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The derivation of a set of rates that can be used to determine the Operation and Maintenance Costs of Municipal Engineering Services in residential areas in the Western Cape

By

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2006

Executive Summary

This research project was pursued in the light of national legislative requirements, which allude to 'a certain practice of delivery' associated with municipal engineering infrastructure. (South Africa. 1994-2000).

Current large scale delivery demands in the city of Cape Town require wise and intuitive decision making around aspects such as sustainability, levels of service and budgeting. The driving wheels of legislation are centered on a number of framework policies with notions such as 'fast tracking development', 'participatory development', 'multi-year development plans' and 'affordability'.(South Africa. 1994-2000). All of these have an influence on the speed of delivery and the ultimate quality of those services.

In the context of changing policy, government has highlighted the need for sustainable services, which invariably includes total costing, asset management and proactive O&M practice. In support of this, S.A. National Treasury indicates an ongoing thrust in O&M annual expenditure, reaching over 80% of the budget for the 2004/5 financial year. Cape Town has a leading share in this- Mayor Nomaindia Mfeketo describing it as 'massive' and setting the city into a path of sustainability, prosperity and long-term success.

The aim of this dissertation is to arrive at a set of rates or formulae, which could be used at a participatory decision-making level for the estimating of O&M costs for the delivery of municipal civil engineering infrastructure in an urban context. Such a data set would provide a type of 'benchmark for change' - it is not intended to be a data set able to predict the O&M service rates for each town, but rather as part of a strategic model used to predict the O&M rate for a service and so prompt decision-makers to ask questions around actual versus predicted values.

Chapter 2: Literature Review, discusses some of the above themes such as the legislative context for service delivery, maintenance and asset planning. Additional issues such as service standards and components, and the determination of cost rates all provided direction to the research. Rates for O&M were also sourced from the literature, and were used as an 'external source' of comparison on the research.

The Research Methodology in Chapter 3 closes in on some of the gaps identified in the literature review. These are captured in an action-plan format, from which key components for this research were identified. These components are-

- The derivation of a set of rates, and where possible, equations for the O&M costing of civil engineering services (at various levels of service)
- The testing of the equations for accuracy with respect to variability of data between different towns/ applications.

The pilot study at Stellenbosch municipality served to shape the process of information gathering and to identify a number of key variables, which had an impact on the data. These include population sizes, geographic information, service parameters and problems with current O&M practices. These in turn served to address a multi-variable analysis of the data for computing the O&M rates and formulae.

The major sources of data collection were from municipalities in the Western Cape Province. The data records annual budget expenditures for the components of five different civil engineering services – i.e. Roads (Gravel and surfaced), Storm water (reticulation and appurtenances), Sanitation (reticulation and treatment), Solid waste (Landfill, collection and transport), and Water (Reticulation and treatment). Also included is a list of divisors (i.e. road length, pipe length, volume of flow and tonnage of solid waste) to calculate the rates.

The feedback levels and the problems related to the data collection process are highlighted at the end of the chapter.

Chapter 4 deals with the development of rates from the raw data. The raw data was corrected for anomalies and mathematical errors before the statistical analyses for determining the rates were performed. Two sets of values were compiled – Desired Corrected annual Values (DCV) (i.e. the annual cost of the components of the service; e.g. the cost per annum of Gravel Roads), and Desired Corrected annual unit service rates (dcvRates) (e.g. annual cost per kilometer of Gravel Roads). The means, standard deviations and weighted means were developed for these rates.

The results of a Multi-variable Statistical Analysis using a number of variables are recorded in Chapter 5. The procedure involved the use of correlations between the dependant variables (cost or rates) and the independent variables (the divisors). The best correlations were used to determine the applicable unit service rates and their subsequent linear regressed formulae.

Chapter 6 provides a discussion of the analyses outcomes in the form of sensitivity checks. The rates and formulae, which were determined from the regression analyses, are compared to the actual data and conclusions and recommendations of the best estimates are made.

Finally, An attempt is made to validate the formulae by comparing the results to the external data set derived in the Literature Review.

The comparative calculations indicate-

- That in most cases the best estimates are the weighted and straight averages
- That in some cases there are best fit formulae, which can be compared against the weighted means for deriving the individual rates
- In almost all cases there are good comparisons between the rates calculated and those sourced from literature

Plagiarism

“Declaration against Plagiarism-

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Terminology

The following abbreviations and terms are used in this dissertation. They are provided here for purposes of clarification and as a stand-alone reference.

ABBREVIATIONS

AMIP :	Asset Management Improvement Program
CRC:	Critical Replacement Cost
DBSA:	Development Bank of South Africa
DCV:	Desired Corrected Rates [in Rands per annum]
dcrRates:	Desired Corrected Rates for unit services [eg. Rands per km per annum]
GAMAP:	Generally Accepted Municipal Accounting Practices
GIS:	Geographic Information System
IAM:	Infrastructure Asset Management
IDP:	Integrated Development Plan
IIMM :	The International Infrastructure Management Manual
IMIESA:	The Institute of Municipal Infrastructure Engineering of South Africa
IT:	Information Technology
KPI's:	Key Performance Indices
LOS:	Level of Service
MES:	Municipal Engineering Services
MIG:	Municipal Infrastructure Grant
O&M:	Operations and Maintenance
OMP:	Operation and Maintenance Plan
RCM:	Reliability Centered Maintenance
SAICE:	South African Institute of Civil Engineers
SAIMM :	South African Infrastructure Management Manual
SALGA:	South African Local Government Agency
SAP:	Municipal Standard Accounting Program
SMAM:	Sustainable Municipal Asset Management
VIP:	Ventilated Improved Pit
WRC:	Water Research Council
WSDP:	Water Services Development Plan
Wtd.Mean:	The Weighted Mean (or Weighted average)

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Chapter 1: Introduction

Municipal engineering services delivery is at the core of national legislation such as the Development Facilitation Act and the White Papers on Municipal Services Partnerships, Housing, Water and Sanitation.

The frameworks for such legislation have resulted in billions of rand spent and enormous backlogs in infrastructure needs being met over the last ten years. However, the focus on Capital expenditure is slowly shifting and the need for Asset Management is being highlighted more than ever.

1.1 Context

Proper Asset Management includes the need for proper Maintenance and Operational (O&M) expenditure and planning. Government has indicated for example, that infrastructure funds such as the annual Municipal Infrastructure Grant can only be effected once municipalities have tabled a detailed O&M budget with each application.

At a municipal level, decision-making with respect to O&M budgeting is generally approached via a process of 'educated guessing' based on historical patterns of expenditure within the municipality. This process has however been compounded by the problems of rapid urbanization, declining subsidies, financial dilemma within local authorities, inefficient methods of service delivery, low payment levels and inadequate financial reporting.

Local Authorities need a tool that will assist them in decision-making around cost determination in a service delivery climate, which is highlighted by community collaboration and political drive.

1.2 Contents of the Dissertation

The dissertation begins with a Literature Review (Chapter 2) covering various aspects of Municipal Services Delivery in South Africa and the Western Cape as it pertains to O&M cost determination. The study seeks to identify gaps in O&M costs determination by assessing the following-

- supportive legislation
- the need for a proven method of O&M practice
- the formulation of a method for cost determination based on the use of cost rates and cost drivers
- the level of Asset Management practice and Ring Fencing in our country, and
- the existing methods and models of O&M cost determination across our municipalities.

Chapter 3 addresses the Research approach used in this dissertation. The methodology evolves from the issues, which are highlighted in Chapter 2. It addresses the Research Question '*What are the Operation and Maintenance (O&M) costs of municipal engineering services in municipalities in the Western Cape?*' It does this by identifying the key deliverables of the research and the necessary activities to meet these deliverables.

Chapters 4 and 5 respectively address the data collection and analyses components of the research. These Chapters provide a logic flow of the scope of data collected and tabulations and discussions of the levels of return or feedback from the data-collection process. It also incorporates all the calculations and statistical analyses performed on the data.

Chapter 6 provides a discussion and sensitivity analyses of the results of chapter 5 by comparing the formulae or rates derived in the regressions with that of the actual data sets and with those rates derived in the literature review in Chapter 2.

Conclusions and recommendations as well as proposals for further studies are presented in Chapter 7.

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Chapter 2: Literature Review

Certain main themes have emerged from readings undertaken in this research. The current section seeks to address those themes, as they are contextualised under the research topic. In turn, these discussions will serve to formulate a methodology for the research process of this project.

2.1 Municipal Engineering Services Delivery

For the purposes of this report, the term ‘Municipal Engineering Services delivery’ refers to the delivery of civil engineering services in an urban municipal context.

This delivery has its focus at the municipal level and in turn refers to the supply of potable water, the hygienic removal and disposal of sewage, the protection of life and property from storm water, the disposal of solid waste, and the provision of a road based transport system.

2.1.1 Relevant Legislation

Government has a constitutional responsibility to ensure that all South Africans live in an environment that is not harmful to their health or well being. (SA. Constitutional Assembly,1996). This implies having access to an adequate supply of water, sanitation and solid waste removal facilities. This is further reflected in the Development Facilitation Act (SA,1995), and the Housing Act (SA,1997).

In these legislation, the term ‘adequate supply’ is synonymous to the term ‘basic services’, in keeping with a service delivery approach which encourages ‘some services for all people’; albeit a first phase level of service provision with the intention that the service or service package will be upgraded as community affordability levels allow.

Table 1 below highlights in an ‘action table’ format the scope of support offered to municipal services delivery in South Africa. The format and headings of this table evolved from a perusal of the various legislation (column 1).

Table 1: Municipal Services Delivery in South Africa: Legislative Framework

Policy reference	Service type and consumption level	Time to implement service delivery	Need for innovation	Sustainability	Use of existing Resources	Agent responsible for service delivery and M&O	Access to Financial Resources
SA. Office of Prsident (1995). Development Facilitation Act No. 67/1995	'Basic services'- mainly from health and hygiene point of view	'Speed up land development and reconstruction'	'Apply extra-ordinary measures'	The service choice must be integrated with holistic development	Make use of existing bulk infrastructure	Municipality	Act gives no direct access
		Service choice and delivery is subject to a certain general principles of decision making and conflict handling (includes proper dispute handling, time for comments and deliberation around technology and choices etc)	Service type should promote diversity of land uses (even at point of individual erven)	Encourage environmental sustainability	Service choice must discourage the phenomena of urban sprawl and contribute to developing compact towns/ cities	There must be a signed service agreement between the municipality and the applicant	Act alludes to fact that grants and subsidies are available
			Meet basic needs	Be affordable	Optimise use of existing infrastructure which is in excess of current needs	Municipality provides bulk and connector services and public services	
				Service choice must ensure the safe utilization of land	Members of community be allowed to actively participate in the development process	Applicant provides internal services from grants and subsidies	
					Develop skills and capacities of the locally disadvantaged persons		
SA. Gov. Gazette (2000). White Paper on Municipal Services Partnerships.	'Schedule 4 and 5' services are hi-lighted in the Act and include: cleansing, refuse removal, municipal roads and water and sanitation	The concept of Municipal Services Partnerships is meant to fast-track service delivery (multi-level involvement)	Within an environment of competitive bidding	The transfer of ownership is encouraged and includes community involvement	Outsource utility functions to private sector or local community teams	National, Provincial and Local government	Act gives no direct access but alludes to roles and responsibilities which encourage the use of donor funds

Table 1 Cont: Municipal Services Delivery in South Africa: Legislative Framework

Policy reference	Service type and consumption level	Time to implement service delivery	Need for innovation	Sustainability	Use of existing Resources	Agent responsible for service delivery and M&O	Access to Financial Resources
SA. Gov. Gazette. (1997). Housing Delivery Act 107/1997	Low cost Housing Projects involving a top structure and a suite of services	The 'Gateway Project' fast-tracks housing delivery to meet of 2010 deadline	Meaningful consultation with individuals and communities, wide ranges of tenure and housing options, integrated development	Setting up of multi-year development plans, Social integration, community and recreational facilities, stimulate private investment, wide stakeholder participation, reliable data bank for forward planning and monitoring, affordable	Promote education, wide ranges of options	Local Government	Act indicates that loans and grants are encouraged and that subsidies are available
SA. Dept Environ Affairs. (1997). White Paper on Environmental Management Policy (July 1997)	Project specific: all types and levels of services especially those threatening the biosphere	Fast-tracking: unplanned and rapid urbanization	Environmental planning must be incorporated into development thinking	Good governance, democracy and human rights, holistic development, 'polluter pays'	Conservation and equitable usage of resources	Local Government: There is a need for a lead agent or department to facilitate integrated environmental management	Act gives no direct access
SA. Dept Treasury (nd). GMAP- Government Accepted Accounting Practice	All services			GMAP provides a more universally accepted and uniform practice of accounting	GMAP will ensure lower costs for implementation and delivery of services	Local government	GMAP will create a platform for better collaboration in lieu of donor funding
SA. Gov. Gazette. (2000). Local Government Municipal Systems Act 32/2000	All services		Encourages community participation		Identifies rights, powers and duties of government and community role players		
SA. DWAF. White papers on sanitation, water services and waste management (1994)	Water, sanitation and waste	Immediate effect	Targets the needy and historically disadvantaged	Affordability		National, provincial and local government	Various government programs

The aim of this dissertation is to derive rates for O&M costing. It forms part of a broader decision making tool for the determination of a suite of municipal engineering services within an urban environment. (Del Mistro. 2004).

Table 1 presents the desired mode and ethos of services delivery for our country. This alludes to a certain practice of delivery, which inevitably affects the standard and levels of services involved. For example, such terms as 'speed-up or fast-track development', 'apply extraordinary innovative measures of delivery', 'integrated service and technology choices', 'make use of existing services', 'services agreements', 'participatory development', 'multi-year development plans', 'affordability', 'wide ranges of options' etc all have a direct or indirect bearing on the pace at which services are delivered and the ultimate quality and sustainability of those services.

This in turn has a direct bearing on the need for a proper O&M culture to be put in place.

2.1.2 Policy Frameworks and service provision

In an effort to guide and speed up the process of service delivery, the government has implemented various policy frameworks to close the gap between the 'haves' and the 'have-nots'. These include (South Africa. Guide to National Subsidies. 2000)-

1. The Reconstruction and Devolvement Program (RDP 1994)
2. The National Housing Subsidy Scheme (1994)
3. The Consolidated Municipal Infrastructure Program (CMIP replaced the RDP in 1998)
4. The Municipal Infrastructure Grant (MIG replaced the CMIP in 2004)

The MIG consolidates seven previous municipal infrastructure grants and will be fully functional as from the beginning of the 2006/2007 local government financial year. The grant allocations are R4.4 billion, R 5.2 billion and R 6.0 billion in 2004/05 to 2006/07 respectively. (South Africa. National Treasury. 2004).

Each of these programs has contributed to the delivery of numerous new and upgraded infrastructure projects in South Africa, including in the Western Cape.

2.1.3 The need for an O&M Focus

Figure 1 shows that the emphasis has largely been on the capital investment in new or upgraded services without due consideration of the maintenance and sustainability needs of such services in the medium and long term (see Figure 1). The result is that much of the maintenance activities surrounding such infrastructure (some of which are over 10 years old) are merely reactionary, with very little forward planning in terms of preventative maintenance.

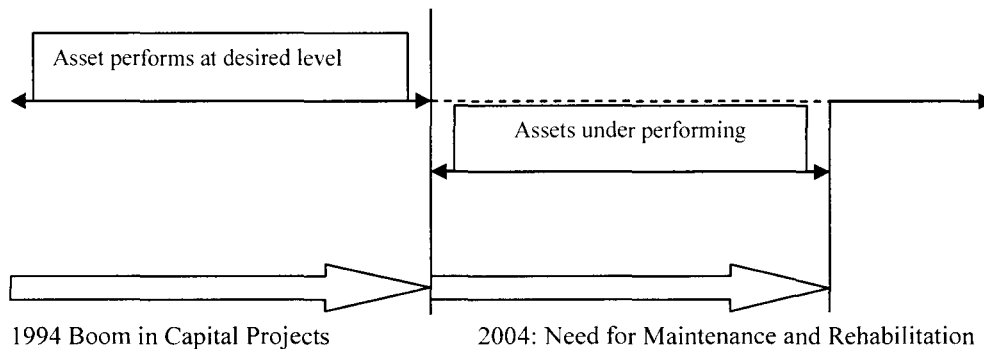


Figure 1: A shift in service delivery emphasis

A fundamental start to what would be a more sustainable approach to service delivery would be to consider ‘asset life-cycle costs’ of municipal engineering services, of which a proper Operation and Maintenance cost practice would form a vital subset (Jooste and Page. 2004). This concept once again underscores the need for ‘preventative or predictive maintenance’ instead of ‘reactive maintenance’.

Today, given the context of changing policy, government is seeking to strike a balance between the level of service delivered and the sustainability of such services. The result is that, in the urban context, much deliberation has been evoked so as to steer away from a ‘one-size-fits-all approach’, toward an approach, which recognizes that community participation involves informed decision-making about the municipal services options available as well as about the total costs of options on a comparative basis. In fact, MIG moneys will only be transferred to municipalities once they demonstrate that their budgets make sufficient provision for Maintenance and Operation costs, besides addressing basic service backlogs (National Treasury RSA.2004).

In support of this, a perusal of the total S.A. National Treasury Operating Expenditure Report for 2004/5, indicates a definite thrust in O&M expenditure-

- The percentage split for O&M is 83.2 % as apposed to 16.8% for the national Capital Budget
- The Western Cape has the second highest provincial O&M budget, a total of R15.2 billion, i.e. 18% of the R 84 billion nation wide O&M budget.
- Salaries (staff costs) still enjoy the major share of the budget (30%), followed by electrical purchases (such as pump station costs) (16%), and actual O&M activity costs (7%).

Mayor Nomaindia Mfeketo described the O&M budget as ‘massive’ and setting the city into a path of sustainability, prosperity and long term success. It also shifts the long-term trends of underinvestment in O&M. (SA Cities. Western Cape, 2004)

The three year budget plan trends for Cape Town indicate a 6-7% incremental growth in O&M expenditure per annum. (Cape Gateway, 2004)

This splurge in O&M expenditure calls for sound governance around decision making of O&M spending to ensure proactive interventions and long-term sustainability.

2.2. Level and Standard of Service and the need for maintenance planning

The prevailing emphasis on service delivery has resulted in, for instance, numerous low-cost housing units and related services being delivered in the Western Cape. The sustainability of this infrastructure is a question hotly considered amongst interested and participating groups and individuals.

2.2.1 Level of Service (LOS) and Standard of Service (SOS)

There is a difference between the Level of Service delivered and the Standard of Service achieved during the life time of a municipal asset.

LOS refers to the quantity of the service (example the number of taps provided in a community), whilst SOS refers to the quality of the service (i.e. a measure of how often the taps malfunction or the reticulation mains burst). (Gildenhuys. BC, 2002). SOS is also directly related to the time the service (or perceived service) meets its expected performance. This milestone may even be preceded by some rehabilitation of the service.

It can thus be concluded that in the above scenario (number of taps provided); the capital costs may vary enormously, whilst the maintenance costs would be a function of the reliability of the service and service components in providing the desired standard of performance at the given consumption on a sustained basis.

Depending on the level of maintenance and operational practice performed, an asset or service may have various permutations of the SOS/LOS relationship. For instance, infrastructure which has a high SOS (well maintained), may not necessarily have a high LOS (e.g. not enough taps at the time). The converse is also true, i.e. a low SOS, may have had an acceptable level of service at a given point in time, although the sustainability of that service may be in question. The ideal would be to aim for acceptable or optimum levels of SOS and LOS, which have been well-planned and forms part of a well structured maintenance plan.

Figure 2 is an example of a low SOS/ low LOS system implemented as an emergency service in an informal urban residential area. Here, the ratio of standpipes to number of households and the management of the stand tap cum drainage system are below standard.



Fig 2: Low Quality (SOS)-Low Standard (LOS):
A standpipe with undesirable greywater conditions

There will be a range in the total asset costs for the particular level and standard of service.

In the example of the standpipe (i.e. low SOS and low LOS) in Figure 2 above, the capital cost for similar installations will vary marginally, whilst the maintenance costs could range from negligible (assuming low standard – i.e. service provider chooses not to engage in routine maintenance activities) to substantial (if high standard – i.e. provider chooses to do routine maintenance). In the former scenario, the asset value will begin to reach criticality sooner and contingency steps such as asset replacement may need to be considered.

The arguments around SOS and LOS should be kept in mind when determining O&M costs for a suite of services. For instance, gravel roads with open channel storm water side drains may sound like a cost effective LOS, but may not achieve its desired SOS should there be an insufficient O&M budget to meet the challenge of routine work on driveway crossings and side drain cleansing.

2.2.2 The need for a proven Maintenance Method

In his book 'Reliability Centered Maintenance' (RCM), John Moubray (1997), highlights the following outcomes of an RCM analysis (paraphrased) -

- Learning about functions (e.g. to supply 60 litres of water per day per person, i.e. 'SOS Maintenance')
- A better understanding of how the asset can fail and the root causes of each failure (e.g. taps not functioning due to spindles dislodging resulting in a shortfall in supply points, i.e. 'LOS Maintenance')
- A list of proposed tasks designed to ensure that the asset continues to operate at its desired level of performance (e.g. check spindles visually for loose or missing parts, i.e. 'Routine Maintenance')

(The examples are not taken from his book but have been chosen to fit into the context of this thesis.)

The proposed tasks are then packaged in one of three ways, i.e. either as maintenance schedules to be done by the maintenance department, as revised operating procedures for the operators of the asset, or as an item where design changes are needed to deal with situations where maintenance cannot help the asset to achieve its desired performance under its operating conditions. (John Moubray.1997)

Routine maintenance activities play a vital role in ensuring that the originally intended purpose of the service is sustained. To rephrase, the standard of a service at a given level (e.g. gravel or surfaced road), can only be sustained if proper maintenance planning is ensured. The following figure illustrates the importance of routine maintenance in the design life of a municipal service such as a road (SANRAL.2003)-

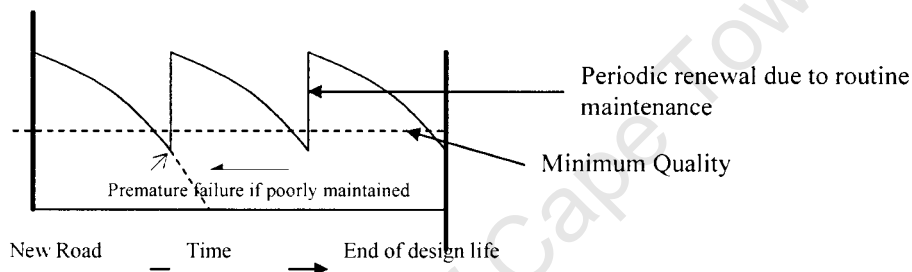


Figure 3: Diagrammatic Presentation of Routine Maintenance (periodic renewal) on a Road

(The figure highlights the effects of a poor maintenance regime on the design age of an asset.)

It can be seen from Figure 3, that should there be an absence of adequate routine maintenance; the road would reach premature failure way before the end of its intended design life.

In conclusion, a proper maintenance planning regime such as the RCM Model proposed by Moubray, would do much in securing sound O&M costing in our cities. A look at the current methods used in O&M cost budgeting amongst municipalities in the Western Cape will form part of this dissertation (Section 2.3.2).

2.2.3 Components of Infrastructure Services (Package of components)

The term infrastructure refers to an integration of municipal engineering services, which together seek to meet the real and perceived needs around the urbanization of a city or urban township. For this dissertation, the desired infrastructure components or services (with levels of service) for consideration are-

- Roads (Graded, Gravel and Surfaced)
- Storm water (Reticulation as per road type)

- Sanitation (Chemical, Ventilated Improved Latrines, Septic Tanks, Waterborne reticulation and Treatment facilities)
- Solid waste (Practices for Collection, Transportation, Transfer and Landfill), and
- Water services (communal standpipes, yard taps and house connections)

A 'package' of municipal engineering services refers to the suite (integrated components) of engineering services for a particular town or area. Such a package of services would typically form part of the National Housing Delivery program. An example is displayed in Figure 4 below. It shows the spread of service levels (LOS) for each of the municipal services (1 to 4).

The Figure also highlights (shaded dots) the selected package of services for Vukuzehele, an urban settlement in Cape Town. The selected package or suite of services is-

- Surfaced Roads with acceptable layer work preparation (i.e. base coarse, sub-base and insitu subgrade preparation)
- Buried storm water reticulation with manholes, kerbs, channels and junctions
- A bulk storm water outfall works
- Water reticulation pressure mains with household connections
- Bulk water supply and treatment
- Waterborne sanitation reticulation
- Sanitation treatment works
- A high level of solid waste management (house collections transported to skips, transfer stations and landfill sites)



(* This structure is typically found for projects falling under the state housing delivery programme of the Western Cape).

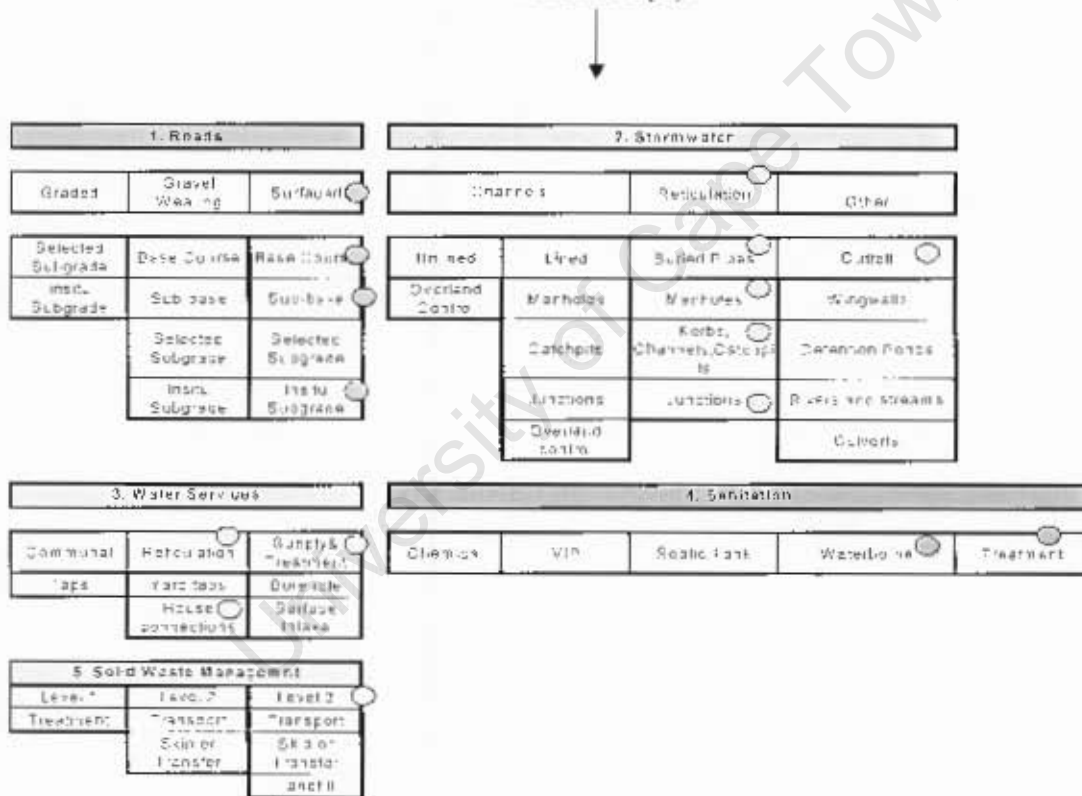


Figure 4*: Package of Municipal Engineering Services: Vukuzhela, Cape Town (see shaded dots)

This selected suite in Figure 4 would be classified as a high LOS assuming that supply levels match the perceived and desired performance of the infrastructure.

Various packages of municipal services could be compared in terms of their overall O&M costs. These would then form a basis for decision making around infrastructure selection in a settlement over and above the related Capital Cost.

2.3 O&M cost rates for budgeting Municipal Engineering Services

By definition, Operation and Maintenance (O&M) costs are *'All other costs (other than Capital Expenditure), needed to provide services such as maintenance of roads, ensuring water is available when needed, controlling health and traffic. In order to do this salaries must be paid, fuel must be obtained for transport, and materials must be purchased, amongst other types of expenditure.'* (DBSA.1997a)

Financial Management is ranked as the highest desired competency amongst municipal officials (Ballard. 1999). Furthermore, the top desired financial skill is accredited to 'knowledge to compile monthly and annual budgets'.

The compilation of an O&M budget is a task, which is performed annually by Local Authorities and it is a requirement of national legislation. (SA National Treasury.1996).

Intuitive or educated guessing based on budget trends and past performances forms a vital part of budget determination. To aid this process, it is useful to have a database of rates for municipal services O&M costing when compiling budget estimates. (Rossouw, 2005).

2.3.1 A definition of O&M cost rates

A municipal service rate is defined as the cost of one unit of service- e.g. the cost in Rand for 1 km of gravel road. There are many methods of calculating unit costs. The selected approach is to derive it from the unit of service selected- i.e. to derive it from the total cost to maintain the entire length of gravel road in a given municipality, or the total cost to treat the total volume of water supplied to that municipality. (Bean and Hussey. 1997).

The unit of service selected depends on the type of service, the reason for costing and the ease of calculation. Most public sector activities are service orientated.

Beside assisting with cost comparisons between various levels and standards of services , the determination of unit cost rates would also assist in developing a basis for establishing prices for the privatization of municipal services, to set targets for productivity within budget constraints (example lengths of road or pipeline), and to identify the potential for cost reduction at the community decision-making level.

Table 2 shows the costing units associated with the different services selected for this study.

Table 2: MO Costing rates for Municipal Engineering Services

Municipal Engineering Service Aspect	Costing unit or rate
Length of road	Rand per kilometre per annum
Length of storm water pipe	Rand per kilometre per annum
Storm water appurtenances	Rand per 'effective kilometre' per annum
Number of chemical toilets	Rand per toilet per annum
Number of Ventilated Improved Pit latrines	Rand per latrine per annum
Number of septic tanks	Rand per tank per annum
Length of sewer reticulation	Rand per kilometre per annum
Sewage treatment	Rand per Megalitre of sewage treated per annum
Solid waste collection	Rand per ton of solid waste collected per annum
Solid waste transportation	Rand per ton of solid waste transported per annum
Solid waste disposal to landfill sites	Rand per ton of solid waste disposal
Length of water reticulation (stand taps, yard taps or house connections)	Rand per km per annum
Water Treatment	Rand per Megalitre of water treated per annum

2.3.2 The Determination of cost rates

These rates can be determined from municipal cost data contained in annual budgets, from studies dealing directly with the subject matter and from physical data for each service as derived from municipal databases.

Key expenditure items in municipal budgets include the following (Bean and Hussey, 1997) –

- Salaries and other employment costs
- Transport
- Accommodation
- Supplies and services
- Support service costs
- Finance costs
- Other expenditure

This indicates that the maintenance and operation cost incurred on the actual activity (example 'resurfacing of roads') is made up of a collection of cost-incurring items including salaries, transport and rental costs to support services and loan repayment costs (Bean and Hussey, 1997).

Municipalities use different methods for forecasting Maintenance and Operation cost expenditure. These include (DBSA, 1997a) -

- a) Intuition or Educated guessing
- b) Traditional Cost Accounting (TCA)

- c) Objective Based Forecasting
- d) Activity Based Costing (ABC)

In all cases the budget is broken down into various cost centres or line items. This process facilitates control, as variations are easily identifiable. It enables annual incremental budgeting; a simple method of adding annual increases onto existing budget figures. (SA GAMAP, 2000)

Educated guessing is perhaps the single-most used method of budgeting used in Municipalities in the Western Cape. It involves working out what income the municipality will get and balances this with the planned expenditure by preparing detailed plans and forecasts.

Traditional cost accounting (TCA) is based on overhead and direct cost determinations, but does not give an accurate determination of the actual costs of a service as does Activity Based Costing (ABC) (Pittsburg University nd).

The tendency in government today is toward a performance-type or objective-based budgeting approach. This implies setting clear and measurable goals by establishing key performance indicators. (DBSA,1997a)

ABC plays an increasingly significant role since it relies on actual activities, which consume resources and which in turn drive costs. (Glad. E, 1994). This concept is largely being used in Water Utility companies such as Rand Water and Umgeni Water. The concept of utilities is further discussed under Section 2.6.

The need for proper planning, programming and comprehensive reviewing, which require lots of work and consultation, is also being highlighted more than ever.

Literature indicates that a host of activities are associated with the maintenance and operation of municipal services. The Tables in section 2.6 begin to unpack these activities for each of the levels of services as indicated.

To determine the cost rates, the physical data for each service activity (for instance the lengths of road and water consumption levels as required from Table 2), would best be retrieved directly from municipal officials.

These costs could also be derived from similar studies done elsewhere in the country or abroad in order to serve as an external data source for comparison with the data received from municipalities.

2.3.3 Data from various literature sources

Results from the following literature studies are collated in Table 3 for various levels of municipal engineering services-

- DBSA: Municipal Services Options: (1997), describes 6 different services at various levels of service. Some typical cost figures are given in the document taken from a number of projects in a number of municipalities. It is noted that there is a large variation amongst municipalities and even within municipal boundaries. The figures therefore only give a rough indication.
- Cotton and Franceys (1991): Services for Shelter: The document gives O&M cost components for a range of municipal services at LOS and unpacks the activities normally associated with the maintenance of each service.
- Guidelines for the Provision of Engineering Services and Amenities (SA): 'Red Book'. (1995)
- Proposal for Monitoring the condition of Municipal Assets in the Western Cape (Africon; 2005)
- Various Reports by the Water Research Commission (WRC) : 1998-2005
- Default rates from various Electronic Costing Models (refer Section 2.7: Table 7)- denoted with asterisks in the Table 3.

The following issues are highlighted regarding the format and content of the data-

- The units are usually shown as 'per erf' whereas there are no erf sizes or orders of magnitude given
- The literature gives no data for storm water facilities
- The roads data (except for the Default rates from various Electronic Costing Models) are mere guideline values, which are given as a percentage of the Capital Costs.

Table 3: Inventory of O&M Costs (excluding overhead costs) at various Levels of Services from Various literature sources

No	ME SERVICE	LOS	DESCRIPTION	MUN. MAINT BUDGET [R/pa]	OPERATIONAL COST [R/Pa]	BULK SERVICE OPERAT S and MAINT [R/Pa]	TARRIF [R/Pa]	TOTAL O&M COST [R/Pa]	SOURCE & COMMENT (S)
1	Sanitation	1	VIP	92	3	1.45	0.45	98.00 (lower 60)*	Assessment of the various options available for sanitation services to the Central Witwatersrand RSC Area : Draft Final June 1994. The comparative Cost Table was from van Niekerk et al, 1988: 15% interest used. DBSA 1997b
		2	Aqua-privy with soak-away	192	3.8	1.50	9.90	207.00-(lower 120)*	
		3	Septic Tank	267	3.8	1.50	124.00	396.00 (lower 256) (upper 900)*	
		4	Solids Free	562	3.80	43.20	124.00	733.00 (lower 600)*	
		5	Waterborne (includes Treatment costs)	589	8.00	58.40	124.00	779.00 (lower 518-624)*	
2	Earthworks, greening, fire breaks and wind breaks	1	Projects with basic Infrastructure only	These services are merely listed for interest since they are primarily applicable to low-cost urban and peri-urban projects. There was no cost data available in the literature covered.				Services for Shelter: Infrastructure for Urban Low-income Housing: Andrew Cotton and Richard Franceys: Liverpool Univ Press: Liverpool Planning 111 1991 For LOS 1-2, the long-term viability of the land is influenced by exposure to flooding, high water tables or erosion by wind and water (see also OM of access routes and storm water system below) For LOS 3-6, the cost recovery of earthworks operations may be seen as part of the cost of acquiring land and providing suitable platform for Infrastructure development.	
		2	Projects with emergency services only						
		3	Roll-over Projects						
		4	In-situ Projects						
		5	Managed Land Settlements						
		6	Greenfield Projects						

3	Storm water	1	Over land open flow furrows with cut-off drains, earth side drains, open dish drains and berms	<u>Maintenance and Operational Costs</u> No cost data available in the literature covered	Services for Shelter: Infrastructure for Urban Low-income Housing: Andrew Cotton and Richard Franceys: Liverpool Univ Press: Liverpool Planning 111 1991 and Informal Settlements Hand Book (PAWC):
		2	Overland flow, free drainage, flow diversion and emergency protection works	R54/hh/pa*	*Table 10 sectn 2.7.2 : Literature review
		3	Shallow, open channels along unsurfaced roads with designated outflows, bulk services and culverts as required	R 44-80 / hh/pa*	*Table 10 sectn 2.7.2 : Literature review
		4	Conventional storm water design: piped system with road carriage acting as overland channel for 1 in 2 yr flood	R 56/ hh/ pa*	*Table 10 sectn 2.7.2 : Literature review
4	Roads	1	Rudimentary gravel roads, access strips for service vehicles	6% of Construction Cost	Africon 2005
		2	Basic grid of access roads for service vehicles	6% of Construction Cost	Africon 2005
		3	Graded roads, surfaced 4-6m carriageway, 6-7m reserves	R 4.84/erf/m* 6% of Construction Cost	Africon 2005 nad *Table 10 sectn 2.7.2 : Literature review
		4	Gravel roads subsequently upgraded	R3.58-R 7.35/erf/m* 4% of Construction Costs	Africon 2005 and *Table 10 sectn 2.7.2 : Literature review
		5	Surfaced or gravel roads with proper road reserve and layer works preparation	R3.30-R 4.82/erf/m* 4% of Construction Costs	Africon 2005 and *Table 10 sectn 2.7.2 : Literature review
		6	Surfaced roads with proper road reserve and layer works preparation	1.5% of Construction Costs	Africon 2005

5	Water	1	Rudimentary network, vendors or tankers. 300 pp/stand tap @ 200 m max. radii; hydrants on formal roads at entrance to settlement	R 120 /erf pa (lower *R 116.76 /hh/pa) 36 – 60 c/kl/erf pa consumption	Cotton et al 1991 and DBSA 1997
		2	Rudimentary or no network; tanker, hand pump, springs or wells supply; no fire hydrants	Not for urban areas	NA
		3	Yard taps	R 264 /erf pa (higher*R 288/hh/a) 8-15 k/erf/m	Cotton et al 1991 and DBSA 1997
		4	Full network, metred erf connections, fire hydrants at low risk group, pressure reduction to reduce leaks, pipe sized for low input pressure, pipe standard for maximum pressure	R 360/erf/pa (higher*R 460/hh/pa) 3% of Capital Cost	Cotton et al 1991 and DBSA 1997
		5	Bulk water provision and treatment	R 1975/ Ml/ pa ((higher*R 2470/hh/pa)	Rand Water Board, 1992 escalated
6	Solid Waste	1	Community based collection with skip or container or small drums for LA central collection point	Less than R 12/ erf/ pa (higher*R 84/hh/m)	Cotton et al 1991 and DBSA 1997
		2	Municipal based kerb-side collection with skip or container or small drums for LA central collection point	R 180/erf/pa (higher* R 218/hh/m)	Cotton et al 1991; and DBSA 1997 and *Table 10 sectn 2.7.2 : Literature review
7	Housing	1	Formal	These services fall outside the scope of this study and are listed merely for completion.	NA
		2	Rental Stock		
		3	Informal		
		4	Formal town house		
8	Community Services	1	Schools		
		2	Clinics		
		3	Cresches		
		4	Community Halls		
9	Open Space	1	Sports field		
		2	Agricultural		
		3	Public		

2.4 Asset Management Practice

Billions of Rands are spent annually in managing and maintaining infrastructure. The combined 2004/05 Capital and Operational budget for municipalities in South Africa amounted to R 101 billion, of which R 84 billion was allocated to the operating functions associated with municipal engineering services; i.e. over 80 percent. (SA National Treasury, 1996).

This, coupled with the challenge of effective decision-making around expenditure, creates the need amongst municipalities to invest into a Life Cycle Approach toward infrastructure management and costing.

2.4.1 A definition of Municipal Infrastructure Asset and Performance Management

Both these concepts may be considered as cornerstones in achieving sustainability in O&M practice.

Asset management is the method that a municipality uses to track its fixed assets such as furniture, computers, even buildings and all other state owned infrastructure such as roads and pipelines under its jurisdiction.

Although the exact details of the task varies widely from one municipality to another, asset management often includes tracking the physical location of assets, managing demand for scarce resources, and accounting tasks such as amortization (i.e. debt recovery) (Answers.ComTM nd)

For instance, the Asset Management of the City of Cape Town's Water Department consists of a dedicated Asset Care Centre, which is solely focused on tracking functions related to water and sanitation treatment services (Snyder, 2005).

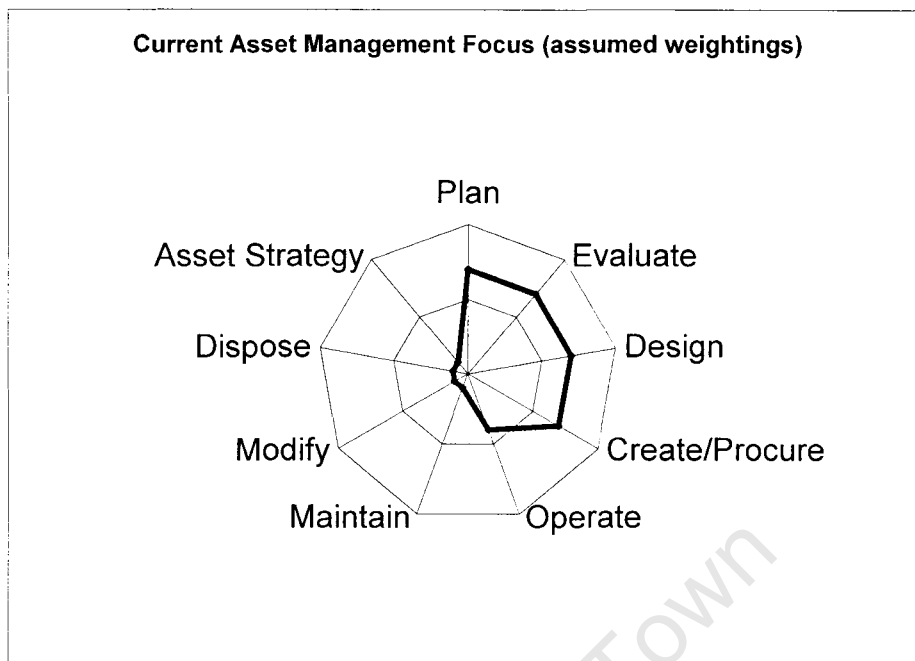
Figure 5 indicates that each service or asset has nine lifecycle elements, which are usually associated with Asset Life Cycle Practice (after Jooste and Page. 2004).

Although there are strides being made in Water and Sanitation treatment management, this cannot be said of most other services in our city or province. As shown in Figure 5, there is a general, province-wide imbalance among the nine lifecycle elements.

At least 40% of these elements – most of which relate directly to O&M practice, are given insufficient attention to as pertaining current asset management practice in our cities in the Western Cape.

The life cycle elements can be further categorized under the following headings-

- Infrastructure creation (strategise, plan, design, create and procure)
- Operation and Maintenance (O&M)
- Refurbishment (modify and maintain)
- Renewal and Replacement (dispose, procure and maintain)



**Figure 5: Current Typical Asset Life Cycle Practice
(Modified after Jooste and Page 2004)**

(The Diagram highlights the problem of current asset management practice, i.e. an emphasis on the Capital implementation as opposed to interventions, which will ensure sustainable practice)

Performance Management

Performance Management is linked to Performance Measurement. The latter is the process of assessing progress toward achieving predetermined goals, while Performance Management is building on that process by adding the relevant communication and action on to the progress achieved against these predetermined goals. (Bourne et al, 2003).

The challenge of immovable asset management to S.A. government is to match its service delivery objectives (predetermined goals) with an efficient and effective immovable assets management practice that incorporates sound performance management (SA. Public Works, 2005).

Decisions on immovable assets have long-term implications and must be based on reliable management information to ensure optimal utilisation of resources.

These decisions must be based on the full impact of costs over the lifespan of an asset and must consider that-

- Immovable assets have lengthy acquisition periods, are costly to create and complex to manage and maintain;
- Timeous maintenance of immovable assets will prevent diminishing lifespan and premature deterioration of asset values; and
- A balance should be established between reactive maintenance, preventative maintenance and renovations.

Government has identified the following requirements (amongst others) for both national and provincial spheres of government to improve on the management and performance of immovable assets (SA. Public Works, 2005):

- *“Benchmarking use ratios,*
- *Benchmarking operating costs ratios, and*
- *Benchmarking return on investment with the aim to measure the effectiveness and efficiency of immovable assets”*

Furthermore, the IDP framework calls municipalities to provide operational strategies that ‘align their resources for the realisation of their development objectives’ and must include a compulsory medium term financial plan that sets out the following -

- *“Capital and O&M practice impacts as it compares with Revenue Raising Strategy*
- *Provision for longer-term maintenance and management of assets (new and existing) in a manner that conforms to the Municipal Systems Act”*

Thus, Asset Management should focus on reliable and operational services at optimum life-cycle costs. Financial measures relating asset performance to financial statements are not widely used in either asset or maintenance management, resulting in an unbalanced view of asset performance. A ‘balanced score card approach’, which links strategic goals and operational outcomes, is needed. Better integration between asset management and organizational functions and hierarchies is needed before assets can be effectively managed. Pragma (SA) has developed a ‘Performance Management Model’ to address the need for decision-making and problem solving at different managerial levels. (Jooste and Page , 2004).

Finally, the following issues need to be considered for incorporation to ensure adequate asset management-

a) Lessons from Private sector

A lot can be learnt from parastatals and private sector infrastructure owners in SA; e.g. keeping adequate asset registers, doing life cycle projections of alternative equipment or processes and then using these to aid in decision making between alternative proposals, and linking staff bonuses to performance measure. (Poggiolini, 2004)

b) Asset Care Centres (ACC)

The use of ‘Asset Care Centres’ (ACC) by staff familiar with Asset Management Implementation Programs for developing maintenance task lists and schedules as part of a computerised maintenance management system for recording the maintenance history of assets. The ACC technology can also rank asset classes and assist in identifying the most appropriate maintenance strategy for that asset- ‘A kick start approach toward asset management’. (Snyder, 2005)

c) Asset Condition Monitoring

This takes into account the deterioration of present assets serving a project and establishes a formal process of maintaining the operational standard of that asset. The process looks at Critical Replacement Costs of assets (CRC), O&M costs as a percentage of CRC and KPI's for reflecting the standard of service. (Africon: 2005)

2.4.2 The need for an Infrastructure Management Manual

Australia and New Zealand have developed a document (Ingenuim 2003), which forms their national standard for asset management at local government level. This document has now become an international blueprint for most countries. The principal author of the document is Maunsell. The aim of the Manual is to present international best practice for all types of infrastructure and assets.

The manual includes guidance on all areas of infrastructure management; i.e.-

- How to implement asset management (organisational structure, corporate objectives, preparing and using AM plans, service delivery issues, review and audit procedures)
- Asset Management Techniques (levels of service, demand forecasting and management, condition assessment and performance monitoring, optimised decision making, risk management, maintenance management, valuations and financial forecasting).
- Asset Management Systems and Data Management.

The Institute of Municipal Infrastructure Engineering of South Africa (IMIESA) has published and launched the South African Infrastructure Management Manual (SAIMM) on 21 June 2006. This follows extensive work by Maunsell, government and industry organisations in South Africa to develop an edition that reflects the issues and legislation specific to South Africa.

The need for a South African Infrastructure Management Manual (SAIMM) was clearly reflected in an article by Poggiolini (2004) published in the South African Institute of Municipal Infrastructure Engineering journal, IMIESA.

In this article, Poggiolini (2004) quotes Alwyn Laubsher in his comment on the 'State of Infrastructure in South Africa' : 'A South African Infrastructure Manual will assist municipalities to measure their performances in providing and maintaining services'.

The Provincial Administration of the Western Cape is currently piloting a condition assessment at Stellenbosch Municipality (Boshoff, 2005). The assessment strategy is based on a proposal prepared by Africon Engineering International (Pty) Ltd as a prelude to the 'State of Infrastructure' in our nation- a type of monitoring audit. This information will play a fundamental role in streamlining the proposed South African Infrastructure Manual.

A few local authorities are already at breaking point (Poggiolini, 2004) and are challenged by a disruption of essential services due to a breakdown of expensive vehicles

or equipment, poor cash flow positions and an inability to replace poorly maintained assets.

“Budget constraints contribute to 25% of the elements that hinder infrastructure maintenance in local authorities. Other factors are a lack of skilled and experienced staff, lack of authority by technical staff members to initiate urgent activities, political interference and lack of capacity by senior management to make decisions, the importance of infrastructure is negated while a lack of business understanding and an inability to manage compound the problem”. (Poggiolini, 2004: after Lawless A).

“The gaps that exist between current municipal infrastructure management practices and more acceptable pro-active environments mainly revolve around the issue that legislative requirements such as the Generally Accepted Municipal Accounting Practices (GAMAP) are too broad and vague for effective application”. (Poggiolini, 2004: after Wall K).

Some of the consequences of failing to apply proper maintenance practice in our cities include (Poggiolini, 2004)-

- “Infrastructure deterioration well before the end of its design life
- Infrastructure-specific problems such as a drop in water pressure due to leaking valves, interruptions of water supplies due to uncontrolled breakages, polluted water courses due to malfunctioning sewer pumps, deterioration of road riding quality due to neglected potholes, leading to further wear and tear of vehicles.
- Ultimately, communities will be deprived of services”

Furthermore, Poggiolini, 2004: after Childes, indicates that “A number of municipalities display a lack of operational integration into the IDP”. It is noted however that the South African Infrastructure Management Manual (SAIMM) recently launched by IMIESA, will play a valuable role in attending to the situation.

A number of consultants provide a variety of Infrastructure Manuals and IT systems that are useful for better-resourced municipalities but not as useful for the majority of South African Municipalities. The problems with most IT systems are that they are expensive to maintain, requiring additional capacity within the municipality, they also need to be tailor made to suit usage and customer requirements, and they need a substantial commitment of in-house resources to collect and verify data (Poggiolini, 2004).

Thus, for Infrastructure Management to be adequate, much more than manuals, systems and proper legislation is needed.

Noticeably, the provision in the SAIMM for assisting decision-making in a public participation forum in terms of understanding asset management (and therefore the impacts of for instance O&M costing), a type of grass roots approach, is not specifically found in literature readings. This has been confirmed through discussions, and the real problem of asset management is that it is complex and needs to be communicated effectively to communities to ensure end-user buy-in. (Jooste and Page, 2005)

2.4.3 South African Legislation on Asset Management

At a policy level, the ‘Government Wide Immovable Asset Management Policy’ (SA. Public Works. 2005), expresses the need for Immovable Asset Management:

- Immovable assets have fallen into a state of disrepair due to a practice of improper funding and maintenance
- Government developed a culture of replacement rather than one of maintenance (or preventative maintenance)
- Government immovable assets have been stripped of their true value
- Assets are not maintained at their optimal value

The causes of these can be attributed to a non-uniform governance framework, lack of proper monitoring and evaluation systems, the low priority afforded to immovable asset management by user departments within the context of the many other challenges they face. There is thus a need for government to prioritise immovable asset management as their core business.

It is considered that suitable legislation be implemented within the SAIMM framework that will-

- “Encourage collaboration between decision makers at the budgetary level
- Provide convincing facts to those responsible for budgetary allocations
- Promote buy-in from National Government and other funders of public infrastructure
- Promote skills training
- Prompt the use of alternative delivery models and agents for infrastructure management
- Assist in the determination of norms, standards, levels of service and key performance indicators”. (Poggiolini, 2004)

Legislation (SA. Public Works, 2005) defines ‘Immovable Assets’ as state owned land (and any immovable improvement on that land), which have enduring value and consist of assets of residential, non-residential or infrastructure nature. The application of the definition means that the types of assets listed below, will be construed to be immovable assets under the subject of this report:

- “Land including but not limited to developed, undeveloped, vacant, cultivated, non-useable or inaccessible land.
- Buildings including but not limited to schools, hospitals, community buildings and houses.
- Rights in land including servitudes, “right to use”, leases.
- Infrastructure including but not limited to roads, railway lines, transmission lines, dams and pipelines.
- Machinery, plant and equipment including but not limited to pump stations, machinery and irrigation systems for as far as such machinery, plant and equipment

- are construed to be immovable in terms of the common law applicable to property”.

The ‘Government Wide Immovable Asset Management Policy’ (SA. Public Works. 2005), includes other assets such as prison buildings, police stations, harbours, and airports etc, which do not fall into the context of this research.

2.5 Ring Fencing of Services

There is a growing trend amongst municipalities to cluster or ring fence its core functions such as the supply, operation and maintenance of electricity or water services with the aim of making it more cost effective and efficient.

2.5.1 The role of Ring Fencing and Utilities/Boards

Ring fencing of services such as water provision assists greatly in determining the true O&M costs of the service. One of the reasons for this is that it allows for the service to function as a clearly defined, separate cost centre, meaning that support functions such as finance, information technology and human resources are all housed within the ring-fenced unit. The advantage is that duplication is avoided within the municipal functions and that economy of scale is achieved. (CTM, 2001)

Ring-fenced units, which operate as public sector water service providers to municipalities, are called Utilities or Boards. The Water Services Act 108 of 1997 and its Amendment Bill (2004), enables the Minister of Water Affairs and Forestry to establish a Water Board to provide bulk water to other water services institutions. This includes treated or untreated water supply to water services authorities as well as direct supplies to industry and mines. Water Boards may carry out secondary activities, which can include internal water reticulation and sanitation services if appointed as water service provider by the water service authority. It may also accept industrial effluent and provide wastewater treatment services if contracted to do so by the water service authority.

The Minister of Water Affairs and Forestry can also authorize Water Boards to fulfill certain water resources management and water conservation functions. This may include water loss and water demand management or water quality management functions.

A positive outcome of privatization (in this case having Utilities) is to ensure that its O&M costs are optimized. The national Guidelines for Economic Regulation of Water Services in South Africa (WRC 77229/04 Mar 2004) indicate that accurate O&M costs depend on-

- “The degree to which the utility regulated operations are well-circumscribed from other operations and costs of the organisation (i.e. ring-fenced)
- Good accounting practice which is able to measure the performances of regulated and unregulated activities
- The prevention of a transfer of resources and costs from one component of the municipal system to the other, and
- An accounting framework (such as ABC), which clearly delineates the true costs of the service provided”

At present, there are fifteen Water Boards across South Africa, of which Overberg Water is the only one operating in the Western Cape. Cost data on actual case study performances with respect to O&M cost savings have not been documented as yet. (Department of Water Affairs, 2002)

2.5.2 International Trends (O&M Implications)

The following paraphrased comments refers to two case studies, which were used to assess the effects that ring-fencing may have on the O&M practice and costs of certain services. (University of Pittsburgh, nd [April 2005]).

a) Indianapolis, Indiana

Here, a partnership constituting a group of private firms of superior professional ability, contributed to the successful contract management, maintenance and operations of two advanced wastewater treatment facilities by a private operator. The following lessons are noted-

- The O&M budget was reduced by nearly 50% in one year
- The number of employees was reduced by 40%
- Instead of lowering rates, the city put savings into a sewer sanitary fund used to improve the city's system
- The total saving to the city over 5 years was 78 million dollars

b) Jersey City, New Jersey

Here too, a public-private partnership was established, which incorporated the privatization of all water services- i.e. the source of supply, treatment, distribution, meter reading, billing and collection. Although the transition was difficult and problematic at first, the three year contract led to-

- Focused role by the City in terms of rate setting and policy-making functions
- A 100 million dollar saving over the five year contract in O&M costs
- The use of cost savings in the capital improvement of the system
- The start of a comprehensive preventative and predictive maintenance program

2.5.3 City Trends (Budget Implications)

Closer to home, the City of Cape Town is in the process of ring-fencing its water services unit (CTM, Dec 2001).

The forecasting of costs in the current arrangements of CTM, however, is a challenge given that there is considerable uncertainty related to the data requirements for financial modeling and forecasting in terms of the value of the assets, the true operating costs of the assets and the volume of water sales.

In trying to determine an approach toward financial modelling, the CTM has adopted a two-fold method:

- “A ‘Business as usual’ approach in which current practices are projected into the future
- A ‘key-strategic issues’ approach in which the key strategic issues and choices faced by the unit are identified and explored in terms of their financial implications”

Five cost drivers were identified as part of a strategic financial model for investigating future operating costs for water and wastewater services. Their costs are expressed as c/kl of water sold as well as in percentage terms. The following figures were recorded as part of this analysis-

- Staff costs are forecast as staying constant. They are currently 30% of operating costs, but will decline as a percentage of total costs in future, to say 25% in the medium term
- Maintenance costs are forecast to rise in real terms in future. They currently account for around 10% of operating costs. The expenditure on maintenance at present is not adequate to maintain the assets in good working order.
- Bulk water purchases costs will increase in the future due to initiatives such as the Berg River Dam. Currently they are at 7% of operating costs.
- Electricity costs and chemicals costs make up about 15% of operating costs. Although electrical costs are forecast to remain constant in real terms, the costs of chemicals are expected to increase as a result of a depreciating rand.
- Remaining expenses (these are classed as ‘other expenses’) make up 38% of operating costs currently. These are very high by international standards and are forecast to decrease by 3% pa in real terms and reach 18% by year ten. This forecast is highly speculative.

Although actual expenditures on maintenance activities (item b) is expected to increase, the analysis indicates that a potential reduction in the total O&M expenditure will occur when services are ring-fenced.

The above section introduced the concept of Ring-fencing and to highlight its effects. The notions of a potentially reduced O&M budget and better overall O&M practice are welcomed and should be kept in mind when assessing budget data from the various municipalities.

2.6 Operation and Maintenance cost drivers

This section identifies the activities, which would normally consume resources for the maintenance and operation of the various services mentioned in Section 2.2.3 (Components of Infrastructure Services).

Such a breakdown of activities could form the basis for applying various costing mechanisms (e.g. Activity Based Costing (refer section 2.3.2) for the determination of O&M costs.

The information is displayed in a stand-alone format (Tables 4 to 8 below) and has been categorized for the five different municipal engineering services selected for this study, i.e. roads, storm water, sanitation, solid waste and water services.

The sources of the information are the ‘Guidelines for Provision of Engineering services and amenities’ (CSIR, amended 1995), and ‘Services for Shelter’ by Cotton and Franceys. (1991. Some of the information, particularly that pertaining to roads, has been verified from discussions with municipal officials at the Bellville Road depot (A. Keyser 2005)

2.6.1 Roads

Table 4: Road O&M cost drivers

Activity	Graded Road	Gravel Road	Surfaced Road	Source
Fix potholes	√	√	√	Red Book SA 1995
Winrow, mix, water, place and recompact	√	√	NA	
Fix footways	NA	√	√	
Fix verges	NA	√	√	
Resealing	NA	NA	√	
Resurfacing	NA	NA	√	
Regraveling	NA	√	NA	
Linemarking	NA	NA	√	
Sign fixing and placing	√	√	√	
Reinstate layerworks	√	√	√	
Flood and storm protection	√	√	√	Cotton 1991
Gradient, camber and cross fall maintenance	√	√		
Potholes fixing	√	√	√	
Drains and channel cleaning and shaping		√	√	
Wages for length men assigned to dedicated portions of road	√	√	√	
Maintenance of speed and access control facilities for prevention of dust nuisance	√	√		
Surface dressing and patching		√	√	
Vegetation control	√	√	√	
Grading and regraveling	√	√	√	

2.6.2 Storm water

Table 5: Storm water O&M cost drivers

Activity	Unlined open channels	Lined open channels	Buried conduits	Detention ponds, canals and other	Source	
River cleaning				√	Red Book SA 1995	
Detention pond cleaning				√		
Piped Reticulation cleaning and repair			√	√		
Catchpit cleaning		√	√	√		
Replace manhole cover and frames		√	√	√		
Repair rain and storm damage	√	√	√	√		
Clean gulleys						
Desilt catchpits, channels and pipework	√	√	√	√		
Activity	Unlined open channels-hand dug	Roads as drain with ined open channels	Buried conduits with high standard road surfaces	Source		
Furrow, clear furrows and remove stagnant water	√	√	√	Cotton 1991		
Fix erosion and scour damage	√	√	√			
De-silt. unblock channels	√	√	√			
Reset lines and levels	√	√	√			
Culvert repairs at entries and exits	√	√	√			

2.6.3 Sanitation

Table 6: Sanitation O&M Cost drivers

Activity	Chemical Toilet	VIP	Septic Tank	Waterborne	Treatment	Source
Clean soakaways			√			Red Book SA 1995
Rodding pipes			√	√	√	
Fix pipes			√	√	√	
Unblock manholes			√	√	√	
Desludging	√	√	√			
Vacuum tanker		√	√			
Chemical dosage	√				√	
Fix and relocate superstructure And buildings	√	√			√	
Regular tests and inspection	√	√	√		√	
Staff training	√		√		√	
Special equipment, parts and materials	√	√	√		√	
Fix pumps					√	
Control and channel grey water	√	√	√		√	

Table 6 cont: Sanitation O&M Cost drivers

Activity	Basic on-site treatment facilities Ex VIP's, chemical toilets and Conservancy tanks	Intermediate onsite treatment facilities eg septic tanks with solids free distribution	Waterborne with full activated sludge treatment off-site	Source
General cleaning, removal of blockages	√	√	√	Cotton 1991
Flushing out		√	√	
Repair and replacement of damaged sewers		√	√	
Management of waste water treatment plant			√	
Effecting minor repairs and general cleaning	√	√		
Emptying and desludging of pits and tanks	√	√		
Remove and re-locate and reconstruct superstructures	√	√		
Maintaining general hygiene systems and practice	√	√		

2.6.4 Solid Waste Management

Table 7: Solid waste O&M Cost drivers

Activity	Level 1	Level 2	Level 3	Source
Street sweeping	√	√	√	Red Book SA 1995
Self-carting	√			
On site disposal	√			
Storage depot	√			
Store on site	√			
Incinerate, cover and compact by hand	√			
Spread by hand and compact by plant		√		
Spread and compact by landfill plant			√	
Transport by tractor, trailer fixed bed or skip truck		√		
Collection vehicles at kerbside		√	√	
Monthly removals	√			
Fortnightly removals		√		
Weekly removals			√	
Use of skips	√	√		
Use of transfer stations and landfill	√	√	√	
Black bags and bins		√	√	

2.6.5 Water services

Table 8: Water O&M Cost drivers

Activity	Communal water point	Yard connection	House connection	Supply and treatment	Source
Chlorine dosage, flocculation and mixing				√	Red Book SA 1995
Sedimentation				√	
Filtration or reverse osmosis				√	
Stabilisation				√	
Pipeline fixing and network checks	√	√	√	√	
Valve replacement, or fixing and checking	√	√	√	√	
Watermetering	√	√	√	√	
Canal and reservoir checks				√	
Water tankers and delivery vehicles	√				
Pump checks and fixing				√	

Activity	Terminal consumer points eg stand-taps, water kiosks, water tanks, vendors, yard taps	Branching patterns with dead ends	Branching patterns with loops and hydrants	Source
Fixing broken or leaking taps	√	√	√	Cotton 1991
Fixing and replacing fractured or leaking pipes	√	√	√	
Fixing or replacing broken or faulty hand pumps	√			
Fixing or replacing faulty valves, meters and fittings	√	√	√	
Period attention to replacing of poor quality materials and workmanship	√	√		
Attending vandalized equipment	√			
Reporting problems to local authority	√			

2.6.6 Groupings and summary leading to research work

A count of maintenance activities for each service across levels of service indicate the following-

- For roads, there are generally the same amounts of maintenance activities for gravel and surface roads
- For storm water reticulation, there is a gradual rise in maintenance activities as levels of service increases. River and detention pond cleaning form the major additional activities for bulk storm water activities when compared to reticulation work
- For sanitation, septic tanks and treatment plants share the highest number of maintenance activities, whilst waterborne services carry the least
- For solid waste services, there is a gradual reduction in maintenance activities as levels of service rise
- Water treatment facilities have the highest number of maintenance activities for water services, with the next highest activities falling within the lowest level of services category, which includes communal water facilities, standpipes and water kiosks

Furthermore, the activities in the above tables can be grouped as follows-

- a) Those that occur regularly (at least once per annum) and can therefore be grouped as Routine Maintenance activities. These can be planned for as part of the annual budget with the previous year's activities serving to inform the budget
- b) Those that occur periodically (more than annually) and are grouped as Periodic Maintenance activities. These are planned for on a quarterly basis, and
- c) Those that are unforeseen but inevitably could occur, and are grouped as Ad-hoc Maintenance activities. These seek a solution under ad-hoc budget arrangements as and when they occur.

The dependant variables overshadowing all these groupings are 'the frequency of occurrence' and 'the items of occurrences'. For example –

- a) If leaking valves and clogging pumps are routine activities, then the dependant variables would be 'the total length of pipe, the number of valves, or the hours of clogging', since their individual cost rates differ, and affect the budget accordingly.

- b) Similarly, if desludging septic tanks and resealing roads are periodic activities, then the ‘volume to be desludged or the area to be resealed’ become critical issues, and
- c) If a municipality cannot afford to replace it’s ageing truck fleet, or constantly has problems with labour presence, then the ‘condition of the truck fleet’ or ‘the labour issue’ becomes independent variables.

Another consideration around independent variables is the amount of labour versus machine- driven activities used in maintenance programs. Current service delivery practice encourages the use of labor-intensive methods. A sample survey was performed at the Bellville South Roads Depot (Keyser, 2005) to determine which activities for road O&M costs are machine-driven and which are labor-driven. An hourly rate for each activity was also acquired. These results are indicated in Table 7.

Table 9: Road M&O costs: Machine vs. Labor Driven

M&O Activity	Best suited R/hr	
	Machine	Labour
Ditch cleaning & cutting	280	
Cleaning & Minor repairs to culverts & bridges		100
Building Scour protection		100
Repair structures		100
Grading unpaved streets	250	
Dragging & brushing unpaved surfaces	200	
Filling potholes		75
Filing unpaved surfaces & slopes	190	
Grass cutting	150	
Repair & Replace Traffic Signs		175
Stockpiling Gravel	280	
Regraveling gravel surfaces	300	

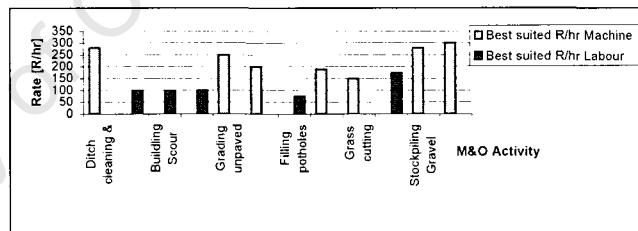


Table 9 indicates that some activities are best suited for labour-intensive operations and the rest for machine work. The hourly rates for the labor-driven activities are generally of a lower order of magnitude compared with the machine-driven ones, but there is no time period (e.g. project duration and number of hours per activity) attached to the rates, and so it would be unfair to say that these activities are necessarily mutually exclusive.

The notion that these activities can be outsourced to community workers or service providers (as job creation activities) is good from a socio-economic viewpoint, but not necessarily from a cost savings perspective. Thus, this research will not pursue this factor in the M&O rates determinations.

2.7 Models used for the determination of O&M Costs for Municipal Engineering Services

The need for an empirical method, mathematical equation or model for determining the O&M costs of municipal engineering services cannot be over-emphasised. As indicated in the sections on asset management and activity based costing, the answer for such a complex problem seems to lie in 'reliability' or 'predictive' maintenance solutions and not in current methods which ride on political will and mere intuition.

2.7.1 Electronic Models

There are a few electronic models developed by consultants, which are customer-specific and which require careful data capturing and capacity at the municipal level. (Palmer Development Group: 2005)-

- a) B.C. Gildenhuis and Associates (2002) for instance developed an Excel Spreadsheet Model to assist municipalities in drawing up sustainable Capital and Operational budgets in accordance with the requirements of the Municipal Systems Act (Act 32 of 2000) and the policies as contained in the Municipal Infrastructure Framework.

The logic (flow diagram) of the model identifies the following inter-related aspects as those, which influence the operational budget-

- Household and prevailing current socio-economic profiles
- Changes in demand, economic change and over all affordability levels
- The level of service provided (Bulk and reticulation costs)
- Inputs into the Capital Budget, and
- Payment levels of household service rates

This model gives default 'service delivery values' for six different municipal services at various levels of service. These values are captured in Table 10 and are also reflected as averages in the combined Table 3 (Section 2.3.3), which shows all the cost data found in various literature sources.

- b) The Free Basic Water Model by the Palmer Development Group (2001) provides some indication of the percentage split between bulk and reticulation system O&M costs for a given municipality. The split given is 1:2.5, i.e. reticulation systems are 2.5 times more costly to maintain than their associated bulk supply components. This is for a water supply system where the unit costs are in the order of R 1.70/kl for bulk water unit and R 5.95/kl for total supply.
- c) The DBSA Combined services Model (2002) lists 6 different municipal services provided at 3 to 6 different levels of service each. A package of services is selected

- d) and the model calculates costs per site for the selected package. The rates used in the model are shown in Table 10 and are also reflected as averages in the combined Table 3 (Section 2.3.3), which shows all data found in various literature sources.
- e) The District Services Model (Access Africa, 2000) uses the rates shown in Table 10, and are averaged in the combined Table 3 (Section 2.3.3), which shows all data found in various literature sources.

2.7.2 Model Default Rates

The default rates used in the models are shown in Table 8.

Table 10: Model Default Rates

Service	Model			
	BC Gildehuys Model (1997 Base yr)	Cost sheets sent to DWAF by PDG (2000)	The DBSA Combined services Model (ver. 5.2) Thompson (Marginal costs) 2000)	The District Services Model (Ver. 1.1 PDG 2000) and Free Basic*
Graded Roads	5.00 R/hh/month	na	4.67 R/hh/month	2.10 R/ month
Gravel Roads	4.70 R/hh/m	na	10.00 R/hh/m	3.60 R/m
Surfaced Roads	3.63 R/hh/m	na	6.00 R/hh/m	13.50 R/m
Storm water unlined retic	4.50 R/hh/m	na	4.33 R/hh/m	(Includes Storm Water reticulation)
Storm water lined retic	3.70 R/hh/m	na	6.67 R/hh/m	
Storm water buried retic	4.75 R/hh/m	na	4.50 R/hh/m	
Storm water Appurtances	na	na	na	na
Sanitation Bucket	na	43 R/hh/month	na	na
Sanitation VIP	2 R/hh/m	6 R/hh/m	5.00 R/hh/m	5 R/hh/month
Sanitation Septic Tank	na	9 R/hh/m	8.00 R/hh/m	10- 20 R/hh/m
Sanitation Aqua Privy	na	na	na	10- 22 R/hh/m
Sanitation hallow Sewres	na	15 R/hh/m	na	na
Sanitation Waterborne Ret	na	35 R/hh/m	14.00 R/hh/m	30 – 40 R/hh/m
Sanitation Treatment	na	1.19 R / kl	1.29 R/kl	na
Solid Waste Transport	na	na	na	na
Solid Waste Comm coll	7.00 R/hh/m	na	8.00 R/hh/m	6 R/hh/m
Solid Waste Kerbside Coll	16.50 R/hh/m	na	15.00 R/hh/m	15 R/hh/m
Solid Waste Transfer	na	na	na	na
Water standpipes	12.00 R/hh/m	9.40 R/hh/m	5.50 R/hh/m	12 R/hh/m*
Water yard taps	26.00 R/hh/m	21.30 R/hh/m	12.50 R/hh/m	24 R/hh/m*
Water Reticulation	44.75 R/hh/m	35 R /hh/m	13.50 R/hh/m	60 R/hh/m 5.84 R/hh/m*
Water Treatment	25.00 R/hh/m	1.50 – 2.00 R/kl	3.15 R/kl	1.83-3.16 R/kl*

* The Free Basic water rates are shown for comparison only since these apply largely to low-income and rural areas (Holtzhausen L. 2005)

2.7.3 Model Structure

The above models together cover a wide spectrum of application. These range from service-specific costing to broader service-package costing. The costing parameters used in these models include-

- The influence of settlement type

These range from urban to rural and are considered at various settlement densities. The influence of adverse settlement circumstances is also considered.

The District Services Model records five settlement types: Urban, Dense, Village, Scattered and Farmland

- The influence of socio-economic factors

This is illustrated in the logic flow diagram of the BC Gildenhuys Model (2002):

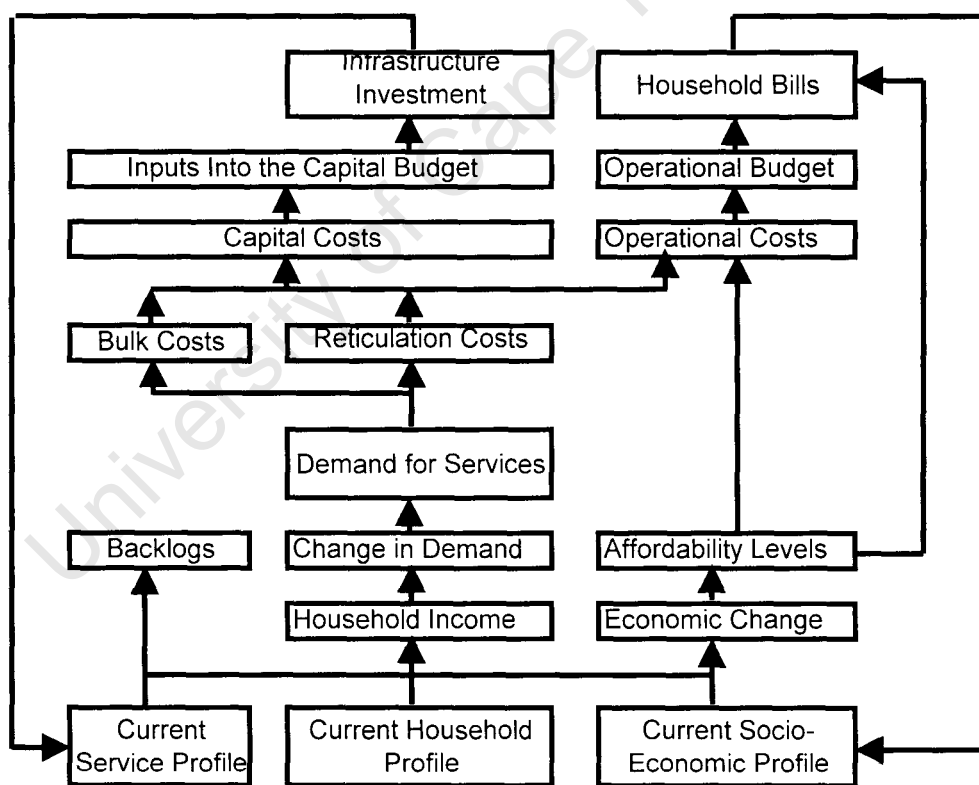


Figure 6: The BC Gildenhuys Model (April 2002)

- The influence of Capital Costs for bulk and reticulation services
- Community affordability levels (influenced by household profiles, socio-economic factors and economic change)
- Demographic data around population and erven

It is noted that all of these models are complicated Excel Spreadsheets derived with the client objectives in mind.

A perusal of these models has highlighted the following issues, which will form part of the research process in this dissertation-

- The need to validate the data by an external referencing system such as the default data found in the electronic models
- The need to consider parameters such as area influence (settlement type), socio-economic effects (e.g. budget deficits), and demographic data such as population sizes
- The need to explore a broader, simplified approach toward cost determination (such as averaging data from municipal budgets) as apposed to a sophisticated electronic costing model, which are often customized for specific cases. Such a simplified approach will be exposed to normal statistical methods of analyses so as to ensure the integrity of the results attained.

2.8 Summary and way forward

Some of work performed and the methods used in O&M practice and costing were discussed.

The gaps perceived from these literature studies were captured in an action-plan format in Table 11, which seeks to formulate an approach toward bridging these gaps by way of desired outcomes or deliverables.

a) Deliverables-

Table 11 shows some of the possible deliverables for a research project of this nature.

Table 11: Research Deliverables highlighted from Literature Review

Literature Review Topic	Highlights	Gaps Perceived	Formulation of research ideas	Desired Outcomes/ Deliverables
Municipal Service Delivery	Increased O&M expenditure; a focus on sustainable delivery	Pro-active practice lacking; estimating of O&M costs. Sustainability	Benchmarking of rates as a basis for privatization and for setting productivity targets; steps needed to formulate O&M practice	A stand alone set of rates which can be used to determine or predict OM costs; a method for predicting O&M costs for given services
Levels of service and standards	Alternative levels of service, quality vs. quantity, high total asset costs, no basis for MO cost determination	Cost comparisons between various levels of service; need for a proven maintenance method	What are the packages of municipal services and how do they compare in cost; categorization of maintenance components into service standards and levels	A comparison of costs for various packages of municipal services; categorize cost components into levels and standards of service
O&M Cost Rates – Determination and Values from Literature Sources	Fundamental to costing, Municipal Decision-making. Data exists	Data are mainly per capita and not representative of Mun budgets	Can a derivation of rates from actual budgets accurately predict O&M costs given the complexity and variation of cost driver activities	Comparison of Municipal - derived rates with that of literature sourced rates
Asset Management	O&M costs are a vital part of the lifecycle elements of the municipal asset	Tools are needed to assist municipalities to do asset assessments and for performance measurement	A formula is needed to model all the O&M cost components	An O&M formula that considers the variation of municipal accounting practices and other local factors
Ring Fencing	This practice leads to accurate estimating and control of O&M costs	Very little data on local ring fencing practices	Establish a database of current practice costs which can be used for substantiating utility practices in future; is the perception that a larger O&M Budget is needed, a correct one?	The study should highlight the need for interventions such as ring fencing
O&M Cost Drivers	Defined activities which consume O&M resources	A need to cost these activities	Is there a relationship between cost and number / frequency of activities?	A list of activities and their frequencies brought together in a model
OM Cost Models	The models are complicated computer programs, which use inherent rates for client-specific objectives	Default values are case-specific and have limited application	Derive a model, set of rates or equation based on simply derived rates from actual O&M budgets and measure its use in multiple cases	A set of formulae for determining O&M costs for urban areas

3. Research Methodology

3.1 Overview

The research project itself was scoped from Table 11 to include the key deliverables so that the work could be accomplished within a reasonable time frame and within a researchable focus.

Key components and deliverables-

The key components and deliverables envisaged for this research are-

- The derivation of a set of equations for O&M cost rates for civil engineering services (at various levels of service)
 - These rates and equations should be simple and easily used at a public participation level
 - The study of cost components from line item categories in the municipal budget for each service
- The testing of the equations for accuracy with respect to variability of data between different towns/ applications.

The research methodology is consequently patterned by the research outcomes listed above.

The research involves the collection of O&M data and converting it into a useful format for Urban Settlements. The research will attempt to ensure that sufficiently representative data is sourced and analysed, and that the variability of data between different towns is accounted for in the derivation of equations for multiple applications.

A number of items make up the annual O&M municipal cost. These items must be considered when comparing the different cost rates from individual municipalities, since they may be affected by the municipal size, budget deficits, and the size of the population served as well as by other unique parameters, which are related to the site and situational factors of the settlement.

These are independent variables and can form part of the basis for a linear regression on the data and consequent derivations of parameters for the costing formulae (Cloete, 2005)

b) Research activities-

The above research deliverables could be realized in a number of ways. The activities listed below offered a framework of approach for this research-

- A pilot study at one municipality to identify and collate O&M cost information
- Develop a Questionnaire or systematic tool for gathering data at other municipalities
- Collect O&M data from municipalities province wide (ex. interviews, budgets, GIS data etc)*

- Collate data in a usable format for further manipulation
- Identify various factors of adjustments and corrections to ensure accuracy of data
- Employ statistical methods to analyse data
- Derive an equation to model the data

** An initial perusal of municipal budgets showed that the data was not available in a suitable format. The analysis therefore required a lot of trial and error, not i.t.o. theory but i.to. of the format. A pilot study of one town therefore assisted with terminology and methodology and the outcome identified various factors of adjustment to ensure the accuracy of the data.*

The liaison with municipalities followed the necessary protocols and proper channels of communication. A database of contact details pertaining to each municipality in the Western Cape was obtained from the Provincial Department of Local Government and served to initiate the data collection process.

This data base contained all relevant contact details of Municipal Managers at the District and Local levels of government.

A questionnaire approach served to initiate the data collection process. It also provided a means of reference with roleplayers, and created a basis for telephonic discussions.

Various checks and balances were employed to ensure that the data was accurate and correct. This was done by identifying protocols from the pilot study, mathematical checks, signatories, and extracts of relevant working documents such as budgets and GIS data.

The data was collated in a user-friendly manner, which enabled it to be used in various mediums for further manipulation and statistical analyses.

c) The Research Problem

The research was narrowed down into the following researchable question-

‘What are the Operation and Maintenance (O&M) costs of municipal services in municipalities in the Western Cape?’

The following three sub-problems were used as enabling objectives to the research process.

- What and where are the sources of such O&M data?
- Has such data been or can such data be converted into a usable format?
- Is there enough data to generate sufficient statistical confidence?

In doing the research, the notion as to whether such data could be used to account for variations between towns- a type of sensitivity analysis- to generate equations for multi-applicability, was assessed.

f) Research Objective

The objective was to *Formulate or develop an equation or set of rates that can calculate or derive O&M costs of ME services to a residential area; if the area is described using a set of parameters. These parameters are to be kept to a minimum*

This objective was further enabled by:

- Exploring the activities associated with O&M Costs of services in an urban town
- Generating a model for such activities.

The aim was thus to gather O&M cost data for various municipal services. It was further intended to benchmark rates for services and to derive a relationship or expression for these rates given the site and situational issues such as topography and other factors that might affect the O&M costs.

e) Research Hypothesis

The following statement was formulated as an experimental hypothesis in order to give direction with respect to the address of the problem statement in this dissertation:

'The cost structures of M&O activities can be simplified and still provide sufficiently accurate data for public participation processes.'

Furthermore, this study pre-supposed that much of the costing data could be derived from discussions with Local Government, which annually formulates its O&M budgets.

f) Research Delimitation

Whilst the major focus of the research was around costs, there were other factors, which bear impact on this research because they form part of the framework for a broader Decision Making Tool to be used for community participation (Del Mistro, 2005)

These are: - 'Appropriate ways of presenting such cost data in the Decision Making Tool', 'the dynamics accompanying decision making around costs', the issue of 'Job Creation' and also 'Affordability Levels among benefactors'.

These do not however affect the current research and were therefore omitted from the research exercise.

Secondly, unless the scope of the study was drastically reduced to say one municipal engineering service such as gravel roads costing, it was not the intention to measure rates for each of the activities covered in Chapter 2.

Instead, it was assumed that the rates determined from municipal budgets would be

sufficiently accurate for the purposes of estimating O&M costs.

3.2 Data Collection

a) Scope of Data Collection

Data was collected for five (5) Municipal Engineering (ME) services from municipalities in the Western Cape Province. Table 12 indicates the desired scope of data collection for each of the services.

Table 12: Desired Scope of O&M Cost Data Collection across municipalities in the Western Cape

	ME Service	Level of Service				
		1	2	3	4	5
1	Roads	Graded Roads	Gravel Roads	Surfaced Roads		
2	Storm water	Reticulation	Appurtenances			
3	Sanitation	Chemical	VIP	Septic Tank	Reticulation	Treatment
4	Solid Waste	Tonnage	Transfer	Collection	Transported	
5	Water	Reticulation	Treatment			

There are a total of 24 local municipalities in the Western Cape. Except for Cape Town, each resides under one of 6 District Municipalities as shown in Table 13. The municipal regions are shown graphically on the municipal boundary demarcation plan in Figure 7

Table 13: List of Municipalities in the Western Cape

No.	District Municipality	District No	Municipal Region	Mun No.
1	Cape Town	Metro	Entire Metro	Metro
2	West Coast District Municipality	DC1	Matzikama Mun	WC011
			Cederberg Mun	WC012
			Begrivier Mun	WC013
			Saldanha Bay	WC014
			Swartland Mun	WC015
3	Cape Winelands	DC2	Witzenburg	WC022
			Drakenstein	WC023
			Stellenbosch	WC024
			Breede Valley	WC025
			Breede River	WC026
4	Overberg	DC3	Theewaterskloof Mun	WC031
			Overstrand Mun	WC032
			Cape Agulhas Mun	WC033
			Swellendam Mun	WC034
5	Eden	DC4	Kannaland Mun	WC041
			Hessqua Mun	WC042
			Mossel Bay Mun	WC043
			George Mun	WC044
			Oudtshoorn Mun	WC045
			Bitou Mun	WC047
			Knysna Mun	WC048
6	Central Karoo	DC5	Laingsburg Mun	WC051
			Prince Albert Mun	WC052
			Beaufort West Mun: Murraysburg	WC053

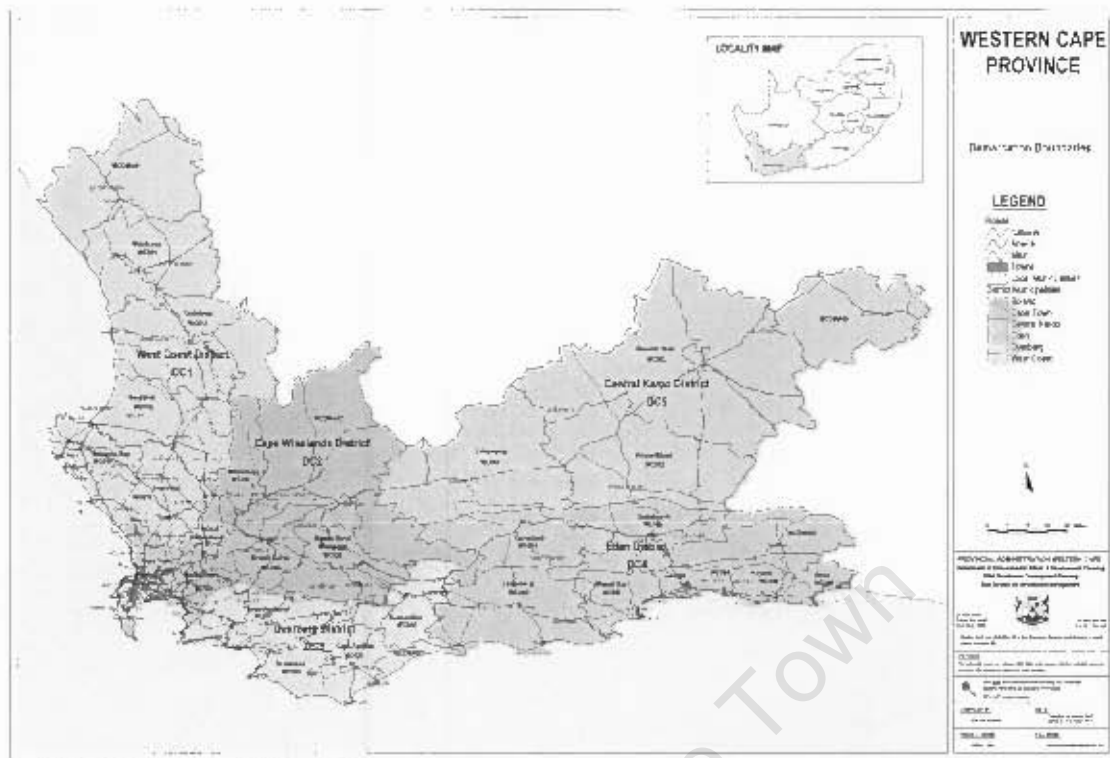


Figure 7: Municipal Boundary Demarcations

b) Data Sources

The municipalities listed in Table 13 are the primary sources of information. The data from the literature sources (Chapter 2) are not necessarily specific to the Western Cape and may not be in the format desired for this research. However, where applicable, the latter was used as a means of external comparison for the results achieved in this project (Chapter 6).

The sourcing of data within municipalities was streamlined from protocols derived from the pilot study. However, these invariably included the following activities-

- Interviews and discussions with municipal officials involved in O&M practice and delivery
- Information extracted from annual O&M budgets for municipalities within the Western Cape
- Situational and site specific information derived from GIS sources, maps and demographic profiles of the settlements

c) Data Collection Process

The data collection process is captured in the flow chart shown in Figure 8

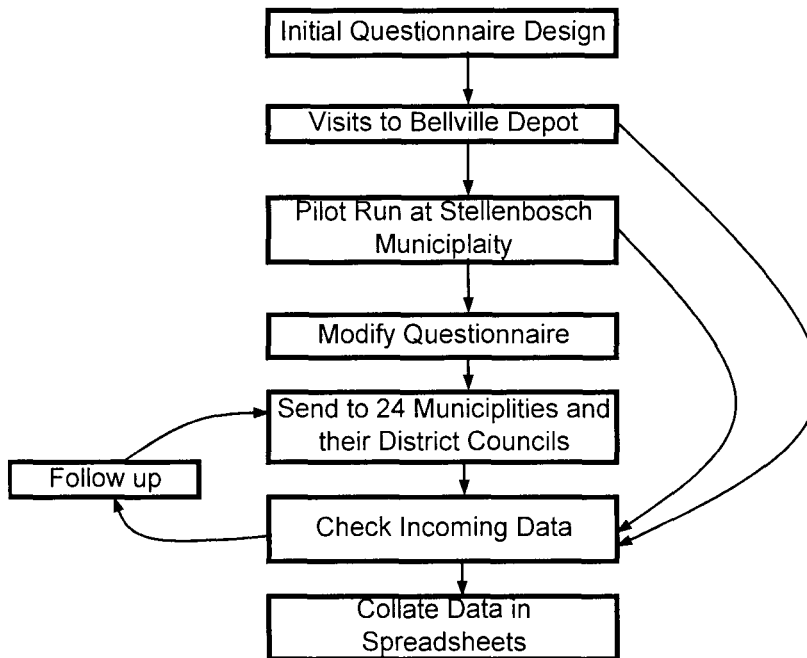


Figure 8: The Data Collection Process

The Initial-Design Questionnaire

A blank copy of the questionnaire is found in the Appendix A of the dissertation. The format was intended to be skeletal so that it could be shaped during the pilot study by the necessary factors of adjustment and so ensure representivity of the data.

At this stage, the questionnaire was entirely centered on the annual O&M costs and capacities (lengths, volumes etc) of the Municipal Engineering Services. It lacked input around the demographic, site and situational factors, which could affect the costs of the services.

d) The Pilot Study at Stellenbosch Municipality

This study was run over three weeks and involved the following-

- Regular (twice a week) visits to the municipality's Professional and Technical Division
- Across-the-desk discussions with municipal officials involved in service delivery and budgeting
- Collation of budget extracts
- Determination of budget costs for various services
- Discussions around budget deficits and O&M activities causing problems

Figure 9 shows a chart of the interactions with Professional and Technical staff at the Municipality of Stellenbosch.

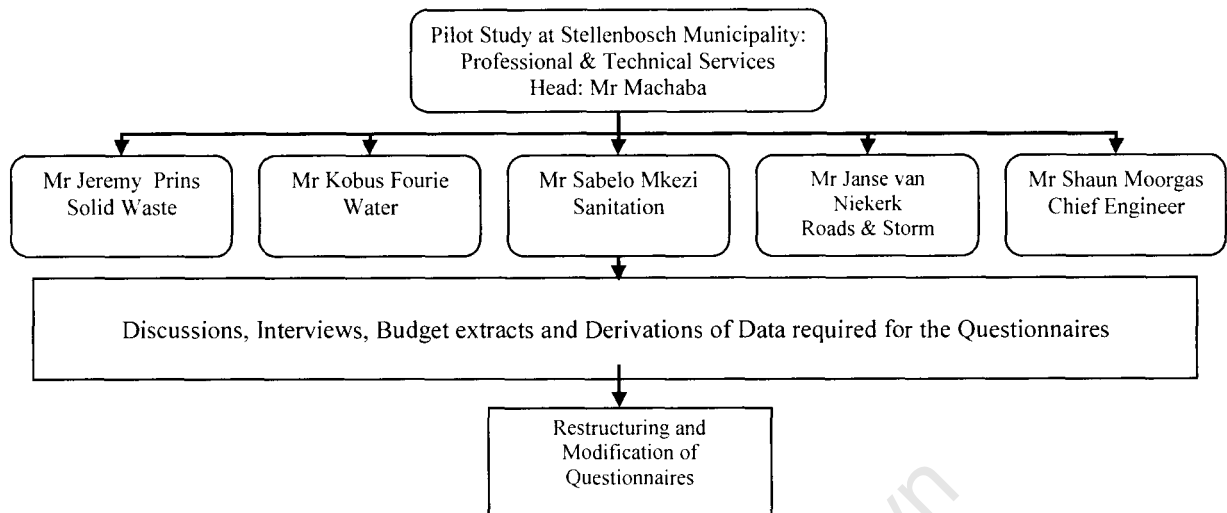


Figure 9: Structure of Pilot Study: Stellenbosch Municipality

Lessons learnt from the Stellenbosch Pilot Study

The pilot study proved to be fruitful and provided insight and exposure into the O&M processes affecting this project in the following ways-

- The methods used to determine the annual O&M cost budgets
- The study of O&M cost budget items across ME services
- The costing of line items on the SAP (Standard Accounting Practice) Model (this provided insight into real time expenditures)
- Contact and discussions with key persons involved with O&M practice
- The percentage deficits on O&M budgets
- The problems encountered with O&M practice across ME services

Although not directly applicable to the research, the following items also formed part of the lessons learnt at the municipality-

- Exposure to the day-to-day operations at the municipal maintenance depots
- The roles and responsibilities of municipal staff with respect to O&M practice
- The logging of beneficiary complaints and subsequent itemizing of work done
- The methods used in the follow-up of complaints and in the use of plant, materials and labour for O&M

Modifications to Original Questionnaires

The work at Stellenbosch municipality consequently led to the modification of the Initial Questionnaires. Five blank copies of the Modified Questionnaires, one for each ME

Service, are found in Appendix B of the dissertation. The five services are roads, storm water, sanitation, solid waste and water provision services.

Beside the original information retained from the Initial Questionnaires, there were the inclusions of-

- The name and code number of the residing district and municipality
- Contact details of the person(s) providing the information
- The contact details of the O&M Superintendent
- The number of sites (formal and informal) served by the ME Service
- The topography of the settlement area
- An indication of the percentage deficit on the O&M budget
- An indication of problems experienced with O&M practice for the ME Service
- A log of whether the relevant budget extracts were provided

e) Data Collection Response

The revised questionnaires were subsequently e-mailed to the 24 municipalities in the Western Cape, as well as to their 6 respective District Councils. This process was run over three months with regular daily follow-ups via telephone calls, telephonic interviews and further electronic mailing, where necessary. The level of response on the questionnaires is shown in Table 14.

All the District Municipalities are represented by the data received. However, amongst the municipalities, an average return of 47% was received with about 56% for roads, and storm water services, and 52% for water services. The levels of return for sanitation and solid waste were 46%.

The 47% over-all return implies that on average about 16 municipalities provided data for each of the five services recorded. For sanitation and solid waste however, the return was lower - about 13 municipalities.

An acceptable degree of statistical confidence would be achieved had there been a return from around 25 to 28 sources (Cloete 2005). For this study, therefore, this would require a 100% sample. This implies that an external means of validating the results would have to be used such as the data collected in the literature review (Chapter 2).

Reasons for low response levels

The following issues encountered during the data collection process, significantly hampered the amount of data received from municipal officials-

- There was a heavy reliance on electronic and telephonic means of data retrieval due to the widespread locations of data sources. Personal visits to municipalities (where possible) proved to be the best
- In spite of adhering to proper institutional protocols of submitting the questionnaires, the questionnaires had to be resent on numerous occasions directly to specific officials assigned to do the work

- Numerous follow-up attempts ended up with empty promises or no responses at all (most times after a number of detailed conversations with the relevant officials involved)

Table 14: Level of Return on Questionnaires

No	District Municipality	District No	Municipal Region	Mun No.	Data received				Budget extracts	Comments	Type of Settlement	Date Received	
					Rds_Sw	Sanitation	Solid_Waste	Water					
1	Cape Town	Metro	Entire Metro	Metro			1	1				Oct	
		Bellville	Bellville	Metro	1				Yes	Yes	Urban Mixed	Oct	
2	West Coast District Municipality	DC1	Matzikama Mun	WC011	1	1	1	1	No	No	Mixed 80/20 U/R	7-Nov	
			Cederberg Mun	WC012									
			Begrievier Mun	WC013									
			Saldanha Bay	WC014									
			Swartland Mun	WC015	1	1		1	Yes	No			9-Nov
3	Cape Winelands	DC2	Witzenburg	WC022									
			Drakenstein	WC023	1			1				24-Nov	
			Stellenbosch	WC024	1	1	1	1	Yes	Yes		14-Oct	
			Breede Valley	WC025	1	1	1	1					
			Breede River	WC026	1	1	1	1	Yes	Yes	Rural Mixed (Flat&Steep)		28-Oct
4	Overberg	DC3	Theewaterskloof Mun	WC031	1			1	No			9-Nov	
			Overstrand Mun	WC032									
			Cape Agulhas Mun	WC033	1	1	1	1	Yes	Yes	Mixed (Steep&Flat)		28-Oct
			Swellendam Mun	WC034									
5	Eden	DC4	Kannaland Mun	WC041									
			Hessqua Mun	WC042	1								
			Mossel Bay Mun	WC043									
			George Mun	WC044	1	1	1	1	Yes, Rds SW	Yes	Flat Urban		11-Nov
			Oudtshoorn Mun	WC045	1	1	1	1	No	Yes	Flat 90% & Steep 10%		24-Oct
			Bitou Mun	WC047									
Knysna Mun	WC048												
6	Central Karoo	DC5	Laingsburg Mun	WC051	1	1	1	1	Yes	Yes	Rural Flat	21-Nov	
			Prince Albert Mun	WC052									
			Beaufort West Mun, Murraysburg	WC053	1	1	1	1	Yes	NA	Urban steep and flat		2-Nov
Date 13/12/2005					Totals =		14	10	10	13			
Percentage Progress					56%	40%	40%	52%					
Overall Progress					13/12/2005	47%							

The spreadsheets of data from each municipality are enclosed in the Appendix C of this report.

Omission of Levels of Service

It is also noted that there was too little data received for Graded Roads, VIP's and Septic Tank Sanitation services (refer Table 12 Chapter 3.2). These levels of service were consequently omitted from the data analyses process.

f) Data Capturing

Once the returned questionnaires were checked for completeness and correctness, the data was then captured on a purpose-made template in an Excel spreadsheet. Table 15 illustrates this for the road, storm water and solid waste data of Stellenbosch Municipality.

In cases where budget extracts were received, this was acknowledged on the templates.

Table 15: Excel Template: Roads, storm water and solid waste: Stellenbosch Municipality

No.	District Municipality	District No	Municipal Region	Mun No.	Budget extracts	Comment	No of Sites	Settlement type
3	Cape Winelands	DC2	Stellenbosch	WC024				
Rds_Sw	Graded Rds [km]				0	Yes	Up to 9 areas are covered in the survey data	26433 (needs clarity)
	Graded [R/yr]				0			
	Gravel Rds [km]				31.8			
	Gravel [R/yr]				231350			
	Surface Rds [km]				270			
	Surface [R/yr]				1800000			
	SW Pipes [km]				220			
	SW Pipes network [R/yr]				2000000			
	Rest of SW System [R/yr]							
	% O&M deficit							
O&M Concern		The major cost component concern is that of worker-absenteeism. The result being that contractors must be hired to do work, and hence double wages for labor is paid. Janse van Rensburg						
Solid_Waste	Solid Waste Production [Tonnes/yr]				140000	Yes	Follow up with Jeremy Filles. An extract of actual expenditures for 2004/05 was received for comparison. Superintendants: Mr Gosinin 808-8273 & Heyns 808-82 66	21335 Formal and 2500 Informal
	Solid Waste Collection [R/yr]				14401018			
	Solid Waste Transportation [R/yr]				1933752			
	Landfill Site Disposal [Tonnes/ yr]				190865			
	Landfill Site Disposal [R/ yr]				1927236			
	% O&M deficit				30%			
O&M Concern		Too many contractors are involved in the delivery process, costing the mun too much: R 5M pa over-expenditure; process can be centralised; also, private co. running dumping site @ R 1.8 M pa.: Jeremy Prins						

3.3 Data Analyses Process

The analyses were aimed at determining O&M Cost rates and or formulae for each level of service. Means, standard deviations, variable correlations and linear regression equations were computed from a statistical analysis of the data.

The unit rates were represented within services in the following manner -

- As the cost rate per unit measure of service (eg. R per km or per m of road per annum)
- Where possible, as formulae derived from the variables affecting these rates

The factors representing these costs were then discussed and conclusions drawn from this.

a) Compilation of data components

There are eight components of the data pertaining to each municipality (refer Appendix B 2: Modified Questionnaire)-

- Reported Cost Data (Rand per annum) by service
- Cost Data from the annual budgets (2005/6) for each service (Rand per annum) by service
- Data on population size (number of erven)
- Data on geographic descriptions- these were confined to area type (i.e. rural or urban), and topography (i.e. steep or flat)
- Data on relevant service dimensions (e.g. lengths of road, volume of water treated, tonnage of waste disposal, etc)
- Data on Budget Split components for each service
- Comments on problems with O&M delivery and comments on budget deficits
- Name and contact details of municipal officials responsible for completing questionnaires

Variables

The *dependant* variable used for linear regression is the annual 'O&M Cost or Cost Rate', whilst the four categories of *independent* variables used were the 'population' (number of sites), 'percentage urban' (area-type), 'topography' (percentage steepness), 'lengths or volumes of flow or tons' (service dimensions).

Two additional variables were considered because of their influence on the variability of the type of data. These were 'problems with O&M' (a measure of the concerns related to the O&M practice for that service), and 'accounting practice' (a measure of the extent of O&M budget funds allocated to the various line items).

These variables were studied and were used to amend the budget cost data received from the municipalities as follows-

- The percentage deficits on the O&M budgets given by municipal officials were used to increase the budget figures

- The budget costs were further amended by omitting the line item ‘capital expenditure’ (Capex) because this cost is directly linked to capital loans.

b) Data preparation

The received data was collated and checked for completeness and accuracy. Where possible, it was then compared against budget extracts (where received). In some cases, municipal officials indicated a shortfall on actual values or budgets; these were used to adjust the figures accordingly to produce the ‘Desired Corrected Values (DCV)’ for O&M Costs.

The flow chart in Figure 10 illustrates this process.

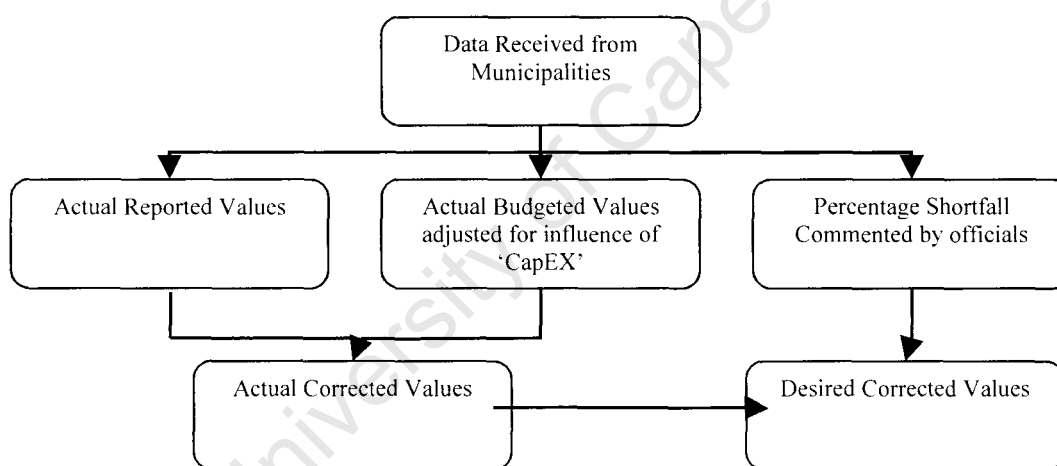


Figure 10: Flow Chart of Data Manipulation

c) Formulation of variable descriptors for use in Linear Regressions

The following descriptors were formulated and assessed for usage prior to the linear regression process.

- Topographic Descriptor ('Topog')-

The topographic descriptor refers to the average percentage steepness of the settlements under municipal jurisdiction. This factor ranges from unit value for steep areas to zero for

flat areas.

These are shown in Table 16 for the municipalities.

Table 16 : Municipal Topographic Descriptors

	Municipality	Topography	Factor [%Steep]
1	Cape Metro	10% steep, 90% flat	10
2	Cape Bellville	100% flat	0
3	Matzikama	mixed	50
4	Swartland	90% flat	10
5	Drakenstein	steep	90
6	Stellenbosch	Flat	30
7	Breedevallei	mixed	50
8	Breederivier	mixed	50
9	Thewaterskl	mixed	50
10	Cape Agulhas	mixed	50
11	Hessqua	flat	30
12	George	mixed	50
13	Oudtshoorn	90% flat, 10% steep	10
14	Laingsburg	flat	30
15	Beaufort West	mixed	50

- Formulation of area descriptor ('RU')-

The area descriptors refer to the average level of urbanization of the settlement under municipal jurisdiction.

These are shown in Table 17 for the 15 municipalities.

The 'area factor' like the 'topographic factor' is a percentage indicator ranging from unit value for urban areas to zero for rural areas.

Table 17: Municipal Area Descriptors

	Municipality	Rural/Urban (RU)	Factor
1	Cape Metro	urban	1.00
2	Cape Bellville	urban	1.00
3	Matzikama	80% urban 20% rural	0.80
4	Swartland	rural	0.00
5	Drakenstein	urban	0.80
6	Stellenbosch	urban	0.50
7	Breedevallei	mixed	0.50
8	Breederivier	rural	1.00
9	Thewaterski	mixed	0.50
10	Cape Agulhas	urban	1.00
11	Hessqua	50% urban 50% rural	0.50
12	George	urban	1.00
13	Oudtshoorn	urban	1.00
14	Laingsburg	mix	0.50
15	Beaufort West	mix	0.50

- Municipal O&M Problem Descriptor ('OMP')-

The municipal 'problem descriptor' is a value derived from the comments given in questionnaires relating to the level of O&M as problems perceived by municipal officials for each service in each municipality.

Three 'problem' categories were identified- i.e. 'severe' =2, 'moderate' = 1 and 'minor' =0 problems.

These are listed in Table 18.

This variable was not used in the actual regression analyses because of its subjectivity and because it is was not received for all the data provided. However, where municipal officials provided comments on the 'percentage budget deficit', these percentages were used to amend the data before doing the statistical analyses.

Table 18: Municipal Level of O&M Problems

Municipality	Issues	Roads	Storm water	Sanitation	Solid Waste	Water
CTM Metro	65% deficit in SW Budget- more cleaning cycles needed; difficult procurement of roads- no infrastructural concerns given	1	2	n/a	0	0
Matzikam	Non given	0	0	0	0	0
Cedbg	Non given	n/a	n/a	n/a	n/a	n/a
Begriv	Non given	n/a	n/a	n/a	n/a	n/a
Saldanh	Non given	n/a	n/a	n/a	n/a	n/a
Swartl	Non given	0	0	0		0
Witzenbg	Non given	n/a	n/a	n/a	n/a	n/a
Drakens	Old infrastructure needs replacing (ex. pipelines) but funds and resources are stagnant (5% cap on budget growth pa)	0	1	n/a	n/a	2
Stellenb	Worker absenteeism, sewer pumps old, needs repairs/replacement, unforeseen expenses: 30% deficit	1	1	2	2	1
BreedeV	Roads and SW budget not sufficient- no estimate given	1	0	1	1	1
BreedeR	Roads and SW budget not sufficient- no estimate given	1	1	0	0	0
Theewat	Roads, SW and Water budgets not sufficient- 25% inadequate	1	1	n/a	n/a	1
Overstr	Non given	n/a	n/a	n/a	n/a	n/a
Cape Ag	SW Pipes and channels is main OM concern- no deficit given	0	1	0	0	0
Swellen	Non given	n/a	n/a	n/a	n/a	n/a
OverbGDM	Non given	n/a	n/a	n/a	0	n/a
Kannal	Non given	n/a	n/a	n/a	n/a	n/a
Hessqua	Unquantified deficit in Roads budgets	1	0	n/a	n/a	n/a
Mosselb	Non given	n/a	n/a	n/a	n/a	n/a
George	35% deficit on Rds and SW budget; deficit on Sanit budget not given; ageing Solid Waste veh. Fleet; city fast-growing	2	1	0	1	0
Oudtsh	25% deficit on Rds and SW budget due to ageing streets	2	1	0	1	0
Bitou	Non given	n/a	n/a	n/a	n/a	n/a
Knysna	Non given	n/a	n/a	n/a	n/a	n/a
Laingsb	56% deficit on Rds & SW budget; 12% on Solid Waste	2	2	0	1	0
Prince Albert	Non given	n/a	n/a	n/a	n/a	n/a
BeaufortWest	No deficits on budget recorded	0	1	0	0	0
Cape Bellville	15% deficit on Roads budget recorded	1	0	n/a	n/a	n/a

- Dimensional descriptors ('Pop', 'km', 'Ml' and 'Ton')-

The 'dimensional' descriptors refer to the number of erven and the lengths, masses and volumes of municipal services under discussion. The latter are captured in Chapter 4 for each municipal service, whilst the number of erven were referred to as 'population' and is shown in Table 19.

Table 19: Number of erven across Municipalities

	Municipality	No. of erven (Pop)
1	Cape Metro	725000
2	Cape Bellville	73068
3	Matzikama	6843
4	Swartland	32690
5	Drakenstein	29463
6	Stellenbosch	26433
7	Breedevallei	19431
8	Breederivier	16696
9	Thewaterskl	8000
10	Cape Agulhas	9481
11	Hessqua	14411
12	George	30000
13	Oudtshoorn	22500
14	Laingsburg	1146
15	Beaufort West	1650

- Budget-split descriptors (*Accounting Practice* i.e. 'AP')

This variable was not used in the linear regression analyses because it is subject to political will and accounting practices, and it is not necessarily controlled by site and situational factors relating to the municipal services. However, it is listed and discussed here because it does highlight the budget allocations to 'actual' O&M activities.

The budget data was used to identify the actual components of the budget and their relative percentage splits with respect to the overall O&M costs. Examples for the Stellenbosch municipality are shown for the roads and solid waste services in Table 20.

Table 20: Roads and Solid Waste Budget Splits: Stellenbosch Municipality

Stellenbosch	Budget Split Items					
	Salaries	General	MO*	CapEx	ContribCap	Total
Roads	3,151,530.00	4,058,430.00	2,647,000.00	132,900.00	2,250.00	9,992,110.00
	31.5%	40.6%	26.5%	1.3%	0.0%	100.0%
Solid Waste	4,375,500.00	8,509,000.00	989,240.00	0.00	0.00	13,873,740.00
	31.5%	61.3%	7.1%	0.0%	0.0%	100.0%

Explanation of budget split items

The following meanings for the budget split items were derived from discussions with municipal officials and the literature review in Chapter 2-

- The ‘salaries’ component includes provision for existing staff, casual staff, new staff due to salaries, fringe benefits and salary increases,
- ‘General’ refers to the day to day running expenses and administering of the municipality,
- ‘MO’ refers to expenses incurred due to on-the-ground O&M activities such as fixing potholes, servicing pump stations etc.,
- ‘Capex’ refers to payments on redemption and interest for loans made on capital works (in some cases this is based on potentially large capital loans), and
- ‘ContribCap’ refers to contributions to Capital income in the form of ‘allowances’ under the O&M budget for 'planned/perceived future expenses on small capital works and infrastructure such as office equipment. For example, if the municipal depot is thinking of purchasing a new pump or office plotters worth R 250 000, then allowances (phased) will be made in the annual O&M budget. The ‘ContribCap’ usually forms a very small part of the overall O&M budget.

Observations

Together these descriptors give an indication of the ‘accounting practice’ of the municipality for the service under consideration.

For instance, from Table 20, it is noted that-

- Around 27% of the total budget is spent on actual O&M activities for roads, and only 7% is spent for Solid Waste
- Salaries carry an equal weighting as a percentage of the O&M budget
- Most expenditures occur on General items such as the operational issues related to administration and overhead costs

The municipal ‘Accounting Practice’ (AP) descriptors for each service across the municipal data submitted are shown in Table 21.

Table 21: Municipal Percentage splits for O&M activity 'Accounting Practice' across services

Region and City	Salaries	General	MO*	CapEx	ContribCap	Total
Swartland	47%	10%	13%	15%	15%	100%
Stellenbosch	32%	41%	26%	1%	0%	100%
BreedeRiver	49%	24%	11%	16%	1%	100%
Agullas	48%	18%	16%	17%	1%	100%
George	21%	7%	45%	27%	0%	100%
Laingsburg	17%	43%	23%	9%	9%	100%
Beaufort West	29%	66%	5%	0%	0%	100%
Average =			20%			

Sanitation Total	Salaries	General	MO*	CapEx	ContribCap	Total
Swartland	46%	31%	10%	7%	7%	100%
Stellenbosch Compost	20%	69%	12%	0%	0%	100%
Stellenbosch Sanit	26%	31%	38%	5%	0%	100%
BreedeRiver	34%	39%	7%	20%	0%	100%
Agullas	45%	25%	15%	13%	1%	100%
Laingsburg	39%	43%	16%	3%	0%	100%
Beaufort West	50%	8%	2%	0%	40%	100%
Average =			14%			

Sanitation Treat	Salaries	General	MO*	CapEx	ContribCap	Total
Stellenbosch Tot	0%	77%	23%	0%	0%	100%
Stellenbosch Franshk	0%	52%	36%	12%	0%	100%
Stellenbosch Pniel	58%	28%	15%	0%	0%	100%
Stellenbosch Wemmerhk	0%	49%	51%	0%	0%	100%
Average =			31%			

Solid Waste	Salaries	General	MO*	CapEx	ContribCap	Total
Stellenbosch	32%	61%	7%	0%	0%	100%
BreedeRiver	49%	31%	9%	10%	1%	100%
Agullas	54%	27%	17%	2%	1%	100%
Oudsthoorn	17%	52%	23%	4%	4%	100%
Laingsburg	57%	36%	6%	0%	0%	100%
Beaufort West	50%	8%	2%	0%	40%	100%
Solid Waste Transfer Station						
Stellenbosch	12%	80%	8%	0%	0%	100%
Overberg DM	0%	41%	2%	26%	31%	100%
Oudsthoorn	79%	21%	0%	0%	0%	100%
Average =			8%			

Table 21 continued : Municipal Percentage splits for O&M activity 'Accounting Practice' across services

Water Total	Salaries	General	MO*	CapEx	ContribCap	Total
Swartland	22%	67%	2%	4%	4%	100%
Stellenbosch	22%	61%	17%	0%	0%	100%
Breede River	25%	41%	7%	27%	0%	100%
Agullas	33%	22%	9%	35%	1%	100%
Laingsburg	20%	74%	4%	1%	0%	100%
Beaufort West	37%	16%	7%	40%	0%	100%
Average =			8%			

Water Treat	Salaries	General	MO*	CapEx	ContribCap	Total
Stellenb:Idasvalley	73%	14%	13%	0%	0%	100%
Stellenbosch	34%	36%	29%	0%	1%	100%
Stellenb:Paradyskl	38%	57%	5%	0%	0%	100%
Stellb: Franshk	0%	65%	31%	0%	4%	100%
Average =			20%			

The figures illustrate that (for the data submitted)-

- 'Salaries' and 'General' general make up most of the O&M service budget
- MO* activities form a comparatively small part of the total O&M service budget. They range from 8% of the total budget (water and solid waste services), to about 30% of the total budget (sanitation treatment services). Roads and storm water and water treatment MO* activities form 20% of their total O&M budget
- The percentages for 'CapEx' are as high as 40% (Beaufort West). This is a concern considering that this part of the budget is related to loans for possibly large capital projects

The use of the 'Accounting Practice' variable in the data analyses process

The issue of concern relating to this variable is the levels of expenditures allocated to actual O&M practice. The two obvious deviators are 'CapEx' and 'ContribCap'. The latter is usually linked to 'small perceived capital works', whilst the former is potentially linked to large capital loans already committed.

It was therefore considered prudent under the research to amend the budget data received from municipalities by omitting the percentage allocated to 'CapEx'.

3.4 Summary and way forward

An enormous amount of time and effort was put into the data collection process. However, the response levels were below expectation and the data will have to be validated from information collated in the literature review process (Chapter 2).

The data includes reported annual budget expenditures for the components of five different civil engineering services, which can be adjusted where there are reported deficits in the maintenance budget. Also included is the divisors (i.e. road lengths, pipe lengths, volumes of flow and tonnes of solid waste) to calculate the rates. Furthermore, information on budget components (line items), area type and size as well as topography is also available.

This information made possible the formulation of various descriptors, which were used as independent variables for linear regression analyses. These were also used to gauge the sensitivity of the data across the different municipalities.

To assist in the way forward, the data analyses process is summarized in Figure 11

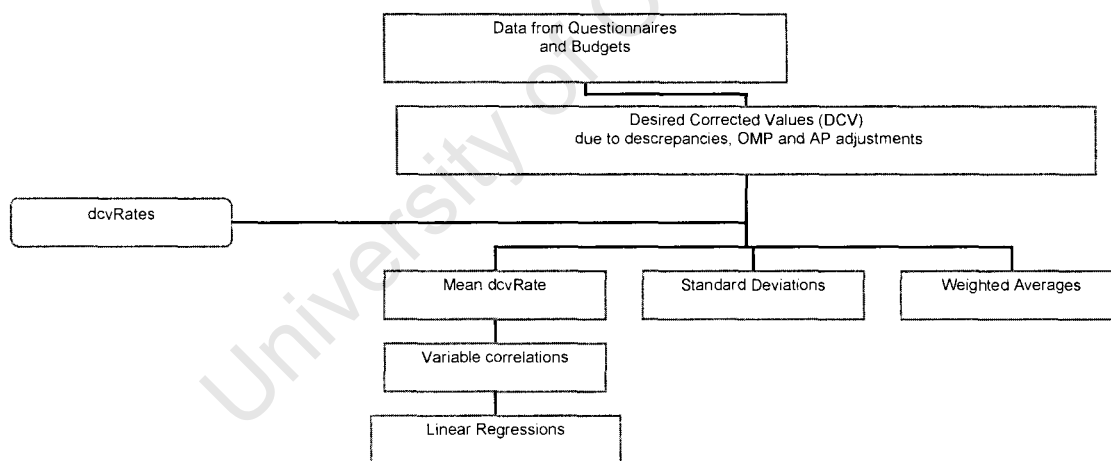


Figure 11 : Way Forward: Schematic build up to Linear Regressions

4. Development of dcvRates

4.1 Overview

The DCV (Desired Corrected Values) for each municipality were derived from the Questionnaire Feedback Data in accordance with the flow chart in Figure 10 for each of the services and levels of service. These DCV's were further manipulated as per the flow chart in Figure 11 to produce dcvRates and descriptive statistics shown in this Chapter. The calculations were performed in an Excel spreadsheet, where:

- The corrected values (in R pa) = average of (Given values + Budget values)
- The desired corrected values (in Rpa) = DCV's = the corrected values in (a) increased by the percentage budget deficit. In cases where there was no deficit, the value in (a) was used as the DCV
- The desired corrected value rate = dcvRate = the DCV divided by the relevant length of road or the megalitres of water or sanitation, or the tonnage of solid waste as the case may be.

$$\text{i.e. dcvRate} = \frac{\text{DCV}}{\text{(relevant divisor)}} \quad \text{in R pkm pa or R pMl pa or R pTon pa}$$

Extracts from this spread sheet are presented in Tables 22 to 32 for each of the services across individual municipalities.

The following statistics were further computed for each of the services and levels of services-

- Straight averages = the average of individual DCV and dcvRates

$$\text{i.e: Average DCV} = \frac{\sum \text{DCV per mun.}}{\text{No. of municipalities}}$$

$$\text{Average dcvRate} = \frac{\sum \text{dcvRates per mun.}}{\text{No. of municipalities}}$$

- The standard deviations of the DCV and dcvRates
- Weighted average = the sum of all the DCV totals (R pa) across all municipalities, divided by either the total length of road or pipeline, or the total tonnage of solid waste, or the total volume of water or sanitation as the case may be.

$$\text{i.e Wtd. Avg} = \frac{\sum \text{DCV per mun.}}{\sum \text{km of road or pipe}} \quad \text{or} \quad \frac{\sum \text{DCV per mun.}}{\sum \text{km of road}} \quad \text{or} \quad \frac{\sum \text{DCV per mun.}}{\sum \text{Ml of water or sanitation}}$$

These are shown in Tables 22 to 32, and summarised in Table 33 for each of the services.

Given the variations of size and situation across municipalities, the only meaningful discussions will be prompted by comparing the straight average dcvRates with the

weighted averages; although the average DCV and its standard deviation are also shown for completeness.

The standard deviations serve to highlight the expected variation in data. In cases where there are *outlying* (unusually high) dcvRates, a comment is made to reflect the adjustment in the mean dcvRate as a basis for later sensitivity analyses (Chapter 6).

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4.2 Gravel Roads

There are 15 data sets for the Gravel roads costs. The dcvRates are much dispersed, ranging from R 2000 pkm pa (Theewaterskloof) to R 73 291 pkm pa (George).

The average of the rates was calculated to be R 21 673 pkm pa, with a standard deviation of R 23 478 pkm pa, while the weighted average was calculated to be R 20 522 pkm pa. The lower weighted average highlights the influence of economies of scale between the municipalities, and best reflects the influence of higher km on the data.

Alternatively, the slightly higher average reflects the comparatively higher values shown by George, Hessqua and Laingsburg. When these high *outlying values* are omitted, the mean drops to R 10 858 pkm pa.

Table 22: Gravel Road Statistics

	Municipality	Data from Questionnaire feedback_2005				Corrected Values_2005		
		Km	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pkm pa
1	Cape Metro	185.00	2,000,000	2,000,000	80	2,000,000	3,600,000	19,459
2	Cape Bellville	111.00	1,198,000	1,198,000	15	1,198,000	1,377,700	12,412
3	Matzikama	48.00	100,000	100,000	0	100,000	100,000	2,083
4	Swartland	97.00	1,026,521	872,543	0	949,532	949,532	9,789
5	Drakenstein	54.00	256,000	256,000	50	256,000	384,000	7,111
6	Stellenbosch	31.80	231,350	1,145,183	0	688,266	688,266	21,644
7	Breedevallei	22.50	19,620	156,100	0	87,860	87,860	3,905
8	Breederivier	50.70	350,000	1,559,285	0	954,643	954,643	18,829
9	Theewaterskl	12.50	20,000	20,000	25	20,000	25,000	2,000
10	Cape Agulhas	36.20	551,326	457,601	0	504,463	504,463	13,935
11	Hessqua	30.00	1,666,000	1,666,000	0	1,666,000	1,666,000	55,533
12	George	74.00	1,600,000	6,434,843	35	4,017,422	5,423,519	73,291
13	Oudtshoorn	47.00	550,000	550,000	25	550,000	687,500	14,628
14	Laingsburg	2.00	80,000	89,180	56	84,590	131,960	65,980
15	Beaufort West	8.00	18,000	54,000	0	36,000	36,000	4,500
Average							1,107,763	21,673
Std_dev							1,508,059	23,478
Wtd_avg							n/a	20,522

4.3 Surfaced Roads

There are 15 data sets for the Surfaced road costs. The dcvRates are much dispersed and range from R 545 pkm pa (Matzikama) to R 82 298 pkm pa (Laingsburg).

The average dcvRate is R 23 007 per km pa, with a standard deviation of R 25 267 per km pa, while the weighted average was calculated to be R 13 154 per km pa.

The lower weighted average highlights the influence of economies of scale between the municipalities, and best reflects the influence of higher km on the data, which rises to R 20 443 pkm pa if the data for Cape Metro and Bellville are excluded.

Alternatively, the higher average reflects the comparatively high *outlying* values shown by Laingsburg and Oudtshoorn, which drops to R 13 885 pkm pa if their data are ignored.

Table 23: Surfaced Road Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value		
		Km	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pkm pa
1	Cape Metro	9152.00	64,000,000	64,000,000	80	64,000,000	115,200,000	12,587
2	Cape Bellville	1680.00	7,137,500	7,137,500	15	7,137,500	8,208,125	4,886
3	Matzikama	110.00	60,000	60,000	0	60,000	60,000	545
4	Swartland	231.00	6,843,726	5,817,167	0	6,330,447	6,330,447	27,405
5	Drakenstein	485.00	6,049,000	6,049,000	50	6,049,000	9,073,500	18,708
6	Stellenbosch	270.00	1,800,000	4,420,355	0	3,110,178	3,110,178	11,519
7	Breedevallei	249.50	370,458	4,116,750	0	2,243,604	2,243,604	8,992
8	Breederivier	178.40	1,000,000	4,455,360	0	2,727,680	2,727,680	15,290
9	Thewaterski	55.00	150,000	150,000	25	150,000	187,500	3,409
10	Cape Agulhas	147.30	2,243,379	1,862,005	0	2,052,692	2,052,692	13,935
11	Hessqua	320.00	5,833,000	5,833,000	0	5,833,000	5,833,000	18,228
12	George	415.00	2,900,000	11,513,509	35	7,206,754	9,729,119	23,444
13	Oudtshoorn	130.00	8,600,000	8,600,000	25	8,600,000	10,750,000	82,692
14	Laingsburg	14.00	700,000	777,140	56	738,570	1,152,169	82,298
15	Beaufort West	12.00	8,000	500,000	0	254,000	254,000	21,167
						Average	11,794,134	23,007
						Std_dev	28,842,337	25,267
						Wtd_avg	n/a	13,154

4.4 Storm water Reticulation

There are 15 data sets for the Storm water reticulation costs. The values are much dispersed and range from R 341 pkm pa (Matzikama) to R 38 200 pkm pa (Laingsburg).

The average of the rates was calculated to be R 9 416 per km pa, with a standard deviation of R 10 492 pkm pa, while the weighted average was calculated to be R 15 451 pkm pa.

In this case, the higher weighted average could be an indication of diseconomies of scale, meaning that there are forces that cause the larger municipalities to operate their stormwater services at increased per-unit costs. The weighted average drops to R 4 576 pkm pa if the data for Cape Metro and Bellville are ignored. Compared to the mean, this is very low, which indicates that the weighted average is somewhat driven by the high km and cost of Cape Metro.

The mean remains relatively stable (R 8 674 pkm pa) when the value for Cape Metro is omitted from the data.

Table 24: Storm water Reticulation Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value			
		Km	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pkm pa	
1	Cape Metro	5500	66,000,000	66,000,000	65	66,000,000	108,900,000	19,800	
2	Cape Bellville	500	581,000	581,000	15	581,000	668,150	1,336	
3	Matzikama	88	30,000	30,000	0	30,000	30,000	341	
4	Swartland	194	700,000	709,188	0	704,594	704,594	3,632	
5	Drakenstein	250	900,000	900,000	50	900,000	1,350,000	5,400	
6	Stellenbosch	220	600,000	1,485,000	0	1,042,500	1,042,500	4,739	
7	Breedevallei	250	410,000	410,000	0	410,000	410,000	1,640	
8	Breederivier	150.2	188,680	294,000	0	241,340	241,340	1,607	
9	Thewaterskl	22	30,000	30,000	25	30,000	37,500	1,705	
10	Cape Agulhas	33.8	80,000	348,600	0	214,300	214,300	6,340	
11	Hessqua	34	500,000	500,000	0	500,000	500,000	14,706	
12	George	255	360,000	1,734,480	35	1,047,240	1,413,774	5,544	
13	Oudtshoorn	40	600,000	600,000	25	600,000	750,000	18,750	
14	Laingsburg	7.8	200,000	182,000	56	191,000	297,960	38,200	
15	Beaufort West	6	105,000	105,000	0	105,000	105,000	17,500	
							Average	7,777,675	9,416
							Std_dev	27,978,135	10,492
							Wtd_avg	n/a	15,451

4.5 Storm water appurtenances

There are 15 data sets for the Storm water appurtenances costs. The DCV are shown as annual cost rates in rands per *km of reticulation*. The values are much dispersed and range from around R 114 pkm pa (Matzikama) to R 81 000 pkm pa (Laingsburg).

The average of the rates was calculated to be R 21 319 per km pa, with a standard deviation of R 23 348 per km pa, while the weighted average was calculated to be R 32 288 per km pa.

The higher weighted average could be an indication of diseconomies of scale, meaning that there are forces that cause the larger municipalities to operate their stormwater services at increased per-unit costs. The weighted average drops even further to R 11 228 pkm pa if the data for Cape Metro and Bellville are omitted. Compared to the mean, this is very low, which indicates that the weighted mean is driven by the high km of Cape Metro.

The mean remains relatively stable (R 19 687 pkm pa) when the value for Cape Metro is omitted from the data, however the influence of high *outlying* dcvRates (eg. Laingsburg) cannot be ignored, causing the mean to drop to R 15 895 pkm pa, if omitted.

Table 25: Storm water Appurtenances Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value		
		Km	Given Rpa	Budget Rpa	%Deficit	Corrected_Rp a	DCV Rpa	dcvRate R pkm pa
1	Cape Metro	5500	120,000,000	120,000,000	80	120,000,000	216,000,000	39,273
2	Cape Bellville	500	500,000	500,000	15	500,000	575,000	1,150
3	Matzikama	88	10,000	10,000	0	10,000	10,000	114
4	Drakenstein	250	1,394,400	1,394,400	50	1,394,400	2,091,600	8,366
5	Stellenbosch	220	1,400,000	3,500,000	0	2,450,000	2,450,000	11,136
6	Breederivier	150.2	380,000	380,000	0	380,000	380,000	2,530
7	Cape Agulhas	33.8	980,000	980,000	0	980,000	980,000	28,994
8	Hessqua	34	1,000,000	1,000,000	0	1,000,000	1,000,000	29,412
9	George	255	840,000	5,544,000	35	3,192,000	4,309,200	16,899
10	Oudtshoorn	40	100,000	100,000	25	100,000	125,000	3,125
11	Laingsburg	7.8	405,000	405,000	56	405,000	631,800	81,000
12	Beaufort West	6	203,000	203,000	0	203,000	203,000	33,833
						Average	19,062,967	21,319
						Std_dev	62,031,574	23,348
						Wtd_avg	n/a	32,288

4.6 Sanitation Reticulation

There are 10 data sets for the Sanitation reticulation costs. The devRates are much dispersed and range from around R 485 pkm pa (Matzikama) to R 22 189 pkm pa (Beaufort West).

The average of the devRates was calculated to be R 9 513 per km pa, with a standard deviation of R 6 237 per km pa, while the weighted average was calculated to be R 8 009 per km pa.

The lower weighted average highlights the influence of economies of scale between the municipalities, and best reflects the influence of higher km on the data, which rises to R 8 790 pkm pa if the data for George is excluded.

Table 26: Sanitation Reticulation Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value			
		Km	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pkm pa	
1	Matzikama	103	50,000	50,000	0	50,000	50,000	485	
2	Swartland	278	3,214,752	4,181,936	0	3,698,344	3,698,344	13,303	
3	Stellenbosch	242	2,338,250	2,221,338	20	2,279,794	2,735,753	11,305	
4	BreedeVallei	230.3	1,900,000	1,900,000	20	1,900,000	2,280,000	9,900	
5	Breederivier	265	191,000	220,032	0	205,516	205,516	776	
6	Cape Agulhas	63.1	650,000	565,500	0	607,750	607,750	9,632	
7	George	650	4,100,000	4,100,000	0	4,100,000	4,100,000	6,308	
8	Oudtshoorn	188	2,140,000	2,140,000	0	2,140,000	2,140,000	11,383	
9	Laingsburg	24	240,000	232,800	0	236,400	236,400	9,850	
10	Beaufort West	22	476,320	500,000	0	488,160	488,160	22,189	
							Average	1,654,192	9,513
							Std_dev	1,530,971	6,237
							Wtd_avg	n/a	8,009

4.7 Sanitation Treatment

There are 10 data sets for the Sanitation Treatment costs. The DCV are shown as annual cost rates in rands per MI of sewage treated. The values are much dispersed and range from R 89 pMI pa (Laingsburg) to R 3 265 pMI pa (Breederivier).

The average of the rates was calculated to be R 906 per MI pa, with a standard deviation of R 1 026 per MI pa, while the weighted average was calculated to be R 847 per MI pa.

The lower weighted average highlights the influence of economies of scale between the municipalities, and best reflects the influence of higher km on the data, which rises to R 1 108 pkm pa if the data for Breedevallei is excluded.

Alternatively, the higher average reflects the comparatively higher *outlying* values shown by Breederivier and George, which drop to R 478 pkm pa if their data are ignored.

Table 27: Sanitation Treatment Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value		
		MI	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pMI pa
1	Matzikama	630	120,000	120,000	0	120,000	120,000	190
2	Swartland	4380	4,822,128	4,822,128	0	4,822,128	4,822,128	1,101
3	Stellenbosch	8067	1,622,837	1,622,837	20	1,622,837	1,947,404	241
4	BreedeVallei	10293	900,010	900,010	20	900,010	1,080,012	105
5	Breederivier	2520	9,801,383	6,654,960	0	8,228,172	8,228,172	3,265
6	Cape Agulhas	3920	1,679,710	1,770,880	0	1,725,295	1,725,295	440
7	George	6137	12,120,000	12,120,000	0	12,120,000	12,120,000	1,975
8	Oudtshoorn	2617	3,060,000	3,060,000	0	3,060,000	3,060,000	1,169
9	Laingsburg	185	16,500	16,500	0	16,500	16,500	89
10	Beaufort West	825	400,000	401,693	0	400,847	400,847	486
						Average	3,352,036	906
						Std_dev	3,985,572	1,026
						Wtd_avg	n/a	847

4.8 Solid Waste Landfill

There are 11 data sets for the Solid waste landfill services. The DCV are shown as annual cost rates in rands per tonnage of solid waste. The values are dispersed and range from around R 5 pton pa (Breedevallei) to R 348 pton pa (Overberg District).

The average of the rates was calculated to be R 94 pton pa, with a standard deviation of R 111 per ton pa, while the weighted average was calculated to be R 52 pton pa.

The value for the weighted average is driven by the *outlying data* of Cape Metro (dcvRate = R 56 pton pa). When the values for Cape Metro are omitted, the weighted average drops to R 28 pton pa.

In this instance, therefore, the mean dcvRate is the more stable predictor since it remains relatively stable, when high tons are omitted or included from the data set. The influence of high outlying dcvRates on the mean (ex. Overberg and Cape Agulhas) is noted, however, dropping the mean to R 50 pton pa, if omitted.

Table 28: Solid Waste Landfill Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value			
		Ton	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pTon pa	
1	Cape Metro	1,990,000	112,380,000	112,380,000	0	112,380,000	112,380,000	56	
2	Matzikama	2,000	200,000	200,000	0	200,000	200,000	100	
3	Stellenbosch	190,665	1,927,000	2,600,000	30	2,263,500	2,942,550	15	
4	BreedeVallei	65,000	300,000	300,000	10	300,000	330,000	5	
5	Breederivier	6,780	872,000	1,224,000	0	1,048,000	1,048,000	155	
6	Cape Agulhas	3,600	851,470	834,441	0	842,955	842,955	234	
7	George	36,000	2,850,000	2,736,000	0	2,793,000	2,793,000	78	
8	Oudtshoorn	37,000	426,245	430,000	0	428,123	428,123	12	
9	Laingsburg	4,784	55,000	55,200	12	55,100	61,712	13	
10	Overberg DM	2,900	1,160,000	858,400	0	1,009,200	1,009,200	348	
11	Beaufort West	1,382	27,500	27,500	0	27,500	27,500	20	
							Average	11,096,640	94
							Std_dev	33,607,140	111
							Wtd_avg	n/a	52

4.9 Solid Waste Collection

There are 11 data sets for the Solid waste collection services. The dcvRates are dispersed and range from around R 11 pton pa (Breedevallei) to R 840 pton pa (Overberg District).

The average of the rates was calculated to be R 311 per ton pa, with a standard deviation of R 244 per ton pa, while the weighted average was calculated to be R 177 per ton pa.

The value for the weighted average is controlled by the high tons for the Cape Metro (dcvRate = R 179 pton pa).

In this instance, therefore, the mean dcvRate is the more stable predictor since it remains relatively stable, when high tons are omitted from the data set. The influence of high scatter data on the mean (ex. Overberg) is noted, however, dropping the mean to R 258 pton pa, if omitted.

Table 29: Solid Waste Collection Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value		
		Ton	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pTon pa
1	Cape Metro	2430000	434,500,000	434,500,000	0	434,500,000	434,500,000	179
2	Matzikama	2000	720,000	720,000	0	720,000	720,000	360
3	Stellenbosch	140000	14,400,000	13,900,000	30	14,150,000	18,395,000	131
4	BreedeVallei	70757	725,000	725,000	10	725,000	797,500	11
5	Breederivier	8900	2,371,000	3,321,000	0	2,846,000	2,846,000	320
6	Cape Agulhas	3744	2,000,000	1,960,000	0	1,980,000	1,980,000	529
7	George	36000	18,100,000	18,100,000	0	18,100,000	18,100,000	503
8	Oudtshoorn	37000	3,190,000	3,347,520	0	3,268,760	3,268,760	88
9	Laingsburg	4784	510,000	512,000	12	511,000	572,320	120
10	Overberg DM	2900	2,800,000	2,072,000	0	2,436,000	2,436,000	840
11	Beaufort West	1382	439,680	500,000	0	469,840	469,840	340
						Average	44,007,765	311
						Std_dev	129,685,412	244
						Wtd_avg	n/a	177

4.10 Solid Waste Transport

There are 11 data sets for the Solid waste transport services. The dcvRates are very dispersed and range from R 2 pton pa (Breedevallei) to R 177 pton pa (Overberg District).

The average of the rates was calculated to be R 75 pton pa, with a standard deviation of R 67 pton pa, while the weighted average was calculated to be R 33 pton pa.

The value for the weighted average is driven by the high tons of Cape Metro.

In this instance, therefore, the mean dcvRate is the more stable predictor since it remains relatively unchanged when high tons are omitted from the data set. The influence of high *outlyer* data on the mean (eg. Overberg and Breederivier) is noted, however, dropping the mean to R 53 pton pa, if omitted.

Table 30: Solid Waste Transport Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value		
		Ton	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pTon pa
1	Cape Metro	2430000	79,990,000	79,990,000	0	79,990,000	79,990,000	33
2	Matzikama	2000	290,000	290,000	0	290,000	290,000	145
3	Stellenbosch	140000	1,930,000	2,600,000	30	2,265,000	2,944,500	21
4	BreedeVallei	70757	110,000	110,000	10	110,000	121,000	2
5	Breederivier	8900	1,265,000	1,773,000	0	1,519,000	1,519,000	171
6	Cape Agulhas	3744	494,000	484,120	0	489,060	489,060	131
7	George	36000	1,700,000	1,700,000	0	1,700,000	1,700,000	47
8	Oudtshoorn	37000	1,950,000	2,006,400	0	1,978,200	1,978,200	53
9	Laingsburg	4784	73,500	73,740	12	73,620	82,454	17
10	Overberg DM	2900	580,000	444,000	0	512,000	512,000	177
11	Beaufort West	1382	35,000	35,000	0	35,000	35,000	25
						Average	8,151,019	75
						Std_dev	23,845,248	67
						Wtd_avg	n/a	33

4.11 Water Reticulation

There are 13 data sets for the Water reticulation services. The dcvRates are much dispersed and range from R 1 232 pkm pa (Matzikama) to R 60 844 pkm pa (Stellenbosch).

The average dcvRate was calculated to be R 18 174 pkm pa, with a standard deviation of R 16 824 pkm pa, while the weighted average was calculated to be R 21 496 pkm pa.

The higher weighted average could be an indication of diseconomies of scale, meaning that there are forces that cause the larger municipalities to operate their water reticulation services at increased per-unit costs (with the exception of Cape Metro) .

The high *outlying* dcvRate for Stellenbosh municipality causes the average rates to drop to R 14 618 and R16 227 pkm pa respectively, when omitted from the data sets.

Table 31: Water Reticulation Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value			
		Km	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pkm pa	
1	Cape Metro	596	1,430,000	1,430,000	0	1,430,000	1,430,000	2,399	
2	Matzikama	178.5	220,000	220,000	0	220,000	220,000	1,232	
3	Swartland	379	10,346,000	9,932,160	0	10,139,080	10,139,080	26,752	
4	Drakenstein	577	5,652,000	5,652,000	0	5,652,000	5,652,000	9,795	
5	Stellenbosch	476.63	29,000,000	29,000,000	0	29,000,000	29,000,000	60,844	
6	BreedeVallei	318.62	6,680,000	6,680,000	0	6,680,000	6,680,000	20,965	
7	Breederivier	230	530,000	386,900	0	458,450	458,450	1,993	
8	Thewaterskl	72.3	220,000	220,000	25	220,000	275,000	3,804	
9	Cape Agulhas	203.8	4,000,000	2,600,000	0	3,300,000	3,300,000	16,192	
10	George	645	21,540,000	21,540,000	0	21,540,000	21,540,000	33,395	
11	Oudtshoorn	297	7,140,000	7,140,000	0	7,140,000	7,140,000	24,040	
12	Laingsburg	40.5	300,705	411,840	0	356,273	356,273	8,797	
13	Beaufort West	22	716,441	429,865	0	573,153	573,153	26,052	
							Average	6,674,150	18,174
							Std_dev	8,990,590	16,824
							Wtd_avg	n/a	21,496

4.12 Water Treatment

There are 13 data sets for the Water Treatment costs. The dcvRates are dispersed and range from around R 48 pMI pa (Matzikama) to R 4 392 pMI pa (Laingsburg).

The average of the dcvRates were calculated to be R 1 169 per km pa, with a standard deviation of R 1 144 per MI pa, while the weighted average was calculated to be R 810 per MI pa

Although nearly equal to the dcvRate for Cape Metro, the weighted average highlights the influence of economies of scale between the municipalities, and best reflects the influence of higher volumes on the data. The weighted average remains relatively unchanged at R 831 pMI pa if the data for Cape Metro is excluded.

Alternatively, the higher average is influenced by the *outlying* dcvRate of Laingsburg. Should this value be omitted, the average drops to R 900 pMI pa, whilst the weighted average remains unchanged.

Table 32: Water Treatment Statistics

	Municipality	Data from Questionnaire Feedback_2005				Corr_Value		
		MI	Given Rpa	Budget Rpa	%Deficit	Corrected_Rpa	DCV Rpa	dcvRate R pMI pa
1	Cape Metro	251302	202,120,000	202,120,000	0	202,120,000	202,120,000	804
2	Matzikama	8000	380,000	380,000	0	380,000	380,000	48
3	Swartland	4274	5,263,000	5,263,000	0	5,263,000	5,263,000	1,231
4	Drakenstein	13139	9,120,000	9,120,000	80	9,120,000	16,416,000	1,249
5	Stellenbosch	11680	5,710,000	5,710,000	0	5,710,000	5,710,000	489
6	BreedeVallei	12264	7,190,000	7,190,000	0	7,190,000	7,190,000	586
7	Breederivier	5928	11,760,000	11,760,000	0	11,760,000	11,760,000	1,984
8	Thewaterskl	1500	300,000	300,000	25	300,000	375,000	250
9	Cape Agulhas	4780	2,000,000	2,000,000	0	2,000,000	2,000,000	418
10	George	6176	9,300,000	9,300,000	0	9,300,000	9,300,000	1,506
11	Oudtshoorn	6294	2,300,000	2,300,000	20	2,300,000	2,760,000	439
12	Laingsburg	40.8	150,400	208,000	0	179,200	179,200	4,392
13	Beaufort West	200	360,000	360,000	0	360,000	360,000	1,800
						Average	20,293,323	1,169
						Std_dev	54,861,328	1,144
						Wtd_avg	n/a	810

4.13 Summary and Way forward

Table 33 summarises the statistics gathered in Tables 22 to 32 for the services studied.

The following observations are raised about the data and the statistics-

- The data is widely spread (large standard deviations)
- The comparison between weighted averages and straight averages highlight the potential of economy of scale and (in some cases) diseconomy of scale
- There are *outlying* data, which in some cases tends to drive the average dcVRates

Table 33: Summary of Municipal O&M dcVRates

	Municipal Engineering Service	Calculated dcVRates [R per unit pa]			Selected rate*	Ammended Avg when removing high <i>outlying</i> data
		Average dcVRate	Std Dev on Average dcVRate	Weighted Average dcVRate		
1	Km of Gravel Roads	21,673	23,478	20,522	Wtd Avg	10,858
2	Km of Surface Roads	23,007	25,267	13,154	Wtd Avg	13,885
3	Km of Stormwater Reticulation	9,416	10,492	15,451	Average	8,674
4	Km of Stormwater Appurtanences	21,319	23,348	28,077	Average	15,895
5	Km of Sanitation Reticulation	9,513	6,237	8,009	Wtd Average	8790**
6	MI of Sanitation Treated	906	1,026	847	Wtd Average	478
7	Tons of Solid waste Landfill	94	111	52	Average	50
8	Tons of Solid waste Collected	311	244	177	Average	258
9	Tons of Solid waste Transported	75	67	33	Average	53
10	Tons of Solid waste Total	475	398	254	Average	331
11	Km of Water Reticulation	18,174	16,824	21,496	Wtd Average	14,618
12	MI of Water Treated	1,169	1,144	810	Wtd Average	900

* These selected rates are subject to the further evaluations in Chapters 5 & 6

** This value is an amended wtd. Average based on large length

As a way forward, linear regressions were performed on the dcVRates in the light of the variables affecting them.

The data sets were not filtered from *outlying* data, which gave opportunity for the development of 'best fit' regression formulae.

5. Regression Analyses using multi-variables

5.1 Overview

In order to model the dcvRates, it was chosen to do a linear regression analyses of the data.

The annual DCV and the dcvRates are considered to be the dependant variables of the regression. Some of independent variables (parameters) affecting these rates are tabulated in Tables 16 to 18.

The analysis steps shown in Figure 12 are outlined below -

- a) The dependant and their corresponding independent variables were tabulated for each service across the municipalities. The standard deviation and averages (as per Tables 22 to 32) were also displayed to enable stand-alone comparisons with regression results.
- b) Correlations were firstly run between the DCV's (dependant) and independent variables.
- c) The best correlations (preferably exceeding 0.7 or else the closest from 0.4 upwards) were then used to confirm the validity of using the *default* dcvRates (Tables 22 to 32), or for selecting alternative dcvRates for regression. The alternative rates here, are calculated between the total annual cost (DCV) and the well-correlated variable(s) i.e. a rate between this independent variable and the dependant variable; e.g. for the 'pop' variable, the rate = Rands per pop per annum (i.e. R ppop pa).

In cases where more than one dcvRate was prominent, the *default* dcvRate (Tables 22 to 32), or else the highest correlated independent variable was pursued for regression.

- d) The correlation values between the rates (dcvRate) e.g. R pkm pa against the independent variables was then derived;
- e). The correlations between the independent variables were then perused (inter-correlations). From this, the independent variables, which appeared to merit inclusion, were selected for the regression.

In some cases an increasing stepwise regression was run for the dcvRates as dependant variable (with a desired entry level of $F = 4$) - i.e. R pkm pa or per ton or per Ml.

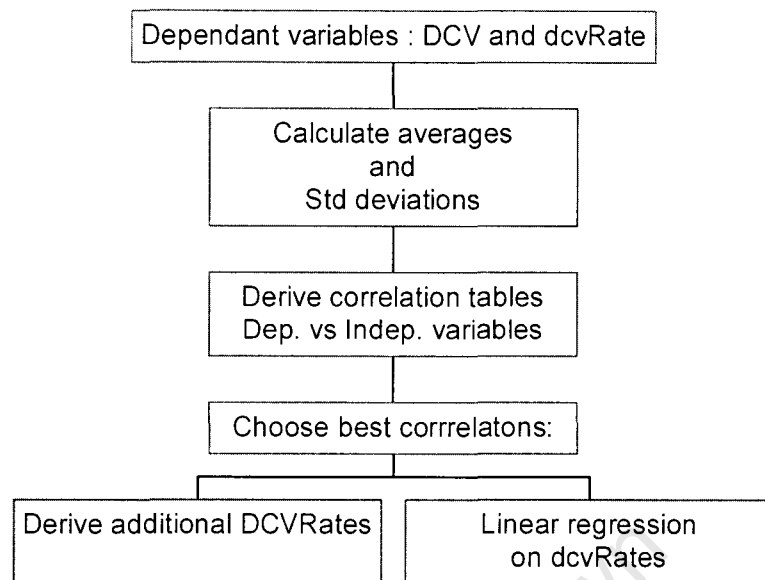


Figure 12: Steps toward the Regression analyses

The following rules of thumb were applied whilst doing the regressions-

- Correlations of 0.7 and more were desired; else work was continued with the next 'best' correlations
- Good correlations between independent variables implied that only one could be included into the regression equation (usually the one that correlated best with the dependant variable)
- R-squared values in excess of 0.7 were considered good;
- A minimum t-stat value of 2 was desired for each independent variable to be considered statistically relevant.

For reference purposes, the following abbreviations were adopted for the variables –

- *DCV* = annual Desired Corrected Value
- *dcvRate* = rates for annual Desired Corrected Value
- *Pop* = The number of erven served by the municipal service
- *Topog* = The percentage steepness of the municipal settlement
- *RU* = The area descriptor defining the level of urbanization (Rural/Urban) of the municipal settlement
- *Km* = The length of road or pipeline service in kilometers
- *Ml* = The volume of water or sanitation treated
- *Ton* = The tonnage of solid waste treated

The results of the multi-variable analyses for each service, are outlined and discussed in sections 5.2 to 5.14

NB:

- Typical Regression Analyses output data are shown in Appendix D
- Although the regression analyses rules of thumb were adhered to as best as possible, there were cases where the closest or next best results were displayed. This implies that if a correlation of 0.7 or higher was not attainable, then marginal correlations down to 0.4 were pursued.
- In some cases the process could not be improved upon and the regression equations were not statistically acceptable, implying that the devRate was the best value that could be obtained from the data set.
- The recommendations in sections 5.2 to 5.14 are tested in Chapter 6: Discussion

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5.2 Gravel Roads

The 'km' (0.6) and 'pop' (0.5) variables correlated best with DCV, and the R pkm pa dcvRate was chosen (higher correlation). All correlations between the dcvRate and the independent variables were statistically invalid.

As a mere formality, step-wise linear regressions were performed on the dcvRate using each independent variable (including 'km'). The 'best' result was for 'pop', yet with a poor R^2 and poor t-stat values. This indicates that the result for the dcvRate cannot be improved upon ($t=3.3$).

Table 34: Gravel Roads: Linear Regression Results

	Mun	km	Pop	Topog	RU	DCV [R pa]	dcvRate [R pkm pa]
1	Cape Met	185	725000	10	1	3600000	19459
2	Cape Bel	111	73068	0	1	1377700	12412
3	Matzikam	48	6843	50	0.8	100000	2083
4	Swartlan	97	32690	10	0	949532	9789
5	Drakenst	54	29463	90	0.8	384000	7111
6	Stellenb	31.8	26433	30	0.5	688266	21644
7	Breedeva	22.5	19431	50	0.5	87860	3905
8	Breederi	50.7	16696	50	1	954643	18829
9	Thewater	12.5	8000	50	0.5	25000	2000
10	Cape Agu	36.2	9481	50	1	504463	13935
11	Hessqua	30	14411	30	0.5	1666000	55533
12	George	74	30000	50	1	5423519	73291
13	Oudtshoo	47	22500	10	1	687500	14628
14	Laingsbu	2	1146	30	0.5	131960	65980
15	Beaufort	8	1650	50	0.5	36000	4500
a	Mean					1,107,763	21,673
	Std_Dev					1,508,059	23,478
	Wtd_Mean					n/a	20,522
b	Correlation with DCV	0.6	0.5	-0.2	0.4		
	Correlation with dcvRate	-0.1	0.0	-0.1	0.1		
	km	1.0	0.8	-0.5	0.3		
	Pop	0.8	1.0	-0.4	0.3		
	Topog	-0.5	-0.4	1.0	0.1		
	RU	0.3	0.3	0.1	1.0		
c: regression	Item	Variables				dcvRate	R= 0.03
	B	0.00				21957	R-Squ = 0.00
	t-stat	-0.1				3.3	AR-squ = -0.08
	Conclusion	Best correlation with DCV is 'km'; but no correlations with dcvRate. The regressions indicate that dcvRate has the only statistically acceptable t-stat. Therefore dcvRate cannot be improved upon.					

5.3 Surfaced Roads

The 'km' (1.0) and 'pop' (1.0) variables correlated best with the DCV. All correlations between the dcvRates and the independent variables were statistically invalid, making it difficult to run meaningful regressions.

The 'highest' correlation with the dcvRate was 'topog' (0.4); this gave a t-stat of 1.0 for the variable, which is low, indicating that the dcvRate was the best predictor. However, a sensitivity check on the resultant regression formula was done (Chapter 6).

Table 35: Surfaced Roads: Linear Regression Results

	Mun	km	Pop	Topog	RU	DCV [R pa]	dcvRate [R pkm pa]	
1	Cape Met	9152	725000	10	1	115200000	12587	
2	Cape Bel	1680	73068	0	1	8208125	4886	
3	Matzikam	110	6843	50	0.8	60000	545	
4	Swartlan	231	32690	10	0	6330447	27405	
5	Drakenst	485	29463	90	0.8	9073500	18708	
6	Stellenb	270	26433	30	0.5	3110178	11519	
7	Breedeva	249.5	19431	50	0.5	2243604	8992	
8	Breederi	178.4	16696	50	1	2727680	15290	
9	Thewater	55	8000	50	0.5	187500	3409	
10	Cape Agu	147.3	9481	50	1	2052692	13935	
11	Hessqua	320	14411	30	0.5	5833000	18228	
12	George	415	30000	50	1	9729119	23444	
13	Oudtshoo	130	22500	10	1	10750000	82692	
14	Laingsbu	14	1146	30	0.5	1152169	82298	
15	Beaufort	12	1650	50	0.5	254000	21167	
a	Mean						11,794,134	23,007
	Std_Dev						28,842,337	25,267
	Wtd_Mean						n/a	13,154
Inter-correlations b	Correlation with DCV	1.0	1.0	-0.4	0.3			
	Correlation with dcvRate	-0.2	-0.1	-0.3	0.0			
	km	1.0	1.0	-0.4	0.3			
	Pop	1.0	1.0	-0.4	0.3			
	Topog	-0.4	-0.4	1.0	0.1			
RU	0.3	0.3	0.1	1.0				
c: regression : 'pop' with dcvRate	Item	Variables				dcvRate	R= 0.13	
	B	-0.02				24256	R-Squ = 0.02	
	t-stat	-0.1				3.4	AdjR-squ = -0.06	
	Conclusion	The poor t-stat for the variable indicates that the dcvRate cannot be improved upon						
c: regression : 'topog' with dcvRate	Item	Variables				dcvRate	R= 0.27	
	B					34037	R-Squ = 0.08	
	t-stat					2.7	AR-squ = 0.00	
	Conclusion	The poor marginal t-stat for the variable indicates that the dcvRate could be the best predictor; however a sensitivity analyses on the formula: Y =34037 - 295*Topog will be done						

5.4 Storm water Reticulation

The variables that correlate best with the DCV are 'km' and 'pop'.

There were no statistically valid correlations between the dcvRate and the independent variables. The correlations between independent variables indicate that 'km' and 'pop' relate best (1.0). All the linear regressions pointed toward the rate as being the best result.

Table 36: Storm water reticulation: Linear Regression Results

	Mun	km	Pop	Topog	RU	DCV [R pa]	dcvRate [R pkm pa]
1	Cape Met	5500	725000	10	1	108900000	19800
2	Cape Bel	500	73068	0	1	668150	1336
3	Matzikam	88	6843	50	0.8	30000	341
4	Swartlan	194	32690	10	0	704594	3632
5	Drakenst	250	29463	90	0.8	1350000	5400
6	Stellenb	220	26433	30	0.5	1042500	4739
7	Breedeva	250	19431	50	0.5	410000	1640
8	Breederi	150.2	16696	50	1	241340	1607
9	Thewater	22	8000	50	0.5	37500	1705
10	Cape Agu	33.8	9481	50	1	214300	6340
11	Hessqua	34	14411	30	0.5	500000	14706
12	George	255	30000	50	1	1413774	5544
13	Oudtshoo	40	22500	10	1	750000	18750
14	Laingsbu	7.8	1146	30	0.5	297960	38200
15	Beaufort	6	1650	50	0.5	105000	17500
a	Mean					7,777,675	9,416
	Std_Dev					27,978,135	10,492
	Wtd_Mean					n/a	15,451
b Inter-correlations	Correlation with DCV	1.0	1.0	-0.3	0.3		
	Correlation with dcvRate	0.2	0.2	-0.3	-0.1		
	km	1.0	1.0	-0.3	0.3		
	Pop	1.0	1.0	-0.4	0.3		
	Topog	-0.3	-0.4	1.0	0.1		
	RU	0.3	0.3	0.1	1.0		
c: regression	Item	Variables				dcvRate	R= 0.23
	B	0.01				8503	R-Squ = 0.05
	t-stat	0.9				2.9	AR-squ = -0.02
	Conclusion	The poor t-stat for the variable indicates that the dcvRate cannot be improved upon					

5.5 Storm water Appurtenances

The variables that correlate best with the DCV are 'km' and 'pop'. There were no statistically valid correlations between the dcvRate and the independent variables. The correlations between independent variables indicate that 'km' and 'pop' relate best (1.0).

A linear regression was performed on dcvRate using 'pop' and step-wise additions of the remaining variables. The results are marginal for 'pop' and acceptable for 'RU'. When running the regression with 'RU' on its own, the t-stat for 'RU' drops to 1.7, which is marginally acceptable. Two equations were thus produced for further validation (Chapter 6).

Table 37: Storm water appurtenances: Linear Regression Results

	Mun	km	Pop	Topog	RU	DCV [R pa]	dcvRate [R pkm pa]
1	Cape Met	5500	725000	10	1	216000000	39273
2	Cape Bel	500	73068	0	1	575000	1150
3	Matzikam	88	6843	50	0.8	10000	114
4	Drakenst	250	29463	90	0.8	2091600	8366
5	Stellenb	220	26433	30	0.5	2450000	11136
6	Breederi	150.2	16696	50	1	380000	2530
7	Cape Agu	33.8	9481	50	1	980000	28994
8	Hessqua	34	14411	30	0.5	1000000	29412
9	George	255	30000	50	1	4309200	16899
10	Oudtshoo	40	22500	10	1	125000	3125
11	Laingsbu	7.8	1146	30	0.5	631800	81000
12	Beaufort	6	1650	50	0.5	203000	33833
a	Mean					19,062,967	21,319
	Std_Dev					62,031,574	23,348
	Wtd_Mean					n/a	32,288
Inter-correlations	Correlation with DCV	1.0	1.0	-0.4	0.3		
	Correlation with dcvRate	0.2	0.2	-0.1	-0.5		
	km	1.0	1.0	-0.4	0.3		
	Pop	1.0	1.0	-0.4	0.3		
	Topog	-0.4	-0.4	1.0	-0.1		
	RU	0.3	0.3	-0.1	1.0		
c: regression : dcvRate with 'pop' and 'RU'	Item	Variables			dcvRate	R= 0.59	
	B		0.04		-58650	64815	R-Squ = 0.35
	t-stat		1.3		-2.1	2.8	AR-squ = 0.20
	Conclusion	Y = (64815 - 58650*RU + 0.04*Pop) : to be validated (Chapter 6). Low t-stat for 'pop'					
c: regression : dcvRate with 'RU' only	Item	Variables			dcvRate	R= 0.47	
	B				-470334	58946	R-Squ = 0.22
	t-stat				-1.7	2.5	AR-squ = 0.14
	Conclusion	Y = (58946 - 47034*RU) : to be validated (Chapter 6). Marginal t-stat for 'RU'					

5.6 Sanitation Reticulation

The variables that correlate best with the DCV are 'km' and 'pop', whilst for the dcvRate, the 'RU' variable showed some correlation (-0.5). The correlations between independent variables indicate that 'km' and 'pop' relate best (0.8).

A linear regression was performed on the dcvRates using 'pop' and step-wise additions of the remaining variables. The result showed acceptably for 'RU' only on both dcvRates considered. The t-stats for dcvRate (R pkm pa) are better than that for the 'R ppop pa' rate; however, the 'RU' t-stat is still marginal (1.7).

As shown in Table 38, only one formula is thus considered for recommendation and further validation in Chapter 6.

Table 38: Sanitation Reticulation Linear Regression Results

	Mun	km	Pop	Topog	RU	DCV [R pa]	dcvRate1 [R pkm pa]	dcvRate2 [R ppop pa]
1	Matzikam	103	6843	50	0.8	50000	485	7.3
2	Swartlan	278	32690	10	0	3698344	13303	113.1
3	Stellenb	242	26433	30	0.5	2735753	11305	103.5
4	BreedeVa	230.3	19431	50	0.5	2280000	9900	117.3
5	Breederi	265	16696	50	1	205516	776	12.3
6	Cape Agu	63.1	9481	50	1	607750	9632	64.1
7	George	650	30000	50	1	4100000	6308	136.7
8	Oudtshoo	188	22500	10	1	2140000	11383	95.1
9	Laingsbu	24	1146	30	0.5	236400	9850	206.3
10	Beaufort	22	1650	50	0.5	488160	22189	295.9
a	Mean					1,654,192	9,513	115
	Std_Dev					1,530,971	6,237	86
	Wtd_Mean					n/a	8,009	99
b Inter- correlations	Correlation with DCV	0.8	0.9	-0.4	-0.3			
	Correlation with dcvRate1	-0.3	-0.1	-0.3	-0.5			
	km	1.0	0.8	0.0	0.2			
	Pop	0.8	1.0	-0.4	-0.1			
	Topog	0.0	-0.4	1.0	0.4			
	RU	0.2	-0.1	0.4	1.0			
c: regression: dcvRate1 [R pkm pa] with 'RU'	Item	Variables				dcvRate	R= 0.5	
	B				-9429	15925	R-Squ = 0.26	
	t-stat				-1.7	3.8	AdjR-squ = 0.17	
	Conclusion	Y= (15925 -9429*RU) : to be validated (Chapter 6) . Marginal t-stat for 'RU'						
d: regression: dcvRate2 [R ppop pa] with 'RU'	Item	Variables				dcvRate	R= 0.4	
	B				-106	187	R-Squ = 0.17	
	t-stat				-1.3	3.0	AR-squ = 0.07	
	Conclusion	Discard this regression: t-stat for 'RU' too low						

5.7 Sanitation Treatment

The variable that correlates best with the DCV, is 'pop' (0.6). The dcvRate thus adopted was 'R ppop pa'.

For the dcvRate, the 'RU' variable correlated marginally (0.5) and the correlations between independent variables indicate that 'MI' and 'pop' relate best but marginally (0.6). Linear regressions were performed on the dcvRate (i.e. on 'R ppop pa'), using step-wise additions of the variables. Table 39 shows the results.

Table 39: Sanitation Treatment Linear Regression results

	Mun	MI	Pop	Topog	RU	DCV	dcvRate1 [R pMI pa]	dcvRate2 [R ppop pa]	
1	Matzikam	630	6843	50	0.8	120000	190	18	
2	Swartlan	4380	32690	10	0	4822128	1101	148	
3	Stellenb	8067	26433	30	0.5	1947404	241	74	
4	BreedeVa	10293	19431	50	0.5	1080012	105	56	
5	Breederi	2520	16696	50	1	8228172	3265	493	
6	Cape Agu	3920	9481	50	1	1725295	440	182	
7	George	6137	30000	50	1	12120000	1975	404	
8	Oudtshoo	2617	22500	10	1	3060000	1169	136	
9	Laingsbu	185	1146	30	0.5	16500	89	14	
10	Beaufort	825	1650	50	0.5	400847	486	243	
a	Mean					3,352,036	906	177	
	Std_Dev					3,985,573	1,026	162	
	Wtd_Mean					n/a	847	201	
b	Inter-correlations								
	Correlation with DCV	0.2	0.6	0.1	0.4				
	Correlation with dcvRate[Pop]	0.0	0.2	0.3	0.5				
	MI	1.0	0.6	0.1	-0.2				
	Pop	0.6	1.0	-0.4	-0.1				
	Topog	0.1	-0.4	1.0	0.4				
RU	-0.2	-0.1	0.4	1.0					
c1: regression: dcvRate [R ppop pa] with 'RU'	Item	Variables				dcvRate	R= 0.45		
	B				218	29	R-Squ = 0.20		
	t-stat				1.4	0.3	AR-squ = 0.11		
	Conclusion	Reject regression result : t-stats are statistically inadequate							
c2: regression: dcvRate [R ppop pa] without 'RU'	Item	Variables				dcvRate	R= 0.78		
	B	-0.04	0.02	8.58		-265	R-Squ = 0.61		
	t-stat	-2.2	2.8	2.8		-1.6	AR-squ = 0.42		
	Conclusion	The t-stats for the variables are adequate, but that for the constant is marginal. The result will be further validated in Chapter 6: Y = (8.56*Topog + 0.02*Pop - 0.04*MI - 265)							
c3: regression: dcvRate [R ppop pa] without 'RU' and 'MI'	Item	Variables				dcvRate	R= 0.54		
	B		0.007	5.10		-130	R-Squ = 0.29		
	t-stat		1.3	1.5		-0.7	AR-squ = 0.09		
Conclusion	Reject regression result : t-stats are statistically inadequate								

5.8 Solid Waste Landfill

The variables that correlate best with the DCV are 'ton', 'pop' and 'topog', whilst for the dcvRate, the 'topog' variable was highest (0.6). As expected, there is a very good correlation between 'ton' and 'pop' (1.0). There is also a good correlation between 'topog' and the variables 'pop' and 'ton' (0.6).

A linear regression was performed on the default dcvRate (i.e. R pton pa) using 'pop' and step-wise additions of the remaining variables, until statistically acceptable results were achieved. As shown in Table 40, the dcvRate (regression c) appears to be the best predictor.

Table 40 Solid waste Landfill Linear Regression results

	Mun	Ton	Pop	Topog	RU	DCV [R pa]	dcvRate [R pton pa]	
1	Cape Met	1990000	725000	10	1	112380000	56	
2	Matzikam	2000	6843	50	0.8	200000	100	
3	Stellenb	190665	26433	30	0.5	2942550	15	
4	BreedeVa	65000	19431	50	0.5	330000	5	
5	Breederi	6780	16696	50	1	1048000	155	
6	Cape Agu	3600	9481	50	1	842955	234	
7	George	36000	30000	50	1	2793000	78	
8	Oudtshoo	37000	22500	10	1	428123	12	
9	Laingsbu	4784	1146	30	0.5	61712	13	
10	Overberg	2900	16966	70	0.5	1009200	348	
11	Beaufort	1382	1650	50	0.5	27500	20	
a	Mean						11,096,640	94
	Std_Dev						33,607,140	111
	Wtd_Mean						n/a	52
b Inter- correlations	Correlation with DCV	1.0	1.0	-0.6	0.3			
	Correlation with dcvRate	-0.2	-0.1	0.6	0.1			
	Ton	1.0	1.0	-0.6	0.3			
	Pop	1.0	1.0	-0.6	0.3			
	Topog	-0.6	-0.6	1.0	-0.3			
	RU	0.3	0.3	-0.3	1.0			
c : regression : dcvRate with 'pop' only	Item	Variables				dcvRate	R= 0.12	
	B	-5.96E-05				99	R-Squ = 0.01	
	t-stat	-0.35				2.64	AR-squ = -0.1	
	Conclusion	The t-stat for the constant is statistically acceptable, but not that of the variable. This could imply that the dcvRate is the best predictor						
d : regression : dcvRate with 'topog' and 'RU'	Item	Variables				dcvRate	R= 0.72	
	B					4	156	
	t-stat					2.86	1.36	
	Conclusion	The regression is rejected because of the low t-stat values for the 'RU and the constant						
e : regression : dcvRate with 'topog' only	Item	Variables				dcvRate	R= 0.63	
	B					4	-59	
	t-stat					2.5	-0.9	
	Conclusion	The t-stat for the constant is not statistically acceptable, so the regression is rejected						

5.9 Solid Waste Collection

The variables that correlate best with the DCV are 'ton', 'pop' and 'topog', whilst for the dcvRate, the 'topog' variable was highest (0.7). As expected, there is a good correlation between 'ton' and 'pop' (1.0). There is also a good correlation between 'topog' and the variables 'pop' and 'ton' (0.6).

A linear regression was performed on the dcvRate using 'pop' and step-wise additions of the remaining variables. As shown in Table 41, the dcvRate (regression c) appears to be the best predictor.

Table 41: Solid waste Collection Linear Regression results

	Mun	Ton	Pop	Topog	RU	DCV [R pa]	dcvRate1 [R pton pa]	
1	Cape Met	2430000	725000	10	1	434500000	179	
2	Matzikam	2000	6843	50	0.8	720000	360	
3	Stellenb	140000	26433	30	0.5	18395000	131	
4	BreedeVa	70757	19431	50	0.5	797500	11	
5	Breederi	8900	16696	50	1	2846000	320	
6	Cape Agu	3744	9481	50	1	1980000	529	
7	George	36000	30000	50	1	18100000	503	
8	Oudtshoo	37000	22500	10	1	3268760	88	
9	Laingsbu	4784	1146	30	0.5	572320	120	
10	Overberg	2900	16966	70	0.5	2436000	840	
11	Beaufort	1382	1650	50	0.5	469840	340	
a	Mean						44,007,765	311
	Std_Dev						129,685,412	244
	Wtd_Mean						n/a	177
b Inter-correlations	Correlation with DCV	1.0	1.0	-0.6	0.3			
	Correlation with dcvRate	-0.2	-0.2	0.7	0.1			
	Ton	1.0	1.0	-0.6	0.3			
	Pop	1.0	1.0	-0.6	0.3			
	Topog	-0.6	-0.6	1.0	-0.3			
	RU	0.3	0.3	-0.3	1.0			
c : regression : dcvRate with 'pop' only	Item	Variables				dcvRate	R= 0.18	
	B	-2.10E-04				327	R-Squ = 0.03	
	t-stat	-0.6				4.0	AR-squ = -0.10	
	Conclusion	The t-stat for the constant is statistically acceptable, but not that of the variable. This could imply that the dcvRate is the best predictor						
d : regression : dcvRate with 'topog' and 'RU'	Item	Variables				dcvRate	R= 0.77	
	B					11	319	
	t-stat					-362	-1.5	
	Conclusion	The regression is rejected because of the low t-stat values for the 'RU' and the constant						
e : regression : dcvRate with 'topog' only	Item	Variables				dcvRate	R= 0.71	
	B					9	-66	
	t-stat					3.0	-0.5	
	Conclusion	The t-stat for the constant is not statistically acceptable; so the regression is rejected						

5.10 Solid Waste Transport

The variables that correlate best with the DCV are 'ton', 'pop' and 'topog', whilst for the dcvRate, the 'topog' variable was highest (0.6). As expected, there is a good correlation 'ton' and 'pop' (1.0). There is also a good correlation between 'topog' and the variables 'pop' and 'ton' (0.6).

A linear regression was performed on the dcvRate using 'pop' and step-wise additions of the remaining variables. As shown in Table 42, the dcvRate (regression c), and the outcome of regression (d) will be further validated in Chapter 6

Table 42: Solid waste Transport Linear Regression results

	Mun	Ton	Pop	Topog	RU	DCV [R pa]	dcvRate1 [R pton pa]
1	Cape Met	2430000	725000	10	1	79990000	33
2	Matzikam	2000	6843	50	0.8	290000	145
3	Stellenb	140000	26433	30	0.5	2944500	21
4	BreedeVa	70757	19431	50	0.5	121000	2
5	Breederi	8900	16696	50	1	1519000	171
6	Cape Agu	3744	9481	50	1	489060	131
7	George	36000	30000	50	1	1700000	47
8	Oudtshoo	37000	22500	10	1	1978200	53
9	Laingsbu	4784	1146	30	0.5	82454	17
10	Overberg	2900	16966	70	0.5	512000	177
11	Beaufort	1382	1650	50	0.5	35000	25
a	Mean					8,151,019	75
	Std_Dev					23,845,248	67
	Wtd_Mean					n/a	33
b Inter-correlations	Correlation with DCV	1.0	1.0	-0.6	0.3		
	Correlation with dcvRate	-0.2	-0.2	0.6	0.3		
	Ton	1.0	1.0	-0.6	0.3		
	Pop	1.0	1.0	-0.6	0.3		
	Topog	-0.6	-0.6	1.0	-0.3		
	RU	0.3	0.3	-0.3	1.0		
c : regression : dcvRate with 'pop' only	Item	Variables			dcvRate	R= 0.21	
	B	-6.58E-05			80	R-Squ = 0.04	
	t-stat	-0.7			3.6	AR-squ = -0.06	
	Conclusion	The t-stat for the constant is statistically acceptable, but not that of the variable. This could imply that the dcvRate is the best predictor					
d : regression : dcvRate with 'topog' and 'RU'	Item	Variables			dcvRate	R= 0.74	
	B				2.5	141	-136 R-Squ = 0.55
	t-stat				2.8	2.1	-1.9 AR-squ = 0.44
	Conclusion	The t-stats are acceptable and the formula : $Y = 2.5 * \text{Topog} + 141 * \text{RU} - 136$ will be further evaluated in Chapter 6					
e : regression : dcvRate with 'topog' only	Item	Variables			dcvRate	R= 0.54	
	B				2.0	-5	R-Squ = 0.30
	t-stat				2.0	-0.1	AR-squ = 0.22
	Conclusion	The t-stat for the constant is not statistically acceptable; so the regression is rejected					

5.11 Solid Waste Total

The variables that correlate best with the DCV are 'ton', 'pop' and 'topog', whilst for the dcvRate, the 'topog' variable was highest (0.7). As expected, there is a good correlation 'ton' and 'pop' (1.0). There is also a good correlation between 'topog' and the variables 'pop' and 'ton' (0.6).

A linear regression was performed on the dcvRate using 'pop' and step-wise additions of the remaining variables. As shown in Table 43, the dcvRate (regression c), and the outcome of regression (d) will be further validated in Chapter 6.

Table 43: Solid waste Total Linear Regression results

	Mun	Ton	Pop	Topog	RU	DCV [R pa]	dcvRate1 [R pton pa]	
1	Cape Met	2430000	725000	10	1	626870000	258	
2	Matzikam	2000	6843	50	0.8	1210000	605	
3	Stellenb	140000	26433	30	0.5	24282050	173	
4	BreedeVa	70757	19431	50	0.5	1248500	18	
5	Breederi	8900	16696	50	1	5413000	608	
6	Cape Agu	3744	9481	50	1	3312015	885	
7	George	36000	30000	50	1	22593000	628	
8	Oudtshoo	37000	22500	10	1	5675083	153	
9	Laingsbu	4784	1146	30	0.5	716486	150	
10	Overberg	2900	16966	70	0.5	3957200	1365	
11	Beaufort	1382	1650	50	0.5	532340	385	
a	Mean						63,255,425	475
	Std_Dev						187,121,425	398
	Wtd_Mean						n/a	254
b	Inter-correlations							
	Correlation with DCV	1.0	1.0	-0.6	0.3			
	Correlation with dcvRate	-0.2	-0.2	0.7	0.1			
	Ton	1.0	1.0	-0.6	0.3			
	Pop	1.0	1.0	-0.6	0.3			
	Topog	-0.6	-0.6	1.0	-0.3			
RU	0.3	0.3	-0.3	1.0				
c : regression : dcvRate with 'pop' only	Item	Variables				dcvRate	R= 0.18	
	B	-3.40E-04				502	R-Squ = 0.03	
	t-stat	-0.6				3.8	AR-squ = -0.1	
	Conclusion	The t-stat for the constant is statistically acceptable, but not that of the variable. This could imply that the dcvRate is the best predictor						
d : regression : dcvRate with 'topog' and 'RU'	Item	Variables				dcvRate	R= 0.78	
	B					17	588	
	t-stat					3.5	1.6	
	Conclusion	The t-stat values for the 'RU and the constant are marginal. The formula : (Y = 17*topog + 588* RU - 677) will be evaluated in Chapter 6						
e : regression : dcvRate with 'topog' only	Item	Variables				dcvRate	R= 0.70	
	B					15	-133	
	t-stat					3.0	-0.6	
	Conclusion	The t-stat for the constant is not statistically acceptable; so the regression is rejected						

5.12 Water Reticulation

The variable that correlates best with the DCV is 'km'. There are no acceptable correlations with the dcvRate. The correlations between independent variables were equally unacceptable.

A linear regression was performed on the dcvRate using 'pop' and step-wise additions of the remaining variables. As shown in Table 44, the results showed closest only for the regression with the 'RU' variable. However, the t-stat for 'RU' and R² values are very low. The indications are therefore that the dcvRate could be the best predictor of the data.

Table 44: Water reticulation Linear Regression results

	Mun	km	Pop	Topog	RU	DCV [R pa]	dcvRate1 [R pkm pa]	
1	Cape Met	596	725000	10	1	1430000	2399	
2	Matzikam	178.5	6843	50	0.8	220000	1232	
3	Swartlan	379	32690	10	0	10139080	26752	
4	Drakenst	577	29463	90	0.8	5652000	9795	
5	Stellenb	476.63	26433	30	0.5	29000000	60844	
6	Breedeva	318.62	19431	50	0.5	6680000	20965	
7	Breederi	230	16696	50	1	458450	1993	
8	Thewater	72.3	8000	50	0.5	275000	3804	
9	Cape Agu	203.8	9481	50	1	3300000	16192	
10	George	645	30000	50	1	21540000	33395	
11	Oudtshoo	297	22500	10	1	7140000	24040	
12	Laingsbu	40.5	1146	30	0.5	356273	8797	
13	Beaufort	22	1650	50	0.5	573153	26052	
a	Mean						6,674,150	18,174
	Std_Dev						8,990,590	16,824
	Wtd_Mean						n/a	21,496
b Inter- correlations	Correlation with DCV	0.6	-0.1	-0.1	-0.1			
	Correlation with dcvRate	0.3	-0.3	-0.2	-0.3			
	km	1.0	0.4	0.0	0.3			
	Pop	0.4	1.0	-0.4	0.3			
	Topog	0.0	-0.4	1.0	0.2			
	RU	0.3	0.3	0.2	1.0			
c: regression : 'RU' with dcvRate	Item	Variables				dcvRate	R= 0.3	
	B				-15785	29223	R-Squ =0.1	
	t-stat				-1.0	2.5	AR-squ =0.0	
	Conclusion	The t-stat for the constant is statistically acceptable, but not that of the variable. This could imply that the dcvRate is the best predictor						

5.13 Water Treatment

The variables that correlate best with the DCV are 'MI' and 'pop' (1.0). No decent correlations were found between the dcvRate and the independent variables. The correlations between independent variables indicate that 'MI' and 'pop' relate best (1.0).

A linear regression was performed on dcvRate using 'pop' and step-wise additions of the remaining variables. The result showed acceptably for the constant only.

Table 45: Water Treatment Linear Regression results

	Mun	MI	Pop	Topog	RU	DCV [R pa]	dcvRate [R pMI pa]	
1	Cape Met	251302	725000	10	1	2.00E+08	804	
2	Matzikam	8000	6843	50	0.8	380000	48	
3	Swartlan	4274	32690	10	0	5263000	1231	
4	Drakenst	13139	29463	90	0.8	16416000	1249	
5	Stellenb	11680	26433	30	0.5	5710000	489	
6	Breedeva	12264	19431	50	0.5	7190000	586	
7	Breederi	5928	16696	50	1	11760000	1984	
8	Thewater	1500	8000	50	0.5	375000	250	
9	Cape Agu	4780	9481	50	1	2000000	418	
10	George	6176	30000	50	1	9300000	1506	
11	Oudtshoo	6294	22500	10	1	2760000	439	
12	Laingsbu	40.8	1146	30	0.5	179200	4392	
13	Beaufort	200	1650	50	0.5	360000	1800	
a	Mean						20,130,246	1,169
	Std_Dev						54,275,829	1,144
	Wtd_Mean						n/a	804
b	Inter-correlations							
	Correlation with DCV	1.0	1.0	-0.4	0.3			
	Correlation with dcvRate	-0.1	-0.1	0.0	-0.2			
	MI	1.0	1.0	-0.4	0.3			
	Pop	1.0	1.0	-0.4	0.3			
	Topog	-0.4	-0.4	1.0	0.2			
RU	0.3	0.3	0.2	1.0				
c: regression : 'RU' with dcvRate	Item	Variables				dcvRate	R= 0.11	
	B	0				1215	R-Squ = 0.01	
	t-stat	-0.4				3.5	AR-squ = -0.08	
	Conclusion	The t-stat for the constant is statistically acceptable, but not that of the variable. This could imply that the dcvRate is the best predictor						

5.14 Summary

The multi-variable analyses provided a platform for identifying which variables best correlate with the DCV's and dcvRates. The regressions further explored the possibility of finding formulae, if any, for modelling the dcvRates across the various services.

These results are summarized in Table 46.

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Table 46: Summary of Multi-variable analyses results

	Service	dcvRate adopted from correlations between variables and DCV	Regression analyses results on dcvRate [Rand per unit pa]**	Way forward*
1	Gravel Roads	R pkm pa	Not acceptable	Use dcvRate
2	Surfaced Roads	R pkm pa	Marginal result $Y = (34037 - 295*Topog)$	Check formula against dcvRate across municipalities
3	Storm water reticulation	R pkm pa	Not acceptable	Use dcvRate
4	Storm water appurtances	R pkm pa	Marginal result $Y = (64815 - 58650*RU + 0.04*Pop)$	Check formula against dcvRate across municipalities
			Marginal result $Y = (58946 - 47034*RU)$	Check formula against dcvRate across municipalities
5	Sanitation reticulation	R pkm pa	Marginal result $Y = (15925 - 9429*RU)$	Check formula against dcvRate across municipalities
6		R ppop pa	Not acceptable	Use dcvRate
7	Sanitation Treatment	R ppop pa	Marginal result $Y = (8.56*Topog + 0.02*Pop - 0.04*MI - 265)$	Check formula against dcvRate across municipalities
8	Solid waste Landfill	R pton pa	Not acceptable	Use dcvRate
9	Solid waste Collection	R pton pa	Not acceptable	Use dcvRate
10	Solid waste Transport	R pton pa	Acceptable $Y = 2.5* Topog + 141*RU - 136$	Check formula against dcvRate across municipalities
11	Solid waste Total	R pton pa	Marginal $Y = 17*topog + 588* RU - 677)$	Check formula against dcvRate across municipalities
12	Water reticulation	R pkm pa	Not acceptable	Use dcvRate
13	Water Treatment	R pMI pa	Not acceptable	Use dcvRate

*These results were evaluated in the sensitivity tests in Chapter 6

6. Discussion of Analyses Outcomes

This chapter addresses the issue of testing the results recorded in Chapters 4 and 5 (Tables 33 and 46).

This was done by comparing the dcvRates and averages as derived from the observed data (Table 33) with that derived from the multi-variable analyses formulae in Table 46 (if any).

Furthermore, an attempt was made to validate the results by comparing it to the external data sets derived in the Literature Review (Table 3).

6.1 Comparison of dcvRates

The comparisons are shown in Tables 47 through 58. The following data are highlighted –

- The dcvRates for the individual services across municipalities (observed rates)
- The average and regressed dcvRates (expected rates)

Comparison criteria

The following criteria were used to set tolerances for screening the rates and identifying the most suitable option (s) -

- An upper ratio limit of 1.5 between the ‘observed’ and ‘expected’ rates
- A lower ratio limit of 0.7 between the ‘observed’ and ‘expected’ rates
- A mean ratio closest to 1.0 between the ‘observed’ and ‘expected’ rates

The above criteria (developed by the author) were used to derive at a weighted percentage score for each ‘expected’ dcvRate as follows-

$$\text{Score} = \frac{(\text{RE}) * 10 + (\text{NE} - \text{LL}) * 5 + (\text{NE} - \text{UL}) * 3}{\text{NE} * 10} * 100$$

Where:

- LL = Number of ratios exceeding lower limit of 0.7
- UL = Number of ratios less than upper limit of 1.5
- NE = Number of data entries (municipalities)
- RE = Number of ratios within the criteria envelope

NB: The higher multiplier (5) is set for (NE – LL) because this difference equates to higher, more conservative, predictions or budget estimates, as apposed to the lower multiplier (3) for (NE – UL).

6.1.1 Gravel Roads

As shown in Table 47, the weighted average produces the best score given the screening criteria. It is therefore recommended.

Table 47: Gravel roads: Comparison of dcvRates [R pkm pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression	Ratio
1	Cape Met	19459	20522	0.9	21673	0.9	10858	1.8	na	na
2	Cape Bel	12412	20522	0.6	21673	0.6	10858	1.1		
3	Matzikam	2083	20522	0.1	21673	0.1	10858	0.2		
4	Swartlan	9789	20522	0.5	21673	0.5	10858	0.9		
5	Drakenst	7111	20522	0.3	21673	0.3	10858	0.7		
6	Stellenb	21644	20522	1.1	21673	1.0	10858	2.0		
7	Breedeva	3905	20522	0.2	21673	0.2	10858	0.4		
8	Breederi	18829	20522	0.9	21673	0.9	10858	1.7		
9	Thewater	2000	20522	0.1	21673	0.1	10858	0.2		
10	Cape Agu	13935	20522	0.7	21673	0.6	10858	1.3		
11	Hessqua	55533	20522	2.7	21673	2.6	10858	5.1		
12	George	73291	20522	3.6	21673	3.4	10858	6.7		
13	Oudtshoo	14628	20522	0.7	21673	0.7	10858	1.3		
14	Laingsbu	65980	20522	3.2	21673	3.0	10858	6.1		
15	Beaufort	4500	20522	0.2	21673	0.2	10858	0.4		
Ratios > Lower Limit (0.7)				9	8	11				
Ratios < Upper Limit (1.5)				12	12	9				
Ratios within envelope				6	5	5	na			
Mean ratio				1.1	1.0	2.0				
Score				66%	63%	59%				

6.1.2 Surfaced Roads

The best score is attained by the straight average. It is therefore recommended.

Table 48: Surfaced Roads: Comparison of dcvRates [R pkm pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression	Ratio
1	Cape Met	12587	13154	1.0	23007	0.5	13885	0.9	31087	0.4
2	Cape Bel	4886	13154	0.4	23007	0.2	13885	0.4	34037	0.1
3	Matzikam	545	13154	0.0	23007	0.0	13885	0.0	19287	0.0
4	Swartlan	27405	13154	2.1	23007	1.2	13885	2.0	31087	0.9
5	Drakenst	18708	13154	1.4	23007	0.8	13885	1.3	7487	2.5
6	Stellenb	11519	13154	0.9	23007	0.5	13885	0.8	25187	0.5
7	Breedeva	8992	13154	0.7	23007	0.4	13885	0.6	19287	0.5
8	Breederi	15290	13154	1.2	23007	0.7	13885	1.1	19287	0.8
9	Thewater	3409	13154	0.3	23007	0.1	13885	0.2	19287	0.2
10	Cape Agu	13935	13154	1.1	23007	0.6	13885	1.0	19287	0.7
11	Hessqua	18228	13154	1.4	23007	0.8	13885	1.3	25187	0.7
12	George	23444	13154	1.8	23007	1.0	13885	1.7	19287	1.2
13	Oudtshoo	82692	13154	6.3	23007	3.6	13885	6.0	31087	2.7
14	Laingsbu	82298	13154	6.3	23007	3.6	13885	5.9	25187	3.3
15	Beaufort	21167	13154	1.6	23007	0.9	13885	1.5	19287	1.1
Ratios >Lower Limit (0.7)				12	9		12		9	
Ratios < Upper Limit (1.5)				10	13		10		12	
Ratios within envelope				7	7		7		6	
Mean ratio				1.7	1.0		1.7		1.0	
Score				67%	71%		67%		66%	

6.1.3 Storm water Reticulation

The weighted mean has the highest score and is recommended although it has the lowest mean ratio. The weighted mean is also more conservative (predictions comparatively larger) and it displays the most ratios within the design envelope.

Table 49: Storm water reticulation: Comparison of dcvRates [R pkm pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression	Ratio
1	Cape Met	19800	15451	1.3	9416	2.1	8674	2.3	na	na
2	Cape Bel	1336	15451	0.1	9416	0.1	8674	0.2		
3	Matzikam	341	15451	0.0	9416	0.0	8674	0.0		
4	Swartlan	3632	15451	0.2	9416	0.4	8674	0.4		
5	Drakenst	5400	15451	0.3	9416	0.6	8674	0.6		
6	Stellenb	4739	15451	0.3	9416	0.5	8674	0.5		
7	Breedeva	1640	15451	0.1	9416	0.2	8674	0.2		
8	Breederi	1607	15451	0.1	9416	0.2	8674	0.2		
9	Thewater	1705	15451	0.1	9416	0.2	8674	0.2		
10	Cape Agu	6340	15451	0.4	9416	0.7	8674	0.7		
11	Hessqua	14706	15451	1.0	9416	1.6	8674	1.7		
12	George	5544	15451	0.4	9416	0.6	8674	0.6		
13	Oudtshoo	18750	15451	1.2	9416	2.0	8674	2.2		
14	Laingsbu	38200	15451	2.5	9416	4.1	8674	4.4		
15	Beaufort	17500	15451	1.1	9416	1.9	8674	2.0		
Ratios > Lower Limit (0.7)				5		6		8		
Ratios < Upper Limit (1.5)				14		10		10		
Ratios within envelope				4		1		3		na
Mean ratio				0.6		1.0		1.1		
Score				62%		47%		53%		

6.1.4 Storm water Appurtenances

The weighted average has the highest score. Although the straight average and regressed rates have better mean ratios, they tend to predict fewer ratios within the design envelope and more ratios above the upper limit; i.e. they are less conservative.

The weighted average is therefore recommended.

Table 50: Storm water Appurtenances: Comparison of dcvRates [R pkm pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio	Regression2	Ratio
1	Cape Met	39273	28077	1.4	21319	1.8	15895	2.5	35165	1.1	11912	3.3
2	Cape Bel	1150	28077	0.0	21319	0.1	15895	0.1	9088	0.1	11912	0.1
3	Matzikam	114	28077	0.0	21319	0.0	15895	0.0	18169	0.0	21319	0.0
4	Drakenst	8366	28077	0.3	21319	0.4	15895	0.5	19074	0.4	21319	0.4
5	Stellenb	11136	28077	0.4	21319	0.5	15895	0.7	36547	0.3	35429	0.3
6	Breederi	2530	28077	0.1	21319	0.1	15895	0.2	6833	0.4	11912	0.2
7	Cape Agu	28994	28077	1.0	21319	1.4	15895	1.8	6544	4.4	11912	2.4
8	Hessqua	29412	28077	1.0	21319	1.4	15895	1.9	36066	0.8	35429	0.8
9	George	16899	28077	0.6	21319	0.8	15895	1.1	7365	2.3	11912	1.4
10	Oudtshoo	3125	28077	0.1	21319	0.1	15895	0.2	7065	0.4	11912	0.3
11	Laingsbu	81000	28077	2.9	21319	3.8	15895	5.1	35536	2.3	35429	2.3
12	Beaufort	33833	28077	1.2	21319	1.6	15895	2.1	35556	1.0	35429	1.0
Ratios >Lower Limit (0.7)				6		6		7		6		6
Ratios < Upper Limit (1.5)				11		9		7		9		9
Ratios within envelope				5		3		2		3		3
Mean ratio				0.8		1.0		1.3		1.1		1.0
Score				69%		58%		50%		58%		58%

6.1.5 Sanitation Reticulation

The straight average has the highest score and enjoys more ratios within the envelope. It is therefore recommended.

Table 51: Sanitation Reticulation: Comparison of dcvRates [R pkm pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio
1	Matzikam	485	8009	0.1	9513	0.1	na	na	8382	0.1
2	Swartlan	13303	8009	1.7	9513	1.4			15925	0.8
3	Stellenb	11305	8009	1.4	9513	1.2			11211	1.0
4	BreedeVa	9900	8009	1.2	9513	1.0			11211	0.9
5	Breederi	776	8009	0.1	9513	0.1			6496	0.1
6	Cape Agu	9632	8009	1.2	9513	1.0			6496	1.5
7	George	6308	8009	0.8	9513	0.7			6496	1.0
8	Oudtshoo	11383	8009	1.4	9513	1.2			6496	1.8
9	Laingsbu	9850	8009	1.2	9513	1.0			11211	0.9
10	Beaufort	22189	8009	2.8	9513	2.3			11211	2.0
Ratios >Lower Limit (0.7)				8		8			8	
Ratios < Upper Limit (1.5)				8		9			8	
Ratios within envelope				6		7		na	6	
Mean ratio				1.2		1.0			1.0	
Score				76%		83%			76%	

6.1.6 Sanitation Treatment

The regression rates have the highest score and enjoy comparatively more ratios within the design envelope.

The regression formula : $(Y = 8.56*Topg + 0.02*Pop - 0.04*Ml - 265)$ R ppop pa is thus recommended.

Table 52: Sanitation Treatment: Comparison of dcvRates [R ppop pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio
1	Matzikam	18	201	0.1	177	0.1	na	na	275	0.1
2	Swartlan	148	201	0.7	177	0.8			299	0.5
3	Stellenb	74	201	0.4	177	0.4			198	0.4
4	BreedeVa	56	201	0.3	177	0.3			140	0.4
5	Breederi	493	201	2.5	177	2.8			396	1.2
6	Cape Agu	182	201	0.9	177	1.0			196	0.9
7	George	404	201	2.0	177	2.3			518	0.8
8	Oudtshoo	136	201	0.7	177	0.8			166	0.8
9	Laingsbu	14	201	0.1	177	0.1			7	2.0
10	Beaufort	243	201	1.2	177	1.4			163	1.5
Ratios >Lower Limit (0.7)				6	6	6				
Ratios < Upper Limit (1.5)				8	8	9				
Ratios within envelope				4	4	5	na			
Mean ratio				0.9	1.0	0.9				
Score				66%	66%	73%				

6.1.7 Solid waste Landfill

The straight average score is the highest and this rate is therefore recommended.

Table 53: Solid waste Landfill: Comparison of devRates [R pton pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio
1	Cape Met	56	52	1.1	94	0.6	50	1.1	na	na
2	Matzikam	100	52	1.9	94	1.1	50	2.0		
3	Stellenb	15	52	0.3	94	0.2	50	0.3		
4	BreedeVa	5	52	0.1	94	0.1	50	0.1		
5	Breederi	155	52	3.0	94	1.6	50	3.1		
6	Cape Agu	234	52	4.5	94	2.5	50	4.7		
7	George	78	52	1.5	94	0.8	50	1.6		
8	Oudtshoo	12	52	0.2	94	0.1	50	0.2		
9	Laingsbu	13	52	0.3	94	0.1	50	0.3		
10	Overberg	348	52	6.7	94	3.7	50	7.0		
11	Beaufort	20	52	0.4	94	0.2	50	0.4		
Ratios >Lower Limit (0.7)				6		5		6		
Ratios < Upper Limit (1.5)				6		8		6		
Ratios within envelope				2		3		2		na
Mean ratio				1.8		1.0		1.9		
Score				55%		63%		55%		

6.1.8 Solid waste Collection

The amended average scores the highest and is recommended. It also has the most ratios within the design envelope.

Table 54: Solid waste Collection: Comparison of devRates [R pton pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio
1	Cape Met	179	177	1.0	311	0.6	258	0.7	na	na
2	Matzikam	360	177	2.0	311	1.2	258	1.4		
3	Stellenb	131	177	0.7	311	0.4	258	0.5		
4	BreedeVa	11	177	0.1	311	0.0	258	0.0		
5	Breederi	320	177	1.8	311	1.0	258	1.2		
6	Cape Agu	529	177	3.0	311	1.7	258	2.1		
7	George	503	177	2.8	311	1.6	258	1.9		
8	Oudtshoo	88	177	0.5	311	0.3	258	0.3		
9	Laingsbu	120	177	0.7	311	0.4	258	0.5		
10	Overberg	840	177	4.7	311	2.7	258	3.3		
11	Beaufort	340	177	1.9	311	1.1	258	1.3		
Ratios >Lower Limit (0.7)				9		6		7		
Ratios < Upper Limit (1.5)				5		8		8		
Ratios within envelope				4		4		5		na
Mean ratio				1.8		1.0		1.2		
Score				62%		67%		72%		

6.1.9 Solid waste Transport

The regression rates score high together with the weighted mean, and have the better mean ratio. The regression formula: $(Y = 2.5 * \text{Topog} + 141 * \text{RU} - 136)$ R pton pa is thus recommended.

Table 55: Solid waste Transport: Comparison of devRates [R pton pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio	
1	Cape Met	33	33	1.0	75	0.4	53	0.6	30	1.1	
2	Matzikam	145	33	4.4	75	1.9	53	2.7	102	1.4	
3	Stellenb	21	33	0.6	75	0.3	53	0.4	10	2.2	
4	BreedeVa	2	33	0.1	75	0.0	53	0.0	60	0.0	
5	Breederi	171	33	5.2	75	2.3	53	3.2	130	1.3	
6	Cape Agu	131	33	4.0	75	1.7	53	2.5	130	1.0	
7	George	47	33	1.4	75	0.6	53	0.9	130	0.4	
8	Oudtshoo	53	33	1.6	75	0.7	53	1.0	30	1.8	
9	Laingsbu	17	33	0.5	75	0.2	53	0.3	10	1.8	
10	Overberg	177	33	5.4	75	2.4	53	3.3	110	1.6	
11	Beaufort	25	33	0.8	75	0.3	53	0.5	60	0.4	
Ratios > Lower Limit (0.7)				9			6			7	8
Ratios < Upper Limit (1.5)				6			7			7	7
Ratios within envelope				5			3			4	5
Mean ratio				2.3			1.0			1.4	1.2
Score				68%			61%			65%	70%

6.1.10 Solid waste Total

The regression rates score highest. The formula: $(Y = 17 * \text{Topog} + 588 * \text{RU} - 677)$ R pton pa is thus recommended.

Table 56: Solid waste Total: Comparison of dcvRates [R pton pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio
1	Cape Met	258	254	1.0	475	0.5	331	0.8	81	3.1852
2	Matzikam	605	254	2.4	475	1.3	331	1.8	643	0.9
3	Stellenb	173	254	0.7	475	0.4	331	0.5	127	1.4
4	BreedeVa	18	254	0.1	475	0.0	331	0.1	467	0.0
5	Breederi	608	254	2.4	475	1.3	331	1.8	761	0.8
6	Cape Agu	885	254	3.5	475	1.9	331	2.7	761	1.2
7	George	628	254	2.5	475	1.3	331	1.9	761	0.8
8	Oudtshoo	153	254	0.6	475	0.3	331	0.5	81	1.9
9	Laingsbu	150	254	0.6	475	0.3	331	0.5	127	1.2
10	Overberg	1365	254	5.4	475	2.9	331	4.1	807	1.7
11	Beaufort	385	254	1.5	475	0.8	331	1.2	467	0.8
Ratios > Lower Limit (0.7)				9			6	7		10
Ratios < Upper Limit (1.5)				5			9	6		8
Ratios within envelope				4			5	3		8
Mean ratio				1.9			1.0	1.4		1.3
Score				62%			74%	59%		85%

6.1.11 Water reticulation

The weighted and straight averages both score the highest. However, the higher weighted average implicates diseconomies of scale, and is therefore recommended.

Table 57: Water Reticulation Total: Comparison of dcvRates [R pkm pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio
1	Cape Met	2399	21496	0.1	18174	0.1	14618	0.2	na	na
2	Matzikam	1232	21496	0.1	18174	0.1	14618	0.1		
3	Swartlan	26752	21496	1.2	18174	1.5	14618	1.8		
4	Drakenst	9795	21496	0.5	18174	0.5	14618	0.7		
5	Stellenb	60844	21496	2.8	18174	3.3	14618	4.2		
6	Breedeva	20965	21496	1.0	18174	1.2	14618	1.4		
7	Breederi	1993	21496	0.1	18174	0.1	14618	0.1		
8	Thewater	3804	21496	0.2	18174	0.2	14618	0.3		
9	Cape Agu	16192	21496	0.8	18174	0.9	14618	1.1		
10	George	33395	21496	1.6	18174	1.8	14618	2.3		
11	Oudtshoo	24040	21496	1.1	18174	1.3	14618	1.6		
12	Laingsbu	8797	21496	0.4	18174	0.5	14618	0.6		
13	Beaufort	26052	21496	1.2	18174	1.4	14618	1.8		
Ratios >Lower Limit (0.7)				7	7	9				
Ratios < Upper Limit (1.5)				11	11	8				
Ratios within envelope				8	8	7	na			
Mean ratio				0.8	1.0	1.2				
Score				89%	89%	81%				

6.1.12 Water Treatment

The straight average scores the highest and also displays the best mean ratio. It is also more conservative and is thus recommended.

Table 58: Water Treatment Total: Comparison of dcVRates [R pMl pa] yr: 2005/06

	Mun	Observed	Wtd Avg	Ratio	Straight Avg	Ratio	Amended Avg	Ratio	Regression1	Ratio
1	Cape Met	804	810	1.0	1169	0.7	900	0.9	na	na
2	Matzikam	48	810	0.1	1169	0.0	900	0.1		
3	Swartlan	1231	810	1.5	1169	1.1	900	1.4		
4	Drakenst	1249	810	1.5	1169	1.1	900	1.4		
5	Stellenb	489	810	0.6	1169	0.4	900	0.5		
6	Breedevea	586	810	0.7	1169	0.5	900	0.7		
7	Breederi	1984	810	2.4	1169	1.7	900	2.2		
8	Thewater	250	810	0.3	1169	0.2	900	0.3		
9	Cape Agu	418	810	0.5	1169	0.4	900	0.5		
10	George	1506	810	1.9	1169	1.3	900	1.7		
11	Oudtshoo	439	810	0.5	1169	0.4	900	0.5		
12	Laingsbu	4392	810	5.4	1169	3.8	900	4.9		
13	Beaufort	1800	810	2.2	1169	1.5	900	2.0		
Ratios >Lower Limit (0.7)				9		7		8		
Ratios < Upper Limit (1.5)				7		10		9		
Ratios within envelope				6		7		7		na
Mean ratio				1.4		1.0		1.3		
Score				75%		84%		82%		

6.2 Comparison with literature rates

The recommended rates were subsequently compared with the rates recorded in the literature review (Table 3). This exercise served as a means of external validation of the data.

It should, however, be noted that the literature rates are derived from residential townships, whilst the rates derived in this dissertation are citywide, municipal rates. In fact the average rates are representative of a number of municipalities across the Western Cape.

The dimensions for the rates in the literature review (Table 3) are in Rands per erf per annum.

The recommended municipal dcvRates (as derived in Section 6.2) were thus converted to R ppop pa (i.e. Rands per erf per annum) by multiplying these with the unit total for each service per municipality, then dividing the answers by the number of erven (i.e. 'pop') for the municipality, and then averaging these.

It is noted that the literature review only covers the following 8 services-

- Gravel roads
- Surfaced roads
- Water reticulation
- Water treatment
- Sanitation reticulation
- Sanitation treatment
- Solid waste collection
- Storm water reticulation

6.2.1 Gravel Roads

The values are in the same order of magnitude and compare well on average with the literature-based figures.

Table 59: The dcvRates rates vs. literature based rates for Gravel Roads

	Mun	Pop	km	Recommended dcvRate Wtd mean R pkm pa	dcvRate converted [R ppop pa]	R ppop pa Literature*
1	Cape Met	725000	185	20522	5	43 - 92
2	Cape Bel	73068	111	20522	31	
3	Matzikam	6843	48	20522	144	
4	Swartlan	32690	97	20522	61	
5	Drakenst	29463	54	20522	38	
6	Stellenb	26433	31.8	20522	25	
7	Breedeva	19431	22.5	20522	24	
8	Breederi	16696	50.7	20522	62	
9	Thewater	8000	12.5	20522	32	
10	Cape Agu	9481	36.2	20522	78	
11	Hessqua	14411	30	20522	43	
12	George	30000	74	20522	51	
13	Oudtshoo	22500	47	20522	43	
14	Laingsbu	1146	2	20522	36	
15	Beaufort	1650	8	20522	100	
Avearges=					51	68

6.2.2 Surfaced Roads

It is noted that the literature-based rates are around 5 times lower than those determined for the dcvRates under the current study for the Western Cape.

Table 60: The dcvRates rates vs. literature based rates for Surfaced Roads

	Mun	Pop	km	Recommended dcvRate Straight Avg R pkm pa	dcvRate converted [R ppop pa]	R ppop pa Literature
1	Cape Met	725000	9152	23007	290	40 - 72
2	Cape Bel	73068	1680	23007	529	
3	Matzikam	6843	110	23007	370	
4	Swartlan	32690	231	23007	163	
5	Drakenst	29463	485	23007	379	
6	Stellenb	26433	270	23007	235	
7	Breedeva	19431	249.5	23007	295	
8	Breederi	16696	178.4	23007	246	
9	Thewater	8000	55	23007	158	
10	Cape Agu	9481	147.3	23007	357	
11	Hessqua	14411	320	23007	511	
12	George	30000	415	23007	318	
13	Oudtshoo	22500	130	23007	133	
14	Laingsbu	1146	14	23007	281	
15	Beaufort	1650	12	23007	167	
Averages=					296	56

6.2.3 Water Reticulation

The comparisons are shown Table 61.

The average dcvRates are in the same order of magnitude as the literature based rates. .

Table 61: The dcvRates rates vs. literature based rates for Water Reticulation

	Mun	Pop	km	Recommended dcvRate Wtd Avg R pkm pa	dcvRate converted [R ppop pa]	R ppop pa Literature
1	Cape Met	725000	596	21496	18	248 - 325
2	Matzikam	6843	178.5	21496	561	
3	Swartlan	32690	379	21496	249	
4	Drakenst	29463	577	21496	421	
5	Stellenb	26433	476.63	21496	388	
6	Breedevea	19431	318.62	21496	352	
7	Breederi	16696	230	21496	296	
8	Thewater	8000	72.3	21496	194	
9	Cape Agu	9481	203.8	21496	462	
10	George	30000	645	21496	462	
11	Oudtshoo	22500	297	21496	284	
12	Laingsbu	1146	40.5	21496	760	
13	Beaufort	1650	22	21496	287	
Average=					364	287

6.2.4 Water Treatment

The literature rates only occur as R per MI pa. The results show a very good comparison between the literature-derived rates and that of the current study for the Western Cape.

Table 62: The dcvRates rates vs. literature based rates for Water Treatment

	Mun	MI	Recommended dcvRate Straight Avg R pMI pa	R pMI pa Literature
1	Cape Met	251302	1169	1481
2	Matzikam	8000	1169	
3	Swartlan	4274	1169	
4	Drakenst	13139	1169	
5	Stellenb	11680	1169	
6	Breedevea	12264	1169	
7	Breederi	5928	1169	
8	Thewater	1500	1169	
9	Cape Agu	4780	1169	
10	George	6176	1169	
11	Oudtshoo	6294	1169	
12	Laingsbu	40.8	1169	
13	Beaufort	200	1169	
Average=			1169	1481

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6.2.5 Sanitation Reticulation

The literature-sourced rates are on average 3 times that of the Western Cape figures as shown.

Table 63: The dcvRates rates vs. literature based rates for Sanitation Reticulation

	Mun	Pop	km	Recommended dcvRate Straight Avg R pkm pa	dcvRate converted [R ppop pa]	R pop pa Literature
1	Matzikam	6843	103	9513	143	168 - 480
2	Swartlan	32690	278	9513	81	
3	Stellenb	26433	242	9513	87	
4	BreedeVa	19431	230.3	9513	113	
5	Breederi	16696	265	9513	151	
6	Cape Agu	9481	63.1	9513	63	
7	George	30000	650	9513	206	
8	Oudtshoo	22500	188	9513	79	
9	Laingsbu	1146	24	9513	199	
10	Beaufort	1650	22	9513	127	
Avearges=					125	324

6.2.6 Sanitation Treatment

The average dcvRates comparisons are in the same order of magnitude as that of the literature based rates.

Table 64: The dcvRates rates vs. literature based rates Sanitation Treatment

	Mun	Pop	Topog	MI	Recommended dcvRate Y =8.56topog+0.02p op-0.04MI-265 R ppop	R/erf/pa Literature
1	Matzikam	6843	50	630	275	218
2	Swartlan	32690	10	4380	299	
3	Stellenb	26433	30	8067	198	
4	BreedeVa	19431	50	10293	140	
5	Breederi	16696	50	2520	396	
6	Cape Agu	9481	50	3920	196	
7	George	30000	50	6137	518	
8	Oudtshoo	22500	10	2617	166	
9	Laingsbu	1146	30	185	7	
10	Beaufort	1650	50	825	163	
Avearges=					236	218

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6.2.7 Solid Waste Collection

The rates are around 2.3 times higher than the literature values.

Table 65: The dcvRates rates vs. literature based rates Solid waste collection

	Mun	Pop	Ton	Recommended dcvRate Amended Avg R pton pa	dcvRate converted [R ppop pa]	R pop pa Literature
1	Cape Met	725000	2430000	258	865	218
2	Matzikam	6843	2000	258	75	
3	Stellenb	26433	140000	258	1366	
4	BreedeVa	19431	70757	258	939	
5	Breederi	16696	8900	258	138	
6	Cape Agu	9481	3744	258	102	
7	George	30000	36000	258	310	
8	Oudtshoo	22500	37000	258	424	
9	Laingsbu	1146	4784	258	1077	
10	Overberg	16966	2900	258	44	
11	Beaufort	1650	1382	258	216	
Average=					505	218

6.2.8 Storm water Reticulation

The literature values range from R 56-80. The Wtd.Mean is around 1.5 times higher than the literature-based value.

Table 66: The dcvRates rates vs. literature based rates for Stormwater Reticulation

	Mun	km	Pop	Recommended dcvRate Wtd Avg R pkm pa	dcvRate converted [R ppop pa]	R pop pa Literature
1	Cape Met	5500	725000	15451	117	56 - 80
2	Cape Bel	500	73068	15451	106	
3	Matzikam	88	6843	15451	199	
4	Swartlan	194	32690	15451	92	
5	Drakenst	250	29463	15451	131	
6	Stellenb	220	26433	15451	129	
7	Breedeva	250	19431	15451	199	
8	Breederi	150.2	16696	15451	139	
9	Thewater	22	8000	15451	42	
10	Cape Agu	33.8	9481	15451	55	
11	Hessqua	34	14411	15451	36	
12	George	255	30000	15451	131	
13	Oudtshoo	40	22500	15451	27	
14	Laingsbu	7.8	1146	15451	105	
15	Beaufort	6	1650	15451	56	
Average=					104	68

7. Conclusions and recommendations

The concluding comments and recommendations are centred around the original objective of this dissertation, i.e. *to arrive at a set of rates or formulae, which could be used at a participatory decision-making level for the estimating of O&M costs for the delivery of municipal civil engineering infrastructure in an urban context.*

7.1 Conclusions

The rates analyses indicate that-

- In two-thirds of the 12 data cases, the weighted average and straight average dcVRates are best suited for predicting the O&M costs.
- With respect to economies (or diseconomies) of scale, the weighted averages are best suited for prediction
- With respect to variability of data (particularly high outlying data), the amended average, which excludes outliers is best suited for prediction. (ex. the case of Solid Waste Collection)
- In three cases, Sanitation Treatment, Solid Waste Transport and Total Solid Waste, the regression formulae are the best predictors
- The calculated rates across the Western Cape region are generally the same or higher than the literature based rates across all services, except for sanitation reticulation, where the values are around 3 times lower. This exercise served well to validate the analysed data, given the limitation of sample size.

7.2 Recommendations

The following dcVRates are recommended for use in predicting the O&M costs for municipal engineering services. The assessment was based on 2005/06 data and situational factors across municipalities in the Western Cape:

a)	Gravel Roads data	= R 20 522 pkm pa (Weighted average)
b)	Surfaced Roads data	= R 23 007 pkm pa (Straight average)
c)	Storm Water Reticulation	= R 15 451 pkm pa (Weighted average)
d)	Storm Water Appurtenances	= R 23 007 pkm*pa (Weighted average)
e)	Sanitation Reticulation	= R 9 513 pkm pa (Straight average)
f)	Sanitation Treatment	= $Y = 8.56 \text{ topog} + 0.02 \text{ pop} - 0.04 \text{ MI} - 265$ (R ppop pa)
g)	Solid waste Landfill	= R 94 pton pa (Straight average)
h)	Solid waste Collection	= R 258 pton pa (Amended average)
i)	Solid waste Transport	= $Y = 27 \text{ topog} + 141 \text{ RU} - 136$ (R pton pa)
j)	Solid waste Total	= $Y = 17 \text{ topog} + 588 \text{ RU} - 677$ (R pton pa)
k)	Water Reticulation	= R 21 496 pkm pa (Weighted average)
l)	Water Treatment	= R 1 169 pMl pa (Straight average)

* The km for Storm Water Appurtenances refers to reticulation lengths

Such a data set would provide a type of 'benchmark for change' - it is not intended to be a data set able to predict the O&M service rates for each town, but rather as part of a strategic model used to predict the O&M rate for a service and so prompt decision-makers to ask questions around actual versus predicted values.

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APPENDIX A

Initial Design Questionnaire

UNIVERSITY OF CAPE TOWN

Department of Civil Engineering

Survey to develop unit costs for municipal engineering services

We are compiling a data base on the operational costs of the municipal engineering services. It would be greatly appreciated if you could provide as much of the following information as possible.

Roads:

The length of graded roads in the municipality: km.

Annual expenditure on maintaining graded roads (2003/2004): R/year

The length of gravel roads in the municipality: km.

Annual expenditure on maintaining gravel roads (2003/2004): R/year

The length of surfaced roads in the municipality: km.

Annual expenditure on maintaining surfaced roads (2003/2004): R/year

Stormwater management

The length of stormwater pipes in the municipality: km.

Annual expense on maintaining the stormwater pipe network (2003/2004): R/year

Ann. expense on maintaining the remaining stormwater system (2003/2004): R/year

Sanitation

How many chemical toilets are there in the municipality: units

Annual expense on maintaining the chemical toilets (2003/2004): R/year

How many VIP units are there in the municipality: units

Annual expense on maintaining the VIPs (2003/2004): R/year

How many septic tanks are there in the municipality: units

Annual expense on maintaining the septic tanks (2003/2004): R/year

The length of sewer pipes in the municipality: km.

Annual expense on maintaining the sewer pipe network (2003/2004): R/year

The annual volume of sewage treated (2003/2004) Mega litres/year

Annual expense on sewage treatment (2003/2004): R/year

Water supply

The length of water supply pipes in the municipality: km.

Annual expense on maintaining the water pipe network (2003/2004): R/year

The annual volume of water consumed (2003/2004) Mega litres/year

Annual expense on water treatment / supply (2003/2004): R/year

Solid waste

The tonnes of solid waste produced in the municipality: tonnes/year

Annual expense of collection (2003/2004) R/year

Annual expense of transportation (2003/2004) R/year

The tonnes of solid waste disposed to landfill site: tonnes/year

Annual expense of disposal to landfill site (2003/2004) R/year

Thank you for your assistance

APPENDIX B

Modified Questionnaires

B1: Roads and Storm Water

Name of Municipality: _____				
Names of District(s) Served under this table of data: _____				
No. of erven (formal): _____				
No. of erven (informal): _____				
Name of Municipal Official providing data: _____ (Tel: _____)			Name of Depot Superintendent: _____ (Tel: _____)	
Item	Information Needed	Measurement	Your Answer Please	Please provide comments on items causing main O&M concerns. "Breakdown on grader or a lack of personnel etc"
1	The length of graded roads in the Municipality	km		
2	Annual Expense of maintaining graded roads in the Municipality (2004/2005)	R/yr		
3	The length of gravel roads in the Municipality	km		
4	Annual Expense of maintaining grave roads in the Municipality (2004/2005)	R/yr		
5	The length of surfaced roads in the Municipality	km		
6	Annual Expense of maintaining surfaced roads in the Municipality (2004/2005)	R/yr		
7	The length of stormwater pipes in the Municipality	km		
8	Annual Expense of maintaining the stormwater network in the Municipality (2004/2005)	R/yr		
9	Annual Expense of maintaining the remainder of the stormwater system in the Municipality (2004/2005)	R/yr		
Is the annual O&M budget sufficiently covering all costs? _____				Yes or No. % deficit: _____
Could you please enclose the relevant extract from your O&M Budget (2004/2005)?				
How would you describe the major part of the area served by the above service?			Ex: Rural with flat topography/ steep rural/ urban with flat topography/ steep urban etc.	
Answer: _____				

This survey questionnaire forms part of a Community Decision-Support-Tool for the selection of Municipal Engineering Services in an upgrade scheme.

Thank you.

B2: Sanitation

Name of Municipality: Names of District(s) Served under this table of data: No. of erven (formal): No. of erven (informal):
--

Name of Municipal Official providing data : Tel:	Name of Depot Superintendent : Tel:
---	--

Item	Information Needed	Measurement	Your Answer Please	Please provide comments on Items causing main O&M concern (ex. 'regular breakdowns on pumps, etc')
1	How many chemical toilets are there in the municipality	No. of units		
2	Annual Expense of maintaining the chemical toilets in the Municipality (2004/2005)	R/ yr		
3	How many VIP units in the Municipality	No. of units		
4	Annual Expense of maintaining VIP units in the Municipality (2004/2005)	R/ yr		
5	How many septic tanks are there in the Municipality	No of units		
6	Annual Expense of maintaining septic tanks in the Municipality (2004/2005)	R/ yr		
7	The length of sewer pipes in the Municipality	km		
8	Annual Expense of maintaining the sewer pipe network in the Municipality (2004/2005)	R/yr		

9	Volume of sewage treated in the Municipality (2004/2005)	Mega litres per year		
10	Annual expense on sewage treatment (2004/2005)	R/ year		

Is the annual O&M budget sufficiently covering all costs p.a.?	Yes or No: % deficit:
Could you please enclose the relevant extract from your O&M Budget (2004/2005)?	
How would you describe the major part of the area served by the above service?	Ex: Rural with flat topography/ steep rural/ urban with flat topography/ steep urban etc Answ:

This survey questionnaire forms part of a Community Decision-Support-Tool for the selection of Municipal Engineering Services in an upgrade scheme.

Thank you.

B3: Solid Waste

Name of Municipality: Names of District(s) Served under this table of data: No. of erven (formal): No. of erven (informal):
--

Name of Municipal Official providing data : Tel:	Name of Depot Superintendent : Tel:
---	--

Item	Information Needed	Measurement	Your Answer Please	Please provide comments on Items causing main O&M concern (ex. 'Truck fleet is ageing')
1	The tones of solid waste produced in the Municipality	Tones/ yr		
2	Annual Expense of collection (2004/2005)	R/ yr		
3	Annual expense of transportation (2004/2005)	R/ yr		
4	The tones of solid waste disposed to landfill site:	Tones/ yr		
5	Annual expense of disposal to landfill site (2004/2005)	R/ yr		

Is the annual O&M budget sufficiently covering all costs p.a.?	Yes or No: % deficit:
Could you please enclose the relevant extract from your O&M Budget (2004/2005)?	
How would you describe the major part of the area served by the above service?	<u>Ex: Rural with flat topography/ steep rural/ urban with flat topography/ steep urban etc</u> Ans:

This survey questionnaire forms part of a Community Decision-Support-Tool for the selection of Municipal Engineering Services in an upgrade scheme.

Thank you.

B4: Water

Name of Municipality: Names of District(s) Served under this table of data: No. of erven (formal): No. of erven (informal):
--

Name of Municipal Official providing data : Tel:	Name of Depot Superintendent : Tel:
---	--

Item	Information Needed	Measurment	Your Answer Please	Please provide comments on Items causing main O&M concern (ex. 'Breakdowns on supply pumps or expensive treatment works etc')
1	The length of water supply pipes in the Municipality	km		
2	Annual Expense of maintaining water pipe network in the Municipality (2004/2005)	R/ yr		
3	The annual volume of water consumed the Municipality	Mega litres/ year		
4	The Annual Expense of water treatment or supply in the Municipality (2004/2005)	R/ yr		

Is the annual O&M budget sufficiently covering all costs p.a.?	Yes or No: % deficit:
Could you please enclose the relevant extract from your O&M Budget (2004/2005)?	
How would you describe the major part of the area served by the above service?	Ex: Rural with flat topography/ steep rural/ urban with flat topography/ steep urban etc Answ:

This survey questionnaire forms part of a Community Decision-Support-Tool for the selection of Municipal Engineering Services in an upgrade scheme.

Thank you.

C2: West Coast District: Matzikama and Swartland Municipalities

No.	District Municipality	District No	Municipal Region	Mun No.	Budget extracts	Comment	No of Sites	Settlement type	Municipal Region	Mun No.	Budget extracts	Comment	No of Sites	Settlement type
	West Coast District Municipality	DC1	Matzikama Mun	WC011					Swartland Mun	WC015				

Rds_Sw	Graded Rds [km]														
	Graded [R/yr]														
	Gravel Rds [km]	48													
	Gravel [R/yr]	100000													
	Surface Rds [km]	110													
	Surface [R/yr]	60000													
	SW Pipes [km]	88													
	SW Pipes network [R/yr]	30000													
	Rest of SW System [R/yr]	10000													
	% O&M deficit	0													
	O&M Concern	The length of sw pipe was not provided. This was assumed to be 80% of the surface rd length							None recorded						

Sanitation	Chemical Toilets [No]														
	Chemical Toilets [R/yr]	0													
	VIP's [No]	0													
	VIP's [R/yr]	0													
	Septic Tanks [No]	400													
	Septic Tanks [R/yr]	0													
	Sewer Pipes [km]	103													
	Sewer Pipe Network [R/yr]	50000													
	Volume Sewage Treated	630													
	Sewage Treatment [R/yr]	120000													
	% O&M deficit	0													
	O&M Concern	No cost was given for septic tank O+M							None recorded						

Solid_Waste	Solid Waste Production [Tonnes/yr]														
	Solid Waste Collection [R/yr]	720000													
	Solid Waste Transportation [R/yr]	290000													
	Landfill Site Disposal [Tonnes/yr]														
	Landfill Site Disposal [R/yr]														
	% O&M deficit	0													
	O&M Concern														

Water	Supply pipe Length [km]														
	Network Cost [R/yr]	220000													
	Consumption [Ml/yr]	8000													
	Treatment/Supply Cost [R/yr]	380000													
	% O&M deficit	0													
	O&M Concern	None given							None recorded						

C3a: Cape Winelands: Drakenstein and Stellenbosch Municipalities

		Municipal Region	Mun No	Budget extracts	Comment	No of Sites	Settlement type
		Drakenstein	WC023				
Rds_Sw	Graded Rds [km]		0	No	Information received from DL Carstens: 807 4708; superintendents: M Apples and J Schoonraad: 807-32 86/50	26000 sites (Paarl only) and 20 463 sites (Paarl, Wellington, Saron and Gouda) with 5000 informal sites	Steep Urban
	Graded [R/yr]		0				
	Gravel Rds [km]		54				
	Gravel [R/yr]		256000				
	Surface Rds [km]		485				
	Surface [R/yr]		6049000				
	SW Pipes [km]		Not available				
	SW Pipes network [R/yr]		2294400				
	Rest of SW System [R/yr]		Not available				
	% O&M deficit		50%				
O&M Concern		None recorded					
		Stellenbosch	WC024				
			0	Yes	Up to 9 areas are covered in the survey data	26433 (needs clarity)	
			0				
			31 8				
			231350				
			270				
			1800000				
			220				
			2000000				
		The major cost component concern is that of worker-absenteeism. The result being that contractors must be hired to do work, and hence double wages for labor is paid. Janse van Rensburg					
Sanitation	Chemical Toilets [No]		5	Yes	The length of the sewer pipe network was omitted. Follow up with Sabelo Mkezi- we agreed to use 80% of entire rd network	26433 (needs clarity)	
	Chemical Toilets [R/yr]						
	VIPs [No]						
	VIPs [R/yr]						
	Septic Tanks [No]		6				
	Septic Tanks [R/yr]		329621				
	Sewer Pipes [km]		242				
	Sewer Pipe Network [R/yr]		2336250				
	Volume Sewage Treated		8067				
	Sewage Treatment [R/yr]		1622837				
O&M Concern		There is a growing need for ad-hoc council decisions to carry unforeseen expenses. Ex: R 120 000 for settling tank that was broken for over 1yr; no reserve fund, worker absenteeism >60%; skills are lacking @ operator level; growth in consumption due to new developments not accounted for; sewer pumps are breaking 4x pa. Gavin Pridden, Superintendant. 808-8255/082 321 7959					
Solid_Waste	Solid Waste Production [Tonnes-yr]		140000	Follow up with Jeremy Pillies: An extract of actual expenditures for 2004/05 was received for comparison, Superintendents: Mr. Gosmin 808-8273 & Heyns: 808-82 66	21335: Formal and 2500: Informal	Urban Flat	
	Solid Waste Collection [R/yr]		14401018				
	Solid Waste Transportation [R/yr]		1933752				
	Landfill Site Disposal [Tonnes-yr]		190865				
	Landfill Site Disposal [R/yr]		1927236				
	% O&M deficit		30%				
	O&M Concern		Too many contractors are involved in the delivery process, costing the mun too much. R 5M pa over-expenditure, process can be centralised, also, private co. running dumping site @ R 1.8 M pa. Jeremy Phins				
Water	Supply pipe Length [km]		577	No	Information received from Hanne Bignaut: 807 4725; superintendant: Tony Endley: 807-32 65	26000 sites (Paarl only); and 20 463 sites (Paarl, Wellington, Saron and Gouda) with approx. 5000 informal sites.	Steep Urban
	Network Cost [R/yr]		5651870				
	Consumption [Ml/yr]		13139				
	Treatment/Supply Cost [R/yr]		9192900				
	% O&M deficit		80%				
	O&M Concern		Old infrastructure needs to be replaced (ex. pipelines), but funds are lacking. Municipality grew significantly through amalgamation, development and servicing of informal settlements, yet resources are stagnant (5% growth cap on OM Budget)				
			476 63	Yes	A breakdown per up to 6 areas are given (on file) Kobus Fournie	26433 (needs clarity)	
			29000000				
			11680				
			5710000				
		Problems are with labor not pitching for up to 3 days at a time, and with the fact that specialists contractors needed for paving, surfacing etc when pipe bursts are located where high-finish surfacing needs to be reinstated. Kobus Fournie					

C3b : Cape Winelands: Breede Vallel and Brede Rivier Municipalities

	Municipal Region	Mun No	Budget extracts	Comment	No of Sites	Settlement type		Municipal Region	Mun No	Budget extracts	Comment	No of Sites	Settlement type								
	Breede Valley	WC025						Breede River	WC026												
Rds_Sw	Graded Rds [km]	0	Not submitted	Information submitted by Gilbert Titus: 023-3482632. Depot superintendent: N Swartz. 023-3482600. Split for gravel/surfaced and length sw pipe was assumed, since not submitted.	19431	Rural with flat topography			229.1	Pending	The cost of graded rds are lumped with that of gravel roads. The cost for resurfacing is from IMQS program. SW costs are all lumped into rd costs.	16696	Rural with mixed topography								
	Graded [R/yr]	0																			
	Gravel Rds [km]	22.5																			
	Gravel [R/yr]	A portion of R 395311																			
	Surface Rds [km]	249.5																			
	Surface [R/yr]	A portion of R 395311																			
	SW Pipes [km]	250																			
	SW Pipes network [R/yr]	410000																			
	Rest of SW System [R/yr]	Not applicable																			
	% O&M deficit	Not stated																			
	O&M Concern	Lack of personnel & lack of training. The annual O&M budget is not sufficiently covering all costs currently- no percentage deficit was given						Budget is not sufficient- no indication of deficit was given													
Sanitation	Chemical Toilets [No]	Not applicable	Not submitted	Information submitted by Gilbert Titus: 023-3482632	19431	Rural with flat topography		2	Pending	The annual O&M budget is sufficient	16696	Rural flat and steep									
	Chemical Toilets [R/yr]	Not applicable																			
	VIP's [No]	21463																			
	VIP's [R/yr]	Not given																			
	Septic Tanks [No]	Not applicable																			
	Septic Tanks [R/yr]	0																			
	Sewer Pipes [km]	230.237																			
	Sewer Pipe Network [R/yr]																				
	Volume Sewage Treated	10293																			
	Sewage Treatment [R/yr]	900010																			
	% O&M deficit	Not submitted																			
	O&M Concern	Regular blockages on sewer mains. The annual O&M budget is not sufficiently covering all costs currently- no percentage deficit was given						None were provided													
Solid_Waste	Solid Waste Production [Tonnes: yr]	70756.9					Not Submitted	Information submitted by Gilbert Titus: 023-3482632. Depot superintendent: W. Visser: 023-3482600					19431	Rural with flat topography		8900	Pending	The annual O&M budget is sufficient	16696	Rural flat and steep	
	Solid Waste Collection [R/yr]	Part of R1133256																			
	Solid Waste Transportation [R/yr]	Part of R1133256																			
	Landfill Site Disposal [Tonnes: yr]	Not submitted																			
	Landfill Site Disposal [R/ yr]	Part of R1133256																			
	% O&M deficit	Not given																			
	O&M Concern	Truck fleet ageing						None were provided													
Water	Supply pipe Length [km]	318.615	Not Submitted	Information submitted by Gilbert Titus: 023-3482632. Depot superintendent: 023-3482600	19431	Rural with flat topography		230	Pending	The annual O&M budget is sufficient	16696	Rural flat and steep									
	Network Cost [R/yr]	6675863																			
	Consumption [Ml/yr]	12264.365																			
	Treatment/Supply Cost [R/yr]	7190019																			
	% O&M deficit	0																			
	O&M Concern	Regular busting of water pipes due to AC Pipes which are very old						None were provided													

C4a: Overberg: Theewaterskloof and Cape Agulhas Municipalities

4 Overberg DC3		Theewaterskloof Mun (Grabouw) WC031					Cape Agulhas Mun WC033					
Rds_Sw	Graded Rds [km]	12.5	Not supplied	Information received from G Engelbrecht : 021-859 2507	5000 Formal and 3000 Informal	A mix of rural and urban with flat and steep topography		Yes	Municipal Official providing Data: HJ Breytenbach tel: 028-4251919	8991 Formal and 490 Informal	Urban steep and flat	
	Graded [R/yr]	20000										
	Gravel Rds [km]	12.5					36.2					
	Gravel [R/yr]	20000										
	Surface Rds [km]	5.5					147.3					
	Surface [R/yr]	150000										
	SW Pipes [km]	22					33.8					
	SW Pipes network [R/yr]	30000										
	Rest of SW System [R/yr]											
	% O&M deficit	25%										
O&M Concern	The O&M budget is 25% inadequate pa					O&M Budget for Streets and SW all lumped as one value = R 5 519 940. Major cost concern for SW is around pipes and channels(follow up needed)						
Sanitation	Chemical Toilets [No]		Pending. Sent to janba@wkw.org.za				0	Yes	Municipal Official providing Data: DH du Toit: 028-4251919	8991 Formal and 490 Informal	Urban steep and flat	
	Chemical Toilets [R/yr]						0					
	VIP's [No]						265					
	VIP's [R/yr]											
	Septic Tanks [No]						2913					
	Septic Tanks [R/yr]											
	Sewer Pipes [km]						63.1					
	Sewer Pipe Network [R/yr]											
	Volume Sewage Treated						391968					
	Sewage Treatment [R/yr]											
% O&M deficit		0										
O&M Concern						O&M Budget for Sanitation all lumped as one value = R 2 329 710						
Solid_Waste	Solid Waste Production [Tonnes/yr]		Pending. Sent to janba@wkw.org.za				3744	Yes	Municipal Official providing Data: W Linnert: 028-4251919	8991 Formal and 490 Informal	Urban steep and flat	
	Solid Waste Collection [R/yr]											
	Solid Waste Transportation [R/yr]											
	Landfill Site Disposal [Tonnes/ yr]						3600					
	Landfill Site Disposal [R/ yr]											
	% O&M deficit						0					
O&M Concern						O&M Budget for Solid Waste all lumped as one value = R 3 345 350						
Water	Supply pipe Length [km]	72.5	Not supplied	Information received from G Engelbrecht: 021-859 2507	5000 Formal and 3000 Informal	A mix of rural and urban with flat and steep topography	203.8	Yes	Municipal Official providing Data: DH Du Toit: 028-4251919	8991 Formal and 490 Informal	Urban steep and flat	
	Network Cost [R/yr]	220000										
	Consumption [Ml/yr]	1500					1477711					
	Treatment/Supply Cost [R/yr]	300000										
	% O&M deficit	25%					0					
O&M Concern	The O&M budget is 25% inadequate pa					O&M Budget for Water all lumped as one value = R 7 945 270						

C4 b : Overberg : District Municipality

	4 Overberg	DC3	Overberg DM	DC3				
Rds_Sw	Graded Rds [km]							
	Graded [R/yr]							
	Gravel Rds [km]							
	Gravel [R/yr]							
	Surface Rds [km]							
	Surface [R/yr]							
	SW Pipes [km]							
	SW Pipes network [R/yr]							
	Rest of SW System [R/yr]							
	% O&M deficit							
	O&M Concern							
	Sanitation	Chemical Toilets [No]						
Chemical Toilets [R/yr]								
VIPs [No]								
VIPs [R/yr]								
Septic Tanks [No]								
Septic Tanks [R/yr]								
Sewer Pipes [km]								
Sewer Pipe Network [R/yr]								
Volume Sewage Treated								
Sewage Treatment [R/yr]								
% O&M deficit								
O&M Concern								
Solid_Waste	Solid Waste Production [Tonnes/yr]		29000					
	Solid Waste Collection [R/yr]		2799840					
	Solid Waste Transportation [R/yr]			Yes				
	Landfill Site Disposal [Tonnes/ yr]				Information received from Henk Matthee : 028-425 11 57 and Rryno Gouws: 021-951-8420			
	Landfill Site Disposal [R/ yr]				10966			
	% O&M deficit							
O&M Concern								
Water	Supply pipe Length [km]							
	Network Cost [R/yr]							
	Consumption [Ml/yr]							
	Treatment/Supply Cost [R/yr]							
	% O&M deficit							
O&M Concern								

C5a: Eden: Hessqua and George Municipalities

Eden WC04		Hessqua Mun WC042		George Mun WC044									
Rds_Sw	Graded Rds [km]		0	Not given	The information was given by Danvor Fillias @ Hessqua Mun. 028 713 24 18. The R 7 M for surface rds includes all the SW costs as well.	Not given	Not given		Yes	Graded and gravel rds the same, entire sw system costed. Info received from Joubert Swainnepoel @ 044-801 9111	30000 (to b confirmed)	Flat to slightly steep Urban	
	Graded [R/yr]		0										
	Gravel Rds [km]		30										
	Gravel [R/yr]		2000000										
	Surface Rds [km]		320										
	Surface [R/yr]		7000000										
	SW Pipes [km]		34										
	SW Pipes network [R/yr]												
	Rest of SW System [R/yr]												
	% O&M deficit												35%
O&M Concern		The assessment shows an unquantified deficit in the O&M budget				Large deficit in budget							
Sanitation	Chemical Toilets [No]			The information pending from Ethen Steyn @ Hessqua Mun. 028 713 24 18/ cell 082-5691473. He will also fwd pop and topographic detail				0	None	Info from Mr Avenise @ 044-801 9111	30000 (to b confirmed)	Flat to slightly steep Urban	
	Chemical Toilets [R/yr]							0					
	VIPs [No]							0					
	VIPs [R/yr]							0					
	Septic Tanks [No]							220					
	Septic Tanks [R/yr]							0					
	Sewer Pipes [km]							650					
	Sewer Pipe Network [R/yr]							4000000					
	Volume Sewage Treated							6137					
	Sewage Treatment [R/yr]							12118187					
% O&M deficit				Not given									
O&M Concern						The percentage deficit on the budget was not given							
Solid_Waste	Solid Waste Production [Tonnes/yr]			The information pending from Ethen Steyn @ Hessqua Mun. 028 713 24 18/ cell 082-5691473. He will also fwd pop and topographic detail				36000	None	Info from Mr Giel Groen @ 044-801 9206. Superintendent. 044-801 9217 -Janse. 044-801 9217	30000 (to b confirmed)	Flat to slightly steep Urban	
	Solid Waste Collection [R/yr]							18100000					
	Solid Waste Transportation [R/yr]							1700000					
	Landfill Site Disposal [Tonnes/ yr]							36000					
	Landfill Site Disposal [R/ yr]							2850000					
	% O&M deficit												0
	O&M Concern							Fast growth of George and the ageing of vehicle fleet					
Water	Supply pipe Length [km]			The information pending from Ethen Steyn @ Hessqua Mun. 028 713 24 18/ cell 082-5691473. He will also fwd pop				645	None	Questionnaire incomplete Consumption from RED Book. Info received from H Janse. 044-801 9217	30000 (to b confirmed)	Flat to slightly steep Urban	
	Network Cost [R/yr]							21542110					
	Consumption [Ml/yr]							6176					
	Treatment/Supply Cost [R/yr]												
	% O&M deficit												
O&M Concern						No comments							

C5b : Eden: Oudtshoorn Municipality

5 Eden		DC4	Oudtshoorn Mun	WC045			
Rds_Sw	Graded Rds [km]		0	Not submitted	Streets ageing & lack of funds for renovations & resealing. Lack of SW funds	14500 Formal & 600 Informal	Urban with Flat Topography: 90% Flat, 10% steep
	Graded [R/yr]		0				
	Gravel Rds [km]		47				
	Gravel [R/yr]		550000				
	Surface Rds [km]		130				
	Surface [R/yr]		8600000				
	SW Pipes [km]		40				
	SW Pipes network [R/yr]		600000				
	Rest of SW System [R/yr]		100000				
	% O&M deficit		25				
O&M Concern		Streets ageing & lack of funds for renovations & resealing. Alsoa lack funds for Stormwater Maintenance					
Sanitation	Chemical Toilets [No]		0	Yes	Info. Supplied by: P. Burger 044 272 4634. the data for septic tanks are actually for conservancy tanks	14500 Formal & 600 Informal	Urban with Flat Topography: 90% Flat, 10% steep
	Chemical Toilets [R/yr]		0				
	VIP's [No]		135				
	VIP's [R/yr]		12000				
	Septic Tanks [No]		220				
	Septic Tanks [R/yr]		Included in pipe network expenditure				
	Sewer Pipes [km]		188				
	Sewer Pipe Network [R/yr]		2144555				
	Volume Sewage Treated		2617				
	Sewage Treatment [R/yr]		3061016				
% O&M deficit							
O&M Concern		None recorded					
Solid_Waste	Solid Waste Production [Tonnes/yr]		37000	Yes	Informatio supplied by Mr Boel Vermaak: 044-2033173/-3166	11782 Formal and 850 Informal	Urban with Flat Topography: 90% Flat, 10% steep
	Solid Waste Collection [R/yr]		3190472				
	Solid Waste Transportation [R/yr]		1947252				
	Landfill Site Disposal [Tonnes/ yr]		37000				
	Landfill Site Disposal [R/ yr]		426245				
	% O&M deficit		0				
O&M Concern		Insufficient capacity of landfill site. Scavanging on landfill site- approx. 200 illegal reclaimers!					
Water	Supply pipe Length [km]		297	Not Submitted	None Given	11200 Formal & 450 Informal	Urban with Flat Topography: 90% Flat, 10% steep
	Network Cost [R/yr]		7140000				
	Consumption [MI/yr]		6294				
	Treatment/Supply Cost [R/yr]		2300000				
	% O&M deficit		20				
O&M Concern		No concerens were noted					

C6: Central Karoo: Laingsburg and Murraysburg Municipalities

	Central Karoo DC5	Laingsburg Mun WC051					Beaufort West Mun Murraysburg WC053						
Rds_SW	Graded Rds [km]		0	Yes	Info. Supplied by: Alida Groenewald 083 283 8220; the superintendent is: Bertie van As: 073171 5896	1146 Formal	Rural Flat		2	Yes	Information from JD Neethling: 023-491000	250 Formal and 1400 Low Cost Housing	Urban flat and steep
	Graded [R/yr]		0					5000					
	Gravel Rds [km]		2					8					
	Gravel [R/yr]	Included below						18000					
	Surface Rds [km]		14					12					
	Surface [R/yr]	1557000						8000					
	SW Pipes [km]		7.8					1.3					
	SW Pipes network [R/yr]	Included above						308770					
	Rest of SW System [R/yr]	Included above						0					
	% O&M deficit	56%						0					
	O&M Concern	Very large deficit in budget						There are 13 km of SW channels beside the 1.3 km pipes					
Sanitation	Chemical Toilets [No]		0	Yes	Info. Supplied by: Alida Groenewald 083 283 8220; the superintendent is: Bertie van As: 073171 5896	1146 Formal	Rural Flat		0	Yes	VIP's are carried at Farmer's expense. JD Neethling: 023-491000	250 Formal and 1400 Low Cost Housing	Urban flat and steep
	Chemical Toilets [R/yr]		0					0					
	VIP's [No]		30					168					
	VIP's [R/yr]	Included below for Matiesfontein only						NA					
	Septic Tanks [No]		5					0					
	Septic Tanks [R/yr]	Included below						0					
	Sewer Pipes [km]		24					22					
	Sewer Pipe Network [R/yr]	256083						476320					
	Volume Sewage Treated	185											
	Sewage Treatment [R/yr]	Included above											
	% O&M deficit	None						0					
O&M Concern				No costs and volumes are given for treatment of sewage!									
Solid_Waste	Solid Waste Production [Tonnes/yr]		4784	Yes	Info. Supplied by: Alida Groenewald 083 283 8220; the superintendent is: Bertie van As: 073171 5896	1146 Formal	Rural Flat		1382	Yes	Information from JD Neethling: 023-491000	250 Formal and 1400 Low Cost Housing	Urban flat and steep
	Solid Waste Collection [R/yr]	Included below						439680					
	Solid Waste Transportation [R/yr]	Included below											
	Landfill Site Disposal [Tonnes/ yr]	4784						1382					
	Landfill Site Disposal [R/ yr]	636393											
	% O&M deficit	12%						0					
O&M Concern	The budget is limited and not sufficiently covering all costs			None									
Water	Supply pipe Length [km]		40.5	Yes	Info. Supplied by: Alida Groenewald 083 283 8220; the superintendent is: Bertie van As: 073171 5896	1146 Formal	Rural Flat		22	Yes	Information from JD Neethling: 023-491000	250 Formal and 1400 Low Cost Housing	Urban flat and steep
	Network Cost [R/yr]	Included below						716441					
	Consumption [Ml/yr]	408						200					
	Treatment/Supply Cost [R/yr]	451105											
	% O&M deficit	None						0					
O&M Concern	None recorded			No costs are given for treatment of water or supply!									

D: Typical SPSS Output Data

e.g. Solid Waste Transport

Correlations

		Ton	Pop	Topog	RU	dcvRate
Ton	Pearson Correlation	1	.999**	-.566	.309	-.237
	Sig. (2-tailed)		.000	.070	.354	.484
	N	11	11	11	11	11
Pop	Pearson Correlation	.999**	1	-.553	.337	-.211
	Sig. (2-tailed)	.000		.077	.311	.534
	N	11	11	11	11	11
Topog	Pearson Correlation	-.566	-.553	1	-.311	.545
	Sig. (2-tailed)	.070	.077		.352	.083
	N	11	11	11	11	11
RU	Pearson Correlation	.309	.337	-.311	1	.309
	Sig. (2-tailed)	.354	.311	.352		.356
	N	11	11	11	11	11
dcvRate	Pearson Correlation	-.237	-.211	.545	.309	1
	Sig. (2-tailed)	.484	.534	.083	.356	
	N	11	11	11	11	11

** Correlation is significant at the 0.01 level (2-tailed).

Descriptive Statistics

	Mean	Std. Deviation	N
dcvRate	74.7273	66.92995	11
Topog	40.9091	18.68397	11
RU	.7545	.25045	11

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24631.973	2	12315.987	4.886	.041 ^a
	Residual	20164.208	8	2520.526		
	Total	44796.182	10			

a. Predictors: (Constant), RU, Topog

b. Dependent Variable: dcvRate

Correlations

		dcvRate	Topog	RU
Pearson Correlation	dcvRate	1.000	.545	.309
	Topog	.545	1.000	-.311
	RU	.309	-.311	1.000
Sig. (1-tailed)	dcvRate	.	.042	.178
	Topog	.042	.	.176
	RU	.178	.176	.
N	dcvRate	11	11	11
	Topog	11	11	11
	RU	11	11	11

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.742 ^a	.550	.437	50.20484	.550	4.886	2	8	.041

a. Predictors: (Constant), RU, Topog

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-135.942	72.411		-1.877	.097
	Topog	2.541	.894	.709	2.842	.022
	RU	141.441	66.693	.529	2.121	.067

a. Dependent Variable: dcvRate