Development of Communal Washing Facilities for the Northwest Settlements of Windhoek, Namibia

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WPI

City of Windhoek

DEVELOPMENT OF COMMUNAL WASHING FACILITIES FOR THE NORTHWEST SETTLEMENTS OF WINDHOEK, NAMIBIA

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by

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Report Submitted to:
Professor Arthur Gerstenfeld, Worcester Polytechnic Institute
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EXECUTIVE SUMMARY

The goal of this project was to work with the City of Windhoek and community leaders of the Northwest Settlements to form a joint solution to the need of communal washing facilities. In order to accomplish this goal, we worked to complete three objectives.

The first objective was to develop a building plan for the communal washing facilities including a building design feasible for construction that we presented to community leaders for recommendations. Our first step in developing the building plan was to inspect current makeshift structures used for washing by the informal settlers and to inspect toilet facilities installed by the City of Windhoek in the Havana, Okahandja Park, and Greenwell Matongo Northwest Settlements. We then discussed wet and dry toilets, washing facility designs, low-cost practical building materials, and methods for recycling grey water with local professionals Architect Nina Maritz and Building Designer Stefani van Zyl from Urban Dynamics, a local community development company who works in the Northwest Settlements for the City of Windhoek. Within the City of Windhoek Municipality, we interviewed City Water Engineers J. A. Burger and H. I. Peters, City Bulk and Wastewater Chief Engineer F. Brinkmann, and Town Planners Hugo Rust and Heike Cronje on these same topics. Integrating techniques we learned from these professionals, we created a simple modular building design that would allow for both short-term relief, and the capability for later upgrading when financial resources become available by the community members. This design included a toilet, a drain for immediate alleviation of the standing grey water problem, walls to provide privacy, and a personally filled tank for manual showering. In order to finalize our design, we met with community leaders from the Northwest Settlements three times at the Shack Dwellers Federation of

Namibia (SDFN) office, had two consultations with Branch Manager J. J. Oberholzer of ROCLA, a local pre-cast concrete company, and met with representatives from two local building supply warehouses.

The second objective was to discuss the issues with prepayment and to create a set of recommendations for a pricing structure that met both the needs of the City of Windhoek and the needs and financial constraints of the inhabitants of the informal settlements. We initially researched the flat rate payment system that is currently in place in the informal settlements, which allows individuals to use an unlimited amount of water. The total cost of the water used for an entire community is divided up equally by all of the households. Thus, no one household pays more than another household. We researched the flat rate payment system by interviewing the City of Windhoek Bulk and Wastewater Chief Engineer F. Brinkmann and Community Development Officer Edwin Jahs. We then investigated the concept of prepayment of water, discussing both the technical issues involved, as well as the recent social debates. With prepayment, each household is held responsible for the amount of water they use. We pooled various sources for experienced opinions on the subject of prepayment, including interviews and discussions on prepayment with City Professionals H. Cronje, F. Brinkmann, J. A. Burger, E. Jahs, H. I. Peters, H. Rust, and representatives Chairman Mac Hengari, General Manager of Corporate Affairs Zelna Hengari, Marketing Manager Justuce Tjirimuje, and Technical Representative Bernard Griffiths from Nossob River Systems, a Namibian prepayment meter company. We also reviewed recent social issues found in the Namibian national newspaper, The Namibian, and the March 2004 study by the Labour Resource and Research Institute in Katutura, Windhoek on water privatisation in Namibia. Lastly, we spoke to fifty-three Northwest Settlement community leaders at the SDFN to hear

their views on prepayment. Due to the complexity of the controversial issue of prepayment and its potential injustice to the poor, we aimed to produce recommendations rather than a solution for a pricing structure.

The last objective was to develop recommendations for a maintenance and management plan that would be run effectively by the inhabitants and would provide employment for locals. To accomplish this, we began by discussing maintenance and management plan strategies with the City of Windhoek Community Development Officer E. Jahs, and consulted a maintenance and management plan for the Havana Settlement written by Urban Dynamics. We also investigated reducing the number of people assigned to each facility and discussed the feasibility of this idea with community leaders. This, we felt, would increase the sense of ownership for each household, and thus increase the likelihood that household members would do their part to keep this facility maintained. Lastly, we discussed training a few locals in the areas of maintenance and upgrading techniques. This would serve as a potential source of employment of these individuals as each group of households gradually gains the resources and desire to upgrade their shared facility.

Through our interviews with the local professionals mentioned previously, we learned about the problems of vandalism in the informal settlements. This greatly affected our building plan in terms of the materials and components we used and how we designed them into the facility. We decided to not expose the water piping inside the facility in order to prevent its theft. This led us to choose ROCLA concrete structures because they could pre-cast piping into the concrete walls.

The community leaders we worked with chose one large ROCLA structure over two smaller structures. The two small structures would have had one structure

house a toilet and the other structure house a washing or shower room, while the large structure includes both rooms in a single structure, separated by a dividing wall.

In our investigation into toilets for our facility, we looked at both wet and dry toilets. Wet toilets have a low initial cost, but have a high installation cost when the facility is far from the municipal sewer lines. Dry toilets have a high initial cost, but require no connection to a municipal sewer line, so they can be installed anywhere at the same installation cost.

While studying the pros and cons for both flat rate and prepayment water payment systems, we uncovered many technical and social problems that have existed in the past with both systems. We learned that in some areas of Windhoek, upwards of fifty percent of informal settlers do not pay their flat rate water bill. In areas of the country that use prepayment meters, technical problems have occurred that cause people to lose their water connection for long periods of time. We have also found that there is great social pressure against the use of prepayment meters in Namibia.

From our findings, we developed twenty key recommendations. The following highlights our recommendations for the building plan, pricing structure, and the maintenance and management plan.

For the structure, we recommend using the single large concrete ROCLA design with two separate rooms; one for a toilet and the other for a washing or shower room. After the locations of the new facilities have been determined, the average distance from a facility to the municipal sewer line should be calculated. At a distance of 37.7 metres, the cost of a wet toilet and a dry toilet, including installation costs, are the same. If the average distance from the facilities to the municipal sewer line is greater than 37.7 metres, we recommend using a dry toilet. Otherwise, we

recommend using the wet toilets. This is due to cost differences between the two toilet systems and the cost to run piping from the municipal sewer to the facilities.

We recommend that four households share each facility. If financially possible, the number of households per facility should be reduced. Additionally, we proposed a rotation of shared duties plan. Under this plan, the households of each block would share all the duties that need to be performed on the facility for general upkeep. Each household using the facility would be responsible for part of the upkeep through a daily rotation of duties.

If the City of Windhoek uses prepayment meters, we recommend that the cost of prepaid water should be on a graduated scale in which households who use more water have to pay more per kilolitre than households who use less water. This can be achieved first if each household had a dollar amount saved on their prepayment tags. Then, when a household uses water, the amount they are charged per kilolitre increases with usage. At the beginning of each month, the households will start over and will be able to buy water at the lowest cost. This system, a hybrid of the present flat rate systems and traditional prepayment systems, guarantees payment for the City of Windhoek for its water distribution services, satisfies basic water needs at low cost for households who cannot afford higher costs, and is designed to encourage people to conserve water. Specific water costs depend on the bulk rate for water, as set by NamWater, the parastatal responsible for distributing water throughout Namibia.

Our final recommendation is to implement this project, including the building plan, the pricing structure, and maintenance and management plan, initially in one informal settlement community in Windhoek for evaluation. If the system is accepted by the community and is deemed satisfactory by the City of Windhoek, then we recommend implementing the project in other communities.

ABSTRACT

Our project, completed at the WPI Namibian Project Center, was to work with the City of Windhoek Sustainable Development Division and community leaders of the Northwest Settlements of Windhoek, Namibia to create a building plan, a set of recommendations for a pricing structure, and a set of recommendations for a maintenance and management plan for a communal washing facility. Our project goal was completed through meetings and interviews with local professionals on technical and social issues, archival research, and community meetings.

AUTHORSHIP PAGE

Adam Bryant, Andrew Campbell, and J. Patrick Salmon, Jr. all contributed equally on this project in research, design, and writing.

ACKNOWLEDGEMENTS

We would like to acknowledge the many individuals and organizations who have helped us with our project over the past four months. First we would like to thank the City of Windhoek Sustainable Development Division, including our liaison Chief Planner Harold Kisting. We also wish to acknowledge Heike Cronje and Hugo Rust from the Sustainable Development Division for always answering our questions and bringing us to out to the settlements.

The input we received from J. A. Burger and F. Brinkmann from the City of Windhoek's Bulk and Waste Water Division helped us greatly in developing our physical design and formulating our recommendations for a pricing structure. Architect Nina Maritz helped us develop ideas that were practical for the informal settlements of Windhoek.

The consultations with J. J. Oberholzer from ROCLA helped with the pricing completion of our building design. Mac Hengari, Chairman of Nossob River Systems, was a valuable resource in giving us great input into prepayment systems in Namibia, including his attitudes on recent social issues. We would also like to thank him for donating a sample water prepayment meter for demonstration purposes to the community and in our presentations.

Without the help of the Shack Dwellers Federation of Namibia (SDFN) we would have never been able to gain input from community leaders of the Northwest Settlements. We would especially like to thank Edith, the President of SDFN, for her help in coordinating our meetings. Without the help of our Afrikaans and Oshiwambo translators, Simon and Profilius Halwoodi, communicating ideas with the Northwest Settlement community leaders would have been impossible.

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We truly thank you all.
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CHAPTER 1. INTRODUCTION

Water supply sources and methods of sanitation vary widely across the world. The proportion of households in major cities connected to water pipelines and sewers in the world is ninety-four percent and eighty-six percent, respectively, whereas these proportions in Africa are only forty-three percent and eighteen percent (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2003). In comparison with the rest of the world, Africans have less access to clean water and have less proper means of disposal or reuse. African countries having dry climates have the additional problem of limited resources on top of limited access. Namibia is the driest country in Southern Africa (Heyns et al., 1998). As a result, the country must be creative in collecting and administering its resources – specifically water.

The Sustainable Development Division, our sponsor with the City of Windhoek (see Appendix A), is particularly concerned with water conservation in Windhoek, the capital city of Namibia. The water used by Windhoek is managed by Namibia Water Corporation Ltd. (NamWater), a government parastatal (see Glossary), formed in 1997 to provide clean water to the people of Namibia (NamWater, 2001). NamWater receives its water for Windhoek from groundwater through the use of boreholes (see Glossary), from reservoirs resulting from the damming of ephemeral rivers (see Glossary), and through the reclamation of water.

NamWater has had to be strategic in managing its water via reclamation of wastewater. In order to increase the reliability of its water supply, the City of Windhoek has applied a method known as "water banking," which is essentially a replenishing of an aquifer (see Glossary) with water during the wet season and drainage during droughts (Sibanda, 2002). Although the conservation of Windhoek's water is an issue throughout Windhoek, there is a great need to reclaim grey water

(see Glossary) in the informal settlements (see Glossary). Therefore, it was first important to understand why the grey water is not reclaimed today.

The inhabitants of informal settlements are currently using makeshift structures for bathing that do not tie into the pipelines and waterworks of the city. The water serves its momentary purpose and then is lost to the ground through improper draining methods. When this grey water collects on the ground, it creates bad odours, causes erosion, and forms breeding places for mosquitoes, which can lead to the spread of diseases.

Currently, there are public facilities for the informal settlers that are equipped only with toilets. These facilities use water that is paid for by a flat monthly rate. J. A. Burger, a section engineer for the City of Windhoek, has stated that the settlers pay this flat monthly rate for unlimited use of water for the toilets and for all other water consumptions. This rate is equal for all the settlers in a community and fluctuates to cover the costs of the whole community's consumption from the previous month (personal communication, 24 March 2004).

The goal of this project was to design cost effective and affordable communal washing facilities for the Northwest Settlements (see Glossary) of Windhoek. The washing facility needed to meet the privacy needs and sanitary needs of poor families, promote the reuse of water, and be simple enough to be reparable by those using the facility, as it would be their responsibility to fix it when in need of repair. The complete physical building plan was designed with the continuous input of the community leaders of the Northwest Settlements. The design is of a facility with two rooms, one for a toilet and the other for a shower. The facility is designed with the flexibly to include either a dry or wet toilet, depending on the facility's location with

respect to the municipal sewer lines. The design was drawn in complete detail, including the dimensioned drawings that can be used to manufacture the facility.

At the request of our sponsor, we investigated water prepayment systems as an alternative to the current flat rate payment system. The investigation was completed through interviews and reviewing recent social issues in Namibia. We then made recommendations for a plan to make users pay according to the amount of water they would use via prepayment as opposed to the flat monthly rate payment plan already in place. To keep the facilities maintained, we made recommendations for a long-term maintenance and management plan. This plan was designed so that the community, not the municipality, would be responsible for the facility's care. Urban Dynamics (2003), a local community development company that works with the City of Windhoek, stated that past project experiences with maintenance and management plans in the informal settlements performed by the City of Windhoek failed when the City assumed full responsibility of service. The City of Windhoek does not have enough manpower to support the demands for frequent service in the informal settlement areas of Windhoek. In order for the facility to gain acceptance by the community, it was essential for the community leaders to become involved in the planning process for the design of the facility, the pricing structure, and the maintenance and management plan.

Working with the City of Windhoek and the community leaders of the Northwest Settlements, we found a joint solution for the washing facilities, including the building plan, pricing structure, and maintenance and management plan. This solution was designed to be used in any Windhoek informal settlement community and should be implemented first in one community for evaluation. If the physical facility design, pricing structure, and maintenance and management plan are accepted

by the community and are deemed satisfactory by the City of Windhoek, then it can be implemented in other communities.

CHAPTER 2. LITERATURE REVIEW AND BACKGROUND

In the process of designing a communal washing facility for the informal settlements of Windhoek, it is important to familiarize oneself with the source of the issues of this project. Following this introduction, this chapter will explore Namibia's climate, explore the topic of water reclamation, and explain water usage to demonstrate reasons to save water and why it is important for the community members to have to pay for the water used. We will discuss the outcomes of certain studies that show what incentives for community involvement have been successful and why it is beneficial to have a society aware of the need for conservation of water. The chapter will continue to discuss information on informal settlements and existing problems with public policy in order to familiarize the reader with the present situation. Lastly, we will discuss the importance of community development, as it will be essential to a long-term solution to communal washing facilities.

Namibian Resources

An understanding of Namibian Resources and how to conserve them is essential for those dealing with water issues in this dry country. Namibia is the driest country in Southern Africa, and thus dams, boreholes, water recycling, aquifers (see Glossary), and other strategic methods are employed to use and conserve water in the most effective manner.

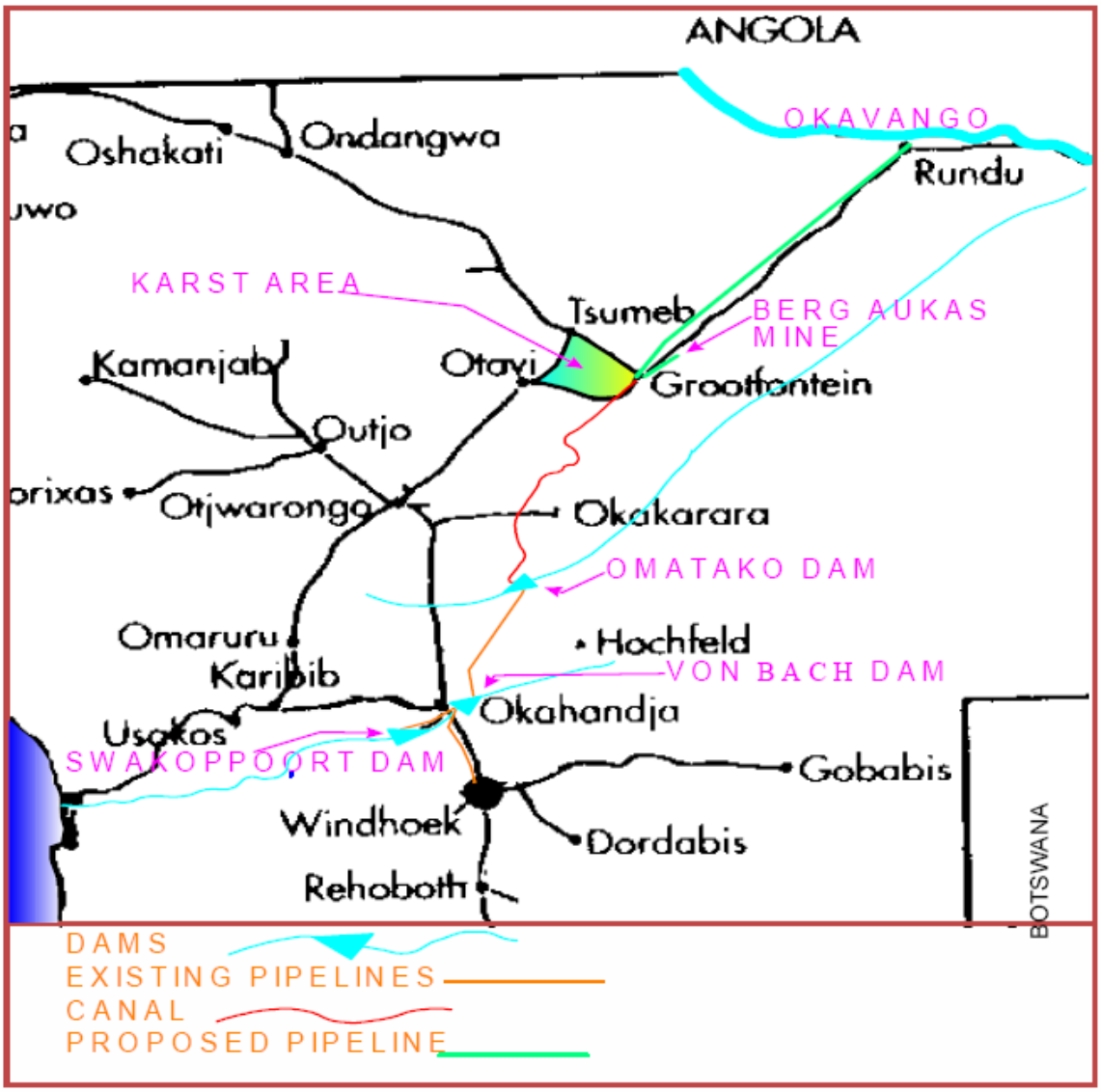
Water Supply

The exceedingly arid climate of Namibia mandates tight constraints on water usage, making it crucial to understand details of the area's water resources. The entire country of Namibia suffers from an arid climate due to the combination of low

rainfall, and a high rate of evaporation. Of all the rainfall in Namibia, approximately eighty-three percent is lost to evaporation and about fourteen percent is used by plants (Heyns et al., 1998). In the City of Windhoek, the average annual rainfall is 360 millimetres and the average annual evaporation is 3400 millimetres. This large amount of evaporation occurs largely within the reservoirs. The nearest perennial river (see Glossary) is the Okavango, which is located seven hundred kilometres northeast of Windhoek (Van der Merwe, 1999). Since there is so little precipitation and the closest perennial river is so far from the city, sources of water around Windhoek are minimal. According to Harold Kisting, Chief Planner of the Sustainable Development Division of the City of Windhoek, the aquifers and lakes are the only reliable sources (personal communication, 26 April 2004).

Windhoek receives its water by three main routes: from the use of groundwater from boreholes, from the reservoirs behind three dams in ephemeral rivers, and through reclamation of water. As of 2000, there were fifty official boreholes in use by the City, yielding 2.3 Mm^3 of water per year. There are also three dams in the intermittently flowing rivers to the north of the city, which together yield 20 – 25 Mm^3 of water per year, 17 Mm^3 per year of which goes towards Windhoek's supply. This three-dam system yields a sufficient water supply ninety-five percent of the time (Van der Merwe, 2000). The water reclamation plant in use in Windhoek, as of 2000, produced 2.9 Mm^3 of useable water per year (Van der Merwe, 2000). A map indicating water sources may be viewed below in **Map 1**. The Water Institute of South Africa (WISA) reports that 461 litres and 1106 litres of water are required per person per day for those living a "low lifestyle" and "high lifestyle" respectively (WISA, 2003). The need to conserve is evident as the dams, reservoirs, and reclamation plant yield a total of only 22.2 Mm^3 litres per year. With a population of

223 364 (City Life, 2001), citizens of Windhoek have an average of only 272 litres produced per person per day. It is important to note though that water is not just used by the citizens of Windhoek, it is also used by industries. This causes the amount of water produced per person per day to significantly drop.



Map 1: Water Resources of Namibia (Van der Merwe, Case Study on Water Demand Management in Windhoek, 1999)

The technique of artificial recharge is growing in popularity in Namibia in order to reduce the loss of water due to evaporation. According to Van der Merwe (2000), there is an estimated 15 – 25 Mm^3 of unused underground storage capacity

with a minimum possible annual recharge of 10 – 15 Mm^3. With artificial recharge, water is taken from the reservoir supply and injected into the underground cavities into which the boreholes are tapped. Doing this reduces the amount of time that the water is vulnerable to evaporation, therefore minimizing water loss to evaporation (Van der Merwe, 2000). As this technique is increasingly put into effect, the effect will be an increase in the amount of available water to Windhoek and the surrounding areas. This technique was first attempted in 1996 to test whether artificial recharge had a significant impact. No negative impact on water quality was observed. Based on that test, it is estimated that for every 1.0 Mm^3 of water pumped into underground aquifers, 0.4 Mm^3 will be saved from evaporation. In addition, it was observed that some of the surrounding boreholes were recovering water at four times the normal rate (Van der Merwe, 1999). The use of recharge offers much greater assurance that water will be available in drought conditions. NamWater estimated in 1999 that the cost of artificial recharge would be N$0.76 per cubic metre, including overhead service costs. Unfortunately, there are no more recent figures confirming or refuting this estimation. The 1999 figure, however, shows how cost efficient artificial recharge is compared to the normal bulk supply cost of N$2.40 per cubic metre (Van der Merwe, 1999).

Water Usage

Currently, the issue of water compensation is a very controversial issue. Water is a basic need for survival. While some believe NamWater is privatising water through tariffs placing this basic need above the reach of the country's most financially vulnerable, others realize the need for compensation so that Namibia's

scarce water supply will be conserved. These issues will be discussed under "Pricing Structure" in Chapter 4.

A major issue with water usage in Namibia stems from the fact that in many cases, the water users are not directly paying for the full amount of water that they use. The extra costs of water are usually paid for by community taxpayers. According to Heyns et al. (1998) this lack of direct payment in Namibia causes the user to be less mindful of the use of water. Additionally, in the past in Namibia, water was supplied for free to rural communities. As a result, many Namibians feel that it is their right to have free water (Heyns et al., 1998). In addition, many Namibians are using abundant amounts of water because they have a critical misconception that there is no real water crisis. Many believe that more water can always be brought in from the outside (Pallet, 1997). Heyns et al. (1998) suggests that charging the user for the amount of water they use may be a very effective solution to reduce this excessive use of water.

J. A. Burger, a Section Engineer for the City of Windhoek (personal communication, 24 March 2004), describes the payment system already in place in the informal settlements. He says every household pays a set price for water in the beginning of each month to cover an unlimited use for that month. The next month's flat rate will rise or fall to cover the costs of the preceding month's consumption. The water costs are divided equally among the community households so that all pay the same rate. See Appendix B for the minutes from our 24 March 2004 meeting with city water engineers, including J. A. Burger.

Heyns et al. (1998) suggests the use of committees that collect water use fees in compensation for maintaining water supplies. These committees would then have the power to revoke the privilege of access to the water supply as long as there are

alternative water supplies available. Such water may be obtained from locations such as local boreholes or rivers, as long as the water is safe for drinking. Pallet (1997) notes that some households, even with increased pricing, continue to use excessive amounts of water. He suggests that penalties of shutting water off for a certain amount of time should be used, when consumption of water is raised past a predetermined limit (Pallet, 1997). Another possible solution that would protect the wellbeing of the consumer against full water cut-off could be to limit the user to the lowest calculated amount of water required for survival if payment is not made or if overuse occurs. The pay-by-use plan requested by our sponsor would be an immediate request for compensation. In this case, without payment, the users will not receive their shower.

Water Reclamation

Since water in Namibia is in limited supply, the reuse of water is a necessity for the sustenance of a growing population (Van der Merwe, 1999). The process of reusing water through reclamation plants has been in service in Windhoek since 1968, when the Goreangab water reclamation plant was built. The capacity of this facility has continually been upgraded over the years to meet the water demands of the increasing population (Van der Merwe, 1999). As of 2000, it was estimated that twenty-eight percent of water used in Windhoek came from the Goreangab plant (Van der Merwe, 1999). The Goreangab water reclamation plant reclaims water from domestic sewage to supply 250 000 residents with clean water (Le Roux, 2003). Le Roux (2003) reports that certain computerized instruments and weekly operation updates indicate whether the plant is in compliance with water quality requirements. According to Kisting, when the reclamation plant shuts down due to technical

problems, NamWater, the bulk supplier of Namibia's water, continues to supply Windhoek with sufficient clean water from the lakes (personal communication, 26 April 2004).

Water reuse and recycling is also useful on a more local scale. On-site recycling of water could be used to further conserve water. An example of this type of on-site management of water use is Namibia Brewers Ltd. As reported by Butler (1996), Namibia Brewers Ltd. reuses its waste water by feeding it into ponds. These ponds are used for supporting eight varieties of fish, which then can be sold for income. By using the wastewater from the brewing process for farming fish, much more can be gained from the water before it is discarded. This example presents a valuable idea in that users should make attempts to consider what purposes their wastewater may serve before it is ultimately discarded to the ground. If water must be lost to the ground, some effort should be made to direct it to an agricultural source. According to Kisting the Northwest Settlement communities have already implemented new uses for the water. In the Havana settlement, overflow from the toilet facilities flows into pits to water nearby trees (personal communication, 16 March 2004).

Case Studies: Water Saving Incentives

Throughout the world, many studies have been done on water and people paying for their water. Though perhaps under less restrictive water constraints than Namibia, other countries are still motivated to discover new conservation techniques. Studying these techniques may lead to potential solutions for Namibia.

Offering incentives is what made water savings possible in South Africa as revealed in a study that took place at Kruger National Park. Inside the park, visitors

who were staying overnight were split into two groups. The control group spent their visit just as people had in the past. This meant no special training about water and electricity was given to them. Individuals in the second group, the test group, were all told why saving water and electricity was important, were given guides showing how they could save resources, and were helped in doing so. They were given facilities with low flow showerheads, fewer light bulbs, dual flush toilets, and other energy-saving devices. During their stay, the control group had no financial incentive to limit the use of resources, while the test group individuals were all charged based on the amount of water and electricity used. The more resources they used, the more money they had to pay to stay inside the park (Pallet, 1997).

The results of this study are interesting, but unfortunately have some flaws. Pallet (1997) discusses these flaws by pointing out that the people visiting a national park are not typical people. This also means they are not fully representative of all Kruger citizens as the percentage of people visiting the park who are concerned with the environment is higher than the percentage of people concerned about the environment in the general public. This population is also likely to contain wealthy vacationers or tourists. The researchers assumed that people visiting an environmental game reserve would already be environmentally conscious. It is possible the control group may have been trying to save resources while those in the test group would have saved resources regardless of the study. Though confounding variables exist in this study, the results are still important because they do show the expected outcome that the people who were given incentives used their resources more conservatively (Pallet, 1997). The average savings of the test group over the control group were seventy-three percent for water and sixty percent for electricity (Pallet, 1997). The incentive to save money worked in this study.

Unfortunately, there was no study done whose results might be applicable to Windhoek citizens. It would be advantageous to test these incentives on Windhoek citizens in a similar study where confounding variables might be reduced through random sampling techniques. The results from such a study would help to verify the previous study's results that incentives to save money are successful in water conservation.

In Tanzania, the Pangani River provides water to over four million inhabitants. Historically, the use of water from the river was free, referred to as a 'gift from God.' In the mid 1990s, after years of discussions about water fees, it was decided that water fees were needed. No incentives were given to people, just a demand for payment to control the heavy use of water being extracted from the Pangani (Pallet, 1997). Going from no cost to having to pay for the water, the people of the Pangani basin were shocked. The average rate of people paying their fees was only forty-five percent. In the specific areas where personnel from the Pangani Water Basin Office visited with the consumers, the average rate of people paying increased to ninety percent (Pallet, 1997). Working with the people who were affected by the new system helped tremendously. This study is an example of how change can come when people are given the chance to understand the problem and become part of the decisions for the pursuit of a solution.

Unlike the pay-as-you-use system in Kruger National Park, Montaigne (2002) reports that farmers in India had to pay a set price to use water, regardless of their use. The low cost of the water was due in part to the government subsidies. Montaigne states that the farmers had no incentives to use less water and thus many used more water than needed. This is not just a problem in India, as problems like this are found all around the world. Most governments over-subsidize water for farmers, rendering

the amount of water that farmers use irrelevant in the eyes of the farmers. Methods such as drip irrigation (see Glossary) can reduce the amount of water farmers use, but without an incentive to make the change from traditional ways to water efficient ways, people are less likely to change (Montaigne, 2002).

These studies all point out how and why water should be conserved, but more importantly, they show why some people do not conserve water when they are unaware of the need to do so. The incentives in the South African study show that people can change, while the progress made in Tanzania shows that people have changed once they learned the reasons why change is necessary.

The value of water is more than what people pay, regardless of the cost (Heyns et al., 1998). Without water, people cannot live and farmers cannot produce crops. The Economist (19 July 2003) argues that raising water prices can encourage people to use water resources more efficiently. The article asserts, however, that if the farmers using water have to pay the full amount of the cost of their water, regardless of watering methods like drip irrigation, they could go bankrupt. While Montaigne (2002) argues government subsidies are too high in India, The Economist (2003) says subsidies that are too low are just as bad. A careful decision on water prices is essential to create a solution in which people can afford the water and still make conscious choices to use water effectively.

Sanitation

The community members' understanding of sanitary upkeep is essential for this project because the cleanliness of any facility and of the water affects the state of health of the people who use the facility.

Need for Education

A lack of hygiene is a very critical problem around the world today. This problem is mostly caused by the improper disposal and handling of human waste. According to the Water Supply and Sanitation Collaborative Council (WSSCC), diarrhoeal disease causes approximately five million deaths a year worldwide (Ghosh & Karanja, 2003). The majority of this number occurs in areas where proper sanitation is not used. The chairman of the WSSCC has been quoted remarking on the deaths due to poor hygiene, "This is inexcusable in this day and age when the simple act of hand-washing after going to the toilet, before handling food and after changing babies nappies can cut the death rates by almost half" (Ghosh & Karanja, 2003).

In a study carried out by the UN Water Sanitation and Hygiene for All (WASH) program in the Korogocho slums and Soweto slums in Nairobi, Kenya, it was revealed through a survey that far too few people in this community adhered to good hygiene and sanitation. It was reported that only twenty-two percent of the people surveyed washed their hands after handling babies' faeces, and only forty-nine percent used water and soap or ash to wash their hands. The study also showed that only sixty-five percent of those studied had been taught to wash their hands (Ghosh & Karanja, 2003). This statistic reveals that many people who have been educated about hygiene still do not use it. In many cases, this may be because they lack the means of a water supply for sanitation purposes.

Water Cleansing

Since Windhoek is such an arid city, conservation of water is one of the most important issues that needed to be considered. Used wash water may be cleansed and

reused by the City to promote conservation. This would contribute to the recycling process in which used washing water could be reused for other purposes. Thus, we did not need to incorporate a water cleaning system in this project's facility design. However, certain cleaning methods can be seen in Appendix C.

Informal Settlements

Informal settlements are found around the world. They are, as the name suggests, regions of a city where people have made their home by building some sort of makeshift shack. Chief Planner Kisting explains that people in the informal settlements of Windhoek build their shacks on government owned land and pay a rent to cover developmental costs of the City of Windhoek. Some of the settlers have a low income from the textile factories such as Ramatex or private businesses within the settlements, while others have no income at all (personal communication, 16 March 2004). Clark University Professor Timothy Downs (see Appendix D) notes that in many places around the world, people build their homes wherever they find land in the informal settlements; there is no rationale for a particular spot, other than the fact that it is available. Since people do not know their neighbours, there is little sense of community (personal communication, 5 February 2004). WPI Professor Creighton Peet, who has years of experience in Nepal and Taiwan and who advised six projects in 2003 in Namibia (see Appendix D), elaborated about Windhoek by saying that it is unlike many informal settlements around the world. In many cases, people actually live with their own ethnic group, which then causes a sense of community (personal communication, 9 February 2004). Understanding informal settlements in general is important, but understanding the Windhoek informal settlements in particular will offer more to the project.

The City of Windhoek (2001) has estimated that the informal settlement population of the city in 2001 was approximately 65 503 or 26.04 percent of the total population of the city. This number was growing from 1995 when only 15.41 percent of the population lived in the settlements. Windhoek anticipates this number will continue to grow in the near future. In 1997, the City released numbers indicating that of the registered 8 171 households, only 2 200 households were settled in areas with communal services. This indicates that the majority of registered settlers did not have communal services, and if most registered settlers did not have these services, it may be safe to say that unregistered settlers also did not have them.

Windhoek Northwest Settlements Today

The Sustainable Development Division of the City of Windhoek has implemented toilet facilities in the Northwest Settlements, some of which have met with difficulty in the areas of vandalism, allocation of use, and theft of parts. Figure 1 shows one of the many facilities that have been installed. According to Harold Kisting, a city standard maximum number of forty-five people can share a facility. The average household size is 4.2 members, thus making a maximum of eleven household's per facility (personal communication, 29 March 2004).

Figure 1: Toilet facility constructed in the Northwest Settlements (16 March 2004)

Many of the corrugated iron roofs on these facilities were suspected to have been stolen by the community members and put to use as additional siding for the makeshift shacks. H. Kisting says the situation is puzzling as to why many of these facilities are mistreated or used for alternate purposes (personal communication, 16 March 2004). Figure 2 shows a typical makeshift shower structure used by the settlers while Figure 3 shows the improper draining of these structures and the grey water that accumulates from this improperly disposed washing water.

Figure 2: A typical makeshift shower structure used by the settlers of the Northwest Settlement (16 March 2004)

Figure 3: Improper draining of makeshift structures conducive to grey water surface pools in the Northwest Settlements (16 March 2004)

Often the grey water (see Glossary) will accumulate on one's lot after the use of a makeshift shower structure. According to H. Kisting, in order to dispose of these displeasing puddles, some of these settlers have extracted the piping from the facilities or other areas and laid them in a trench sloping downward away from the lot. This leads to roadside puddles and thus the environmental degrading for the surrounding community resulting from efforts to free one's lot from grey water build-up. He marvels at the intelligence and creativity in these communities that might be harvested for progress but at this moment detract from the success of the integration of these facilities (personal communication, 16 March 2004).

According to J. Korrubel, Director of the Habitat Research and Development Centre in Windhoek, for long-term maintenance of City-implemented facilities, it will be advantageous to provide a means for personal employment (personal communication, 17 March 2004). This is because personal businesses thrive in the Northwest Settlements, whether they are as simple as basic car repair or bar ownership.

Plumbing Technologies

It is important to understand the plumbing strategies used within homes to gain a basic understanding for what has already been done successfully, what could be implemented in the informal settlement washing facilities, or what could be modified and implemented. Systems have been developed to save water and control where clean water and wastewater travels within our homes. These pre-tested methods will likely be considered in the design of the washing facilities for the Northwest Settlements and are explained in Appendix E.

WPI Professor John Bergendahl stated in an interview (see Appendix D) that efforts to use America's standard plumbing techniques such as the use of copper and PVC tubing with pumps may be too costly for an area such as Windhoek's informal settlements (personal communication, 29 January 2004). He suggested another method where some sort of large plastic floor might be implemented with a slope to a certain focal point in the centre of the facility. This way, all the shower water would collect into this large pool or 'settlement tank' with no losses, save evaporation.

A siphoning process could be used to drain the water from the plastic settlement tank through a sand filter. As sand would not be a scarce resource in Windhoek, this type of filtering might be considered. Bergendahl believes that there is a possibility the sand filter would clean most of the impurities and maybe some soap detergents out of the water, but would not rid the water of all bacteria and pathogens. The sand filtering method may be sufficient for a few cycles of the water, but at some point, the bacteria and pathogens would need to be eliminated.

Bergendahl made the suggestion of chlorinating the water after filtration to take care of this problem. He was also sure to mention the downfalls of using chlorine and said that the chlorinated water would need to sit in the sun to be converted to chloride. After the water has been reused a few times, it may then be used for irrigation or watering trees. However, he warns that an excess of chloride may cause agricultural issues.

Simply collecting the water would be a step in the right direction. Bergendahl's ideas, though low cost, may or may not be appropriate to this project, as a design prone to bacteria build-up and constant siphon filtering could prove to be short-lived. According to our sponsor, the project's facilities may simply collect the wastewater, as water filtering and recycling will be done at the reclamation plant.

Bergendahl's ideas, however, are notable in areas where there is minimal access to such water cleaning facilities.

Prepayment Systems

The washing facilities will need a payment system. In order to avoid problems such as payment refusal by the users, it was advantageous to research successful prepayment methods that might be implemented in the informal settlements of Windhoek.

M. Rabe (2001), the Deputy Director of ESI Africa Water Sub Directorate, reports on Mogale City, South Africa, where a decision was made in 1998 to implement prepayment water meters in residential areas financially similar to the informally settled areas in Windhoek. It was decided that all existing connections would receive those water meters and any additional customers would have the option to apply for a prepayment meter. Those meters were constructed on the customers' property in efforts to create the concept of ownership. The initiators of such a plan realized in the beginning the need for community acceptance of such a system. Large meetings were held in the target communities combined with a distribution of informational pamphlets. After the researchers started to foresee success in this new system, a door-to-door advertisement scheme was implemented to encourage new applications. Results showed the prepayment meter plan to be extremely successful as evidenced by extremely low vandalism rates and the abundant inflow of applications.

In a case study for Kagiso, a township of Mogale City, an area of low income and high unemployment rates, Rabe reported that prepayment was accepted. Though there are differences between Mogale City, South Africa and informal settlements in

Namibia it is still beneficial to see how people respond to prepayment meters in a variety of low income areas. In Mogale City, every site had its own personal meter. Results indicated that the total water supplied to the area decreased, the total cost to supply the water decreased, and the average income to the City from water bills of the inhabitants increased. As with any new system, there were problems. Meters and fittings would sometimes leak, the batteries would fail, and electronic communications would sometimes break down. Rabe concludes from these studies that success in prepayment requires intense time commitment from the service provider to keep the meters functioning technically, but is beneficial in the long-run because the responsibility of water consummation is placed on the consumer or rather the community (Rabe, 2001). The benefits and drawbacks of such a system will need to be weighed before prepayment is implemented in this project's washing facilities in Windhoek.

In some parts of Namibia, water meters have been installed so payment can be applied according to use as seen in Figure 4.

Figure 4: Prepayment water meter in Havana Northwest Settlements, Windhoek (16 March 2004)

In two informal settlements of Katima Mulilo, Chotto and Kabwe, there has been vandalism on these meters with damage costs in excess of N$80 000 (The Namibian, 26 June 2003). The town clerk has reported that more water meters will continue to be installed in the settlements. It is clear from the vandalism that someone does not want the meters and does not want to be charged for the water. In the city of Rundu, the Mayor has asked the citizens of the informal settlements to use the new pre-paid water systems. The Mayor has already made threats to the citizens, saying if they do not use the new system, the City Council would close access to the water pipe in the troublesome areas (The Namibian, 9 July 2003). Months later, NamWater stopped providing fifty percent of the normal water amount because people were not paying for the water (The Namibian, 4 September 2003). There is obviously a need to involve the community in these conservation projects in order to make the City's concern everyone's concern.

Low-income communities are not unwilling to budge when it comes to paying for water. A pilot study was done on Ciudad Juarez, Mexico, a water deprived city across the border from El Paso, Texas. This study demonstrated that even the poor were willing to pay for water, provided it was clean, reliable, and not heavy on cost. This example came from a community where the water users were involved through community development in the planning and designing of the water source that belonged to them (Downs & Suffet, 2002). Similarly, reliable sources of water from prepayment metres have been implemented by the City in hopes that the community will be more receptive to paying for their water.

Some meters have been carefully designed for technological reliability to improve community acceptance (Metering International, 2002). The manufacturer, Syntell, claims no batteries or parts with limited life are used to eliminate the need for routine maintenance, the components in the design are composed mostly of plastics whose lack of value discourages theft, and the meters are easy to install and operate (Metering International, 2002). It is important to foresee potential problems with the community's reaction to these meters and compensate for these in the design, as it is very unlikely the inhabitants of Windhoek will be initially receptive to paying for water that was once free. If the system uses batteries, community frustration will arise from breakdowns. If the system contains valuable parts, members of the community could try to steal its parts and thus destroy the product's ability to function. If it is complex, unnecessary frustration might be expected. Technological advancements thus reduce the need for frequent servicing by the City as well as reduce frustration levels in the community resulting from broken meters unable to dispense water.

Public Policy: Water and Health

Before one decides to implement prepayment meters, public health impacts must be questioned. In developing countries, many die from diseases due to lack of clean water. In South Africa, a case study was done in 2002 on a cholera outbreak in the Madlebe Tribal Authority areas. The conversion to prepayment water facilities resulted in what was essentially a water cut-off as the citizens could not or would not pay. This in turn caused many deaths due to water-borne diseases from the use of impure alternate water resources (Public Citizen, 2004). Thus, before any prepayment meters are used in Windhoek's water facilities, careful planning and gathering of information will be needed to ensure that these people will have a means to afford and access clean water. The issue of the City's involvement in the daily lives of the informal settlers can already be seen in Windhoek.

At the moment, 314 toilet facilities have been installed for the estimated 80000 people living in the Windhoek informal settlements (Tjaronda, 2004). Unfortunately, many of the facilities are locked so no one can use them. Figure 5 shows two locked toilet facilities in the Havana Northwest Settlements.

Figure 5: Two locked toilet facilities in the Havana Northwest Settlements whose keys are owned only by designated households (16 March 2004)

Tjaronda (2004) reports that the City is collecting information on who the registered settlers are and who the illegal settlers are. According to the City's public relations officer Ipupa Davids, once the City has an accurate idea about who should be allowed to use the facilities, the City will assign people to their toilet facility. When a community has been assigned to a particular toilet facility it will be unlocked (Tjaronda, 2004). Public policy becomes a larger issue when government parastatals make life altering decisions such as allocating water use.

NamWater is the government parastatal that distributes water throughout Namibia. NamWater does not give water away for free. Instead, they rely on payment from local authorities. If NamWater does not receive payment, they are left with the decision of how to react. If they shut off the water to the community, people could die. If they do nothing in response, then people have no reason to pay their bills.

To address the issue of non-payment, NamWater has reduced the amount of water provided to Rundu, a City in Northeast Namibia. In 2000, NamWater reduced the amount of water provided to Rundu by twenty-five percent because of a N$5 million debt (The Namibian, 9 November 2000). In 2003, a fifty percent reduction in water was placed on Rundu for a continuing debt in the millions of dollars range. In addition to the latest reductions, NamWater completely shuts off the water in the evenings (The Namibian, 4 September 2003). The reductions have caused problems that range from the inconvenience of low water pressure at home to hospitals not having enough water for doctors to wash hands and clean surgical tools (The Namibian, 4 September 2003).

Community Development

H. Swanepoel has had much experience with community development in South Africa. She stressed the importance of community involvement, advocating that even the poorest of individuals are entitled to be a part of any decision making process (Swanepoel, 1997). G. Gran, who is also experienced in community development practices, states "it should be clear by now that…development cannot and should not be externally managed. More properly, development should be but lightly guided" (Gran, 1983). Thus, the community must be fully involved so deeply that they become the driving force behind their own development, more so than the government or other outside position in power.

In order to initiate involvement in the community, the community must first be enlightened about what needs to be improved. This must be the initial foundation laid to add a sense of purpose to any following community action (Swanepoel, 1997).

According to Urban Dynamics (2003), who are town and regional planners for the City of Windhoek, projects in the informal settlements performed by the City of Windhoek indicated the importance of placing maintenance and management responsibilities on the community. The City has not been able to support the regular service demands in the informal settlement areas of Windhoek. In order to involve the community, the city is developing an educational program in the Havana Extension 1 settlements so the citizens of Havana Extension 1 might be trained in areas to make them more responsible citizens. This includes education on use and maintenance of facilities, community health, physical services, and solid waste disposal. This training is designed to place the community in charge of its own welfare: maintaining its water points, having the power to raise pricing under their own initiative to pay for upkeep, leading against vandalism, and fixing damages themselves while charging those responsible. The Sustainable Development Division anticipates that a successful solution, which helps a community manage itself, will then be pursued in other similar settlements (Urban Dynamics, 2003).

A case study was done on the restoration of the Goreangab Dam area in Windhoek (Namibia Resource Consultants, 2000). The goal of that project was to develop a citywide environment awareness campaign and create a cleaner environment surrounding the dam including a reduction in pollution. The project was overseen by the Goreangab Action Committee (GAC), which was created by the Windhoek City Council in 1996. GAC educated the community in hopes for long-term sustainability through public awareness and involvement. One of the initial phases in that project was to train the members of the city council and community in Environmental Impact Assessment (EIA) so that the project might be run largely by

volunteer labour. The results of the EIA and prepared management plan for the dam were discussed with the community leaders.

The next phase was to offer incentives for community participation. Topics about how the project might address the community's social and economic needs were considered and compromise was met through a few satisfied conditions of the community: the community might use the established reed beds and surface aquaponics (see Glossary) for income, and the city would improve the informal settlement public toilet facilities and connect household toilets to water and sewage pipelines. The Faculty of Agriculture at the University of Namibia took leadership of the reed beds and aquaponics project while the community members were being trained. After a while, the community would adopt this project and begin to make money for themselves. The success of involvement in this project was mostly a result of social and economic benefits extended to those in the Greenwell Matongo settlements on the border the dam.

Involvement of the city residents, however, was not fully successful. GAC attributed this to the failure of the awareness campaign to communicate the dam's importance to the city's water supply and environmental sanitation and health. The educational awareness program that was implemented only stressed the dam's importance to those within its immediate boundaries. Additionally, they believed that this project's success was restricted when the city council assumed too strong of a leadership position in the project. As a result, the Namibia Resource Consultants learned some lessons from this case. They believed that if the community involvement had been more widespread, more community enthusiasm would have resulted. They attributed their fault in this area to the fact that when dealing with citywide problems, the immediate community demands were easier to satisfy, and

thus the city's demands were put aside. Long-term complete educational programs on environmental issues were deemed necessary before one could expect citywide results. In retrospect, the project facilitators believed they missed some opportunities to involve the community and thus create a greater sense of ownership.

Although their experiences with the community-led Environmental Impact Assessment increased the project work's duration, its success proved to them the power of community participation and consultation as well as the capacity of the community to implement long-term management. Furthermore, that project proved the vitality of incorporating non-government organizations (NGOs), as they increased the ability of the local authority to deal with community-based environmental programs. They concluded that the participation of these NGOs would be crucial to the long-term success of large-scale environmental procedures (Namibia Resource Consultants, 2000).

That case study shows how vital it will be to incorporate the community in the conceptual design of Windhoek's public washing facilities. It may be beneficial to review some successful methods used by those who have had extensive experience in community development to see how they mirror the successes found in the previous examples.

Clark University Professor Richard Ford (see Appendix C) has had numerous successes with community projects in several locations around Africa. Ford worked closely with the people of the community of Mbusyani, Kenya to identify the primary issues that they needed to address. The resulting issues that became apparent were that they were struggling with water shortages, health problems, food production, and employment. Using the community's input to evaluate what could be done to resolve their issues, Ford and the community were able to make plans and then advancements

(Ford, 1998). By involving the local people, Ford and his team were able to identify their problems and systematically work to reach lasting solutions.

Through Ford's experiences, he learned the importance of community involvement. Through community involvement, everyone working on the project is able to better understand the needs and wishes of the community. In addition, if the project is done in close collaboration with members of the community, the community is more likely to take ownership and responsibility of the project (Ford, personal communication, 21 January 2004).

Swanepoel (1997) believes community development, in general, makes the community aware of their need to awake themselves to potential objectives for improvement. Once they gain the skill to observe their situation critically, they may become aware of other areas of need. Thus, one community development project often leads to others due to the sole initiative of the community that has resulted from gaining this new observational training (Swanepoel, 1997).

In any community development project, the leader must not ignore the obstacles of illiteracy, dependency, or apathy (Swanepoel, 1997). Illiteracy may result in a community member feeling a sense of inferiority, leading to withdrawal from the project. These individuals tend to fear their contribution may not be worthwhile. In other situations, the community becomes so dependent on the frequent guidance of government organizations, that they lose the will to volunteer for the well-being of the community. They therefore begin to expect payment for their efforts. Lastly, some individuals in the community accept their poor financial status and prefer to pity themselves, accepting poverty as a part of life. Innovation tends to scare these individuals because of the risk that their contributions might be done in vain (Swanepoel, 1997). Those obstacles cannot be ignored, but rather must be

overcome in the process of community development. Recognizing, addressing, and accommodating these obstacles wherever possible is essential for any community leader (Swanepoel, 1997).

CHAPTER 3. METHODOLOGY

Project Goal

Our project goal was to work with the City of Windhoek and the community leaders of the Northwest Settlements to form a joint solution to the need of communal washing facilities. These facilities included a shower and a toilet. In order to reach this solution, we needed to involve the community through considering several objectives.

Objective One was to develop a *Building Plan* that included a modular building design checked for feasibility and presented to the community for recommendations.

Objective Two was to discuss the issues with prepayment and to create a set of recommendations for a *Pricing Structure* that met both the needs of the City of Windhoek and the needs and financial constraints of the inhabitants of the informal settlements.

Objective Three was to develop recommendations for a *Maintenance and Management Plan* that would be run effectively by the inhabitants and would provide employment for locals.

Methods

Throughout the course of the project, we helped the community realize the need for improved washing facilities, as well as involved them in decision making processes.

While spending a day at the Shack Dwellers Federation of Namibia (SDFN) office in the informal settlements, we were introduced to community leaders

representing the people of their community. We intended to use purposive sampling (see Glossary) to specifically search for community leaders from multiple communities, followed by snowball sampling (see Glossary) to find more of these leaders. The only individuals at the SDFN office, however, were community leaders, and thus we used convenience sampling (see Glossary) among these leaders for candidates in our discussions. We chose to work directly with community leaders due to lack of organization and communication barriers that we found when we attempted to work with the general public. In a meeting with ten community leaders who volunteered to meet with us, we discussed what each one knew about water conservation and sanitation issues. We looked for response patterns from these individuals that indicated a general understanding of the project and the need for an improved washing facility. After this meeting, we discussed our project with approximately fifty-five leaders from multiple communities, where we achieved more complete representation of the Northwest Settlements and a larger variation of ideas. To minimize language and cultural barriers between ourselves and the informal settlers, we used a student translator from the Polytechnic of Namibia, Profilius Halwoodi, who had experience working with these communities.

Once we were aware of the community leaders' understanding of the need for washing facilities, we met with a different group of six community leaders at the SDFN under the same volunteer selection process used previously. We discussed the existing problems with the makeshift washing structures as well as the people's needs. Through this exercise with the leaders, we explored the topics of severe health issues due to lack of washing and the present water crisis. This helped to reveal the need for modification to the current situation of unsanitary grey water accumulation and water wastage.

Objective 1: Building Plan

In order to learn about the physical current washing structures in the informal settlements, we inspected ten existing makeshift structures in the Northwest Settlements of Havana, Okahandja Park, and Greenwell Matongo, focusing on their outer wall construction, the floor surface, and the water runoff. Additionally, we observed four different types of toilet facilities implemented by the City of Windhoek in the Okahandja Park and Havana settlements in order to better understand some previous solutions. In meetings with professionals in each of the areas of architecture, water engineering, bulk and waste water engineering, and project management, we discussed dry and wet toilet designs, washing facility designs, low-cost practical building materials, and methods for recycling grey water.

Integrating techniques we learned from these professionals, we created a draft of a simple modular building design that would allow for both short-term relief, as well as capability for later upgrading when financial resources become available by the community members. This draft merely included a toilet, a drain for immediate alleviation of the standing grey water problem, walls to provide privacy, and a personally filled tank for manual showering. This design's simplicity and basic functionality leaves room for future improvement by the community, gradually increasing their ownership of the facility. We visited the existing toilet facilities in Okahandja Park to record their structural dimensions and evaluate the qualitative characteristics such as sufficient lighting and aesthetic appeal that might serve a purpose in our facilities.

After formulating our rough physical building design, we brought it to the community leaders at the SDFN office for their initial thoughts and impressions about its viability. Using their suggestions and our previous findings, we drew up a

modified dimensioned design and brought it to ROCLA, a local building company, to confirm its feasibility. Through contacts with the Builder's Warehouse and Pupkewitz Megabuild, local building supply warehouses, we priced materials to be used in the design and compared the two companies' costs. We presented these technical drawings and costs to the community leaders of the Northwest Settlements at the SDFN office, receiving feedback on design alternatives. This allowed us to modify our design in a way that satisfied the community. After a final consultation with ROCLA, we drew up a final detailed design for submission with this report.

Objective 2: Pricing Structure

To better understand the current flat monthly rate payment plan in the Northwest Settlements, we researched the amount and method by which each household pays. We did this by referencing city statistics. In order to find an alternative to this system that can result in non-payment and lack of motivation to conserve water, we investigated prepayment systems in which the community members would need to pay immediately for any consumption. In a meeting with the Chairman of Nossob River Systems, a Namibian prepayment meter company, we discussed the benefits, technical advances, and the problems with the meters, as well as their potential for implementation in Windhoek's Northwest Settlements. Due to the controversial issues surrounding prepayment and its application to the poor, we pooled various sources for experienced opinions on the subject. These sources included a water engineer from the City of Windhoek, the Chairman of Nossob River systems, a Community Development Officer for the City of Windhoek, and two recent Namibian articles: "Labour study slams water charges as 'new Apartheid'" and "No free water, says Angula", and the Labour Resource and Research Institute's

March 2004 report on water privatisation in Namibia. Lastly, we spoke to fifty-three Northwest Settlement community leaders at the SDFN at one of their weekly meetings to allow them to express their views on prepayment. Due to the complexity of the controversial issue of prepayment and its potential injustice to the poor, we aimed to produce recommendations rather than a solution for a pricing structure.

Objective 3: Maintenance and Management Plan

The implementation of a maintenance and management plan is essential for the long-term success of our proposed facilities. We discussed maintenance and management plan strategies with a Community Development Officer for the City of Windhoek, and consulted a plan for the Havana Settlement written by Urban Dynamics, a local community development company who works for the City of Windhoek. According to Harold Kisting, the Chief Planner of the Sustainable Development Division of the City of Windhoek, the City has a standard maximum of forty-five people who can share a facility (personal communication, 29 March 2004). In our meeting with the fifty-three community leaders, we discussed with them the feasibility of reducing the number of people assigned to each facility based on how much money they were willing to pay for the facilities. This, we felt, would increase the sense of ownership for each household, and thus increase the likelihood that household members would do their part to keep this facility maintained. Additionally, we proposed a rotation of shared duties plan in which each household would be responsible for the upkeep of the shared facility through a daily rotation. Lastly, we discussed training a few locals in the areas of maintenance and upgrading techniques. This would serve as potential employment of these individuals as each group of households gradually gains the resources and desire to upgrade their shared facility.

These plans aimed to keep the facilities self-sustained, allow accessible bathing to all, and dissuade people from using improper draining structures.

By establishing partnerships, utilizing community leaders representing the Northwest Settlement population, and informing the citizens of the necessity of our project, we established community involvement, the initial step of project ownership, which we hope will lead to a self-motivated and self-sustained community.

CHAPTER 4. RESULTS AND ANALYSIS

Community Involvement

It was important to meet with the community leaders to discuss their problems, needs, and wants in a washing facility. This would allow them to share in the development of the project. The community leaders' unanimous attitude was that communal washing facilities are needed.

In the first part of our meeting with ten community leaders at the Shack Dwellers Federation of Namibia (SDFN) office on 30 March 2004, we discussed why installing shower and toilet facilities in the Northwest Settlements to replace the existing makeshift structures would be needed. Some of the leaders acknowledged that the problems with the existing washing facilities were the water runoff, the smell due to this water collecting in puddles, as well as mosquitoes finding a breeding place in these pools of water.

In the second part of the meeting, we uncovered many issues that the community had about their future washing facility. The primary concern that most of the community leaders expressed was the issue of who would pay for the facility and how much it would cost. According to some leaders, their current cost of water was N$20 to N$30 per month per household. Some leaders felt that there was no need for prepayment meters, believing the current method of payment worked well. Many of the community leaders attending the small community meeting expressed support of dry toilets and noted the benefits of water conservation. They had seen dry toilets in many of the communities and did not view them as inferior to flush toilets. Dr. Anna Miller, the director of Namibia Housing Action Group (NHAG), conducted the large meeting at the SDFN and expressed much scepticism towards the use of dry toilets

because of their very high initial cost of about N$5 000 (personal communication, 30 March 2004).

The community explained the current state of both the washing and toilet facilities. At the moment, approximately twenty people share the same toilet facility in the informal settlements. These toilet facilities were installed and are maintained by the City. One leader who represented the Habitat Two informal settlement community of the Northwest Settlements said that relying on the community to share the duties of cleaning and maintaining a facility would not be a very large or difficult issue. She supported the idea of a daily rotation of cleaning duties among the different households. Today, the daily rotation of cleaning duties system is not used because the City has taken the responsibility of cleaning the facilities.

The community leaders had some concerns about problems associated with the installation of public washing facilities. One of these concerns was the people's security at night. This security issue, they believed, applies mostly to women, who would not feel comfortable walking alone at night to go to the toilet or shower. In order to alleviate this problem, they suggested a larger number of facilities should be built closer to people's homes so that people would only have to make a short walk from their homes to the facility. Another problem that leaders expressed was that they would not like to have to wait to take a shower, a potential problem that may arise if too few facilities are built. If people will have to wait to take a shower, they may be inclined to not use the facility and return to showering at their convenient makeshift structures.

Building Plan

After meeting with the community to better understand their situation and what they would accept in a washing facility, we developed a building plan which included the design of the material, structural, shower, toilet, and plumbing components of the facility.

Building Materials

The surrounding structure of the toilet and shower units is essential as it will provide the privacy, aesthetics, and security important to the community users. Low cost and practical building materials were necessary in the construction of the building plan. The fact that these facilities will be relatively small and shared by only a few households also affects the building materials that will be practical.

Nina Maritz (personal communication, 17 March 2004), the architect of the Habitat Research and Development Centre (HRDC) building, which is currently under construction, is implementing the use of a variety of innovative building materials in its design. Maritz's goal for this building's design was to explore a variety of alternative building materials to support energy efficiency, decrease cost, and increase living comfort. Of the many options for building materials that she explored, the ones that she believes may be practical for use in a washing facility include: interlocking bricks that require no mortar, compacted soil mixed with a small percentage of concrete, and used tyres filled with sand.

The interlocking bricks used for part of the construction of the HRDC are visually appealing as the reader can judge from Figure 6. Maritz stated that these bricks can be made on site, but they do require the rental of a machine for brick compaction. Unfortunately, she indicated that the machine is quite expensive and

would only be cost efficient if used for large projects (personal communication, 17 March 2004).

Figure 6: Interlocking bricks to be used for the walls of the Habitat Research and Development Centre

Another structural material that Maritz used in the building of the Habitat Research and Development Centre (HRDC) that was a candidate for our design was compacted soil mixed with four percent concrete. This material provides adequate strength and resilience against water erosion. Figure 7 shows a display of these compacted soil walls. On the left is a wall made of compacted soil with a mix of four percent concrete. The right side shows a wall made purely of compacted soil with no concrete added. The wall without any concrete was sturdy but could crumble fairly easily when the edge was pushed. The left wall with the concrete added could handle a lot more wear. Maritz noted that the walls composed of this material can be made and constructed completely on site and by local people with little training (personal communication, 17 March 2004).

Figure 7: Compacted soil wall samples at the Habitat Research and Development Centre. Left half shows compacted soil with four percent concrete. Right half shows compacted soil with no cement.

Another innovative use of materials for a wall structure was the use of tyres to house the safe and archive room in the HRDC. This building material has already been used in California (personal communication, 17 March 2004). Maritz designed the walls for the HDRC with free old tyres from tyre businesses, since giving the old tyres away for free saves these businesses the cost of disposal. The walls were constructed by stacking the tyres like bricks while filling the insides of them with sand. Figure 8 shows this type of tyre wall structure.

Figure 8: Tyres used as a building material for walls at the HRDC

These walls work very well for insulation and are fire resistant. The walls could be painted for better appearance or even covered by another material to increase their visual appeal (personal communication, 17 March 2004).

Another more conventional option for a building material is to use bricks. There is a local company in Windhoek, China Great Wall, which retails red bricks. The costs involved with this wall type would include only the cost of the bricks and the mortar. Maritz said that the labour of laying the bricks could be done by the community, which would help to create a sense of ownership of the facility. This material option would keep almost all of the business within the Windhoek area (personal communication, 18 March 2004). See Appendix B for the minutes from the 18 March 2004 Maritz meeting.

Pre-casting structures (see Glossary) with cement is another viable way to construct the facility. The ROCLA Company offers this service and has a location in Windhoek. They offer two standard structures that could be used for shower and toilet facilities. ROCLA's Windhoek Branch Manager, J. J. Oberholzer, stated that

pre-casting a different structure would require that a new mould (see Glossary) be built, which would cost an estimated N$150 000 to N$200 000. This high cost reduced the selection to the two existing options. In both of the following structures, almost any types of fittings or equipment can be cast into the walls for no extra cost over the cost of the fixtures or hardware. Holes to let in light can also be included in the casting at no extra cost (personal communication, 6 April 2004). See Appendix B for minutes from our 6 April 2004 meeting with ROCLA.

According to Oberholzer, the first option for a pre-cast structure is the concrete toilet shelter, which can be seen in Figure 9. The cost of this is N$1 500, which only includes the concrete casting with no fittings or doors. Oberholzer said, for no difference in price, the mould (see Glossary) could be adapted so that the structure can be equipped with either shower fittings or toilet fittings (personal communication, 6 April 2004).

Figure 9: ROCLA concrete toilet shelter (6 April 2004)

Mr. Oberholzer described the second option for a pre-cast structure as a concrete unitized bathroom. That structure is slightly more than twice as large as the first option, with a height of 2.24 metres, a width of 2.00 metres, and a depth of 1.52 metres.

The cost of this model, according to Oberholzer, is N$3 400, which like the first option, includes only the concrete structure (personal communication, 6 April 2004). See Appendix F for dimensioned drawings of both structures. In a meeting with fifty-three community leaders of the Northwest Settlements, the leaders told us they preferred the larger structure over two of the smaller structures if a dividing wall was placed down the middle of the larger structure to divide it into two private rooms (personal communication, 20 April 2004). The dividing wall would allow for

someone to use the toilet half of the facility while someone else is showering in the other half. Vance, a technical advisor for Namibian Housing Action Group (NHAG) and a resident in the Greenwell Motango Settlement, also expressed his preference was the larger structure (personal communication, 16 April 2004). In addition to community preference, there are other reasons for the selection of this design over other material designs as the surrounding structure to be used to house the toilet and shower units in this project. See Appendix B for minutes from our 16 April 2004 and 20 April 2004 meetings at the SDFN office.

ROCLA is able to pre-cast any piping within the concrete walls, adding to the durability of the design. No pipes will be exposed and thus theft will be reduced. According to Heike Cronje, a Town Planner for the Sustainable Development Division of the City of Windhoek, ROCLA was a little less expensive than Adcon, their pre-casting competitor in Windhoek. Adcon was used by the City of Windhoek in the recent implementation of the toilet facilities in the Havana Settlements only because ROCLA was busy with orders at the time the project needed to progress (personal communication, 23 March 2004). Lastly, this specific ROCLA branch is located in Windhoek, and thus delivery costs will be reduced and local employees supported.

Aesthetics

According to Architect Nina Maritz, one must not overlook aesthetics when designing a facility to simply meet the basic needs of a population. A facility must not only be visually appealing to the users on the inside and outside, but it also must have every aspect designed for its use by people. Maritz stated that it is very

important for the users to appreciate a facility so that they accept it and are motivated to take care of it (personal communication, 18 March 2004).

Maritz advised us to involve the community in painting the facilities. That would be an inexpensive way to involve the community in creating aesthetic appeal. A more expensive technique might be to build a round structure rather than the standard box shape. She feels that would be more visually appealing as well (personal communication, 18 March 2004).

Stefani van Zyl from Urban Dynamics in Windhoek also discussed some aesthetic ideas (see Appendix B for minutes from our 25 March 2004 meeting with Urban Dynamics). She was concerned about the possibility that there would not be enough lighting inside (personal communications, 25 March 2004). If the facility is too dark to use, then people are not going to use it. According to Kisting (personal communication, 25 March 2004), the high-mast streetlights in the informal settlements flood the areas with light at night. The lighting from the high-masts will be able to enter the facilities through the light holes in the walls. Maritz made the suggestion to have a small gap above and below the door to allow light from the sun and the high-masts to enter the room (personal communication, 18 March 2004). The completion and handing over ceremony for the high-mast lights to the Havana community occurred in March, 2004. Though not all the settlements have been supplied with these lights, Kisting adds, the project is in progress for most areas (personal communication, 22 April 2004). The issue is how to provide enough light into the facility from outside. Maritz and van Zyl had similar ideas on how to approach this dilemma. Van Zyl agreed with Maritz's idea of leaving a small gap above and below the door and suggested looking at the current toilet facilities for lighting techniques (personal communication, 25 March 2004).

Quick Fixes

Sometimes the best solution for an informal settlement cannot be implemented at the desired moment. Reasons that prohibit installations include lack of immediate funding or rough terrain where piping cannot be installed underground without the use of heavy machinery. In cases such as these, quick fixes can be used. Quick fixes are solutions that relieve the current situation and are intended to develop into a more permanent solution. This can be done by constructing a modular design, within which is a pre-planned design for permanent potential. As resources become available, the quick fix may easily be upgraded into the long-term fix.

The problem of grey water runoff from the existing makeshift washing facilities can be solved with a quick fix. Section Engineer J. A. Burger of the City of Windhoek says a quick fix in this instance could be a concrete slab one meter by one meter (personal communication, 24 March 2004). This slab would collect the grey water and direct it down a drain into the municipal sewer system. This would be easy to implement because people in the informal settlements already have their own makeshift structures, which could be placed over the concrete slab. All that would need to be provided would be the concrete slab and an underground pipe layout. This would be quicker to implement than a full washing facility with running water, walls, a roof, and a door (personal communication, 24 March 2004). In the future, when the community gains the resources and desire, these additions could be made. Although this solution will not be the most convenient to use and aesthetically appealing, it will solve the most important problem by eliminating the stagnant pools of non-recycled water. This solution is also less expensive and would allow for many facilities to be

installed, eliminating the potential problem of people having to wait to use the facilities.

Quick fixes do not just apply to the building of the whole structure; they can be applied to one part of the structure. One key element of a washing structure is running water. Laying pipe work for running water is not easy in the informal settlements of Windhoek due to the rough terrain. The communities already have running water at a local standpipe, which they use for all their water needs, including bathing. Kisting says a quick fix in this situation is to have the community carry buckets of water from their standpipe to the new washing facility (personal communication, 24 March 2004). This will not be any extra work for people since this is what they are doing today with their makeshift structures. Inside the new washing facility, people can pour the water into a bucket above their heads and the water will come out the showerhead if the person wants a shower. If the people want to wash without the shower, as they do today in their makeshift structures, they can wash themselves with the water they bring to the facility. This facility's solid wall structure would provide more privacy than the existing makeshift structures, and would include the capability for future direct water connections when resources become available.

Quick fixes are not the final solution to any problem. They exist to give temporary relief when needed. With this in mind, it is important to take into account what will be needed in the future and make simple recommendations about how to make the design capable of future modifications.

Use of Grey Water

Grey water is domestic wastewater including sink drainage, washing machine discharge, or bathwater. This does not include any water containing human excrete (EPA Glossary, 2003). It is important to reuse grey water as much as possible in the dry country of Namibia. There are multiple methods for reuse, whether they are using the water multiple times for different applications or sending the grey water back to the Goreangab Reclamation Plant for processing into a new potable source.

We discussed methods with Architect Nina Maritz on recycling grey water. The first was feeding the grey water from the shower to nearby trees or other agriculture. There would be a few potential problems with this method according to Maritz, as over time, harmful soap detergents might pollute the soil (personal communication, 18 March 2004). According to H. I. Peters (personal communication, 24 March 2004), the Chief Engineer for Technical Support for the City of Windhoek, using a filter for the soap would not be a solution to this problem since filters quickly clog with soap and hair.

We also discussed a possible design with Maritz, where the water drainage from the shower might be stored and used to flush the toilet. We found that this design would prove to become too complicated, as it has many inherent technical issues such as frequent filter clogging. This design concept is seen in Figure 10. See Appendix G for technical details on the workings of this system as well as obstacles in the design.

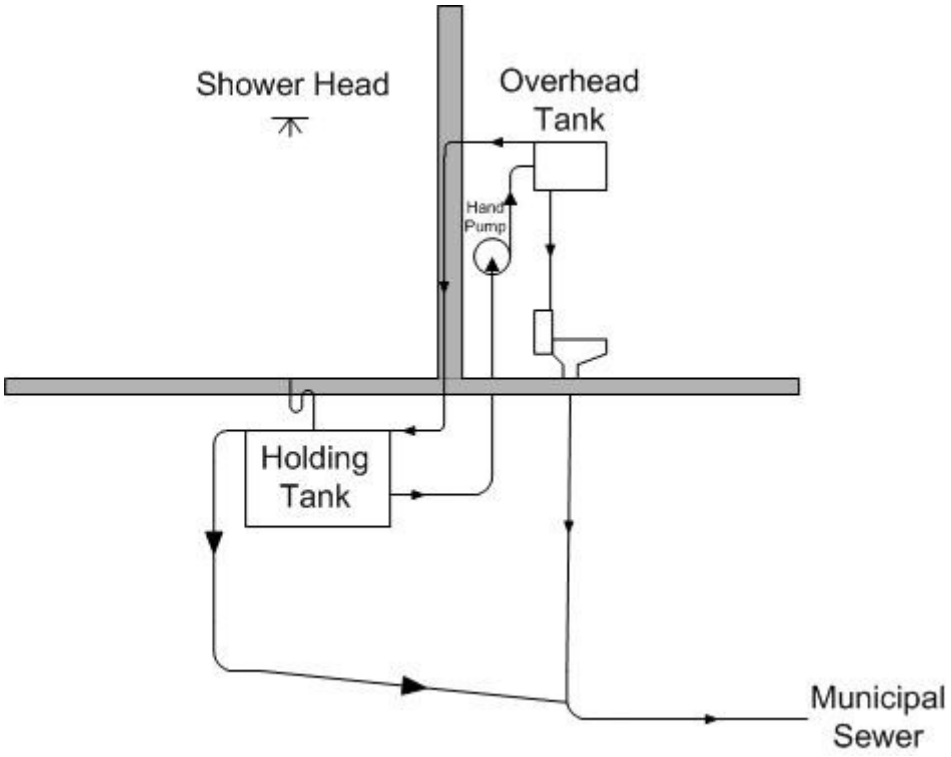


Figure 10: Shower water reuse design concept

Theft of Parts

When designing any building plan, it is important to consider the potential for theft and vandalism in the low income urban areas such as the Northwest Settlements. The building design must be as rugged as possible in order to protect the facility's long-term functioning.

Many sections of the informal settlements of Windhoek have homes built with free materials. Specific materials were discussed in our previous section entitled "Building Materials". People will find free materials to use, and in some cases, they will steal the materials. When designing a structure to be placed into the informal settlements, it is important to take into account the fact that some people will want to steal parts for their own use. However, our structure with its anti-theft measures must still be built to fulfil all the needs of the people. It is also important to realize that even though some people steal from the community, most do not.

One facility component that could be stolen is doors. H. Kisting reported that the wet toilets found in the Havana settlements today have one hinge that spans the length of the door. This hinge was also pre-cast into the structure in order to prevent theft (personal communication, 30 March 2004). J. A. Burger, Section Engineer for the City of Windhoek, had the idea of not using a door at all in the facility design. Instead, he suggested a 'wrap-around' layout as illustrated below in Figure 11**,** which would still provide privacy, but unfortunately does not provide as good security as facilities with doors do (personal communication, 24 March 2004).

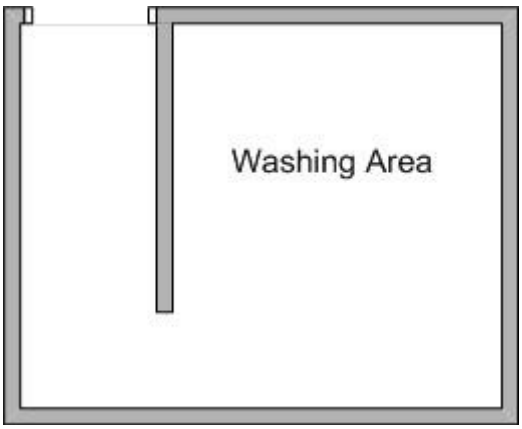


Figure 11: Wrap around washing facility without door

Even parts underground can be stolen. Stefani van Zyl of Urban Dynamics pointed out that people from outside the community can enter and steal the pipes. She said that everything in the structure needs to be robust so it is not stolen (personal communication, 25 March 2004). If a valuable part is necessary for the facility's function, such as a hand pump, efforts must be made to implement the part in such a way that if it is stolen or removed, it will be useless to the thief.

Architect Maritz pointed out that expensive items, like solar panels, would be stolen in the informal settlements (personal communication, 18 March 2004). M. Hindjou, Project Manager for Land Delivery for the City of Windhoek, noted that one

can now cast a pump into a wall in order to prevent its theft. These pre-cast pumps would need to be broken to be able to remove them from the structure. Hindjou continued by saying that since people will not steal a pump that would be useless, one need only worry about vandalism. He explained that most of the informal communities are beginning to realize the city projects are intended to improve their conditions and thus vandalism is becoming less of a problem in Windhoek (personal communication, 24 March 2004).

Shower

According to Urban Dynamics' Stefani van Zyl (personal communication, 25 March 2004), shower facilities are a new idea in the informal settlements that would solve many problems. Van Zyl said the disposal and recycling of bathing water will solve the immediate problems of grey water build-up, because all water will be directed through a drain into the municipal sewer and to the Goreangab Reclamation Plant. The drainage from the shower will also help the community in the prevention of future problems with sewage pipe blockages. Oftentimes, in the informal settlements, she said the amount of water in the municipal sewer is not sufficient to flush the sewer of solid waste. This results in blockages and strong unpleasant odours. She believes that the additional influx of shower water drainage into the sewer system would certainly help alleviate the situation (personal communication, 25 March 2004).

Designs

Our research led us to the development of two designs for the washing facilities, each depending on whether or not the City and community decide upon a

wet or dry toilet. Based on an SDFN meeting with fifty-three community leaders, we learned that the decision between a wet and dry toilet largely depends on the terrain of a particular area. In certain areas in the informal settlements, the community leaders believe it is infeasible to dig trenches for pipeline connections for wet toilets (personal communication, 20 April 2004).

Washing Facility with Wet Toilet Design

If the community and City prefer a wet toilet in the facility in a particular area, the shower design will be affected. The outside of this design may be seen in Figure 12, whereas Figure 13 shows the inside layout.

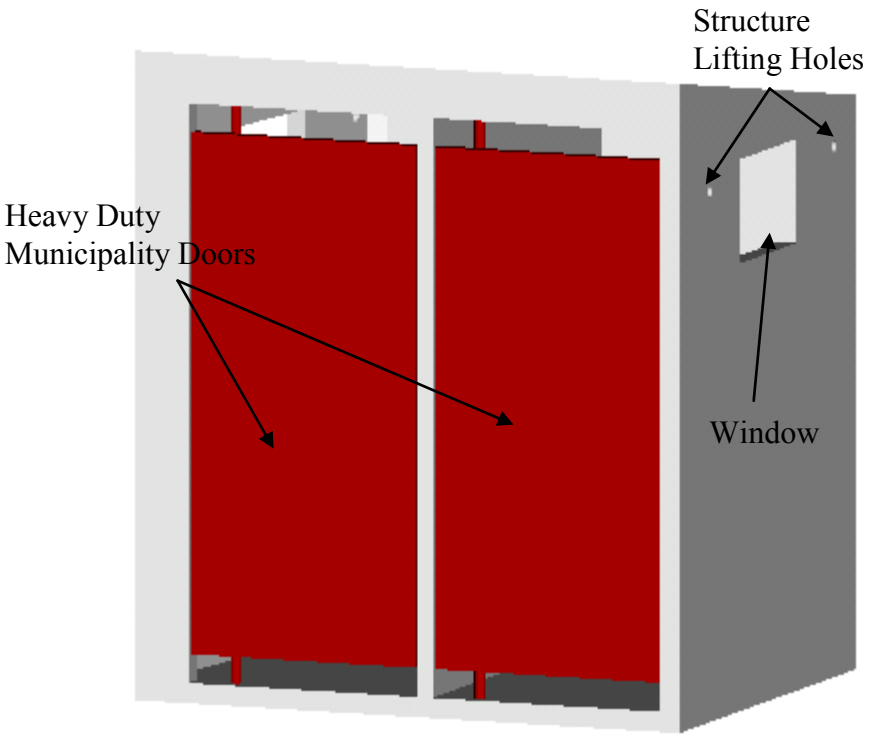


Figure 12: External view of facility for shower and wet toilet (shower on left, toilet on right)

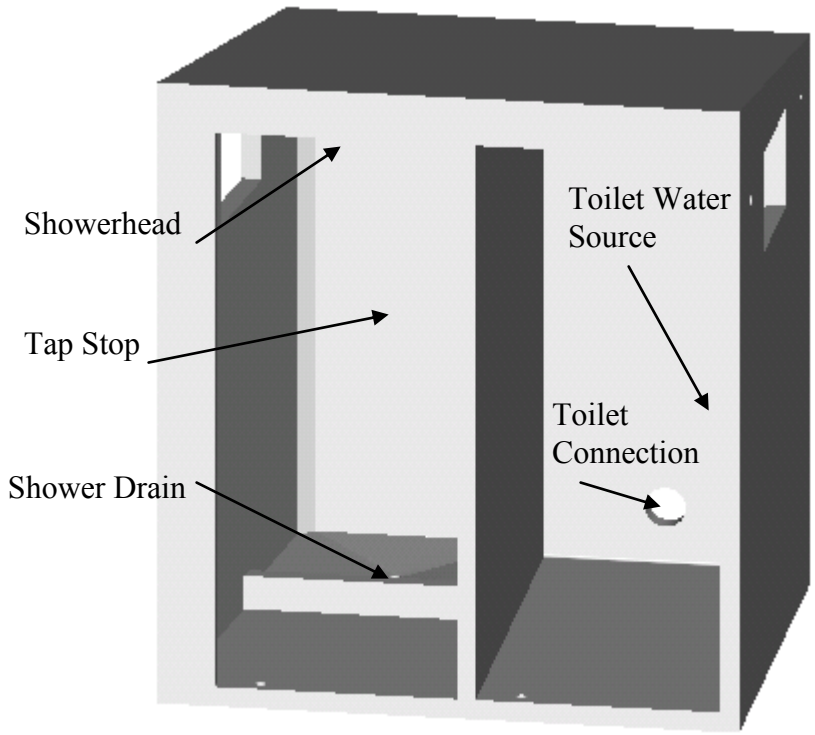


Figure 13: Inside layout of facility for shower and wet toilet (shower on left, toilet on right)

The flush toilets require an incoming source of water as well as sewer piping. Since the labour and expense of digging waterline trenches to the wet toilet will be required, it is reasonable to split the water source at the facility to both the toilet and the shower. The design will include a tap stop valve (see Appendix H) for flow interruption to prevent continuous water consumption. A tap stop valve is simply a fitting that allows the opening and closing of a particular point in the water pipe. This design provides the user with a constant convenient shower water supply, as flow initiation and regulations may be made within the facility. Figure 14 shows the facility in wire-frame, while Figure 15 shows the facility with the concrete structure hidden to reveal the cast piping.

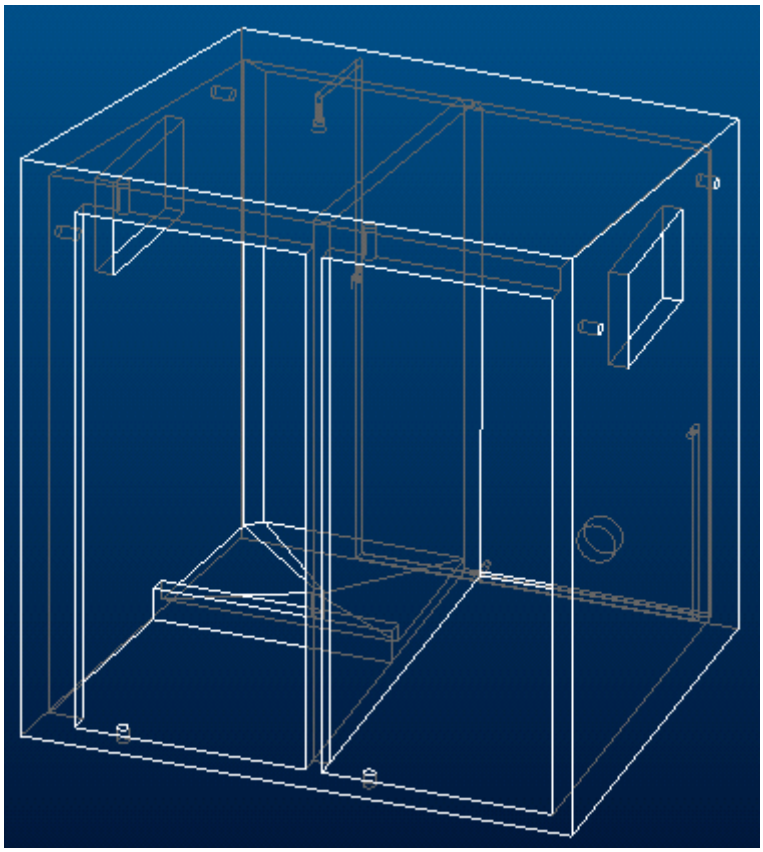


Figure 14: Wet toilet washing facility design in wire-frame

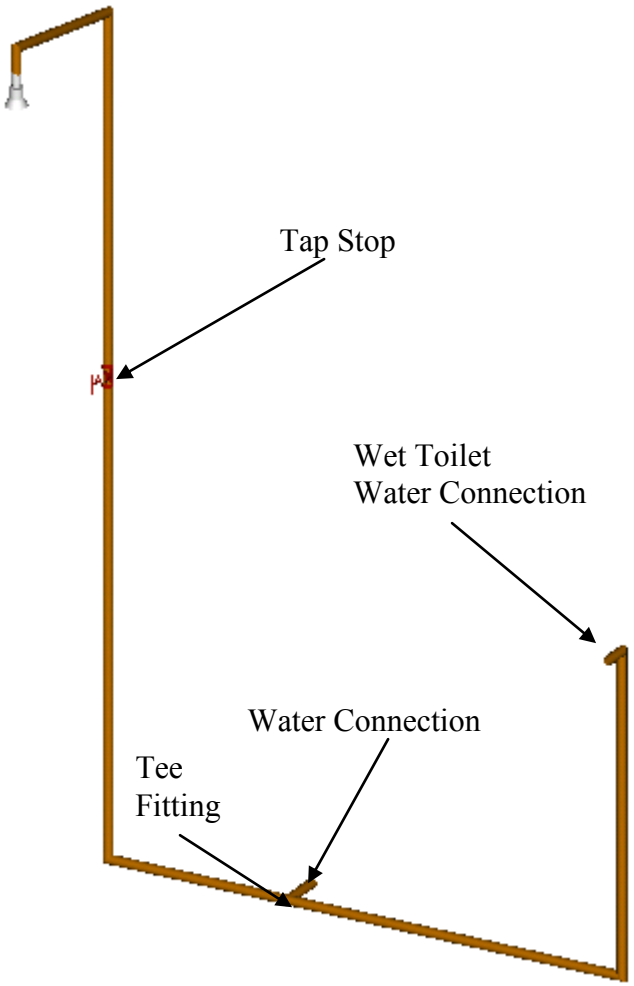


Figure 15: Wet toilet washing facility design with structure hidden to reveal cast piping

As Figures 14 and 15 illustrate, all piping and fittings within the facility are cast into the concrete ROCLA wall structure. The 20 millimetre copper piping splits at the tee fitting to enter both shower and toilet compartments. Pressurised flow to the showerhead (see Appendix H) is interrupted by the tap stop as seen in Figure 16.

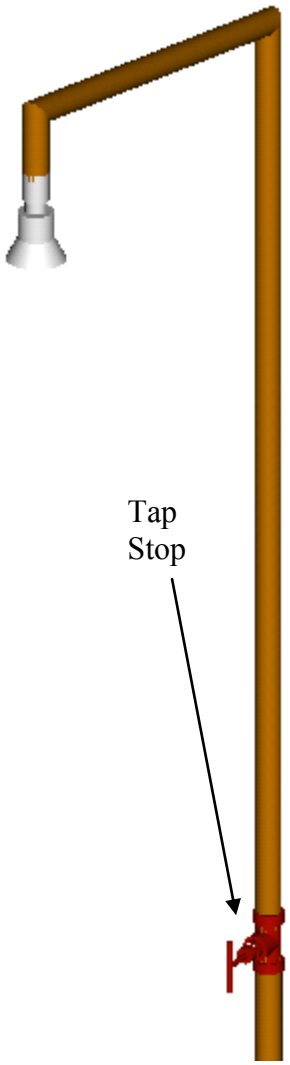


Figure 16: Tap stop on shower water line

Twenty millimetre High Density Polyethylene (HDPE) Class 10 piping will be used for the water source connections, while the sewage piping used will be the standard 110 millimetre PVC. The 40 millimetre PVC piping used for the shower drainage connects to the 110 millimetre so that both toilet sewage and shower wastewater will flow together to the municipal sewer. As Stefani van Zyl mentioned (personal communication, 25 March 2004), the additional influx of water from the toilet will help reduce the tendency of sewage pipeline clogging. This will help to eliminate unpleasant odours in the informal settlement communities.

The community and City may prefer to install a prepayment meter (see Appendix I) in this design in order to place more restriction on water consumption than just the opening and closing of a tap stop. The meter may be installed on the pipe as shown in Figure 17, by merely cutting the pipe and attaching ninety degree elbows to bring the ends out of the wall for inlet and outlet connections. The user will still have a constant convenient shower water supply, as flow initiation and regulations may be made within the facility. To initiate flow, however, the user must not only open the ball cock valve to receive water, but must also insert their credited tag into the prepayment meter.

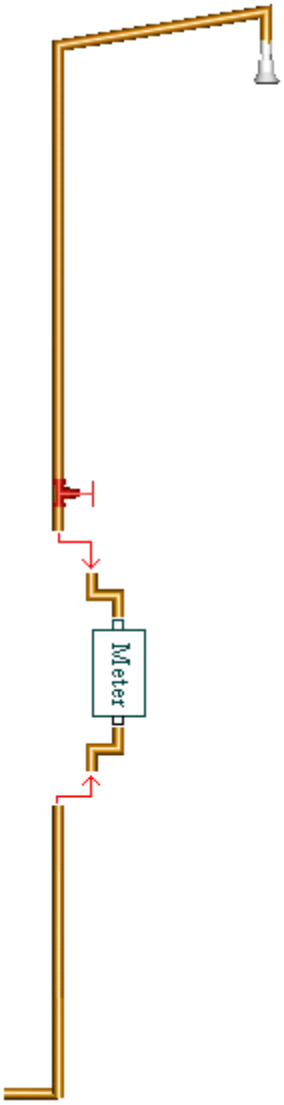


Figure 17: Internal piping alteration for potential prepayment meter connection

This facility needed to be simple and compact for feasibility, yet large enough for those who might be reluctant to use a cramped shower. Otherwise, individuals returning to their convenient makeshift structures would continue to add to the current non-reclaimed grey water issue. In this washing facility design, there is enough room for a mother to wash her children. Figure 18 shows a top view of the inside of the facility where it is evident that a mother can stand next to the shower floor while she washes her child who may stand above the drain.

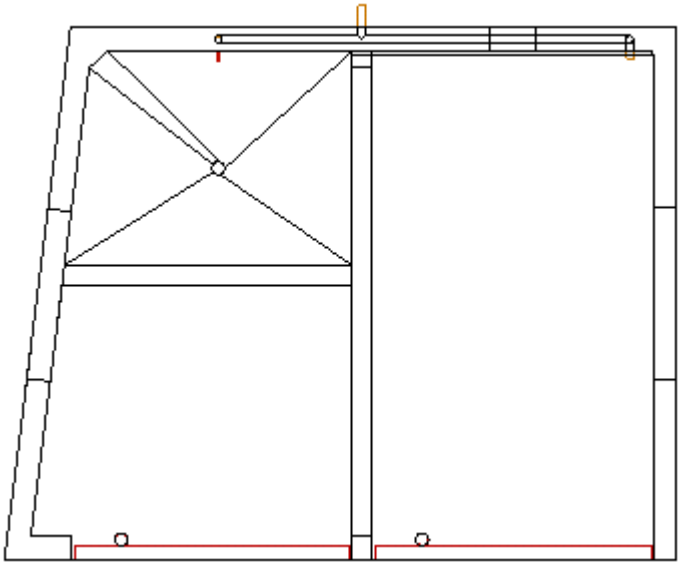


Figure 18: Top view of the inside of the wet toilet washing facility design (shower on left, wet toilet on right)

Modular Washing Facility with Dry Toilet Design

If the community and City prefer a dry toilet in the facility in a particular area, the shower design will be affected. An external view of this design may be seen in Figure 19, while the inside of the facility may be seen in Figure 20.

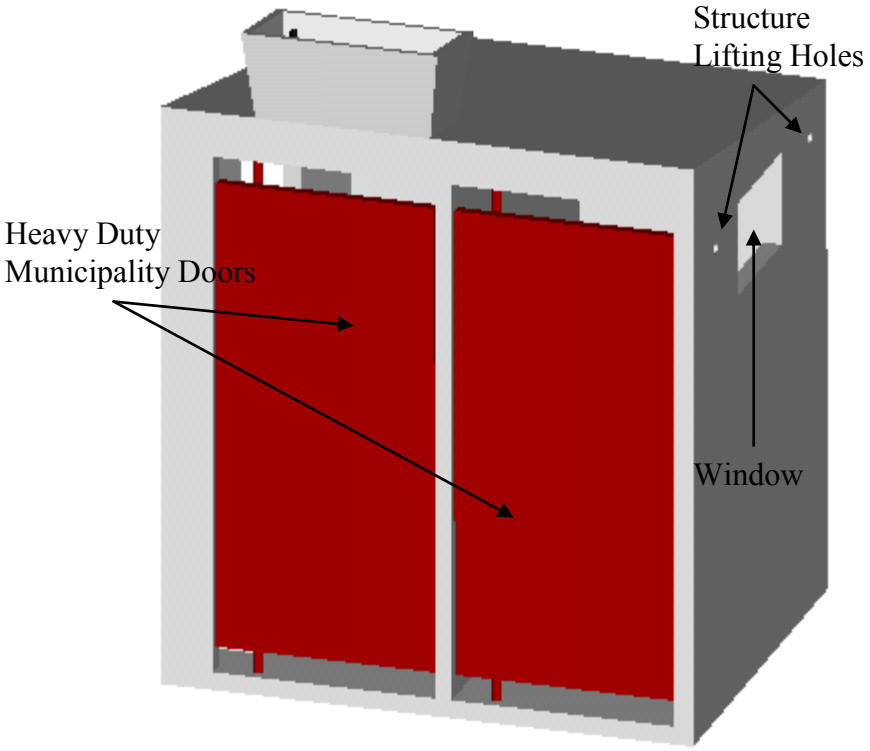


Figure 19: External view of facility for shower and dry toilet (shower on left, toilet on right)

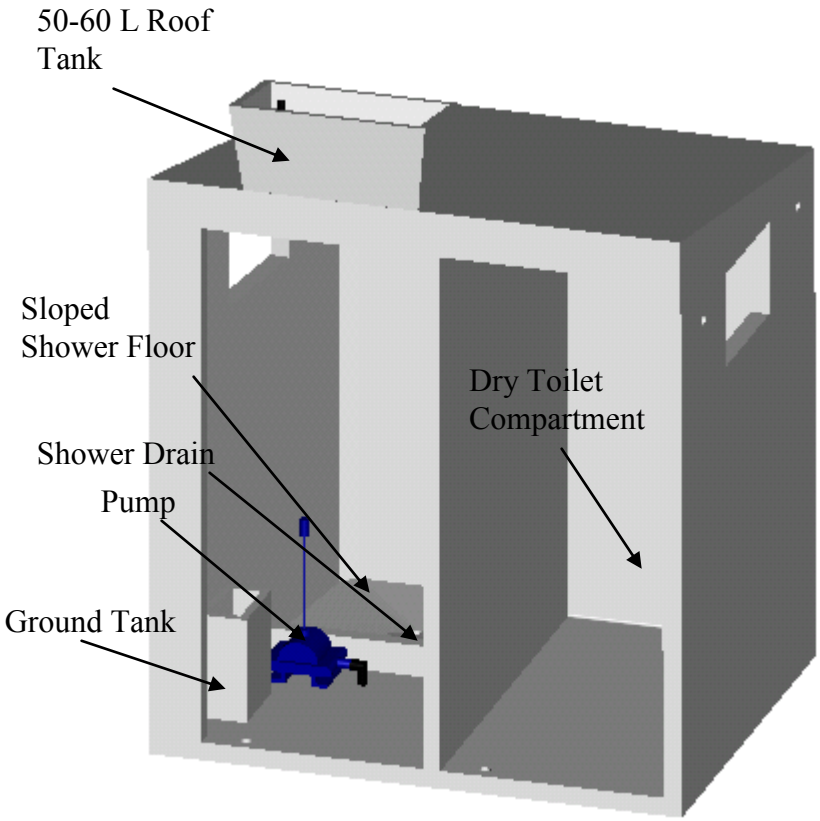


Figure 20: Inside layout of multiple user Enviro Loo dry toilet modular washing facility design (shower on left, toilet on right)

The dry toilets do not require an incoming source of water or the large 110 millimetre diameter sewage piping specific for flush toilets. Thus, in the first stage of this modular design, the only piping connection needed will be a 40 millimetre diameter sewage pipe to drain the shower water from the facility to the municipal sewer. There are two ROCLA concrete tanks, one on the floor inside the facility, the other on the facility's roof. These tanks are 10.75 and 50 litres respectively. Figure 21 shows the facility in wire-frame view, while Figure 22 shows the facility with the concrete structure hidden to reveal piping and other fittings.

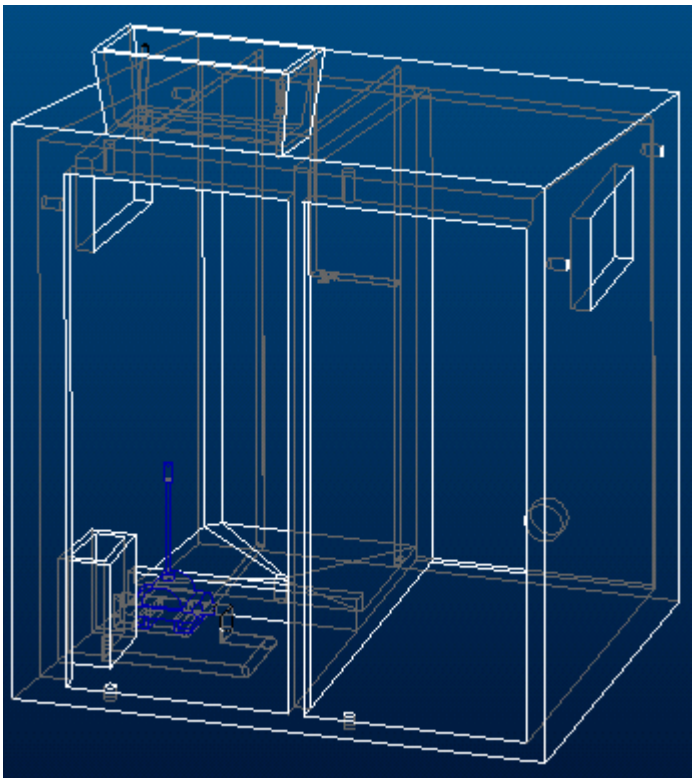


Figure 21: Washing facility design with dry toilet in wire-frame

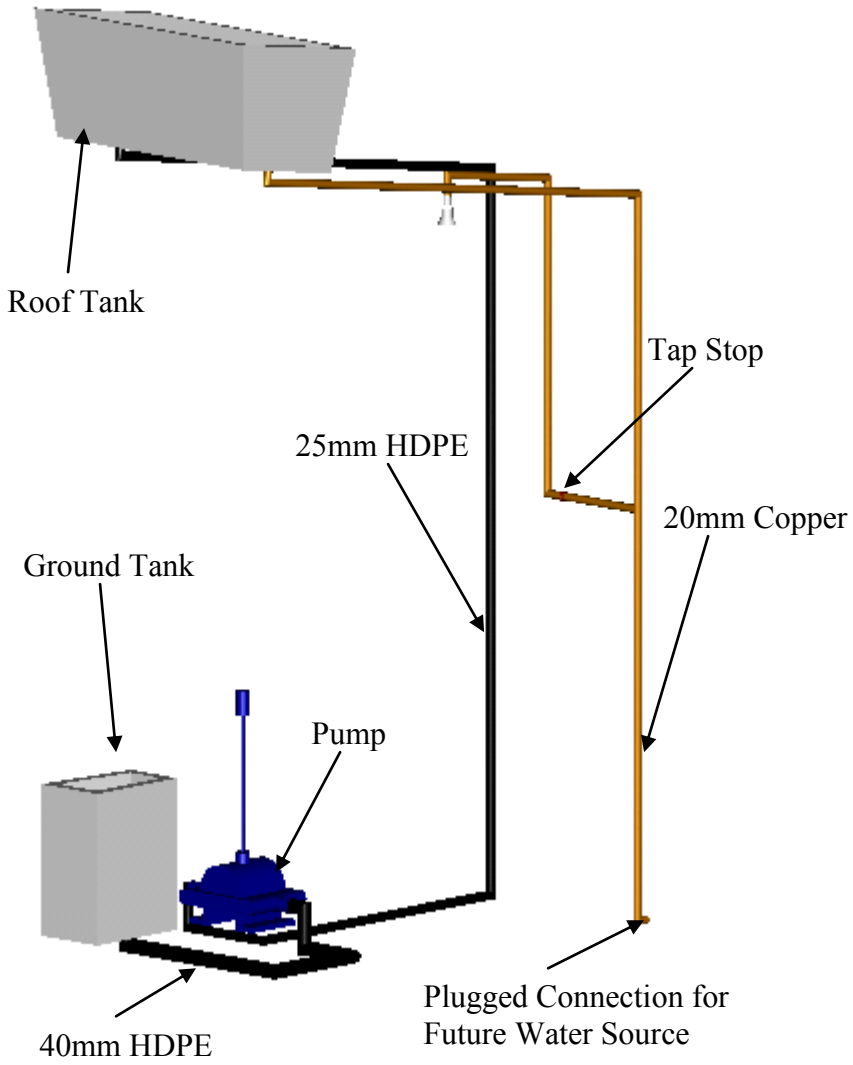


Figure 22: Dry toilet facility design with ROCLA structure hidden to reveal cast piping

Piping is run from the floor tank, down through the ROCLA pre-cast concrete structured floor, and up to a Jabsco Amazon Warrior hand pump. In order to protect this pump from theft and vandalism, as advised by R. Woortman (personal communication, 19 April 2004), the owner of AFRO Pumps, a metal cover can be cast around the pump with a slot exposing only the pump handle. This slot would also minimize the movement of the handle, preventing potential pump damage due to over extension. See Appendix B for minutes from our 19 April 2004 meeting with AFRO Pumps.

According to Woortman, the pipe lead-in from the floor tank to the pump should be equal in diameter to the pump inlet so as not to restrict inward flow to the pump (personal communication, 19 April 2004). A reduction is then used from the pump outlet to the roof tank using 25 millimetre black HDPE Class 10 piping. This HDPE Class 10 pipe extends above the bottom surface (see Figure 23) of the roof tank so that the water pumped into the tank will spill over the edges of the pipe and into the tank. Should the pump ever experience a small leak, the water will be trapped in the roof tank, unable to flow in the reverse direction back to the ground tank. Thus, the users would not have to rush their shower to avoid their above water supply leaking back into the ground tank.

The drainage pipe from the roof tank extends a little higher than the bottom surface of the tank. This allows all the water in the tank to drain except for the bottom two centimetres, which might be expected to contain small amounts of settled sand or dirt that is undesired in the piping system.

Woortman added that if sand or dirt gets into the water tanks, this should not damage the pump because it is a diaphragm pump. At most, the sand might prevent the valves from closing all the way and thus minimal leaking may occur (personal communication, 19 April 2004). The tanks in this design have lockable concrete covers to help prevent such contamination.

To shower with this facility design, the user must simply fill up a bucket at the local standpipe, and then bring it back to the washing facility just as they do currently with their makeshift structures. Here, the user will dump the water into the ground tank, then hand pump the water to feed the roof tank. Through gravity feed, the water in the tank will drain as far as the closed tap stop valve. After one has sufficiently

filled the tank to one's discretion, the tap stop valve may be opened and regulated for various shower flow pressures.

The cost to connect this facility directly to a water connection is N$3 079, which is similar to the system using the hand pump which costs N$3 018. The direct connection would be more convenient, because the task of fetching buckets of water from the standpipe would be eliminated. Having a direct connection, however, might result in excessive amounts of water consumption. Additionally, according to Edwin Jahs, a Community Development Officer of the Community Development Division of the City of Windhoek, children may leave the water running and waste excessive water (personal communication, 20 April 2004). These are potential problems with the wet toilet washing facility design unconnected to a prepayment meter. See Appendix B for minutes from our 20 April 2004 meeting with Edwin Jahs.

With the pump design, the user has to work for every shower, is limited to the initial water supply deposited into the tank, and is thus less likely to waste water. In a meeting with fifty-three community leaders at the SDFN, the pump design was the popular choice as they too believed less water would be wasted (personal communication, 20 April 2004).

The dry toilet washing facility design is modular because if the pump method is unsuccessful, a water connection may still be hooked up to the facility. The preplanning of this alteration includes only the minimal costs of piping materials. These piping materials are pre-cast in the original facility design. Figure 23 illustrates the possible future connection process, where the roof tank drain will be plugged, and the bottom previously plugged (see Appendix H) opening may be directly connected to an underground water source. This connection will completely remove the pump

and tank component from the new functioning shower system. The pump and tanks may then be removed and used elsewhere.

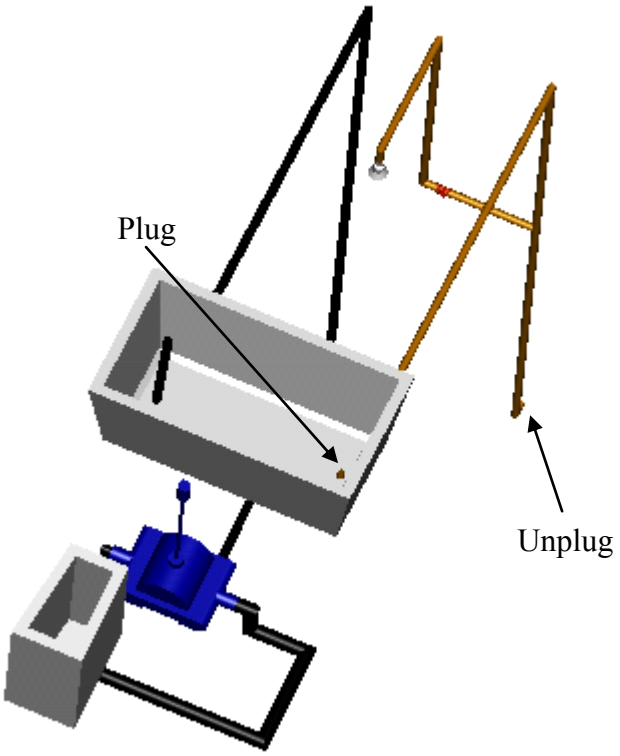


Figure 23: Future water connection process

To avoid previously discussed problems with potential water wastage from a direct connection, the community and City may later decide on prepayment meters (see Appendix I). If the City or community anticipates the possibility of prepayment in the future, the initial design will be altered slightly as seen in Figure 24.

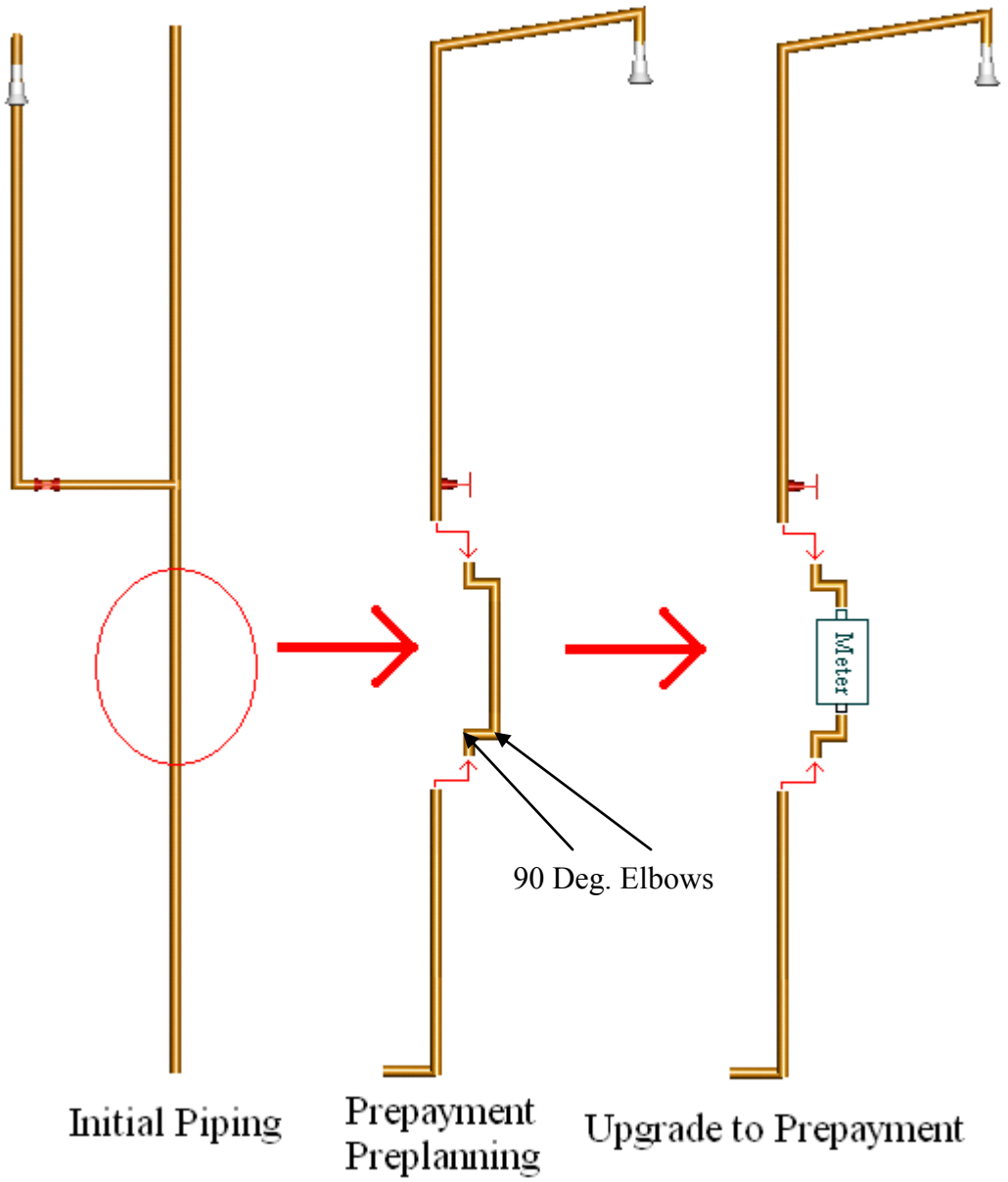


Figure 24: Prepayment meter design preplanning

Along the piping, just below the tap stop, a section of piping will have been removed. Each open end will have been brought beyond the inside surface of the facility via ninety degree elbows. Before the direct connection, these two ends will be connected. A protective cover could be added to protect this small amount of exposed piping from theft. When prepayment meters are installed, the cover may be cut away, and a section from the exposed piping will be removed so the inlet and outlet of the meter may bridge the gap and measure the flow of water consumption.

The washing facility with a dry toilet is also simple and compact for feasibility, yet still suitable for mothers who need to wash their children. Figure 25 shows a top view of the inside of the facility where it is evident that a mother can stand next to the shower floor while she washes her child who may stand above the drain.

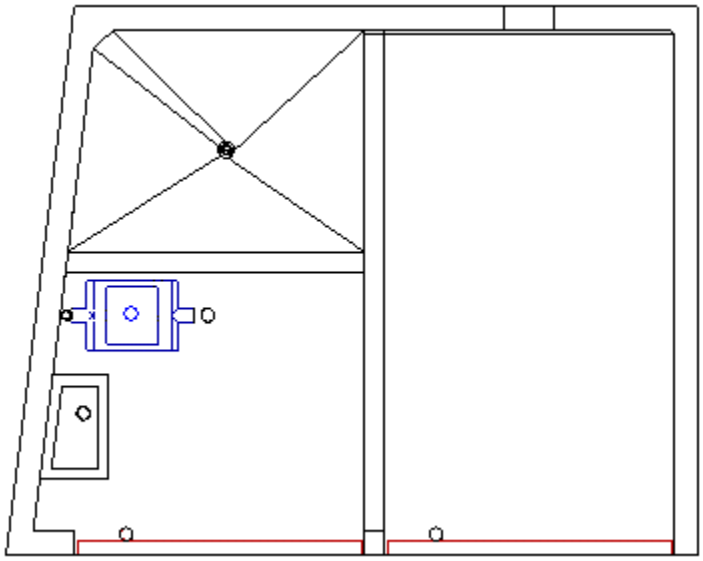


Figure 25: Top view of inside of dry toilet washing facility design

Toilets

One of the requirements in the design of the washing facility is the inclusion of a toilet. A detailed investigation into many different types of toilets is necessary in order to make a reasonable decision about what toilet to use. This decision process should include consideration of costs (both long-term and short-term), Namibia's scarce water supply, community preferences, maintenance, and methods of waste disposal. One of the preliminary choices to make is to decide between using a dry toilet or a wet toilet.

Dry Toilet Designs

Dry toilets are a very intriguing idea for a number of reasons. They avoid the need for a separate septic system or a sewer system, the waste can be used for fertilizing purposes, and the consumption and cost of water is completely eliminated. Dry toilets also have ventilation systems to dry the waste, most of which use some form of whirlybird ventilation. See Appendix J for more information on whirlybirds.

In areas with scarce water supply, dry toilets are becoming a popular alternative to the flushing of waste from a site that was once thought of as the ideal solution. The wet toilet solution results in ninety-five percent of all developing country sewage being discharged untreated into water resources (World Resources Institute, 1992). The dry toilet design, however, offers a cleaner treatment process. Each person produces approximately five hundred litres of urine and fifty litres of faeces per year. When this amount of faeces is dried, however, its volume is reduced to a bucketful. Problems occur with the mixing of these two human excretions to form larger volumes of pollution.

Dry toilets have been installed in many locations including some communities of the Northwest settlements of Windhoek, although they have not yet been put into use. In a community meeting at the Shack Dwellers Federation of Namibia (SDFN) office, a small group of ten leaders had very positive feelings about the dry toilets. They had seen the Enviro Loo and Cool Maintenance toilets in Okahandja Park, and they felt that they were very desirable facilities (personal communication, Mar 30, 2004). One major drawback of the dry toilets is the very high initial cost.

Enviro Loo

The Habitat Research and Development Centre (HRDC), located in Windhoek just outside the Northwest Settlements, is currently under construction. The design of this building is centred on the idea of pioneering energy efficiency. One idea that has been implemented in this design is the use of Enviro Loo waterless toilets that in the past have been valuable in areas with low water availability. The Enviro Loo has evolved through extensive studies since February 1993, where more than eleven thousand units have been installed in South Africa and neighbouring countries, as well as Ghana, Uganda, India, Greece, Cyprus, Brazil, USA, and Australia. The Enviro Loo has currently been installed in Okahandja Park and can be viewed in Figure 26.

Figure 26: Corrugated iron toilet facility implementing the Enviro Loo design in Okahandja Park (31 March 2004)

The Enviro Loo system is easy to install, and thus can be built as a community project. The unit comes complete with all components needed for assembly and does not use any water connection, chemicals, or electrical power. The unit, when used, is odourless and prohibits any fly breeding within the system. The ventilation system and the high internal temperatures result in a negative pressure, inhibiting the air flow back into the toilet pan. Its material properties are durable against the ultra-violet conditions in Namibia and its rugged construction makes it a suitable solution to urban development projects. Furthermore, its secure connections do not allow any harmful seepage of sewage into the environment. The Enviro Loo's fittings and

separators provide efficient means for liquid and solid waste separation, and thus efficient evaporation, and its unique design allows for easy and sanitary waste removal without the use of special tools. The Enviro Loo needs only minimal service in the first eighteen months after installation, and depending on the number of users of the facility, the waste must only be removed approximately once per year. The drawback to this system is its expense. The 2004 estimated cost for the upgrading of Okahandja Park A, B, and C with this system is N$13 516.59 per unit. The breakdown of this total cost may be viewed in Table 8 in Appendix J.

Due to the increased cost from when they were installed in Okahandja Park in 2003, the Enviro Loo may no longer be feasible to install in the informal settlements. It might be advantageous, however, to look into how initial cost compares to the long-term savings in water. For more technical details about the Enviro Loo system, see Appendix J.

Cool Maintenance

The Cool Maintenance toilet is a modification of the Dryloo carousel concept of waste bag replacement (Schroeder, 2002). Hugo Rust, a Town Planner for the Sustainable Development Division for the City of Windhoek, gave us a tour of the dry toilet facilities in the Okahandja Park community.

The Dryloo system has been used successfully in South Africa for more than twenty-five years, and just recently the Cool Maintenance system has begun to be used in Namibia (Kaumbi, 2002). In Okahandja Park, the City put in about ninety-two Cool Maintenance toilets. At this point, the toilets have not yet been given to the residents to use, so no evaluation can be made about this project's success. Rust explained that four to five households will share each unit when they are given to the

community (personal communication, 31 March 2004). See Appendix B for minutes from our 31 March 2004 tour of Okahandja Park. Figure 27 shows the inside and outside of the Cool Maintenance dry toilet facility with the sewage pit cover opened.

Figure 27: Inside and outside view of Cool Maintenance dry toilet facility with the sewage pit cover opened

Hugo Rust said we could use the 2004 estimated Enviro Loo installation costs to estimate the Cool Maintenance installation costs because they are very similar. The price of the unit is simply changed to that of the Cool Maintenance system in the estimate (personal communication, 31 March 2004). The total estimated cost for this dry toilet design is N$12 915.25 for one unit. A breakdown of the total cost estimate for 2004 may be viewed in Appendix J**.**

The Cool Maintenance is not considerably less expensive than the Enviro Loo and does not have as long a track record in Namibia. For more technical details about the Cool Maintenance system, see Appendix J.

Other Systems

The Atlas Plastics Latrine and the Primary Effective Toilet (PET) were also evaluated for use in the communal washing facilities. They were eliminated for not satisfying basic requirements. Details on the Atlas and PET systems can be seen in Appendix J.

Wet Toilets

A wet (or flush) toilet is one viable option as a type of toilet for inclusion in the proposed washing facility. These toilets include a cistern or tank that is filled by an external water source connection. Waste is disposed of by quickly emptying a large amount of water from the cistern to the toilet bowl. This large sudden influx of water forces the waste down the bowl and through a trap (see Appendix E) to the municipal sewer line. Wet toilets are so common that there is little reason to doubt that the use of wet toilets would not be accepted by the community in our design. A benefit of the wet toilet is the low initial cost, as a plastic cistern toilet unit is only approximately N$310.

A strong argument against the use of a wet toilet, however, is that they use a substantial amount of water. In Windhoek, where water is a limited resource, it is crucial to take all possible measures to conserve. According to City Water Engineer J. A. Burger, a typical wet toilet uses ten to fifteen litres per flush (personal communication, 21 April 2004). In addition to this large consumption, the user will have to constantly pay for the water, increasing the wet toilet's total cost over time.

One important point to consider in the decision of whether to use wet toilets is the issue of payment for flush water. We discuss this issue later in the "Pricing Structure" section of this chapter.

Full Facility Design

In the design process, it was necessary to price different supplies from local Windhoek building companies so the potential builder might be aware of the least expensive supplier. Pupkewitz Megabuild and Builder's Warehouse are two building warehouses in Windhoek. After many product comparisons, Pupkewitz Megabuild was the less expensive supplier as seen in Appendix K.

The 2002 building plans for Havana Extension 1 provide the external 110 millimetre sewage piping distances needed to connect the toilet facilities to the municipal sewer lines for fifty-eight facilities. These plans show the piping layouts for the northern and southern half of this settlement. In order to get a sense of the average distance of external piping trenches needed for our facilities, we recorded the distances from the main sewer line to each facility and constructed a distribution graph of these varying distances. This distribution is seen in Figure 28. The data for this distribution is in Appendix L.

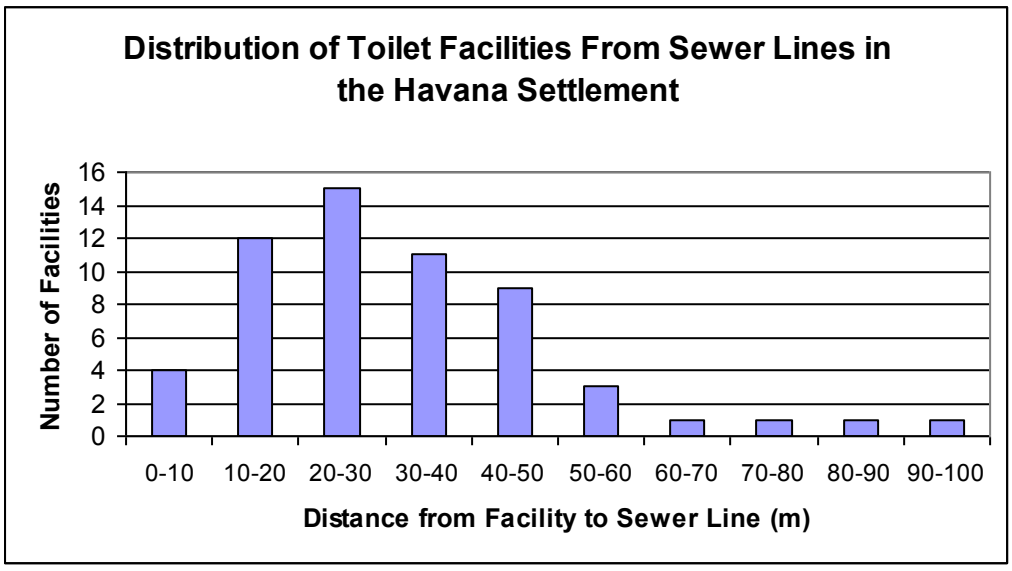


Figure 28: Distribution of toilet facilities from municipal sewer lines in the Havana Extension 1 Settlement: derived from Water Consulting Engineers, 2002

Most of the toilet facilities required 20 to 30 metres of external piping, while outliers did exist on both sides of this range. Table 1 shows the average calculated toilet facility external piping distances over the entire Havana Settlement Extension 1 area.

Table 1: Average external piping distances needed for toilet facility connections in the informal settlements

	Average Distance (m)
South Half	33.178
North Half	32.103
Total	32.763

Source: Windhoek Consulting Engineers. (August 2002). Upgrading of Havana Extension 1 Bulk Long Section.

According to J. A. Burger, using these averages will provide an accurate estimation for the amount of external sewer piping needed in the informal settlements. Additionally, though water source lines were not provided on the building plan layout, they may be approximated by the sewer pipe distances; while some facilities may be closer to the water lines than the sewer lines, others will be farther away, maintaining the average (personal communication, 21 April 2004). See Appendix B for minutes from our 21 April 2004 meeting with J. A. Burger.

Lastly, in order to complete the final estimated facility costs and present them to the City of Windhoek and the Northwest Settlement Communities, the amount of plumbing materials within the facility needed to be calculated. Appendix M shows the total calculated pipe lengths for the different piping materials in both the wet and dry toilet shower facility designs. The total estimated costs of the two washing facility designs may be seen in Table 2. Appendix N shows the breakdown of these total costs.

Table 2: Total costs for communal washing facility designs

Design	Namibian Dollars	US Dollars
Washing facility with wet toilet design		
With Nossob prepayment meter	19963.33	3219.89
Without Nossob prepayment meter	23463.33	3784.41
Washing facility with dry toilet design	24805.78	4000.93
Washing facility with dry toilet design modular addition		
With Nossob prepayment meter	3079.44	496.68
Without Nossob prepayment meter	6579.44	1061.20

Viewing these costs, it is evident the dry toilet washing facility is more expensive than the washing facility with the wet toilet design. The wet toilet washing facility design, however, is within comparison to the dry toilet washing facility design because it requires more external piping in the expensive area of trench digging and pipe installation. Its necessity for both a 20 millimetre water connection and 110 millimetre sewer pipe narrow the gap in costs between the two designs. In its first stage of modularity, the dry toilet washing facility only requires 40 millimetre external piping for shower water drainage. Table 3 shows J. A. Burger's (personal communication, 16 April 2004) calculated costs of piping materials, trench excavation, labour, and all other anticipated costs for external piping connections of 110 millimetre PVC, 20 millimetre HDPE class 10, and 40 millimetre PVC. See Appendix B for minutes from our 16 April 2004 phone conversation with J. A. Burger.

Table 3: Calculated costs of trench digging and pipe lay work for various external piping

110mm PVC	40mm PVC	20mm HDPE
N$300/m	N$120/m	N$94/m

Source: personal communication, 16 April 2004

The external piping needed for the wet toilet washing facility is much more costly.

In order to see how the dry and wet toilet washing facility costs compare in the costly area of trench digging for external pipes, it was beneficial to plot the costs of each design over various facility distances to the municipal water and sewer lines. Figure 29 illustrates these cost comparisons. This graph was produced by the following equations:

Washing Facility with Wet Toilet Design: **N$10 555.89 + N$300x + N$94x**

x = Facility distance from municipal sewer lines
N$10 555.89 = Facility costs excluding external piping

Washing Facility with Dry Toilet Design: **N$20 874.58 + N$120x**

x = Facility distance from municipal sewer lines
N$20 874.58 = Facility costs excluding external piping

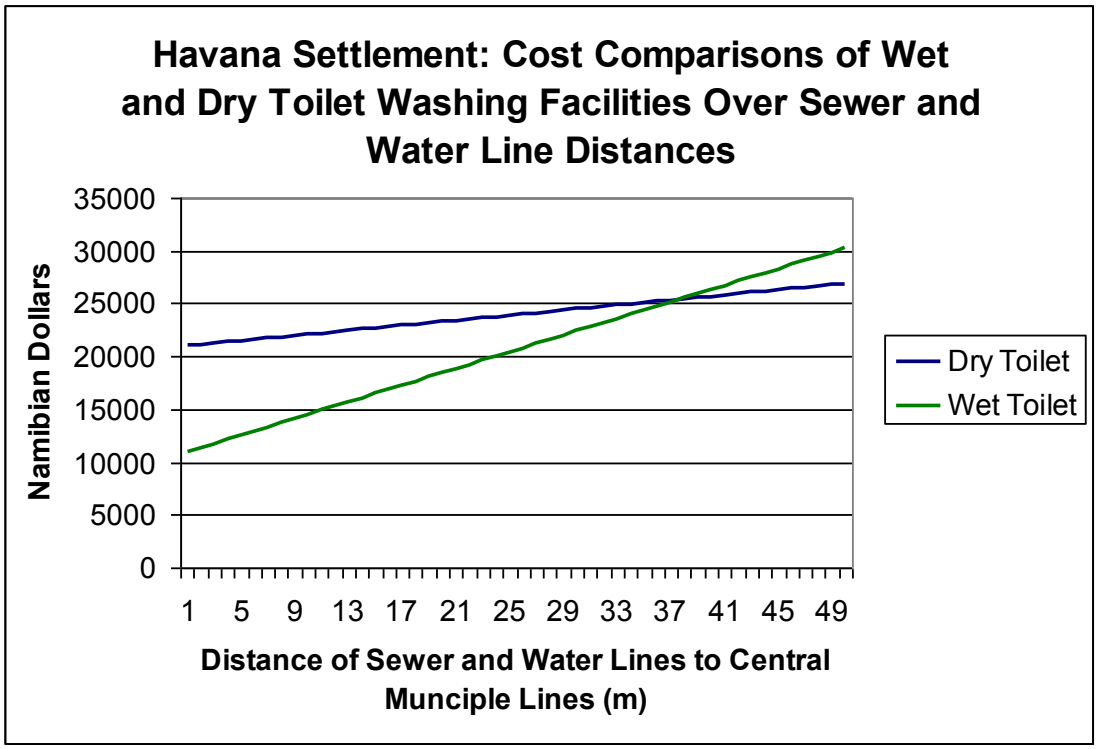


Figure 29: Cost comparisons of wet and dry toilet washing facility designs at various external piping distances

According to the graph above, the two design costs converge when the facility is 37.7 metres from the municipal water and sewer lines. At any distance less than 37.7 metres, the dry toilet is more expensive.

Community Developmental Costs

According to Kisting, the inhabitants in the informal settlements pay the developmental costs of any upgrading projects implemented by the City of Windhoek (personal communication, 27 April 2004). Based on the City's Havana Extension 1 March 2004 Occupational Rights Levy for the recent upgrading of this settlement, the City will recover eight and a half percent of the initial developmental costs per year. The following equation shows the cost per household per month to compensate the City at that recovery rate:

$$\frac{.085X}{12H} = Y$$

X = Total city developmental costs

H = Number of households sharing the facility

Y = Total developmental costs per household per month

Figure 30: Equation for developmental costs per household per month

The current developmental cost for each toilet facility block in Havana Extension 1 installed by the City is N$26.20. This cost is divided by the number of households sharing each toilet facility. In addition to the developmental costs, each household must also pay additional flat rates. These additional expenditures include sludge tariffs, water consumption, and refuse removal. Since March, 2004, according to the Havana Extension 1 Occupational Rights Levy, the sludge tariff per month is N$8.09, water consumption is approximately N$16, and refuse removal is N$6.05. According

to M. Hindjou (personal communication, 7 April 2004), the Project Manager for Land Delivery of the City of Windhoek, if a dry toilet is used in the design, the water consumption tariff will be reduced by about fifty percent.

Based on the total estimated costs for each of our facility designs, each household will pay the City monthly developmental costs according to Figures 31 and 32.

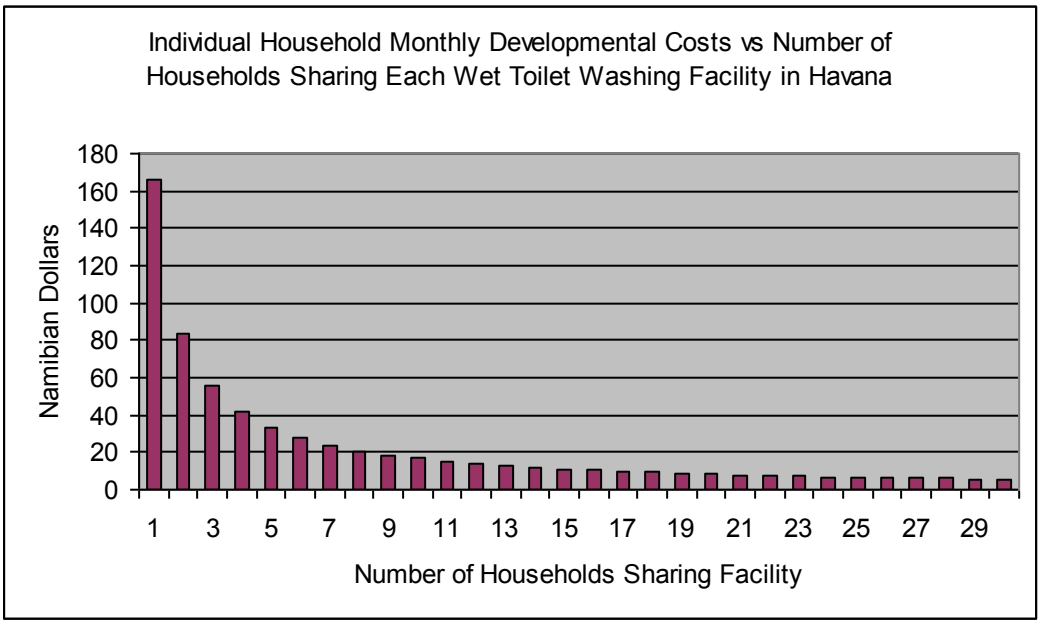


Figure 31: Community household developmental costs based on the number of households sharing each wet facility

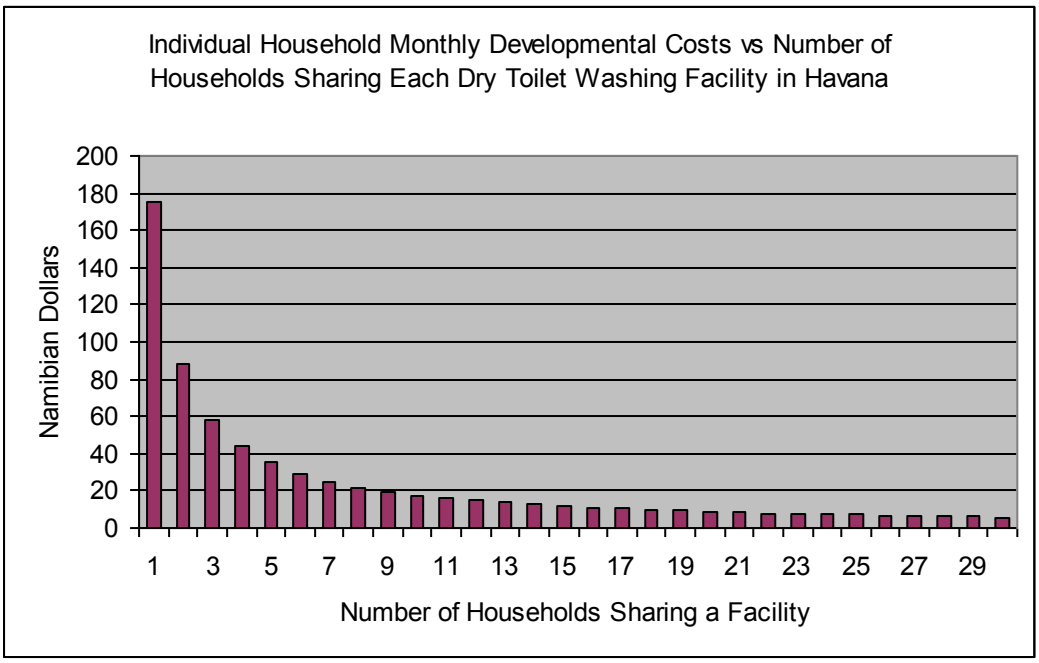


Figure 32: Community household developmental costs based on the number of households sharing each dry facility

The fewer households that share a facility, the larger the monthly individual household cost becomes. The more households that share a facility, however, the further the distance between each household and their respective facility. According to Kisting, when calculating the monthly developmental costs per household, the City first assumes thirty households will share each facility. At this point, individual blocks are investigated to see if it is feasible for fewer households to share the facility costs (personal communication, 30 April 2004). It will be the community's job to derive an optimal number of households to share each facility. They will do that by weighing the costs with convenience for their individual situations.

Water Economics for Proposed Designs

According to the Aloe newsletter, a monthly newsletter distributed by the City of Windhoek for city residents, NamWater sells water in bulk to the City, who then

distributes it to the residents. NamWater changes the water tariffs once a year at the discretion of Parliament. As a result of these changes, the City must alter its charges so that it will be able to repay NamWater (Water tariffs: basic and consumption, January 2004). According to the tariffs described in the Aloe Newsletter tariff tables (see Appendix O), the community members of the Northwest Settlements pay N$27.81 per household for their monthly basic connection charge. Water consumption tariffs are added onto this base charge at N$7.37 per kilolitre, with an additional flat rate VAT of N$1.11.

According to J. A. Burger, eighteen to twenty-five households share the toilet facilities in the informal settlements with an average of 4.2 individuals per household. Each of these individuals flushes the toilet an average of two times per day. He calculated the total average household consumption to be 200 litres per day. The daily amount of water used for toilet flushing at 10 to 15 litres per flush is 105 litres per household. When this amount is subtracted from the total of 200 litres, 95 litres remains for additional household consumption such as washing, cooking, drinking, and other daily uses (personal communication, 21 April 2004).

In order to get a sense of the water savings in a dry toilet system, it would be advantageous to perform some calculations on a particular informal settlement in Windhoek. According to Cronje, the Havana settlement is composed of approximately 1 300 households (personal communication, 27 April 2004). Based on the previous water consumption averages, a dry toilet would conserve water over time as illustrated in Figure 33.

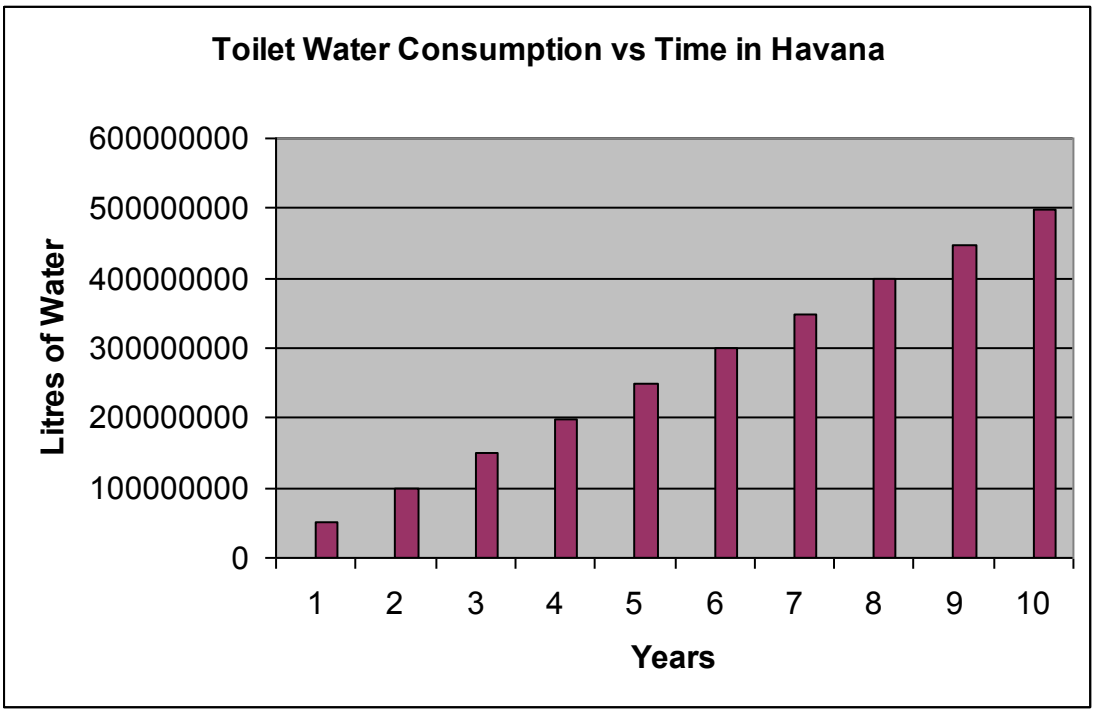


Figure 33: Average flush toilet water consumption over time in the Havana Settlement

Based on the tariffs shown in the Aloe Newsletter, the City of Windhoek and the Havana Settlement will pay the following amounts over time for that toilet water consumption as seen in Figure 34. If dry toilets were used in Havana instead of wet toilets, Figure 34 shows how much money would be saved.

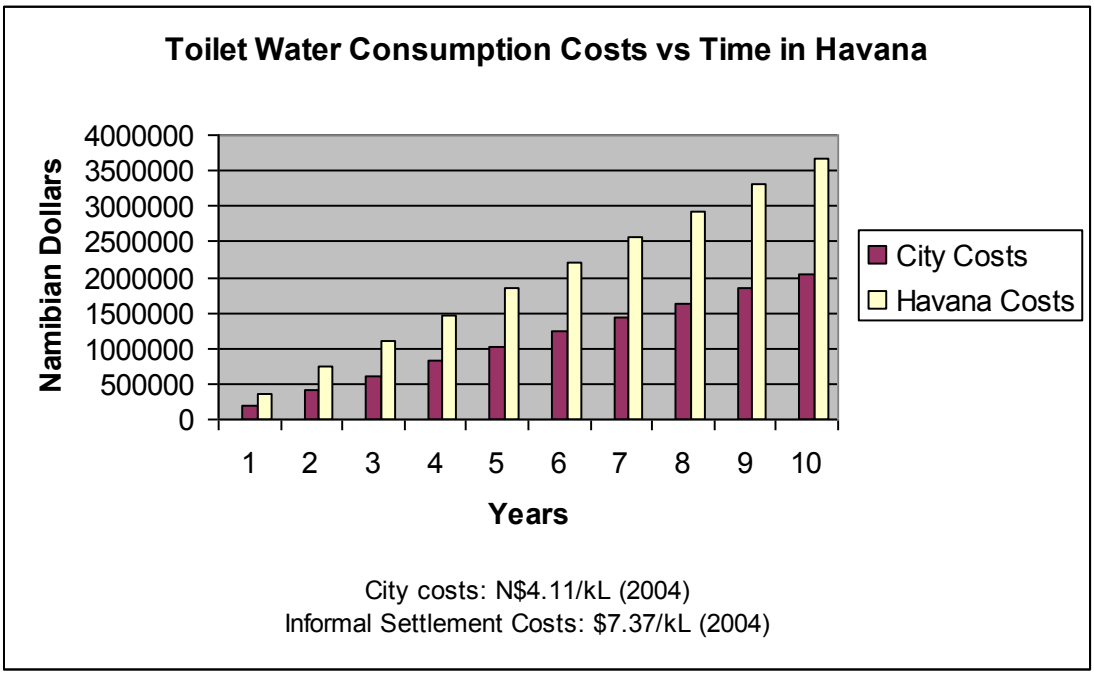


Figure 34: City and Havana Settlement water consumption costs over time for supporting the current flush toilet systems

Figure 35 reveals the amount of money that each individual Havana household would save in water costs over time if dry toilets were used as opposed to wet toilets.

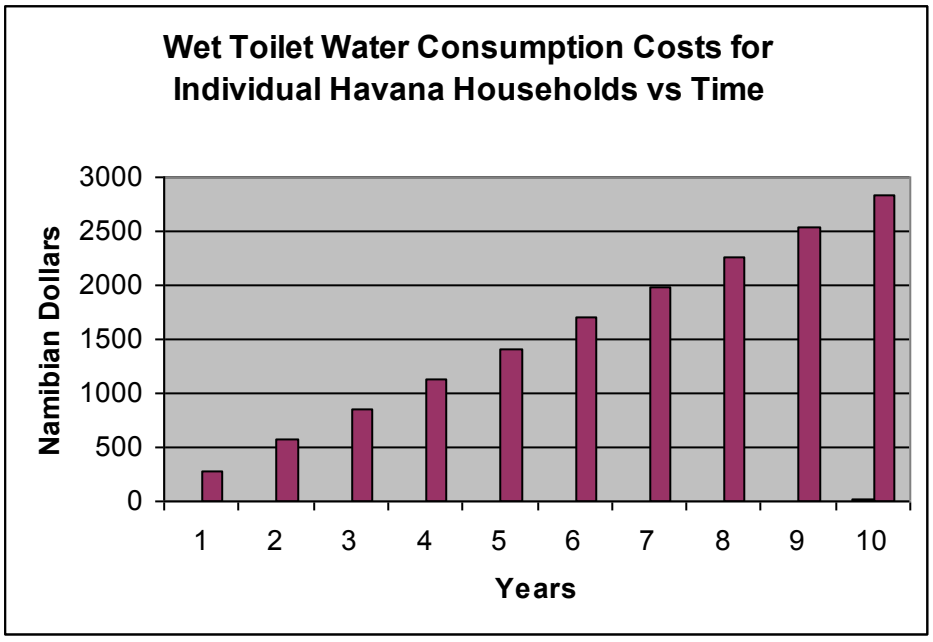


Figure 35: Average toilet water consumption costs for individual households in the Havana Settlement over time

In the dry country of Namibia, where water is scarce, it was advantageous to investigate the area between the two plot lines in Figure 29 before the 37.7 metre distance. The difference in costs between the two facility designs up to 37.7 metres in external piping distances may be viewed in Figure 36.

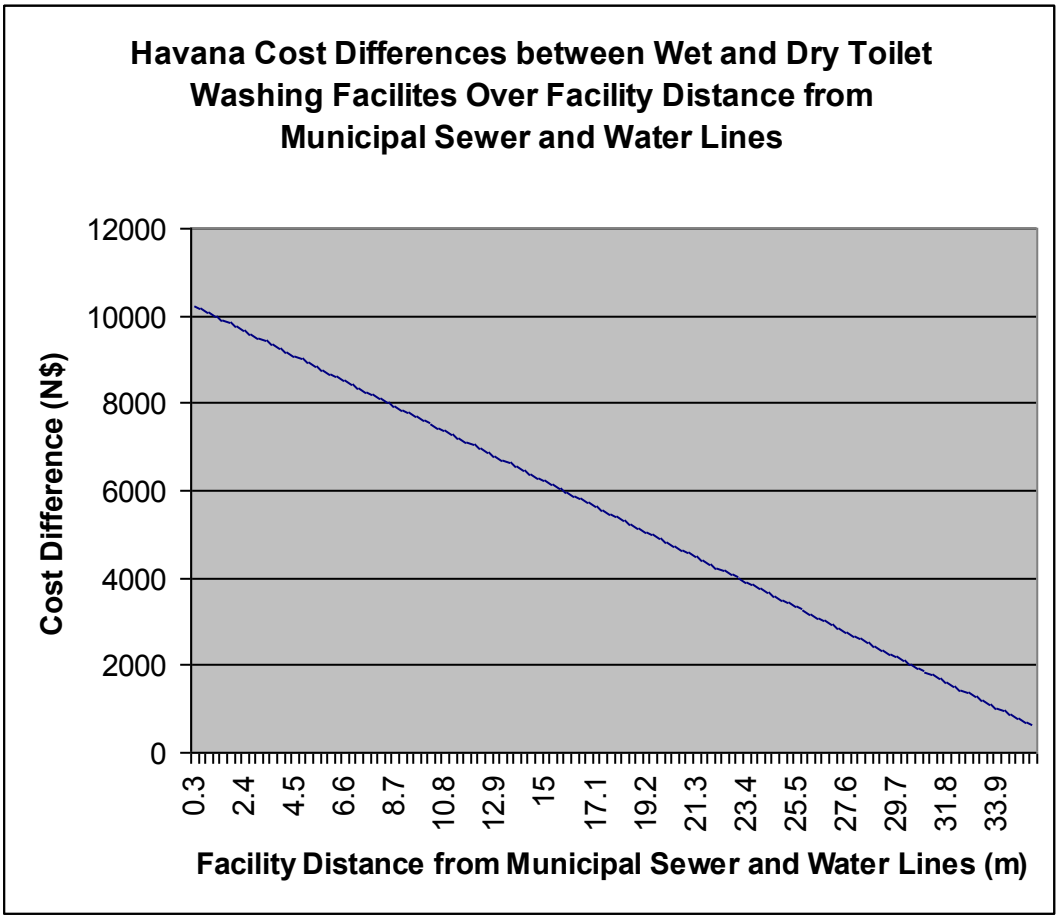


Figure 36: Havana cost differences between wet and dry toilet washing facilities at various distances from municipal sewer and water lines

Figure 37 shows the time for wet toilet water consumption costs to balance these cost differences at any external piping distance before 37.7 metres for both the City and individual Havana households. This graph was produced based on the assumption that each household consumes 105 litres of water in toilet flushing per day, and that four households will share each facility just as they will in Okahandja Park with the Cool Maintenance toilet facilities.

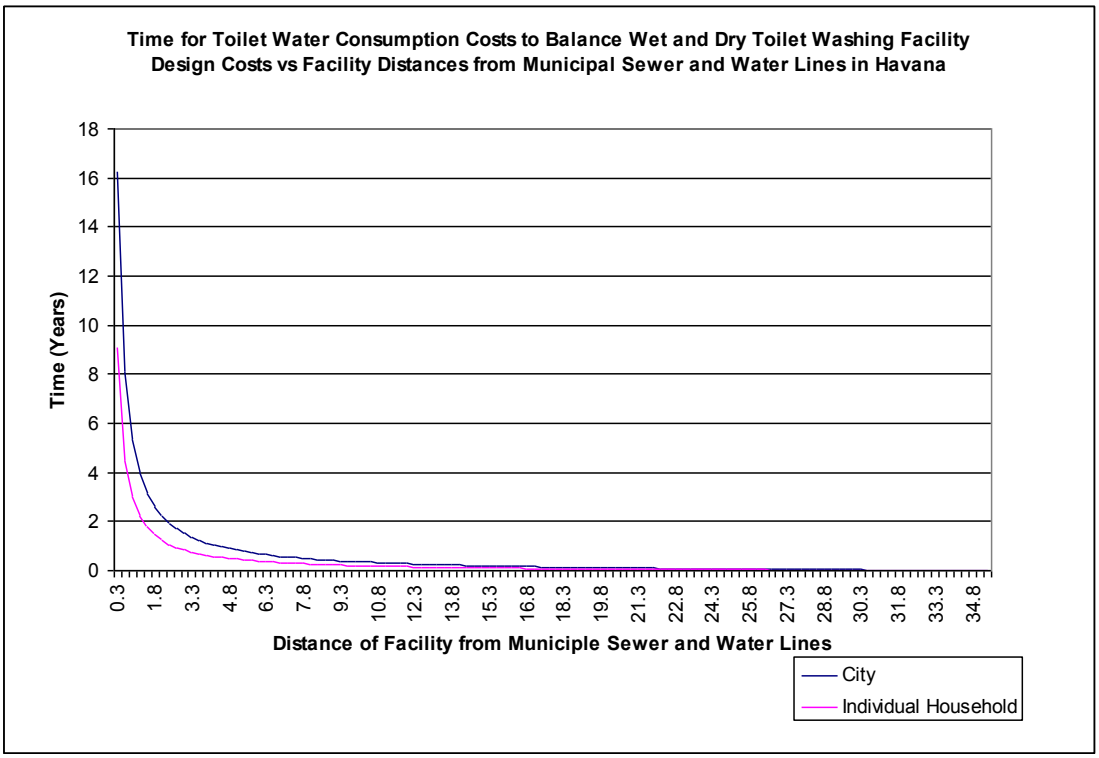


Figure 37: Time for toilet water consumption costs to balance wet and dry toilet washing facility design costs verse facility distances from municipal sewer and water lines in Havana

J. A. Burger estimated that out of the daily 95 litres of water used per household after toilet flushing, approximately seventy percent is used for showering (personal communication, 27 April 2004). In the Havana Settlement, a washing facility design that drains into the municipal sewer would reclaim grey water over time as illustrated in Figure 38. This graph shows that in a ten year period, over three-hundred million litres of water would be sent to the reclamation plant.

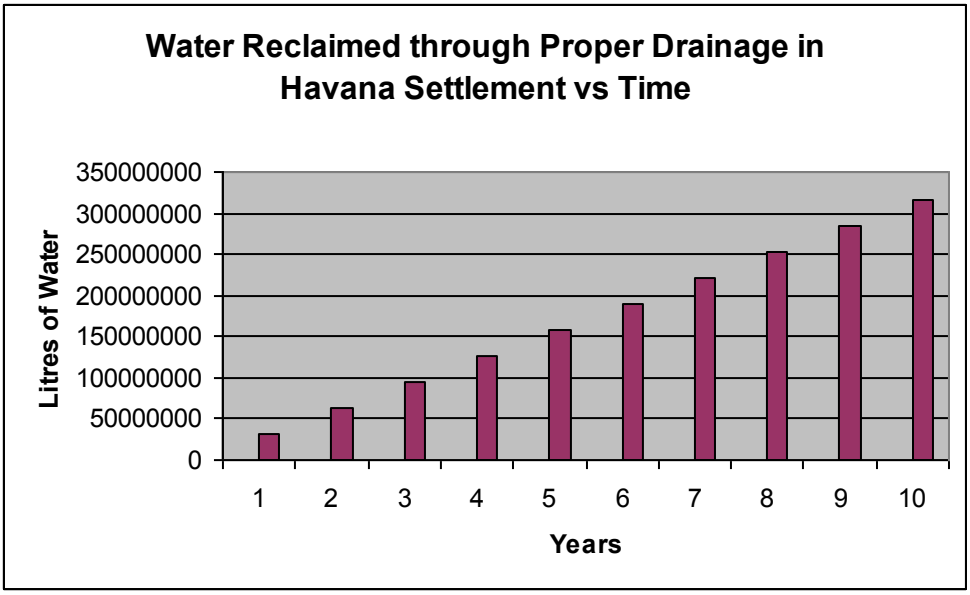


Figure 38: Water that could be reclaimed through proper shower drainage in the Havana Settlement over time

Incentives to use the Washing Facility Design

A crucial consideration for our project is to ensure that its importance will be understood by those who will use it. If the project is carried out and completed, it will have gained nothing if the community does not see its value and thus refrains from using it. Since this project was to design toilet and shower facilities for the informal settlements, it is important that the people who live in the informal settlements feel the need for such a facility.

Based on discussions with community leaders in the Northwest Settlements of Windhoek, we found that the community acknowledges that there are problems with the existing facilities they use. One major problem with the current system of washing is that the makeshift structures do not provide proper drainage. With these facilities, people bring buckets of water in with them to wash themselves. The used water drains directly onto the ground. This water runs off and collects in a puddle nearby. From talking with the community leaders about their current washing

structures, we have found that the residents who live in the informal settlements do recognize that the problem of the grey water building up in puddles on the ground is a very important problem. They commented on the resulting issues of bad odours and mosquitoes from these unsanitary puddles (personal communication, 30 March 2004). See Appendix B for minutes from our 30 March 2004 meeting with SDFN.

We do not believe the community members will opt to use the old makeshift structures over the communal washing facilities, as there are many advantages with the newly proposed designs. One of the requests of many of the leaders was that the new facility should provide adequate privacy (personal communication, 30 March 2004). There is little privacy with the current makeshift structures, since there is no roof and the walls reach only approximately 1.5 metres high. With our proposed design using the concrete structure made by ROCLA, there will be sufficient privacy, since the rooms for showering and for the toilet are completely enclosed short of high windows and gaps above and below the doors for light admission.

An additional reason to believe that the facility will be used is the fact that the people will be paying for it. They will not have a choice in paying for the facility, so they cannot decide to refuse payment for the new facility and use their old facility. There still exists the possibility, however, that people will not use the facility due to it being more convenient to use their own makeshift structure. In order to reduce this possibility, we aim to have as few people use each facility as reasonably feasible. With a few households assigned to each facility, the facility will be located a convenient distance from each of the households.

Pricing Structure

The individuals in the informal settlements are currently paying a flat monthly rate for the water used. The Havana Extension 1 Occupational Rights Levy indicates this rate to be nearly N$16 per household per month. Burger explains that this flat rate is shared equally by all those in the informal settlement communities and will go up or down the following month depending on the consumption of the previous month. This ensures compensation for all water over time (personal communication, 24 March 2004). This payment plan, however, does not encourage limited consumption or conservation, as there is no direct payment. Every individual may waste water and share the increased water costs equally with the rest of the community the next month. This plan is also susceptible to non-payment since the users can refuse to pay for water they have already used, as is often the case in the Northwest Settlements. With this system of many individuals sharing a standpipe, the City is unable to shut off water to one individual without affecting the neighbours. In these cases, the City is faced with the financial burden to NamWater in covering certain settlers' unpaid water costs. One advantage of the monthly flat rate system is that it is more technically reliable than a prepayment system.

Nossob River Systems is a Namibian company that designs and manufactures water prepayment meters for sale in Namibia, South Africa, Botswana, and countries outside of Africa such as Guatemala. According to Mac Albert Hengari, the Chairman of Nossob River Systems, their recent prepayment meters have had a great sales record. In Soweto, South Africa, their implementation has been a long-term project that has spread to Namibia where 8 000 to 9 000 meters have been installed in twenty locations. The initial plan of installing 500 meters in Northern South Africa has increased to 4 000 and then again to 20 000 meters. These large production

numbers indicate that the officials in Soweto believed that the prepayment meters were the best method for water distribution and payment collection. These prepayment meters were also installed in Johannesburg, outside Okahandja, Katima, the Democratic Resettlement Community (DRC) informal settlements of Swakopmund, and a pilot study has been approved for Katutura and the Windhoek informal settlements (personal communication, 13 April 2004).

Hengari noted three major problems with this new model of prepayment: lack of acceptance by the community, limited management capabilities by local authorities, and technical problems with the system. Through these problems, Nossob has learned that the meter installation must be preceded by community involvement to reduce community rejection (personal communication, 13 April 2004). See Appendix I for more technical details on prepayment meters and see Appendix B for minutes from our 13 April 2004 meeting with Nossob River Systems.

Prepayment meters provide an alternative to paying a monthly flat rate as they force the user to pay for water before gaining access to it. Any excess consumption is instantly felt financially by the user. The social implications with this solution, however, are quite complicated. Lindsay Dentlinger, the author of *Labour study slams water charges as "new Apartheid"* in The Namibian, discusses a report from the Labour Resource and Research Institute (LaRRI) on water privatisation. LaRRI was formed in 1998 as an organisation in Katutura that aims to collect and release information on Namibian labour and socio-economic issues (LaRRI, 2003). Dentlinger described the views of the LaRRI report by saying that "while prepaid water systems are being marketed as the solution to bad debts and water conservation, they are in fact worsening the plight of the country's [Namibia] most vulnerable." (Dentlinger, 7 April 2004). This article (see Appendix P) further explained the

injustice with the prepayment meter system, as the poor are being targeted with prepayment before the wealthier, larger consumers. Because of its lack of affordability, the poor are being forced to reduce the amount of water they use, which was already insufficient, resulting in basic public health issues (Dentlinger, 7 April 2004). According to the LaRRI report, clean drinking water should be a basic human right. The report suggests a free minimum amount of water be accessible to the poor who are facing poor hygienic conditions in efforts to afford water bills (LaRRI, 2004).

Hengari believed this article missed two important points, the first of these being the lack of distinguishing between technology and policy. In South Africa, the constitution states that each person must be provided a free minimum amount of water needed to survive. The meters have the flexibility of offering a set amount of water for free before the meter charges for the dispensing of water. He says it is either the town council's or the government's place to decide this set amount; not the prepayment meter company. This flexibility in the prepayment meter, he believes, places basic water needs within reach of the poor (personal communication, 13 April 2004).

The second point that Hengari emphasized was that he believes the article neglected to address the fact that there is not a significant amount of water in Namibia, and thus there needs to be a cost for water so that everyone will conserve water and have enough. He looked past the stated injustice in the article and said the informal settlements are targeted for prepayment because these are the areas with no reliable method of payment collection. Hengari believes technology and education is needed to conserve as much as possible in areas where non-payment is a possibility and reality. He stated that everywhere these meters have been installed, there is an approximate thirty percent drop in water consumption. Though he believes in a

minimum amount of free water for the poor and agrees the rich do not need this advantage, he expressed his opinion that everyone needs to pay for their water for the sake of conservation. He says this because he believes if people do not pay for their own water, they will not care about how much they consume (personal communication, 13 April 2004).

The LaRRI report on water privatisation blames Nossob River Systems for many of the problems found today in the Swakopmund Democratic Resettlement Community (DRC) settlements. In the DRC, water prepayment was used on communal standpipes. In October 2001, Nossob reported that most of the twenty-two standpipes installed with prepayment meters during the past year were no longer working. Nossob said that the problems were from vandalism, and new tamper-proof systems would be implemented. LaRRI notes that since October 2001, there have been many mechanical failures in the prepayment meters (LaRRI, 2004). The Namibian confirmed the failures by reporting the problems encountered by the citizens of the DRC three months after the new vandal proof Nossob meters were installed (The Namibian, 13 November 2002).

The village council of Uis, Namibia has blamed Nossob River Systems for 187 meters that are not working out of the 215 meters installed. Uis's income is just N$36 000 a month from the working water prepayment meters, but it needs to raise more. Each month the inhabitants of the village use water and electricity that costs N$500 000. Without raising enough money from the community members due to unreliable water prepayment meters, the village is forced to pay for the water and electricity, and is thus going into debt (New Era, 1 March 2004).

As a result of using prepayment meters in the Swakopmund Democratic Resettlement Community settlements, many citizens are not gaining access to clean

water. LaRRI interviewed DRC citizens for the water privatisation report and learned that many people who cannot afford water through prepayment or who cannot rely on the prepayment meters because they are faulty are forced to retrieve their water from a standpipe at the nearby Mondesa cemetery. The water at the cemetery is not safe to drink. It is intended only to be used to water the cemetery plants (LaRRI, 2004).

In Windhoek, prepayment meters are in place in some of the informal settlements. One settlement that has them is Greenwell Motango. Vance, a technical advisor for Namibian Housing Action Group (NHAG) and a resident of Greenwell Motango said that he would prefer using them over paying a monthly flat rate if they were more reliable, but they are not at this time. When the meters do not work, people have to walk far distances to find another meter that is working in order to get water. This problem is similar to the problems found in the Democratic Resettlement Community settlements of Swakopmund. Vance added that when the meters break, it takes upwards of three or four months before they are fixed, which leaves nearby households with the inconvenience of walking far distances for the next three or four months (personal communication, 16 April 2004). See Appendix B for minutes from our 16 April 2004 meeting at the SDFN office.

Prior to the use of prepayment meters in the DRC, LaRRI reports that citizens of the DRC had small gardens to grow the food they could not afford. Now that people do not have reliable access to water, the LaRRI report says plant life has disappeared (2004, pp. 14). Since people cannot grow their own food, they have to buy it all. LaRRI adds that some people living in the DRC have to choose between buying food and prepaying for water (LaRRI, 2004).

LaRRI also reports that in Stampriet, Namibia, when Nossob River Systems installed a water prepayment system, problems began to develop. The existing water

network needed to be updated, and in order to do the rehabilitation of the network, Nossob charged the Village Council of Stampriet an additional N$1.2 million. While doing the initial work on the existing water network, Nossob caused damages to city pipelines that allowed water to be lost. Stampriet's monthly bill from NamWater increased from N$20 000 before Nossob involvement, to N$80 000 after the Nossob mistakes. Problems with water loss were not just in Stampriet. Citizens of the Democratic Resettlement Community settlements also complained that to pay for water, they had to pay a higher rate that included charges for underground water leaks that they did not cause (LaRRI, 2004).

Although problems have existed with water prepayment meters in the past, some people still look towards them with optimism. F. Brinkmann, the Chief Engineer for Bulk and Waste Water for the City of Windhoek, feels that the new meters should an improvement and could be used in the future in the City of Windhoek in places other than the informal settlements. Today the prepayment meters are used mainly in the informal settlements because the City is not receiving money for all the water it supplies to the informal settlements. Brinkmann reported that the City receives its water from NamWater at a rate of N$4.11 per kilolitre and sells the water to the citizens of Windhoek at a rate that is based on the amount of water each person uses. Households who use less than six kilolitres per month are only charged N$4.17 per kilolitre, yet Brinkmann says many people in the informal settlements do not pay. To counter any arguments made that the poor would be penalized with prepayment before the heavier consumers, the City has instituted various consumption rates that increase with increased consumption. The full list of consumption rates can be seen in Table 4.

Table 4: 2004 City of Windhoek water consumption rates

Consumption	Tariff
0 – 6 kL / month	N$4.17 / kL
6 – 45 kL / month	N$6.94 / kL
6 – 36 kL / month during drought	N$6.94 / kL
> 45 kL / month	N$12.78 / kL
> 36 kL / month during drought	N$12.78 / kL

Brinkmann thinks that if prepayment meters work properly, they can help alleviate this problem of non-payment, and that prepayment meters could be implemented in other areas of Windhoek (personal communication, 21 April 2004). See Appendix B for minutes from our 21 April 2004 meeting with Brinkmann.

Without the help of the national government, Brinkmann feels that the City of Windhoek will be unable to provide water for free to people, simply because it is too expensive. Brinkmann said the issue of the national government subsidising water is a policy issue; not an issue of how much the water costs. In the past, the Namibian government has not provided free water to citizens, and Brinkmann feels this will continue to be true in the future (personal communication, 21 April 2004).

Brinkmann feels a bigger issue with prepayment of water is not whether or not the national government helps subsidize water, but rather how much work the local authorities put into the prepayment systems. He stated that the local authorities who oversee the sale of water to people need to take an active part in managing the water and the prepayment of the water. Brinkmann feels if the local authorities do not take an active part, then the water prepayment will not work. He recommends having people on the ground to watch the meters and verify they are still working, as well as managing the whole system (personal communication, 21 April 2004).

When considering prepayment for the use of toilet systems, it is important to realize the challenge. If forced to pay to flush the toilet, the poor would simply not flush to save money. One way to avoid this sanitary issue would be to request payment for admittance into the toilet facility. Hengari (personal communication, 13 April 2004) noted that this might result in complete use refusal. Hengari also proposed adding the cost of the water consumption from the toilets into the cost of the shower so the toilet costs might be included automatically. This would allow people to use the toilet without paying each individual time, thus eliminating the problem of not flushing or not using the facilities to save money.

In response to the LaRRI report on water privatisation, Helmut Angula, the Minister of Agriculture, Water and Rural Development with the Namibian government, assured that water was not unaffordable for most Namibians, and stated that it would be impossible to have free water provisions in Namibia. Angula further compared the cost of water to that of beer and remarked on the large number of Namibians who buy excessive amounts of beer and then complain about affording water. He said NamWater was not privatising water and ensured that it was NamWater's board of director's responsibility to provide affordable and reliable water supplies (Dentlinger, 13 April 2004).

Angula further stated that the critics needed to see the difference between personal water use needs and economic uses such as farming. According to NamWater, there is an average 25 litres for each person in Namibia to use for personal uses each day, which is greater than the United Nations recommended fifteen (Dentlinger, 13 April 2004).

Any payment system, such as the monthly flat rate system, has pros and cons. Table 5 displays these.

Table 5: Pros and Cons of monthly flat rate water payment

Pros of Monthly Flat Rate	Cons of Monthly Flat Rate
• More dependable than prepayment meters	• Cost shared by many with no individual held accountable for excessive water use • Many people do not pay • If one person does not pay, the water cannot be shut off for everyone

The pros and cons of prepayment meters are more complex because the social debate about prepayment is a sensitive issue in Namibia. The technical and social pros and cons can be seen in Table 6.

Table 6: Pros and Cons of water prepayment

Pros of Prepayment	Cons of Prepayment
• Supports local Namibian company (Nossob River Systems) • Guarantees payment for water • Good for preventing public debts • People are conscious of how much water they use and how much they save • Good for water conservation • Inhabitants of informal settlements support it • Creates small businesses to sell water credits with the vending unit	• Possible hardware failure that can cause frustration and inconveniences • Hardware failure can cause people to use unsafe water • The poor may be forced to use less than sufficient water consumptions • With no water or electricity bills, people may not pay other bills

The LaRRI report agrees with more cons about prepayment than it does pros. If a prepayment system is to be used, LaRRI suggested giving people a minimal amount of water for free. As mentioned before, Hengari supports this idea for the poor (personal communication, 13 April 2004) and Brinkmann feels it is not feasible (personal communication, 21 April 2004). With a water prepayment system, the poorest people will have access to minimal water or access to unsafe water like the water found in the cemetery near the DRC. The LaRRI report argues that the prepaid

water system increases medical costs and thus places a burden on the health sector due to the use of unsafe water when meters break or when people do not wish to pay for water (2004, pp. 15). The report does not go into detail on this point and recommends a further study be directed on this subject (LaRRI, 2004).

It is important to not only listen to the views of the national government, manufacturers of the prepayment systems, citizens who have already used prepayment, and the local authorities, but also the citizens of the informal settlements who might use the new prepayment meters here in Windhoek. When we asked a group of fifty-three community leaders from various settlements of Windhoek at a community meeting at the SDFN if they favoured prepayment or the current flat rate payment, the vast majority said they favoured prepayment (personal communication, 20 April 2004). Community Development Officer Edwin Jahs with the City of Windhoek's Community Development Division confirmed the support of prepayment of water by the Northwest Settlement community members. He said that even though fifty percent of people in the settlements do not pay the flat rate for water, he conjectured eighty percent of the people in the settlements are in favour of water prepayment. Jahs could not explain the inconsistencies in the numbers, but felt they were both accurate portrayals of the population. Many people who do not pay for water feel that water should be free, but even with that belief, Jahs feels that a dependable prepayment system will work well in Windhoek (personal communication, 20 April 2004).

Maintenance and Management Plan

The formation of a maintenance and management plan for the proposed washing facility designs is crucial to consider so as to ensure that the facilities will be

sustained and used for the purposes for which they were designed. Improvements in maintenance and management plans have not yet been perfected. Proposed ideas from various sources have all been very similar in terms of involving the community in making decisions, assigning community maintenance tasks, and educating the community in management skills. This section looks at methods for maintenance and management in the Northwest Settlements of Windhoek, particularly those that have been developed by two local organizations that we believed to represent and uphold the common ideals for community development success: Urban Dynamics and the Community Development Division of the City of Windhoek. Both these sources have many years of experience working directly with the people in the Northwest Settlements of Windhoek, and thus are able to provide valuable guidelines to follow in designing a maintenance and management plan specifically for the communal washing facilities in Windhoek's Northwest Settlements.

Urban Dynamics is a community development company who works with the City of Windhoek in the Northwest Settlements. They have recently developed a plan for the maintenance and management of the Havana Extension 1 toilet facilities. See Appendix Q for a more detailed description of this plan. The Community Development Division of the City of Windhoek, we found, was another valuable resource in understanding how to involve the community in a maintenance and management plan.

Full cost recovery of maintenance and management procedures will be necessary if the City is to sustain a facility development project. Thus, labour must be used efficiently and effectively. Urban Dynamics emphasizes in their work, the importance of using available resources to their potential. This includes the involvement and labour of the community members themselves, which will in turn

result in their gaining a sense of ownership. In our communal washing facility design, external piping costs were a large expense in the total cost of the facility. In order for the City to recover some costs and use labour efficiently and effectively, they could employ the community members in the excavation of the pipe trenches. This would directly involve the community and greatly reduce the community's developmental cost.

An important step in any maintenance and management plan is to educate the community on how to use and maintain the facility. According to Community Development Officer Edwin Jahs, the Community Development Division educates the community about how to properly use the facilities, and motivates them to maintain their own facilities through meetings and demonstrations. These demonstrations are helpful for those from rural areas unfamiliar with how to operate the facilities in the informal settlements (personal communication, 20 April 2004). Demonstrations would be especially important for the communal washing facilities. The washing facility with a dry toilet may appear complex before operational instructions are clearly explained through example. We noticed this need when the community leaders experienced confusion upon the introduction of our design at the SDFN office. The community's basic understanding of how to use the facility will need to precede their ownership and maintaining of their facility block.

According to Edwin Jahs (personal communication, 20 April 2004), toilets in the informal settlements are currently being maintained by the City's Maintenance Department. Unfortunately, this department does not have enough manpower for regular visits and check-ups on the facilities, and thus inspections are done on an ad hoc basis.

Urban Dynamics states that there are a few underlying principals to focus on in any community development project. In order to provide community initiative, the City must become actively involved. Many past maintenance and management systems conducted by the City of Windhoek have not been successful. After critical thought, Urban Dynamics decided the solution to the need of a successful maintenance and management plan would arise only when the communities were given responsibility of the facilities that they used. The idea that followed was a neighbourhood committee selection for each ablution block. In the case of Havana, where nineteen households shared each block, it was deemed reasonable that this committee consist of five people selected by the members of the same block in a democratic fashion. This committee would then report to the main community committee who would report to the City of Windhoek. Figure 39 illustrates this structure.

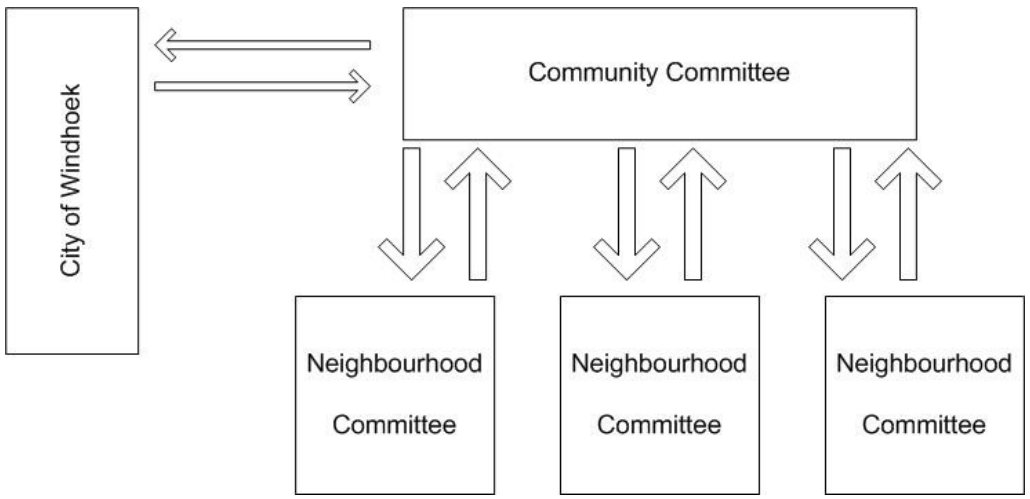


Figure 39: Maintenance and management plan diagram (Urban Dynamics, 2003)

The Community Development Division of the City of Windhoek would train each of the neighbourhood committees in their managing responsibilities. According to Edwin Jahs, this system is showing success in the Havana Settlement (personal

communication, 20 April 2004). For our project's communal washing facilities, we suggest using a similar structure as these neighbourhood organizations. Reducing the amount of households who share each facility, we expect the community members in each block will take more responsibility for the upkeep. The neighbourhood committees could be advised to create a rotation of shared duties plan that would involve everyone in the maintenance of the facility.

Urban Dynamics reported that some community members are trained in the areas of basic building techniques as well as other technical skills. The settlers learned many of these skills from aiding a contractor in the installations of facility blocks. Urban Dynamics reported that the neighbourhood could hire these individuals in the future for the upgrading and repairing of the facilities. Jahs, however, experienced problems with this plan. He said that in the past, the City elected young individual volunteers in the community to have apprenticeships and receive training in maintenance skills. This was viewed as a way to empower young people. Once they were trained, however, these youths asked for payment, but the City was unable to afford to pay those wages.

In the communal washing facilities, a revised plan could be implemented. Those who gain skills from their labour in the installation process may be hired by the community members for periodic maintenance and repairs. Their compensation would be divided by the household members sharing each block.

According to Jahs, many facilities have been vandalized, usually at night time by outside criminals. The parts that are stolen, usually hardware, are resold on the black market. Some members of the community volunteer their services without expecting payment, doing repairs to the facility out of their own initiative. When

parts are stolen, these individuals become frustrated from seeing their efforts done in vain. This frustration leads to neglect.

Jahs believes increased security in the low income areas would solve many problems (personal communication, 20 April 2004). According to ten Northwest Settlement community leaders at the SDFN, many women are scared to walk the streets at night due to the poor security within the areas (personal communication, 30 March 2004). Jahs awaits the results of the high mast streetlight project in Havana, believing the outside criminals are the main source of the vandalism. People in the community are unlikely to rob from their own community, since everyone knows each other. Community criminals disturbing public facilities have had their houses burned or vandalized from angry neighbours. Thus, controlling the crime from the outside is a large concern in the protection of these facilities (personal communication, 20 April 2004).

A neighbourhood watch programme would be useful for the communal washing facilities to eliminate fear that might dissuade people, especially women, from using the facility. The neighbourhood committees could develop their own security system, which would make the women feel more secure about using the facility at night. This security effort is to ensure that everyone would feel comfortable using the facility, thus feeling more inclined to maintain their block.

In an additional effort to increase the community's sense of ownership of the facility, it is a good idea to encourage people to personalize their facility. This could be done by painting the walls of the structure, installing shower curtains, or making other aesthetically pleasing modifications. ROCLA can be requested to add extra mounting sockets at N$5 each throughout the internal structure of the facility. These

mounting sockets would allow the community to install, onto the walls, items like shelves, clothes hooks, or structural additions.

CHAPTER 5. RECOMMENDATIONS AND FUTURE DIRECTIONS

Through the process of working with community leaders and local professionals, we have developed recommendations for the building plan, pricing structure, and maintenance and management plan. The following twenty recommendations are listed in order of importance, starting with most important.

Recommendations

1. We recommend using the single large concrete ROCLA design for the facility's structure with the inside layout as shown in Figure 13 on page 54.

2. We recommend implementing this project, including the building plan, the pricing structure, and maintenance and management plan, in one informal settlement community in Windhoek for evaluation. If the system is accepted by the community and is deemed satisfactory by the City of Windhoek, it should be implemented in other communities.

3. We recommend that four households share each facility. If more than four share the facility, there is a risk that community members will face inconvenience in walking great distances and waiting for its use, and will thus return to using their makeshift structures. If financially feasible by the community, the number of households per facility should be reduced.

4. We recommend the City of Windhoek should subsidize the installation of dry toilets in the washing facilities throughout the Northwest Settlements. Namibia must face its dire water shortage problem and conserve wherever

possible. The City should perform a feasibility study on installing dry toilets in all the facilities and produce a cost benefit analysis for this plan. Finally, they should create a long-term plan for compensation for the initial high costs.

5. If it is not financially feasible to install dry toilets in all the facilities in one community, the toilet selection process must be based on lowest cost. After the locations of the new facilities in a particular community have been determined, the average distance from a facility to the municipal sewer line should be calculated. At a distance of 37.7 metres, the cost of a wet toilet and a dry toilet, including installation costs, are the same. If the average distance from the facilities to the municipal sewer line is greater than or equal to 37.7 metres, we recommend using a dry toilet throughout the particular community, and if the average is less than 37.7 metres, we recommend using the wet toilets throughout the particular community. This is due to cost differences between the two toilet systems and the cost to run piping from the municipal water and sewer systems to the new facilities.

6. Based on its extensive track record, we recommend using the Enviro Loo toilet in the dry toilet washing facility design even though it is more expensive than the Cool Maintenance system. If the recently installed Cool Maintenance system in the Okahandja Park settlement proves to be successful, the Cool Maintenance option should be used instead because it costs less and because it is manufactured by a local Namibian company unlike the South African Enviro Loo.

7. If prepayment meters are used, we recommend that the cost of prepaid water should be on a graduated scale, in which households who use more water have to pay more per kilolitre than households who use less water. This can be achieved first by having each household purchase a dollar amount that is saved on their prepayment tags. Then, when a household uses water, the amount they are charged per kilolitre increases with usage. At the beginning of each month, the households will start over and will be able to use water at the lowest cost. This system, a hybrid of the present flat rate systems and the traditional prepayment systems, guarantees money for the City of Windhoek for its water distribution services, satisfies basic water needs at low cost for households who cannot afford higher costs of water, and is designed to make people conserve water. Specific water costs should depend on the bulk rate for water as set annually by NamWater.

8. We recommend providing connections for a prepayment meter in the facility, even though one is not to be installed at the initial stage of usage. Although there is a lack of evidence that proves current meters are completely reliable, new advancements in technology may make prepayment meters desirable. This connection will allow for easy implementation of prepayment meters in the future.

9. Prepayment meters should be installed in the facilities if excessive water consumption follows the implementation of a direct water connection for the shower and it is evident that new technical advancements have corrected old prepayment meter problems.

10. If a prepayment meter is to be installed in one facility, prepayment meters must be installed in all facilities and on all standpipes in that particular community at the same time. This will prohibit individuals assigned to the prepayment water from using the water from the flat rate standpipes for free.

11. For water conservation reasons, we recommend using the hand pump system over the direct water connection even when it is simple and affordable to make a direct water connection in the washing facility with the dry toilet design. With a pump, people cannot let the water run accidentally and would be less likely to waste shower water they have to work to supply.

12. When the facility has a direct water connection and a wet toilet, we recommend not charging any money for the use of the toilet. Instead, the City should recover the loss by increasing the costs of shower water. We recommend this plan because charging for using the toilet could lead to people not flushing or people not using the toilet.

13. If prepayment meters are used, we recommend the development of a more structured method for meter supervision. This supervision by the City of Windhoek should regularly check all of the meters to verify each one is still providing water to the households it serves. With supervision of meters, the inhabitants of the Northwest Settlements will have a reliable source of water.

14. We recommend the City of Windhoek ask for community members to volunteer their time and labour to installing the facilities and digging the trenches for the external piping, a costly component in our design. This will reduce developmental costs as well as increase the community members' sense of ownership of the project so that they will use the facilities, maintain and manage the facilities, and will not vandalize their own facility.

15. The City of Windhoek and the Shack Dwellers Federation of Namibia should advise the community to develop their own rotation of simple maintenance duties between households. This will support community responsibility and care of the facilities as well as increase community ownership and satisfaction in their neighbourhood.

16. We recommend the City of Windhoek train a few locals in maintenance and upgrading techniques so that they can be involved in the facility's repair or upgrades. This will provide the community with a more reliable maintenance service as well as increase community ownership.

17. We recommend that the community using the facilities should implement a volunteer community watch programme. This programme would involve community members actively watching the facilities in their community for crime, including theft and vandalism.

18. With prepayment meters, community members should be advised about creating a small business of selling water credits with a portable vending unit

as described in Appendix I. This will provide employment in the informal areas, as well as engender community support for the system.

19. The community should remain informed about building and installation costs, so that changes can be made if the facilities become unaffordable. The facility may become unaffordable when the building supply costs increase. Dramatic cost increases have occurred in the past when the cost of the Enviro Loo increased by almost fifty percent in just two years.

20. The current cost of the hand pump is N$3 018. We recommend researching other less expensive pumps that serve the same purpose, but do not cost as much. This could drastically reduce the overall dry toilet washing facility price.

Future Directions

This project can be continued in many ways. The issue of water prepayment has been explored, but not yet solved. Prepayment is an issue that will be debated for many years. The development of a specific prepayment plan for both the informal settlers and for residents from more affluent areas in Windhoek could be explored by Worcester Polytechnic Institute (WPI) students as an Interactive Qualifying Project (IQP) or by Polytechnic of Namibia (PoN) students.

Another area of research that can be continued, which was shown in Figure 10 on page 53 and detailed in Appendix G, is reusing grey water on-site. This can be researched by a WPI undergraduate student working on the Major Qualifying Project

(MQP), senior year technical project, or by a PoN student. This could also be done through a partnership between WPI and PoN students.

The City of Windhoek can continue this project by working with specific communities that will need communal washing facilities in the future. At the same time, the City of Windhoek can make the decision to use the design we have developed or to invite tenders to be submitted by outside companies to view a variety of different ideas. The City of Windhoek can use our ideas in developing the list of technical specifications and conditions that these companies will need to meet in their designs.

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APPENDICES

Appendix A: Mission and Background of the City of Windhoek

Windhoek, the capital city of The Republic of Namibia, is at the centre of everything important in Namibia. The University of Namibia and Polytechnic of Namibia, the Namibian Stock Exchange, two Airports, State Radio and Television networks, and all foreign missions are found in Windhoek (City of Windhoek, 2004). The city government of Windhoek intends to continue serving its people and better the life of its citizens.

The City of Windhoek focuses on six main missions in its aim to be a "centre of excellence" as quoted below:

- Render affordable, effective services and infrastructure to our customers through the optimal use of resources, technology and sound financial management.
- Create competitive economic development opportunities, while applying sound environmental management principles.
- Promote a user-friendly culture while encouraging public participation and ensuring customer satisfaction.
- Seek co-operation between Government, parastatals and the business community in pursuit of synergy between service providers.
- Promote tourism.
- Ensure a crime-free and safe environment (City of Windhoek, 2004).

To successfully complete these six missions, the City has many departments, each with their own goal. The breakdown of the City of Windhoek structure is shown in Figure 40.

City of Windhoek Structure

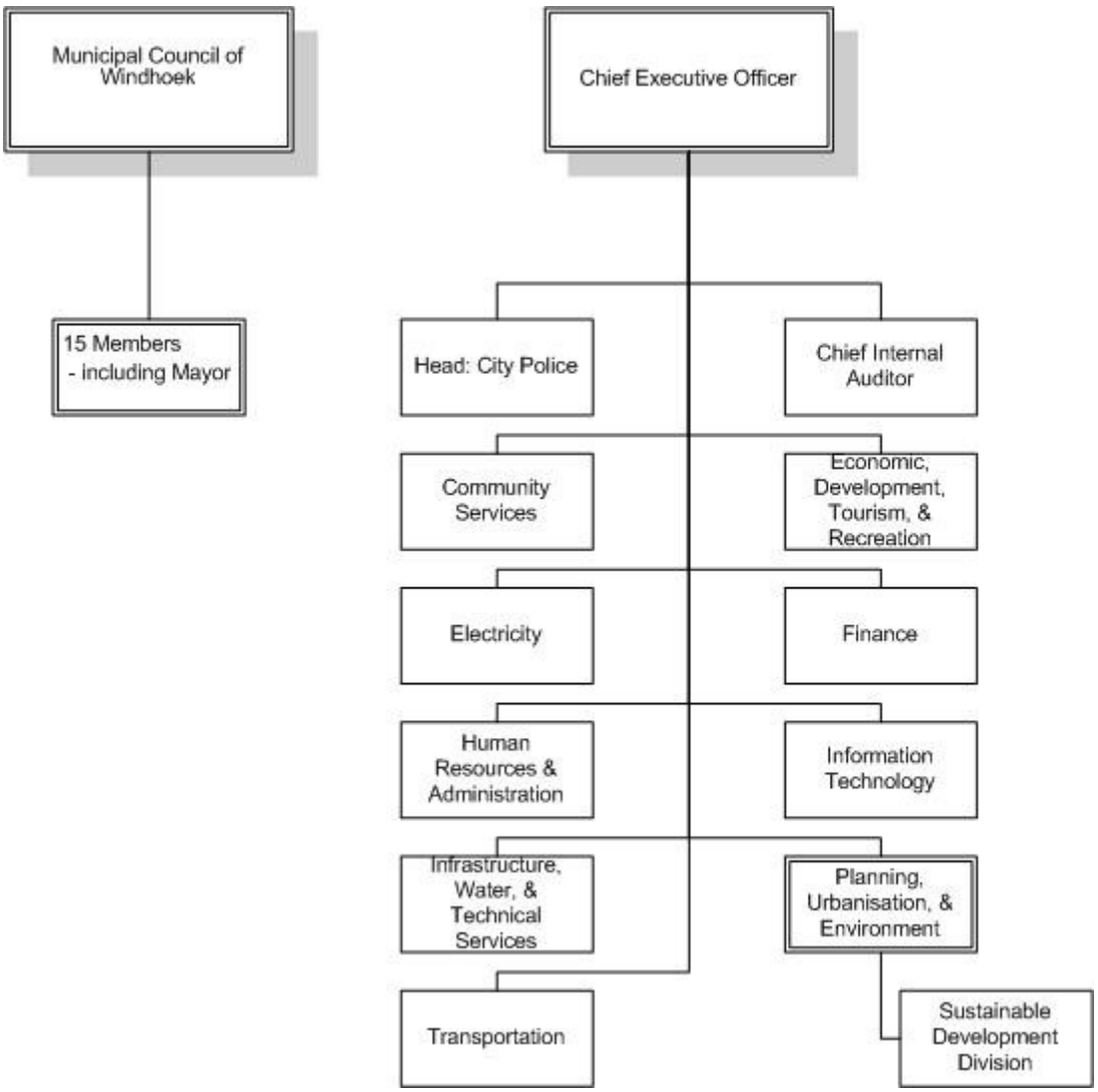


Figure 40: Chart of City of Windhoek Structure. Derived from pictures and documents from City of Windhoek's website: (Councillors, 2003; Municipal Council of Windhoek, 2003; Top Structure, 2003)

Windhoek is home to 230 000 of the 1.9 million Namibian citizens (The World Factbook, 2003). Included in the Windhoek population are 19 694 families living in the informal settlements (Urban Demographics, 2004). The Sustainable Development Division of the City of Windhoek states that their mission is to work to develop the informal settlements in a way that is sustainable to the environment and the people. Creating a means to make the lives of the citizens better without taking

into account the environment is unacceptable to the City. The breakdown of the Sustainable Development Division is shown in Figure 41.

Sustainable Development Division Structure

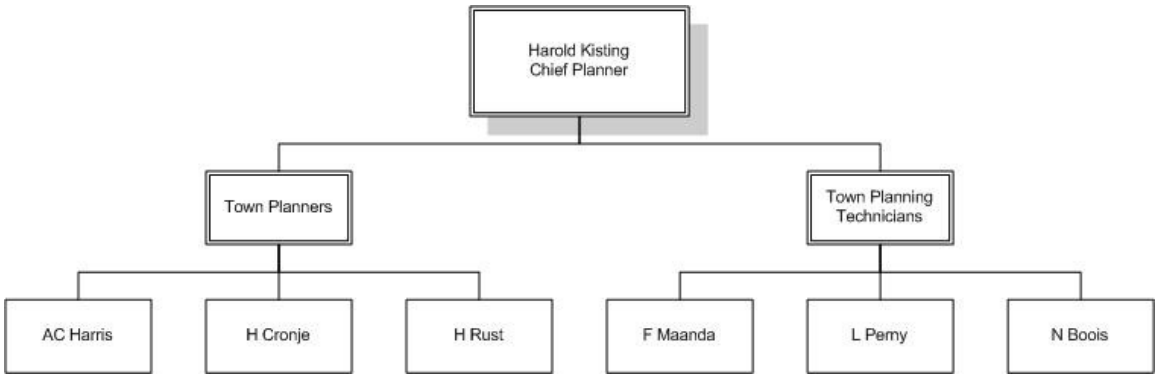


Figure 41: Chart of Sustainable Development Division Structure (personal communication H. Kisting, 30 March 2004)

Appendix B: Meeting Minutes

18 March 2004 – Architect Nina Maritz

Attendees:

Nina Maritz
Harold Kisting
Adam Bryant
Drew Campbell
Patrick Salmon

We had a meeting with Architect Nina Maritz to discuss building ideas and materials. The following are the meeting highlights.

- It is more important to be humane than cheap (Kisting)
- There are thirty households for every two toilets in Havana (Kisting)
- At a minimum the facilities should include a toilet, shower, and standpipe
- Questions to consider:
    - Who is the waste from the dry toilets going to belong to?
    - Who gets to use this waste for their garden?
- For privacy facility must have secure doors, which is an added expense
- Havana toilets have steel doors. Our facilities will need two doors – one for toilet, one for shower
- Building material idea: Red clay bricks from China Great Wall on Birmingham Street. Brick work is good when want to involve community.
- If we pre-cast off-site it's cheaper, but doesn't include community.
- Roofs and floor must be sloped so easier to mop, and less pipes and less clogging.
- Use half-pipe for outside drainage to prevent clogging.
- Must decide whether to raise shower floor with half-pipe to feed holding tank. Holding tank may be above or underground.
- Underground tanks need strength against soil pressure. Put plastic barrel inside metal drum.
- Above ground tanks cannot use plastic because of harmful UV rays in Windhoek.
- Any tank will need waterproofing to avoid corrosion.
- Use grey water for toilets by using hand pump then gravity feed. May need sand filter or charcoal filter in tank.
- Don't use solar power because it will be stolen in the informal settlements.
- Talk to Stefani van Zyl about feeding grey shower water to water nearby tree or other agriculture.
- In Havana they are using flush master toilets. These need pressure and are complicated and expensive and may need a filter.
- Soap contaminants in ground should not be a big issue for the short-term.
- When waste stays wet, pathogens will grow.
- Urine will eat away at concrete and cinder.
    - Use plaster lining.
- Need outlet for holding tank overflow
- Doors should open inside for privacy.

- Painting and using different building geometries would make the facility look friendlier and it will be more fun for builders. This is a little more expensive
- Instead of using a whirlybird for dry toilet ventilation pipe, use wire mesh to avoid theft.
- Use Builder's Warehouse for prices on supplies.
- For dry toilets, black pipe must face north.
- The Enviro Loo dry toilet was designed for South Africa and may not be as useful here.
- In order to allow light in, instead of using windows, make gaps on top and bottom of doors.
- Use fibreglass for windows, instead of real glass.
- Use holes w/ PVC in cast walls for cross ventilation.
- When we make drawings, show all measurements and describe measurements
- Prices will change all the time.

24 March 2004 – City of Windhoek Water Engineers

Attendees:

M. Hindjou – Project Manager: Land Delivery
H. I. Peters – Chief Engineer: Technical Support
J. A. Burger – Section Engineer
F. Brinkmann – Chief Engineer: Bulk and Waste Water
H. Kisting
Adam Bryant
Drew Campbell
Patrick Salmon

This meeting with City of Windhoek water engineers covered topics of prepayment, toilet and shower designs, and quick fixes. The following are the meeting highlights listed by topic.

<u>Prepayment</u>

- New meters are much better than the old ones.
    - In Havana they aren't doing well.
- Tokens are used with these prepayment meters.
- Currently, these prepayment meters are used only with standpipes.
- Prepayment meters need electricity. They usually use batteries.
- Community Leaders collect approximately N$5 or N$6 to pay the City (flat rate)
    - The flat rate is adjusted by community for their past consumptions.
- If the community gets too far behind on payments, the water will be cut off.
- Open standpipes cause problems with payment.
- Toilets are not prepaid.

<u>Wet Toilets</u>

- People do not like having septic tanks on their property
    - We should inform people it is okay.

    - It is hard to dig/drill in ground in the Northwest Settlements. Using a jackhammer would be necessary.
- There would be problems with pumping grey water from holding tank due to clogging.
- Sand filters will clog with soap.
- Look into pre-cast pump from NamWater to prevent theft
- Pump could otherwise be stolen.
- Overflow issues
- Not enough grey water for flushing
    - It takes approximately 2 litres to wash.
    - It takes approximately 7 litres to flush. We probably could get away with approximately 5 litres.
    - In the winter time, Northwest settlers wash less.
- A mini sewer system could be used to connect many toilets to one septic tank
- People may not want to pump toilet water.
- Very few areas are without sewers
    - We could probably just put waste into municipal sewer system.
- We could hire someone to pump the toilet.
- Flush Masters work very well, but are expensive.

Showers

- If we provide a shower, they may not use it.
- Don't heat the water.
    - Individuals could heat the water if they want to.
- People don't have cash on them to pay all the time.
- Including a dressing area is important
- We should worry about vandalism, but should not make it a major focus.
- Doors could be stolen, so possibly use no doors by using a wrap-around wall.
- Use concrete slab to collect water.

Misc

- We don't need a sink.
- Using others' ideas should not be a problem (in terms of patents/copyrights).
- At the end of the standpipe, use a flexible hose so people can move it into a bucket.

Contacts

- For pipes cast in walls:
    - Adcon, Owner Faulker Gogol
    - ROCLA

Four Main Points to Consider

- Water Consumption
- Acceptance
- Vandalism
- Community Involvement

Possible Quick Fixes

- Shower idea:
    - People can bring their own water.
    - Use buckets to pour into an overhead tank.

25 March 2004 – Urban Dynamics

Attendees:

Stefani van Zyl
Herald Kisting
Adam Bryant
Drew Campbell
Patrick Salmon

In this meeting with Stefani van Zyl from Urban Dynamics, the discussion focussed mainly on how to deal with community development issues. Since van Zyl has had much experience working in the Northwest Settlements of Windhoek, she was able to give us valuable feedback about our design considerations.

- For the settlers, environmental issues are not a high priority.
    - They are more concerned about food, survival, and health.
    - They are less worried about gardening.
- Urban Dynamics likes to work with community.
    - Through workshops, have them identify their issues.
    - Show them the drainage problem.
    - Then establish cause and effect by finding the roots of the problems
    - Some experience a mind shift when they see the reality of things.
        - Compare methods in richer neighbourhoods versus the informal settlements.
    - Each community comes up with an action plan for their own priorities.
- Toilet facilities are high on the priority list.
    - Washing facilities are new issue and have not really come up before.
- The community does not have control of who uses the facilities amongst themselves.
    - This brings up their need for a management system.
- People come in from the outside of the settlements and steal pipe work out of the ground.
    - Everything has to be robust.
- In the Goreangab area, there is a valley of informal settlers surrounded by formal settlers.
    - Sewage pipes from formal settlements run through informal settlements.
    - There is not enough grey water in sewage pipes today, which leads to clogging.
        - Shows two sides of the issue: engineering verses environmental
- H. Kisting said people see dry toilets as inferior to flushing toilets, van Zyl agreed.
- Kisting said to do surveys to see how toilets are currently used.

- Use local materials and have people erect structures themselves.
- She pointed out that working with new communities is very difficult.
- People like to see exactly how things work.
    - A transparency display of our design would be beneficial.
- Test the designs and discuss them with the community leaders.
- Use a pre-cast design with a toilet and next to this, have a showerhead and drainage (concrete slab)
    - This allows for future additions (modular system)
- If we use pre-cast structures, we would need to build a lot to be cost effective.
    - Need to look at other building materials.
- Kisting said to find out how many households can share a facility.
    - Kisting thinks today about three households share a facility.
- Today there is limited knowledge about hygiene.
- Maybe train a small group of community members to build the structures.
- In her opinion, the main goal is to get the people to want to take care of themselves.
- Other issues to consider:
    - Women are scared to use facilities.
        - It's good that one can see into the present makeshift structures to ensure that no one is being harmed or attacked.
    - Lighting inside.

30 March 2004 – SDFN

Attendees:

10 Community leaders from the Northwest Settlements
Anna Miller
Adam Bryant
Drew Campbell
Patrick Salmon

This meeting was our first meeting with the people from the Northwest Settlements. We brought to them very rough ideas for designs, including a sketch of a possible washing facility design. We were able to find out from them what their main concerns were concerning a washing facility.

- Translator – Profilius Halwoodi
- The main concern with the community was that they would have to pay for the facilities.
- They view dry toilets as being clean and good.
    - Dry toilets are already in place in some areas of the Northwest Settlements, like Okahandja Park C.
- They said that problems with the present situation are:
    - Water run off leads to malodours and mosquitoes.
- They want a tall structure.
- These people from Habitat 2
- One idea was to make the facility relatively small so it would fit in with the rest of the buildings.

- Approximately twenty people now share toilet facilities.
- They prefer to use the term ‘public’ to describe facilities.
- At the present, dry toilets are taken care of by the City of Windhoek.
- An idea for maintenance is for each house to have a different day to clean.
    - Some people won’t always follow this, but it should work overall.
- They estimate that they use about twenty to twenty-five litres of water per washing.
- Children wash themselves.
- Today they pay thirty dollars a month, and twenty dollars a month in some areas.
- They don’t think prepayment is needed.
- Their view on wet toilets is that they waste money and water.
- They were interested in sinks for washing dishes.
- One of their concerns is that dry toilets are expensive.
- Their worries about outside toilets include:
    - Security at night
    - Women don’t want to walk at night
- They are concerned about needing to wait for showers with a public shower facility.

31 March 2004 – Okahandja Park

Attendees:

Hugo Rust
Adam Bryant
Drew Campbell
Patrick Salmon

Hugo Rust, a Town Planner in the Sustainable Development Division, took us to Okahandja Park, a part of the Northwest Settlements, in order to view the dry toilets that have been installed there. He also took us to Stubenrauch Planning Consultants, which was a distributor of Enviro Loo toilets, so that we could get a closer look at the Enviro Loo toilets.

<u>Cool Maintenance Dry Toilets</u>

- Dimensions are:
    - 145 cm (depth) X 90 cm (width) X 210 cm (height)
- The slope of the roof is:
    - Rise/run: 16/145
- Four to Five households will use each facility.
- These facilities have not been tested in a large area before this project.
- Cool Maintenance did not make the metal structure that surrounds the facility.
- The toilet uses a two bag system on sliding tray.
- There is a big open tank underground, underneath and behind the toilet.
    - Rain water was on the inside, indicating that it was not completely sealed.
    - The cover to the pit did not have a lock.

Enviro Loo Dry Toilets

- One facility had a huge step to get inside.
    - This was due to its placement on the landscape.
- These toilets used the same outside structure that the Cool Maintenance toilets did.
- The instructions were in English.

SPC – Stubenrauch Planning Consultants

- We viewed the large Enviro Loo systems.
- Flap for flushing did not appear to have a great seal.
- The waste does not go directly into a bag.
- Inside there is one large tray that holds the solid waste, with holes for liquids to drain to the bottom.
- We were told there may be a problem with too much liquid.
    - In some places, you can add an overflow hole.
        - This prevents smells.
        - This leads to some environmental concerns.
- These toilets are made in South Africa.
    - They are shipped here via trucks.
    - They are easily stackable.

06 April 2004 – ROCLA

Attendees:

J. J. Oberholzer
Adam Bryant
Drew Campbell
Patrick Salmon

In this meeting, we talked with Mr. Oberholzer, Windhoek Branch Manager, about the options that ROCLA could offer for a structure for our washing facilities. The following is the information that we gained from this meeting.

- Manufacturing new moulds costs N$150 000 – N$200 000.
- Putting piping in the walls is no problem.
- Usually water piping is 15-20 mm copper.
- Drain sizes are 40-50 mm.
- Full bathroom structure itself costs approximately N$3 400
    - Includes only concrete casting without doors.
- Individual toilet or shower structure itself costs approximately N$1 500
    - Includes only concrete casting without doors.
- Standard cheap door that lets light in above and below costs N$130 per door.
- Standard doors come from South Africa.
- Municipality prefers stronger doors which cost N$450 per door.
    - Stronger door are made from 1.5mm thick steel.
- Oberholzer advises using cheaper doors because both will be vandalized.
- There are no extra costs for holes in the walls for light.
- ROCLA makes all structures out of concrete only.

- The tank is probably better cast out of concrete so it won't be vandalized.
- The shower floor will be sloped for drainage.
- Steps are available at N$15 per step.
    - These are manhole type steps so people must use hands to climb them.
- Proper stairs would be very expensive.
- It is not a problem to put in a dividing wall in the larger structure.
- It is better to have piping in wall outlet on the left or right bottom, but not in the middle, because it gets in the way of toilet connection.
- When the piping in the wall outlet was high, it was vandalized.
    - It is better to have the piping low.
    - If the piping is below the ground, it might be hard to access it, but is still doable.
- Steps would need to go in the back wall because of the casting process.
- It is easier to use a concrete roof than other types of roofs.
- A pulley could be used to raise buckets instead of carrying them up, but this risks theft.
- Moulds are in South Africa at the moment, but it would take about a week to get them in Windhoek.

13 April 2004 – Nossob River Systems

Attendees:

Mac Albert Hengari
Zelna Hengari
Justuce Tjirimuje
Bernard Griffiths
Adam Bryant
Drew Campbell
Patrick Salmon

In this meeting, we discussed the prepayment meter products that Nossob River Systems offers as well as discussed the social issues surrounding prepayment meters in Namibia.

- Nossob expresses its success by saying that 8 000 – 9 000 meters have been installed in Namibia in 20 different locations.
- In Soweto, South Africa, the meters are a long-term project.
- In Northern South Africa, orders have increased from 500 to 4 000 to 20 000.
- 3 types of problems exist with prepayment meters:
    - Acceptance by the community.
        - They have learned that the meter installation must be preceded by community involvement to reduce rejection.
            - They had problems in Katima, Namibia with managing
    - Limited management capacity by local authority.
        - There is a team in Katima to help local authorities.
    - Technical problems with the system.
- After revising technical problems, the meters can stand splashing of water but not complete submergence.

- Tampering
    - Meters are designed so that evidence of tampering can be seen.
    - Two large screws hold the system in place.
        - Over the screws, a seal is placed that will prevent people from removing the system without it being noticeable.
- These meters have been installed in Swakopmund (DRC Informal Settlements), Johannesburg, outside Okahandja, Katima and a pilot study is in process for Windhoek for the informal settlements and Katutura.
- How the two different types work:
    - Multiple User Machine:
        - Machine holds data on overall usage.
        - Individual users have tags that hold how much credits they have left.
    - Single User Machine:
        - User buys credits and transfers them to the machine. There is no need to use the tag each time the user wants water.
- Technical Details on Machines can be obtained by viewing data on tags.
    - This always needs to be managed by Local Authorities so they can use data mining to see:
        - if people are showering or not.
        - consumption rates.
        - patterns.
        - low battery levels.
- Transfer of data is made from tags to vending unit.
    - Personal data is on tag.
    - Meters store lots of data, which is transferred to tags when a tag is used.
    - The data on the tags is transferred to the Vending Unit when someone buys more credits.
    - The Vending Unit transfers the data to the Local Authority (LA) every so often.
    - Once the LA has the data, they can then analyze the data.

<u>Costs:</u>

- The following costs include installation, but vary slightly with piping and installation requirements:
    - Bigger Meter (multiple use) → N$3 500
        - Battery life of about 5 years
    - Smaller Meter (single household use) → N$1 700
        - Battery life of about 8 years
- Battery replacement is the only real maintenance. There's always the possibility of technical difficulties.
    - To replace the battery, they remove the unit and replace it with a new meter. This new meter replacement costs only the price of a new battery which is insignificant.
- According to Justuce, the meters have a 1 year guarantee.

<u>Reaction to the Namibian Article: 07 April 2004</u>

- He believed the article missed 2 important points:

1. It did not distinguish between technology and policy.

    - In South Africa, it is written into the constitution that each person must be provided a free basic amount of water needed to survive.
        - These meters have this flexibility.
        - It is either the town council or government to decide this amount.
2. There is not a lot of water available in the country, so water needs to have a cost to control water consumption so that everyone can have enough.
    - The informal settlements are targeted more because there is no method of payment collection.
    - We need to use technology to conserve as much as possible.
    - M. A. Hengari wants to give some amount of water for free to the poorer people and says more financially stable people don't need to get this certain amount for free, just the poor people.
- M. A. Hengari has seen up to 30% drop in water consumption with these meters.
- Payment is essential to conservation.

<u>Toilets</u>

- The only way you can have someone pay for toilet use, is if they have to pay to enter.
- Costs of toilet can be added into costs of shower
    - Both facilities can be provided with the basic free amount.
- Nossob also sells dry toilets.

<u>Vending Units</u>

- People can get credits on their tags at the office, or can have someone in the community credit them with a portable vending unit.
    - This person can make a profit off of this unit by buying lots of credits at a discount, then selling at regular price.
    - Vending unit is not too expensive.

16 April 2004 – SDFN

Attendees:

Edith (Katutura East)
Elizabeth (Habitat Two)
Henri (NHAG)
Vance (NHAG)
Selma (SDFN)
Adam Bryant
Drew Campbell
Patrick Salmon

In this meeting, we came prepared with some fairly solid plans with cost estimates for each variation of the designs.

<u>Woman from Katutura East - *Edith*</u>

- Theft can happen at night.

    - She was very sure that theft would occur.
    - She would rather see the facilities attached to individual homes.
- Cleaning could be a problem when lots of people use the facilities.
    - She was very concerned with people not cleaning.
    - She thinks that if few households use the facility, cleaning might not be a problem.

Henri and Spanish Woman – *Namibian Housing Action Group (NHAG)*

- They recommended that we go to a Tuesday evening meeting with technical people to discuss our ideas.
- Woman was interested in the two-structure design.
    - She wanted to know prices for each piece individually.

Vance – *lives in Greenwell and is a technical advisor with Namibian Housing Action Group (NHAG)*

- He does not think the municipality would like dry toilets.
- He liked the pump idea with the showers.
- He agrees about connecting to sewers for grey water.
- He prefers wet toilets.
    - If pipes are present, then use flush toilets.
- He believes dry toilets are good for temporary applications.
- He prefers not to have prepayment meters.
    - His experiences are that the meters break so then people have to go and walk farther to find a meter that works.
    - Authorities do not service the meters on time.
        - If they break, they may have to wait three to four months before they get fixed.
    - If meters were more reliable, then they would be fine.
- Sometimes people delay payments of water and the charge will carry over to the next month.
- People know that health is important.
- He prefers having one toilet per household.
- People can wash themselves with just buckets.
    - Using buckets is a good way to wash because people can control how much water they use.
    - With showers, people end up using much more water.
- He would like to see community involvement in this project.
- If people share the facility, no one would want to take responsibility for it.
- We need to educate people.
- He prefers the large facility over the two small ones.
- If four households use the facility, no one will care about the maintenance and management.
    - Neighbours could discuss how to share responsibility.
- Overall, he thinks that the project will work.

Selma – SDFN

- She liked the larger design better.
- Small does not look good.
    - It looks dark.

16 April 2004 – J. A. Burger

Attendees:

J. A. Burger
Adam Bryant

This correspondence was a telephone communication in which technical information was gained about piping for the facilities, such as costs and sizes. Some technical information was also gained about flush toilets.

Drainage Piping – (40mm)

- We will be safe with 40 mm for shower drainage piping
- N$120/m includes material for 40 mm water source piping, trench excavation, and all other costs
    - Believes this estimate will be close enough to 40 mm shower drainage piping

Sewage Piping - (110mm)

- This is the standard diameter piping used
- 13 or more households may connect to this piping
- N$300/m includes piping material, trench excavation, manholes (at 60m intervals)

Water Source Piping – (25mm)

- N$94-5/m includes piping, valves, trench excavation, and various fittings
    - Believes this estimate will be close enough to 20mm water source drainage piping

***Note**: These costs he calculated using averages and he uses them as he feels they are a very accurate representation. These prices are on the higher side of cost and he believes they may be reduced through community participation and labour

Toilet Water Consumption

- Eighteen to twenty-five households currently share each toilet facility in the Northwest Settlements.
- Assume two flushes per person per day.
- There is an average of 4.2 people per household.
- There is an average of two hundred litres of water flushed per household per day.
    - This translates to six kilolitres of water used for the toilet per household per month.

19 April 2004 – George Esterhuiz

Attendees:

George Esterhuiz
Adam Bryant

This was a telephone correspondence in which clarification on the water tariff tables from the Aloe January 2004 newsletter were made.

- Water tariffs are adjusted yearly by NamWater, sold to the City of Windhoek, who must then recover the costs to pay back NamWater. This is done through these tariffs.

Basic Charge Table:

- The informal settlements fall under the domestic category.
- The basic charge is the monthly base fee regardless of any water use.
    - This charge is per standpipe.

Consumption Table:

- The Informal Settlements may be placed under the WC 22 category: "Flats/ legal entities 5 or more units with communal meter/s"

19 April 2004 – Afro Pumps

Attendees:

R. Woortman
Adam Bryant
Drew Campbell

We met with Woortman at Afro Pumps in order to find a pump that we could use in the washing facility. We received all the important detailed information about the most practical pump he had for our purpose. We also talked about his views on prepayment meters as well as his ideas for a facility structure.

Recommends using Jabsco Amazon Warrior (PN 29280-0000)

- This pump was designed as a bilge pump for boats.
- The cost for this pump is N$3 018.
- This pump would have to be bolted on and would not be able to be cast in.
- The pump has an 18 inch removable handle.
- The diaphragm is made of nitride.
- The casing and parts are made of powder coated die-cast aluminium.
    - This is corrosion resistant.
- Little maintenance is required.
- Sand will not cause problems because it is a diaphragm pump.
- We could use a strainer at the bottom of the tank to keep things out that could clog the pump.
- Pump can be run dry, and is therefore more resilient to misuse.
- A cheaper meter option costs N$1 500 but is not recommended because it is made of plastic.

- To protect the pump from theft, it can be put in a welded-shut metal box with a slit for a handle.
- We should not have a piping reduction before the pump's 1.5 inch inlet
    - He suggests going from 1.5 inch pipe to 25 millimetre for outlet.
- Water will not flow in reverse direction through pump.
- Vertical placement of pump does not mater.
- Water connection can be hooked up to the same pipeline as the pump in the future.
    - Water will flow in the direction of pump flow without operating the pump.

His views on prepayment meters

- Water meter will not work.
    - The Nossob card does not work.
    - Half the meters in Katima are not working.

Alternative structural design:

- Afro Pumps has made sheet metal structures.
    - It uses 25mm square tubing for structure
    - It uses 1.8 X 1.2 meter sheets of 1.6mm sheet metal with gauze inside.
    - The sheet metal could be welded together to avoid theft.

20 April 2004 – Community Development Division

Attendees:

Edwin Jahs
Adam Bryant
Drew Campbell
Patrick Salmon

In this meeting, we spoke with a Community Development Officer from the City of Windhoek about the living conditions and his community development experiences in the informal settlements.

- Toilets are currently maintained by the City's Maintenance Department.
    - The Maintenance Department does not have enough man power to maintain all of these facilities.
    - Maintenance is done on an ad hoc basis.
        - There are no maintenance plans.
    - Maintenance Department sometimes does periodic inspections.
- Community reports problems (vandalism).
- In the past, they have experienced vandalism.
    - Iron roofs have been removed as well as fittings to resell on the black market.
    - Theft normally occurs at night.
    - People are afraid of criminals at dark. Sometimes criminals walk around with guns.
    - High mast lights probably will help.

- The final revision of a maintenance plan for Havana is currently being developed.
- The Community Development Division goes out and educates community about how to properly use facilities.
- Systems need to be rugged because some things break (plastic flush handles).
- People do maintain facilities themselves.
- People from rural area do not know how to use these facilities.
- There are ten to twenty families per one or two toilets.
    - They divide the maintenance among themselves.
- The City establishes a community committee.
    - The community committee then has to elect one representative from every twenty households.
    - The City mainly communicates with the executive community and the block community.
- The Community Development Division motivates the community through meetings and demonstrations.
- In the past, the Community Development Division has had the idea of giving elected people apprenticeships where they receive training in maintenance.
    - It was voluntary.
    - It was a way of empowering young people.
    - Once people were trained, they asked for payment, but the City could not afford to pay them.
- One job that a community member could have is security.
- The idea of someone selling the prepayment credits or employing someone who can fix the facility sounded like a good idea to Jahs.
- Jahs commented on how complex the issue of prepayment is.
- He said that 80% of the community wants prepayment because approximately 50% do not pay their monthly bills.
    - Non-payment is often due to the belief that free water is a right.
- He said that prepayment is a good solution if it was dependable.
- The City is still waiting to see what effect the high mast street lights in Havana are going to have.
    - He feels that they might decrease vandalism.
- He suspects that criminals are from the outside of the community.
    - People in the community are not likely to rob from the same community because people's homes have been burnt down or broken by community members for that reason.
- People will not like hand pumps for standpipes because they have these in rural areas and want to move away from it.
    - They would prefer regular pressure system.
- They would accept pumps for pumping up water in bathing facilities like with our proposed design.
- Every household currently has their own makeshift washing structure.
- Some people in the community fix or do repairs out of their own initiative.
    - It makes these people frustrated when the facilities become vandalized.
        - This frustration then leads to neglect.
- He liked the idea of using a pump to pump water to the roof for the shower.

20 April 2004 – SDFN

Attendees:

Fifty-three community leaders of the Northwest Settlements
Simon – translator
Adam Bryant
Drew Campbell
Patrick Salmon

In this meeting, we presented a few different choices for the community leaders to choose from. We had them choose between the one large or two small structures, wet or dry toilets, and prepayment or flat rate payment plan. Discussions and concerns followed these questions, which gave us insight about their thinking and rationale.

- We presented two options for ROCLA structure.
    - The vast majority liked the one large facility.
- We discussed prices for toilets.
    - Dry toilets cost approximately N$120 per month per facility.
    - Wet toilets cost approximately N$105 per month per facility.
- They asked if the facility was going to be inside the house.
- We asked that they decide between wet or dry toilets.
    - They said that it really depends on the area.
        - One said that terrain plays a big role.
- We asked that they decide between the pump shower and the running water shower.
    - The majority wanted the pump shower because it would not waste water.
- They were concerned about the dry toilet, thinking that it was unsanitary.
- They were concerned that sharing dry toilets would cause people to get sick.
- They had many questions about the dry toilets. They did not have a good understanding of them at all.
- When asked about the prepayment meters almost all seemed to want prepayment meters.
- There were many concerns about sharing the facility.
    - They were about half and half split about thinking that sharing is okay.

21 April 2004 – Brinkmann

Attendees:

F. Brinkmann
Adam Bryant
Drew Campbell
Patrick Salmon

Our meeting with Brinkmann answered many questions we had about payment policy for water in Windhoek and its Northwest Settlements. He was also able to answer many technical questions that we had.

<u>Payment Structures:</u>

- There is no difference of cost for water by income level.
- For homes with individual water connection, there are three tariff levels.
    - 0-6m^3 – low tariff ; 6-36m^3 – middle tariff level ; 36 – on – high tariff
    - Graduated tariff levels do not apply to standpipes. Standpipes pay a flat rate.
- No special payment plans exist for the poor.
- There is a need for social intervention in informal settlements.
- The City buys water for N$4.11 per kilolitre and sells at low tariff level for N$4.17.
- The City cannot afford to give free water.
    - There is no help from National government.
- Prepayment is a good idea in principal that has definite advantages.
    - Prepayment meters are bound to get technical problems.
    - He believes prepayment will eventually become more widespread.
- Some prepayment meter companies include Watermaster and Nossob.
- Newer prepayment systems should be better.
- He does think that prepayment meters could be used in areas outside the informal settlements.
- With meters, people need to be sent out periodically to check on them.
- There are some problems with the flat rate payment.
    - In some areas, money is not being paid.
- If prepayment is used for water and electricity, money may not be paid for other things like facilities.
- Communities handling their own accounts is difficult and has not been successful.

<u>Technical Questions:</u>

- The pipe layout that we have in our design will be appropriate.
- The height of the upper tank will not make a significant difference in pressure.
    - We should focus mainly on aesthetics and vandalism.
- He believes the ground water tank should go inside the facility to avoid outsiders contaminating it.
- We should put a cover over the tanks to avoid contamination.
- The size of the tanks should be 20 litres for plenty of shower water.
- We do not need to worry about the sand getting into the pipes from the tank.
    - Any sand will be flushed out by water pressure.
- We can use a standard shower trap.
- We should use a stop stake to vent the toilet and shower drainage.
- Drainage and sewage pipes should be sloped 1:60 in the trench.
    - An overflow gully should be located after the stop stake to prevent sewage backup into the facility.
- The septic pipe from the toilet goes out the back of the facility, then underground.
- For the wet toilet facility, use a tee to divide the water supply to the toilet and the shower.
- With the stop-cock, a washer can be replaced without removing the full fitting.
- Our positioning of the meter on the wall is appropriate.

21 April 2004 – Burger

Attendees:

J. A. Burger
Adam Bryant
Drew Campbell
Patrick Salmon

This meeting gave us some useful information about piping layouts that we needed to know in order to estimate prices for external piping. We also gained information about water use in the Northwest Settlements.

- One flush of a toilet uses approximately ten to fifteen litres.
- He says that two flushes per person per day is a good estimate.
    - This number seems low because people are not there all day long.
- The figure of two hundred litres of water used per household per day is for all water uses.
- For a 40mm pipe, the trench should be 600mm wide.
- For a water pipe, the trench should be one metre wide.
- The maximum walking distance from a home to a standpipe is two hundred metres.
- Any location that is desired for a facility should be no more than 50 metres to a sewer.
- We can use the sewer piping outlay for Havana to determine the average distance between the facilities and the sewers and waterlines.
- We can use the same stop stake for the shower and the toilet.
    - The air vent on top of the stop stake will provide adequate ventilation for toilet.

22 April 2004 – ROCLA

Attendees:

J. J. Oberholzer – Branch Manager of ROCLA
Adam Bryant
Drew Campbell
Patrick Salmon

We had this meeting in order to finalize the design of the washing facility. We confirmed with Oberholzer that our design was possible for them to build. We also asked him for close estimates for every component of the structure so that we would have an accurate estimate for the price of the facility.

- Fifty to sixty litre concrete tanks cost approximately N$170
    - A twenty litre tank would have a similar cost because they would need to make a new mould.
    - Concrete covers could be made for about N$45.
        - They would not be too heavy for the elderly.
        - There are inexpensive methods to add locks.

- There is no difference in cost between having the ground tank inside or outside the facility.
- For any in-wall piping, the costs are just the costs of the piping material.
- The structure only includes three walls.
    - A fourth wall can be built for N$670.
    - No plumbing may be run in the fourth wall.
- The dividing wall may cost about N$335, including labour.
- A window can be made at very little additional cost.
    - The window can be moved to other points in the structure.
- There is no extra cost to fix the structure with dry toilet capabilities.
- There is no extra cost for the pipe to run through the ceiling and then through the top tank.
- Floors can be sloped toward the drain and the shower grate can be cast in:
    - The cost of labour for this would be N$50.
    - The only additional cost would be the cost of the shower grate material.
- Having the tank on the roof will not be too much weight for the structure to support.
- A cover for the pump would be better made with metal than with concrete.
    - ROCLA can cast in sockets which the pump could be screwed into for N$5 each.
- We may leave sockets for mounting shelves for clothes.
- The toilet connection outlet hole may be moved to any wall in the facility.
- Within town delivery costs are N$400 per unit.
    - Two large structures may be delivered at one time.
    - The delivery of the structure will place the structure in desired location only if it is easily accessible and set up for placement (minimal installation work).
- The structure weighs around 2.7 tons.
- All cost estimates are based on budget figures.

Appendix C: Technical Details on Sanitation

Even though the City of Windhoek is capable of recycling grey water from the municipal sewers by treating it at the Goreangab reclamation plant, it may be desirable to someday recycle water on-site. This would be advantageous in the area of money savings, since people would not have to pay again for the reused water. The following discussion highlights how chemical treatment, particularly chlorination, should be properly used to treat grey water. These treatments could be done on-site if desired and if done in a proper and safe manner.

In addition to some filtration methods, chlorination of grey water may be desirable. According to WPI Civil and Environmental Engineering Professor John Bergendahl (personal communication, 29 January 2004), filtering water alone will rid the grey water of dirt particles but would not rid the water of any bacteria or pathogens. After every few cycles, or perhaps every cycle, the issue of eliminating the bacteria and pathogens that could lead to sickness and infection should be addressed (personal communication, 29 January 2004). One viable method of addressing this issue is to treat the filtered grey water with chlorine. Before one implements such a solution, it would be important to have a good understanding about the limitations and consequences of this solution.

According to Zagory (2003), the use of chlorine to sanitise water is widely used. Chlorinated water does not fully clean and sterilise the substances with which it comes in contact, but serves to sanitise the water by diminishing the microbiological count. Zagory also mentions that in actuality, chlorine is not much better in cleaning substances than clean, potable water is (Zagory, 2003). When using chlorine to sanitise water, it will be necessary to periodically retreat the water, since organic material in the water will decrease the effectiveness of the chlorine. In order for

chlorine to remain effective, the grey water should remain relatively clean, the pH of the water should not be too high, and the concentration of chlorine must be sufficient (Zagory, 2003).

Hypochlorite is the best form of chlorine in terms of its abilities as a disinfectant (Zagory, 2003). There are, however, other treatments that can be used as an alternative to hypochlorite that can effectively sanitise the water for use with washing facilities. Chlorine dioxide is generally more expensive, but its advantage is that it works on a larger range of pH levels of water and is more effective at lower concentrations than hypochlorite (Zagory, 2003). Ultraviolet light can also be used to sterilise water. Some of its advantages are that it leaves the water clear of chemicals and its ability to disinfect is not affected by water pH level. Also important to note is that the water must be clear for this method to be effective (Zagory, 2003). Peroxyacetic acid or other organic acids mixed with sodium hydroxide may be used for sanitising water. This mixture is useable over a larger pH range (Zagory, 2003).

Table 7 is taken from the article, Wash Water Sanitation: How Do I Compare Different Systems? (Zagory, 2003). This table shows the effect of the pH range, the sensitivity to organic matter, and the microbe killing function of each type of water sanitation method.

Table 7: Activities and environmental sensitivities of wash water sanitizers.

Activities and environmental sensitivities of wash water sanitizers.			
	pH	**Organic Matter**	**Biocidal Activity**
Hypochlorites	6.0-7.5	Very sensitive	Oxidizer
Chlorine dioxide	6.0-10.0	Sensitive	Oxidizer
Ozone	6.0-8.0	Somewhat sensitive	Oxidizer
Peroxyacetic acid	1.0-8.0	Somewhat sensitive	Oxidizer
UV light	Not affected	Somewhat sensitive	Disrupts DNA

Source: http://www.davisfreshtech.com/articles_washwater.html

Appendix D: Summary of Interviews

Through interviews with WPI and Clark University Professors we were able to gain perspective into technical and social issues we would encounter in Namibia. Professor Bergendahl spoke about water and engineering issues, whereas Professors Downs and Ford each gave us information on performing community development. Lastly, Professors Peet and Bell, who each had spent time in Namibia, gave us background information on Namibia and spoke briefly on community development.

Summary of Personal Communication with WPI Professor John Bergendahl

Professor John Bergendahl is a Professor of Civil and Environmental Engineering at Worcester Polytechnic Institute. His teaching interests include physical and chemical treatment processes. This area may be important to our project in terms of finding methods for treatment of water to maintain a high level of sanitation with our washing facility.

Our contact with Professor Bergendahl was very helpful because he had some very insightful ideas that could be very effective if applied to this project.

In terms of the structural design, Bergendahl suggested that we may want to design the facility with a sloped plastic floor that can drain the wash water into one central location for effective drainage and collection. Once the water is collected, the water may then be processed for cleaning and reuse.

We also discussed methods for cleaning water. He highlighted a few options that could be used independently or together to clean and sanitise the water. The first approach he talked about was the use of a settlement tank. The settlement tank would work by using a large container to hold the water for a period of time, allowing the denser dirt particles to settle to the bottom of the container. This method would be a

first step in cleaning the water on a more bulk scale. The water would be further cleaned by passing it through a filter. This would effectively take out many of the impurities from the water, and would be feasible since sand is an available resource in Windhoek.

Using these two methods may effectively clean the water to a certain degree, but they will not rid the water of bacteria and pathogens. In order to do so, Bergendahl suggested the chlorination of the water. The process of chlorinating the water will kill the bacteria and pathogens, making the water much safer to use. Bergendahl told us that if chlorination of the water were employed, the water should be allowed to sit in the sun to convert the chlorine to chloride. This is an important step to take, because chlorine could cause agricultural problems if chlorinated water is drained into fields.

After explaining to us these processes that may be of value in this project, he noted that it may be important to consider the types of soaps that the people use. This may affect the ways in which we should process the water. Bergendahl lastly referred us to the American Waterworks Association (AWWA) who would be a good resource when considering water treatment.

Summary of Personal Communication with Clark Professor Timothy Downs

Professor Timothy Downs is a Professor of Environmental Science and Policy at Clark University. He has had years of field experience working with communities in Mexico, the United Kingdom, and the United States. Though Professor Downs does not have specific experience with Namibia, he has worked in many other places around the world using community development. Throughout our forty-five minute

discussion with him, we talked about how to go about using community development techniques that could help make this project a success.

Professor Downs told us that when working in informal settlement areas, it is a very good idea to work with the community leaders and said that if we can convince the actual leaders to come, more could be accomplished.

He stressed considering how long people have been living in the informal settlements. If it is a really short amount of time, there might be no sense of community, rendering the project more difficult. When working with the community, Downs advised us to remember to get input from many types of people, ranging for example from single mothers to older generations.

He told us that we should take time to walk around surveying the informal settlements and letting people know why we are there. He stressed that we should build trust with the people with which we are working. He also noted that we should make sure that when we develop ideas, we present many alternatives from which they may choose. He stressed that it is important that we do not impose our ideas on them.

Downs presented to us some conceptual ideas to think about for dealing with community development. He told us to ask seven important questions about our project: "What? How? Where? Why? Who's involved? When? What are the costs?." Sources of information that he recommended we look at were the UN WASH program and case studies done by the World Bank.

Downs provided a general description of methodology for projects involving the apparent need for community development. He said that success depends on establishing working groups who are composed of leaders or representatives of the community. It is desirable to have each of these leaders bring some unique skill to the project so that ideas might be abundant and diverse. During project initiation, it is

essential to peruse the area, meet as much of the community as possible, inform them as to the purpose of the project, and thus build an initial foundation of trust. Downs stressed the formation of partnerships with community leaders and non-government organizations so that the project would constantly be in compliance with regulations and standards. An educational "briefing" is a strategic way to start the project, as it informs the community of their need to conserve water, as well as show them the need for clean accessible water for sanitation reasons. After this education, speaking to many different people and organizations will generate different alternatives for the project, alternatives among which the community may choose. This way, the researcher is not offering one option and thus forcing the community in one direction. Lastly, Downs stressed the value of the Integrated Capacity Building Approach as the guidelines form the boundaries of a conceptual pentagon. When laid down, it resembles a round table where the community leaders each bring something unique to the project and thus establish the community's sense of ownership and belonging (personal communication, 5 February 2004).

Summary of Personal Communication with WPI Professor Creighton Peet

Professor Creighton Peet is a Program Coordinator in the Interdisciplinary and Global Studies Department at WPI. He advised projects in Namibia in 2003. Supervising these projects, he experienced what life is like in the informal settlements of Windhoek. Talking with him allowed us to learn a lot about the area where our project will be located.

As Professor Peet described, most of the inhabitants do not pay for their water. The inhabitants usually have to walk as much as 250 meters to get their water from a communal tap. From what Peet witnessed, their bathing consists of bringing back

water from the community tap and pouring the water over themselves. This way of washing is very inefficient in terms of water conservation, since the water is not properly drained and reused. Professor Peet also mentioned that the City is growing in population, and because of this, the government will soon be forced to charge for water.

We also learned from Professor Peet that in Windhoek, more so then other places around the world, the people who live in the informal settlements mostly live with their own ethnic groups, and do in fact have a sense of community. Having a solid understanding about the inhabitant's present situation will help us greatly in designing a facility that will improve their conditions.

Summary of Personal Communication with Clark Professor David Bell

Professor David Bell is a Professor of International Development at Clark University. He has done extensive work in Southern Africa dealing with education, empowerment, social transformations, and community development (Clark University, 2003). He grew up in South Africa and lived for one year in Namibia until 1988, when he moved to the United States.

In our conversation, Bell told us a lot about the history and the political issues in Namibia. Prior to WWI, this land was a German colony. After WWI, South Africa gained control of the region that is now Namibia. It essentially became a fifth province of South Africa. The apartheid was prevalent during the time of South African control.

When asked about the apartheid, Bell told us that it was a very complex issue and the apartheid had different meanings to different people. The informal settlements that we are dealing with, he believes, did not exist when he was there.

However, he explained to us what he believed the informal settlements might be like. He said that many of the people who inhabit the informal settlements are from central Africa.

The area on which he went most into detail was what the people are like. He said that the people are very polite, but there is also quite a bit of petty theft. Bell mentioned that this is because people often find ways around paying for services like electricity, and they may very likely do the same for water. This could lead to damaged equipment. For these reasons, Bell believes that a prepayment system would be the best method for payment. Bell also mentioned that the people there may not know what they need, so we should not rely on finding out what the problems are simply by asking them.

Professor Bell advised us about how to interact with the people of the informal settlements. He said to make sure that they believe that we do want to hear them, let them know that any information they give is confidential, and be open about why we are there. He also warned us to not expect there to be much infrastructure, and also that it may be common for the informal settlers to simply request money from us.

Professor Bell gave us a couple references to look into about water and infrastructure development in Namibia. He referred us to the Rössing foundation, as well as to the author, Deepa Naragan, who writes for the World Bank about water projects. The questions that he recommended we ask when carrying out the project are: 'Where does funding for water come from?' and 'What is government policy in Namibia in terms of water?'.

Summary of Clark Professor Richard Ford's Community Development Background

Professor Richard Ford is a Research Professor at Clark University with the International Development, Community and Environment department. In this department, he serves as director of the Center for Community-Based Development. He has led several projects in Africa focusing on community development and sustainable development. Ford, along with Barbara Thomas-Slayter and Charity Kabutha, developed the Participatory Rural Appraisal method (Clark University, 2003).

Appendix E: Technical Details on Plumbing

It is important to understand successful plumbing methods so that where possible, these proven techniques may be implemented in the washing facilities.

An online basic plumbing guide (http://www.easy2diy.com/) explains how water enters a home via the water main, flows through the meter, and then forks. Some of the water goes to the hot water heater while the rest goes to supply cold water needs. Typically, main water supply pipelines within the house are 1" to ¾" in diameter, while the pipes that branch off of these are usually ½". Fixtures such as the sink and shower use traps. This is either a bend in the water line or a reservoir that is always filled. Water gets "trapped" in these reservoirs to seal the water lines so that sewer gas cannot seep through the drains and cause unpleasant odours. **Figure 42** illustrates this idea of a trap in a sink.

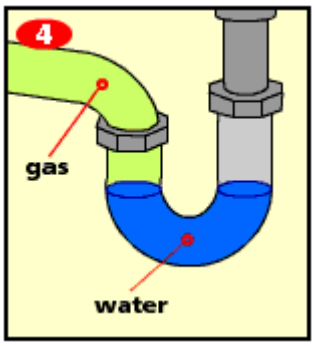


Figure 42: Sink trap used to block the flow of sewer gas (Easy2Technologies, http://www.easy2diy.com/cm/easy/diy_ht_index.asp?page_id=35694452)

Wastewater, or rather used water, enters the drain and flows through a pipe that comes to a tee joint. One part of this tee goes up while the other leads downward. The upper pipeline ties into the roof vent, which is basically an air pipe that releases any suction created by the water going into the downward part of the tee. The wastewater passes out though a series of clean outs which are similar to tee joints with the bottom of the tee angled at forty-five degrees. This end is threaded and capped, enabling

wastewater clogs to be cleaned should the problem arise. **Figure 43** shows this clean out.

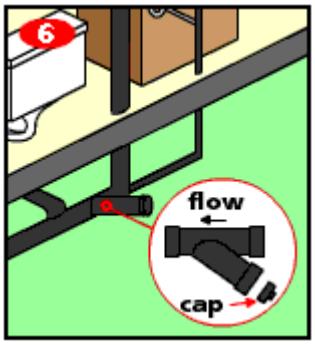


Figure 43: Clean Out used as access to clogs in the wastewater system (Easy2Technologies, http://www.easy2diy.com/cm/easy/diy_ht_index.asp?page_id=35694452)

Different piping materials are used for different types of water. Copper tubing, PVC, and galvanized pipe are typically used for freshwater transport, while ABS pipe, galvanized pipe, and cast iron pipe are usually used to carry wastewater.

Water saving technologies should also be kept in mind when designing the communal washing facilities. Not only is it important to attract the inhabitants of Windhoek away from their improper draining structures, it is essential that the properly draining water in the facilities is conserved as much as possible at the source. Companies such as Magic Tech for example, have developed water saving methods via regulators. These regulators control the variations of pressure in the water lines with the use of an o-ring that maintains constant water pressure. With Magic Tech's regulators, any pressure between one and ten bars may be maintained constantly. Water flows between the core of the housing and the o-ring, and as pressure increases, the o-ring is compressed and reduces the water cross sectional flow area. As the water pressure decreases, the o-ring expands and enlarges the area of flow. These regulators are meant to be applied in-line with the present plumbing and are thus easy to install. Fifty percent of the water may be conserved, and an even flow reduces

splash or side spray (Magic Water Savings, 2004). Water savers will be essential in this arid country.

Appendix F: ROCLA Dimensioned Drawings

In the washing facility designs, it is important to be able to see dimensions so one can visualize the spatial layout. The piping and components whose exact position is dependent on the piping (i.e. the pump) are not featured below, as there are no specific dimensions reserved for the plumbing. The facility will still operate the same, provided the piping is run similarly to what is viewed in the "Shower" section. The more "concrete" components in the design are discussed below.

Although the ROCLA concrete toilet shelter was not used in our design for a full washing and toilet facility, it is still a viable option. In some informal settlements where toilet facilities have already been installed, this unit, whose drawings may be viewed in Figure 44, is still a viable option. The toilet may simply be removed and a shower system installed.

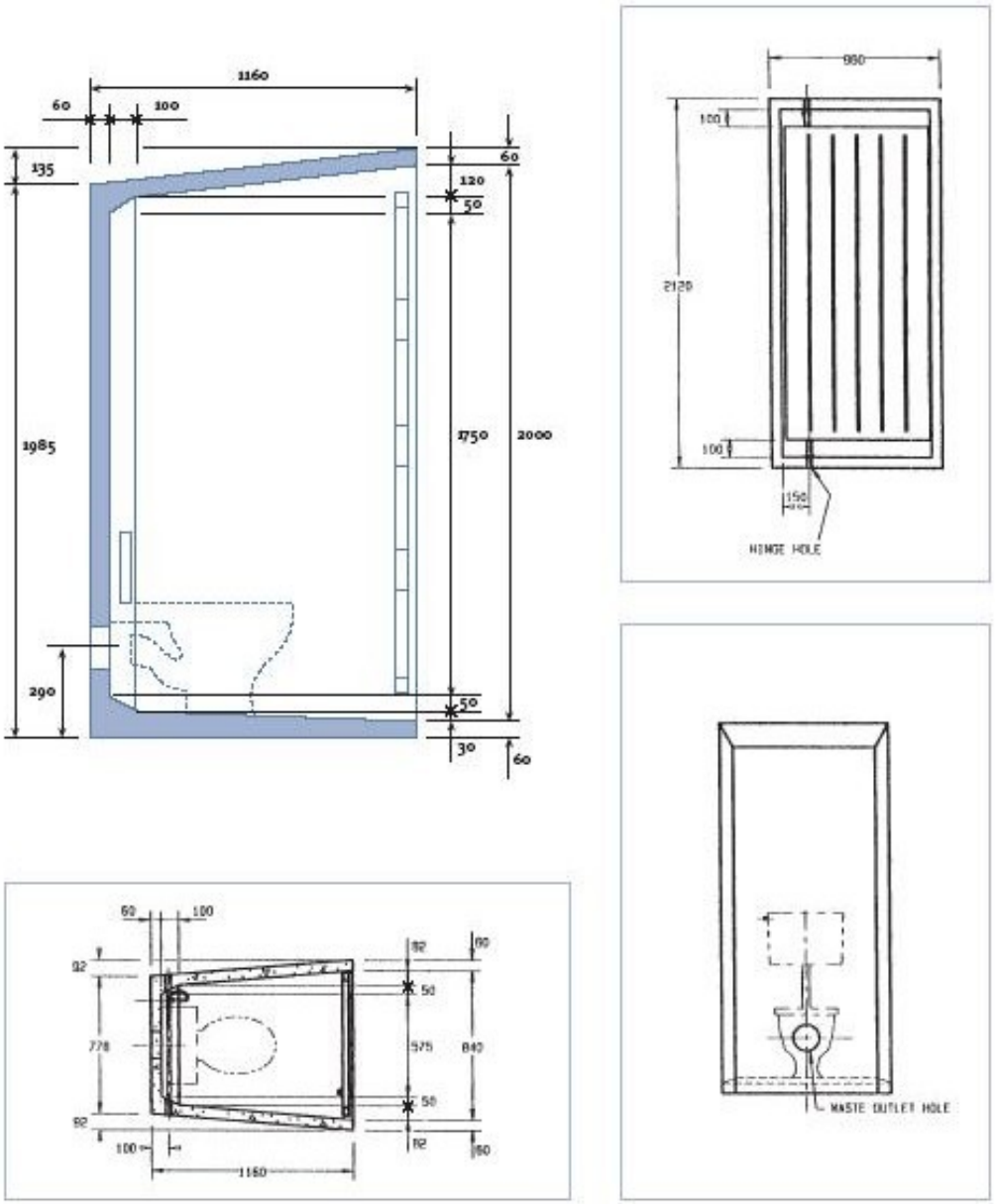


Figure 44: Single ROCLA Toilet Structure (**http://www.rocla.co.za**)

The ROCLA concrete unitized bathroom was the preferred choice by the community, was financially feasible, had the capability for pre-cast piping, and thus was the structure used to house the toilet and shower in both wet and dry toilet washing facility designs. Figure 45 shows the dimensioned drawings of this stock structure. The only addition featured beyond the basic structure is the outer wall in which doors will be mounted.

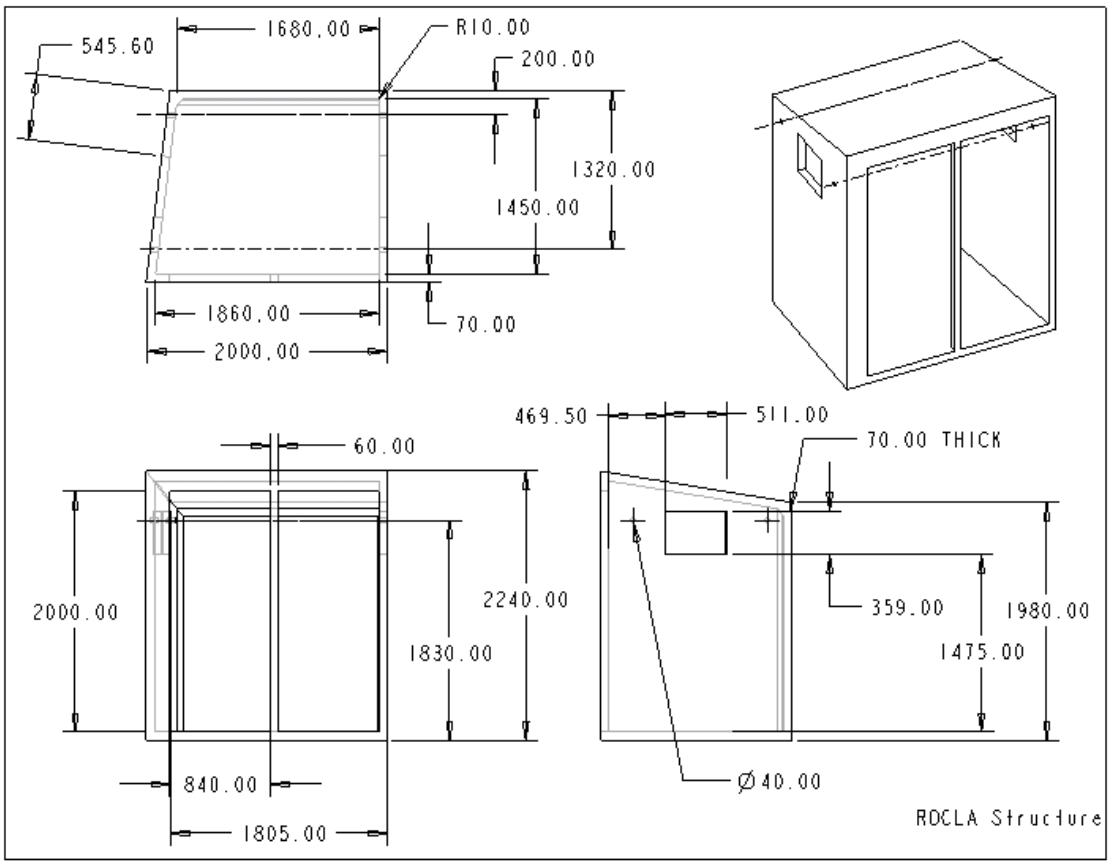


Figure 45: ROCLA large concrete unitized bathroom dimensioned drawings

ROCLA was also able to build concrete water tanks, which will be used in the dry toilet washing facility design. Their original tank holds an estimated volume of 50 to 60 litres and is dimensioned in Figure 46. This tank is used as the roof tank in the dry toilet washing facility design. According to Oberholzer (personal communication, 22 April 2004), smaller tanks can be made for a similar price because the smaller amount of material compensates for the labour involved with producing a new mould. A smaller tank of approximately 10.75 litres will need to be custom designed as the ground tank in the dry toilet washing facility design, which is featured in Figure 47. See Appendix B for minutes from our 22 April 2004 meeting with ROCLA.

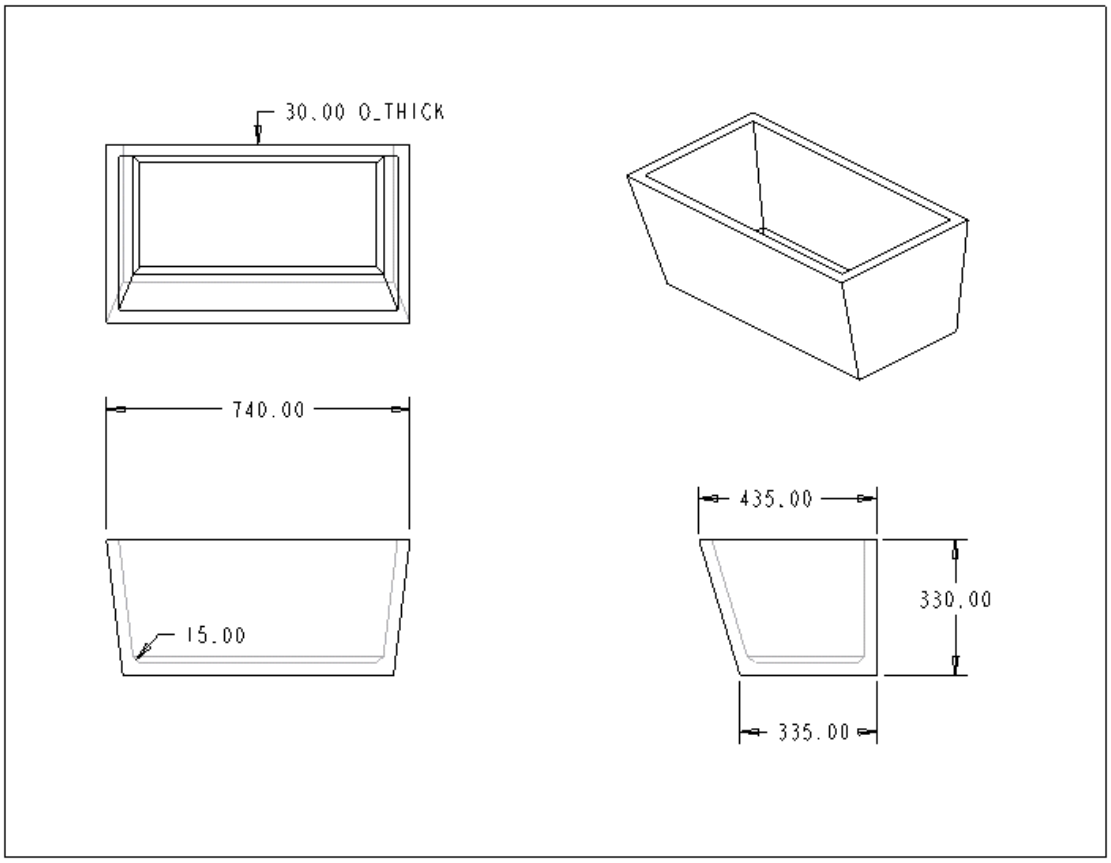


Figure 46: 50 to 60 litre ROCLA concrete tank (roof tank)

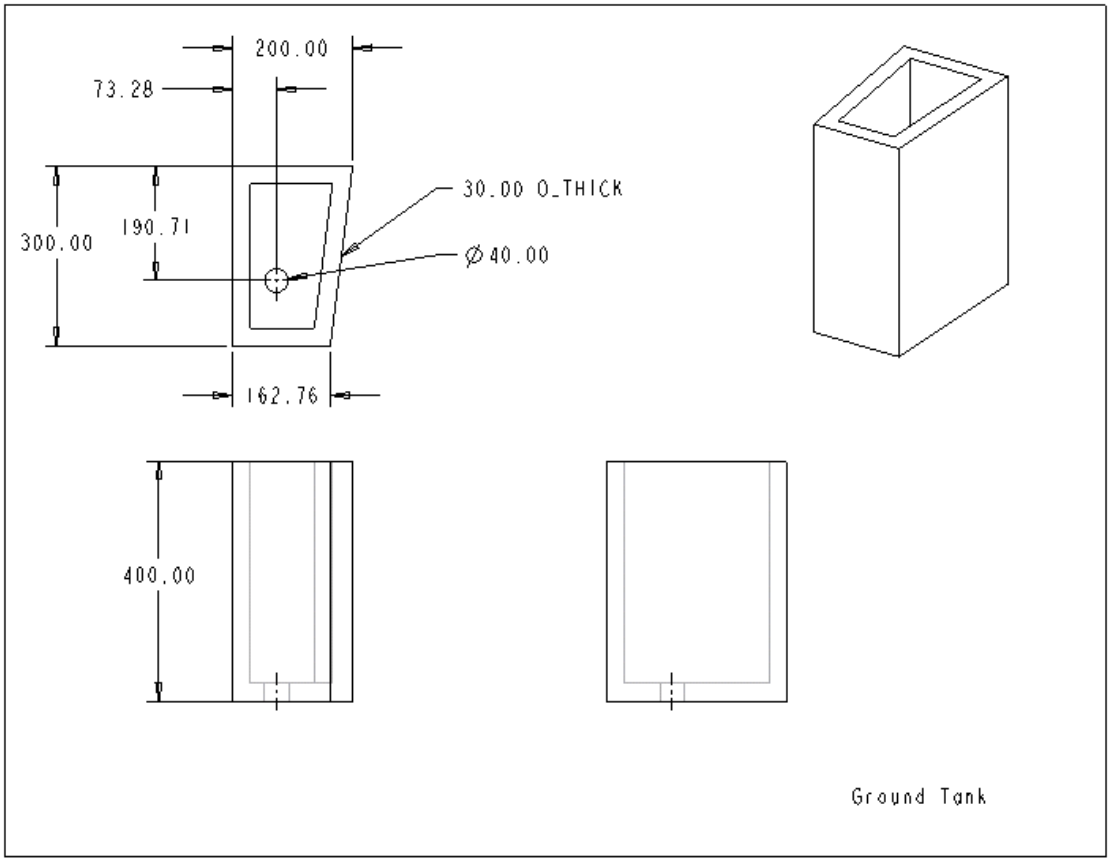


Figure 47: An approximate 10.75 litre custom ROCLA concrete tank (ground tank)

Appendix G: On-site Reuse of Grey Water

Using shower water to flush a wet toilet would be a viable solution to the grey water problem in the Northwest Settlements. The water used for the shower could be used twice before it is sent back to the municipal sewer. The concept is ideal in theory, yet has a few problems that would need to be resolved before it could be implemented.

In the design shown in Figure 10 on page 53 under "Use of Grey Water" in Chapter 4, the shower floor would have short raised sides with the floor sloped to a half-pipe drain. The half pipe would help to reduce clogging of hair that might result in using full piping. This would direct the grey water to an underground storage tank. An outlet pipe to this tank would be attached a certain height from the bottom of the tank so that only the cleaner water would be extracted while the hair and soap might be allowed to settle to the bottom of the tank. This outlet pipe would run up the wall in the facility to a hand pump and then to another holding tank above the toilet. The user would pump the water into the toilet tank and then flush the toilet using this water. The toilet would be attached to the municipal sewer where the water that had already been used twice would be sent to the Goreangab Plant for processing. Both tanks would require overflow releases. Overflow in the shower tank would be directed through piping to the municipal sewer to which the toilet outlet is attached. The overflow in the toilet tank would result from over pumping by the user and thus would be directed back to the shower tank for reuse at a later time (personal communication, 18 March 2004).

Unfortunately, there are problems with this design. We brought this idea to the water engineers of the City of Windhoek, and though they were intrigued by the idea, they found certain problems that would need to be resolved for its success.

Eventually, clogging would occur in the drain and the shower recovery tank outlet. H. I. Peters, the Chief Engineer in technical support, explained even a sand filter would clog in very little time (personal communication, 24 March 2004). The system would require an open structure where one might have access to remove the particles periodically. Such a system might present problems in urban communities where piping, valves, and tanks might be stolen for personal use if exposed. The other issue remaining was replenishing the toilet tank water. J. A. Burger reasoned that most likely there would not be enough water from showers to be the sole source for the toilet tank. He stated showers use less water than one flush of a toilet. This would present the need for another inlet and source of water to feed the toilet tank when the shower tank's supply is insufficient (personal communication, 24 March 2004). A complex mechanism would then be required to allow the toilet tank to fill by the shower tank and then switch over to a standpipe source at the moment the shower tank supply was insufficient. Complex mechanisms will add to the cost of this design, as well as present a potential problem with part theft.

Appendix H: Piping Fittings Cast in the ROCLA Structure

Fittings were needed for pipe connections and additional plumbing parts outside and within the walls of the facility design. These are standard parts used to create strong joints and maintain function requirements over time.

The showerhead will be attached to the 20 millimetre cast copper piping via a 20 to 15 millimetre ninety degree reducer coupling. One end of the coupling is threaded to allow a detachable connection for the 15 millimetre showerhead. When connecting the showerhead, Teflon tape will be wrapped around the threads to provide a seal against water leaks. The other end of the coupler is soldered to the 20 millimetre copper water piping. The showerhead and coupler may be seen in Figure 48.

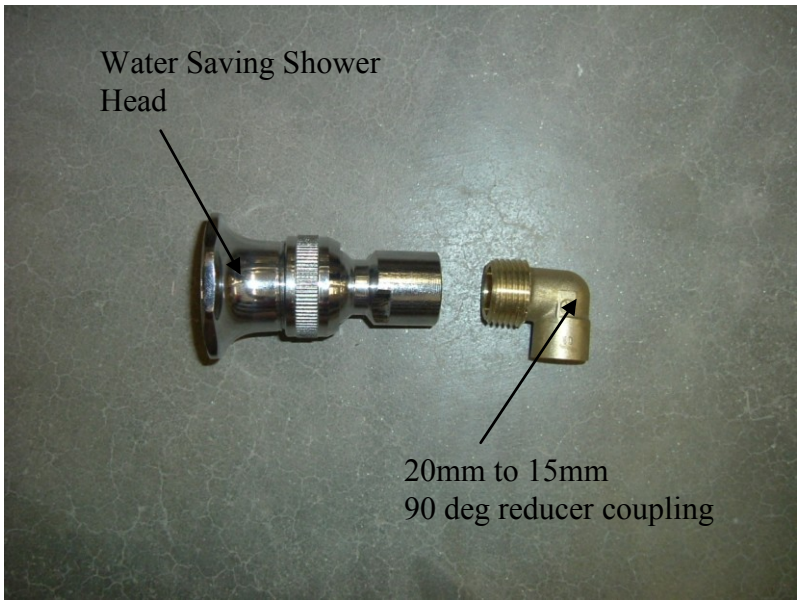


Figure 48: Water saving showerhead and 20 millimetre to 15 millimetre ninety degree reducer coupler

The dry toilet washing facility design is modular and thus contains piping for future connections. These connections, however, must be plugged when not in use. In the first stage of the modular design, a plug will be required in the connection point for possible future attachment to water source external piping. If the pump design

turns out to be a failure, this connection will be unplugged and the roof tank drain will be plugged to prevent the water connection from bypassing the shower head.

Plugs provide an adequate seal, yet are easy to open when the need arises. In the dry toilet washing facility design, a 22 millimetre coupler will be soldered to the copper piping cast in the ROCLA structure. The plug is screwed into the threaded end of the coupler. This configuration may be seen in Figure 49.

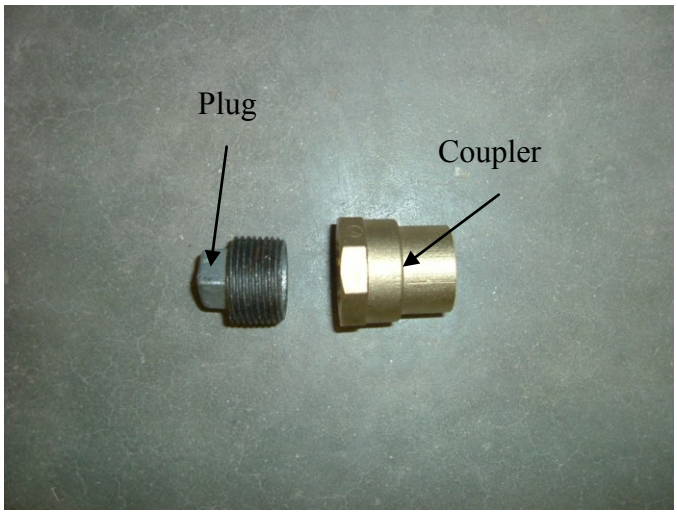


Figure 49: Plug and coupler

In order to initiate, regulate, and terminate showerhead flow, a tap stop is used. This fitting interrupts the 20 millimetre copper water line and is cast partly into the ROCLA concrete structure. Each end of the tap stop is screwed into threaded couplers with Teflon tape, while the other end of each coupler is soldered to the copper pipe. Thus, the tap stop connects a break in the water line. Water flow may be regulated by turning the handle on the tap stop which changes the diameter of the pipe through which water may pass. This configuration may be seen in Figure 50.

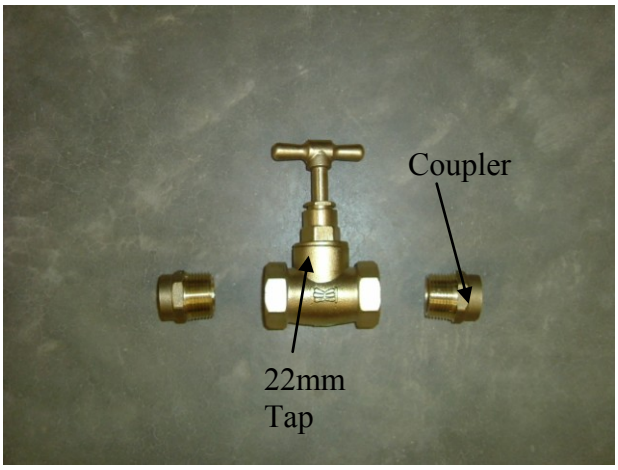


Figure 50: Coupler and tap stop

The tap stop will be an important component in both facility designs. In the washing facility with the wet toilet design, this fitting, when in the off position, will prevent the continuous consumption of water when the shower is not in use. In the washing facility with the dry toilet design, the tap stop will prevent the roof tank water from pouring out the showerhead while the user is still filling up the water tanks.

All the shower water will drain from the facility through a heavy duty metal drain and trap in the ground. The water will flow down the drain and into a trap. This trap is always filled with water so unpleasant sewer gas will be unable to seep back through the drainage pipe and into the facility. A 40 millimetre PVC adaptor will be needed to attach the metal drain to the 40 millimetre PVC piping that will run to the municipal sewer system. This adaptor connects simply with threads. Figure 51 illustrates this connection.

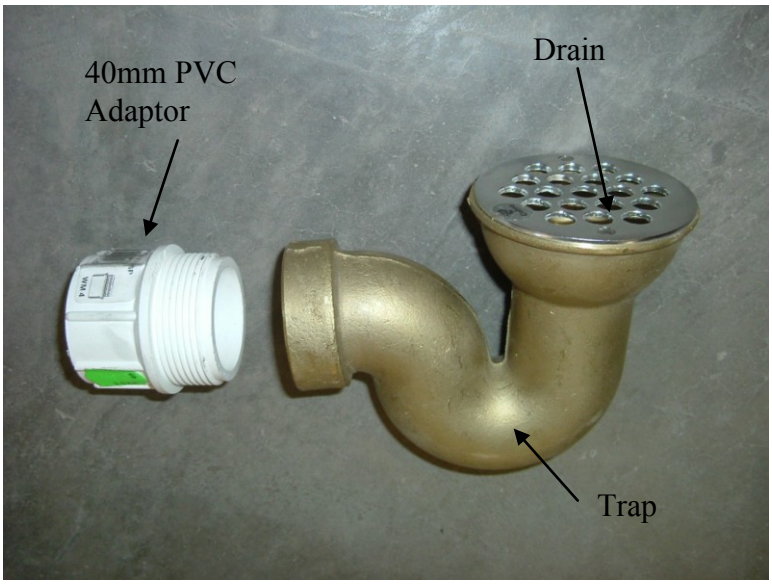


Figure 51: Metal drain and trap with 40 millimetre PVC adaptor

The 40 millimetre PVC drainage pipe will run from the drain and trap into a 110 millimetre stop stake. The stop stake is a point for overflow release should the sewer pipes be blocked and unpleasant waste and grey water be directed back into the facility through the drain. See Figure 52 for the piping layout to be implemented in the washing facility designs. In this figure, the sink piping to the stop stake will be similar to that of the shower piping for the shower in the washing facility.

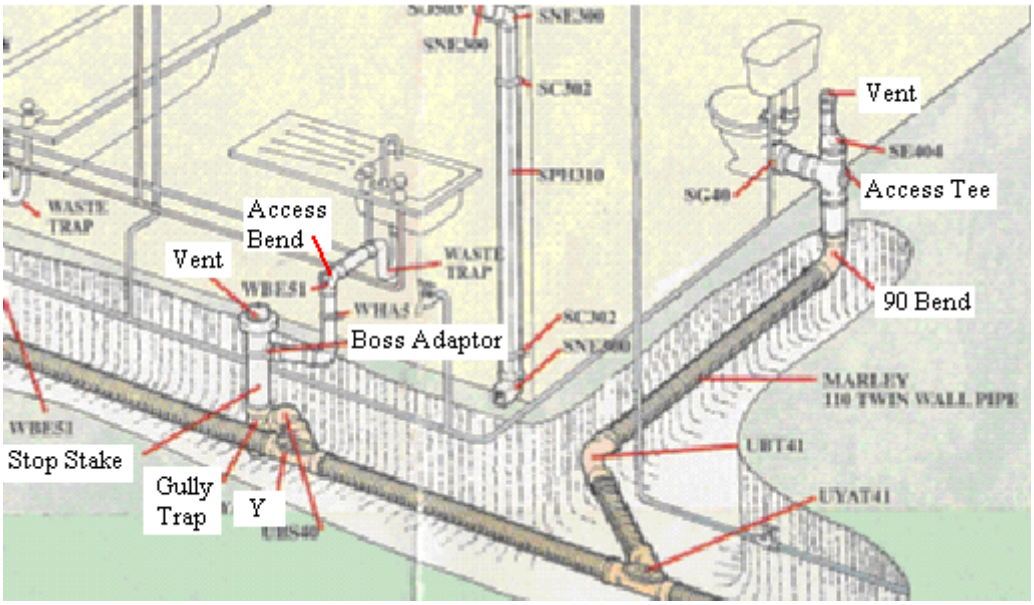


Figure 52: Common household underground piping (Marley Plumbing Systems, 1999)

As seen in Figure 52, the connection of the 40 millimetre PVC drainage piping to the stop stake will be done with a boss adaptor. This adaptor holds the 40 millimetre piping in place at the entrance hole on the 110 millimetre stop stake. This boss adaptor fitting and the required reducer may be seen closely in Figure 53.

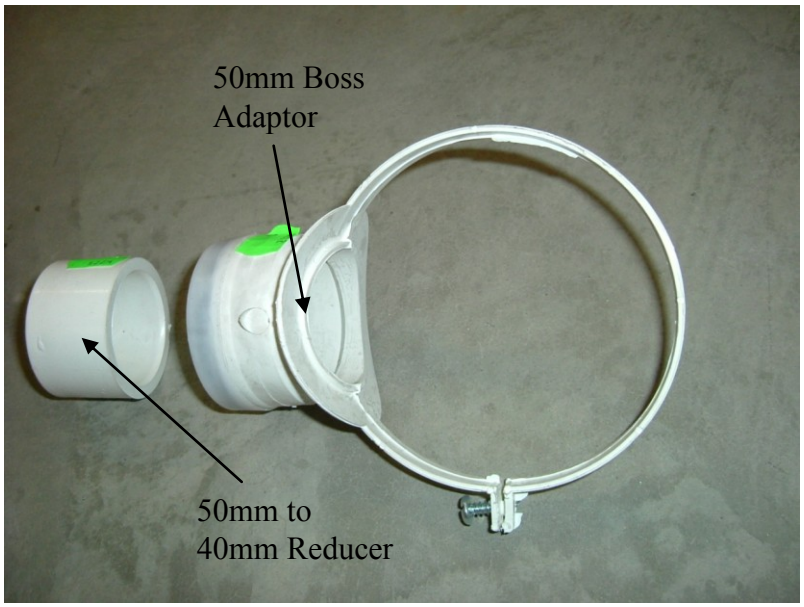


Figure 53: 50mm Boss Adaptor and 50mm to 40mm reducer

In order for the drainage water to be allowed to flow further, ventilation will be required to break the vacuum within the piping. This is done by attaching a vent at the top of the stop stake. This vent allows the release of pipe vacuum and allows spillage of any sewer water back-up over the top of the stop stake. This vent is attached to the stop stake with glue and can be viewed in Figure 54.

Figure 54: 110mm vent for stop stake

The shower water drainage will continue to join the main 110 millimetre sewage pipe at the "Y" seen in Figure 52. The toilet will use the same vent as the stop stake and the toilet sewage will also flow through a "Y" into the main 110 millimetre line to the municipal sewer as can be seen in Figure 52.

Appendix I: Technical Details on Prepayment Meters

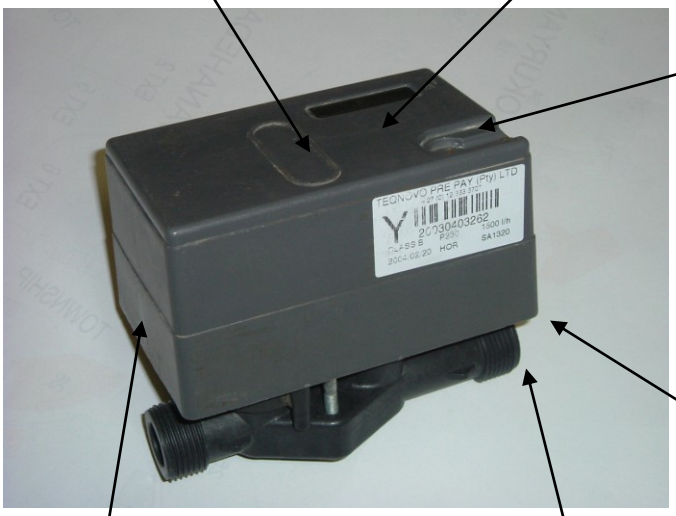
Nossob River Systems made some recent developments in prepayment meters. Although many controversial issues of water privatisation surround prepayment systems, it was still beneficial to look into a system that has potential for success in the future.

The technical component of these meters was addressed for improvement. Chairman Mac Hengari of Nossob River Systems said the meters initially faced problems with malfunction in the presence of water, but after technical revision, the meters can stand water splashing and most other contact short of complete submergence (personal communication, 13 April 2004). The management system keeps detailed records of users' transactions and has the capability to print graphs and tables that might show trends in consumption over time. The local authority can then periodically check this data for abnormalities or trend breaks that might indicate tampering with the water source to bypass the meter for free water. Additional tamper prevention features include the special cover. Illegal removal of the cover results in the closure of the shut-off valve, thus making the program unusable. At this time, the meter must be replaced by a new one, a process that takes less than five minutes.

In this meter system, each user is given a personal key, known as a tag, where all their water credits and personal data are stored. The meters also store data, including the meters' current battery life condition and the specific user's water consumption history. This data is transferred to the tags upon use. When the tag runs out of credits, the user brings it to a portable vending unit or to the local authority to transfer their tag data. The vending unit can be purchased by a community member for less than N$1 000. The individual can make a profit with the vending unit,

purchasing water credits at a discounted price and then selling those credits at regular cost to other community members. Periodically, the owner of the portable vending unit will transfer the accumulation of data to the local authorities. The local authorities are able to view all the tag data, view meter battery levels, and establish consumption patterns for each user, so they might see whether or not certain individuals are showering. Thus, there is no network needed for these standalone machines. The tags provide the link from the community to the central data location (personal communication, 13 April 2004).

Hengari says Nossob is mainly using two meters, the first being the single user machine as seen in Figure 55. This model is used primarily for single household use, and costs approximately N$1 700 complete with installation and a one year guarantee. The household members purchase additional credits for their tag, then bring it home and insert their tag into the meter. At this instant, the meter downloads all the credit information, and will dispense water to the household until the credits are used. The battery life for this model is approximately eight years, and is the only maintenance needed besides unexpected technical difficulties. When the battery needs replacement, the whole unit is removed and replaced with a new meter at the insignificant cost of a new battery. Meanwhile, the service provider fixes the old meter at the factory (personal communication, 13 April 2004).



Meter Length (From inlet to outlet connection): 165mm
Meter Height (centre of connection pipe to top surface): 116mm

Technical Specifications

Rated Flow	1.5 m^3/hr
Maximum operating pressure	16 bar
Minimum operating pressure	.3 bar
Meter Replacement time	Less than 5 minutes
Mass	1 kg

Figure 55: Nossob River Systems Teqnovo single user prepayment meter and design specification

The second model, according to Hengari, is the multiple user meter. This meter operates under the same data transferring method as the single user machine, yet costs N$3 500 under the same one year guarantee. The battery life expectancy is

approximately five years. This meter is intended for multiple users in a public setting. Each individual inserts their tag in the meter that will only dispense water when a tag is present. The older models required the user to insert their tag and push down for controlled on and off flow. The newer models in process are allowing the user to use a dial for flow regulation to free both hands during dispensing (personal communication 13 April 2004). This will be necessary in any shower facility.

Appendix J: Technical Details for Dry Toilet Systems

There are a number of dry toilet designs that have been developed for countries in southern Africa, where arid climates are regular and water is scarce. Among these designs are the Enviro Loo, Cool Maintenance, Atlas Plastics Latrine, and Primary Effective Toilet (PET). Some of these designs would be more effective than others in the Northwest Settlements of Windhoek, Namibia.

Whirlybird – Cool Maintenance and Enviro Loo dry toilet ventilation

Whirlybirds provide ventilation in many restaurant kitchens or wherever there is heat or non-circulated air that needs to be expelled. Most of the dry toilet designs use whirlybirds to provide adequate ventilation in the drying process of the waste. According to the A. H. Bennett Company, whirlybirds or turbines are designed with shaped aluminium vanes that provide circular motion via wind. This motion provides a decrease in pressure in the sewage pit which pulls in air from the outside, through the sewage pit, and out the ventilation pipe. These turbines provide low-cost ventilation in areas with typical wind speeds of eight kilometres per hour and can still function with wind speeds over two-hundred twenty-five kilometres per hour. Their lubricated bearings allow long life of the product with no maintenance, and the large number of curved specially edged vanes inhibits rain water entry (A. H. Bennett Company, 2002).

Enviro Loo Dry Toilets

According to Nina Maritz, the architect of the Habitat Research and Development Centre (HRDC), the Enviro Loo design has been successful in South

Africa and is now being explored in Namibia. The waste storage design may be viewed in Figure 56.

Figure 56: Outdoor waste storage utilized in the Enviro Loo design outside the Windhoek Habitat Research and Development Centre (March 17, 2004)

Nina Maritz explains that after one uses the toilet, one simply pulls the lever on the back of the toilet. This flips the deposited waste into a storage box located inside the black plastic containers. This storage box is split levelled with holes in the floor of the top level. The liquid waste is allowed to drain separately from the solid waste and

collect at the bottom. The polyethylene plastic storage container and vent pipes are painted black, causing the internal temperature to rise to approximately eighty degrees Celsius with the hot day sun. This heat sterilizes the waste and reduces the air pressure inside, allowing the liquid waste to escape as evaporation as air flows out through the vent. One must periodically rake forward the older drier waste and shovel it into drier bags that hang higher within the pit. Over a time of approximately one month, the solid waste is completely dried out and all germs are killed. The container may then be opened and the waste removed from the bags and shovelled out into gardens as environmentally safe fertilizer (personal communication, March 17, 2004).

Andries Cloete, a representative of Innovative Sustainable Solutions CC, wrote a proposal to the City of Windhoek in efforts to sell the Enviro Loo toilet system. This document claims wastewater filled with nitrate from pit-latrines is directly accountable for the contamination of groundwater sources. Enviro Loo has looked into a solution to this problem. Cloete reports that the manhole cover, outlet vent pipe, and backrest are guaranteed for sixty months from the date of the invoice against faulty materials and workmanship and that there are two models. The 2010 model is made for one to ten uses per day while the 2040 model is designed for one to forty uses per day. If included in our facility design in the informal settlements, each facility would be intended to be used to its user capacities.

Table 8 shows the estimated cost for implementing the Enviro Loo system in the Northwest Settlements based on the 2003 costs for the design's installation in Okahandja Park A, B, and C.

Table 8: A 2004 estimate of the Enviro Loo dry toilet system

Subject: Upgrading of Okahandja Park A, B, and C Dry Toilet Facilities.

Item Description	Unit	Rate (N$)	Quantity	Total (N$)	Total (US$)
Site management (principle agent)	Item	2500.00	1	2500.00	403.23
Site foreman	Item	5000.00	1	5000.00	806.45
Material and labourer transport for toilet unit	Item	5000.00	1	5000.00	806.45
Manufacture and erection of surrounding structure	No	2520.00	5	12600.00	2032.26
- Installation of multiple user Enviro Loo toilet unit	No	1020.00	5	5100.00	822.58
Multiple user Enviro Loo toilet unit	No	5260.87	5	26304.35	4242.65
Excavation work for waste pit	m^3	115.50	4.5	519.75	83.83
Pedestals and additional concrete ground work					
- Concrete	m^3	902.00	1.55	1398.10	225.50
- Formwork	m^2	240.00	1.44	345.60	55.74
Sub Total				**58767.80**	**9478.69**
VAT at 15%				8815.17	1421.80
Total for 5 units				67582.97	10900.49
Each Unit Total				**13516.59**	**2180.10**

Source: J. Groenewald Properties cc. (2004). Upgrading of Okahandja Park A,B and C. Windhoek.

The recent changes in Enviro Loo toilet cost came from the Okahandja Park Implementation Completion Report in January, 2004. The rest of the prices include all the additional work that must be done for installation.

Cool Maintenance Dry Toilets

The Cool Maintenance system is designed for ten to forty users, and uses no water, no chemicals, and is odourless. The black vent pipe is submerged into the sewage pit. The black pipe heats up and the whirlybird spins due to convection. This

prevents any build-up of gases and thus corrosion of the concrete pit that would result from constant liquid and gaseous contact (Kaumbi, 2002). Figure 57 shows the sewage pit beneath the facility, in which there is a sliding tray with two compartments on four rollers. Inexpensive, porous waste bags are hung in each of the two compartments. These bags are produced locally by workers at Ehafo, a Namibian organization for disabled people (Kaumbi, 2002). One positions a waste bag compartment directly beneath the toilet and as the facility is used, this bag will fill. The porous bags allow the liquids to drain from the solids, reducing the moisture content to less than fifty percent (Schroeder, 2002). Due to the whirlybird, the liquids are evaporated and no odours are allowed into the toilet room. After six to nine months, when the first bag is filled, the next compartment with the empty bag is slid under the toilet. This allows extra time for the first bag to dry out. At six to nine months, however, the waste in the bag is completely decomposed and sanitary to handle. The only training required for this system is how to replace the bag when both are filled (Schroeder, 2002).

Figure 57: Cool Maintenance waste bag compartments

Table 9 shows the breakdown of the total 2004 estimated costs for the Cool Maintenance design.

Table 9: A 2004 estimate of the Cool Maintenance based off the Enviro Loo estimate for Okahandja Park

Item Description	Unit	Rate (N$)	Quantity	Total (N$)	Total (US$)
Site management (principle agent)	Item	2500.00	1	2500.00	403.23
Site foreman	Item	5000.00	1	5000.00	806.45
Material and labourer transport for toilet unit	Item	5000.00	1	5000.00	806.45
Manufacture and erection of surrounding structure	no	2520.00	5	12600.00	2032.26
- Installation of Cool Maintenance toilet unit	no	1020.00	5	5100.00	822.58
Cool Maintenance toilet unit	no	4737.96	5	23689.80	3820.94
Excavation work for waste pit	m^3	115.50	4.5	519.75	83.83
Pedestals and additional concrete ground work					
- Concrete	m^3	902.00	1.55	1398.10	225.50
- Formwork	m^2	240.00	1.44	345.60	55.74
Sub Total				**56153.25**	**9056.98**
VAT at 15%				8422.99	1358.55
Total for 5 units				64576.24	10415.52
Each Unit Total				**12915.25**	**2083.10**

Source: J. Groenewald Properties cc. (2004). Upgrading of Okahandja Park A,B and C. Windhoek.

N$4 737.96 in the table is the recent cost of the Cool Maintenance System based on the fact that it cost the City N$435 892.97 for ninety-two units. This cost would be slightly higher if fewer units were constructed. These figures came from the Okahandja Park Implementation Completion Report in January, 2004.

Atlas Plastics Latrine

The Atlas Plastics Latrine is another dry toilet, but it is different from many of the other designs. Instead of allowing liquids to evaporate and solids to dry out, the Atlas system has a digester tank (septic tank) underground that allows the solids to dissolve in water over time (Roschlau, 2002). To begin the dissolving process, an

initial amount of water is needed. No more water is needed after the initial water is added. The system also does not need any chemicals, though the company does sell them to accelerate the digestive process. After five or six years of use, the digester tank will become full and will need to be emptied based on forty uses a day (Roschlau, 2002). Under more uses per day, the digestive process will take longer, the waste will pile up faster, and more frequent visits by the septic pump truck will be required. The Atlas toilet does not entirely satisfy all that is desired for an informal settlement communal washing facility application. The main drawbacks to this system are it can contaminate the groundwater and it requires the use of a special truck to empty the waste.

The Atlas toilet system is not a completely dry system because there is water in the sewage pit that "digests" the waste. Because it retains water in the sewage pit, there exists an overflow drain which allows the excess liquid to exit through a pipe into the ground. Even though the runoff is minimal, this is undesirable because it can lead to bad odours as well as contamination of the groundwater. Another disadvantage of the Atlas system is that disposal of the waste requires a certain suction truck to remove the waste from the toilets pit. This requires there to be access to each facility for this truck which is very impractical as many of the roads in the Northwest Settlements are narrow and the washing facilities may, in many cases, be far away from the road (Roschlau, 2002).

Primary Effective Toilet

The Primary Effective Toilet (PET) unit includes the cover, pan, seat, and vent pipe. In building this latrine, a concrete foundation or base is not used. Instead, the PET sits directly on the ground over a hole dug in the earth. Due to its simplicity, the

PET can be installed in only four hours by untrained and unskilled people. Once the pit has filled, rather than cleaning the waste out of the pit, the entire structure must be moved to a new location over a newly dug hole, and the old pit must be filled back up with soil to cover the waste and odours. Based on the CSIR estimations that a person produces 40 litres of waste per year, and that the pit be dug to a capacity of eighteen hundred litres, the pit should be filled in eight years if it were to be used by six people. The latrine is not very heavy at thirty-two kilograms, which makes moving not a difficult task. The PET utilizes a vent pipe in order to keep the odours away from the user. A fly screen is also used in the vent pipe to keep flies away from the waste inside the pit as well as from the toilet area. The system is made out of polyethylene, which is highly resistant to damage by UV radiation. Calcamite, the makers of the PET, also provides a fifteen year manufacturer's guarantee for the performance of the materials of the tank. The superstructure that surrounds the toilet may be either purchased or built by the owner (Community Health Environment Developers CC, 2002).

Johan Reyneke from the Community Health Environment Developers CC. (C.H.E.D.) wrote a proposal on the Primary Effective Toilet (PET) to the City of Windhoek in efforts to sell the product to the City. The PET by Calcamite is a more basic design than most of the other dry toilets discussed in this section. It was originally designed as an emergency latrine. This product is too recent to gain any quality feedback from consumers (Community Health Environment Developers CC, 2002).

The Primary Effective Toilet (PET) could be a potential quick fix for the Northwest Settlements, but it is not permanent enough to be used in our communal washing facility design. The PET was developed as an emergency use toilet where

the toilet essentially sits above an unlined pit. Once this pit is full, the toilet is designed to be moved to a new location and the pit covered up with soil. It allows waste to drain into the ground, which is unacceptable in the Northwest Settlement area. It is also not appropriate for these washing facilities because its design necessitates its relocation after the pit is full (Community Health Environment Developers CC, 2002). The washing facilities that are to be used in the Northwest Settlements will be permanent structures and cannot accommodate an impermanent toilet.

Appendix K: Pupkewitz Megabuild and Builder's Warehouse Price Comparisons

When building the washing facility, the City and community will mainly be concerned about costs. One way to reduce these costs will be to purchase materials from the less expensive local building suppliers. In order to give the City advice on plumbing product purchases, we first recorded the piping and fittings needed in the two washing facility designs, and then priced each product at two of Windhoek's building suppliers – Builder's Warehouse (BW) and Pupkewitz Megabuild (PM). Table 10 shows these pricing comparisons for the dry toilet washing facility design, while Table 11 shows the comparisons for the wet toilet design.

Table 10: Builder's Warehouse and Pupkewitz Megabuild prices on dry toilet washing facility design plumbing

	BW (N$)	PM (N$)	Different Product Comparisons (N$)	Quantity	BW (N$)	PM (N$)
20 mm copper						
90 deg bend	3.93	4.11		6	23.58	24.66
Tee	6.72	6.38		1	6.72	6.38
Plug	2.54	2.54		1	2.54	2.54
Plug coupler	7.69	7.42		1	7.69	7.42
15 mm showerhead	66.63	45.19	X	1	66.63	45.19
90 deg showerhead 22 mm to 15 mm adaptor	6.64	7.08		1	6.64	7.08
22 mm tap stop	77.44	70.21		1	77.44	70.21
22 mm tap stop coupler	6.88	6.76		2	13.76	13.52
25 mm black plastic pipe						
90 deg bend	24.26	22.82		6	145.56	136.92
40 mm black plastic pipe						
90 deg bend	56.60	61.61		5	283.00	308.05
Reducer coupling (40 mm to 25 mm)	56.60	46.25		1	56.60	46.25
40 mm PVC						
Metal drain and trap	143.54	123.23		1	143.54	123.23
PVC adaptor	7.42	7.60		1	7.42	7.60
90 deg access bend	6.84	4.05		1	6.84	4.05
Total					**847.96**	**803.10**
Piping						
20 mm Cu piping (5.5 m)	151.72	114.10		1	151.72	114.10
25 mm black plastic piping per m	5.10	4.97	PM only sells by 5 m lengths	4.64	23.66	23.06
40 mm black plastic piping per m	13.08	12.12	PM only sells by 5 m lengths	1.05	13.73	12.73
40 mm PVC piping (4 m length)	53.06	44.86		8.19	434.56	367.40
Total					**623.68**	**517.29**

Table 11: Builder's Warehouse and Pupkewitz Megabuild prices on wet toilet washing facility design plumbing

	BW (N$)	PM (N$)	Different Product Comparisons (N$)	Quantity	BW (N$)	PM (N$)
20 mm copper						
90 deg bend	3.93	4.11		5	19.65	20.55
Tee	6.72	6.38		1	6.72	6.38
15 mm showerhead	66.63	45.19	X	1	66.63	45.19
90 deg showerhead 22 mm to 15 mm adaptor	6.64	7.08		1	6.64	7.08
22 mm tap stop	77.44	70.21		1	77.44	70.21
22 mm tap stop coupler	6.88	6.76		1	6.88	6.76
40 mm PVC						
Metal drain and trap	143.54	123.23		1	143.54	123.23
PVC adaptor	7.42	7.60		1	7.42	7.60
90 deg access bend	6.84	4.05		2	13.68	8.10
40 mm to 110 mm boss adaptor	25.56	23.51		1	25.56	23.51
50 mm to 40 mm reducer	5.12	4.05		1	5.12	4.05
110 mm PVC						
Y	80.28	77.19		1	80.28	77.19
Access Tee	100.84	100.72		1	100.84	100.72
Gully trap	93.31	100.57		1	93.31	100.57
Vent	74.69	108.35	X	1	74.69	108.35
Total					**728.40**	**709.49**
Plastic Cistern Toilet	X	310.00		1		310.00
Piping						
20mm Cu piping (5.5m)	151.72	114.10		1	151.72	114.10
40 mm piping (6 m length)	91.32	67.30		1	91.32	67.30
110 mm PVC piping (6 m length)	130.69	119.30		5.46	713.57	651.38
Total					**956.61**	**832.78**

According to Oberholzer, ROCLA prefers to order their plumbing requests for their structures from Pupkewitz Megabuild (personal communication, 6 April 2004).

In both designs, Pupkewitz Megabuild turned out to be the overall lower cost supplier, which will in turn help to lower production costs.

Appendix L: External Pipe Distances

External piping added to the facility costs considerably, as building trenches requires labour, excavation equipment, and material costs. In order to supply the Northwest Settlement community leaders with accurate cost estimates for the washing facility designs, we needed to have a basic understanding of the external piping costs. A 2002 building plan layout of the Havana Extension 1 settlement toilet facilities was drawn by the Windhoek Consulting Engineers. The plan divided the settlement into northern and southern halves, where all fifty-eight toilet blocks were shown with their respective 110 millimetre underground PVC piping distances needed to connect each facility to the municipal sewer line. We recorded all these distances to find the average external piping distances that would be needed to connect the washing facilities to municipal sewer lines in the Northwest Settlements. These recordings can be viewed in Table 12. J. A. Burger agreed the average calculated distance would provide an accurate representation of all the Northwest Settlements, and could also approximate the water source piping distances that would be needed in the wet toilet washing facility design (personal communication, 21 April 2004).

Table 12: External pipe distances in Havana Extension 1 for thirty-five south locations and twenty-three north locations

Havana Ext 1 Sewer Line Distances from Current Toilet Facilities

South Half

	Distance (m)
S1	26.518
S2	25.178
S3	35.297
S4	32.918
S5	13.837
S6	40.514
S7	48.273
S8	54.085
S9	41.963
S10	14.223
S11	17.825
S12	26.141
S13	34.471
S14	6.822
S15	7.630
S16	57.695
S17	38.868
S18	45.083
S19	24.224
S20	98.944
S21	28.223
S22	32.220
S23	25.297
S24	44.317
S25	77.386
S26	13.928
S27	18.611
S28	41.894
S29	18.913
S30	19.321
S31	33.777
S32	22.902
S33	30.978
S34	46.988
S35	15.952

North Half

	Distance (m)
N1	17.621
N2	22.624
N3	40.325
N4	25.203
N5	30.499
N6	85.015
N7	28.692
N8	33.697
N9	25.904
N10	15.067
N11	36.805
N12	48.618
N13	16.543
N14	67.309
N15	28.892
N16	5.018
N17	14.431
N18	35.015
N19	22.480
N20	59.206
N21	22.259
N22	25.048
N23	3.000

Source: Windhoek Consulting Engineers. (August 2002). Upgrading of Havana Extension 1 Bulk Long Section.

The average external piping distance calculated from this building plan of the Havana

Extension 1 settlement was 32.76 metres.

Appendix M: Calculated Pipe Lengths for the Washing Facility

In developing total cost estimates for each washing facility design, we needed to consider the cost of the piping to be cast within the facility. Although the plumbing viewed in the "Shower" section does not require exact dimensions for successful functioning, the piping layout displayed is one option for success. Using Pro-Engineer, a computer drafting program, we drew our design and the piping layout, and then used the program to add up all the piping section lengths. These lengths are displayed in Table 13 for the dry toilet washing facility design and in Table 14 for the wet toilet washing facility design.

Table 13: Dry toilet washing facility design within structure piping lengths

	40mm HDPE Class 10	**20mm cu**	**20mm HDPE Class 10**
Pipe lengths within structure	1058.64	5050.36	4650.62
Number of 90 deg bends	5	6	6
Number of Tee fittings	0	1	0

Table 14: Wet toilet washing facility design within structure piping lengths

	20mm cu
Pipe lengths within structure	4535.84
Number of 90 deg bends	5
Number of Tee fittings	1

Appendix N: Total Estimated Cost Breakdowns for the Washing Facility

It was important to provide the City with our breakdown of total costs in the event individual components of our design might be altered. For example, if a new local company begins selling less expensive products than those priced in our design, the City may be able to see directly what impact these lower costs will have on the total costs. Additionally, the City may wish to see the large areas of cost in the design so that they might search for alternative methods to reduce these costs. Tables 15 and 16 show the breakdown of the total costs for the wet and dry toilet washing facility designs, respectively. Table 17 shows the additional cost to connect the dry toilet washing facility design to a direct water connection should the pumping system be unsuccessful. The United States Dollar value in the following tables is based off of the conversion of 6.2 Namibian Dollars to 1 US Dollar.

Table 15: Washing facility with wet toilet design costs

Item Description	Rate (N$)	Quantity	Total (N$)	Total (US$)
ROCLA Company				
Concrete Unitized Bathroom	3400.00	1	3400.00	548.39
Municipality heavy duty doors	450.00	2	900.00	145.16
60 mm dividing wall	335.00	1	335.00	54.03
Fourth wall	670.00	1	670.00	108.06
Sloped shower drain floor casting	50.00	1	50.00	8.06
Mounting sockets	5.00	20	100.00	16.13
Delivery w/ minimal installation work	400.00	1	400.00	64.52
Pupkewitz Megabuild Plumbing				
20 mm copper				
90 deg bend	4.11	5	20.55	3.31
Tee	6.38	1	6.38	1.03
15 mm showerhead	45.19	1	45.19	7.29
90 deg showerhead 22 mm to 15 mm adaptor	7.08	1	7.08	1.14
22 mm tap stop	70.21	1	70.21	11.32
22 mm tap stop coupler	6.76	1	6.76	1.09
Piping per 5.5 m length	114.10	1	114.10	18.40
40 mm PVC				
Metal drain and trap	123.23	1	123.23	19.88
PVC adaptor	7.60	1	7.60	1.23
90 deg access bend	4.05	2	8.10	1.31
40 mm to 110 mm boss adaptor	23.51	1	23.51	3.79
50 mm to 40 mm reducer	4.05	1	4.05	0.65
Piping per 6 m length	67.30	1	67.30	10.85
110 mm PVC				
Y	77.19	1	77.19	12.45
Access Tee	100.72	1	100.72	16.25
Gully trap	100.57	1	100.57	16.22
Vent	108.35	1	108.35	17.48
Plastic cistern toilet	310.00	1	310.00	50.00
Pipe Trench Digging				
20 mm HDPE Class 10 pipe per trench metre	94.00	32.76	3079.44	496.68
110 mm PVC pipe per trench metre	300.00	32.76	9828.00	1585.16
Wet Toilet Grand Total				
Without Nossob River Systems prepayment meter			**19963.33**	**3219.89**
With optional Nossob River Systems prepayment meter (N$3500)			**23463.33**	**3784.41**

Note: ROCLA costs are the Branch Manager's estimates.

Table 16: Washing facility with dry toilet design costs

Item Description	Rate (N$)	Quantity	Total (N$)	Total (US$)
Enviro Loo				
Site management (principle agent)	2500.00	1	2500.00	403.23
Site foreman	5000.00	1	5000.00	806.45
Material and labourer transport for toilet unit	5000.00	1	5000.00	806.45
Installation of multiple user Enviro Loo toilet unit	1020.00	5	5100.00	822.58
Multiple user Enviro Loo toilet unit	5260.87	5	26304.35	4242.65
Excavation work for waste pit (m^3)	115.50	4.5	519.75	83.83
Pedestals and additional concrete ground work				
Concrete (m^3)	902.00	1.55	1398.10	225.50
Formwork (m^2)	240.00	1.44	345.60	55.74
Sub Total			**46167.80**	**7446.43**
VAT at 15%			6925.17	1116.96
Total for 5 units			53092.97	8563.40
Each Unit Total			**10618.59**	**1712.68**
AFRO Pumps				
Amazon Warrior hand pump	3018.00	1	3018.00	486.77
ROCLA Company				
Concrete Unitized Bathroom	3400.00	1	3400.00	548.39
Municipality heavy duty doors	450.00	2	900.00	145.16
60 mm dividing wall	335.00	1	335.00	54.03
10.75 L concrete tank	170.00	1	170.00	27.42
55 L concrete tank	170.00	1	170.00	27.42
Concrete tank cover	45.00	2	90.00	14.52
Fourth wall	670.00	1	670.00	108.06
Sloped shower drain floor casting	50.00	1	50.00	8.06
20 mounting sockets	5.00	20	100.00	16.13
Delivery w/ minimal installation work	400.00	1	400.00	64.52

Note: ROCLA costs are the Branch Manager's estimates.

Table 16 continued on following page.

Table 16 continued

Item Description	Rate (N$)	Quantity	Total (N$)	Total (US$)
Pupkewitz Megabuild Plumbing				
20 mm copper				
90 deg bend	4.11	6	24.66	3.98
Tee	6.38	1	6.38	1.03
Plug	2.54	1	2.54	0.41
Plug coupler	7.42	1	7.42	1.20
15 mm showerhead	45.19	1	45.19	7.29
90 deg showerhead 22 mm to 15 mm adaptor	7.08	1	7.08	1.14
22 mm tap stop	70.21	1	70.21	11.32
22 mm tap stop coupler	6.76	2	13.52	2.18
Piping per 5.5 m length	114.10	1	114.10	18.40
25 mm HDPE Class 10 pipe				
90 deg bend	22.82	6	136.92	22.08
Piping per metre	4.97	4.64	23.06	3.72
40 mm HDPE Class 10 pipe				
90 deg bend	61.61	5	308.05	49.69
Reducer coupling (40 mm to 25 mm)	46.25	1	46.25	7.46
Piping per metre	12.12	1.05	12.73	2.05
40 mm PVC				
Metal drain and trap	123.23	1	123.23	19.88
PVC adaptor	7.60	1	7.60	1.23
90 deg access bend	4.05	1	4.05	0.65
Pipe Trench Digging				
40 mm PVC pipe per trench metre	120.00	32.76	3931.20	634.06
Grand Total			**24805.78**	**4000.93**

Table 17: Washing facility with dry toilet design additional cost for modular upgrading

Item Description	Rate (N$)	Quantity	Total (N$)	Total (US$)
Pipe Trench Digging				
20 mm HDPE Class 10 pipe per trench metre	94.00	32.76	3079.44	496.68
Total Upgrading Costs				
Without Nossob River Systems prepayment meter			**3079.44**	**496.68**
With optional Nossob River Systems prepayment meter (N$3 500)			**6579.44**	**1061.20**

Appendix O: Windhoek Water Tariffs

The City charges all of Windhoek's inhabitants for water after purchasing the water from NamWater. The City has developed a payment structure based on the consumer's connection size and consumption description. A breakdown of water costs for the Northwest Settlements was useful in determining the magnitude of the cost efficiency for using dry toilets over wet toilets. Table 18 shows the basic monthly charges for various connections, while Table 19 shows the consumption tariffs for various consumers.

Table 18: Basic monthly water charges required or needed by residents for various connection types

BASIC CHARGE	Tariff	VAT		Total	
Diameter of meter inlet		Domestic	Non-Domestic	Domestic	Non-Domestic
15 mm	11.62	0%	1.74	11.62	13.36
20 mm	27.81	0%	4.17	27.81	31.98
25 mm	45.27	0%	6.79	45.27	52.06
40 mm	296.68	0%	44.50	296.68	341.18
50 mm	522.40	0%	78.36	522.40	600.76
80 mm	1 711.80	0%	256.77	1 711.80	1 968.57
>80 mm	4 179.20	0%	626.88	4 179.20	4 806.88
Fire connections	474.60	0%	71.19	474.60	545.79

Source: Water Tariffs: Basic and Consumption (2004, January). Aloe, pp 3.Windhoek, Namibia.

Table 19: Water tariffs for various consumers

CONSUMPTION Tariff Code	Consumer description	Tariff per Kilolitre	VAT	Total
WC 10	Domestic			
	• 0 – 0.200 kl per day (0-6 kl p.m.)	4.17	0%	4.17
	• 0.201 – 1.50 kl per day (6-45 kl p.m.)	6.94	0%	6.94
	• more than 1.50 kl per day (>45 kl p.m.)	12.78	0%	12.78
WC 13	Domestic with Flat (Special Agreement)			
	• 0 – 0.200 m3/day (0-6 m3/mth)	4.17	0%	4.17
	• 0.201 – 1.8 m3/day (6-54 m3/mth)	6.94	0%	6.94
	• more than 1.8 m3/day (> 54 m3.mth)	12.78	0%	12.78
WC 20	Non-Domestic	7.37	1.11	8.48
WC 22	Flats/ legal entities 5 or more units with communal meter/s	7.37	1.11	8.48
WC 50	Communal Water Points (special agreements)	6.94	1.04	7.98
WC 26	Sport Fields (grass) which cannot be connected to purified effluent network (with effect from 16-06-97)	1.14	0.17	1.31
WC 70	Brakwater Consumers (NamWater cost = N$3.27 + 15% surcharge)	4.73	0.71	5.44

Source: Water Tariffs: Basic and Consumption (2004, January). Aloe, pp 3.Windhoek, Namibia.

According to Heike Cronje, Town Planner for the City of Windhoek Sustainable Development Division, the informal settlements are currently using 15 millimetre water connection pipes. Unfortunately, the City is encountering pressure problems using this piping diameter, and thus Cronje advised we perform our calculations on a 20 millimetre connection. She further explained the informal settlements would be categorized as a WC 22 connection: Flats/legal entities five or more units with communal meter/s (personal communication, 25 March 2004).

George Esterhuizen, the recommended contact for inquiries on the table above, stated the informal settlements are considered domestic water connections in Table 19. The basic charges are for each standpipe in the community and are paid monthly as a flat rate before any water consumption costs (personal communication,

19 April 2004). See Appendix B for minutes from our 19 April 2004 phone conversation with Esterhuizen.

The monthly cost of water in the informal settlements may be calculated as: N$27.81 (Basic Charge for 20 millimetre connection) + N$7.37 x kL (cost per kilolitre) + 1.11 (VAT)

kL = number of kiloliters of water used per month

Appendix P: Namibian Articles on Prepayment

Prepayment is a very controversial issue faced currently in Namibia. Some believe prepayment forces the poor to inadequate water consumption when they are unable to pay for water at the exact moment of need. Others understand the dilemma that NamWater must be compensated for providing water to Namibians. Additionally, without pricing on water, the country's scarce valuable resource may be consumed without caution. Figure 58 is a newspaper article from the Namibian taking the critical stance on prepayment and water costs, while Figure 59 is a Namibian article refuting claims from the previous article, focusing on the need for a pricing system on Namibia's water.

Labour study slams water charges as 'new Apartheid'

• LINDSAY DENTLINGER

AN in-depth study of privatised water services in Namibia says that while prepaid water systems are being marketed as the solution to bad debts and water conservation, they are in fact worsening the plight of the country's most vulnerable.

Titled 'Water Privatisation in Namibia: Creating a New Apartheid?', the report released by the Labour Resource and Research Institute (LaRRI), contends that the system is exposing thousands of the country's poor to preventable diseases and death.

"The prepayment water system is hostile to public health and negatively affects the social and environmental conditions of the poorest sections of society," says the author of the report, Jade McClune.

Using the experiences of the DRC informal settlement at Swakopmund as an example of the hardships people suffer as a result of the system, the study questions whether this policy is becoming "the new apartheid".

"Prepaid meters are not being installed in the rich suburbs nor in the industrial areas where vast amounts of water is being consumed. They are only being installed in the working class areas, where the majority of the black population live," says the report.

According to the study, thousands of people go without sufficient water to meet their daily personal hygiene, nutritional health or childcare needs.

"The pricing and method of prepaid water supply inhibits consumption by the poor in a drastic way," the study contends.

The situation in a number of towns and villages across the country which use this system is also documented and the report subsequently concludes that the argument that the poor must pay for basic water infrastructure is flawed.

The LaRRI report maintains that the national housing policy is also being contradicted in situations where defaulters are evicted from their homes for being unable to pay their water bills.

Placing basic water services beyond the reach of the country's poorest citizens is impoverishing the rural population further making them unable to secure water for their farming activities, claims the study.

LaRRI recommends that access to clean drinking water be protected by legislative and institutional guarantees as a basic human right.

It further suggests that an assessment be undertaken to establish the correlation between the privatisation of water services and disease prevalence.

A free minimum amount of household water supply should be implemented "to safeguard the interest of indigent families, children and pensioners", it says.

Ideally, the provision of basic water services should be re-incorporated into the public sector as a core function of Government, the labour institute says.

Photo: Maggi Barnard

FORTUNATE ... Boys at Omihana village, north of Uis, drink from a water pump, seemingly unaware what a precious commodity water is, especially in rural areas. According to calculations, Government will have to provide clean water to 20 370 additional rural people a year in order to meet the Millenium Development Goal of halving the number of people without access to clean water and sanitation.

Figure 58: Dentlinger, Lindsay. (2004, April 7). Labour study slams water charges as "new Apartheid". The Namibian. pp. 5.

No free water, says Angula

• LINDSAY DENTLINGER

A TOP Government official has dismissed claims that water is unaffordable for most Namibians and ruled out the possibility of the precious resource being supplied free.

Inaugurating the new board of water utility NamWater last week, Minister of Agriculture, Water and Rural Development, Helmut Angula, said claims that Government was making water unaffordable had not been considered within the context of social realities.

"Water does not come cheap. It comes with a lot of investment," said the Minister. "There is no way possible to provide free water in this country otherwise the whole system will collapse."

Angula, who compared the affordability of water to the purchase of beer, said: "How much is the price of a 340 millilitre bottle of beer? How many Namibians buy beer? We know how much that costs. Some buy about seven a week. It is incredible how people make [others] believe that water is not affordable in Namibia."

NO FREE WATER ... Minister Angula.

Bulk water supply for pensioners, he said, was being sold by NamWater at N$3,70 per cubic metre (1 000 litres) a month – about 30 cents less than the standard rate of just over N$4,00.

Angula also dismissed as "incredible propaganda" allegations that the country's water provision system had been privatised through the establishment of NamWater.

NamWater, he said, would remain a wholly-owned State entity.

"State remains state. It doesn't mean it [water provision] is privatised because it [NamWater] charges its citizens".

Angula said a new Water Bill was in the pipeline and would give rise to new institutions to regulate the industry – among these an Independent Pricing Regulator to deal with issues of affordability.

He said it was the board's responsibility to ensure reliable and affordable services and acceptable tariff policies and structures.

The NamWater board has been trimmed from nine to five members in accordance with Government policy.

Engelhard Haihambo from the Engineering Council of Namibia was elected Chairman. Other members who will serve for the next three years are: Moses Shakela, a NamWater employee; Abraham Nehemia of the Ministry of Agriculture, Water and Rural Development; Nangula Hamunyela from the Namibia Chamber of Commerce and Industry; and Jacobus du Toit from the Institute of Chartered Accountants of Namibia.

They face the immediate challenge of introducing increases in water tariffs for next year in line with a Cabinet decision.

According to the Minister, many Ministries and other State institutions defaulted on water payments because increases were introduced after their budgets had already been approved.

The Minister said that water providers were faced with the challenge of overcoming a cultural belief that water should be free of charge. Coupled with this, he said, were the broader social realities that led to the non-payment of bills.

He said the price of water would not be deemed exorbitant for pensioners if they were only responsible for paying for their own water.

Angula said critics should also distinguish between the amount of water needed for personal use and that needed for economic activities.

According to NamWater, provision is made for a daily supply of 25 litres of water per person – more than the United Nations prescribed amount of 15 litres per day.

Angula said he could understand farmers' complaints that they were unable to pay for water for their cattle but, on the other hand, they were reluctant to reduce their livestock herds.

Photos: Lindsay Dentlinger

NEW BROOMS ... NamWater's new board was inaugurated by Minister of Agriculture, Water and Rural Development Helmut Angula (seated, centre). The new members are, standing: Abraham Nehemia, Engelhard Haihambo, Moses Shakela, Nangula Hamunyela and Jacobus du Toit. Seated are Agriculture Permanent Secretary Kahijoro Kahuure (left) and NamWater CEO Vaino Shivute.

Figure 59: Dentlinger, Lindsay. (2004, April 13). No free water, says Angula. The Namibian. pp. 5.

Appendix Q: Urban Dynamics Maintenance and Management Plan

In order to better understand the concept of a workable maintenance and management plan, we investigated Urban Dynamics' recently designed plan. Urban Dynamics is a local community development company who largely works with the City of Windhoek in the Northwest Settlements. Urban Dynamics prepared a report in October, 2003 for the Sustainable Development Division of the City of Windhoek regarding the maintenance and management plan for the toilet facilities in the Havana Extension 1 informal settlement. This settlement did not have a structured maintenance and management plan for the facilities at the time of this report and the plan's implementation is still in progress in 2004. Urban Dynamics is managing the physical upgrading of Havana Extension 1, including the construction of seventy-nine communal water and sanitation facilities. It is also their job to find a suitable maintenance and management plan to help facilitate the long-term life and use of these communal blocks. According to Stefani van Zyl from Urban Dynamics, past experiences proved that large responsibility placed on the City in maintenance and management would lead to failure (personal communication, 25 March 2004).

Urban Dynamics states that an educational program should be made as a prerequisite for the maintenance and management plan. With this plan, the community would receive education on their rights, their monthly payment duties, the use and maintenance of the facilities, training for community health, proper solid waste removal, and other training applicable to low income urban life. This training in the developing process should help make the settlers responsible citizens of Windhoek. The Community Development Division of the City of Windhoek should provide this training at the moment the facilities are leased to the settlers.

Urban Dynamics recommends that it should be each community member's responsibility to pay the City of Windhoek for the use of the facilities. In addition, the settlers should be encouraged to look out for their fellow community members to ensure they are paying their bills as well (Urban Dynamics, 2003). This should create a system of trust and constant concern for one's neighbour. Urban Dynamics believes recommendations for managing payment and information on how to compensate the City for its provisions should be offered to the community in the education program.

To aid neighbourhood committees, which are small groups of democratically elected individual block leaders, Urban Dynamics discussed with them methods of facility care. In order to keep out strangers and potential vandals, locks would be added and keys issued only to those using the facilities. After this, every user of the facilities would be trained in the importance of flushing sewage as well as assigned to a cleaning roster produced by the neighbourhood committee. This way, all would contribute equally to the cleaning of the facilities.

Over time, the individuals sharing a facility might come up with their own cleaning program, provided it is effective and suits all users. Lastly, under the leadership of the committees, the users of a block would compose a list of penalties for each case of negligence, the enforcing of which will be done by the neighbourhood committee.

Urban Dynamics (2003) expects normal wear and tear on certain parts of the Havana Extension 1 facility. In these cases, the community committee would appoint trained members of the community so when the need arises, they might be hired for their skills. All maintenance problems would then be addressed to the neighbourhood committee who would send the trained technician to fix the problem. A fair payment rate would be decided upon amongst the service providers and the neighbourhood

committee. When the service provider has fixed a block, the neighbourhood committee would check the work and then pay them using money from the community who is using the facility. The community members would agree on the individual contributions. This system, Urban Dynamics believes, would lend to preventative maintenance by looking after the well being of the facilities.

The Community Development Division of the City of Windhoek will monitor the facilities over the course of the year and review the maintenance and management system in regards to the inspections and consultation with the community commentary on the maintenance and management plan. The City will use the results of these discussions in their decision to make any changes in the system. The pros and cons of the system will simultaneously be shared with the Community Development Division. The community leaders will be allowed this same chance to report their feedback on the system with the City of Windhoek so recommendations about its further implementation in other projects can be made. By involving the community in these changes, the modified system is more likely to be accepted.

At the moment, the City is responsible for the solid waste removal. This may change in the future as some of the Havana Extension 1 volunteers and contractors will be able to monitor the workings of the facilities. If in the future community members wish to purchase their shared ablution block from the City, the Community Development Division will help them do so.

According to the Windhoek community development company, Urban Dynamics, the City must ensure health standards and consider how a lack of community maintenance will gradually degrade these standards of the facility. The Health division of the City of Windhoek would be responsible for periodic checks of the facilities for proper sanitation and general hygiene. Any problems

would be reported to the City divisions so that the correct use of toilets and good hygiene practices might be added to the educational manual used to train the community members.

Urban Dynamics suggested that each user of the block agree to a statement that obliges them to be responsible to their elected leadership and follow the established maintenance and management plan democratically selected by each block.

GLOSSARY

Aquifer – Underground rock or sand that can serve as reservoirs for groundwater

Boreholes – Drilled holes in the ground from which water is pumped

Convenience Sampling – Sampling only individuals who are the most convenient to sample

Drip Irrigation - An irrigation method where low pressure pipes or tubes filled with water slowly drip onto a landscaped or other planted area. Under this low pressure system, less water is lost to evaporation

Ephemeral Rivers – Rivers that flow on the surface only after an abundance of rain

Grey Water – Domestic wastewater including sink drainage, washing machine discharge, or bathwater. This does not include any water containing human excrete

Groundwater – Water that naturally flows beneath the surface

Informal Settlements – Dense settlements where communities inhabit self-constructed shelters under conditions of informal or traditional land tenure. These settlements occur as a result of the current land administration failing to address the needs of the whole community and are known for their rapid, unstructured, and unplanned development

Mould – A hollow cavity specifically designed to form material into a desired shape

Northwest Settlements – A common name for the informal settlement areas of Windhoek, Namibia

Parastatal – A corporation that is partly or wholly controlled by the government

Perennial River – Rivers flowing on the surface all year round

Pre-cast Structure – Concrete structure that is made in a mould, in which piping can be run inside the walls

Purposive Sampling – Sampling a specific group of people

Snowball Sampling – Conducting research by asking previously questioned individuals for more people you can contact