses included: 4% said they threw their greywater onto a particular area of open ground to clean their yard or for stabilising the sand or cement; 5% considered it hygienic to discard wastewater in a particular area; and 4% said that they discarded it in a particular place to keep it away from neighbours’ properties.

### 5.5.2 Quality of the surface water drainage in Hangberg

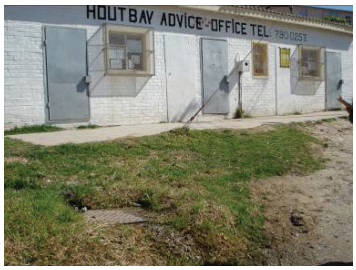
The impact on the settlement of the wastewater disposal practices identified above was a concern raised by the Hangberg in-situ Development Association (HiDA). The researchers were thus asked to collect and analyse water samples in and around the settlement. A number of water samples were drawn from three sites in the settlement where wastewater was observed flowing from various stormwater drains. A further site was selected at the outlet of drainpipe that was discharging wastewater onto the rocky beach and thence into the sea. The test results are presented in Table 5.2 and show unacceptable levels of *E. coli*, P and N.

### 5.5.3 Greywater management in Hangberg

Hangberg residents have had limited access to basic municipality-supplied services since 2001. Since then, as previously mentioned, many bungalow owners, considering the communal toilets were considered to be unhygienic, have installed toilets in their homes (HiDA, 2007) and connected them informally to the sewers in the settlement (Figure 5.13). Unlike Langrug and Waterworks, Hangberg’s residents managed to install these services with their own limited resources and without formal institutional help.

**Figure 5.13: A connection to the shallow sewer system**

**Table 5.2: Water quality test results from Hangberg** (7 September 2007)

| Sampling site | Water quality variable | | | Photograph taken at sampling site |
|---|---|---|---|---|
| | ***E. coli*** **(counts/100 mℓ)** | **Total Kjeldahl Nitrogen (TKN)** | **Total Phosphorous (P)** | |
| **1. Stormwater drain between council flat and easterly bungalow** | 1,000 | 3.0 | 3.4 |  |
| **2. Stormwater drainpipe discharging into main access road** | 600 | <0.15 | <0.10 |  |
| **3. Stormwater outside Advice Office** | >1,000 | 17.2 | 2.9 |  |
| **4. Outlet pipe discharging to sea** | >1,000 | 1.9 | 2.1 |  |

For many, however, greywater continued to be discarded either onto the ground where it was either absorbed into porous sandy soils or whence it flowed into the stormwater system of the neighbouring formal area. The HiDA and DAG therefore requested that greywater management should be included in the CoCT planned 2009 upgrade of the settlement which also included the addition of more toilets and tapstands; a request to which the CoCT acceded. Since Hangberg is a high density settlement, there is little space for on-site treatment, e.g. a wetland, and not much opportunity for the beneficial use of the greywater. The recommendation was therefore that all wastewater, including greywater, should be discharged into the municipal sewage system and treated at the Hout Bay WWTW. An extract of the proposed plan (Figure 5.14), generated by a researcher and later incorporated in the tender brief, shows the location of existing shack dwellings together with proposals for location of proposed greywater disposal pipes. GIS mapping and spatial analysis was used to quantify the total length of each proposed pipeline and to establish the drainage points so that no bungalow would be more than 5 metres from a communal toilet.

The contract to upgrade the sewerage in Hangberg was awarded in June 2009, but when the contractors attempted to commence work, the HiDA expressed anger that there had been no consultation with them by the contractor regarding the final location of the toilets (see letter of grievance from the Chairperson of the Association in Appendix D). The contractor then abandoned the job and, by the end of 2009, it remained uncertain whether the work would proceed.

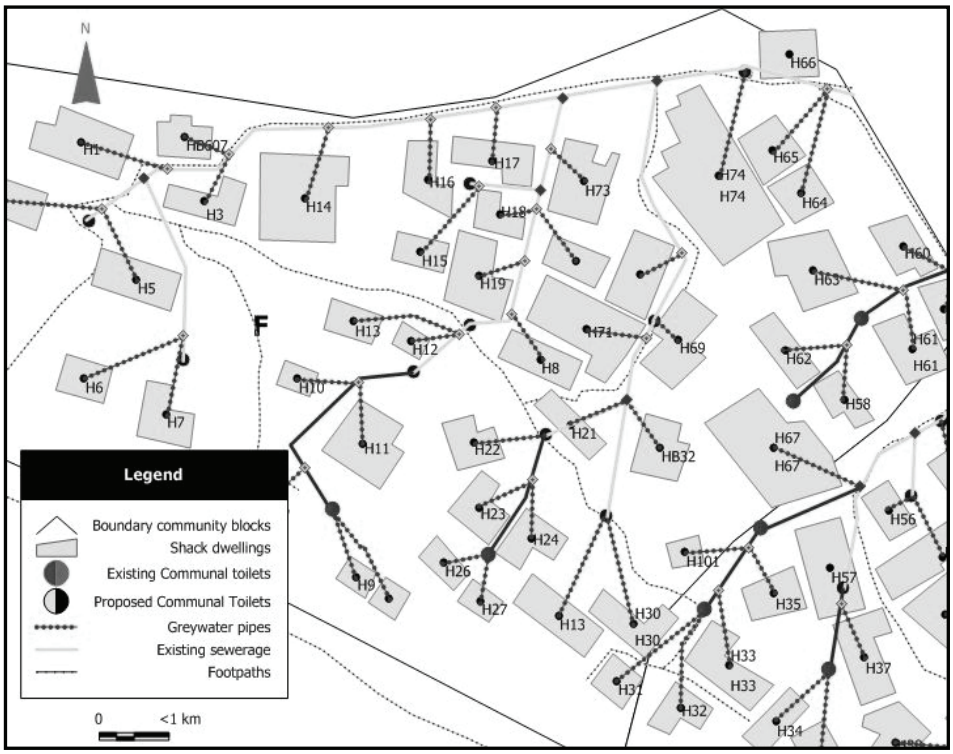



**Figure 5.14: Proposed greywater sewer plan**

A focus group discussion with members of the HiDA provided insight into how many residents had been able to provide water and sanitation services to their own homes. One participant attributed it to many residents having the financial means to afford the materials and, in some cases, to pay a plumber for installation. Another noted that some residents installed their own services because a toilet and bathroom was a means to gain local status, adding that those residents without such services were perceived as lacking ability to care for themselves. It was also said that the reason many households were able to install the services was because they helped each other. At least two members explained that the Hangberg community was 'one big family' where people help each other in the communal interest. They added that residents help each other because of their history as part of a fishing village that has been through tough times and where they have learnt to care for each other. Yet another participant suggested that the erstwhile strong sense of community was now faltering at Hangberg because of diverse social ills (e.g. drug and alcohol abuse) and loss of livelihoods (from subsistence fishing). He said that today residents help each other only because they expect either some form of payment or a return favour.

Considering the planned *in-situ* upgrade, the focus group's discussion led to one participant claiming that, prior to DAG's involvement, there had been a power struggle in the committee, but that this had changed with DAG's support and facilitation – precisely, he suggested, because DAG had involved them in everything to do with the upgrade process rather than imposing decisions on them. General agreement followed that, since the process was complex and challenging, facilitation from 'outside' agencies was necessary but that it needed to be participatory and that all decisions yet to be taken would have to be reached through a process of community participation.

The discussion demonstrated the importance, at least in participants' perspective, of mechanisms to ensure a process in which stakeholders co-operatively reach decisions necessarily, in this instance, with support from DAG as much as from the Municipality. The latter was evident when, in 2007, the City Mayor had visited the settlement, met the Civic Association and pledged support for the project; encouraging relevant municipal officials to accept the necessary responsibility to facilitate the upgrade. Subsequently local authority officials were instructed to notify all households listed on the most recent community register of their right to security of tenure.

## 5.6 Paarl informal settlements

### 5.6.1 Services provided by Drakenstein Municipality

In 2003 the Drakenstein Municipality began responding to numerous complaints from the Department of Water Affairs and the local Irrigation Board arising from the discharge of polluted stormwater into the Berg River originating from informal settlements in its area of jurisdiction. By mid-2004 the Municipality had launched a 'Provisions of Basic Services Project to Informal Settlements' programme. Consulting Engineers were commissioned to investigate potential modes of water, sanitation and greywater management. They concluded

that waterborne sanitation in the form of communal toilet blocks should be installed at all informal settlements in the municipal area.

**Figure 5.15: Cut-off trench in the river to divert polluted water to the WWTW**

**Figure 5.16: Stormwater diversion pipe in Drommedaris**

The municipality began with a short-term intervention before improving services. It excavated cut-off trenches at strategic points near most of the informal settlements situated in and around Paarl close to the Berg River to intercept polluted runoff during dry periods of low flow (Figures 5.15 and 5.16). In at least one instance the trench was across the bottom of an ephemeral stream. Sewer pump stations were installed to pump wastewater from the trenches to the local WWTW, thus reducing the volume of polluted water reaching the river.

Work in the informal settlements themselves commenced in December 2007 with the installation of communal toilet blocks, each cubicle being locked and its key allocated to a group of households. Tapstands were erected next to the toilet blocks; each comprising a standpipe discharging into a drain created within a standard pre-cast concrete ring. The designers' assumption was that, if people used the tapstands correctly, most greywater would be conveyed via the sewage system to the WWTW. Simultaneous with the installation of these amenities, information sessions were held to advise residents how to use the facilities and to raise awareness about health hazards associated with contaminated water. The work was deemed to have been completed only when each site had been raised to a 'point of satisfaction' that had to include an operational management plan to ensure that services were regularly maintained.

## 5.6.2 The four sampled settlements

### 5.6.2.1 Oliver Tambo

Oliver Tambo comprises two pieces of land on either side of a road separating municipal land alongside Mbekweni formal settlement and the railway line on Spoornet land. The settlement is densely populated: some 3,500 people live in 670 structures (van Wyk, 2008). In 2008

thirteen Absolute Ablutions Container Toilets (AACT) and standpipes were installed on the Mbekweni side, but only limited service infrastructure was provided for on the Spoornet land despite many requests from residents there. Those living closest to the road have better access to municipal services. Tapstands to a standard design were installed adjacent to the AACT communal sanitation centres (Figure 5.17) in a bid to improve hygiene after toilet usage, but the proximity of the standpipes to the toilets proved inconvenient for washing laundry and kitchen utensils, resulting in many residents carrying water to their homes and discarding greywater onto the ground at the nearest convenient point. Observations and interviews revealed however that those living close to these tapstands did their washing and discarded greywater there – or close by. They claimed they did so for one or both of two reasons: the tapstands provided the only nearby source of fresh water; and they offered a convenient place to discard greywater. It was noted that large volumes of greywater were being discarded on the ground around the tapstands in this manner – or directed into the nearby formal stormwater drainage system in the road – and also that the sewage system was regularly blocked. Meanwhile, residents living near the railway line usually discarded their waste – including faeces and greywater – on the open ground next to the line (Figure 5.18). They explained that they only went to the AACT centres to collect water – presumably because of the distance from the homes. It was thus unsurprising that the stream near the settlement was visibly polluted.

**Figure 5.17: Standard tapstand adjacent to AACT ablution block**

**Figure 5.18: Rubbish, faeces and greywater deposited next to railway line**

One long-term Oliver Tambo resident (he had lived there for seven years) estimated that he used 60 litres of water per day to clean his home and household utensils; double on laundry days. He explained that he collected water from the closest standpipe and could carry a maximum of two 20 litre buckets at a time to his home. He did all his cleaning and laundry on a small sand bank alongside a furrow running past his house, and discarded greywater from bathing and washing clothes and household utensils there (Figure 5.19).


**Figure 5.19: Examples of greywater disposal in Oliver Tambo settlement**

He also claimed that residents were insufficiently informed by the municipality before the AACT units were installed, saying he recalled just one brief meeting where the local ward councillor informed residents that toilets would be provided. He added that the AACTs needed more frequent servicing than was then the case because, he said, they regularly overflowed, depositing faeces on the ground. He also suggested that the nearby tapstands and drains also needed more frequent servicing than they were getting because of blockages which were responsible for the large volumes of water flowing down the furrow alongside his home. Furthermore, he expressed concern about the sewage pump station and the area near the stormwater drains, complaining that the pump station, installed in 2008, had actually exacerbated conditions because blockages caused sewage overflows that contaminated the surrounding area. This resulted, he said, in a health risk to the young children who played in the contaminated areas while their parents were at work. Finally, he claimed that residents were reluctant to work as a community:

> '*Nothing is happening…those days are gone and it is very odd or not common to see the community working together. Yes the community can act together but only if certain things happen…that is…if one's neighbours who also have the same problems as you…can be open and willing to discuss issues and stand together with regards to the situation with the toilets and standpipes, the polluted water flowing through the area etc. But this will need to be assisted from the outside* (by the Drakenstein Municipality). *Yes…some individuals do try to change the situation for themselves; for example I clean along the ditch in front of my house and I know of two other men who do the same.'*

What these data suggest is that, despite the interventions introduced by the Drakenstein Municipality, inadequate maintenance and a lack of suitable places to wash laundry and household utensils had continued to result in an unpleasant and unhygienic environment. Whilst the pump station clearly reduced flows of polluted water into the Berg River, frequent technical failures continued to create hazardous conditions for those living in its vicinity.

#### 5.6.2.2 Drommedaris

With some 546 structures housing 3,200 people at the time of the study, Drommedaris was the second largest informal settlement in the Drakenstein municipal area. As in Oliver Tambo, Drommedaris was split into two: 70% of the houses being located on Spoornet land alongside a railway line and 30% on municipal land adjacent to an enclosed sports ground serving Mbekweni formal settlement. According to residents, the sports ground caretaker had complained to the municipality that Drommedaris residents were discarding their greywater over the pre-cast wall surrounding the sports field. In 2006 the Ward Committee thus called a special meeting, inviting residents from both parts of the settlement to attend. The agreement reportedly reached there was that greywater should thence forward be discarded into kerbside stormwater drains in Drommedaris Road whence it would run into the stormwater system. Residents were reportedly discouraged from discarding greywater at tapstands without formal drainage, and those living on Spoornet land were asked not to use the land next to the railway line as a greywater and rubbish dumpsite. All were told to use the kerbside stormwater drains for their wastewater disposal. Observations and interviews revealed however that that resolution had led to a new set of problems, as related by one woman living on Spoornet land:

> *"Some people at first listened to the committee and began throwing the wastewater in the street by the drain…but not too long after that people began seeing other people dump all sorts of things there too…and now (pointing to the road) it looks like that…it cannot even be easily cleared because now everything goes down and water that gets thrown there, stays there"*

There was much evidence that the stormwater drains were indeed incapable of dealing with the waste being disposed into them along the kerbsides (Figure 5.20). Furthermore, the fact that greywater was being deposited into stormwater drains defeated the objective of trying to reduce polluted discharges into the Berg River.

**Figure 5.20: Blocked stormwater drain on Drommedaris Road**

Most people living on the municipal side of the road found it convenient to do their laundry and other washing at the tapstand where they drew water. Some, however, said that long queues often formed at standpipes, especially during weekends, and that residents had neither the time nor patience to walk back and forth to the road to dispose of their greywater, and so simply tossed it on the ground alongside where they did their laundry.

Streams of greywater were observed flowing from the tapstands (Figure 5.21) through the settlement, eroding foundations of structures, and collecting and stagnating in the low-lying area between the settlement and the railway embankment. One such stream that meandered through the settlement ended in a small wetland area filled with thick bush and reeds behind the settlement next to the railway line. Residents expressed unhappiness with the situation complaining that the wetland area had become a dumping ground where flies, mosquitoes and rats bred.

**Figure 5.21: Tapstands in Drommedaris showing poor drainage**

### 5.6.2.3 Fairyland

Fairyland was different from Drakenstein's other informal settlements in that the physical layout of the settlement had been planned and constructed before the first residents had built shacks there. As regards wastewater disposal, specially designed communal washing areas had been laid alongside the streets linked with drainage channels designed to direct all wastewater, including stormwater, to the local sewer. The tapstands along the settlement's gravel streets were also linked to these open channels. The wastewater was conveyed towards the back of the settlement where it passed through a specially designed structure (Figure 5.22) that diverted low flows – predominantly greywater – into the sewage system through two entrances that were screened to prevent entry of gross solids, whilst surplus water –

hopefully of relatively clean stormwater generated during rainy periods – bypassed the structure and was directed to the Berg River. Every Monday morning workers from the settlement, appointed on three month renewable contracts, cleaned the channel network and removed obstructions. They were also tasked to do this whenever residents or municipal monitors reported blockages.

**Figure 5.22: Structure diverting greywater to sewer in Fairyland**

**Figure 5.23: Original toilet and wash facilities in Fairyland**

There were two types of communal toilets and wash centres at Fairyland. Rows of single toilet units with free standing wash basins and taps aligned in a row opposite the toilets (Figure 5.23) had been installed initially, subsequently followed by AACT units in keeping with the municipality's 'Provisions of Basic Services Project to Informal Settlements' programme. Tapstands were located outside each toilet unit and surrounded by a concrete surface sloping towards a roadside wastewater channel (Figure 5.24). Each facility was fenced off to control access while single toilet cubicles were each allocated to five households, each supplied with a key.

Communal tapstands were also scattered around the settlement with standpipes mounted on a concrete base surrounded by kerbs on three sides and excess water flowing into roadside drainage channel from the open side (Figure 5.25). Four randomly selected residents, three women and one man, agreed to be interviewed with the help of an isiXhosa speaking interpreter. Two of the women had lived in Fairyland for more than 12 years while the other two respondents had lived in the settlement for approximately one year. All four claimed that they discarded their greywater into a channel close to their home or else alongside a communal standpipe if they had washed laundry there. Comments extracted from interviews and the fieldworker's observation reports all suggested that the drainage system at Fairyland was being utilised as planned having been accustomed as part of everyday life:

**Figure 5.24: Standpipe draining to a channel outside an AACT unit in Fairyland**

**Figure 5.25: Communal tapstand in Fairyland**

> *'I don't throw wastewater in the road because it looks bad and also adds to the bad fly and mosquito problem. I use the gutters [channels] because it is best and not because the local settlement committee requested (or expected) us to do so'.*
>
> *'All clothing gets taken to the standpipe, along with blankets and bedding, to be rinsed'.*
>
> *'It [discarding wastewater into a channel] is not only convenient but also the right thing to do'.*

Acceptance of the system was despite only minimal consultation with Fairyland residents having occurred prior to the infrastructure's installation. Selected extracts from interviews with at least two residents confirmed that very little consultation took place:

> *'The municipality didn't really consult much with the community…they* (the Drakenstein Municipality) *mainly came and supplied us with these facilities. When I first arrived 15 years ago there were no standpipes near my structure. A few years later this* (referring to a tapstand) *was installed and I was merely told that I could now share this new tap with others.'*
>
> *'The only thing I remember was being told by the municipality that temporary container toilets, which could flush, were being installed and that we would eventually receive houses…but no consultation about these facilities were discussed with us at any point in time. I arrived in 1996…about twelve years ago and most of the standpipes and toilets you see were already here at the time'.*

Nevertheless, respondents felt that the municipality's actions allowed for a relatively acceptable standard of living and conditions in Fairyland:

*'The Municipality workers regularly clean the streets and gutters [channels] in Fairyland. We do not have to wait long for broken taps to be fixed and I especially appreciate the fact that they also clean the pathways between our homes'.*

*'The Drakenstein Municipality has provided us with rubbish bins; they have organized regular cleaning projects and supplied us with more toilets in the form of container toilets. Before, the old toilets – and by this I mean the free standing cement toilets that you see in the front on the settlement as well as those on the sides – these toilets did not work properly and were always blocked. The new container toilets are more efficient and appear to work much better as they do not block as easily as the others … The toilet areas for the most part are well kept and regularly maintained and this is a huge improvement to the way things were before'.*

Blignaut (2008) claims that what he calls Fairyland's 'gutter' system had had a major positive impact on greywater management in the area, although he has also emphasized that it has required that the municipality continue to support cleaning projects in the area and to ensure that the system functions efficiently:

*'…the Drakenstein Housing Department has people cleaning Fairyland's gutters on a regular basis and, if the blockages are controlled … then most of the greywater will find its way into the sewage system via the drains at the back of the settlement… The greywater will then find its way to the sewage works where it will be treated and returned to the river as cleaner water.'*

In summary, residents appeared satisfied with the facilities and services being provided by the municipality. Most were content to use the standpipe, toilet and refuse facilities provided. Moreover, residents explained that their ability to share these facilities with others rested on their own, their neighbours and the municipality frequently keeping a 'good hand on it'.

#### 5.6.2.4 Simondium

The toilets and communal washing area in Simondium were found to be in a filthy state because of poor drainage, especially around the two standpipes which were mounted on a raised concrete ring and provided with a single gulley to drain wastewater via an almost constantly blocked drain into a conservancy tank ostensibly cleared once a month. The result was that excess water flowed onto the surrounding ground (Figure 5.26). Residents complained that the number of standpipes was insufficient and that the ones they had were defective. Both were fitted with crank handles that had to be rotated to get the water to flow. If the handle was cranked too fast, water was wasted (Figure 5.27); too slowly and it took ages to collect a bucketful. The six toilets used a Ventilated Improved Pit (VIP) dry sanitation system – installed because the settlement was far from any formal sewer system and far enough away from any streams not to be a threat.


**Figure 5.26: Poor drainage at the washing facilities in Simondium**

**Figure 5.27: Tap operated by a crank handle in Simondium**

In both interviews and a small focus group discussion, residents said that they wanted waterborne toilets, as well as basins and drains so they could do their cleaning and have better places to discard greywater, most of which was being deposited either on the ground near the standpipes or alongside their houses, some of which were extremely makeshift. They also said they wanted such facilities to be fenced off and locked to prevent passersby using and abusing them – which they claimed was occurring because the facilities were at the front of the settlement alongside a busy road. Further, they expressed concern over what they said had been 20 years of municipal neglect which, as previously mentioned, was probably a result of the settlement being on the border between two municipal areas and never clearly recognised as the responsibility of either. As one resident said, *'... I would have to say that the municipality is currently doing nothing for me and the area where I live because I haven't seen or heard them do anything.'* As Blignaut (2008) pointed out, Simondium had been excluded from Drakenstein Municipality's earlier policy and intervention plans – something that became very clear when the two junior municipal officials tasked with monitoring conditions in informal settlements (and who acted as fieldworker's assistants) looked surprised when informed that the settlement was within their area of jurisdiction.

Five Simondium residents participated in one-on-one interviews: two men and three women. All but one man had lived there for over 12 years; the exception had been there four years. Their explanations as to how they disposed of greywater included:

> *'All cleaning is done at my structure where I live, near bottom end of settlement. Greywater is thrown into the flower garden surrounding my home'.*
>
> *'My house is to the back of the settlement and is too far from the standpipe. I have to pay someone to fetch fresh water so that I can do my cleaning and washing at home. Greywater is thrown over the pre-cast wall near my house where most other people also thrown their greywater… I put it on my garden in the past but it died because it needed more fresh water, not greywater, and the standpipes were too far to go to collect water for a garden…'.*

*'Most of my cleaning and washing is done at my home which is at the bottom end of the settlement and is a long way from the toilets and standpipes with drainage facilities. ...greywater is thrown on the heap of rubbish a few meters away from my home'.*

In summary, greywater management in Simondium appeared to be failing largely because of regular blockages at the communal tapstands and/or because the septic tank often overflowed. With communal facilities limited to a single washing area with just two standpipes and six toilets alongside, residents near the facilities used them as washing areas, albeit that there was almost constant flooding; and those living toward the back of the settlement carried water to their homes and discarded wastewater by way of convenience either on the ground around their homes or by tossing it over a wall on three sides of the settlement.

## 5.7 Summary of conditions in case study areas

Table 5.3 summarises conditions in each of the case study settlements, particularly in respect of service provision, the existing greywater disposal practices, and the types of greywater management interventions that were trialled during the course of the research.

**Table 5.3: Summary of conditions at case study settlements**

| Detail | Settlement name | | |
|---|---|---|---|
| | **Langrug** | **Waterworks** | **Hangberg** |
| **Municipality** | **Stellenbosch** | **Theewaterskloof** | **City of Cape Town** |
| **Approximate population** | 5,000 | 3,000 | 1,500 (400 households) |
| **Surface drainage** | Mainly erosion gulleys to cut-off ditch and formal stormwater conduit | Mainly erosion gulleys draining to informal ponds. Formal stormwater system in road | Cut-off ditch to intercept runoff from the mountain. Otherwise erosion gulleys |
| **Water supply** | Communal tapstands – both single and at communal washing areas. Notionally connected to the sewer system but many blockages | Communal tapstands – mostly with no formal drainage. One connected to stormwater system | Communal tapstands with no formal drainage |
| **Sanitation** | Communal flush toilets but poorly maintained. Most residents use buckets and/or the "bush" | Limited number of flush toilets "commandeered" by individual households. Some VIPs – all dysfunctional. 70% of people use "bush" | A mixture of communal and private flush toilets connected to a shallow sewer system. Some use "bush" |
| **Washing facilities** | Communal laundry/scullery areas provided but generally poorly maintained | None formally provided | None formally provided. Some privately installed |
| **Greywater disposal/ impacts** | Disposed on ground; flows into Franschhoek River together with stormwater – and effectively blackwater | Disposed on ground; flows through settlement, drains into soil. Blocked sewers lead to overflows/pollution | Disposed on ground, into stormwater system and thence to the sea |
| **Interventions** | Crate and trench soakaway; Wash basin and soakaway both tried but unsuccessful and removed | Drum filters tried but unsuccessful and removed | *In-situ* upgrade process underway (water, sanitation and stormwater drainage) |
| **Comments** | Limited interest from individuals. No identifiable street committee. Negligible municipal involvement in greywater interventions | Limited interest from individuals. Minimal assistance from street committee and municipality | Driven by CoCT, DAG and HiDA. Many residents have installed their own in-house services (37% toilets, 79% water) |

**Table 5.3 (cont.): Summary of conditions at case study settlements**

| Details | Settlement name | | | |
|---|---|---|---|---|
| | **Oliver Tambo** | **Drommedaris** | **Fairyland** | **Simondium** |
| **Municipality** | **Drakenstein** | | | |
| **Approximate population** | 3,500 (670 households) | 3,200 (546 households) | 2,900 (573 households) | 84 (21 households) |
| **Surface drainage** | Mainly erosion gulleys | Mainly erosion gulleys. Informal wetland next to the railway line. Formal stormwater system in the road | Formal: base flow to sewerage; peak flow ultimately goes to Berg River | No formal drainage |
| **Water supply** | Communal tapstands. Those linked to AACT toilet blocks are connected to the sewer system. Otherwise no formal drainage | Communal tapstands. Those linked to AACT toilet blocks are connected to the sewer system. Otherwise no formal drainage | Communal tapstands draining to the sewer system; overflow to the river | Communal tapstands linked to conservancy tank |
| **Sanitation** | Communal AACT flush toilets | Communal AACT flush toilets | A mixture of communal flush toilet units | Pit latrines |
| **Washing facilities** | Residents expected to use tapstands at AACT blocks | Residents expected to use tapstands at AACT blocks | Communal washing areas draining through open channels to sewer system | Communal washing area next to tapstands |
| **Greywater disposal/ impacts** | Tapstands at AACT blocks drain to sewer. Otherwise disposed on ground and ultimately flows to Berg River causing pollution | Tapstands at AACT drain to sewer. Majority disposed into kerbside drains or on ground and ultimately flows to Berg River causing pollution | Formal: base flow to sewerage; peak flow ultimately goes to Berg River | Poor drainage and, blocked sewers, Conservancy tank pumped monthly; overflows occur |
| **Interventions** | 'Provision of Basic Services to Informal Settlements' programme – but not yet implemented in Simondium | | | |
| **Comments** | Municipality / consultants involved in upgrading of basic services; minimal public consultation | Municipality / consultants involved in upgrading of basic services; minimal public consultation | Well-planned settlement; municipality takes full responsibility for ongoing maintenance | Settlement ignored by Municipality owing to dispute regarding jurisdiction |

# 6. Discussion

## 6.1 Introduction

The study's intention was to develop and apply a participatory action research (PAR) process characterised by a collaborative approach in design, action and reflexive revision with a view to assisting residents in informal settlements improve their management of greywater. It had only very limited success. This chapter discusses some of the reasons for this; attributing it on the one hand to conditions in the respective settlements, and on the other to the very limited engagement by the respective local authorities, especially in Waterworks and Langrug. It concludes by evaluating the success of the study in addressing its original objectives.

## 6.2 Conditions in the settlements

In the two settlements where PAR was attempted, the fieldwork team failed to locate suitable local social structures, such as street committees or neighbourhood groups that were prepared to become involved in efforts to address greywater management problems. In Langrug, no street committee were identified, while in Waterworks the street committee's limited interest waned after the initial experiments failed. This meant that efforts to encourage sufficient numbers of residents to participate in creating and evaluating various alternative greywater management options were largely fruitless.

The study's experiments with greywater soakaways, as described in Chapter 5, were not particularly successful for two main reasons: local participants were generally unwilling to engage in further experimentation in a bid to make improvements (e.g. change the orientation of a soakaway; avoid discarding greywater generated all at once, limit access); and there were no local social or administrative structures that would support them. In effect the experiments in Langrug and Waterworks ended up being demonstrations by outsiders in the form of fieldworkers, with just passive support of local volunteers, rather than an authentic collaboration of a kind anticipated by a PAR approach. Such an approach does not and cannot work in this way, except in the sense that the demonstrations, if successful, might encourage residents to mobilise in order to replicate the intervention and thereby to achieve locally determined goals, possibly in continuing collaboration with outside agents.

In other words, the experiments with simple greywater management technologies failed because of the limited interest and participation by two key actors: the residents themselves and the local authority officials. The research team was thus forced to concede that, without that form of authentic participation, any attempt to promote collective management of greywater is likely doomed, no matter how good the technology – and the simple technologies used in this study were not particularly successful.

It became clear that local level collective co-operation and interest was very limited, especially as regards just greywater management concerns. People's priorities focused on concerns with access to an adequate and readily accessible water supply, individual toilets in their own homes, proper housing and electricity, as well as regular jobs, rather than greywater

disposal problems (Adams *et al.,* 2007). The research team's experience in Langrug and Waterworks has been such that one must conclude that the study's starting hypothesis, that a 'bottom-up' approach to managing greywater offers a more sustainable approach than a 'top down' one, is not supported by the evidence obtained in those two settlements. Indeed, it is arguable that such an approach is misplaced in such contexts or, at the most, is possible only when a series of specific conditions have been met. That is not to say that local people who stand to benefit from interventions to improve circumstances in their living environments should be excluded from decision making about such interventions. It is, rather, to make the point that it is misplaced to expect such people unilaterally to take on the tasks both of decision making and of driving the processes of service delivery – or to do so with minimal outsider encouragement or facilitation. The local authority's responsibility for service delivery is crucial and, even where an NGO or some other similar outside agency intervenes, such as in Hangberg, it can only be to the extent that it is able to mediate between residents in such a settlement and local authority officials.

The Hangberg case illustrates the kinds of conditions that are needed for local people to become involved with deciding about and implementing such interventions. Most importantly, that case is marked by a long-term and almost open-ended commitment to collaboration between an NGO (DAG) and a local-level organisational structure (Hangberg in situ Development Association, HiDA), the existence of which had itself been stimulated by the NGO's presence. The improvements in the settlement towards which that collaboration was designed to work were also far more all-encompassing than the greywater management concerns of the present research study – concerns which significantly limited the research team's focus in Langrug and Waterworks. As is indicated by its very name, the HiDA's brief was to seek means to improve or upgrade all conditions in the settlement, not just those concerned with greywater management: the plan represented in Figure 5.14 provides for management of both grey- and blackwater, and its disposal towards a standard municipally administered WWTW.

Yet, even in that instance, it became clear that the process was far from smooth. Once the HiDA committee had managed, with DAG's guidance and help, to engage the responsible local authority (CoCT) in providing infrastructural development and appoint a private contractor to implement the predetermined plan, the process began to falter. Indeed, by the time research had been completed, the process appeared to have stalled completely because the private contractor had, as seems all too often to occur, ridden roughshod over the concerns of residents as expressed by the Committee. Moreover, by that point DAG too had withdrawn its involvement, and it remains moot at the time of writing whether the Committee, having been empowered by the earlier process, will manage to find means to resolve the impasse. If it does, it will provide evidence that real collaborative participatory action can indeed work both for successful implementation of infrastructural development such as is needed for greywater management in high density informal settlements, and for enabling local-level administrative structures to grow in ways that they can sustain themselves by ensuring popular involvement in processes of service delivery and maintenance and by actively engaging with local authorities to achieve such goals.

The Hangberg case further exemplifies a finding of this study; that local authority (municipal) structures have to be actively involved in any process of infrastructural upgrading of informal settlements. Even with DAG's long term involvement as an NGO concerned to build social capital, it was the local authority, in the form of CoCT that had to provide the resources, including much of the technical and especially administrative expertise, to be able to deliver the kinds of services that were required. Indeed, the very fact that the CoCT had to commission a private contractor to undertake the technical work, thereby implementing the planned interventions, indicates that its agents recognised the limited capacity of the local population to implement such a project alone – that despite local residents' proven ability to create private ad-hoc grey- and blackwater management systems. Moreover, the CoCT's failure to monitor the process closely, once it had commissioned the private contractor, illustrates clearly how crucial the local authority's role is at all stages of such a process, including subsequent system management too – outsourcing seems inevitably to come with severe limitations.

The above shows that the present study's intentions to develop a participatory approach, in contrast to a more conventional 'top-down' approach where a local authority unilaterally designs and implements a wastewater management system, were not wholly misplaced. It also indicates, however, that setting up a neat dichotomy between 'bottom-up' and 'top-down' is counterproductive since, as the Hangberg case shows, continuing collaboration between 'top' and 'bottom' is necessary for achieving some degree of success – in that instance 'top-down' intervention was needed to ensure that those in positions of power (at the 'top') would develop the capacity (and the will) to 'listen to and hear' what the needs and priorities are of those at the 'bottom'. The Groot Drakenstein cases provide further evidence of precisely that – even though, in those instances, the greywater management system installed there had been implemented through a process that was driven primarily from the 'top' and down towards its beneficiaries on the ground.

As indicated in Chapter 5, the study's research in Groot Drakenstein focused on four different informal settlements administered by that municipality. As further indicated there, they were somewhat different from one another – differences that provide a useful means to understand the extent to which the municipality's 'top-down' interventions had worked (or not).

Simondium exemplifies a situation similar to that in both Langrug and Waterworks, albeit that it was minuscule by comparison and therefore very low on any municipal priority lists for service provision or upgrade. Moreover, it was not subjected to the kinds of alternative greywater technologies experimented with in those two settlements – and it seemed an inappropriate location to do so precisely because the population density was so small that the disposal of greywater onto nearby ground did not appear to constitute a major environmental hazard. Since Simondium constituted a settlement on invaded land where minimal services had been provided, the local authority's expectation was that residents would eventually be relocated to better serviced areas. Those expectations were based on Simondium being so small that the marginal costs of servicing it were very high, and on its

location on the border of the municipal area – the settlement had sometimes been treated as the responsibility of the neighbouring local authority.

Oliver Tambo and Drommedaris, by comparison, are large and very densely populated and, as shown in Chapter 5, wastewater discarded in those two settlements has indeed proved to be a significant environmental threat as they are located close to the Berg River – much as is the case for wastewater from Langrug into the Franschhoek River. In both Oliver Tambo and Drommedaris, the local authority had unilaterally installed both toilets and standpipes in terms of its own Provisions of Basic Services Project to Informal Settlements' programme, a programme that had included a set of professionally facilitated workshops with informal settlement residents to attempt (with only limited success, however – residents complained of inadequate consultation and no public participation) to advise residents how to use the facilities to best advantage. Given too that provision had been made for all wastewater entering the stormwater system from these areas, as elsewhere in the municipal area, to be pumped to the municipal WWTW – other than at peak flow times when overflows still drained into the Berg River – the facilitator was told to encourage residents to discard greywater into stormwater drains, and reports from the settlements were that most were doing that. Further, provision of locks and keys for AACT cubicles, and their allocation to particular housing units, meant that a sense of residents' propriety was established over both those facilities and over tapstands and stormwater outlets. In addition, municipal officials had been tasked to monitor and report on problems and, since there was also a relatively quick response from municipal technical departments, this meant that there was some sense of mediated cooperation between the local authority and settlement residents, even though the waste management system had been designed, introduced and installed in a 'top down' fashion.

The same applies to Fairyland where a 'top-down' approach was most obvious in that the settlement's water supply, toilet facilities and wastewater system had been designed and almost all installed before residents had occupied their sites and built their shacks – indeed, for the most part, Fairyland represented a serviced informal settlement, albeit with communal rather than individual on-site sewers or water supply services. The 'top-down' character of service provision notwithstanding, cooperation between the local authority and residents was more extensive in Fairyland than in Oliver Tambo or Drommedaris. Local residents there were employed, on a cyclical contract basis, to clear the precast channels running down each roadside, and thus to maintain their runoff capacity in order that they would drain into sewers taking wastewater to the WWTW (other than, again, in peak flow periods when overflow of primarily stormwater still ran through stormwater pipes and thence directly into the Berg River). Moreover, the same municipal monitors who oversaw Oliver Tambo's and Drommedaris's waste disposal processes were able almost immediately to mobilise the contracted Fairyland maintenance personnel. That was at least partly because those personnel were local residents who had assumed some responsibility for conditions in the settlement where they lived and whose work was clearly appreciated – as illustrated by the kinds of positive comments, recorded in Chapter 5, that Fairyland residents made about the efficacy of the system for them. That said, however, the maintenance personnel were not volunteers who simply undertook their work on the kind of self-help basis that is often assumed is possible in

PAR-driven projects. Having been selected from amongst applicants all of whom were Fairyland residents, they were paid for their services, the municipality ultimately footing the bill.

Just as Hangberg provides an example that demonstrates the crucial necessity of collaboration between local authority and informal settlement residents in efforts to address pressing environmental and health concerns such as wastewater and indeed solid waste management, so do Oliver Tambo, Drommedaris and most especially Fairyland – that despite Hangberg's process having taken a kind of mediated 'bottom-up' approach and those in the three Groot Drakenstein settlements a much more explicitly 'top-down' one. Moreover, the experiences of all four give the lie to any idea that adopting a purely 'bottom-up' approach to such challenges is feasible in the conditions of generalised poverty that characterise informal settlements. Rather, they show the necessity of abandoning thinking of the two approaches as if they were pragmatically (rather than ideologically) opposed to one another.

The concept of a 'bottom up' approach to managing greywater in non-sewered informal settlements was used in this study as a point of departure to examine the potential of community-level initiatives in an environment of limited support from agents such as local authority officials, elected councillors or NGOs. The study's findings demonstrate, however, that that is not workable and that impoverished residents of informal settlements have neither the capacity nor the resources unilaterally to install or maintain greywater management systems – nor indeed the motivation to do so when other priorities predominate. In its most literal form, a 'bottom up' approach implies that a grassroots 'community' can achieve its own shared goals by acting on its own with minimal outside intervention. Moreover it also implies the presence of strong local-level social and administrative structures and leadership that can drive such a process. However, as has been shown, that was lacking in all the study sites, with the possible exception of Hangberg, and even there the leadership structure and organisation seemed incapacitated once the NGO that had helped in its establishment had withdrawn and a private contractor had begun intervening without any regard for residents' concerns or wishes. Indeed, that contractor's behaviour reflected the kind of attitude that the research team found to be very common within local authorities with respect to informal settlement residents: 'they are ill-informed and it is we who know how best to address their problems.'

One of the most salient factors emerging from the case studies, and illustrated by the kind of statement cited above, is the gap between local authority officials and settlement residents in terms of their understanding of the situation. That such a gap exists is symptomatic of weak collaboration and co-operation between stakeholders (residents, municipal officials and elected officials alike) and an unwillingness – or inability – to address issues such as greywater management 'as though life depended on it'. The danger of not closing that attitudinal gap is that it leads to increasing polarisation. Such polarisation can in turn serve to widen the gap to a point where the kind of collaboration required to deliver adequate services with support from residents is difficult if not impossible to achieve. It is also a polarisation that is exacerbated by insistence on regarding a 'bottom up' approach as diametrically opposed to a 'top down' approach, rather than recognising the need for bridging

the gap between the two in ways that ensure that all stakeholders recognise the extent of their respective stakes and also of their respective responsibilities.

Both the HCES approach and the Bellagio principles (see Chapter 2) affirm that social engagement by the intended beneficiaries of development intervention projects in their implementation is critical; interventions must not only be socially acceptable but must achieve that acceptability through processes whereby people on the ground experience collaboration with local authority personnel as a `genuine commitment to partnership and empowerment' (DfID, 1998).

As WSSCC / Sandec (2000) have pointed out, closing the gap between extreme positions requires a vision in which human dignity, quality of life and environmental security at household level is central to service delivery – and, it should be added, where respect for such human dignity manifests in recognising local people as knowledgeable participants in all decision making processes. As EAWAG (2005) indicates, moreover, to realise such a vision in practice requires an integrated framework consisting of multi-sector planning (accounting for water supply, sanitation, storm drainage and solid waste management) and multi-actor participation (participation of all stakeholders, beginning at the household and neighbourhood scale), without which successful implementation of sustainable environmental sanitation components is unlikely to be achieved (EAWAG, 2005).

## 6.3 Improving governance

Unexpectedly, since the expectation of the study was that municipal officials would readily collaborate with the researchers, the issue of governance became one of this study's more important facets. That was largely because the 'state of governance' in the municipal areas in which the study took place greatly influenced its outcome. Local authority officials did very little at three of the study sites to support residents to resolve their greywater management problems. This is despite recommendations found in international literature since the 1980s where considerable attention has been given to the importance of local authorities for building capacity at a local level, and where the development of what Putnam (1993) has called social capital is regarded as essential for citizen action that can lead to local-level management and control over civic affairs. It is also despite the explicit intention in South African local governance legislation that such governance should have a strong participatory focus and process (Kruger, 2009).

According to Putnam (1993), social capital is a key attribute of social organization and one that is best identified in the form of social networks, norms and trust that together become instrumental in the facilitation of co-ordination and co-operation. In the context of this study, the development of social capital in the respective settlements and by the respective local authorities might have helped to establish and further the kind of partnerships that could have made a difference when it came to addressing service issues. Yet doing that was beyond the scope of the study – the researchers involved did not (and could not) constitute an NGO, particularly because of the limited time available to them. Moreover, the

respective local authority officials were technicians neither equipped nor with the time to facilitate such development of capital.

Following Putnam's critics, such as Lowndes and Wilson (2001) who have argued that he underestimates the significance of the government and state as agencies for effecting developmental change, it is necessary to stress the importance of local authorities using their capacity as (local) agents of the state to develop such social capital: if for no other reason – and there are many in informal settlement contexts – than to influence democratic performance in processes of ensuring adequate service delivery. That way social capital can be used to facilitate a two-way relationship between civil society and government. Such a relationship is one in which government can establish social capital and simultaneously effect its mobilization for forms of service delivery that are supported by public-private sector partnerships of a kind that Eales (2008) argues can overcome the challenges of providing viable, affordable services in informal settlement-type populations. Eales's argument is that that is because such partnerships have the potential to leverage the combined strengths of government, civil society and non-government organisations / service providers – something acknowledged at the World Summit on Sustainable Development in Johannesburg (UN, 2002) as a means of meeting goals of sustainable development, and specifically MDG water and sanitation targets This potential was also demonstrated in Hangberg, albeit that it seemed not to be sustainable once the NGO withdrew and the local authority left implementation in the hands of a commercial contractor..

### 6.3.1 An overview of circumstances and conditions

Evidence from both Langrug and Waterworks revealed municipal inattention, if not neglect and negligence, resulting in a public health hazard. In both instances the municipal neglect appeared to be a product of the fact that the settlements were on invaded land where neither residents nor the local authority had security of tenure, and that the municipal authorities anticipated that residents would be removed and re-settled elsewhere, or that the respective sites would eventually be upgraded formally.

The fieldwork team made concerted efforts in both settlements to find local representative committees or groups with which they might work and be able to mobilise residents to discuss low-cost technical options for greywater management. While they found evidence of at least one street committee existing and sometimes operating in Waterworks, they found almost nothing of that kind in Langrug – even though there was evidence that Langrug residents had in the past couple of years marched in an organized protest to the municipal offices in Franschhoek. Efforts to introduce greywater management technologies in Langrug ended up being focused on just the handful of individuals who showed interest.

While the Waterworks street committee seemed to be relatively successful in helping residents resolve minor local conflicts, it appeared unable to engage with local government officials, nor even to mobilise people in order to raise complaints. As a consequence, all installations of greywater technologies in Waterworks were undertaken through local, interested individuals. In their efforts to involve the Waterworks street committee in the study's activities, the fieldworkers began by seeking permission to attend street committee

meetings. They were invited to four such meetings, but always only to present their research plans. This meant that they gained little direct knowledge about the content and processes of these meetings. Conversations with individual street committee members on an *ad-hoc* basis did provide some insights and these included the following:

- The street-committee called a general meeting with other residents approximately once every six months.
- Street committee members had been elected at a gathering of residents where members were voted onto the committee by a show of hands.

The committee's own weekly gatherings were described by one member as 'not real committee meetings'. Rather, it was explained, they were gatherings to discuss and attempt to resolve squabbles between residents, interpersonal (including marital) conflicts, and domestic problems such as the consequences of alcohol abuse. The purpose of this, it was said, was to reconcile people so that they could live in peace with each other. Fieldworkers were also told that the function of the street committee was to make decisions on behalf of residents and convey these to a ward committee member who would represent them in ward committee meetings. However, it was further reported to the fieldworkers that the ward councillor himself was unsupportive of Waterworks' residents and disinterested in their concerns – he reportedly regarded them almost as antagonists because, he was alleged to have complained, they had not voted for him (Kruger, 2009).

According to one ward committee member, there was an executive committee on the street committee, with a chairperson, a vice-chairperson, and a secretary; that the street committee meetings did not follow an agenda; and that decisions were reached by talking out problems and issues that were raised, with all committee members gaining a chance to speak their minds. Such decisions were made in terms of a set of implicit rules that included, *in extremis*, the possibility of expelling an individual or household from the settlement, for example when someone had set fire to another house.

Importantly, for this study, no communal or municipal issues were ever discussed in a way that produced a result – primarily, the fieldworkers were told, because *'there is nothing the committee can do without assistance from the municipality, and the municipality does not listen. Sometimes we see problems with taps and toilets, and tell the municipality, but they still don't get fixed'*.

Reporting such problems was done by way of the committee nominating members to go to the municipal offices. These members reported, however, that they often found they were able to speak only to a secretary / receptionist, and were unable to meet with officials. They had decided not to make written reports *'because it takes a long time to get a response, so it is better to speak face to face with them'*. Issues were also reported to a ward committee member who represented Waterworks on the ward committee. When necessary, the street committee would request his attendance at street committee meetings, and it was his responsibility to communicate concerns to the ward councillor. He would also arrange meetings for street committee members with the town manager.

While one resident claimed that it was very difficult to see municipal officials in person, the fieldworkers did see street committee members at the municipal offices, and the town manager claimed that he had spoken personally to the street committee members about the issues they raised. There must, therefore, have been some degree of engagement between residents, committee members and municipal officials. Yet the extent to which concerns were addressed is questionable since simple observations over time revealed that conditions in the settlement remained consistently neglected to a greater or lesser degree.

In summary, the sense gained was that the Waterworks street committee's effectiveness was constrained by its focus on social dynamics internal to the settlement, by the interpersonal dynamics within the committee – both of which undermined its ability to influence municipal officials as regards the needs of settlement residents – and by the ward councillor's effective disinterest in their affairs.

There was even less sense of such formal organisational structure in Langrug. Instead, the fieldwork team found themselves being guided by one local personality – a *shebeen* owner with other entrepreneurial aspirations, who was particularly concerned about the effects of wastewater streams running alongside his site and disrupting his business operations. He was also very concerned about the general conditions in the settlement, and was especially helpful in enabling the fieldworkers to use a kind of 'snowball-sample' process to find individual householders who were willing to allow the team to install and test low-cost greywater devices on or near their own sites. At no stage did any of this result in the construction of any sustained network of interested persons, let alone of a solidifying group or community of interest. Moreover, the local ward councillor in whose constituency Langrug fell, while engaging with residents, seemed incapable of conveying their concerns to council in a manner that resulted in improvements in conditions. Indeed he expressed concern to the fieldworkers that their presence might result in residents mobilising protest action as had occurred previously – something he appeared to fear rather than see as an opportunity to construct workable public-private partnerships.

A synoptic impression of the socio-political context of these two settlements reveals a plethora of fragmented, fragile relationships between residents, locally elected councillors and local authority officials. Each of these three stakeholder groups appeared caught in an environment of frustration and mistrust of the others so that no one group was able to render an effective service as suggested is necessary for good local administration by the illustration in Figure 6.1. The diagram provides a perspective to explain why so little was being achieved by residents, councillors and local authority officials alike.

In Langrug the fieldworkers had little chance to interact with municipal officials, although some meetings were held with local project co-ordinators and some municipal officials. In one such meeting with the Franschhoek town manager, fieldworkers were told of housing plans for the area which, at that stage, involved building RDP houses in an area adjacent to Langrug. Yet apart from a school being built, no other progress was made during the research period. The town manager expressed interest in the research study's aims, but also indicated reluctance to commit any funding. As in the case of Waterworks, he and others repeatedly said that proposals for housing development were reason enough not to engage in

funding interim interventions. Yet it also became clear that housing plans for Langrug seemed even less advanced than those in Grabouw for Waterworks. Moreover, they were constrained by the limited capacity of existing bulk services, which at the time of research were entirely overburdened and were already leading to severe pollution of local rivers (see Chapter 5 and Appendix A). It was thus not feasible for new houses to be built and connected to the existing water and sewage systems. Apart from roads and electricity provision, there were no other clear plans and it appeared that Langrug's communal water and sanitation facilities would thus remain in varying states of neglect, at least until houses were built at a future (uncertain) date.

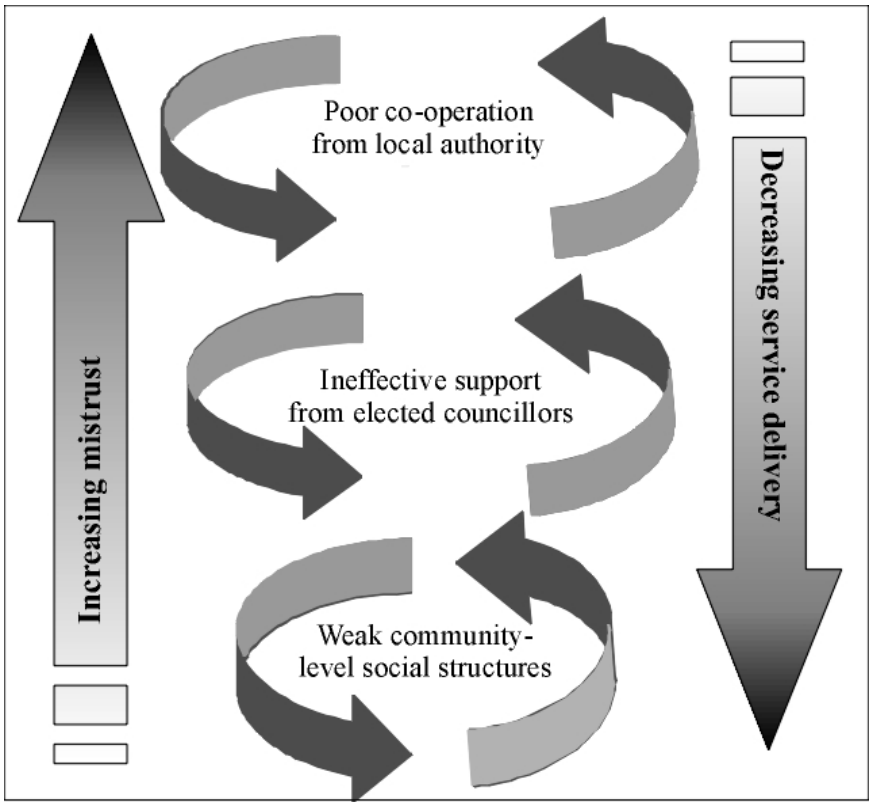



**Figure 6.1: Overview of poor stakeholder relationships that fuels mistrust and ineffective operations**

Although the socio-political context at Hangberg has been shown to be different from that of Langrug and Waterworks, it is apparent that a local Development Association there had been given a mandate and was clear about achieving the goal of an *in-situ* upgrade. Evidence from a focus group discussion shows that the project committee members recognised the support and facilitation offered by DAG. In addition DAG had assisted in bridging the gap between residents and elected councillors, and also involved the City Mayor, who in turn put pressure on municipal officials to deliver the upgrade process.

The picture contrasts sharply with that which was illustrated in the discussion of Waterworks and Langrug. The dimensions and spheres of influence between various

stakeholders now interlocked and in so doing became influential and powerful in achieving a collective understanding, as illustrated in Figure 6.2.

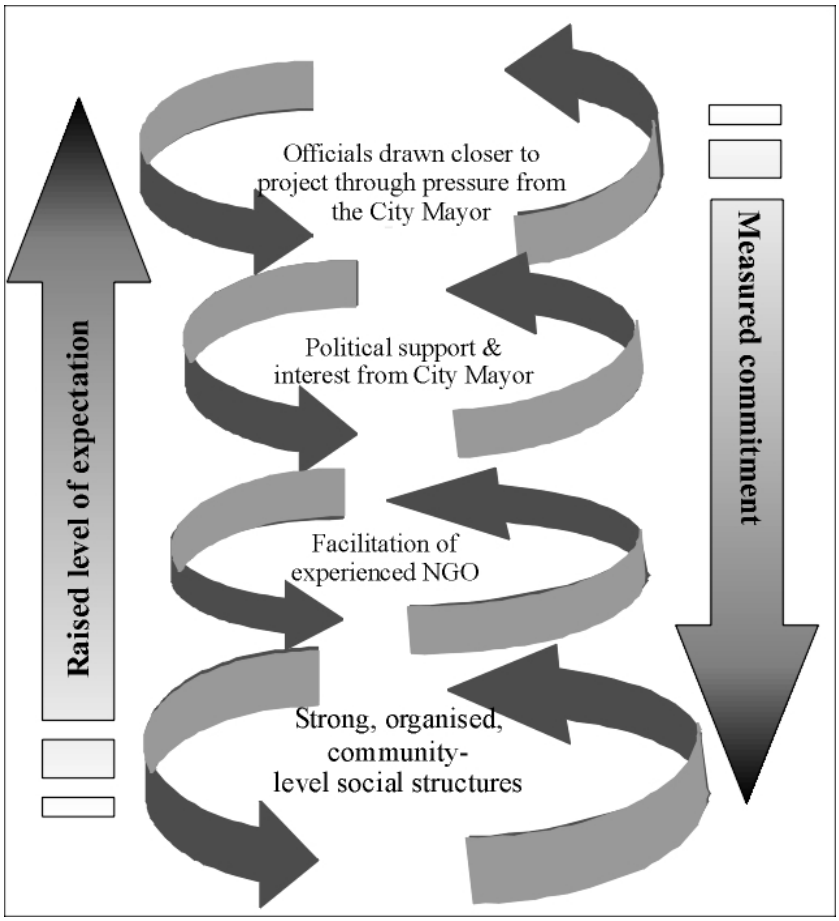



**Figure 6.2: Broad overview of the linkages formed by stakeholder relationships at Hangberg**

## 6.3.2 Assessment of initiatives

The initiatives described in the foregoing have shown that the interventions by the Drakenstein Municipality, more especially in the case of Fairyland settlement, achieved some measure of success. The intervention by CoCT in 2004 to construct a shallow sewer system at Hangberg presented an opportunity for the residents and, although unwittingly at the time, contributed to enabling many households to achieve their own success. Such actions represent a credible feat, but the overall management of the system is poor. Broken pipes frequently result in waste overflows which pose a potential risk to inhabitants.

In both cases these interventions were initiated by the local authority. By contrast, the interventions by the municipality in Waterworks had been minimal and it was probably naïve of the researchers to imagine that further support for this study would be forthcoming. After at least four meetings with the street committee, the research team went ahead, on the basis of support from the street committee, and began installing three drum filters. None of these

installations worked satisfactorily and residents were not keen to adapt the devices further to improve the design. Trench soakaways were offered to a number of individual residents and three householders agreed to install them. Workshops were held with groups of people, usually neighbours, during the process of installation, but even though stone was left nearby for residents to use for constructing their own drainage systems, to the researchers' best knowledge no one in the settlement took this any further. The situation in Langrug was similar. Ten soakaway drainage systems were installed, but subsequently no residents were found to have installed a similar system or to have been prepared to experiment with a different apparatus to manage their greywater.

The soakaways and crude filters that were trialled in households at Langrug and Waterworks proved to be largely ineffective, largely because of a combination of persistent overloading and the residents' wholly explicable unwillingness to experiment further with such devices – they saw it as the local authority's responsibility to provide greywater management systems. Indeed, what the research has shown was that residents were generally unwilling to install such systems on their own or to experiment with their performance. While it is conceivable that more could have been done to change this situation, it was difficult without adequate support from the local authorities that was not forthcoming. An important lesson to be learned therefore is that short-term research studies are ineffective as a means of initiating service delivery, however limited this might appear to be. At best researchers can monitor and report on the efficacy of such projects; they cannot be expected to, nor should they plan to, intervene technically or in a manner other than as possible advocates.

## 6.4 Achievement of the original study objectives

This study hypothesized that sustainable options for the management of greywater in non-sewered settlements were more likely to be achieved when local residents were involved in managing greywater themselves rather than when following a traditional or conventional approach in which the provision of rudimentary engineered services occurs with minimal consultation and involvement of residents who are the end users of these services. For reasons which have been made clear, this hypothesis was not supported by outcome of the study. To the contrary, it became clear that, whilst consultation with local residents would almost certainly lead to more sustainable service delivery, engagement by the local authority is the most critical aspect, without which there can be little expectation of success. With respect to the (amended) objectives, the study achieved the following:

**Objective 1**

*To identify the social challenges that could inform efforts to manage greywater and establish the reasons why previous initiatives to implement management systems were not sustainable in the long term.*

This was largely achieved.

**Objective 2**

*To identify specific socially salient environmental impacts resulting from greywater management practices in non-sewered areas.*

Although water quality samples were taken in Langrug and Hangberg, it became clear that environmental impacts resulting from non-sewered areas could not readily be separated from those associated with the surrounding areas and this line of investigation was discontinued.

**Objective 3**

*To establish specific links between the greywater quality (particularly in respect of the detergents used) and the potential for its beneficial use.*

This was not achieved. The impact of various detergents was never investigated owing to the fact that there is limited potential for reuse of greywater in the context of poorly serviced informal settlements, based on its variable quality.

**Objective 4**

*To identify ways of overcoming social and related obstacles in order to create sustainable management options relevant to local residents.*

This proved impossible in Langrug and Waterworks. It was achieved to a certain extent in Hangberg through the agency of an NGO – and then only after a long period of time.

**Objective 5**

*To identify ways of mitigating environmental impacts that had social purchase amongst settlement residents.*

Although considerable insight was gained into what was problematic, the key finding was that without the agency of the local authority it was very difficult for informal settlements to implement meaningful interventions.

**Objective 6**

*To trial selected interventions by conducting in-situ field experiments, and then to understand the preparedness of residents to manage greywater.*

Trials were carried out with a number of infiltration options – including the crate and trench soakaway and the drum filter – but these were largely unsuccessful. Although it could well be possible to improve the designs or to trial some of the other alternatives, e.g. some of those suggested in Section 5.2, the key obstacle to success was the lack of social organisation that would, for example, prevent the abuse of devices by neighbours. It was not possible to engender the requisite social organisation in the course of the project.

**Objective 7**

*To consult with individuals who had installed the various greywater management options, and modify the various options where necessary based on the new learning and experience.*

This was attempted, but with limited success.

## 6.5 Summary

The study clearly failed in its original purpose. This, however, does not mean it has not made a significant contribution to knowledge. The study went a long way towards bringing about an understanding of what is going wrong with service delivery – and not just greywater management – in informal settlements, and reveals some of the aspects that need to be addressed if there is to be a reasonable likelihood of success. The next chapter highlights the most significant conclusions arising out of the study.

# 7. Conclusions

The study found that Stellenbosch's and Theewaterskloof's municipal officials remain trapped by a vision of residents in Langrug and Waterworks respectively eventually being relocated to formal houses on paved street grids, with electricity, running water and formalised drainage, or of their settlements being almost instantaneously upgraded to meet those conditions. By hanging onto such a vision, and assuming it to be the only way to manage informal settlements, both municipalities have incapacitated themselves and their officials in terms of addressing immediate needs in informal settlements in their areas of jurisdiction. Moreover both were further incapacitated by inadequate financial resources to allow such a vision to be fulfilled and by budget prioritisation processes that tended to inhibit alleviation of immediate challenges. The result, from a greywater perspective, was a toxic mix of filthy water running through the informal settlements, creating severe public health threats and environmental degradation that had the potential, in the case of Langrug, to threaten commercial export agriculture. By contrast the Municipality of Drakenstein had taken a proactive approach to managing the same kind of crisis in informal areas in its area of jurisdiction. Its approach was to reduce the volume of contaminated water that had previously entered the Berg River by directing all wastewater from informal settlements – other than in times of peak stormwater discharges – into the municipal WWTW. The officials concerned had done so with minimal consultation with residents. The short term arrangements at most settlements sampled in the Drakenstein Municipality appeared to have been largely successful. Yet their sustainability depends heavily on the ownership of infrastructure and management of day to day operations by the municipality.

Persistent problems of poor drainage in informal settlements resulting in a direct impact on health and the environment are not new. Unfortunately, even when a drainage system does exist, it often conveys many forms of waste – including solid waste. The existence of a drainage system in itself does not guarantee improved conditions in an informal settlement. Local residents are frustrated at the slow rate of service delivery, which they blame on the municipality.

Recent literature in the field of development interventions has stressed the value of local users' experience and knowledge, and suggests that a greater emphasis be placed on social aspects of service delivery rather than on just the technical (DfID, 1998; WSSCC / Sandec, 2000). That has in turn led to calls for development projects to utilise participatory processes in their planning and implementation – a call that has been reflected in South African policy. Yet, while there is much talk about public participation in the Government decision-making processes, in practice this often involves little more than a hearing of residents' complaints and queries, a standard and abstract response from officials, and planning that is then carried out as if public participation had not actually been sought. Moreover, as one of the researchers on the study team has shown, the tensions between electoral processes, political party demands and the structures of municipal government are such that real participation is almost always a fantasy (Kruger, 2009).

It is obvious that the power relations are biased in favour of those who sit in offices and conduct high level decision-making for, and often also against, the immediate interests of,

those who must live with and utilise the products that derive from their decisions. In the case of the Drakenstein Municipality the officials have had some success largely because the municipality has chosen to invest time and money in finding a workable *modus operandi*.

Sociological studies highlight the emerging importance of relationships between state and civil society for dealing with social and environmental issues. Charley *et al*., (2001) justify constructs for establishing new forms of governance that pursue the ideal of 'sustainable cities', a new 'mental model' that would increase developmental networking between the state, civil society and the market. Using the case of a shantytown in Lagos, Järvelä & Rinne-Koistinen (2005) have shown that none of the state, the market-driven commercial sector, or civil society can alone solve the urgent environmental health problems in such an area, and that they need to find ways of coming together to work on mutually acceptable solutions. A similar case can be made for each of the case studies examined in this report.

One of the main objectives of this study was to deliver an on-the-ground product in the form of low-cost greywater management solutions that were also environmentally friendly, and to do so with the full collaboration and genuine co-operation of local residents during all phases of the process so as to provide opportunities for reflexive learning and modification of proposals. The process and results of this aspect of the study were disappointing to the extent that it can be concluded that PAR methodology is not going to deliver greywater management systems without adequate commitment from the local authorities who, after all, are tasked with service delivery. A further conclusion is that there is little scope for alternative service approaches or opportunity for community-based participation in technical options for greywater management in the informal settlements as they are presently constituted in South Africa.

While some experimentation with soakaways and other forms of crude filters was carried out in the field, the general reception from residents was lukewarm. A myriad explanations have been offered throughout this report to explain why that was so. They include: lack of support from local authority officials; disengaged councillors; residents having other more pressing priorities to attend to; and that the roles played by the researchers were insufficient for them to manage PAR. Nevertheless solace can be gathered from an improved understanding of what can be achieved in the short term and what is likely to be effective in addressing health and the environmental risks.

Another important finding of the study, supported by overwhelming evidence from observations, interviews and conversations with residents, is that local authorities remain critical agents of local level social change, and should increasingly be positioned and resourced so that they can build their own capacity alongside that which inheres in well-functioning, truly representative local social structures such as street and block committees. An associated finding is that a major part of that capacity building amongst officials themselves, as indicated in Chapter 6, must necessarily ensure closure or at least shrinkage of the gap in perspective between themselves and those they are meant to serve, such that they come to recognise that such people's experiences generate potentially useful insights and ideas that are outside of conventional bureaucratic thinking.

The research exercise's failure to help alleviate poverty and poor people's inhumane living conditions through attempting, by way of PAR, to introduce local greywater management systems using low-level technologies can be attributed to at least two factors. One is that that the devices that were installed turned out to be inappropriate in that they became dysfunctional in a matter of weeks. The other is because – as is illustrated diagrammatically in Figure 6.1 – 'on the ground' social structures in both the primary research sites were weak and lacked the capacity to mobilise people for anything other than very occasional incidents of public protest action, and then only when levels of duress had reached a peak. If the kinds of collaboration, co-operation, and mutual trust building between all stakeholders that underpins the ideas behind participatory governance are goals to be aimed for, then the lack of such structures in informal settlements serves primarily as a reminder that intense attention and effort is needed for developing the capacity of the users of greywater and sanitation technologies to manage both their use of those technologies and their relationships with officials in local authorities and in other tiers of government too.

An important conclusion of the present study, based as it was on an intention to use its research exercise, through PAR, to develop such capacity, is that such research exercises are inappropriate vehicles for affecting that kind of capacity building. At most they can be structured to collaborate with NGOs and/or local authorities who have initiated such a process and can report on its efficacy – both in terms of technical outcomes (in this case innovations in greywater management technologies) and in terms of social development outcomes and environmental protection. Moreover, even in those circumstances, as the Hangberg example shows, such processes need to be supported over a very long period of time, precisely because the socio-political constraints that have created the poverty that characterises informal settlements undermine their residents' livelihoods and capacity in a wide range of ways.

# 8. Guidance for greywater management

The following recommendations are based on the issues that arose at the three largely underserviced informal settlements in the Western Cape described in this study (Langrug, Waterworks and Hangberg). It is conceded that no generalizations can be made about other settlements in this province or elsewhere in the country. A 'photo-montage' of observed successes and failures in the management of water-related services in informal settlements is provided in Appendix D and E, and forms the basis of the establishment of guidelines for greywater management, below. Further research is required to add value to these recommendations.

- Sustainable greywater management is characterized by a reduction in the volume of surface wastewater flows and an increase in productive use and reuse of greywater; however, the potential for this reuse appears to be limited in the context of poorly serviced informal settlements. The overwhelming view is that the quality of greywater emanating from informal settlements is highly variable and it may be generally considered a danger to human health. Greywater management in areas without on-site waterborne sanitation must therefore be directed at disposal only, rather than considering it a resource that could be used productively.
- Greywater emanating from non-sewered settlements should be treated as a health hazard to be removed off-site as quickly and effectively as possible. If there are opportunities for treatment, e.g. in a wetland, these should be investigated for their potential contribution to environmental protection.
- Initiatives to manage greywater and the interventions that follow must be undertaken by local authorities as the primary agent of change, but this should be carried out in collaboration and co-operation with all stakeholders, particularly users (recipients) and NGOs working on their behalf, so as to achieve socially acceptable outcomes.
- Information exchange between, and capacity building of officials and informal settlement residents remain the strongest instruments of social change in the development of effective, long-term service delivery. This study has highlighted a number of examples in which residents showed willingness to take the initiative. However, such initiatives must be directed so that the consequences of their actions do not add to the risks of others.
- Investment in the short to medium term needs to focus primarily on improving the health of residents of low-income urban settlements and the receiving environment. This is dependent on improvements in water supply, sanitation and surface drainage, as well as greywater management. Examples such as the shallow sewer system, discussed earlier with reference to Hangberg, Hout Bay, have improved conditions in households significantly. In addition, a well managed communal toilet system with bathroom, washing and laundry facilities (as partially implemented by the Drakenstein Municipality) is an essential service that results in improved standards of hygiene and human productivity.

- The development of definitive health regulations / guidelines for the disposal of greywater in South Africa is critical in view of the negative impacts resulting from indiscriminate greywater disposal practices in poorly-serviced settlements throughout the country.
- Whilst the study itself did not provide direct evidence of the institutional 'blockages' responsible for the inattention and lack of services to the poor who live in conditions that extend barely beyond basic human survival, it appeared that there might well be a need for institutional transformation, without which service implementation will remain limited. *Inter alia*, institutional transformation must be prepared to engage with civil society as the critical site and agent for economic and social development (Oldfield & Stokke, 2006; Kruger 2009).
- There are various drivers which could potentially force greywater management interventions in settlements without on-site waterborne sanitation through behavioural changes at the local authority level. The main factors determining greywater management – or the lack thereof – in the study settlements at present, are environmental (e.g. the potential refusal by the European Union to buy produce irrigated with polluted water from the Franschhoek River), financial (the local authorities did not always appear to have the financial resources to provide adequate services), technical capacity (or lack thereof) and social (local authorities need to engage with their residents).
- Greywater is a sanitation issue – successful management interventions are more likely to occur when they are part of an integrated service delivery package, including water supply, sanitation, drainage, solid waste disposal and hygiene. In addition, increases in water quantity and improvements in surface drainage will likely result in improvements in greywater management and human health.

# 9. Recommendations for further study

This study has identified a number of questions and concerns that warrant further research:

- What are the institutional factors that undermine effective water, sanitation, solid waste disposal and related service delivery in South African informal settlements?
- What are the social dynamics in informal settlements that contribute to low levels of participation in, and high levels of resistance to, community-level engagement with respect to service delivery planning and implementation? How does this relate to issues such as land entitlement and/or land tenure?
- How is the behaviour of residents of informal settlements regarding water and sanitation services conditioned by circumstances within their respective settlements and how does it relate to (and how might it be mobilised for) extending the provision of communal basic services so that they might be incrementally upgraded as resources permit?
- Under what conditions and how might informal settlement residents develop a sense of ownership of, and willingness and to take responsibility for, those parts of the service infrastructure in their settlements that are conventionally privately maintained by suburban residential site owners?
- What combinations of social, financial and technical (including environmental) requirements are necessary to implement, operate and maintain functional basic water, sanitation and related services in informal settlements, and how do changes in those combinations affect service provision and especially maintenance outcomes?
- Is it feasible to capacitate municipal officials to include, as part of their roles, a requirement that they develop governance capacity amongst residents of informal settlements and, if so, how might that be effected?
- Further assess / qualify what influences changes in the quality of greywater over time within settlements as well as differences in the quality of greywater from settlement to settlement.
- Are there Southern African examples of communal sanitation that are proving successful and, if so, under what conditions and how might these be rolled out elsewhere?
- If greywater management is necessarily a component of more general programmes to improve basic service delivery to informal settlements, what is required institutionally to ensure its integration into such programmes, and how might such programmes be structured to ensure that integration?

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# Appendix A

## Chemical and biological assessment of the Stiebeuel River, Franschhoek

Between January 2005 and April 2008, DWAF (now the Department of Water and Environmental Affairs, DWEA) collected water samples on a bi-monthly basis in the Franschhoek River at a site approximately 15 m downstream of the main stormwater outlet (from the urban areas of Groendal and Langrug) and a short distance downstream of the confluence with the Stiebeuel River. Figure A.1 presents 57 *E. coli* sample counts – most of them exceeding by far the recommended levels for human contact (1,000 cfu/100 ml), according to the South African Water Quality Guidelines (DWAF, 1996). Gastro-intestinal illness, among others, can be expected to rise when in contact with *E. coli* counts above 400 cfu/100 ml. Only two samples were less than 1,000/100 ml.

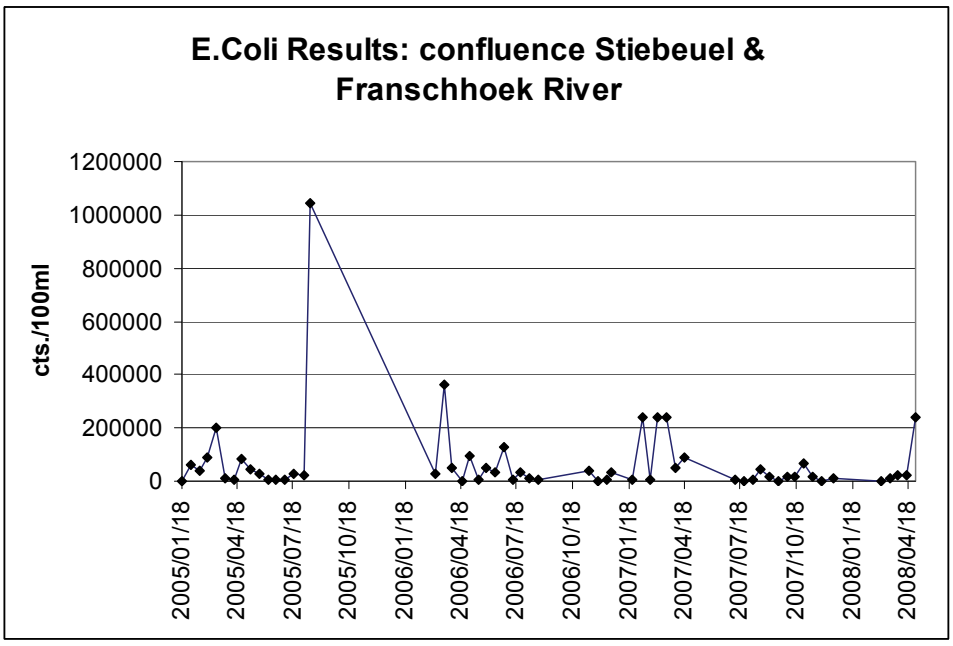



**Figure A.1: *E. coli* measurements at the confluence of the Stiebeuel and Franschhoek Rivers (DWAF, 2008)**

Two point sources of pollution are found in the vicinity of this site, the 'stormwater' pipe largely responsible for draining surface runoff from Langrug and the surrounding urban area of Groendal, and the Stiebeuel Wastewater Treatment Works (WWTW) that treats sewage from Franschhoek. The WWTW discharges its effluent into the Stiebeuel River which in turn discharges into the Franschhoek River some 50 m upstream of the stormwater outlet. Field measurements taken at the point of discharge of the stormwater outlet pipe on 14 May 2008 indicated *E. coli* counts of greater than 1800 counts/100 ml and $PO_4$ exceeding 5 mg/l (the maximum range of the HACH field water testing kit device used). On the other hand, measurements of samples from the river immediately upstream of the Stiebeuel River

confluence showed no presence of $PO_4$ or $NH_3$, while *E. coli* was less than 40 counts/100 ml. This suggests that the WWTW may well be the greatest contribution of pollution to the Franschhoek River.

To verify the sources of pollution, a biological assessment of the affected stretch of the Franschhoek River was carried out using diatoms as an indicator of ecological conditions at selected sites along the stretch. Diatom analysis is a well-established science that can be used, usually in conjunction with other monitoring measures, to infer water quality since these species are sensitive to changes in the chemical and physical conditions of the environment. Diatom communities typically range from opportunistic tolerant species in areas of severe pollution, giving way to less tolerant and more competitively dominant species at the most distant location from the pollution source (Harding *et al.*, 2005). Grab samples were collected by researchers on 1 July 2008 and again on 7 September 2008. Six discreet sites were selected for assessment (Figure A.2).

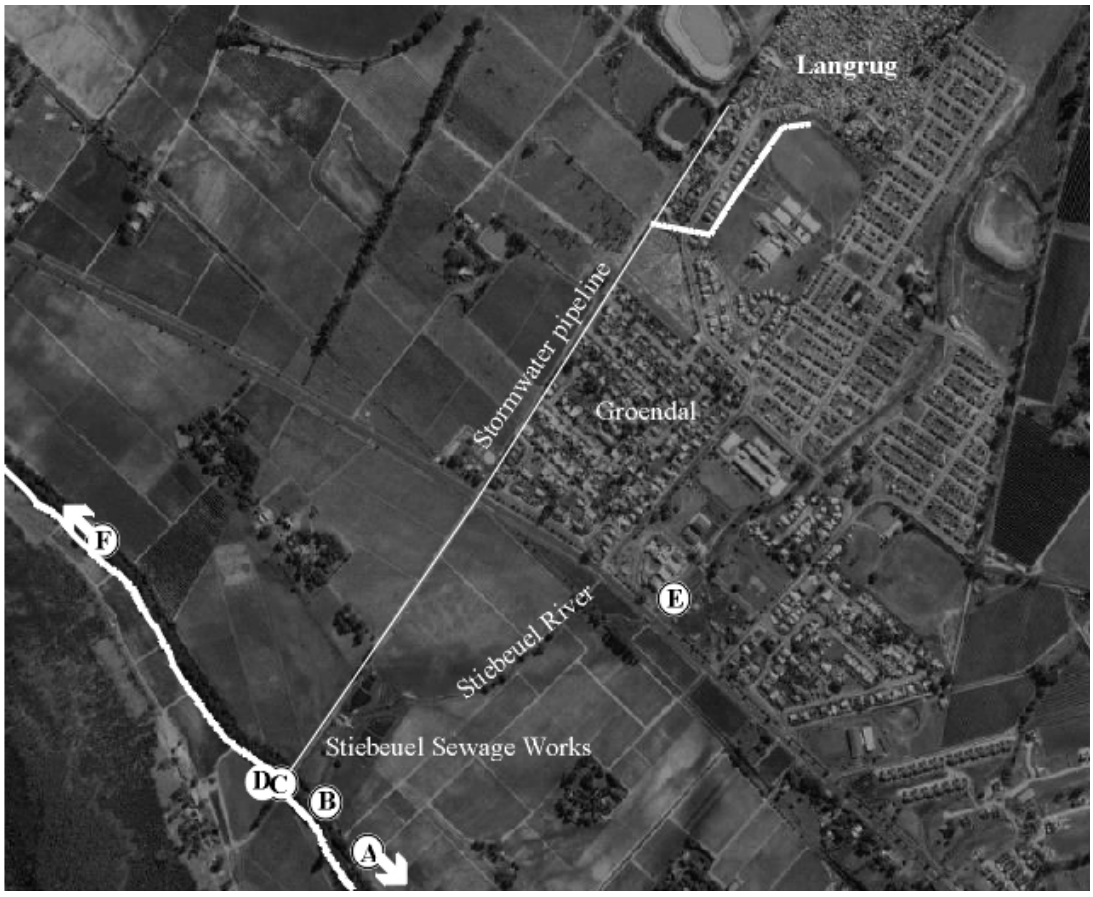



**Figure A.2: Google Earth image showing the location of six study points along the Franschhoek and Stiebeuel Rivers**

Site (A) was located approximately 50 m upstream from the confluence of the Stiebeuel and Franschhoek rivers. Site B was located where the Stiebeuel River discharges into the Franschhoek River together with the discharge of treated water from the Franschhoek WWTW. Site C was located at the mouth of the stormwater pipe that receives inflows from Langrug and surrounding urban area. Site D was located on the bank opposite site C. A further sample was taken upstream of the Stiebeuel River to act as a control (Site E). The

final site was located close to the confluence of the Franschhoek and Berg rivers, downstream of the various point sources of discharge (Site F). See Tables A.1 and A.2 for details of physical and chemical conditions at the sites. All samples were collected from the substratum at a depth of less than 0.5 m (Figure A.3) and therefore fell within the euphotic zone as light is a fundamental requirement for benthic algae to photosynthesise.

**Table A.1: Physical characteristics of study sites**

| Site | Width (m) | Depth (cm) | Water clarity | Shading | Co-ordinates |
|---|---|---|---|---|---|
| A | 9.5 | 40.5 | cloudy | broken | 33`89970S; 19`09336E |
| B | 2 | 20.1 | cloudy | none | 33`89934S; 19`09365E |
| C | 7.5 | 45 | cloudy | broken | 33`89912S; 19`09310E |
| D | 7.5 | 45 | cloudy | broken | 33`89912S; 19`09310E |
| E | ~ | ~ | clear | none | 33`89624S; 19`10066E |
| F | ~ | ~ | clear | none | 33`882545; 19`04767E |

**Table A.2: Chemical conditions measured in the Franschhoek River (7 September 2008)**

| Site | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Ph | 6.9 | 7.2 | 7.1 | 7.2 | 7.3 | 7.3 |
| Temperature | 15.5 | 17 | 16 | 16 | 18 | 18 |
| DO (mg/L) | 28 | 29 | 27 | 28 | 40 | 27 |
| Phosphate (mg/L) | 0 | 2 | 0 | 1 | 0 | 0 |

**Figure A.3: Researchers collecting samples – diatoms from underneath a small rock at Site B (left); and water samples for chemical analysis at site A (right)**

Diatoms were prepared for display on microscope slides and then observed using a Zeiss light microscope at 1000x magnification under oil immersion. Diatom assemblages were identified by species and at form level. Images of dominant species were captured using an Axio camera attached to the microscope. For each site a minimum of 300 frustules were counted. Past studies indicate that anything below three hundred counts is likely to result in variability in the index values. There is no significant variability between 300 and 400 counts (Prygiel *et al.,* 2002; Bartabee, 1986). The factors under consideration during identification were the

morphological structures such as perforations, stigma and rib structures amongst others. Once identifications were complete, diatom indices were calculated using Omnidia Version 4.2

The percentage composition of the five most dominant species found at each of the six sites is presented in Tables A.3 and A.4. Overall twelve species comprised the final list of dominant species found in the July sampling and thirteen taxa were present in the September sample period. Eight of the recorded species were present as dominant species on both occasions. *Navicula seminulum* was the most dominant species and found at sites B (near WWTW) and C (next to stormwater pipe outlet). *N. seminulum* is tolerant of a range of water quality, including brackish and high electrolytic conditions and nutrient-rich waters and has frequently been found in high concentrations in sanitized wastewater effluent (Figure A.4).

**Table A.3: Percentage composition of dominant species collected 1 July 2008**

| SPECIES | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| *Achnanthes oblongella* | 4% | 4% | 10% | | | |
| *Craticula halophila* | | | | 3% | | |
| *Gomphonema parvulum* | 23% | 21% | 12% | 37% | | 0% |
| *Gomphonema pseudoaugur* | | | | 1% | | |
| *Gomphonema pumilum* | 14% | | | | | |
| *Navicula cryptocephala* | | | | | 25% | |
| *Navicula pseudohalophila* | | | 6% | 6% | | 1% |
| *Navicula rhynchocephala* | 4% | 7% | | | 12% | |
| *Navicula seminulum* | 30% | 40% | 26% | | 16% | 75% |
| *Nitzschia palea* | | | | 1% | 15% | 10% |
| *Planothidium rostratum* | | 5% | | | | |
| *Tabularia fasciculata* | | | 5% | | 13% | 2% |

**Table A.4: Percentage composition of the dominant species collected 7 September 2008**

| SPECIES | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| *Achnanthes oblongella* | 8% | | | | | |
| *Gomphonema parvulum* | | 6% | | | | 35% |
| *Gomphonema pseudoaugur* | 32% | | 14% | 4% | | |
| *Gomphonema pumilum* | | | | | | 8% |
| *Navicula germainii* | | | | | 3% | |
| *Navicula seminulum* | 20% | 52% | 32% | 1% | | |
| *Navicula veneta* | | | | | 10% | 7% |
| *Nitzschia liebertruthii* | | | | | 3% | |
| *Nitzschia palea* | | 21% | 6% | 5% | 13% | |
| *Planothidium engelbrechtii* | 5% | 4% | 8% | 6% | | 8% |
| *Planothidium rostratum* | 5% | | 6% | 4% | | |
| *Sellaphora seminulum* | | | | | | 11% |
| *Tabularia fasciculata* | | 6% | | | 34% | |

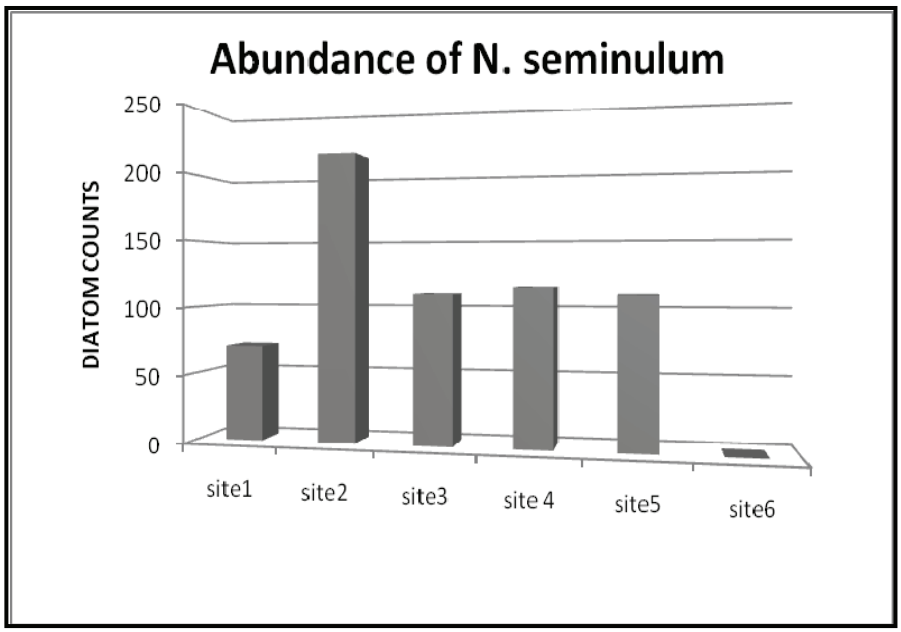



**Figure A.4: *Navicula seminulum* counts recorded across all the study sites, 7 September 2008 (Site 2= B; Site 3 = C, etc)**

The results showed that all SPI (Specific Pollution Index) values indicate poor water quality with scores of less than 9 (Eloranta & Soinenen, 2002) (Figure A.5, see Table A.5 for an explanation of the class limit scores). At site A, the water quality is poor (8.6) but this quality decreases at site B (3.7). Further downstream some recovery is evident as the SPI values increase to 7.1 (sites C and D). At the final site (F) the SPI increases to 7.8. The SPI value of only 4.4 from Site E (control site) is inconclusive.

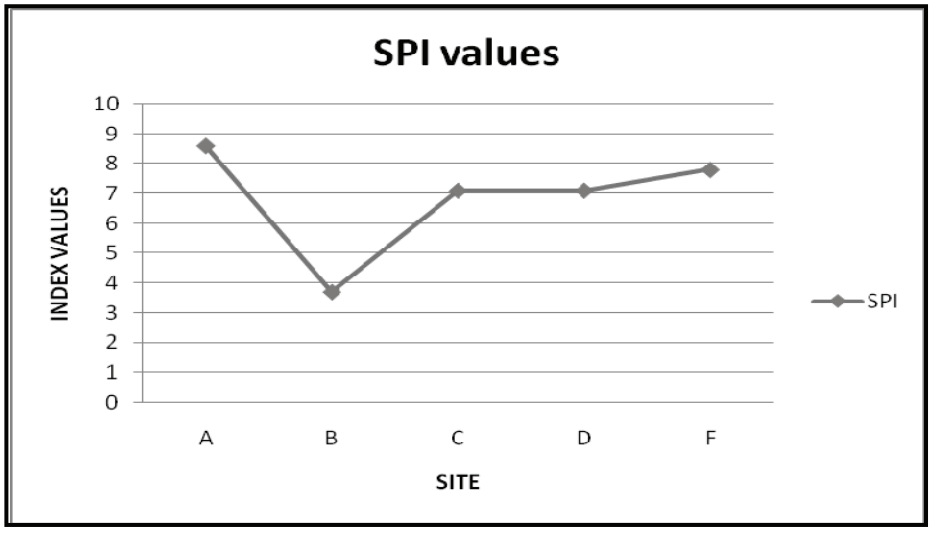



**Figure A.5: Results of diatom index values from samples collected on 7 September 2008**

**Table A.5: Class limit values for SPI (Eloranta & Soininen, 2002)**

| Class | SPI score |
|---|---|
| high quality | >17 |
| good quality | 15 to 17 |
| moderate quality | 12 to 15 |
| poor quality | 9 to 12 |
| bad quality | <9 |

Prior to sampling the Franschhoek River, it was hypothesised that the best water quality would be found at site A, while sites B, C and D were expected to show poor water quality because of their proximity to the point sources of pollution already identified. Finally, if the system was able to recover, it was expected that the water quality would be considerably improved by the time it reached site F.

Results from the water quality analysis show that the dissolved oxygen concentration is highest at site E (40 mg/ℓ) (Table A.2). This site acts as a control for conditions in the Stiebeuel River prior to its convergence with the Franschhoek River. It is well oxygenated as a result of rapid flow and turbulence, and also because of the relatively pristine conditions in the sub-catchment. Lower DO concentrations (29 mg/ℓ) were found at site B (at the confluence of these two rivers). Site B also recorded the highest phosphate level (2 mg/ℓ) which could support the assumption that the WWTW is releasing poorly treated effluent into the river. No phosphate was recorded at Site E. It was however surprising that no phosphate was recorded from samples collected from the stormwater pipe on 7 September 2007 (site C). It was expected that phosphate would be detected given that relatively high levels were measured from streams and ponds at Langrug in September 2008 (refer to Table 5.1 in the main report). It is possible that rainfall for two days prior to sampling (5 and 6 September 2008) may have diluted the concentration. Samples from the stormwater pipe collected on 1 July 2008 showed $PO_4$ levels were well over 5 mg/ℓ.

The biological assessment attempted to establish the impact of two point sources of pollution. The findings conclude that the discharge of water from both the informal settlement and the WWTW were contributing to the deterioration of the ecosystem, but it is possible that the bigger impact was due to the WWTW.

## Correlation

The null hypothesis used in the correlation analysis was $H_1$: no correlation exists. The strongest relationship exhibited by the correlation analysis in Table A.6 existed between pH and temperature (r= 0.86; p= 0.03). Since the $p<0.05$ we can reject the null hypothesis in relation to these two variables. A weak association exists between temperature and dissolved oxygen concentration (r= 0.54; p= 0.27). These variables are considered to have a weak correlation because although they have $r>0.5$ the small data set requires that a higher value is necessary when interpreting "r" value. The significance of the r values is indicated by their corresponding p-value. As the $p> 0.05$ in this case it cannot be assumed that a relationship exists. Other weak associations existed between SPI and pH (r = -0.53; p= 0.28), DO (r= -

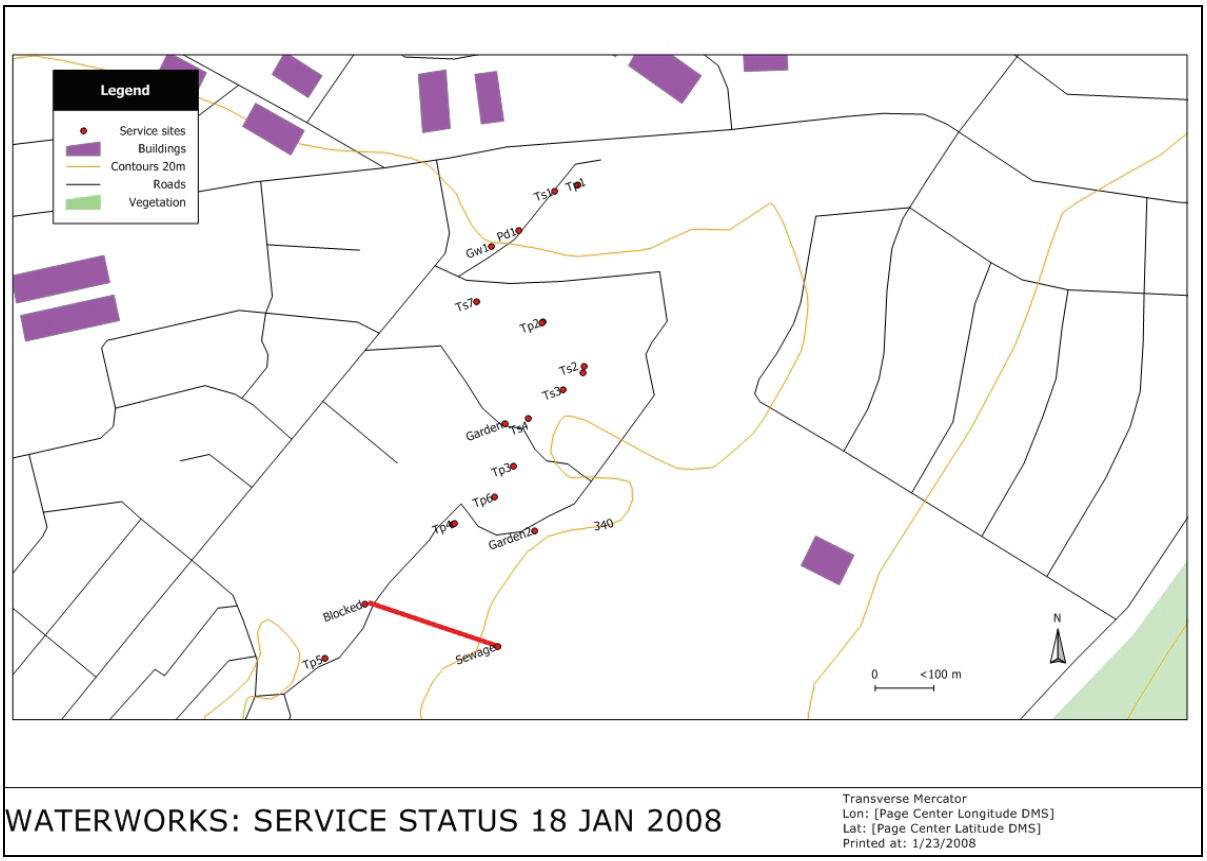
0.60; p= 0.21), and phosphate (r=-0.59; p= 0.21). For these variables there is insufficient evidence to reject the null hypothesis (p>0.05) and it must be concluded that although the "r values" appear significant there is no correlation between SPI and the measured variables. Therefore the diatom index is not affected by spikes in the physico-chemical variables and provides a more consistent representation of past and present water quality.

**Table A.6: Correlation matrix for SPI and measured variables**

| | **SPI** | **ph** | **Temp** | **DO** | **Phosphate** |
|---|---|---|---|---|---|
| **SPI** | 1.0000<br>p= --- | -.5308<br>p=.279 | -.4938<br>p=.319 | -.5970<br>p=.211 | -.5939<br>p=.214 |
| **pH** | -.5308<br>p=.279 | 1.0000<br>p= --- | .8579<br>p=.029 | .4132<br>p=.415 | .1588<br>p=.764 |
| **Temp** | -.4938<br>p=.319 | .8579<br>p=.029 | 1.0000<br>p= --- | .5403<br>p=.268 | -.0551<br>p=.917 |
| **DO** | -.5970<br>p=.211 | .4132<br>p=.415 | .5403<br>p=.268 | 1.0000<br>p= --- | -.1661<br>p=.753 |
| **Phosphate** | -.5939<br>p=.214 | .1588<br>p=.764 | -.0551<br>p=.917 | -.1661<br>p=.753 | 1.0000<br>p= --- |

# Appendix B

## Status of services and initiatives at Waterworks, Grabouw following a field visit on 18 January 2008 (Extract from fieldworkers' report)




Notes:

1. Site specific locations were determined using a GPS.
2. Map data were extracted from the 1:50 000 scale topographic map (3419AA) available from Department of Land Affairs, Surveys and Mapping (2000).

**Blocked – Sewage:** The manhole cover shown as 'Blocked' on the map was overflowing again (first observed in August 2007). Raw sewage was flowing rapidly from this open manhole for approximately 230 m (see path demarcated by bold line on the map). Residents dug a makeshift channel to direct the flow of the water. There was a strong stench from the water. According to one resident the problem had begun seven days prior to this site visit. It seemed as though no one had reported the matter to the municipality. The runoff is eventually absorbed into sand and piles of rubbish lying at southernmost boundary wall immediately below the 340 m contour. The sewerage capacity of Beverly Hills, a formal settlement immediately north-west of Waterworks, is either being exceeded or the drains are blocked. ***The municipality needs to intervene urgently as the situation is dire.***

**Garden:** This garden was initiated by a group of women residents with some support from personnel of the City of Cape Town, who provided some instruction on growing crops, and

with the support of the municipal officials at Grabouw who assisted in demarcating the land for the purpose of establishing a food garden. The area is fenced, approximately 6 x 5 m in extent, and is situated alongside a communal tapstand. The project began in August 2007. The maize appears to be growing well and has reached 2 metres in height. The tapstand has been removed and a hosepipe is now dedicated to irrigate this food garden. ***The loss of a communal tapstand for public use needs further investigation and possible attention.***

**Garden 2:** This is a private initiative in which an area of approximately 12 x 10 m is used for growing maize. It is situated along the southern boundary of the settlement. The 'owner' irrigates the crop with a hosepipe of approximately 120 m attached to a communal tapstand (TP6). ***Restricted access to a communal tapstand either permanently or for short periods needs to be investigated.***

**GW1 – Greywater soakaway:** The soakaway (a drum filter) was installed in a fenced off yard in November 2007. The resident has used the filter since installation, but the smell and presence of water near the top of the drum suggests that the flow is being inhibited either by insufficient holes in the drum or that it has become blocked. It is also possible that the compact, sandy soil 1 m below is insufficiently porous. The resident was not at home at the time of the visit. Once permission has been sought, the drum will be removed and replaced with a simpler soakaway system.

**PD1 – Ponding:** Greywater ponding occurs along the gravel road near the north side entrance to Waterworks. Residents toss their wastewater onto the road. Access to water is relatively in this area of Waterworks because of the proximity of functional tapstands.

**TP1 – Tapstand:** This communal tapstand and washing area is probably one of best designs observed to date. A cement slab (4 m x 2 m) is used for washing laundry and has a tap securely attached to a metal support. Runoff is directed by the gradient and 'bowl' shape of the slab while flow is captured into a municipal pipe. There is a metal grate across the mouth of this pipe. It is the only functional washing place in the settlement. ***Similar communal tapstands and drainage should be implemented elsewhere in Waterworks.***

**TP2 – Tapstand:** This tapstand causes excessive runoff between houses. On the morning of 18 January, volunteers from nearby houses were seen digging makeshift drainage channels to direct the runoff between houses. The area surrounding the tap is muddy with dark, black sand. There is no infrastructure surrounding the tapstand. ***Urgent intervention is required.***

**TP3 – Tapstand:** A relatively under-utilized tapstand with no surrounding infrastructure.

**TP5 – Tapstand:** Originally this tap was fixed to a supporting metal post. A flat concrete slab (4 x 2 m) was intended for use as site for laundry washing. Runoff from the cement slab was intended to flow into a 110 mm pipe. This pipe became blocked and the tap was vandalised. Subsequently grass, weeds, rocks and rubbish have covered the concrete slab. A makeshift tap attached to a flexible hose is now being used by residents in the north-western sector of the settlement. Leakage from this pipe is evident. ***Intervention required.***

**TP6 – Tapstand:** A long hose was seen attached to this tapstand. It is curious that other residents did not seem to mind this private arrangement. The hose leads to Garden 2 described earlier. ***Further investigation is necessary.***

**TS1 – Toilet:** Five waterborne toilets all with individual locks on the doors. All appear to be working according to local residents.

**TS2 – Toilet:** Three chemical / bucket toilet each with a lock on the door. Residents claimed that they were functional.

**TS3 – Toilet:** Three chemical / bucket toilets in filthy state. Abandoned. ***Intervention required.***

**TS4 – Toilet:** Seven chemical / bucket toilets in filthy state. Abandoned. ***Intervention required.***

**TS7 – Toilet:** Five waterborne toilets all with individual locks on doors. All appear to be working.

There were no skips in the settlement. There appears to be no arrangements for the dumping of litter and waste. ***Urgent intervention is required.***

# Appendix C

## Letter of grievance from the Chairperson of the Hangberg in-situ Development Association (HiDA)

*11th July 2009*

*Dear* [redacted]

*In-situ Public toilets contract concerns:*

*As the executive committee of the Hangberg in-situ Upgrading/Development Project and on behalf of the project residents, we would like to express our appreciation for finally securing this toilet contract after so many months. We are however deeply concerned that the toilet contract has commenced without appropriate consultation with the committee. We find it concerning that toilets could simply arrive in Hangberg without us having been properly notified that a contract had been awarded and that toilets were being delivered to Hangberg. During several meetings with yourselves, it is noted that the issue of installing additional public toilets has only been highlighted as a continued priority, reserving an implementation and management plan until a budget has been secured and a final review considered. The need for a meeting with yourself, Wally and the committee was requested in an email last week to ensure that an adequate plan of action was drafted prior to the implementation of the toilets. There are a number of issues which need to be addressed before the contractor can commence work on site, something which we had hoped to bring to your attention at the meeting on Friday 10th July 2009, which you unfortunately failed to attend.*
*We believe it is important to bring to your attention these issues in writing, as a matter of urgency.*

- *First of all**,** the onsite assessment conducted by the committee in June 2008 and the GIS assessment conducted by Kevin Winters in July 2008 needs to be reviewed before the locations of the new toilets can be confirmed, as this **has** changed since last year. This review needs to be done systematically including a desk top review and onsite assessment with the contractor, committee, yourself and possibly Kevin Winters and Wally.*
- *Secondly, please note that the original assessments were based on the premise that the City would provide 48 toilets in priority locations, but now due to the lower number of toilets we also need to identify the new priority locations. ''An indication on when the additional toilets will be provided will further assist the planning process!?'' During various community meetings with the ''back-yard dwellers'', it was said that additional toilets (at least the outstanding 20 from the initial 60 secured for the 'project'), would be secured for their highest priority areas, thus we need to include this issue in our proposed meeting!?*
- *Thirdly, these new locations for the toilets also need to be informed by the findings from the community town planning workshops, facilitated by Wally Johnstone and the committee, which highlighted community priorities specifically with regards to toilets and greywater.*

- *Fourthly, we would please like feedback on the employment of local labour and skilled labour on the toilet contract. The committee has a database of skilled local labourers, which we would like to review with the contractor.*
- *Lastly, we would like to request a meeting at your earliest convenience, including the Contractor, Wally and Kevin Winters, to discuss the plan of action for reviewing and identifying the locations for the new toilets, as well as general project management issues related to the contract prior to any work being done. We believe that this is only fair and a matter of best practice. We must also not underestimate the value added to the identification of the best suited locations by the participating residents surrounding the targeted locations, w.r.t. their experience and need.*

*However, we would like to ensure that this contract is implemented in the best way possible to ensure that the families most in need are addressed. We would ideally like to meet with you before the envisaged near future community meeting, where we hope to provide positive feedback to the community. This contract has the potential to strengthen the relationship between the community, committee and the City of Cape Town…so we hope that this email will be understood in this light.*

*Kind regards,*
*Donovan van der Heyden*
*Hangberg in-situ Development Association (HiDA)-Chairperson*

# Appendix D

## Greywater management options – good practice

### Communal washing areas

Well-frequented undercover washing area at Langrug. Metal taps with pipework protected by cement structure. Deep, well-drained basins largely used for laundry. Limited space for storing buckets and other items, however.

Popular spot for washing at Waterworks – large cement 'dished' drainage area suitable for spreading out laundry and rinsing. Catchpit (60x30cm) covered by metal grate to intercept solids resulting in well-drained area. Note convenience of fence for hanging laundry.

Well-drained, 'dished' wash area with raised working surface for washing and rinsing laundry. Overflow channelled to centre of concrete slab where it enters septic tank. Residents complain about lack of water pressure and irregular emptying of septic tank.

Wash area enclosed by fence and situated along side sanitary unit. Large concreted area provides good working surface while gentle gradient to open gutter allows water to drain swiftly. Fence used to drain and dry laundry.

# Communal tapstands

Secured tapstand at correct height for 25 litre bucket. Concrete base is secure and well drained.

Tapstand catchment allows water to flow along gently sloping hardened surface into open furrow.

Useful way to rinse washing using open crate placed on raised pedestal. However, excess water does not flow into catchpit but creates wet, uncomfortable conditions surrounding tap. Water conservation is an issue.

Tap protrudes 30cm from support structure to make it easier for resident to use large basin without spilling water.

# Drainage

Wetlands absorb percentage of nutrients and heavily metals from wastewater flows. Makeshift bio-filters are useful but can also be catchment for solid waste and anti-social activity.

Greywater drained into catchpit that directs load to sewer. If catchpit blocks, water will flow into stormwater system.

Concrete furrow discharges water along main street in Langrug. Reasonably effective but requires ongoing cleaning.

## Cleaning services

In Langrug, workers were employed to keep the main toilet and washing area clean. Their tasks were limited to cleaning, but not to managing blockages.

## Initiatives

Low flow streams of greywater intercepted by cut off drains and then discharged to sewer.

Attached basin with discharge pipe plumbed deep into soil below. Note drying/holding rack (left) as a convenient, essential item to improve conditions at a washbasin.

## Initiatives (cont.)

Greywater used to irrigate garden of ornamental plants (Simondium).

# Appendix E

## Why things fail

Many observations were made and conversations heard to demonstrate why infrastructure fails. A selection of these failures is captured below together with brief explanations.

### Communal washing areas

Basin is too small. There is no place to put washing and utensils. Tap is broken and has been removed. Basin is now of no use.

Newly installed plastic tap without adequate support. Wired-up to secure connection and prevent some leakage, but is bound to fail.

Drainage area covered with small stones, sand and dust. Plastic grate below is blocked because of this substrate. Users will avoid this basin because their feet will get wet.

# Communal tapstands

Makeshift and fragile. Inadequate drainage causes streams to flow between shacks.

Home-grown modification. Wire crimp tap looks ugly although it works with minimal leakage.

No tap head, but a pair of pliers from a neighbour's house works well.

Poor drainage. Catch pit is blocked. Dirty water remains in enclosure.

## Communal tapstands (cont.)

Residents broke enclosure because drain provided was continually blocked. Now flow is discharged into the concrete furrow provided for stormwater drainage.

# Poor drainage

Collapsed toilet and leaking tapstand/ basin. Foul water is discharged down slope.

Solid waste follows discharge of waste water stream (partly raw sewage).

No hardened surface surrounding these toilets and basin and therefore not favoured by users.

Wetlands in Langrug absorb nutrients from wastewater flows, acting as limited bio-filtration system before water enters stormwater system. On the other hand, poor control can render these areas breeding grounds for pests and a hiding place for anti-social activities.

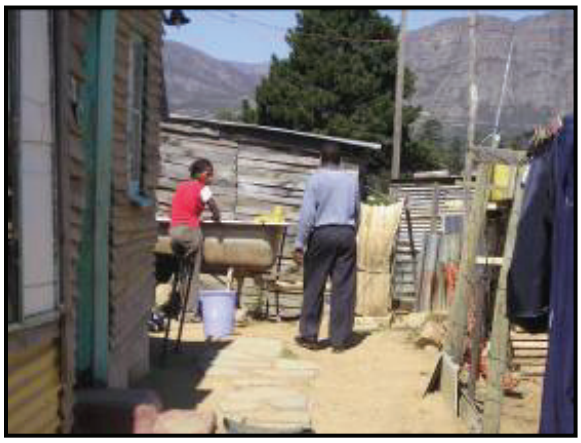
## Poor drainage (cont.)

Solid waste collects in wetlands and attracts flies and mosquitoes. Regular maintenance and cleaning required to maintain these areas.

## Cleaning services

Worker is employed to clean drainage channels, but since there is no place to deposit the dirt, he dumps solid waste on periphery of settlement.

# Initiatives



Washing in yard using wash basin as large tub. While this makes life easier for users, wastewater was being conveyed to a gravel road 50 m away.

Growing vegetables, but not using greywater even in diluted form. He uses freshwater from tapstand nearby.

Communal garden in Waterworks where only freshwater is used. Garden hose was frequently seen attached to communal tap for irrigation of these crops.