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THE GREEN TOWNSHIP INFRASTRUCTURE DESIGN TOOLKIT: CREATING ECO EFFICIENT ENGINEERING SOLUTIONS

SHIAN HEMRAJ SAROOP

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THE GREEN TOWNSHIP INFRASTRUCTURE DESIGN TOOLKIT: CREATING ECO EFFICIENT ENGINEERING SOLUTIONS

Shian Hemraj Saroop

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DECLARATION

This dissertation, except where indicated in the text, is the candidate's own work and has not been submitted in part, or in whole, at any other University or University of Technology.

This research was conducted at the Durban University of Technology under the supervision of Professor Dhiren Allopi.

Shian Hemraj Saroop
MTech (Civil Eng);
PrTech Eng

APPROVED FOR FINAL SUBMISSION

Prof Dhiren Allopi: Promoter
DTech (Civil Eng) (MLST); MDT (Civil Eng) (TN);
Postgrad Dip Eng (Natal); Dip Datametrics (cum laude) (UNISA);
PrTech Eng; FSAICE; MIPET; MSAT; MCILT

DEDICATION

For

Everyone that I Love

ABSTRACT

There is a growing need for co-ordination of design, sustainability, economic and environmental aspects of infrastructure projects. The provision of civil infrastructure has a major impact on the natural environment and on the quality of life.

A literature review conducted highlighted that infrastructure development was focused mainly on the financial and engineering aspects of projects. There is an urgent need to apply technologies and methods that deliver better and more sustainable performance of civil infrastructure as well as a need to establish a standard of measurement for greener infrastructure. The literature review revealed that the existing tools do not adequately rate and monitor civil engineering infrastructure design decisions from concept stage, through to detailed design and implementation.

The objectives of the research were to identify green design technologies that can be used in township infrastructure and to encourage sustainable design on infrastructure township services, at various stages of the project. This would require the development of a green reporting system that incorporates environmentally friendly infrastructure design solutions.

This study identified alternative eco-efficient civil infrastructure design solutions and developed sustainability criteria to analyse the eco-efficiency of infrastructure projects. The study proposed a Green Township Infrastructure Design Toolkit aimed at ensuring high-performance, eco-efficient, economical and environmentally friendly design decisions on stormwater, roads, water and sanitation related to township infrastructure projects. Various case studies were undertaken on a range of infrastructure projects to ensure consistency and reliability of the toolkit. Through a series of green reports, developed for each stage of a project, the toolkit measured the environmental efficiency of the design solutions.

Recommendations suggest that engineering practitioners should endeavour to integrate greener engineering solutions into the traditional method of designing of infrastructure projects. The Green Township Infrastructure Design Toolkit with the use of its green reporting tools ensures the design of sustainable township infrastructure services, by progressively ensuring efficient, affordable, economical and sustainable provision of infrastructure services.

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CHAPTER 1 – INTRODUCTION

1.1 Challenges

Civil engineering projects can have significant site-specific and cumulative impacts on ecological and social systems if not correctly planned, designed and implemented. Adapting infrastructure to reduce climate change is an explicit driver aimed at addressing the issue of flooding, social impacts and sustainability. Making the wrong design choices now will cause future generations to live with a changed climate, depleted resources and without green space and biodiversity

There is a need to apply eco-efficiency concepts to infrastructure development in order to maintain environmental sustainability and mitigate flooding, drought and increased carbon footprint of developments. Sustainability, adaptive and mitigative approaches to climate change, in the design of infrastructure are therefore important steering elements. However only a few rating tools that assess sustainability of infrastructure design.

1.2 Justification of this study

In the area of infrastructure sustainability, there is an urgent need to apply technologies and methods that deliver better and more sustainable performance in a way that is cost effective. Relatively few designers have as yet explored the transformative potential of ecological design and have preferred to remain apolitical and unconcerned with the distributional impacts of design as they affect the health of humans and ecosystems (Van Wyk, 2009).

Bulk infrastructure contributes significantly to the sustainability of a development and needs to be carefully considered. Such infrastructure includes roads, water, sewage and stormwater. All of these can result in loss of critical ecosystems and biodiversity and affect watershed integrity. Further, the environmental effects of unsustainable surrounding infrastructure can outweigh the direct benefits of a green building. There is a need to create an eco-sensitive infrastructure design management system that encourages and promotes the use of “softer” design solutions.

By introducing improved design methods, this study aims to demonstrate that it is possible to overcome the problem of increased carbon footprint by introducing environmentally friendly design decisions prior to the infrastructure design approval process. This increases overall competitiveness by bringing a whole new class of productive solutions to problems while at the same time adding a fresh perspective to the traditional infrastructure design process.

There is a need for tools to assess the environmental impacts of infrastructure design decisions at the design stage, where they will be most influential on the final outcome.

1.3 Aims

In view of the inadequacy of tools to assess the environmental impacts of infrastructure design decisions, the aims of this research study were:

- To incorporate environmentally friendly, ecologically sensitive, innovative design(s) using recyclable material into the design stage of township infrastructure projects.
- To define green infrastructure solutions amongst engineers to ensure a common understanding regarding minimal impact to the environment.
- To establish a standard of measurement for green infrastructure.
- To promote sustainable design of township infrastructure services.
- To highlight the benefits of using greener engineering solutions on infrastructure projects.

This research aims to encourage the incorporation of environmentally friendly, ecologically sensitive, innovative design solutions and the use of recyclable material, at various stages on infrastructure projects. The proposed toolkit is intended to encourage engineers and developers to consider green practices at the earliest stages of project planning, thereby placing fewer burdens on the environment.

1.4 Objectives

The aims of the study can be translated into a number of supporting objectives:

- Develop an interactive decision making toolkit that assists consultants and clients by showing the greener options on infrastructure projects.
- Identify existing green design technologies used in practice and extend these to township infrastructure.
- To define sustainability criteria for township infrastructure design.
- Promote sustainable design on infrastructure township services, by introducing various sustainable design solutions, at various stages of the project, and the use of sustainability reports.

- Develop a green reporting system that allows consultants' decisions, clients' objectives and project requirements to be clearly articulated and readily measured on infrastructure projects.

1.5 Methodology

The methodology for this research study consisted of undertaking a literature review of sustainability concepts, the need for green infrastructure and green technologies that can be applied to township services and green rating systems that are already established. Sustainability infrastructure criteria were identified in order to identify certain focus areas for the client such as environmental quality, resource efficiency, economic or social issues.

A framework for the proposed toolkit was developed together with the proposed outputs. The green technologies identified in the literature review were used to create the actual green township infrastructure rating system. Each infrastructure element underwent a detailed analysis of the potential green interventions that could be implemented from feasibility, to detailed design and construction stage.

Once the green township infrastructure rating system was complete it was evaluated through various case studies in order to determine its suitability and applicability to township infrastructure projects. A variety of projects were chosen such as high income developments, low income developments, industrial parks, mixed use developments and a project with no green interventions to determine its scorings. The rating system scoring method was evaluated and fine tuned in order to determine its applicability and suitability for all types of projects.

1.6 Terminology

Green building

A green building is an environmentally sustainable building, designed, constructed and operated to minimise the total environmental impacts

Green technology

Green technology or environmental technology is the application of environmental science to conserve the natural environment and resources, and to curb the negative impacts of human involvement. Sustainable development is the core of environmental technology.

Sustainable development

Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for generations to come.

Low impact development

Low impact development (LID) is a term used in the United States to describe land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality.

Eco-efficiency

Emphasising the more efficient use of resources (materials, energy, water and land) to deliver goods and services that generate less waste and pollution, minimising environmental impacts and reducing social and economic costs.

Environmentally sound technology (EST)

Environmentally sound technology refers to a wide range of environmentally sound products, services and process that deliver essential needs with minimal ecological impact.

1.7 Overview of chapters

A brief overview of the chapters is presented below:

Chapter 1 – Introduction
This chapter provides the background to the study. It includes the challenges facing infrastructure projects, justification of the research, the research aims and objectives and a brief overview of the chapters.

Chapter 2 – Literature Review: The Need for Sustainable Infrastructure Services and Green Rating Systems
This chapter provides an overview regarding the impact of infrastructure projects on climate change and highlights the deficiencies of current infrastructure projects. Government legislation related to the need for sustainable infrastructure is examined.

This chapter also highlights the influence of early design decisions on environmental impact and sustainability and the need for green technology on infrastructure projects. A critical review of various green rating tools presently available to improve the environmental performance of buildings and roads is presented and the need for a rating system for township infrastructure is raised.

Chapter 3 – Green Technologies that will improve the Environmental Performance on Infrastructure Projects
This chapter discusses the need for green design solutions on civil engineering infrastructure projects and the application of green design elements that improve the environmental performance on township infrastructure projects. It also discusses the advantages of using green technology on infrastructure projects

Chapter 4 – The Green Township Infrastructure Toolkit
The proposed Green Township Infrastructure Toolkit is discussed in this chapter. The purpose of the framework and the detailed description of the Green Township Infrastructure Toolkit are discussed in relation to various project design stages.
This chapter also discusses the use of Sustainability criteria and the proposed Green Reports within the Green Township Infrastructure Design Toolkit. A description of a Green Report is presented and their functions are explained, as well as the advantages of using an eco-approach to design.

Chapter 5 – Case studies

This chapter describes four case studies investigated using the proposed Green Township Infrastructure Design Toolkit. It demonstrates that the Green Township Infrastructure Design Toolkit is more effective than the traditional way of controlling the environmental impacts on infrastructure projects, at a number of different stages in the design process.

Chapter 6– Conclusion and Recommendations

This chapter enumerates the benefits and general conclusions of the study. The Green Township Infrastructure Design Toolkit gives rise to various recommendations, all of which seek to promote affordable infrastructure services.

1.8 Summary

Issues such as poor sustainability, environmental impacts of developments and carbon footprint more than adequately justify this study. This chapter gives an overview of the research study, including the challenges faced by designers, the research aims and objectives and an overview of the chapters. The aims and objectives highlight the need to create green design solutions for infrastructure projects.

There is undoubtedly a need to fundamentally transform the existing infrastructure sector in order to respond to the needs of the client. There is a need for more effective methods of assessing various decision making options on infrastructure projects in order to reduce the environmental impacts of infrastructure services.

CHAPTER 2 – LITERATURE REVIEW: THE NEED FOR SUSTAINABLE INFRASTRUCTURE SERVICES AND GREEN RATING SYSTEMS

2.1 Introduction

Globally, the construction industry is one of the main contributors to the depletion of natural resources and a major cause of unwanted side effects such as air and water pollution, solid waste, deforestation, health hazards, global warming, and other negative consequences. The awareness of environmental impacts is growing and many movements seeking to address sustainability concerns are gaining momentum (Harvey and Wayne, 2008)

This chapter provides an overview regarding the impact of infrastructure projects on climate change and highlights the deficiencies of current infrastructure projects. Government legislation regarding the need for sustainable infrastructure is examined. Various green rating tools presently available to improve the environmental performance of buildings are reviewed in this chapter, which merely focus on building components and do not adequately assess the environmental impacts of infrastructure on developments.

This chapter also highlights the influence of early design decisions on the environmental impact and sustainability of infrastructure projects. The lack of environmental input in the planning and design stage can contribute to unsustainable design solutions, which in turn can contribute to the environmental impacts of projects.

2.2 The effect of climate change on infrastructure sustainability

Climate change has direct and indirect impacts on infrastructure. Population increase, change of location, and human activity alter the demand for roads and has an indirect impact on infrastructure (Austroads, 2004).
The effect of climate change can strain the capacity water infrastructure; reduce water supplies, increase water and air pollution, and increase flooding because of more intense rainfall.

Civil engineers are central to the success of the infrastructure networks that support society and the global economy. To address climate change impacts and develop resilience in infrastructure, the design, construction and operation of infrastructure must be changed (American Society of Civil Engineers, 2009).

Adapting infrastructure to reduce climate change is an explicit driver aimed at addressing the issue of flooding, social impacts and sustainability. Making the wrong design choices now will cause future generations to live with a changed climate and depleted resources.

Road infrastructure presents many opportunities for reducing air pollution, adopting cooler pavements to reduce temperatures, and the use of greener road infrastructure such streetscaping, permeable pavements, warm asphalt, cool and quiet pavements to reduce its environmental impacts.

Sustainable stormwater infrastructure entails the establishment of green networks and green ways, enhance pollution prevention as well as storm water management. It uses technologies, and practices that use natural systems, or engineered systems that mimic natural processes and includes low impact development

Greener sewer infrastructure opportunities include the minimisation of pumpstations , protection of sewer outfalls , primary use of greywater for drip irrigation system, secondary use of greywater which includes a further pump that feeds back to the toilets, irrigation and sprinklers, septic tanks and sewer attenuation

The focus areas for sustainable water infrastructure include reducing water consumption using efficient fixtures, water meters and fittings, a reticulated recycled water supply, water demand management techniques, water efficient fittings and intermediate storage, developing water efficient layouts to decrease pressure and velocities.

2.3 Sustainable infrastructure can provide ways of reducing greenhouse gas emissions

The use of sustainable infrastructure can increase community resilience by filtering polluted stormwater, reducing flooding, restoring flood plains, open space and wetlands by providing retention areas, thereby recharging ground water, reducing ambient air temperatures by adding green areas and alternative road surfacing on the townships.

Sustainable township infrastructure provides ways of alleviating some of the burdens from the greenhouse gas emissions, adaptation, through the following measures:

- The use of alternative construction materials, alternative solutions and products can replace more energy intensive construction materials such as concrete and steel, which can result in carbon savings;
- Green areas protect stored carbon and drastically reducing the amount of carbon dioxide emitted, it also manages flooding;
- Reducing the need to travel by car by improving and linking green walking and cycling routes and local recreation areas;
- Managing high temperatures by providing alternative road surfacing and more space for local recreation areas;
- Conserving the water supply, reducing the stress to vegetation, improving evapotranspiration and water quality and reducing temperatures;
- The proposed toolkit encourages water-and energy-efficient infrastructure for neighbourhoods, thereby reducing the carbon footprint of developments.

2.4 Government's commitment to sustainable service provisions

Infrastructure is a key element for realizing sustained economic growth and sustainable development to achieve the Millennium Development Goals (MDGs), and in particular, MDG 1 (Poverty Reduction) and MDG 7 (Environmental Sustainability).

The South African Government needs to ensure sustainable infrastructure service provision that does not endanger public health, safety and the environment. The constitution provides that local government and municipalities should:

- Ensure the provision of services to the community in a sustainable manner;
- Promote a safe and healthy environment;
- Ensure that municipal services are economical, efficient and effective use of available resources; and
- Ensure that municipal services are environmentally sustainable (Republic of South Africa, 2000).

2.5 The influence of early design decisions on the environmental impact and sustainability on infrastructure projects

During the design stage a large number of environmental interventions can be incorporated, as the design is flexible enough to incorporate relatively significant changes. A sustainable project is managed by totally involving clients in the decision making process.

Figure 2.1 shows the typical life cycle of a project from conception through to operation and maintenance. It illustrates that the ideal time to agree on green interventions on a project is at the concept design stage.

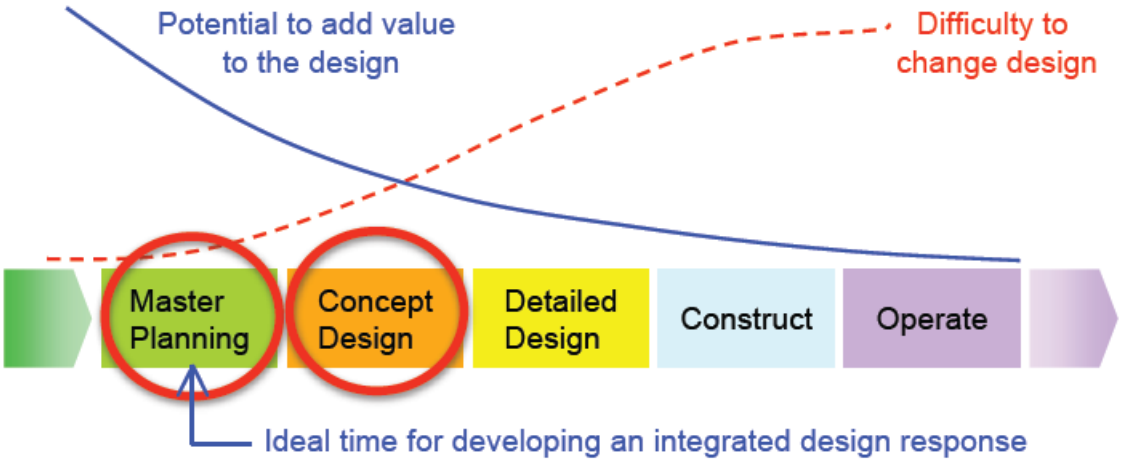


Figure 2.1: Ideal time for developing an integrated design response (Kobacker, 2008)

Figure 2.2 shows the declining influence of environmental interventions on a project as a project progresses from programme phase through to construction. Diligent attention to greener infrastructure solutions from the earliest phases of a project will help guarantee that quality design environmental solutions are incorporated from the beginning.
Early planning for green solutions is crucial as decisions made during the early stages of the development process have a significant sustainable affect than the relatively limited green design interventions which are made later in the process.

Currently design stakeholders are more interested in the project's performance in the later stages of construction, operation and maintenance. However current reporting strategies for sustainability must look at periodically presenting the project's social, economic and environmental performance (Poveda and Young, 2014).

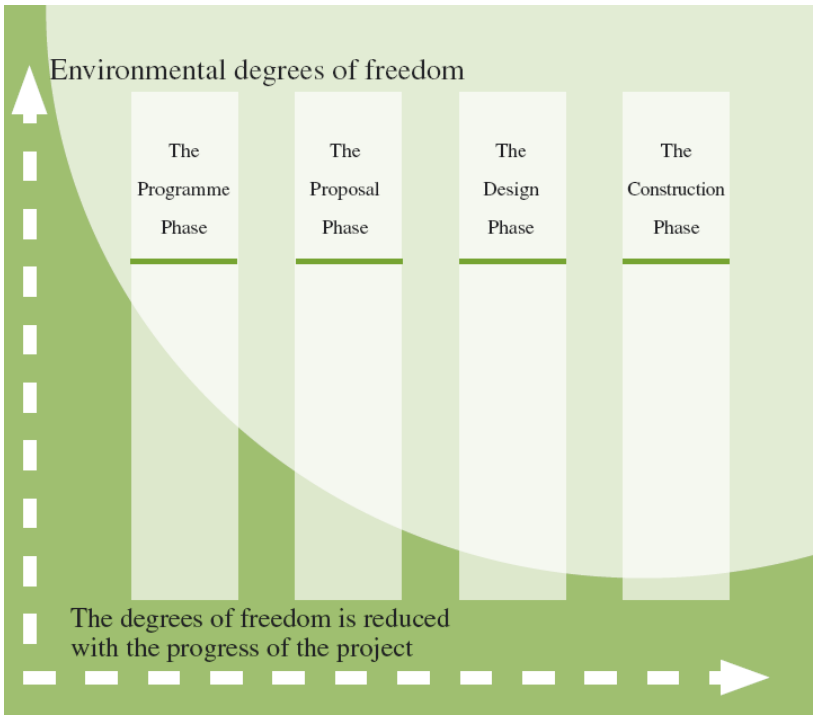


Figure 2.2: The environmental degrees of freedom (European Green Cities Network 2004)

2.6 The need for the use of green technology and a green rating system on civil engineering infrastructure projects

Civil engineering projects can have significant site-specific and cumulative impacts on ecological and social systems if not correctly planned, designed and implemented. Due to the increasing demand for energy, drinking water, clean air, safe waste disposal and transportation, authorities are imposing stricter environmental regulations on infrastructure development. Engineers have to be at the forefront of development finding innovative solutions to maximise water capture, ensuring conservation of the resource from supply through to distribution so that environmental impacts are avoided or mitigated. Understanding the context of the environment in which they work is thus essential (Kilian and Gibson, 2007).

Infrastructure development has been focused primarily on financial and engineering aspects. The environmental agenda and incorporating the eco-efficiency concept into various stages of infrastructure is urgently required among policy-makers, planners and decision-makers. However, the criteria applicable to and measures for developing eco-efficient and sustainable infrastructure are yet to be fully identified (United Nations Economic and Social Commission for Asia and the Pacific, 2006).

Infrastructure plays a significant role in the sustainability of the built environment. Unlike buildings, infrastructure works at a larger scale and requires careful planning to work well and efficiently. Although there are examples of infrastructure projects that have adopted sustainable solutions throughout the country, there are few systems available that rate civil engineering infrastructure projects.

2.7 A literature review on green rating systems used on infrastructure projects

There are numerous building evaluation tools that focus on different areas of sustainable development, however only a few systems are widely acknowledged and really set a recognizable standard for sustainable infrastructure development. The Envision rating tool, Ceequal and Greenroads systems are currently the most popular, influential and technically advanced rating tools available (Nguyen and Altan, 2011).
This study evaluates various green rating tools and reviews their applicability to township engineering services projects, in order to create a decision toolkit that assesses the environmental impacts of township infrastructure design decisions on a development.

2.7.1 LEED for Neighborhood Rating System

The Leadership in Energy and Environmental Design (LEED) for Neighborhood rating system, developed by the U.S. Green Building Council (USGBC) rating system assesses commercial, institutional, and residential buildings and neighborhood developments. The LEED for Neighborhood rating system was developed in 2009 and are categorized under Smart Location and Linkage, Neighborhood Pattern and Design, Green Infrastructure and Buildings (LEED, 2015).

2.7.1.1 A review of the LEED for Neighborhood rating system

The LEED for Neighborhood Development rating system focuses on measures that can reduce the environmental consequences of the construction and operation of buildings and neighborhood infrastructure. The sustainable building technologies proposed to reduce

waste and use energy, water, and materials more efficiently than conventional building practices

The checklist briefly assesses the civil infrastructure in terms of the credits which are summarised in Table 2.1 below.

The LEED rating system lacks a comprehensive approach to life cycle assessment, ecological and economic assessment criteria (Ismaeel, 2012).

The disadvantages of the toolkit are that it does not assess the detailed design components of infrastructure. The transport component is rated by a 7 items, namely; Walkable streets, bicycle facilities, reduced parking footprint, universal design, steep slope protection, access to public space and shaded streetscapes.

These broad criteria do not adequately cover the various opportunities for sustainable and eco-efficient road design.

The stormwater component of a building is assessed under the section ' Green Infrastructure & Buildings ' and contains four credits, namely, Rainwater management, Open space, Floodplain avoidance and Restoration of habitat or wetlands.

Various major items such as stormwater management, attenuation, and low impact development technologies were not assessed. The treatment of stormwater has a huge impact on the environment in terms of erosion control, ground water recharge and reuse for irrigation. The LEED rating system also does not adequately rate or assess the detailed design of the stormwater infrastructure components of a typical township project.

The water component is rated by two items, namely; Water metering and Outdoor water use reduction and do not adequately identify water efficient design interventions that would ensure sustainable water infrastructure on township infrastructure projects.

The sewer component is rated by three items, namely; Wastewater management, Recycled and reused infrastructure and Infrastructure energy efficiency and does not adequately cover the opportunities available to reduce impacts of sewer infrastructure.

A more comprehensive list of sustainable criterion and sub-criterion for township Infrastructure Services is being proposed in in Appendix 2, which covers far more design details, that what is being proposed in the existing model.

2.7.2 The Green Star – Multi Unit Residential Pilot Rating Tool

Green Star – Multi Unit Residential PILOT Rating Tool, created by the Green Building Council Australia (GBCA) in 2008 evaluates the environmental design and performance of Australian buildings based on a number of criteria, including energy and water efficiency, indoor environment quality and resource conservation.

Green Star has developed from existing systems and tools in overseas markets, including the British BREEAM (Building Research Establishment Environmental Assessment Method) system and the North American LEED system, by establishing individual environmental measurement criteria (Green building Council Australia, 2008).

2.7.2.1 A review of the Green Star – Multi Unit Residential Pilot Rating Tool

The benefits of the Green Star – Multi Unit Residential rating tool are that it enables building owners and developers to minimise the environmental impacts of their developments, reduces greenhouse gas emissions, and gives recognition for environmentally sustainable design and deliver health benefits and financial savings for building occupants.

Whilst the checklist is detailed for the building elements, it does not adequately cover the civil engineering aspects of multi unit residential developments.
The above-mentioned tool merely assesses five components of road infrastructure, namely; Car parking minimisation, Cyclist facilities, Commuting public transport, Trip reduction mixed-use and Topsoil preservation, with no emphasis on road design aspects.
The criteria applicable to civil engineering infrastructure is also summarised in Table 2.1.

The water component rates only three aspects, namely; Water efficient appliances, Water meters and Landscape irrigation and does not adequately cover the water design aspects of reticulation design. The stormwater and sewer component are not taken into consideration in the Green Star – Multi Unit Residential rating tool.

A more comprehensive list of sustainable criterion and sub-criterion for township Infrastructure Services is being proposed in Appendix 2, which covers far more design details, that what is being proposed in the existing model.

2.7.3 The Green Star South African Rating Tool

The Green Building Council SA developed the Green Star South African rating tool to provide an objective measurement for multi-unit residential in South Africa. This system was developed on existing systems and tools from overseas markets and reflects various market sectors such as office, retail, multi-unit residential, public and education buildings.
The tool is designed to be used by owners, developers and consultants (e.g. Architects, engineers, quantity surveyors, project managers, building contractors, etc.) to influence the design of multi-unit residential developments. The tool enables these stakeholders to minimise the environmental impacts of their developments and to capitalise on, and receive recognition for, their design initiatives. It also recognises the socio-economic achievements and initiatives of green building projects

The disadvantage of the tool is that it is mainly focused on buildings and lacks the necessary assessment criteria for sustainable infrastructure design (Green building Council South Africa, 2014). The assessment criteria used in the Green Star South African rating tool are Management, Indoor Environment Quality, Energy, Transport, Water, Materials, Land Use & Ecology, Emissions, Innovation and Socio-Economic.
The criteria available on the Green Star South African rating tool are identical to the Australian Green Star Rating tool and do not adequately cover the civil engineering design aspects of residential developments.

A more comprehensive list of sustainable criterion and sub-criterion for township Infrastructure Services is being proposed in in Appendix 2, which covers far more design details, that what is being proposed in the existing model.

2.7.4 A review of the Envision rating tool

The infrastructure rating system Envision was developed by the Zofnass Program for sustainable infrastructure based at the Harvard Graduate School of Design and the Institute for Sustainable Infrastructure and contains 55 sustainability criteria (called ‘credits’) organized into five categories: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate.

Envision focuses on the contribution of infrastructure to the many other systems it is part of, such as urban and natural systems and also addresses the functions of communities such as sustainable growth development, efficient job creation, and general life improvements.

However, in terms of civil infrastructure, the rating system focusses mainly on roads and stormwater and does not adequately rate water sustainability, with the use of only 3 applicable sub-criteria namely, reduce potable water consumption, monitor water systems and protect fresh water.

The toolkit also does not rate sewer infrastructure, which is a major contributor to environmental pollution.

The system focuses on environmental issues related to construction processes and materials rather than operational phases. Even though these approaches can be implemented at the planning, design and construction stages, in current practices it has not been used. European Union countries use the tool to assist in the decision-making process (Bueno *et al*, 2015).

Simpson *et al*, (2015) highlight the inability of Envision to allocate weights to criteria, or offer a checklist customized to particular types of projects.

Whilst Envision is quite extensive, it does not adequately assess the design features of road, water, stormwater and sewer infrastructure, compared to the various criterion proposed by the Green Infrastructure Township Model, in Appendix 2.

2.7.5 A review of the Civil Engineering Environmental Quality Assessment (CEEQUAL) tool

The Civil Engineering Environmental Quality Assessment and Award Scheme, or CEEQUAL, is a UK-based environmental assessment and awards program for improving environmental performance in civil engineering. The sustainability criteria in CEEQUAL consists of 12 key sustainability factors, namely: land use, project environmental management, ecology and biodiversity, landscape, archaeological and cultural heritage, water issues, use of materials, transport, waste, nuisance to neighbours, energy and community relations.

The benefits include improvements to projects through the adoption of best practice including whole-life costing, waste minimisation, resource efficiency (materials, water, and energy) and responses to climate change effects.

CEEQUAL does not have criteria such as Air quality, Noise quality, Pollution control, Erosion & Sediment control, Life cycle cost, Health and safety (Amiril *et al*, 2011).
Simpson *et al*, (2015) highlight the inability of CEEQUAL to employ self-assessment, allocate weights to criteria, or offer a checklist customized to particular types of projects.
CEEQUAL does not adequately assess the design elements and alternative solutions for road, water, stormwater and sewer infrastructure, compared to the various opportunities proposed by the Green Infrastructure Township Model, in Appendix 2.

A more comprehensive list of sustainable criterion and sub-criterion for township Infrastructure Services is being proposed in Appendix 2, which covers far more design details, that what is being proposed in the existing model.

2.7.6 A review of the Green Roads Rating Tool

The Green Roads Rating Tool was developed by the University of Washington and is used in assessing environmental impacts of road construction with its associated stormwater (University of Washington, 2014).
There are various eco-centric benefits such as reduction in raw materials use, water pollution, greenhouse gases, as well as anthropocentric benefits, which are improvement to access, mobility, human health and safety.

The limitations of the tool is that it only covers the road component and its associated stormwater infrastructure and does not assess water design and sewer infrastructure design, which has a major influence on ensuring townships services sustainability. The system merely tracks water usage during construction.

The Green Roads tool does not adequately address the geometric design aspects of roads (i.e. The horizontal alignment), environmentally friendly layout planning, the effect of road grades, vertical alignments and cross sectional elements, all of which have a significant impact on the footprint of roads.

The Green Roads tool does not adequately compare alternative technologies and only assesses 48 components of a road project as compared to the 384 design features that are rated using the proposed Green Infrastructure Toolkit. Further the tool does not allow the user to prioritise multi-sustainable criteria or conceptual setting of green goals.

The Green Road Rating systems, although useful, have the same shortcoming as the Leadership in Energy and Environmental Design (LEED) system for buildings, i.e., those credit-based systems lack objectiveness in the criteria selection and weighting process. The rating procedures in these rating systems are not based on standardized performance metrics; for this reason, the effect of meeting environmental targets in these rating systems cannot be quantified. In addition, too many criteria are used in some systems (e.g., 60 criteria for ENVISION) without consideration of their effectiveness or the trade-offs among criteria (Lee *et al*, 2013).

A more comprehensive list of sustainable criterion and sub-criterion for township Infrastructure Services is being proposed in Appendix 2.

2.8 The controversial nature of weighting criteria rating on projects

Rating systems involve both weights and scores, both of which are qualitative to a large extent. Chandratilake and Dias, (2014) suggest that the variations in weighting amongst the various elements and criteria can be linked to the contextual differences among those countries.

So for example, it would be reasonable that countries with a high per capita consumption of water would seek to reduce consumption by providing a higher weight to water efficiency in their sustainability rating systems. Similarly, countries with huge infrastructure backlogs would rate economy higher than other criteria.

Weighting is one of the most theoretically controversial aspects within the rating systems. Weighting procedures were scrutinized to find the basis for weighting across the tools. Each tool has its own unique way of weighting. Although in some cases all the criteria are assigned equal value, it is common that some criteria are weighed higher based on their performance against the specified benchmarks or accepted norms. Process of criteria selection and weighting assignment is often subjective.

Weighting involves a high degree of subjectivity. The use of words such as partial, majority, almost, considerable, somewhat, substantial, etc. across the weighting system will have assessment result's dependent on the assessor's discretion and intuitive judgment (Sharifi and Murayama, 2013).

2.9 Critical review on the adequacy of green rating systems for civil engineering township infrastructure projects

The literature review of various green rating tools revealed that there is a narrow focussed evaluation on determining the environmental impact of infrastructure design solutions.
Numerous environmental assessment tools were reviewed to assess their applicability to civil engineering township infrastructure services. The criteria for each of the existing rating tools were illustrated under the various elements in Table 2.1.
The existing rating tools do not adequately assess the design components of civil infrastructure and the external environment.
The existing tools do not rate and monitor civil engineering infrastructure design decisions throughout the various design phases.
A more comprehensive list of Sustainable performance criteria for township Infrastructure Services is also being proposed in Table 4.1 in chapter 4, namely Layout Planning, Functional Efficiency, Environmental Quality, Economy, Future Maintenance, Safety, Social, Resources and Construction Efficiency.
A more comprehensive list of sustainable criterion and sub-criterion for township Infrastructure Services is being proposed in Appendix 2.
The existing rating tools do not have standardised reports for scoring the project at different stages, allowing continuous monitoring of the design.

Table 2.1: A review of existing Infrastructure rating tools for various township infrastructure elements

Township infrastructure elements	LEED	Green Star - Multi Unit Residential PILOT	South african Green Star - Multi Unit Residential	Envision rating tool	Civil Engineering Environmental Quality Assessment	Green Roads
Transport	Walkable Streets	Car Parking Minimisation	Provision of Car Parking	Improve Community Mobility & Access	Land use / site selection	Low Impact Development
	Bicycle Facilities	Cyclist Facilities	Cyclist Facilities	Encourage Alternative Modes of	Ecology & Biodiversity	Site Vegetation
	Reduced Parking Footprint	Commuting Public Transport	Commuting Mass Transport	Use Recycled Materials	Material type & availability	Safety Audit
	Visitability and Universal Design	Topsoil preservation	Topsoil	Reduce Excavated Materials Taken Off	Reusability	Bicycle and Pedestrian
	Steep Slope Protection	Trip Reduction - Mixed Use	Local Connectivity	Avoid Unsuitable Development on Steep		Earthwork Balance
	Access to Civic & Public Space			Avoid Adverse Geology		Recycled Materials
	Tree-Lined and Shaded			Improve Community Quality of Life		Long-Life Pavement
				Improve Site Accessibility, Safety &		Ecological Connectivity
Water	Water Metering	Water Meters	Water Sub-Metering	Reduce Potable Water Consumption	Water quality	Water Tracking
	Outdoor Water Use Reduction	Landscape Irrigation	Landscape Irrigation	Monitor Water Systems	water issues	
		Water Efficient Appliances	Potable Water Efficient	Protect Fresh Water Availability		
		Fire System Water	Fire System Water			
Stormwater	Rainwater Management		Environmental Design Initiatives	Protect Wetlands & Surface Water		Runff Flow Control
	Open Space			Avoid Adverse Geology		Runoff Quality
	Floodplain Avoidance			Preserve Floodplain Functions		Stormwater Cost
	Restoration of Habitat or			prevent ground water contamination		
				Manage Stormwater		
Sewer	Wastewater Management					
	Recycled and Reused					

Bueno et al, (2015) undertook an analysis of sustainability tools developed for civil infrastructure in general, such as the Civil Engineering Environmental Quality and Assessment Scheme (CEEQUAL), the infrastructure rating developed by the Zofnass Program for Sustainable Infrastructure and the Institute for Sustainable Infrastructure, Envision and the Leadership in Energy and Environmental Design Rating System for Neighborhood Development (LEED), as well as rating systems focused on roads, Greenroads. He concluded that on evaluating sustainability, none of the tools and methods already analysed are suitable for a holistic assessment of the sustainability of a transport projects.

Further research is recommended to explore existing tools in order to use them more effectively for sustainability appraisal). Furthermore, when applying life cycle cost analysis

(LCA) to transport projects, it is usually confined to materials and engine alternatives for construction machinery, instead of evaluating different design parameters.

Matar et al, (2015) highlight the fact that more than 600 sustainability assessment tools currently exist. Most of these are primarily oriented toward buildings, and do not direct sufficient attention for infrastructure projects.
The few evaluation tools available satisfactorily address infrastructure projects, however lack consensus on evaluation criteria. Matar *et al*, (2015) advises that there are also wide discrepancies between assessment results during the planning and design phases, and the actual performance during real life operation. Most of the available sustainability assessment tools address buildings, while few of them address civil infrastructure projects.
Matar *et al*, (2015) also investigated several sustainability assessment systems and explored their applicability to a particular type of infrastructure projects and found that most of these evaluation tools, still suffered the same shortcomings of the green building rating systems, as they were not based on standardized and quantifiable performance metrics for infrastructure.

2.10 Summary

This chapter highlights the deficiencies and the current state of infrastructure globally and gives an overview of the challenges on infrastructure projects. It highlights the effects of climate change and the urgent need to promote and develop environmentally sustainable infrastructure design solutions and tools, taking into account the eco-efficiency concept in civil engineering infrastructure projects. Government legislation pertaining to sustainable infrastructure expressed the need for sustainable infrastructure provisions. It also describes the need to undertake environmental interventions early in the project life cycle.

There are various rating tools presently available to architects, builders and developers, such as the LEED Green Building rating system, the Green Star Rating Tool, Envision, Green Roads, etc., that rate the environmental performance of buildings. However, it is evident that these tools do not adequately assess civil engineering infrastructure design components on a project. There is an urgent need for a paradigm shift to take a much broader look at infrastructure components, rather than just green buildings.

The literature review revealed that none of the tools adequately rate the environmental impact of design solutions on township infrastructure projects, compared to the various opportunities proposed by the Green Infrastructure Township Model, in Appendix 2.

In light of the above, there is a need for more effective methods of assessing and rating infrastructure design options and components on infrastructure projects. Given the broad global range of issues and challenges, in the quest for creating a sustainable built environment, stakeholders desperately need a consistent framework of indicators to measure sustainable civil engineering infrastructure. This chapter reveals that there is a need to establish a green infrastructure rating tool to serve as a basis for the development of various sustainable, innovative, eco-efficient township infrastructure solutions.

CHAPTER 3 – GREEN TECHNOLOGIES THAT WILL IMPROVE THE ENVIRONMENTAL PERFORMANCE OF INFRASTRUCTURE PROJECTS

3.1 Introduction

In the area of sustainability, there is an urgent need to apply technologies and methods that deliver better and more sustainable performance in a way that is cost effective. Sustainable, adaptive and mitigative approaches to climate change in the design of infrastructure are therefore important steering elements (International Federation of Consulting Engineers (FIDIC), 2009). With designers of infrastructure being held financially accountable for adverse environmental impacts, the construction industry has been subject to much environmental regulation aimed at the safety of the objects constructed and the construction work involved, land use planning, and environmental protection. However, owing to an increasing number of industrial accidents it became clear that regulatory control instruments were not preventing disasters (Boswell, 2005).

In order to stay competitive and to meet upcoming stricter environmental regulations and customer requirements, designers have a key role in designing civil engineering infrastructure so that it is environmentally sustainable. This has compelled engineers to design with greater care and in more detail.

Relatively few designers have explored the transformative potential of ecological design and have preferred to remain apolitical and unconcerned with the distributional impacts of design as they affect the health of humans and ecosystems (Van Wyk, 2009). A new paradigm shift for infrastructure design is required in order to maintain environmental sustainability for township projects. This chapter highlights for the need to implement green design solutions as well as the green technologies that can be implemented on infrastructure projects. The changing roles of engineers will be highlighted, because they need to react to changes in climate.

3.2 The lack of implementing of green technology on infrastructure projects

While there are some good examples of progressive green technology, the socio-economic inequalities and negative environmental issues within many urban areas remain widespread in both developing and developed countries, with slum populations are still increasing.

Barriers preventing clients from committing to a sustainable design approach are presently surplus cost, the limited selection of environmentally responsible materials as well as education into the need for sustainability. The greatest obstacle is the feasibility or cost, which often results in the client disregarding sustainable design. Environmentally responsible materials require greater upfront costs, which clients are often not prepared to pay. Environmental departments in some countries do not control the policy tools required to drive real change. Sustainable design is also not adequately studied at many tertiary institutions (Hankinson and Breytenbach, 2012).

Other barriers to implementing green technology include the scarcity of material on green buildings and infrastructure, the low volume of research on the theme, the lack of indicators for evaluating the sustainability and the lack of a technical norm that establishes a standard construction procedure for a green infrastructure (Kasai and Jabbour, 2014)

3.3 Green design elements that will improve the environmental performance of township infrastructure projects

Innovative approaches to planning and design of civil engineering infrastructure can greatly mitigate the negative impacts of development on the environment.

The green infrastructure concept is one of the means to accomplish sustainable township developments. Green infrastructure entails the establishment of green networks and green ways, enhance pollution prevention as well as storm water management. It uses technologies, and practices that use natural systems, or engineered systems that mimic natural processes and includes low impact development, smart conservation strategies and Urban Green Best Management Practices (M'Ikiugu *et al*, 2012).

This study investigated various green technologies and concepts to suit township infrastructure projects, with the aim of softening the impacts of civil engineering infrastructure on residential developments. Green technology that can be used on infrastructure projects may include the utilization of natural or engineered systems that mimic natural landscapes in order to capture, cleanse and reduce stormwater runoff.

This eco-efficient design approach is a cost-effective and visually appealing approach to site design that involves innovative design technologies for managing civil engineering

infrastructure services. Eco-efficient infrastructure design techniques reduce stormwater runoff, protect watersheds, lowers installation and infrastructure maintenance costs and add aesthetic value. The primary goal of this approach is to protect a community's natural environment and minimize the ecological impacts of urbanization.

3.3.1 The application of green elements on infrastructure projects

The elements that make up civil engineering township infrastructure include roads, stormwater, sewer and water infrastructure. A review of various international infrastructure best practices reveals various alternative approaches to the conventional township infrastructure practices that can be incorporated into the green township infrastructure.

Table 3.1 indicates the various green sustainable solutions that are incorporated into the Infrastructure Services Design Toolkit and categorised under the proposed sustainable performance criteria, namely Layout Planning, Functional Efficiency, Environmental Quality, Economy, Future Maintenance, Safety, Social, Resources and Construction Efficiency.
Four of the nine proposed sustainable criteria, namely Economy, Functional Efficiency, Safety and Environmental Quality were derived from goals that were set out for layout planning and related services for residential township developments (CSIR, Centre for Scientific and Industrial Research, 2005). The performance criteria will be described in detail in Chapter 4.

Road infrastructure presents many opportunities for reducing air pollution, adopting cooler pavements to reduce temperatures, and the use of greener road infrastructure such streetscaping, permeable pavements, warm asphalt, cool and quiet pavements to reduce its environmental impacts.

There are several technologies that can easily be implemented for stormwater infrastructure, including aquifer storage and recovery, bioretention swales and ponds, infiltration basins, rain barrels, french drains, stilling basins and constructed wetlands.

Greener sewer infrastructure opportunities include primary use of greywater which includes a storage tank and overflow into a drip irrigation system, secondary use of greywater which includes a further pump that feeds back to the toilets, irrigation, sprinklers, and septic tanks and sewer attenuation.

Greener water infrastructure opportunities include a reticulated recycled water supply, water demand management techniques, water efficient fittings and intermediate storage.

This study investigated various design solutions that can be used on all types of township infrastructure projects. The eco-efficiency of various solutions will be analysed in proposed Green Reports, presented in Chapter 4.

Table 3.1: Green infrastructure design opportunities that can improve the environmental performance on township infrastructure

GREEN TOWNSHIP INFRASTRUCTURE TECHNOLOGIES				
	ROADS	**SEWER**	**STORMWATER**	**WATER**
1. LAYOUT PLANNING	- Relaxed Setbacks and narrow frontages	.-Layout promote midblock sewer	.- Green corridors-Natural drainage paths	.-Location & Spacing of Fire hydrants
	- Promote concept of greenstreets	.- Minimise sewer pipeline in floodline	.- Multipurpose stormwater facilities	.- Optimised pipe route alignment
	.-Ecological Connectivity-Open spaces	.-Avoidence of pumpstations	.- Open spaces for retarding/ponding sw	.- Reticulation pipes are looped -effeciency
	.- Shared driveways (Permeable)	- Optimised route alignment	.- Buffer systems (width)	.- Piping arranged to allow ready shut off valves
	.-Landscape: Water efficient plantings	.- Contour layout planning	.- Attenuation/ retention facilities planned	.- Low demand land uses on high ground
	- Align roads with natural topography	.- Catchment planning		.- land uses with high demand close to bulk mains
2. RESOURCES	.-Alter Surfacing-Permeable pav/asphalt/conc.	.- Backfill - non commercial source	.- Pipe material - pvc/concrete/hdpe	.- Water demand management measures
	Reinforced Turf, Grass block, Paved strips	.- Reed bed systems	.- Source/type of Bedding	- Smart Zone and bulk metering
	.- Pavement Layerworks-Recycled	.-Manhole types- brick/precast	.- Use of Eco. Fr Manhole types- brick/precast	.- Raw water quantity requirements & availability
	.- Alternative Transportation Options	.-Pipe material - pvc/concrete/hdpe	- Rain water harvesting and Reuse	.- Use of Present & future water consumption figures
	.- Earthworks- balanced-Cut / Fill	.-Avoid the Use of pumpstations	- Recycling of stormwater	.-Promote use Water Efficient fixtures/Appliances
	.- Tree conservation	.- Nutrient resource recovery & reuse	.- Promote aquifer storage and recovery	
3. ENVIRONMENT QUALITY	- Reduce no. of valley crossings	- Reed bed systems	.- Post Development < Predev Flow	.- Use of boreholes & reliability of water source
	- Erosion control measures	-non water-based sewage conveyance	.- Recharge rates maintained	.- Spring protection measures
	- Mitigate impacts on environment	- Prob of groundwater contamination	.- Protection measures of wetlands	.-Water quality & proximity to sources of potential
	.-Reduce clearing and grading (Site Vegetation)	- Flood protection of pumpstation	- Runoff quality-Constructed Wetlands/filters	water supply contamination
	.-Habitat Restoration	- Waste effluent quality	.- Minimize stormwater concentration	.-Valve/Meter/Standpipe located convenient positions
4. FUNCTIONAL EFFICIENCY	.- Use of Permeable pavements	- Separate grey water/ black water	.- Quality of runoff from residential rooftop:	.- Water-Efficient Irrigation & landscaping measures
	- Use drainage and storage functions of roads	.- Oil/grease/grit separators	Downpipe disconnect, Rain Barrels,soakaways	- Use of Roof tank/intermediate storage
	.- Use of cool/warm mix asphalt	.- Use of On-site Treatment	.-Runoff Flow Control-Sand Filters	.- Pressure Management as part of design
	.- Use of Streetscaping	- Primary/Secondary greywater reuse	.-Bioretention swales/ponds/infiltration berms	.- Dry Fire Hydrants. suction pipe systems from pond
	.- Low impact road design	.-Sewer attenuation	-Erosion control(Geotextile/cells,gabions)	.- Efficient water systems design
	.-Enhanced pedestrian facilities/bicycle paths	.- Reticulated recycled water supply	.-Sediment control- Silt fences/Stilling basin	,-Watertight joints/Seals quality - pressures
	- Parking ratios/codes/parking lots	.-Innovative wastewater technology	- Rooftop runoff direct to pervious surfaces	.- Ensure water balance in system
	- Quiet Pavement		.- Stormwater Management Plan	.- Optimised velocity in pipe
	.-Varying detail to create diversity and interest			- Water efficient fittings
5. FUTURE MAINTENANCE	.- Maintainance of grass/natural environment	.-Self-cleaning velocity in sewers	.-Design consider maintenance needs	.- Life span of the pipes and materials
	-Bank slopes must be designed to be gentle	.-Life span of the pipes and materials	.-Flood plain accessible	.- Services watertight
	- Pavement lifecycle design	.-Access for maintenance(Mh & pipe)	.-Life span of the pipes and materials	. -Positioning of trees - proximity of services
	Type of tree planting- prevent leaves falling	.-Erf have a rodding eye	.- Reduce large open spaces	.-Leak Detection devices in retic.
		.-Services watertight	.-Inlet/outlet design to reduce blockages	.- Provisions for future expansion of the system
6. ECONOMY	.- Optimised level of service	.- Optimised level of service	.- Optimised level of service	.- Optimised level of service
	.- Minimize the number of road intersections	.-Increased % mid-block sewer	- Rain water harvesting techniques	.- Use of shared trenches
	.- Use of narrower shorter streets	.-Maximum manhole spacing	.-Use of shared trenches	.- Max. hydrants, airvalve spacing
	.-Curvelinear roads increases no of manholes	.-Use of shared trenches	.- Maximum manhole spacing	.- Apropriate water demands
	.- Pavement Life-Cycle Cost Analyses	.-Long lengths of opens space		.- Use of eco Pipe material - pvc/concrete/hdpe
7. SAFETY	.-Use of traffic calming measures	.-Trench depths <3m	.-Safe discharge routes	.- Increased Fire risk category
	.- Signage and sense of place	.- Position in relation to water pipe	.- Reduced velocity /depth of stormwater flow	.-Velocity of water flowing
	.-Safe street and unique public space	.- Reduced depth of manholes	.- Reduced depth of manholes	.- Reduced depth of manholes
	.-Safe intersection-pedestrian friendliness		.-Inconvenience of overland flow	.- Reduce pressure on pipeline
8. SOCIAL	- Public facilities -- Convenient pedestrian paths / crossings-- Accessibilty during the repair of services-- Planning for social and physical infrastructure-- Ensuring developments contribute to economic growth-- Improving the quality of life for the area-- Informing and involving internal and external stakeholders			
9. CONSTRUCTION	- Environmental Management System-- .-Quality Management System--.-Environmental Training Plan			
	.- Pollution Prevention Plan (Erosion, Sediment, Wind Erosion, Stormwater Management and Materials Pollution Control)			
	.- Noise Mitigation Plan--.-Site Recycling Plan--.- Waste Management Plan			

The following design manuals were used in the review of alternative approaches to conventional design practices:

- BMT WBM Pty Ltd, 2007. *National Guidelines for Evaluating Water Sensitive Urban Design*, Australia
- Knox City Council, 2002. *Water Sensitive Urban Design for the City of Knox*. Knox City Council
- Centre for Watershed Protection, 2007. *Urban Stormwater Retrofit Practices*, Office of Wastewater Management U.S. Environmental Protection Agency Washington, D.C.
- HCCREMS (Hunter Central Coast Regional Environmental Management Strategy), 2007. *Wastewater Reuse: Practice Note 9*. Ed. Kim Duncan & Hugh Cross Hunter Council, Sydney
- Southeast Michigan Council of Governments, 2008. *Low Impact Development Manual for Michigan: A Design Guide for Implementors and Reviewers*, SEMCOG, Michigan, United States of America

3.4 The use of green infrastructure on low income developments

The Green Agenda concentrates on reducing the environmental impact of urban-based production, consumption and waste-generation, focusing on the problems of affluence and over-consumption, issues which are more pressing in developed countries. The Brown Agenda focuses on the problems of poverty and underdevelopment, emphasises the need to reduce the environmental threats to health that arise from poor sanitary conditions, overcrowding, inadequate water provision, hazardous air, water pollution, and local accumulations of solid waste. The Brown Agenda is therefore more pertinent in poor, under-serviced cities. There is a need for more appropriate technologies for low income developments which can:

- Enhance social sustainability through the use of labour-intensive construction activities that also present opportunities for poverty alleviation;
- Promote local economic development by encouraging the use of small companies that are responsible for a large proportion of building material and plant manufacture;
- Reduce material wastage by innovative methods of waste disposal and re-use;
- Conserve water through improved water metering systems, rainwater harvesting systems, re-using water, waterless and low-flow technologies, the use of water on construction sites and in the production of materials;

- Provide innovative building materials and method; and
- Include food gardens to produce nutritious and home-grown food.

Low income developments should strive to meet the sustainability criteria of resource efficiency, use of renewable resources, minimisation of pollution and waste, economic empowerment, health and safety, and human development (Centre for Scientific and Industrial Research, 2002).

3.5 Advantages of using green technology on infrastructure projects

Green township infrastructure technologies can contribute to greenways and green corridors and provide linkages between habitats and wetlands. Green technologies have a number of environmental, economic and community benefits, in addition to reducing the volume of overflows and runoff, which are highlighted below.

Resource benefits:

- Recycling of used products;
- Conservation of natural resources; and
- Recharged ground water flow in streams, thus conserving water supplies.

Environmental benefits:

- Enhancement and protection of ecosystems and biodiversity;
- Increased vegetation which improves air quality by filtering many airborne pollutants;
- Minimization of impervious surfaces, reducing soil erosion; and
- Reduction of concentrations of pollutants.

Economic benefits:

- Reduced infrastructure costs by water collection, storage, treatment and distribution;
- More efficient use of existing infrastructure;
- Reduced operating costs;
- Enhanced asset value and profits; and
- Optimized life-cycle economic performance.

Health and community benefits:

- Improved air, thermal, and acoustic environments;

- Increased community safety;
- Convenience of users;
- Enhanced occupant comfort and health;
- Minimized strain on local infrastructure; and
- Contribution to overall quality of life.

Green technologies provide adaptation benefits for a wide array of circumstances, by conserving and reusing water, promoting groundwater recharge and reducing surface water discharges that could reduce flooding.

In addition to this, vegetation improves urban aesthetics and community liveability by providing recreational and wildlife areas. Green infrastructure may save capital costs associated with paving, creating kerbs and gutters, building large stormwater conveyance systems, other hard infrastructure and costs of repairing the damage caused by stormwater, such as streambank restoration.

3.6 Summary

There is an urgent need to apply eco-efficiency concepts to township infrastructure development. Taking a greener approach to infrastructure development not only mitigates the potential environmental impact of development but makes economic sense as well. By softening the environmental footprint, avoiding waste and finding efficiencies, clients and local governments can increase their long term sustainability.

As can be seen in this chapter, there are numerous opportunities for improving eco-efficiency in infrastructure design. A new paradigm for infrastructure design is required in order to maintain infrastructure sustainability and mitigate flooding and drought.

Engineers need to look at greener technologies rather than just using traditional engineering solutions. This wider perspective can be made operational through the introduction of a suite of sustainability indicators and a rating tool for assessing infrastructure solutions.

CHAPTER 4 – THE GREEN TOWNSHIP INFRASTRUCTURE TOOLKIT

4.1 Introduction

The previous chapter focused on the need to implement greener technologies on township infrastructure projects. The literature review of current practice reveals that no environmental rating systems or tools exist to assess the environmental effects of infrastructure design solutions. This chapter discusses the proposed Green Township Infrastructure Design Toolkit developed to assess the environmental impact of design decisions at each stage of the township infrastructure project.

This toolkit incorporates the concepts of green buildings, low impact developments, sustainability, eco-efficiency and value engineering in evaluating design decisions on civil engineering infrastructure projects. This can result in a project of a higher standard and reduced environmental impact, by focusing on high-performance, eco-efficient, economical design components, thus increasing infrastructure sustainability.

4.2 The Green Township Infrastructure Toolkit defined

This research aimed to develop a toolkit that will encourage environmentally sustainable design on township infrastructure services by integrating a consideration of resources, the environment, ecologically sensitive, innovative design, maintenance and recyclable materials, from the conceptual design stages of a project.

The Green Township Infrastructure Design Toolkit uses the concept of eco-efficiency and allows the designer to evaluate design options, enabling him/her to choose the solution that yields the best performance, with the least environmental impact. The Green Township Infrastructure Design is intended to encourage developers to consider green methods and practices at the earliest stages of project planning, by assessing a number of recommended green practices and its environmental impacts on infrastructure services design, placing fewer burdens on the environment.

4.3 Purpose of the framework

The purpose of the framework is:

- To ensure a value-added, environmental approach to infrastructure design decisions by encouraging environmentally sensitive design development, throughout the design process, allowing for environmental goals to be set, monitored and evaluated.
- To ensure that the work is conducted in a sustainable, effective, manner, by using the proposed Green Reports as a sustainability control mechanism.
- To establish a system for advising the client on the environmental impact of his/her design decisions, allowing for meaningful participation of the client, in developing a sustainable project.

4.4 The Green Township Infrastructure Toolkit methodology

The Green Township Design Toolkit is an infrastructure design rating system that is used throughout the project lifecycle and focuses on high-performance, energy efficient, economical and environmentally friendly infrastructure design, as presented in Figure 4.1. The toolkit analyses various design scenarios and levels of services of infrastructure projects and identifies the elemental parts of design, which appear to be more or less eco-friendly than might have been expected. Various Green Reports enable the client to select a combination of alternatives and evaluate a number of possible design options, along with their environmental implications, at each stage of the design process.

The underlying structure of the Green Township Infrastructure Design Toolkit is based on a hierarchical breakdown of the project into four stages described in Table 4.1.

During the briefing and preliminary design stages (Stage 1 and Stage 2) the client and engineer have a joint responsibility for deciding just how green the project should be, or, alternatively, of deciding what environmental quality of services can be provided. During the detailed design stage (Stage 3), the engineer has the responsibility of designing and maximising the green value of the project. Stage 4 gives the designers an opportunity to add environmental value at the construction stage, by analysing eco-friendly construction material.

Table 4.1: Stages in the Green Township Infrastructure Design Toolkit

Stage		Activities
Stage 1	Feasibility	Establishing preliminary green objectives on infrastructure projects
Stage 2	Preliminary Design	Preliminary green infrastructure services rating
Stage 3	Detailed Design	Green infrastructure rating analysis
Stage 4	Construction	Construction activities eco-analysis

4.4.1 Stage 1– Feasibility: establishing preliminary green objectives on infrastructure projects

The challenges in implementing sustainable developments are setting clear goals, client understanding, designer understanding, evaluation methods and tools, timing, communication and coordination, steering mechanisms, economics as well as management of decisions.

At this stage the engineer and the client agree on the weighting between the various infrastructure elements. Road infrastructure generally takes up a significant portion of the infrastructure projects and is normally allocated the highest percentage; however there may be projects that have no sewer or water components and their weighting can be zero.
The various eco-efficient infrastructure sustainability criteria will be allocated weighing.

There should be some sort of approximate green objectives at this early stage before the design is developed, to avoid unnecessary redesigns. During this phase of the project, the client and the engineer work together to incorporate green goals for the development into the project scope, and to align the goals with the owner's overall vision for the project.

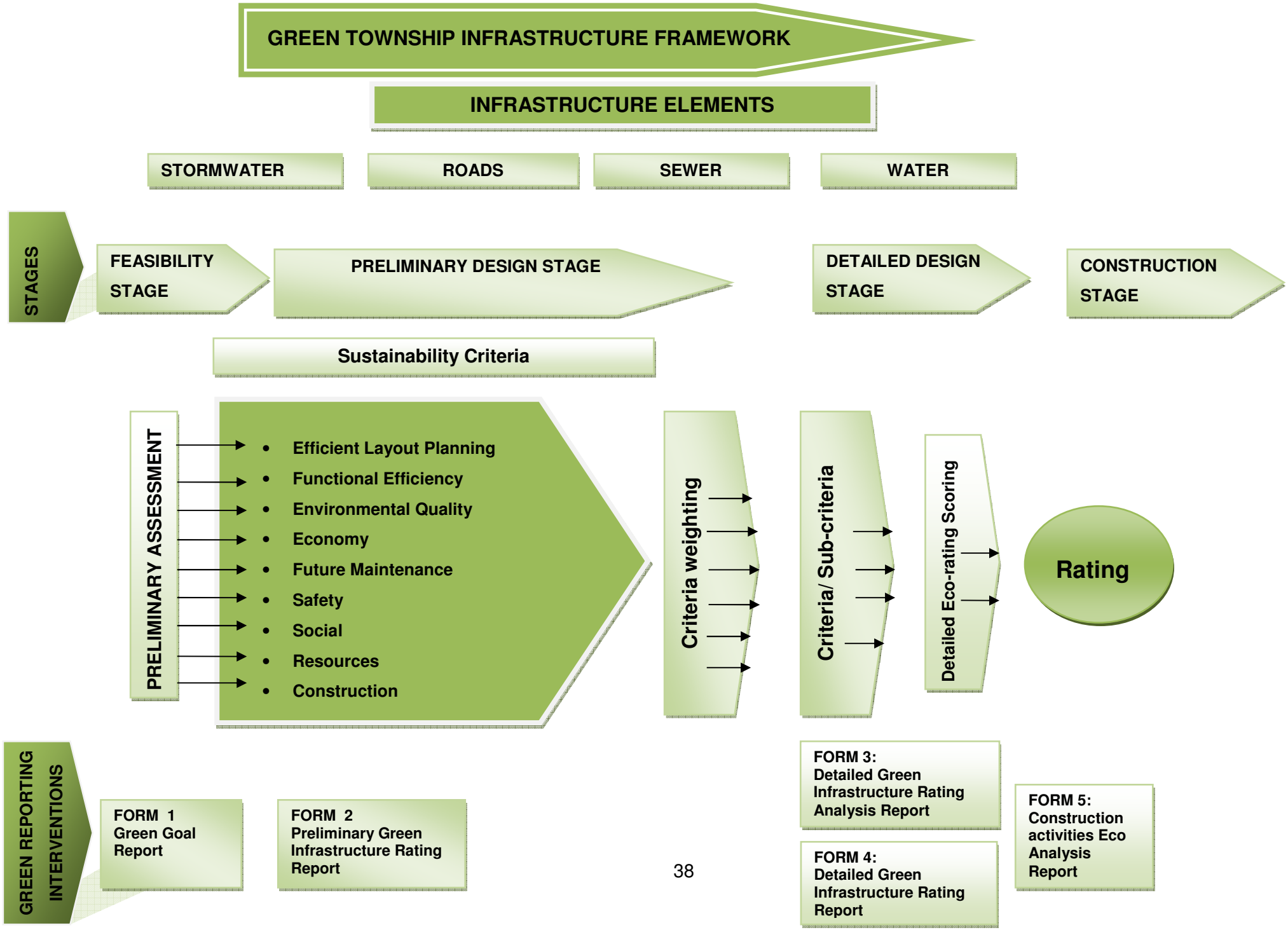


Figure 4.1: The Green Township Infrastructure Design Toolkit

4.4.1.1 The use of sustainability criteria

The client's vision, goals and objectives for sustainability on a project can be translated into a core set of project criteria. While project goals set the direction, the project sustainability criteria provide the means to measure project. They enable clients, engineers and stakeholders to progress toward sustainable development by comparing the performance achieved on a project with the intended performance.

The client may have specific green goals in mind, such as Functional Efficiency, Economy or Social criteria that are more important than the other. The weighting of the various categories are conducted at this early stage, before the design is developed, to avoid redesign later in the process.

Sustainability indicators are useful for monitoring and measuring the state of the environment and reflect the performance of the element (Carden et al, 2009).
Four of the nine criteria proposed, namely Economy, Functional Efficiency, Safety and Environmental Quality were adopted from goals that were set out for layout planning and related services for residential township developments (Centre for Scientific and Industrial Research, 2005).

The Green Township Infrastructure Design Toolkit is based on the following nine eco-efficient infrastructure sustainability criteria:

- Efficient layout planning ensures that infrastructure is placed in environmentally responsible ways;
- Resources criteria encourage an efficient utilisation of materials;
- Environmental quality mitigates the environmental impacts of infrastructure;
- Functional efficiency ensures that infrastructure is designed optimally;
- Future maintenance integrates capital and operation of infrastructure;
- Economy integrates cost effective adoption of green infrastructure options;
- Safety minimises the environmental impact of infrastructure by incorporating safety into the design;
- Social sustainability ensures acceptance of the infrastructure, promoting convenience, social resources and public participation and
- Construction efficiency aims to ensure that infrastructure is constructed with minimal impact to the environment, and contractors are forced to reduce

pollution, minimise erosion, wind and sediment control during the construction activities.

4.4.1.2 Weighting the infrastructure sustainability categories

Weighting the infrastructure sustainability categories enables the project to be tailored to the client's project requirements and specifications at the conceptual stages of the project and to reflect the importance of a particular criterion in a project.

Weighting is one of the most theoretically controversial aspects within a rating system. There could be variations in weighting amongst the various elements and sub criteria, due to area contextual differences. For example, water authority clients with a high per capita consumption of water would seek to reduce consumption by giving a higher weight to water efficiency in their sustainability rating systems. Therefore the model allows the user to modify weighting; however the weighting should be discussed with the client.

The sustainability criteria are a set of performance measures that characterize the sustainability of infrastructure project and is illustrated in Table 4.2. The default weighting of 20% is allocated for Functional Efficiency and 10% for the rest of the sustainability criteria. This weighting is based on industry norms but can be changed, if required by the client and engineer, in order to accomplish specific project goals.

A lot of flexibility exists in the green township design rating system, so that designers can benefit by focusing on specific categories applicable to each design situation. The weighting and setting of targets for the sustainability categories also help the designer understand the many design choices which need to be made in the Green Goal Report.

Table 4.2: Eco-efficient infrastructure performance criteria

Eco-efficient Sustainability criteria	Default Weighting	Description	Indicator
1. Efficient Layout Planning	10%	Placement of infrastructure in environmentally responsible, efficient ways, conserve land	- Reliability of service provision
2. Resources	10%	Encourages the efficient utilisation of materials/ resources, selection of environmentally friendly materials	- Use of local materials
3. Environmental Quality	10%	Design features that mitigate environmental impacts of infrastructure, by reducing the effects of pollutants	- Effluent quality and quantity management - Stormwater management - Compatibility of infrastructure system with surrounding environment - % of increase in environmental stresses
4. Functional Efficiency	20%	Design of infrastructure that maximises functional efficiency of infrastructure	- Efficient functionality of element - Adoption of alternative low impact design technologies
5. Future Maintenance	10%	Maximises the opportunities for integrating capital and operation of infrastructure, ensuring reliability of level of service	- Reliability of service provision - % of budget increase for Operation and Maintenance
6. Economy	10%	Maximises the opportunities for integrated, cost effective adoption of green infrastructure options	- % of budget increase of services
7. Safety	10%	Minimises the environmental impact of infrastructure by incorporating safety into the design	- % decrease of incidence
8. Social	10%	Ensures social sustainability of infrastructure, promoting convenience, social resources and public participation.	- Convenience - Access to facilities - Levels of service (LOS) - Vulnerability to disasters - Health (morbidity and mortality) - Education and awareness
9. Construction Efficiency	10%	Construction activities efficiency	- Pollution Prevention, Erosion, Wind and Sediment control

Figure 4.2 shows an example of a graphical distribution of the various sustainability categories available in the framework. In this example, the client may require the functional efficiency of the infrastructure to be weighted as at 20%, as opposed to the rest of the sustainability criteria that are weighted as a 10%.

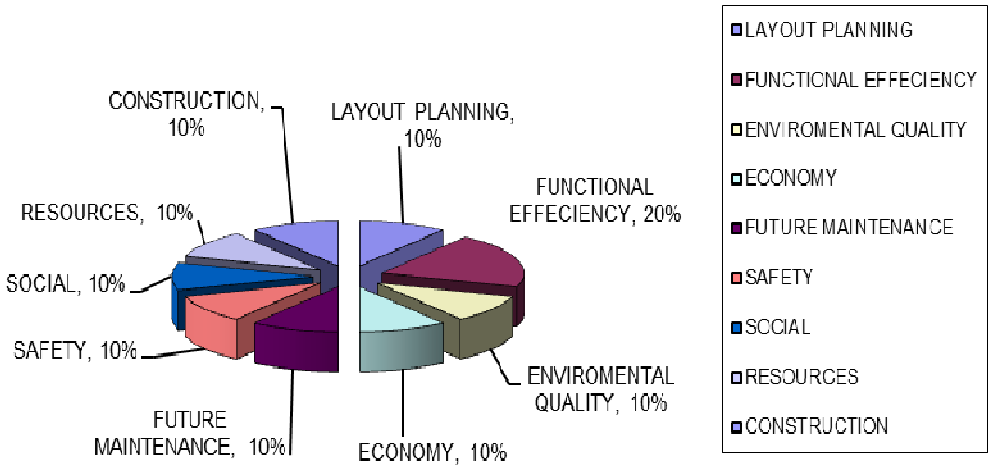


Figure 4.2: Example of a distribution of the sustainability categories

It must be noted that the use of different weighting of criteria and items can result in some slight variances in the overall score, but that there will be little variance in the actual status and goal of the project.

4.4.1.3 Form 1 – Green Goal Report

The engineer works with the client to determine the economic, environmental and social goals for the project. The client may have specific green goals in mind such as saving water, providing a variety of mobility options, or constraints.

The client and engineer decided on the weighting of the infrastructure elements based on the site conditions, type of development, housing typologies. The roads component generally make up 40% of a project component; the stormwater, sewer and water generally make up 20% each of a project component.

There should be some sort of approximate green interventions at this early stage before the design is developed, for the relevant infrastructure elements and sustainability categories. Table 4.3 indicates the level of proposed interventions and its associated scoring, in order to translate these interventions into an overall green goal for the development

The designer will determine their level of proposed intervention for all the infrastructure services under it relevant categories. In determining the level of intervention for the various infrastructure categories, the designer has several choices and may decide to adopt the best solution for the project, adopt a solution that has restricted damage, have some considerations or apply conventional approaches.

This allows the client and the engineer to focus on specific areas and elements on a project, early in the design phase, where design philosophy decisions can be made upfront.

Table 4.3: Scoring of the Proposed Infrastructure Interventions - to determine Green Goal on a project

Proposed interventions	Scoring
Minimal interventions to be undertaken	25
Some considerations for the environment	50
Restricted damage to the environment	75
Best solution to the environment	100

Table 4.4 indicates the results of the specific interventions that would be translated into a single goal, which the client and engineer could achieve on the project. The choices available to a client range from merely complying with a basic standard, to using conventional design, or applying new technologies, through to setting new benchmarks.

Table 4.4: Range of sustainable development goals (Boswell, 2005)

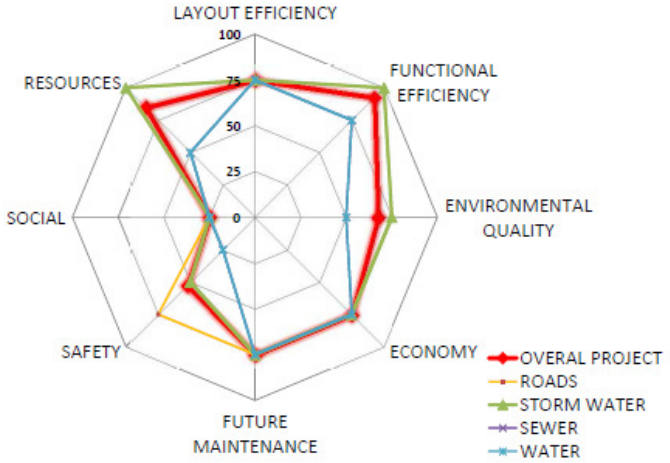
Sustainable development goals	Range of implementation choices	Status	Score
Best solution for the environment	Set a new performance benchmark through new technological developments	Platinum	75 -100
Restrict damage to the environment	Doing what is achievable through innovation and new technologies	Gold	50 - 74
Some considerations for the environment	Apply conventional and current practice with minimal disturbance to environment	Silver	25 - 49
Minimal interventions to be undertaken	Achieve compliance based on regulations	Bronze	0 - 24

The client and engineer work together in the conceptual phase of the project to develop a set of project-specific goals for sustainable development using The Green Goal Report, as illustrated in Figure 4.3. The weighting of the sustainability criteria and weighting between infrastructure elements is also undertaken at this stage, depending on the clients' requirements.

These scorings are also graphically represented in a so-called 'spider diagram' which easily communicates to all parties the current standing and 'green' profile of the project.

CIVIL INFRASTRUCTURE GREEN GOAL REPORT

PERFORMANCE CATEGORIES	ROADS	40%	STORM WATER	30%	SEWER	20%	WATER	10%	Weighted Infrastructure
1 LAYOUT EFFICIENCY	Best solution to the environment	75	Best solution to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	10%
2 FUNCTIONAL EFFICIENCY	Best solution to the environment	100	Best solution to the environment	100	Restricted damage to the environment	75	Restricted damage to the environment	75	20%
3 ENVIRONMENTAL QUALITY	Restricted damage to the environment	75	Restricted damage to the environment	75	Some considerations for environment	50	Some considerations for environment	50	15%
4 ECONOMY	Best solution to the environment	75	Best solution to the environment	75	Best solution to the environment	75	Best solution to the environment	75	15%
5 FUTURE MAINTENANCE	Restricted damage to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	Some considerations for environment	75	10%
6 SAFETY	Restricted damage to the environment	75	Some considerations for environment	50	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	10%
7 SOCIAL	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	5%
8 RESOURCES	Best solution to the environment	100	Best solution to the environment	100	Some considerations for environment	50	Restricted damage to the environment	50	10%
9 CONSTRUCTION	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	5%
WEIGHTED SCORE		31		23		12		5.9	100%



SCORE	71	GOLD	Restricted damage to the environment

Figure 4.3: Screenshot of the proposed Green Goal Report

The actual Green Goal Report is illustrated in Annexure 1. Throughout the project's development process, design decisions will be measured against these targets.

4.4.2 Stage 2 – Preliminary design: preliminary green infrastructure services rating

As the brief is considered and developed, the engineer and the client endeavour to establish some idea of preliminary eco-rating on the project. At this stage a comparison of major design options and selection of the most environmentally friendly level of service is chosen, allowing the least impact on the environment. In this way, progressively innovative, sustainable and efficient design alternatives are developed to an increasing level of detail, by the engineer. This stage provides the best opportunity for environmental interventions, by determining the most environmentally friendly infrastructure solutions.

4.4.2.1 Form 2 – Preliminary Green Infrastructure Rating Report

The Preliminary Green Infrastructure Rating Report involves undertaking comparative eco-analysis of the different scenarios, levels of infrastructure services and options available to the client, in response to the project's goals and objectives. This step involves a sensitivity test of the elements, so that the user can evaluate different scenarios, options and design schemes which enable the consultant to make rational decisions on the environmental impact of design decisions, before he/she starts developing the design.
The weightings are transferred from the Green Goal report, but can be modified, if required.

The Preliminary Green Infrastructure Rating Report, which is illustrated in Annexure 2, can reveal the environmentally sensitive parts of a project which are likely to be the most fruitful areas for evaluation. The most productive areas for analysis are those that have the least impact on the environment. Improvement of early design decisions could ensure a greater measure of control over the ultimate environmental quality and design. This form of analysis does not seek to enforce rigid design

solutions for particular elements, but rather to maintain flexibility of choice of a combination of possible eco-friendly design solutions.

4.4.3 Stage 3 – Detailed Design: Green Infrastructure Rating Analysis

This stage aims to undertake a detailed analysis of various design solutions under various sustainability categories, in order to assess all aspects of infrastructure sustainability. Each category comprises several criteria and sub-criteria that collectively evaluate the overall environmental performance of the project.

4.4.3.1 Form 3 – Detailed Green Infrastructure Rating Analysis Report

The Detailed Green Infrastructure Rating Analysis Report guides decision-makers by choosing key design factors and rating their environmental performance, in order to identify alternative ways in which greener solutions can be achieved.

Figure 4.4 shows a snapshot of a Green Infrastructure Rating Analysis that evaluated the layout functional efficiency of stormwater infrastructure in townships.
Due to the large number of criterion analysed, the Detailed Green Infrastructure Rating Analysis Report is illustrated in Annexure 3.
The various green sustainable solutions that can be used on township infrastructure are analysed under this section of the Infrastructure Services Design Toolkit. The available technologies are categorised under the various sustainable performance criteria, namely Layout Planning, Functional Efficiency, Environmental Quality, Economy, Future Maintenance, Safety, Social, Resources and Construction Efficiency. It offers a new perspective and alternative ways of rethinking how services can be delivered.
Due to the subjective and controversial nature of the scoring of each design element, each criterion, within the performance category was evenly weighted. The criterion score was ultimately determined by the points allocated to the sustainability criteria, for a particular element.

On the establishment of an independent panel of Green infrastructure experts, to roll out the toolkit within the industry, individual scoring of criterion will be allocated, workshopped with all stakeholders and issued for public comment.

The toolkit does however, allow for allocating individual scores to each criterion and a bottom up approach to rating a project.

	INFRASTRUCTURE ELEMENT			
X	PERFORMANCE CATEGORY		Scoring	
xx	Criterion	Ans.	Avail.	Act.
	STORMWATER		20	20
	2.0 FUNCTIONAL EFFICIENCY		20	20
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	0.74	0.74
2	Provision of surface water management system to ensure that the ultimate flow from the development does not result in any negative impacts on downstream properties or watercourse and is managed within the overall site	no	0.00	
		yes	0.74	0.74
3	Has the Master drainage plans been prepared, in collaboration with adjoining communities and authorities, for the existing and future development of the entire	no	0.00	
		yes	0.74	0.74
4	Is >70% of the road designed for sheetflow	no	0.00	
		yes	0.74	0.74
5	Is the maximum velocity <3m/s	no	0.00	
		yes	0.74	0.74
6	<10% of roads have a maximum road gradient >12%	no	0.00	
		yes	0.74	0.74
7	What is the minimum road crown slope- <2%- sediment	no	0.00	
		yes	0.74	0.74
8	Is the maximum road crown slope- <3%-operation problem driving, ware of vehicles	no	0.00	
		yes	0.74	0.74
9	Are the potential drainage and storage functions of roads, roadside channels used	no	0.00	
		yes	0.74	0.74
10	Is >50% of the road gradients <2% - used for retarding stormwater run-off	no	0.00	
		yes	0.74	0.74
11	Is the post development limited to predevelopment	no	0.00	
		yes	0.74	0.74
12	Is the roadside channels designed to prevent erosion	no	0.00	
		yes	0.74	0.74
13	Is the stormwater flow depths < 0.5m	no	0.00	
		yes	0.74	0.74
14	Inlet- are the backwater effects designed for	no	0.00	
		yes	0.74	0.74
15	Are the inlets/pond have swing type grids or are self cleansing to prevent blockages	no	0.00	
		yes	0.74	0.74
16	Quality control at the source-from residential rooftop by disconnecting downpipe, Rain Barrels, soakaway- Prevent pollutant dumping	no	0.00	
		yes	0.74	0.74
17	Does the reticulation limit runoff volumes with the use of bioswales filtering pollution	no	0.00	
		yes	0.74	0.74
18	Does the reticulation limit volumes with the use of retention basin	no	0.00	
		yes	0.74	0.74
19	Are velocities reduced with the use of Check dams	no	0.00	
		yes	0.74	0.74
20	Does the reticulation limit runoff volumes with the use of Porous parking surfaces	no	0.00	
		yes	0.74	0.74
21	In areas where the subsoil and water table are suitable, does the design the surfaces of storage areas allow for the re-charging of the underground water.	no	0.00	
		yes	0.74	0.74
22	Are flood plains and watercourses protected from erosion with Gabions, dissipaters, Reno mattress, stilling basins, Check weir, Riprap protection, Energy reduction, Drop structures, Rip rap basins,	no	0.00	
		yes	0.74	0.74

Figure 4.4: Screenshot of a Green Infrastructure Rating Analysis Report

4.4.3.2 Form 4 – Detailed Green Infrastructure Rating Report

The Detailed Green Infrastructure Rating Report contains the results from the Green Infrastructure Rating Analysis and is illustrated in Annexure 4.

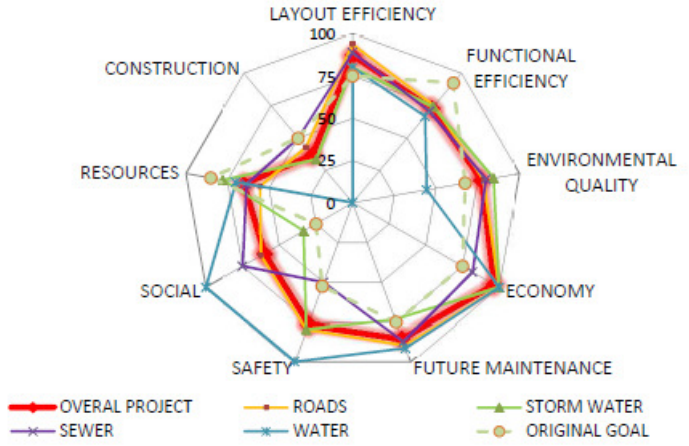
Figure 4.5 shows a snapshot of a Detailed Green Infrastructure Rating Report and the distribution of points amongst the various infrastructure sustainability performance categories, under each infrastructure element.

The Performance Category weightings as well as the weighting of the infrastructure elements were determined at the Feasibility Stage and were merely carried forward to the preliminary and Detailed Green Infrastructure Rating Report.

The Detailed Green Infrastructure Rating Report also graphically illustrates the results in a so-called ‘spider diagram’ and ‘presents the actual score at the bottom of the report, together to with the sustainable development goal achieved.

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	INFRASTRUCTURE ELEMENTS				
		ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	30%	20%	10%	
1.0 LAYOUT EFFICIENCY	10%	9	8	9	8	Points. Achieved
		10	10	10	10	Points. Available
2.0 FUNCTIONAL EFFICIENCY	20%	15	15	14	13	Points. Achieved
		20	20	20	20	Points. Available
3.0 ENVIRONMENTAL QUALITY	15%	12	13	12	7	Points. Achieved
		15	15	15	15	Points. Available
4.0 ECONOMY	15%	15	15	12	15	Points. Achieved
		15	15	15	15	Points. Available
5.0 FUTURE MAINTENANCE	10%	9	7	9	9	Points. Achieved
		10	10	10	10	Points. Available
6.0 SAFETY	10%	8	8	5	10	Points. Achieved
		10	10	10	10	Points. Available
7.0 SOCIAL	5%	3	2	4	5	Points. Achieved
		5	5	5	5	Points. Available
8.0 RESOURCES	10%	6	8	6	7	Points. Achieved
		10	10	10	10	Points. Available
9.0 CONSTRUCTION	5%	2	2	3	0	Points. Achieved
		5	5	5	5	Points. Available
TOTAL PTS.		100	100	100	100	Scoring
WEIGHTED PTS. ACHIEVED		10.5	10.4	9.7	9.6	
WEIGHTED PTS. AVAILABLE		13.0	13.0	13.0	13.0	
TOTAL ACHIEVED		80.6	80.0	74.4	73.7	
TOTAL AVAILABLE		100.0	100.0	100.0	100.0	



SCORE	78	PLATINUM	Best solution to the environment- Benchmark performance

Figure 4.5: Screenshot of a Detailed Green Infrastructure Rating Report

Due to the subjective nature of the points scoring and in order to simplify the scoring system, the weighting of the points allocated to each elements performance criteria were similar to the weightings of the performance criteria.

In order to determine a specific scoring for the criterion, a top down approach was adopted. Firstly the individual elements were weighed against each other to make up 100% of the project.

Each performance criteria scoring was determined by its individual weighting, under the various elements.
In order to simplify the scoring system, the individual criterion scoring was evenly distributed within the performance category.
The toolkit does however, allow for allocating individual scores to each criterion and a bottom up approach to rating a project

The Detailed Green Infrastructure Rating Report also highlights the green goal that is achieved. The report assists the client and engineer to continuously monitor the effects of his/her design decisions as designs are progressively developed. The score is then assessed in terms of Table 4.5 shown below.

Table 4.5: Assessment of the project

Environment not taken into account	0 -24%	▲
Some considerations for the environment	25 - 49%	▲▲
Restricted damage to the environment	50 - 74%	▲▲▲
Best solution for the environment	75- 100%	▲▲▲▲

This Detailed Green Infrastructure Rating Report can be used to fulfil the following purposes:

- To enable clients and designers to appreciate how the target score is distributed among the functional components of a project.
- To enable clients and designers to develop ideas on how the target scores could be allocated, to obtain a more balanced design.
- To allow remedial action to be taken on detailed design.

4.4.4 Stage 4 – Construction Activities Eco-Analysis

The Green Township Infrastructure Design Toolkit encourages the use of sustainable best practices on infrastructure projects as well as environmentally sensitive (‘green’) construction materials. This checklist is intended to encourage developers to consider green building methods and practices at the earliest stages of project planning. At this stage, the main work items are further broken down into detailed selection criteria of individual minor elements that contribute to the eco-impact of the infrastructure element, e.g. type of pipes, bedding material.

4.4.4.1 Form 5 – Construction Eco-Analysis Report

The Construction Eco-Analysis Report, illustrated in Annexure 5, compares the eco-impact of various construction activities that have to be undertaken on the project.
It ensures sustainable performance and eco-efficient construction activities, providing designers and contractors with independent guidance on making the best environmental choices. It offers a new perspective and alternative ways of monitoring how services can be constructed.

This report promotes the following principles:

- Reduce the material intensity of goods and services;
- Enhance material recyclability;
- Reduce the energy intensity of goods and services;
- Reduce toxic dispersion; and
- Maximise the sustainable use of renewable resources.

4.5 Continuous monitoring with the Green Reports

The various Green Reports developed at various stages of the project provide clients and consultants with more control over the environmental impact of design decisions taken and enable a comparison of the options of various engineering solutions.
Table 4.6 shows the Green Reports at each stage of the Green Township Infrastructure Design Toolkit that are found in Appendices 1 to 5. Green Reports are the foundation for an effective sustainability evaluation process and are the basis of a design-to-green approach that contributes to overall sustainability of the project.

Table 4.6: The proposed Green Reports at each stage

STAGE	FORM NO.	REPORT NAME
FEASIBILITY	Form 1	Green Goal Report
PRELIMINARY DESIGN	Form 2	Preliminary Green Infrastructure Rating Report
DETAILED DESIGN	Form 3	Detailed Green Infrastructure Rating Analysis Report
	Form 4	Detailed Green Infrastructure Rating Report
CONSTRUCTION	Form 5	Construction Activities Eco-Analysis Report

The proposed green reports undertake continuous monitoring of green goals in the following steps. Monitoring takes place in three stages and is illustrated in Figure 4.6. This involves establishing, adjusting and testing project goals and monitoring with the use of indicators.

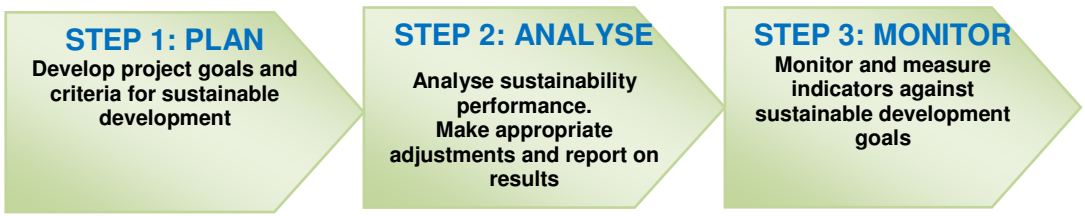


Figure 4.6: Continuous monitoring with the use of the proposed Green Reports

4.6 Benefits of Green Reporting

The Green Reports are developed at the beginning of all the phases of a project to facilitate scope definition and maximise environmental optimisation thereby controlling the environmental impact of infrastructure decisions.

The Green Reports allow various solutions to be evaluated in consultation with the client, consultants and other stakeholders, thereby increasing the transparency of decision making. This in turn improves consultants' accountability for environmental efficiency of projects.

The standard Green Reports were developed within the Green Township Infrastructure Design Toolkit play the following roles:

- Determine the means by which environmental efficiency can be assessed, monitored, quantified and verified at any stage of the project, to ensure a value-added, quality driven, green approach to infrastructure design.
- Provide a basis for the consultants and clients to work together on creating and evaluating sustainable infrastructure solutions, thereby ensuring comprehensive infrastructure planning with maximum stakeholder involvement.
- It provides a graphical method of presenting design results, allowing criteria such as sustainability engineering, practical, social and financial issues to be easily weighed against one another.

4.7 The advantages of using the eco approach to infrastructure design

The Green Township Infrastructure Design Toolkit provides a ready guide to design decisions, ensuring progressive, efficient, affordable, economical, and sustainable provision of infrastructure services. The sustainability criteria set of performance measures for each element. The rating of various design solutions ensures that clients receive the best value for money for the projects that they construct.

The Green Township Infrastructure Design toolkit is intended to encourage developers to consider environmentally sound design solutions at the concept and preliminary design stages of the project, where the environment is impacted the most, thus placing fewer burdens on the environment.

The eco-approach to infrastructure design is an engineering design approach that takes a 'design with nature' approach to mitigate the potential impact of a development. The model

- Encourages the use natural resources efficiently, maximises the use of local materials, under the resources criteria.
- Reduces the ecological footprints of roads, sewer, stormwater and water, allowing ecosystems to function more naturally;
- Adopts future maintenance as a design criteria for infrastructure planning;

- Promotes the reduction, reuse, and recycling of materials when designing each infrastructure element with resource conservation as a design criteria;
- Promotes the conservation and reuse water and the treatment of stormwater runoff on-site under environmental quality considerations; and
- Encourages other modes of transport, e.g. bicycle and pedestrian oriented projects, when considering resource conservation under the road infrastructure.

The framework allows consultants and clients to maximise the opportunities for improving quality and reducing the environmental impact of projects and places a heavy burden on the consultants to make design decisions in the most efficient way possible. The Green Township Infrastructure Design allows engineering, environmental and financial issues to be easily weighed against one another.

4.8 Summary

The Green Township Infrastructure Design Toolkit meets a well-recognised need for improved sustainability reporting of infrastructure design on projects, allowing engineers to create sustainable eco-friendly infrastructure solutions. It provides a methodology or a 'green design 'strategy' with which the designer explores a range of possible green solutions available to him/her on infrastructure projects. This green value approach transforms design goals into specific performance objectives and the Green Infrastructure Reports provide environmentally friendly-infrastructure solutions, permitting the project objectives to be quantified, monitored and verified.

The Green Township Infrastructure Design Toolkit is an interactive tool that uses a multi-criteria analysis approach, allowing for the aggregation of various indicators and variables into a single score result. This enables various stakeholders to minimise the environmental impacts of their developments and to capitalise on, and receive recognition for, their design initiatives. The proposed framework undertakes a qualitative eco-analysis of infrastructure projects, ensuring value-for-money.

CHAPTER 5 – CASE STUDIES

5.1 Introduction

This chapter presents four case studies that were undertaken using the Green Township Infrastructure Design Toolkit, to determine the applicability and utility of the proposed framework.

The purpose of the case studies were to demonstrate the range of socio-economic, health and environmental benefits which are possible using the Green Township Infrastructure Design Toolkit. The conventional design interventions were weighed against the sustainable design interventions on infrastructure projects and an overall rating was given to the project, thus forcing designers to achieve a higher environmental rating and thereby achieving a low carbon footprint.

The systematic analysis of various design solutions, at each stage of the project, guided the designer in determining whether the sustainable development goals were met. As will be seen, the Green Township Infrastructure Design Toolkit encourages project participants to make careful forward planning design decisions, by means of continuous reporting on design decisions and their green ratings.

The Green analysis compared various green alternatives and identified the optimum level of service that could be achieved in order to achieve the green goals that the client had already set. By looking for opportunities for sustainable design improvements that could be achieved through an iterative analysis of alternative design options against the various sustainability criteria, an optimum level of quality was achieved.

The Green Township Infrastructure Design Toolkit ensures that project designs are more carefully examined and that alternative design solutions are developed to ensure that the client receives value for money.

5.2 Case studies overview

The Green Township Infrastructure Design Toolkit provides an indication of sustainability of infrastructure compared to a ‘business as usual’ approach and has

the potential to be developed and applied to residential, industrial and commercial developments.

Four case studies were undertaken to ensure a representative assessment of the framework. The case studies engaged with a range of projects to assess the consistency and applicability of the framework's rating system.

The first case study is a high income development called Blueberry Hills, which aimed to be a green development. The second case study was a low income development, called Siyahlala housing project that aimed to have restricted damage to the environment by using a combination of green solutions and conventional infrastructure. The third case study was an industrial development called Bloemfontein Industrial Park that used best practice green infrastructure stormwater solutions but also had conventional sewer infrastructure. The fourth case study was a low income development called Sunnyside Park that used conventional infrastructure and was chosen to assess how the framework rates conventional infrastructure.

5.2.1 Case Study 1

Case Study 1 is a high income development called Blueberry Hills, which aimed to be a ‘Green Village Development’ incorporating a range of best practice sustainable technologies to serve as a selling point for residential developments. This project involved the provision of infrastructure services to 1420 houses and aimed to demonstrate that contemporary, sustainable living can reduce its ecological and carbon footprint while creating a sense of place with connections to nature. The project aimed to develop a sustainable residential development, for the real estate market.

In this project, the Green Infrastructure Toolkit was utilised in the conceptual phase with the aim of facilitating sustainability infrastructure services design. The following procedures were followed:

- Initial ‘kick-off’ targets were set by the client and engineer, at the feasibility stage.
- The Preliminary Green Rating Report highlighted the various green solutions available and led to the re-definition and fine-tuning of project specific

sustainability targets, in order to increase the level of green intervention. It also pointed out where the design attention should be focused, e.g. water efficiencies, efficient layout planning, recycling and re-use.

- The Detailed Rating Analysis to highlight innovative design solutions available to the consultant, in the search for appropriate sustainable alternatives.
- The Detailed Green Infrastructure Rating Report summarised the results of the Detailed Rating Analysis.

At the feasibility stage, green interventions were proposed and targets were set by the client and engineer, as shown in a screenshot of the Green Goal Report for Case Study 1 in Figure 5.1. The actual Green Goal Report is shown in Appendix 6.

The client and engineer decided on the weighting of the infrastructure elements based on the site conditions.

The Roads component generally makes up 40% of a project component; in additional to its design interventions, its contribution to Green House Gases, carbon footprint, road safety, social impacts, project costs and resources.

Due to the site being situated on a watershed and adjacent to a reservoir, the water network could not be optimised and the weighting was thus reduced to 10%.

The infrastructure element weighting was; roads (40%), stormwater (30%), sewer (20%) and water (10%).

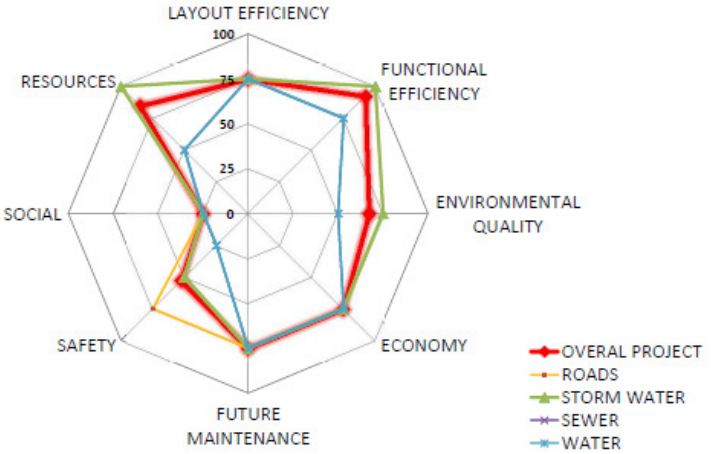
Due to the project being a privately funded green development, the client requested the following weighting of the sustainability criteria, Layout Planning (10%), Functional Efficiency (20%), Environmental Quality (15%), Economy (15%), Future Maintenance (10%), Safety (10%), Social (5%), Resources (10%) and Construction Efficiency (5%).

The road layout was planned in conjunction with the townplanning and architectural design, thus contributing to layout efficient. Due to this being a private development, social and construction efficiency criteria were not high on the client's agenda.

Stormwater management was critical, as the development was a planned as a green village. The client and engineer committed to interventions under the various categories shown in Figure 5.1 and resulted in a green goal rating of 71.

CIVIL INFRASTRUCTURE GREEN GOAL REPORT

PERFORMANCE CATEGORIES	ROADS	40%	STORM WATER	30%	SEWER	20%	WATER	10%	Weighted Infrastructure
1 LAYOUT EFFICIENCY	Best solution to the environment	75	Best solution to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	10%
2 FUNCTIONAL EFFICIENCY	Best solution to the environment	100	Best solution to the environment	100	Restricted damage to the environment	75	Restricted damage to the environment	75	20%
3 ENVIRONMENTAL QUALITY	Restricted damage to the environment	75	Restricted damage to the environment	75	Some considerations for environment	50	Some considerations for environment	50	15%
4 ECONOMY	Best solution to the environment	75	Best solution to the environment	75	Best solution to the environment	75	Best solution to the environment	75	15%
5 FUTURE MAINTENANCE	Restricted damage to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	Some considerations for environment	75	10%
6 SAFETY	Restricted damage to the environment	75	Some considerations for environment	50	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	10%
7 SOCIAL	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	5%
8 RESOURCES	Best solution to the environment	100	Best solution to the environment	100	Some considerations for environment	50	Restricted damage to the environment	50	10%
9 CONSTRUCTION	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	5%
WEIGHTED SCORE		31		22.5		11.8		5.88	100%



SCORE	71	GOLD	Restricted damage to the environment

Figure 5.1: Screenshot of the Green Goal Report for Case Study 1

The Preliminary Green Infrastructure Rating Report highlighted the various design technologies available to the client, which could achieve the desired green goal and is illustrated in Appendix 7. The chosen interventions resulted in a scoring of 77.

At the detailed design stage, the various interventions are shown in the Detailed Green Infrastructure Rating Analysis Report, illustrated in Appendix 8.

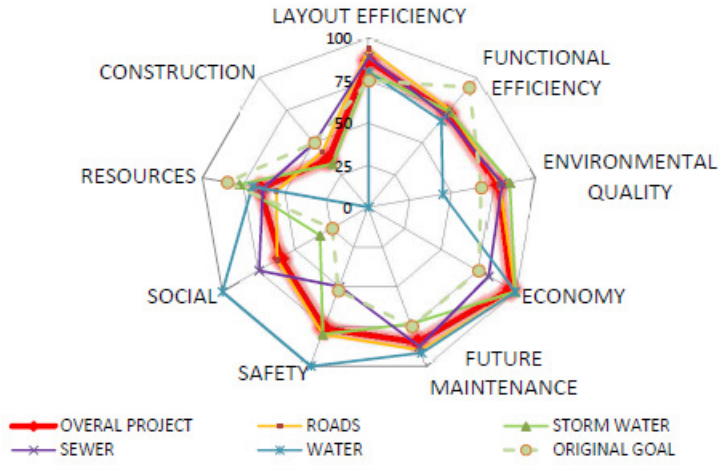
The key sustainable design considerations included reducing water consumption using efficient fixtures and fittings, and developing water efficient layouts to decrease both pressure and velocities. Water meters were installed on the network to allow monitoring of volumes and to identify non-revenue or unbilled water use.

The project also involved the use of sustainable urban drainage systems for development and the use of the storage capacity of the roads and omitting the use of conventional stormwater piping in 80% of the development. Increased on-site stormwater management through attenuation of selected areas to reduce stormwater run-off, and rain gardens and drainage swales were undertaken.

Figure 5.2 illustrates a screenshot of the Detailed Green Infrastructure Rating Report, which is also shown in Appendix 9. The overall project rating of 78 indicated that the project had used the “Best solution to the environment” and had “Set a new performance benchmark through new technological developments”.

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	INFRASTRUCTURE ELEMENTS				
		ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	30%	20%	10%	
1.0 LAYOUT EFFICIENCY	10%	9	8	9	8	Points. Achieved
		10	10	10	10	Points. Available
2.0 FUNCTIONAL EFFICIENCY	20%	15	15	14	13	Points. Achieved
		20	20	20	20	Points. Available
3.0 ENVIRONMENTAL QUALITY	15%	12	13	12	7	Points. Achieved
		15	15	15	15	Points. Available
4.0 ECONOMY	15%	15	15	12	15	Points. Achieved
		15	15	15	15	Points. Available
5.0 FUTURE MAINTENANCE	10%	9	7	9	9	Points. Achieved
		10	10	10	10	Points. Available
6.0 SAFETY	10%	8	8	5	10	Points. Achieved
		10	10	10	10	Points. Available
7.0 SOCIAL	5%	3	2	4	5	Points. Achieved
		5	5	5	5	Points. Available
8.0 RESOURCES	10%	6	8	6	7	Points. Achieved
		10	10	10	10	Points. Available
9.0 CONSTRUCTION	5%	2	2	3	0	Points. Achieved
		5	5	5	5	Points. Available
TOTAL PTS.		100	100	100	100	Scoring
WEIGHTED PTS. ACHIEVED		10.5	10.4	9.7	9.6	
WEIGHTED PTS. AVAILABLE		13.0	13.0	13.0	13.0	
TOTAL ACHIEVED		80.6	80.0	74.4	73.7	
TOTAL AVAILABLE		100.0	100.0	100.0	100.0	



SCORE	78	PLATINUM	Best solution to the environment- Benchmark performance

Figure 5.2: Screenshot of Case Study 1 – Detailed Rating Report

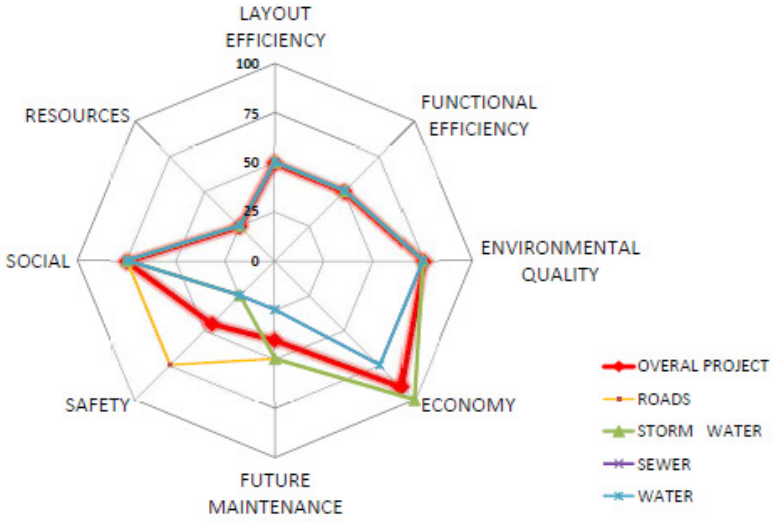
5.2.2 Case Study 2

Case study 2 is a low income development, called Siyahlala housing project. This project involved the provision of infrastructure services to 1221 houses.

The infrastructure element weighting defaulted to roads (40%), stormwater (20%), sewer (20%) and water (20%).

Due to the project being a low income green development, the client requested the following weighting; Layout Planning (10%), Functional Efficiency (20%), Environmental Quality (10%), Economy (15%), Future Maintenance (10%), Safety (10%), Social (10%), Resources (10%) and Construction Efficiency (5%).

Figure 5.3 illustrates a screenshot of the Green Goal Report of Case study 2, used at the feasibility stage of the project. The client and engineer aimed that the development would restrict the damage to the environment by using a combination of green solutions and conventional infrastructure. The proposed interventions resulted in a proposed green goal rating of 58. The actual Green Goal Report of Case study 2 is shown in Appendix 10.



SCORE	58	GOLD	Restricted damage to the environment

Figure 5.3: Screenshot of the Green Goal Report for Case Study 2

In case study 2, the various design technologies chosen by the engineer in the Preliminary Green Infrastructure Rating Report, which is illustrated in Appendix 11 achieved a preliminary scoring of 60.

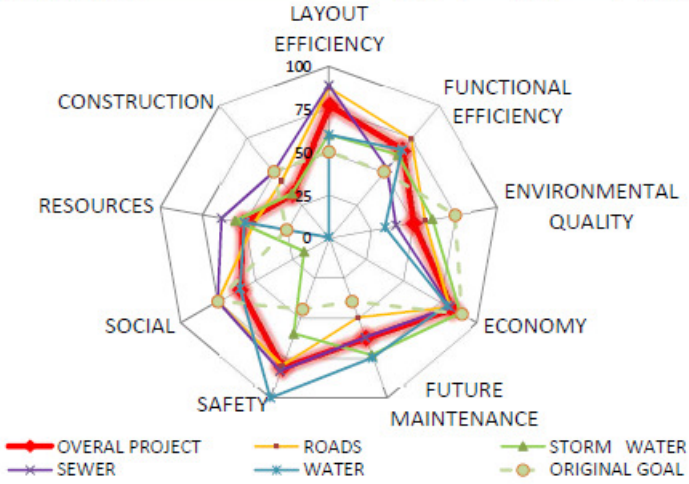
Key project features adopted in the Detailed Green Infrastructure Rating Analysis Report, which is illustrated in Appendix 12 include allowing the road alignment to follow the natural topography and the use of low impact development (LID), which is an engineering design approach to managing storm water runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implemented engineered bioswales with hydrologic controls to replicate the pre-development flow through infiltrating, filtering, storing, evaporating, and detaining

runoff close to its source. The project also involved the minimisation of conventional piped stormwater reticulation by maximising the use of the storage capacity of the roads. Water efficient layouts and pressure reduction measures were undertaken.

Figure 5.4 illustrates a screenshot of the Detailed Green Infrastructure Rating Report, and is shown in Appendix 13. The overall project rating of 66 indicated that the project had a “Restricted damage to the environment”.

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	20%	20%	20%	
1.0 LAYOUT EFFICIENCY	10%	9	6	9	6	Pts. Achieved
		10	*10*	*10*	*10*	Pts. Available
2.0 FUNCTIONAL EFFICIENCY	20%	15	13	11	13	Pts. Achieved
		20	*20*	*20*	*20*	Pts. Available
3.0 ENVIRONMENTAL QUALITY	10%	9	9	6	5	Pts. Achieved
		15	*15*	*15*	*15*	Pts. Available
4.0 ECONOMY	15%	12	13	12	12	Pts. Achieved
		15	*15*	*15*	*15*	Pts. Available
5.0 FUTURE MAINTENANCE	10%	5	7	6	11	Pts. Achieved
		10	*10*	*10*	*15*	Pts. Available
6.0 SAFETY	10%	8	6	8	10	Pts. Achieved
		10	*10*	*10*	*10*	Pts. Available
7.0 SOCIAL	10%	4	1	4	3	Pts. Achieved
		5	*5*	*5*	*5*	Pts. Available
8.0 RESOURCES	10%	4	6	6	5	Pts. Achieved
		10	*10*	*10*	*10*	Pts. Available
9.0 CONSTRUCTION	5%	2	2	3	0	Pts. Achieved
		5	*5*	*5*	*5*	Pts. Available
TOTAL PTS.		*100*	*100*	*100*	*105*	
WEIGHTED PTS. ACHIEVED		*8.8*	*8.1*	*8.0*	*8.5*	
WEIGHTED PTS. AVAILABLE		*12.5*	*12.5*	*12.5*	*13.0*	
TOTAL ACHIEVED		*70.4*	*64.8*	*64.3*	*65.3*	
TOTAL AVAILABLE		*100.0*	*100.0*	*100.0*	*100.0*	



SCORE	67	GOLD	Restricted damage to the environment with innovation and new technologies

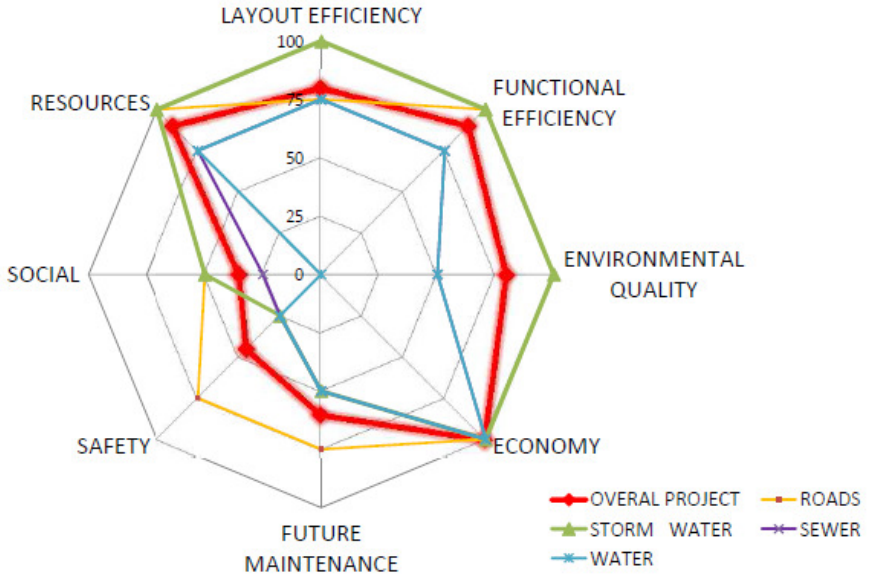
Figure 5.4: Screenshot of Case Study 2 – Detailed Rating Report

A higher rating could have been achieved by using more environmentally sensitive solutions for the sewer infrastructure, use of a primary and secondary greywater system and rainwater harvesting and reuse-recycled stormwater for irrigation.
This case study shows that green interventions can be achieved on low income housing projects using simple engineering interventions that do not have a significant economic impact on the project.

5.2.3 Case Study 3

Case study 3 is an industrial development called Bloemfontein Industrial Park which aimed to use best practice stormwater solutions however conventional sewer infrastructure with pump stations were used, due to the flat topography.
The infrastructure element weighting defaulted to roads (40%), stormwater (20%), sewer (20%) and water (20%).
Due to the project being a high income green development, the client requested the following weighting; Layout Planning (10%), Functional Efficiency (20%), Environmental Quality (15%), Economy (15%), Future Maintenance (10%), Safety (10%), Social (5%), Resources (10%) and Construction Efficiency (5%).

Figure 5.5 illustrates a screenshot of the Green Goal Report of Case study 3, used at the feasibility stage of the project. The actual Green Goal Report of Case study 3 is shown in Appendix 14.



SCORE	76	PLATINUM	Best solution to the environment

Figure 5.5: Screenshot of the Green Goal Report for Case Study 3

The various design technologies chosen by the engineer in the Preliminary Green Infrastructure Rating Report, which is illustrated in Appendix 15 achieved a preliminary scoring of 77.
However at detailed design stage, the flat typology of the site resulted in deep sewer pipes more than 3m deep and 3 sewer pump stations were constructed, which had a negative impact on the environment. This lowered the green rating of the project. The lower score for the sewer component is illustrated in Figure 5.6.

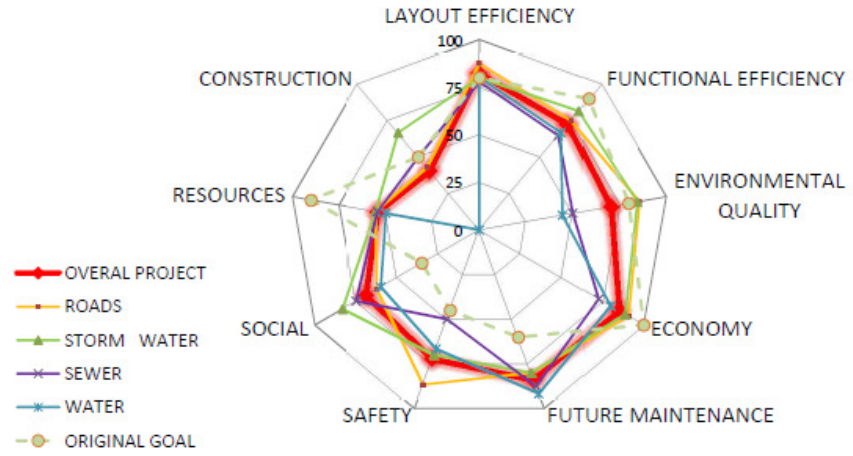
The key interventions undertaken in the Detailed Green Infrastructure Rating Analysis Report, which is illustrated in Appendix 16 was the focus on innovative environmentally sensitive stormwater solutions, including reduction in flooding from the large high density upstream proposed development and biodiversity enhancement.

The conventional solution for stormwater would be via a conventional stormwater pipe network system and would have meant major pipe networks, major costs, maintenance issues and deep trenches. This approach could also have caused problems further along the stormwater drainage network, such as bottlenecks and the use of larger pipes. Moreover, the receiving areas could have suffered increased flood risk, erosion or water quality degradation. Therefore, the implementation of the bioswales and open stormwater system described above was considered to be the most sustainable option. This lowered the total volume of stormwater reaching pipes and reduced the peak flow rates. This also reduced the impervious areas and the associated runoff, preserving and enhancing green spaces, and managing stormwater to reduce total runoff.

Figure 5.6 illustrates a screenshot of the Detailed Green Infrastructure Rating Report, and is shown in Appendix 17. This report indicated that the project achieved a green rating of 74, which is defined as “Restricted damage to the environment” and had “Done what is achievable through innovation and risk taking with new systems and technologies”.

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	20%	20%	20%	
1.0 LAYOUT EFFICIENCY	10%	9	8	8	8	Pts. Achieved
		10	10	10	10	Pts. Available
2.0 FUNCTIONAL EFFICIENCY	20%	15	16	13	13	Pts. Achieved
		20	20	20	20	Pts. Available
3.0 ENVIRONMENTAL QUALITY	15%	13	13	8	7	Pts. Achieved
		15	15	15	15	Pts. Available
4.0 ECONOMY	15%	14	13	11	12	Pts. Achieved
		15	15	15	15	Pts. Available
5.0 FUTURE MAINTENANCE	10%	8	8	9	9	Pts. Achieved
		10	10	10	10	Pts. Available
6.0 SAFETY	10%	9	7	5	7	Pts. Achieved
		10	10	10	10	Pts. Available
7.0 SOCIAL	5%	3	4	4	3	Pts. Achieved
		5	5	5	5	Pts. Available
8.0 RESOURCES	10%	6	6	5	5	Pts. Achieved
		10	10	10	10	Pts. Available
9.0 CONSTRUCTION	5%	2	3	3	0	Pts. Achieved
		5	5	5	5	Pts. Available
TOTAL PTS.		100	100	100	100	
WEIGHTED PTS. ACHIEVED		10.3	10.4	8.4	8.5	
WEIGHTED PTS. AVAILABLE		13.0	13.0	13.0	13.0	
TOTAL ACHIEVED		79.5	80.0	64.3	65.4	
TOTAL AVAILABLE		100.0	100.0	100.0	100.0	



SCORE	74	GOLD	Restricted damage to the environment with innovation and new technologies

Figure 5.6: Screenshot of Case Study 3 – Detailed Rating Report

A higher rating could have been achieved at the detailed design stage to change the level of intervention from “Gold” to a “Platinum” status, which would describe the development as having the “Best solution to the environment”. This could have been accomplished by using more environmentally sensitive solutions to the sewer infrastructure, such as the implementation of noise and odour reduction interventions at the pumpstations, and the use of a primary and secondary greywater system.

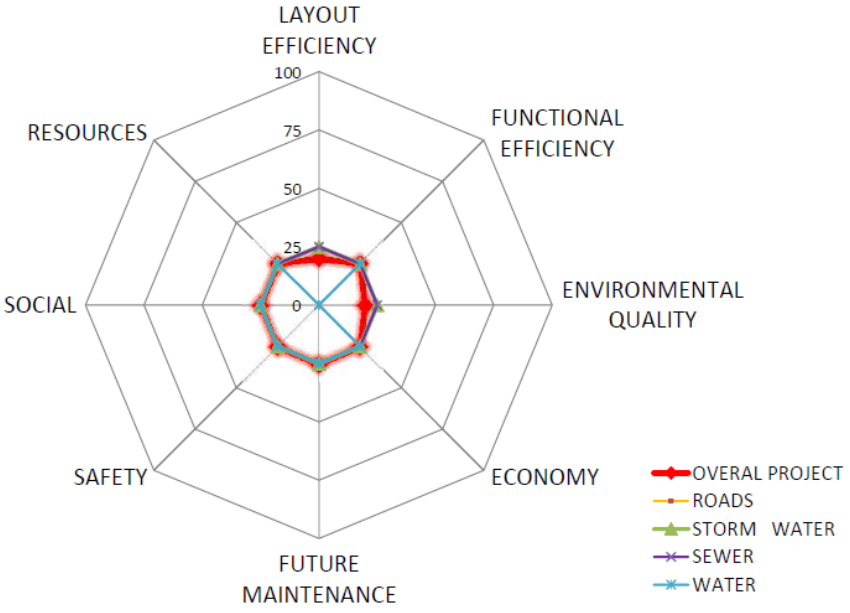
5.2.4 Case Study 4

Case study 4 was another low income development called Sunnyside Park that used conventional infrastructure and was chosen to assess how the framework rates conventional infrastructure. No consideration was given to the environmental impact, social impact, safety or maintenance needs. Its primary objective was to achieve functional requirements by the most economical means.

The infrastructure element weighting defaulted to roads (40%), stormwater (20%), sewer (20%) and water (20%).

Due to the project being a low income development with no interventions, the client requested the following weighting; Layout Planning (10%), Functional Efficiency (20%), Environmental Quality (10%), Economy (15%), Future Maintenance (10%), Safety (10%), Social (5%), Resources (10%) and Construction Efficiency (5%).

Figure 5.7 illustrates a screenshot of the Green Goal Report of Case study 4, used at the feasibility stage of the project. The actual Green Goal Report of Case study 4 is shown in Appendix 18



SCORE	23	Bronze	Minimal interventions to be undertaken

Figure 5.7: Screenshot of the Green Goal Report for Case Study 4

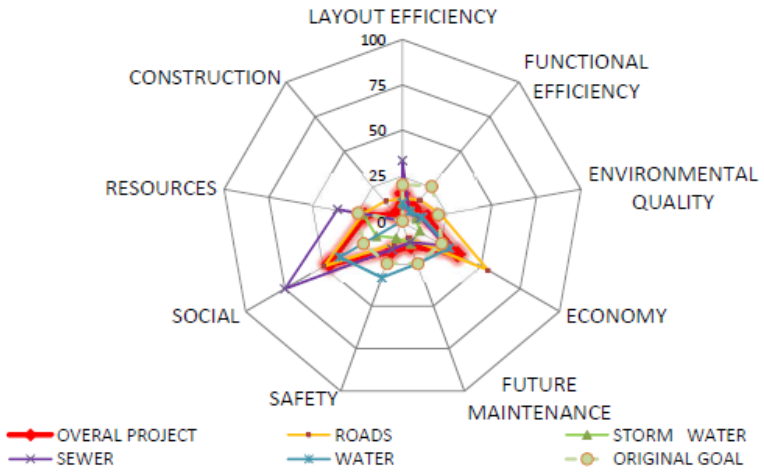
Conventional infrastructure design solutions were chosen by the engineer in the Preliminary Green Infrastructure Rating Report, which is illustrated in Appendix 19 achieving a preliminary scoring of 23.

Purely conventional designs were chosen during the Detailed Green Infrastructure Rating Analysis. This is illustrated in the Detailed Green Infrastructure Rating Analysis Report in Appendix 20.

Figure 5.8 illustrates a screenshot of the Detailed Green Infrastructure Rating Report, and is shown in Appendix 21. The project achieved a green rating of 18, which is defined as “Minimal interventions were undertaken” and the project had merely “Achieved compliance based on regulations”.

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	20%	20%	20%	
1.0 LAYOUT EFFICIENCY	10%	1	1	3	1	Pts. Achieved
		10	10	10	10	Pts. Available
2.0 FUNCTIONAL EFFICIENCY	20%	3	1	1	1	Pts. Achieved
		20	20	20	20	Pts. Available
3.0 ENVIRONMENTAL QUALITY	10%	3	1	2	2	Pts. Achieved
		15	15	15	15	Pts. Available
4.0 ECONOMY	15%	8	2	4	5	Pts. Achieved
		15	15	15	15	Pts. Available
5.0 FUTURE MAINTENANCE	10%	1	1	1	4	Pts. Achieved
		10	10	10	15	Pts. Available
6.0 SAFETY	10%	1	1	2	3	Pts. Achieved
		10	10	10	10	Pts. Available
7.0 SOCIAL	5%	3	1	4	2	Pts. Achieved
		5	5	5	5	Pts. Available
8.0 RESOURCES	10%	2	2	4	0	Pts. Achieved
		10	10	10	10	Pts. Available
9.0 CONSTRUCTION	5%	1	0	0	0	Pts. Achieved
		5	5	5	5	Pts. Available
TOTAL PTS.		100	100	100	105	
WEIGHTED PTS. ACHIEVED		2.9	1.3	2.2	2.0	
WEIGHTED PTS. AVAILABLE		12.3	12.3	12.3	12.8	
TOTAL ACHIEVED		23.6	10.3	17.8	15.8	
TOTAL AVAILABLE		100.0	100.0	100.0	100.0	



SCORE	18	Bronze	Minimal interventions were undertaken- compliance based on regulations

Figure 5.8: Screenshot of Case Study 4 – Detailed Rating Report

A higher rating could have been achieved by using more environmentally sensitive solutions for the various infrastructure elements, as opposed to the conventional infrastructure design solutions that were chosen by the engineer.

Case study 2, which is a similar low cost housing project however resulted in a gold status, indicating that there was “Restricted damage to the environment with the use of innovative technologies”.

5.2.5 Comparison of Case Study 4 with Case Study 2

The two low cost housing case studies were compared to each in order to test the usefulness of the rating in searching for green solutions.

Table 5.1 illustrates the comparison of the rating results of two similar low cost housing projects. The results indicated that Case Study 2 achieved a green rating of 67 and performed satisfactory to moderate scores across all dimensions of sustainability, being able to maintain a balance between the needs of society and preservation of the environment.

Case Study 4 on the other hand demonstrated a significantly different performance, achieving a green rating of 18 and receiving low scores for almost all components, due to the lack of environmental interventions. This therefore offers a useful contrast to the situation in that Case study 4 indicates the results when only conventional designs are used compared to simple, inexpensive green interventions that can be used. In general, the scores tended to conform to the expected performance levels.

Table 5.1: Comparative assessment between Case Study 4 and Case Study 2

		Case Study 4					Case Study 2					
			40%	20%	20%	20%		40%	20%	20%	20%	
	PERFORMANCE CATEGORIES	**OVERALL PROJECT**	ROADS	STORM WATER	SEWER	WATER	**OVERALL PROJECT**	ROADS	STORM WATER	SEWER	WATER	Category Weighting
1	LAYOUT EFFICIENCY	**16**	13	10	33	10	**77**	88	60	89	60	**10%**
2	FUNCTIONAL EFFICIENCY	**10**	15	7	6	7	**67**	75	63	53	67	**20%**
3	ENVIRONMENTAL QUALITY	**14**	21	8	10	11	**50**	57	62	40	33	**10%**
4	ECONOMY	**35**	55	11	27	30	**83**	82	89	82	80	**15%**
5	FUTURE MAINTENANCE	**14**	10	13	13	25	**62**	50	73	63	75	**10%**
6	SAFETY	**17**	13	10	17	33	**81**	80	60	83	100	**10%**
7	SOCIAL	**46**	50	17	75	40	**60**	75	17	75	60	**5%**
8	RESOURCES	**21**	22	22	36	0	**52**	44	56	64	50	**10%**
9	CONSTRUCTION	**6**	14	0	0	0	**34**	43	33	50	0	**5%**
	SCORING	**18**	24	10	18	16	**67**	69	66	62	66	

Figure 5.9 graphically illustrates the values of Table 5.1 in the form of a "spider diagram". It provides a graphical method of presenting design results, allowing the various criteria such as functional efficiency, environmental quality, maintenance, social and financial issues to be easily weighed against one another.

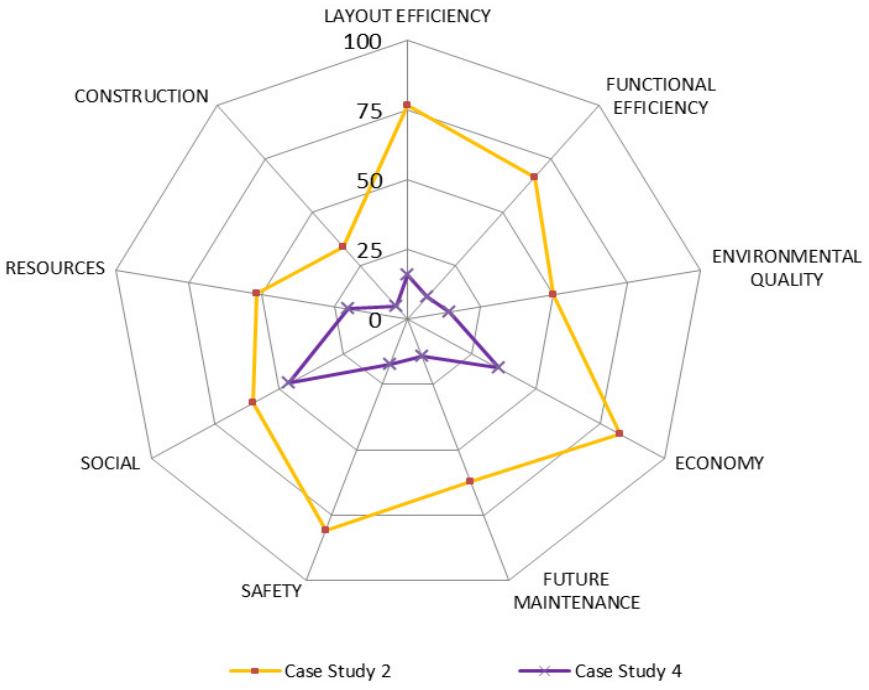


Figure 5.9: Comparative assessment between Case Study 4 and Case Study 2

5.2.6 Sensitivity analysis undertaken to test the effects of weighting criteria and elements

A sensitivity analysis was undertaken on Case Study 4 and Case Study 2 to determine the effect of weighting the various elements and criteria. The weighting for roads, stormwater, sewer and water were distributed equally by 25%.
The sustainability criteria were also weighted equally, by 11.1% for the nine criteria. The impact on the overall results of the case studies, as shown in Table 5.2.

The results indicate that, should the client decide not to focus on specific interventions on a project and decide to weigh the sustainability criteria and infrastructure equally, there will be a minimal impact to the scoring. Case study 4 results stayed the same, however case study 2 results dropped from 67 to 64
The use of different weighting sets resulted in some slight variances in the scores at both elemental and criteria levels, but that there was little variance in the overall scores that could result in the project skipping a sustainability scoring band.

Table 5.2: Sensitivity analysis by distributing equal weighting of the elements and criteria on Case Study 4 and Case Study 2

			Case Study 4					Case Study 2				
	WEIGHTING			25%	25%	25%	25%		25%	25%	25%	25%
	PERFORMANCE CATEGORIES	CATEGORY WEIGHTING	**OVERALL PROJECT**	ROADS	STORM WATER	SEWER	WATER	**OVERALL PROJECT**	ROADS	STORM WATER	SEWER	WATER
1	LAYOUT EFFICIENCY	**11.1%**	**16**	13	10	33	10	**74**	88	60	89	60
2	FUNCTIONAL EFFICIENCY	**11.1%**	**9**	15	7	6	7	**64**	75	63	53	67
3	ENVIRONMENTAL QUALITY	**11.1%**	**13**	21	8	10	11	**48**	57	62	40	33
4	ECONOMY	**11.1%**	**31**	55	11	27	30	**83**	82	89	82	80
5	FUTURE MAINTENANCE	**11.1%**	**15**	10	13	13	25	**65**	50	73	63	75
6	SAFETY	**11.1%**	**18**	13	10	17	33	**81**	80	60	83	100
7	SOCIAL	**11.1%**	**45**	50	17	75	40	**57**	75	17	75	60
8	RESOURCES	**11.1%**	**20**	22	22	36	0	**53**	44	56	64	50
9	CONSTRUCTION	**11.1%**	**4**	14	0	0	0	**32**	43	33	50	0
	SCORING		**18**	23	11	20	17	**64**	68	63	65	62
	ORIGINAL SCORING(FROM TABLE 5.1)		***18***	*24*	*10*	*18*	*16*	***67***	*69*	*66*	*62*	*66*

5.3 Other Considerations

Changes in the weightings have little impact on the overall index score, although they do influence the performance category results.

This highlights the need for caution when using a single ‘element’ or ‘category’ to describe sustainability of a system, except when it is being used as a comparator between sites. It is also critical that a sound methodology is adopted for the selection of appropriate weights.

5.4 Improved quality of life for residents

There is a range of benefits that was achieved:

- Residential developments become safer.
- Residents have greater convenience, and realize significant water and time savings.
- Greater human comfort and aesthetics, and improved health and safety. Peak temperatures drop due to road surfacing and greener areas, thereby reducing the overall discomfort levels. Biodiversity in the area increases. The open storm water system provides a better environment for local plants and wildlife. Flowering perennials and native trees attract birds and insects.
- Training, education and work opportunities created. A range of practical, on-the-job training sessions and community education workshops conducted and local employment created.
- Water savings and the efficiency in the network boosted. Rainwater harvesting reduces water costs and assists when there are water shortages. Water use is efficient, and grey water can be used for food gardens.

As can be seen in the case studies, rainwater storage can enhance water security and provide water for food gardens. Employment was generated for local residents, while training has given households practical skills and a better understanding of sustainability. Such an environment improves the quality of life of individuals and improves overall resilience in urban societies. An improvement in accessibility to basic services and efficiency of service delivery contributes to improved health, productivity and ultimately social and economic upliftment.

5.5 Summary

The green infrastructure rating tool provided a means for sustainability performance reporting of township infrastructure and facilitates sustainability target setting in briefing processes. The chapter demonstrates how the proposed tool can facilitate design decision-making processes and their applications as design tools.

The case studies demonstrate how target/green goals were set through its green goal reporting mechanism, preliminary design solutions screened and detailed designs analysed and rated in terms of sustainability.

The Green Township Infrastructure Design Toolkit ensures that project designs are more carefully examined, and that alternative design solutions are developed to ensure the client's objective of value for money.

The green value analysis approach is incorporated into the proposed Green Township Infrastructure Design Toolkit and readily monitored by Green Reports, so that value management and quality control is achieved.

The case studies demonstrated the range of sustainable design interventions, socio-economic, health and environmental interventions and benefits which are possible through the Green Township Infrastructure Design Toolkit, thus achieving a low carbon footprint. It also indicates how greening interventions in low cost housing can improve quality of life for residents and provide multiple benefits for the country. It points towards a more sustainable approach for housing delivery and human development.

The sensitivity analysis done between the two low cost housing projects indicate the benefits of utilising the Green Township Infrastructure Design Toolkit. The toolkit progressively ensured efficient, affordable, economical, and sustainable provision of infrastructure services, through all phases of the project.

CHAPTER 6 – CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

As projects, clients, environmental agencies and government become more complex and stringent in their requirements, so it becomes more necessary to improve and refine environmental control tools. Clients are demanding that their professional advisers should accept sustainability and infrastructure greening as a central element in the design.

The absence of a systematic and co-ordinated approach to evaluating the environmental impacts of design decisions on infrastructure projects denies the stakeholders, especially municipalities, the synergetic benefits of sustainable infrastructure projects.

The proposed Green Infrastructure Toolkit seeks to ensure that clients and engineers have greater control over the environmental impacts of their design decisions on their projects. The case studies show how clients and project objectives can be readily quantified and verified. Cutting-edge, cost-effective and cleaner technologies must be promoted over conventional designs.

6.2 The limitations of the Green Township Infrastructure Design Toolkit

This research thesis has the following limitations, mainly due to lack of data, time constraints and resource limitations:

- Although the Green Township Infrastructure Design Toolkit includes the triple bottom line of sustainability, the social impacts of the project are qualitative. For example, aesthetic aspects of a project and cultural values of a building are hard to quantify.
- The selection of environmentally responsible materials is limited. Some greener materials need to be imported, which inevitably costs the client. Environmentally responsible materials require greater upfront costs, which clients may not be prepared to pay for it.
- Weighting is one of the most theoretically controversial aspects within the rating systems. Weighting involves a high degree of subjectivity and will have assessment result's dependent on the assessor's discretion and intuitive judgment. The toolkit does, allow for allocating individual scores to each criterion and a bottom up approach to rating a project. However in order to

reach a consensus of the individual scoring, there can be an establishment of an independent panel of Green infrastructure experts, whom can workshop the scoring with all stakeholders and issue for public comment, before rolling out the toolkit.

6.3 The cost of going green on buildings

Most clients do not introduce greening into their projects due to the higher than usual initial capital cost, but it is predicted that the added cost of going green should reduce over time. A four star rated building, which equates to a Gold “status” township services infrastructure project with “Restricted damage to the environment using innovation and new technologies” costs about 3% more than a conventional building of the same size. The payback period on South Africa Green Star rated building was initially calculated at five years, assuming moderate growth in the cost of water and electricity (Uys, 2010).

Balancing the potential benefits against the costs, including manufacturing, installation and downstream costs, is crucial when deciding to implement the green design elements on projects (Boswell, 2010).

The on-going capital investment for the use of potable water reticulation for irrigation is far more costly than the initial capital investment of constructing a stormwater retention pond and capturing runoff and reusing it.

The U.S. Environmental Protection Agency (EPA) undertook 17 case studies of developments that include Low Impact Development (LID) practices and concluded that applying LID techniques can reduce project costs and improve environmental performance. In most cases, significant savings were realized due to reduced costs for site grading and preparation, stormwater infrastructure, site paving, and landscaping. Total capital cost savings ranged from 15 to 80 percent when LID methods were used rather than conventional stormwater management costs. Low Impact Development practices saves money for developers, property owners, and communities while protecting and restoring water quality. (United States Environmental Protection Agency, 2007)

6.4 The benefits of the Green Township Infrastructure Design Toolkit

Effective environmental design enables all involved in a project to respond to project challenges and to understand the interrelationships that result from various decisions about environmental impacts on the project. The benefits of using green engineering were highlighted in Chapters 3 and 5.

The proposed Green Reports enable the client to be kept fully informed of the environmental implications of all his/her design decisions. The measurable outputs of the forms give the executing authorities the opportunity to respond to design decisions on the project. Control is shifted from the consultants to the clients. This approach is in line with the emphasis on assessing outputs and outcomes.

The Green Township Infrastructure Design Toolkit optimises the project value by progressively ensuring environmentally efficient, affordable, economical and sustainable provision of infrastructure services, which will result in a project of higher standard, without the need for additional funds.

The Green Township Infrastructure Design Toolkit is primarily a multi-attribute infrastructure design guidance tool that compares and weighs up various environmental solutions against each other, allowing clients and project managers to choose the most "environmentally preferable" engineering solution.

The toolkit's comprehensive reporting at every stage acts as an early warning system to diagnose major sustainability problems, so that remedial measures can be taken to ensure that the design decisions are still environmentally friendly.

The toolkit allows client and consulting engineers to engage with stakeholders in dialogue throughout the development, design and delivery of a project to ensure that stakeholder environmental issues and concerns are fully considered. It allows for openness and transparency of design.

It would take a user around approximately an hour to rate a project from concept design level to detailed design and would result in huge time savings as opposed to search for alternative design decisions that looks holistically at a project.

6.5 Maintenance of the Green Township Infrastructure Design Toolkit

The Green Township Infrastructure Design Rating System is continually evolving.
On completion of this research, the toolkit will be developed into a web-based system. Users will need to register on the proposed website, in order to use the rating tool. A reference manual will be created, with a version number.
The author is the current steward of The Green Township Infrastructure Design Rating System and is responsible for its on-going maintenance and upkeep; however with time, the toolkit maybe handed to a civil engineering infrastructure institution, where a Project Team will be responsible for keeping the rating tool up to date.

In order to keep up to date with technology, standards and legislation, from time to time, there may be additions, amendments and corrections to the toolkit, which will happen in real-time, and updates to the web-based version, followed by a publication of a paper supporting version, and an email notification to all registered users.
Addenda will be published online to keep the operable version of The Green Township Infrastructure Design Rating System up to date.

6.6 Recommendations

The following recommendations are offered for consideration and implementation in practice.

- Green engineering, low impact design, value engineering, environmental planning and management should be undertaken on infrastructure projects rather than the traditional method of designing of townships.
- Engineers should undertake more environmentally friendly design interventions at the early phases of the project, where they have the most impact.
- The Green Township Infrastructure Design Toolkit should be implemented on projects to monitor the impact of design decisions on the environment. Currently there are no control procedures in place to measure the environmental impacts and effectiveness of infrastructure design decisions.

- Clients need to have a full understanding of the design and the environmental implication of certain design decisions on a project and have mechanisms to rate how sustainable their infrastructure projects are. This can be accomplished with the use of the proposed Green Reporting tools.
- On completion of this research, the Green Township Infrastructure Design Rating System will need be developed into a web-based system.

6.7 Summary

The proposed Green Township Infrastructure Design Toolkit aims to transform the conventional approach to infrastructure design by focusing on high-performance, resource conservation, layout planning, energy efficiency, economical and environmentally friendly infrastructure solutions. Though eco-friendly design is a major component of the green value assessment, several other basic sustainability requirements are also assessed.

The proposed toolkit offers a comprehensive design tool with more than 380 value added design criteria available for assessment of the project at the design stage, where its environmental impacts are most effective and can be used as a checklist for sustainable design. It complements the provision of environmentally friendly infrastructure options in order to support the achievement of more sustainable provision of services to the communities.

The engineer can make more rational decisions by analysing sustainability criteria and weighting sensitivities. The proposed decision support tool for urban infrastructure reflects various dimensions of sustainability, namely, environmental, economic, engineering, and social. The toolkit makes engineers environmentally accountable for their design decisions and provides a graphical method of presenting their results, allowing engineers and environmental issues to be easily weighed against one another.

Finally, the Green Township Infrastructure Design Toolkit is about improving living standards and reducing the environmental impact of infrastructure services. This framework enables Government to make use of private sector expertise in the most effective way possible and enables executing authorities to have final power over

most environmental decisions and contributes to a sustainable service delivery strategy.

The proposed framework is more than just a tool, it is a systematic framework intended to promote the concept of **'Green infrastructure services'**.

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APPENDICES

APPENDIX 1: Green Goal Report

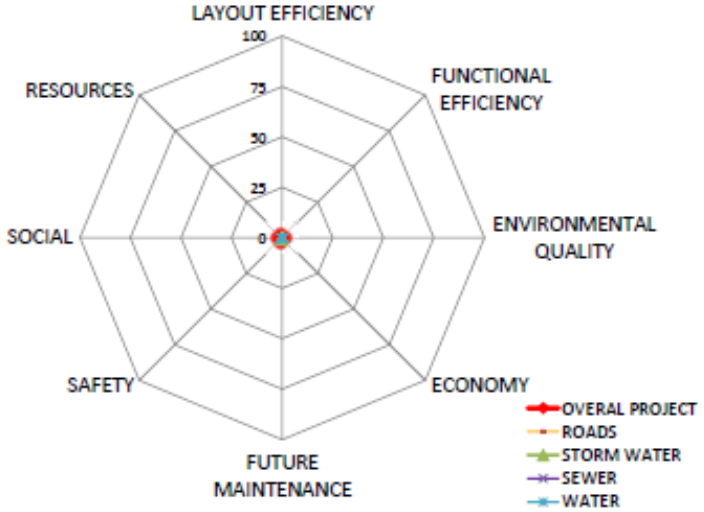
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Date:

Client: xxxxx Compiled by:

CIVIL INFRASTRUCTURE GREEN GOAL REPORT

PERFORMANCE CATEGORIES	ROADS	40%	STORM WATER	20%	SEWER	20%	WATER	20%	Weighted Infrastructure
1 LAYOUT EFFICIENCY	Best solution to the environment		Best solution to the environment		Restricted damage to the environment		Restricted damage to the environment		10%
2 FUNCTIONAL EFFICIENCY	Best solution to the environment		Best solution to the environment		Restricted damage to the environment		Restricted damage to the environment		20%
3 ENVIRONMENTAL QUALITY	Restricted damage to the environment		Restricted damage to the environment		Some considerations for environment		Some considerations for environment		15%
4 ECONOMY	Best solution to the environment		Best solution to the environment		Best solution to the environment		Best solution to the environment		15%
5 FUTURE MAINTENANCE	Restricted damage to the environment		Restricted damage to the environment		Restricted damage to the environment		Some considerations for environment		10%
6 SAFETY	Restricted damage to the environment		Some considerations for environment		Minimum interventions to be undertaken		Minimum interventions to be undertaken		10%
7 SOCIAL	Minimal interventions to be undertaken		Minimal interventions to be undertaken		Minimum interventions to be undertaken		Minimum interventions to be undertaken		5%
8 RESOURCES	Best solution to the environment		Best solution to the environment		Some considerations for environment		Restricted damage to the environment		10%
9 CONSTRUCTION	Minimal interventions to be undertaken		Minimal interventions to be undertaken		Minimal interventions to be undertaken		Minimal interventions to be undertaken		5%
WEIGHTED SCORE		0		0		0		0	100%



SCORE	0	GOLD	Restricted damage to the environment

RANGE OF SUSTAINABLE DEVELOPMENT GOALS

Sustainable goal for development	Range of implementation choices	Status	Score
Best solution to the environment	Set new performance benchmark through new technological developments	PLATINUM	75 -100
Restricted damage to the environment	Doing what is achievable- through innovation and risk taking with new systems and technologies	GOLD	50 - 74
Some considerations for	Apply conventional and current state-of-practice	SILVER	25 - 49
Minimal interventions to be	Achieve compliance based on regulations	Bronze	0 - 24

APPENDIX 2: Preliminary Green Infrastructure Rating Report

THE GREEN TOWNSHIP DESIGN MODEL

PRELIMINARY GREEN INFRASTRUCTURE RATING ANALYSIS

INFRASTRUCTURE ELEMENTS

ROADS		40%	SEWER		20%
	Pts Av	Pts Ach		Pts Av	Pts Ach
LAYOUT EFFICIENCY	8	0		8	0
Typical service layout configuration	1		Typical service layout configuration	1	
landscaping and all public utilities	1		Layout promote midblock sewer> 30% midblock	1	
Promote concept of green streets	1		<10% of length of Sewer pipeline in floodline	1	
Ecological Connectivity-Open spaces and circulation system	1		Avoidance of pumpstations	1	
layout facilitates economical subdivision and min. intersections	1		Alternative Route alignments	1	
Design the internal street layout to inhibit through-traffic	1		Catchment planning	1	
Increased diversity in road reserve through distinction between sic	1		Contour layout planning	1	
Roads aligned with natural topography	1		Sewer lines planned one catchment at a time	1	
RESOURCES	7			7	
Alternative Surfacing technologies -Permeable pav/Grass blocks/(	1		Backfill - non commercial source	1	
Tree conservation <1tree/ha removed	1		Use of onsite materials for Bedding	1	
Re-Use of Pavement Layerworks	1		Manhole sealed in the floodline	1	
Alt Transportation Options such as bicycles, light rail, NMT	1		Pipe material - use of pvc/hdpe vs. /concrete/steel	1	
Earthworks- balanced -Cut / Fill <20% spoil	1		The avoidance of the use of pumpstations	1	
Use of Recycled materials	1		Use of Recycled materials	1	
Conventional use of resources	1		Conventional use of resources	1	
ENVIRONMENT QUALITY	8			8	
Some consideration for reducing envir impact. in the design	1		Some consideration for reducing envir impact. in the desig	1	
Minimal of valley crossings < 1/km	1		<20% pipeline positioned in the flood plains	1	
ramps and paving	1		manholes, outlets, fittings	1	
Erosion control measures @ all outlets	1		Measures to control factors governing odour and noise	1	
Landscaping: Use of Water efficient plantings	1		Provision for protecting surface & sub surface water bodie	1	
Clearing and grading (Site Vegetation) limited to road footprint onl	1		Flood protection of pumpstation and pipeline	1	
Noise reduction through Quiet Pavement, traffic reduction on inter	1		Is the development density < the environmental capacity	1	
Habitat Restoration	1		Waste effluent quality monitoring measures	1	
FUNCTIONALITY EFFICIENCY	11			11	
Conventional systems that achieve minimum compliance	1		Conventional systems that achieve minimum compliance	1	
Use of Drainage and storage functions of roads	1		Primary greywater reuse	1	
Use of Pedestrian / bicycle paths	1		Oil/grease/grit separators	1	
Is the av. road grad/m <5%/m	1		Onsite sewage disposal-Recycle/composting	1	
Innovation- eg. Use of Permeable pavements	1		Secondary greywater reuse	1	
Low impact Development technologies- roads	1		Low impact Development technologies- Sewer	1	
automatic right of way on higher order roads	1		Nutrient resource recovery & reuse	1	
Parking ratios/codes/parking lots	1		Avoid Flat gradients (20% that is <1: 100)- stagnation	1	
Use of street furniture for a positive contribution to area	1		sealed	1	
Roadway system design to be self-cleaning	1		Sanitation system design to have self-cleaning velocity	1	
Additional lanes at major intersections-reduce peak quantity	1		Sewer attenuation-reduce peak quantity	1	
FUTURE MAINTENANCE	8			8	
Some consideration of maintenance in the design of the service	1		Some consideration of maintenance in the design of the s	1	
Maintenance of grass- pioneer grass used	1		Provisions for future expansion of the system	1	
Bank slopes must be gentle >1:1.75	1		Are pipeline susceptible to erosion protected	1	
Pavement lifecycle design >20yrs	1		Service aligned with road/property boundary>80%	1	
Site Vegetation-low water	1		Services watertight	1	
Alternative access for the repair of services	1		Easy access and room for the repair	1	
Type of trees planted allows for minimal leaves to fall	1		Erf have a rodding eye	1	
Street marking- high quality luminous paint	1		Pipe loading in all areas checked	1	
ECONOMY	7			7	
Some consideration of economy in the design of the service	1		Some consideration of economy in the design of the servi	1	
Most economic system/service for target market	1		Most economic system/service for target market	1	
Minimized the number of road intersections	1		Av Trench Depth <2m in over total length	1	
Are narrower, shorter streets used	1		Av. manhole spacing >50m	1	
Too Curvilinear roads increases no of manholes	1		Use of shared trenches> 30%	1	
Conduct Life-Cycle Cost Analyses	1		erf alignments as straight as possible to reduce sewer mh	1	
Is the area devoted to streets minimal- min road widths/reserves	1		Pipe material - pvc/concrete/hdpe.	1	
SAFETY	7			5	
Some consideration of safety in the design of the service	1		Some consideration of safety in the design of the service	1	
Traffic calming measures	1		<10% of length >3m Trench Depth	1	
Signage and pedestrian friendliness	1		Position in relation to water pipe >1m away	1	
the street is designed as a safe and unique public space	1		Compatibility with storm water management	1	
Segregate pedestrians, cyclists and vehicles where traffic speeds/volumes high	1		Measures to reduce the incidence ,spreading of diseases by waste	1	
Road safety Audit	1				
Safe Intersection-site distance, sidewalks, crosswalks, other inters	1				
SOCIAL	8			4	
neighbourhoods	1		ERF access to sewers	1	
Educational Outreach plan - road safety - to community	1		Educational Outreach plan -awareness on Health and sar	1	
Public participation in all stages of the project	1		Public participation in all stages of the project	1	
Public transport facilities and provision of street furniture	1		Provision of employment to local community >100 person	1	
Universal access-layout cater for disabled-Wheelchairs and elders	1				
Provision of employment to local community >100 person days	1				
Measures to preserve Cultural Heritage	1				
Provision of social amenities to the community	1				
CONSTRUCTION EFFICIENCY	6			1	
Environmental management Process, plan and training	1		Sewer Management Plan	1	
Site Waste management plan	1				
Pavement Management System	1				
Quality Management System	1				
Site maintenance plan	1				
Equipment Emissions Reduction Plan	1				
WEIGHTED SCORES	100	0		100	0

Best solution to the environment- Benchmark performance through new technological developments	**0**

THE GREEN TOWNSHIP DESIGN MODEL

PRELIMINARY GREEN INFRASTRUCTURE RATING ANALYSIS

STORMWATER	Pts Av	20% Pts Ach	WATER	20% Pts Av	100% Pts Ach	Weighted
LAYOUT EFFICIENCY	8	0		8	0	10%
Typical service layout configuration	1		Typical service layout configuration	1		
Use of Green corridors-Natural drainage paths	1		Pipe route alignment- looped network efficiency	1		
stormwater pipeline in floodline <10% of total length	1		Water pipeline in floodline <10% of total length of pipe	1		
Multipurpose Attenuation facilities-for retarding sw	1		Location & Spacing of Fire hydrants have a minimum overlap	1		
land use intensities matched to landscape tolerances for swn	1		layout relate to the water pressure zones	1		
SWMP initiated at start of planning for land uses	1		Minimal no of dead-ends to ensure flushing/no stagnation	1		
servitudes for safe, acceptable points of discharge.	1		land uses-high demands & fire risk close to water supply	1		
Reduced SW concentration & hydrological impact	1		Bulk service routed on roads or minimum 5m servitudes	1		
RESOURCES	7			7		10%
Pipe material - use of pvc/hdpe vs. /concrete/steel	1		Water demand management measures	1		
Use of onsite materials for Bedding	1		Zone and bulk smart metering	1		
Manhole types- brick/precast	1		Use of onsite materials for Bedding	1		
Rain water harvesting and Reuse	1		Use of Present & future water consumption figures	1		
Runoff quantity control	1		Promote use Water Efficient fixtures/Appliances	1		
Recycled materials to construct of SW channels/manholes/h	1		Rain water harvesting	1		
Conventional use of resources	1		Conventional use of resources	1		
ENVIRONMENT QUALITY	8			7		15%
Some consideration for reducing envir impact. in the design	1		Some consideration for reducing envir impact. in the design	1		
Post Development < Predev Flow	1		Protect against water contamination	1		
manholes, outlets, fittings	1		manholes, outlets, fittings that is not obtrusive	1		
Recharge rates maintained	1		low-level water audits	1		
Protection measures of wetlands- stagnant water	1		Scour valves positioned for safe discharge- erosion	1		
Runoff quality-Constructed Wetlands/filters	1		Reticulated recycled water supply	1		
Minimize soil erosion; by good vegetation along the water cou	1		Water-Wise Gardening	1		
Increased roughness of drainage way to decrease the velocit	1					
FUNCTIONALITY EFFICIENCY	11			11		20%
Conventional systems that achieve minimum compliance	1		Conventional systems that achieve minimum compliance	1		
Quality control at source-from residential rooftop by disconne	1		Water-Efficient Irrigation & landscaping measures	1		
SW attenuation-reduce peak quantity	1		Use of Roof tank/intermediate storage	1		
Stormwater Management Plan	1		Pressure Management as part of design-Balanced loss/increas	1		
Bioretention swales/ponds/infiltration berms	1		Dry Fire Hydrants. suction pipe systems from pond	1		
Low impact Development technologies- SW	1		Water efficient fittings	1		
Erosion control(Geotextile/cells, gabions)	1		water attenuation-reduce peak quantity	1		
Sediment control- Silt fences/Stilling basin	1		Watertight joints/compression type coupling/Seals quality	1		
Is the av. channel grad/m <5%/m-high velocities	1		Efficient water systems design-Optimised flow/velocity in pipe	1		
Use of roads & parking to control drainage & storage	1		Water reticulation design to be self-cleaning	1		
Are channels lined -earth,-grass, concrete, grass	1		Water hammer analysis	1		
FUTURE MAINTENANCE	8			8		10%
Some consideration of maintenance in the design of the serv	1		Some consideration of maintenance in the design of the servic	1		
Is the design-manholes, pipes and catchpits sized for mainte	1		Sleeves used where pipes cross the road	1		
Flood plain accessible	1		Services Watertight joints/Seals quality	1		
Pipe loading in all areas checked	1		Positioning of trees - proximity of services	1		
Stormwater system design to be self-cleaning	1		Isolation Valves/Meters located in convenient positions @ 90%	1		
Easy access and room for the repair of services	1		Easy access and room for the repair of services	1		
Positioning of trees in close proximity of services > 20m	1		Leak Detection devices in retic.	1		
Inlet/outlet design to reduce blockages	1		Provisions for future expansion of the system	1		
ECONOMY	8			8		15%
Some consideration of economy in the design of the service	1		Some consideration of economy in the design of the service	1		
Most economic system/service for target market	1		Most economic system/service for target market	1		
Non structural controls	1		Use of shared trenches >20%	1		
Use of shared trenches >20%	1		Max. hydrants, airvalve spacing av spacing- 200m	1		
Av. manhole spacing >50m	1		Av Trench Depth <1.2m in over total length	1		
Multipurpose stormwater facilities	1		Conduct Life-Cycle Cost Analyses	1		
Pipe material - pvc/concrete/hdpe.	1		Pipe material - pvc/concrete/hdpe.	1		
Av Trench Depth <2m in over total length	1		Are the air valves , shut off valves in valve rings	1		
SAFETY	6			6		10%
Some consideration of safety in the design of the service	1		Some consideration of safety in the design of the service	1		
<10% of length >3m Trench Depth	1		<10% of length >3m Trench Depth	1		
Velocity /depth of stormwater flowing	1		Supply sufficient for fire fighting requirements	1		
Safe discharge routes	1		Fire risk -High/medium or low	1		
Design accommodates various storm frequencies	1		close to bulk water supply points	1		
Flood warning signs	1		Pressure on pipeline<9bar	1		
SOCIAL	6			4		5%
convenience- minor system designed for high-frequency stor	1		Provision of employment to local community >100 person days	1		
Education and awareness- Rainwater harvesting	1		Educational Outreach plan - water conservation	1		
Public participation in all stages of the project	1		Public participation in all stages of the project	1		
No Inconvenience of overland flow and Temporary storage fa	1		Standpipes located in convenient positions along walkways.	1		
Is access to river walks and open spaces	1					
Provision of employment to local community >100 person da	1					
CONSTRUCTION EFFICIENCY	2			1		5%
Pre construction Stormwater Management Plan	1		Water Operational plan	1		
Siltation control with Sand and hessian bags or Silt fences	1					
	100	0		100		0

Best solution to the environment- Benchmark performance through new technological developments	**GOLD**	**0**

APPENDIX 3: Detailed Green Infrastructure Rating Analysis Report

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Date:
Client: xxxxx Compiled by:

INFRASTRUCTURE ELEMENT- ROADS			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**0.0**
1	Typical service layout configuration	no	0.00	
		yes	0.63	
2	Does the layout promote concept of greenstreets	no	0.00	
		yes	0.63	
3	Does the layout facilitate economical subdivisions, with the use of shared road infrastructure	no	0.00	
		yes	0.63	
4	• Layout integrates the circulation system with dwellings, landscaping and all public utilities	no	0.00	
		yes	0.63	
5	• the percentage township area devoted to roads, parking and footways <30% of total area	no	0.00	
		yes	0.63	
6	• Is there minimum interruption from access movements, intersections, to achieve good mobility, Access road >100m apart	no	0.00	
		yes	0.63	
7	• Provide public transport routes which minimize operating costs while satisfying user requirements for convenience	no	0.00	
		yes	0.63	
8	• Provide reserve widths and alignments which cater for all road users, for services for landscaping, in the most economical way.	no	0.00	
		yes	0.63	
9	• Relate the spacing and layout of intersections to the probable vehicle type, the volume and direction of movement	no	0.00	
		yes	0.63	
10	• Ecological Connectivity-Open spaces and circulation system-integral part of the open space system and appropriate landscaping provided for	no	0.00	
		yes	0.63	
11	• Are short-distance links (<1km) between adjacent neighbourhoods	no	0.00	
		yes	0.63	
12	• Does the road hierarchy requirements provide automatic right-of-way for traffic on higher order roads. additional lanes at intersections provided for to reduce peak traffic with minimum interruption	no	0.00	
		yes	0.63	
13	Design the internal street layout to inhibit through-traffic	no	0.00	
		yes	0.63	
14	• Garages and urban collectors located away from residents, to minimize nuisance to residents from noise, dust and fumes	no	0.00	
		yes	0.63	
15	• Develop the road aligned to the natural topography	no	0.00	
		yes	0.63	
16	• Increase diversity in road reserve. Design and make distinction between sidewalk zone, cycle areas, pedestrian area, refuse areas, planters, lighting, etc.	no	0.00	
		yes	0.63	
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**0.0**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.00	
2	The use of Innovative design techniques, such as the use geogrids to reduce layer thickness, increase pavement life, bearing capacity, differential settlement, etc.	no	0.00	
		yes	1.00	
3	The use of Low impact Development technologies on roads	no	0.00	
		yes	1.00	
4	Are the street furniture well designed items, and placed so as to make a positive contribution to the total street picture	no	0.00	
		yes	1.00	
5	Are there cycle lanes	no	0.00	
		yes	1.00	
6	Are there special details for the design of all road elements, including kerbing, channelling, ramps and different types of paving.eg. Brick paving compared to concrete and asphalt as it creates	no	0.00	
		yes	1.00	
7	Are landscaping and trees used to reduce the impact of large areas of asphalt	no	0.00	
		yes	1.00	
8	Is the potential drainage function of roads maximized by co-ordinating their layouts with the drainage systems.	no	0.00	
		yes	1.00	
9	• Where appropriate, are the medians-<1.5m for safety	no	0.00	
		yes	1.00	
10	• Is the maximum road crown slope(4%)-operation problem driving, wear of vehicles <20% of the total road length	no	0.00	
		yes	1.00	
11	• Is the minimum road crown slope(2%) - prevents sediment loading <5% of the total road length	no	0.00	
		yes	1.00	
12	• Additional lanes at major intersections-reduce peak quantity	no	0.00	
		yes	1.00	
13	• Is the average road grad/m less than 5%/m	no	0.00	
		yes	1.00	
14	• Are parking areas provided (according to Parking ratios/codes) where road will be well trafficked and where appropriate consist of grass blocks, gravel, paving to give it a softer park like image	no	0.00	
		yes	1.00	
	Pedestrian routes			
15	• Do the pedestrian routes minimize walking distances and encourage pedestrian use	no	0.00	
		yes	1.00	
16	• Are there pedestrian facilities (such as sidewalks and crossings)	no	0.00	
		yes	1.00	

17	The project layout promotes walking and discourages the use of vehicles.	no	0.00	
		yes	1.00	
	Bus stops			
18	• Are bus bays provided at major bus stops to minimize delays to other traffic	no	0.00	
		yes	1.00	
19	• Provide shelter against rain, sun, wind as well as benches or a space for resting or eating while waiting for transportation and signage integrated with shelters	no	0.00	
		yes	1.00	
20	• Are gradients designed appropriate to the mode/s of transport using the bus route-<6%	no	0.00	
		yes	1.00	
	3.0 Environmental quality		**15.0**	**0.0**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.07	
2	Noise reduction through Quiet Pavement, traffic reduction on internal streets	no	0.00	
		yes	1.07	
3	• Use of surfacing on roads - Concrete vs. asphalt increases volumetric heat capacities, lower air temperatures	no	0.00	
		yes	1.07	
4	Habitat Restoration measures used	no	0.00	
		yes	1.07	
5	• Provide aesthetic kerbing, channelling, pedestrian refuges, ramps and paving	no	0.00	
		yes	1.07	
6	• Permeable road surface/parking lots -grass blocks- selection of surfacing that has a reduced environmental impact relative to available alternatives.	no	0.00	
		yes	1.07	
7	Does the project layout provides a safe, convenient and attractive environment for walking.	no	0.00	
		yes	1.07	
8	• Preserve natural features such as gullies, outcrops, marshes and existing trees, shrubs and hedges in the layout to create interest, variety and surprise in the vistas along the and along the	no	0.00	
		yes	1.07	
9	Are erosion control measures used in the design of earthworks on steep areas, such as the use of sand bags or Hessian sheets, rehabilitation of exposed soil areas, soil is protected from the	no	0.00	
		yes	1.07	
10	Clearing and grading (Site Vegetation) - road footprint/topsoil removed <50% of road reserve	no	0.00	
		yes	1.07	
11	• Is a variety of access street forms provided to avoid monotony	no	0.00	
		yes	1.07	
12	would there be stock piling of soil or any other materials near a watercourse	yes	0.00	
		no	1.07	
13	Landscaping: Use of Water efficient plantings	yes	0.00	
		no	1.07	
14	Are areas sensitive to erosion such as near water supply points and edges of slopes being developed.	yes	0.00	
		no	1.07	
	4.0 Economy		**15.0**	
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	
2	Most economic system/service for target market	no	0.00	
		yes	1.36	
3	• Can the number of road intersections be minimized through layout configuration	yes	0.00	
		no	1.36	
4	Are the roads too Curvilinear roads- increased no of manholes, kerb lengths	yes	0.00	
		no	1.36	
5	• Are the public transport routes optimized;	no	0.00	
		yes	1.36	
6	• Are the widths of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	
7	• Is the alignment of roadways utilise the maximum criteria in order to reduce earthworks, in with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	
8	• Is the pavement foundation design of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.36	
10	Earthworks- balanced-Cut / Fill <1000m3 spoil	no	0.00	
		yes	1.36	
11	• Can the total length and cost of internal roads be minimized	yes	0.00	
		no	1.36	
	5.0 FUTURE MAINTENANCE		**10.0**	
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.00	
2	• Acceptable pioneer grasses(cynodindactolin) and reeds where applicable	no	0.00	
		yes	1.00	
3	Type of trees planted allows for minimal leaves to fall and clog up drains	no	0.00	
		yes	1.00	
4	Landscaping: Use of Water efficient plantings	no	0.00	
		yes	1.00	
5	• -Bank slopes must be gentle to allow access for maintenance >1:1.75	no	0.00	
		yes	1.00	

6	• Life span of the road pavement >20 years	no	0.00	
		yes	1.00	
7	• Street marking- high quality luminous paint	no	0.00	
		yes	1.00	
8	Alternative access for the repair of road or road closure	no	0.00	
		yes	1.00	
9	High quality Street signage - minimal maintenance >2m from trees/shrubs	no	0.00	
		yes	1.00	
10	Are there subsurface water drainage systems in 80% of cuts >2m to protect road pavements - minimal maintenance of road layerworks	no	0.00	
		yes	1.00	
	6.0 SAFETY		**10.0**	
1	Some consideration of safety in the design of the service	no	0.00	
		yes	0.67	
2	Adequate sight distances at intersections, horizontal curves and crests are commensurate with operating speeds	no	0.00	
		yes	0.67	
3	• Universal access at Intersections-designed to be safe for pedestrians and vehicles. This includes sidewalks, crosswalks, traffic signals and other intersection treatment	no	0.00	
		yes	0.67	
4	• Inhibit through-traffic in internal streets/neighbourhoods	no	0.00	
		yes	0.67	
5	• Segregate pedestrians, cyclists and vehicles where traffic is concentrated or speeds and volumes are high	no	0.00	
		yes	0.67	
6	Traffic calming measures used such as Speed humps, chicanes, street narrowing devices, change in the surface colour or texture, in the immediate vicinity of homes.	no	0.00	
		yes	0.67	
7	• Provide access points to multiple units dwellings only at selected points to control and concentrate traffic	no	0.00	
		yes	0.67	
8	• Provide turning spaces which avoid the need for vehicles to reverse over long distances.	no	0.00	
		yes	0.67	
9	• Are there pedestrian crossings and sidewalks with adequate signage	no	0.00	
		yes	0.67	
10	Road safety Audit undertaken	no	0.00	
		yes	0.67	
11	• Provide mutual visibility between pedestrians and moving vehicles with traffic on main roads;	no	0.00	
		yes	0.67	
12	• is there a potential conflict areas between roads users, pedestrian and cyclists	yes	0.00	
		no	0.67	
13	• Design soft mounds, and plant trees to separate pedestrian from buildings and road	no	0.00	
		yes	0.67	
14	Convenience- Traffic-generating facilities located near entrances to residential areas or adjacent to higher order roads	no	0.00	
		yes	0.67	
15	Are the pedestrian system and parking areas located where they will be overlooked by dwellings or passing traffic and well-lit after dark for greater security	no	0.00	
		yes	0.67	
	7.0 SOCIAL		**5.0**	
1	Does the road contribute to development of previously underdeveloped areas	no	0.00	
		yes	0.63	
2	Educational Outreach plan - road safety	no	0.00	
		yes	0.63	
3	• Ensure that pedestrian crossings on distributor roads are convenient to use	no	0.00	
		yes	0.63	
4	• Minimize distances of pedestrian routes <15min walking time;	no	0.00	
		yes	0.63	
5	Provision of social amenities to the community	no	0.00	
		yes	0.63	
6	• Does the layout cater for disabled and Wheelchairs and elders that may want to sit down	no	0.00	
		yes	0.63	
7	Provision of employment to local community >100 person days	no	0.00	
		yes	0.63	
8	Use of Public transport facilities and provision of street furniture	no	0.00	
		yes	0.63	

	8.0 RESOURCES		**10.0**	
1	Conventional use of resources	no	0.00	
		yes	1.11	
2	Use of Recycled road materials in the layerworks	no	0.00	
		yes	1.11	
3	Is the Kerbing cast insitu or precast	precast	0.00	
		insitu	1.11	
4	Design initiatives that increase the facilitate reused building materials, Recycled materials and	no	0.00	
		yes	1.11	
5	Tree conservation- no of trees <10/ha	no	0.00	
		yes	1.11	
6	Earthworks spoiled- <20%	no	0.00	
		yes	1.11	
7	Promoting Alternative Transportation Options such as bicycles, light rail, Non Motorized Transport	no	0.00	
		yes	1.11	
8	Use of alternative Surfacing other than hot mix asphalt, such as Permeable pave/Grass blocks/porous concrete	no	0.00	
		yes	1.11	
9	Reuse existing materials onsite to minimise materials consumption	no	0.00	
		yes	1.11	
	9.0 CONSTRUCTION		**5.0**	
1	Environmental management Process, plan and training	no	0.00	
		yes	0.71	
2	Site Waste management plan	no	0.00	
		yes	0.71	
3	Pavement Management System	no	0.00	
		yes	0.71	
4	Quality Management System	no	0.00	
		yes	0.71	
5	Site maintenance plan	no	0.00	
		yes	0.71	
6	Equipment Emissions Reduction Plan	no	0.00	
		yes	0.71	
7	• Stockpiles <1000m3 (Hugh stockpiles create dust in wind)	no	0.00	
		yes	0.71	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Date:
Client: xxxxx Compiled by:

INFRASTRUCTURE ELEMENT- STORMWATER

			Scoring	
1.0 LAYOUT EFFECIENCY			**10.0**	**0.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	
2	Does the layout consider hydrological concerns with regards to sw runoff and relationship to plot size, type of land use	no	0.00	
		yes	1.00	
3	Does the layout plan take into account the natural drainage paths(Stream patterns), areas subject to flooding	no	0.00	
		yes	1.00	
4	• Are the land use intensities matched to landscape tolerances for swmp	no	0.00	
		yes	1.00	
5	Are the stormwater facilities integrated with recreation areas;	no	0.00	
		yes	1.00	
6	• Does the swmp use open spaces for retarding or stormwater evaporation ponds to remove partially treated water	no	0.00	
		yes	1.00	
7	Is the length of Storm water services located in special servitudes and not located in road reserve <10% of total length	no	0.00	
		yes	1.00	
8	stormwater pipeline in floodline <10% of total length	no	0.00	
		yes	1.00	
9	• Does the layout reduce the hydrological impact of the development by reducing stormwater concentration	no	0.00	
		yes	1.00	
10	• Was the mdp initiated at start of planning for land uses	no	0.00	
		yes	1.00	
2.0 FUNCTIONAL EFFECIENCY			**20.0**	
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	0.74	
2	Provision of surface water management system to ensure that the ultimate flow from the development does not result in any negative impacts on downstream properties or watercourse and is managed within the overall site	no	0.00	
		yes	0.74	
3	Has the Master drainage plans been prepared, in collaboration with adjoining communities and authorities, for the existing and future development of the entire catchments	no	0.00	
		yes	0.74	
4	Is >70% of the road designed for sheetflow	no	0.00	
		yes	0.74	
5	Is the maximum velocity <3m/s	no	0.00	
		yes	0.74	
6	<10% of roads have a maximum road gradient >12%	no	0.00	
		yes	0.74	
7	What is the minimum road crown slope- <2%- sediment	no	0.00	
		yes	0.74	
8	Is the maximum road crown slope- <3%-operation problem driving, ware of vehicles	no	0.00	
		yes	0.74	
9	Are the potential drainage and storage functions of roads, roadside channels used	no	0.00	
		yes	0.74	
10	Is >50% of the road gradients <2% - used for retarding stormwater run-off	no	0.00	
		yes	0.74	
11	Is the post development limited to predevelopment	no	0.00	
		yes	0.74	
12	• Is the roadside channels designed to prevent erosion	no	0.00	
		yes	0.74	
13	• Is the stormwater flow depths < 0.5m	no	0.00	
		yes	0.74	
14	• Inlet- are the backwater effects designed for	no	0.00	
		yes	0.74	
15	• are the inlets/pond have swing type grids or are self cleansing to prevent blockages	no	0.00	
		yes	0.74	
16	Quality control at the source-from residential rooftop by disconnecting downpipe, Rain Barrels, soakaway-Prevent pollutant dumping	no	0.00	
		yes	0.74	
17	• Does the reticulation limit runoff volumes with the use of bioswales filtering pollution	no	0.00	
		yes	0.74	
18	• Does the reticulation limit volumes with the use of retention basin	no	0.00	
		yes	0.74	
19	Are velocities reduced with the use of Check dams	no	0.00	
		yes	0.74	
20	• Does the reticulation limit runoff volumes with the use of Porous parking surfaces	no	0.00	
		yes	0.74	
21	• In areas where the subsoil and water table are suitable, does the design the surfaces of storage areas allow for the re-charging of the underground water.	no	0.00	
		yes	0.74	
22	Are flood plains and watercourses protected from erosion with Gabions, dissipaters, Reno mattress, stilling basins, Check weir, Riprap protection, Energy reduction, Drop structures, Rip rap basins.	no	0.00	
		yes	0.74	
23	• Are there measures to prevent underground conduits from silting up	no	0.00	
		yes	0.74	
24	• Are channels lined -earth,-grass, concrete, grass	no	0.00	
		yes	0.74	
25	• Is the average channel slopes -<5%	no	0.00	
		yes	0.74	
26	• Are the stormwater outlet structures designed to decrease flow velocity by the use of velocity dissipaters	no	0.00	
		yes	0.74	
27	Sediment control- Silt fences/Stilling basin	no	0.00	
		yes	0.74	

	3.0 ENVIROMENTAL QUALITY		**15.0**	**0.0**
	Erosion control measures			
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.15	
2	• Protection of environmentally sensitive areas;	no	0.00	
		yes	1.15	
3	• Predevelopment ground water Recharge rates are maintained;	no	0.00	
		yes	1.15	
4	SW pipes steeper than 1:3 <10% of the total length	no	0.00	
		yes	1.15	
5	• Consolidate waterways and open space requirements;	no	0.00	
		yes	1.15	
6	• Minimize soil erosion; by good vegetation along the water courses	no	0.00	
		yes	1.15	
7	• Buffer zone>25m between hard and watercourse areas	no	0.00	
		yes	1.15	
8	• Rehabilitation of exposed soil areas to ensure soil protection	no	0.00	
		yes	1.15	
9	• Removal of vegetation on steep areas	yes	0.00	
		no	1.15	
10	Protection measures of wetlands- stagnant water- may become health hazards-Is there a potential of Nutrient enrichment- eutrophication	no	0.00	
		yes	1.15	
11	SW quality treatment with the use storage facilities, Constructed Wetlands/filters	no	0.00	
		yes	1.15	
12	• Increased roughness of the channel or drainage way to decrease the velocity	no	0.00	
		yes	1.15	
13	• Subsurface disposal is not to close to point of rainfall >200m	no	0.00	
		yes	1.15	
	4.0 ECONOMY		**15.0**	
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.67	
2	• What type of system is being used	>50% piped system<50%	0.00	
		<50% piped system>50%	1.67	
3	The use of non-structural control as in relation to structural control of SW.	no	0.00	
		yes	1.67	
4	• Does the reticulation have multipurpose stormwater facilities	no	0.00	
		yes	1.67	
5	• Does the SWMP provide a few, large areas for retaining stormwater, rather than many smaller areas which are more problematic to maintain.	no	0.00	
		yes	1.67	
6	• Does the SWMP attempt to align open drainage systems with natural drainage systems, to minimize the cost of earthworks and pipe works.	no	0.00	
		yes	1.67	
7	• Are the manhole spaced at an the Av. manhole spacing >50m	no	0.00	
		yes	1.67	
8	Is there >30% of shared trenches in relation to separate trenches	no	0.00	
		yes	1.67	
9	Trench Depth <10% of length >3m	no	0.00	
		yes	1.67	
	5.0 FUTURE MAINTENANCE		**10.0**	
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.67	
2	• Are there any services placed in a location that is not easily accessible by public fo rmaintence	yes	0.00	
		no	0.67	
3	• Was the mdp prepared in collaboration with authorizes for future developments	no	0.00	
		yes	0.67	
4	• Is the flood plain accessible to public for maintenance	no	0.00	
		yes	0.67	
5	• Is the design-manholes, pipes and catchpits sized for maintenance	no	0.00	
		yes	0.67	
6	• Are the bulk services routed on roads or minimum 5m servitudes	no	0.00	
		yes	0.67	
7	• Pipe loading in all areas checked	no	0.00	
		yes	0.67	
8	• If services are in midblock, is a 5m building line imposed	no	0.00	
		yes	0.67	
9	• Is due regard for positioning of trees in close proximity of services > 20m	no	0.00	
		yes	0.67	
10	• Are sleeves used where pipes cross the road	no	0.00	
		yes	0.67	
11	• Are the pipes susceptable to erosion protected	no	0.00	
		yes	0.67	
12	• Are the open drains in in >6% lined	no	0.00	
		yes	0.67	
13	• pipes across road >100D	no	0.00	
		yes	0.67	
14	- Is there an acceptable pioneer grass (cynodindactoiln) and reeds established where applicable	no	0.00	
		yes	0.67	
15	• Does the inlet structures designed to reduce clogging, self cleansing, not designed to overflow	no	0.00	
		yes	0.67	

	6.0 SAFETY		**10.0**	
	Aim- Risk of loss of life and significant damage to properties from the run off from the exception heavy			
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.00	
2	• Does the drainage system manage the planned development for the upstream areas, for storms ranging from frequent to rare events?	no	0.00	
		yes	1.00	
3	• Are there safe discharge routes provided for stormwater overland flow. Would the overflow from storage areas protect the downstream property from being inundated,	no	0.00	
		yes	1.00	
4	• In areas susceptible to flooding, is the velocity and/or depth of stormwater flowing in or across streets is within safe limits, with particular attention to potential traffic hazard on higher speed roads.	no	0.00	
		yes	1.00	
5	• Are storms >1:20 yr frequencies accommodated within the design;	no	0.00	
		yes	1.00	
6	•-are the elevation of infrastructure & buildings above the 100yr floodline	no	0.00	
		yes	1.00	
7	• are the manhole covers sealing in flood sensitive areas	no	0.00	
		yes	1.00	
8	• are the any building that have installation of pumps for stormwater	yes	0.00	
		no	1.00	
9	<10% of length >3m Trench Depth	no	0.00	
		yes	1.00	
10	are there flood warning signs informing public of approaching hazards	no	0.00	
		yes	1.00	
	7.0 SOCIAL		**5.0**	
1	• Are the minor system designed for high-frequency storms; so that there is no inconvenience of overland flow routes	no	0.00	
		yes	0.83	
2	• Are the temporary storage areas for stormwater in places where the water would not cause inconvenience during or immediately after storms.	no	0.00	
		yes	0.83	
3	• Is access to river walks and open spaces allowed;	no	0.00	
		yes	0.83	
4	Education and awareness- Rainwater harvesting	no	0.00	
		yes	0.83	
5	Public participation in all stages of the project	no	0.00	
		yes	0.83	
6	• Provision of employment to local community >100 person days	no	0.00	
		yes	0.83	
	8.0 RESOURCES		**10.0**	
1	Conventional use of resources	no	0.00	
		yes	1.11	
2	• Use of onsite materials for bedding	no	0.00	
		yes	1.11	
3	• Use of onsite materials for backfill	no	0.00	
		yes	1.11	
4	Runoff quantity control measures	no	0.00	
		yes	1.11	
5	Rain water harvesting and Reuse -recycled stormwater for irrigation	no	0.00	
		yes	1.11	
6	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc, hdpe	1.11	
7	Does the sytem recharge groundwater	no	0.00	
		yes	1.11	
8	• manhole types-	brick	0.00	
		precast	1.11	
9	Recycled materials to construct of SW channels	no	0.00	
		yes	1.11	
	9.0 CONSTRUCTION		**5.0**	
1	Pre construction Stormwater Management Plan	no	0.00	
		yes	1.67	
2	Education and awareness- Rainwater harvesting	no	0.00	
		yes	1.67	
3	Minimize erosion and control siltation with Sand and hessian bags or Silt fences	no	0.00	
		yes	1.67	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Date:
Client: xxxxx Compiled by:

INFRASTRUCTURE ELEMENT- SEWER			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**0.0**
1	Typical service layout configuration	no	0.00	
		yes	1.11	
2	• Can pumpstations be avoided through the layout reorientation	no	0.00	
		yes	1.11	
3	• Does the layout promote midblock sewer	no	0.00	
		yes	1.11	
4	• Are alternative sewer layouts considered;	no	0.00	
		yes	1.11	
5	Are the Bulk service routed on roads or minimum 5m servitudes If services are in midblock, a 5m building line imposed	no	0.00	
		yes	1.11	
6	Is there a Sewer Catchment Management Plan been done	no	0.00	
		yes	1.11	
7	<10% of total length of Sewer pipeline in floodline	no	0.00	
		yes	1.11	
8	• Is the development Phased in one catchment at a time	no	0.00	
		yes	1.11	
9	Did the layout consider the positioning of trees in close proximity of services >20m	no	0.00	
		yes	1.11	
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.18	
2	• Does the development contain a grey / black water water reuse system	no	0.00	
		yes	1.18	
3	• Does the development contain Secondary greywater reuse	no	0.00	
		yes	1.18	
4	• Are sewers designed to gradients which are steep enough to ensure adequate velocity for self-cleansing	no	0.00	
		yes	1.18	
5	use of Oil/grease/grit separators	no	0.00	
		yes	1.18	
6	• Does the development attempt to minimize discharge to the municipal sewerage system through sewer attenuation	no	0.00	
		yes	1.18	
7	Does the system attempt Nutrient resource recovery & reuse by Recycle/composting	no	0.00	
		yes	1.18	
8	Are there a potential areas >30% of length that are flat (1: 100) that can result in stagnation	yes	0.00	
		no	1.18	
9	Innovative wastewater technology	no	0.00	
		yes	1.18	
10	• Was the Geotechnical conditions taken into account in the design	no	0.00	
		yes	1.18	
11	• Does the Soil profile have good permeability	no	0.00	
		yes	1.18	
12	Are the manholes that are in the 1:100 yr. floodline sealed	no	0.00	
		yes	1.18	
13	• Does the evapotranspiration area in case of an overflow fall within the site	no	0.00	
		yes	1.18	
14	• Does the evapotranspiration area in case of an overflow fall within the wetland	yes	0.00	
		no	1.18	
15	• Is the av. topography >12%-steep slope problematic for sewage	yes	0.00	
		no	1.18	
16	Are there Soakaway/Sewer lines positioned <7.5m from drink water source	yes	0.00	
		no	1.18	
17	• Soakaway/Sewer lines positioned >5m from water table	no	0.00	
		yes	1.18	

	3.0 Environmental quality		**15.0**	
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.50	
2	Design a layout which minimizes nuisance to residents, provides attractive and healthy living conditions, and benefits the environment	no	0.00	
		yes	1.50	
3	Provision for protecting surface & sub surface water bodies from sewage	no	0.00	
		yes	1.50	
4	Provision of aesthetic sewer infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.50	
5	• Are <10% of sewerpipline positioned in the flood plains;	no	0.00	
		yes	1.50	
6	• Is the receiving sewer purification works clear >500m flood plains;	no	0.00	
		yes	1.50	
7	• Is there Erosion protection provided near water course	no	0.00	
		yes	1.50	
8	Waste effluent quality monitoring measures in place	no	0.00	
		yes	1.50	
9	• Are there measures taken to Minimize the obtrusiveness of pumping stations, sewer infrastructure and their environs	no	0.00	
		yes	1.50	
10	• Are there measures taken to control factors governing odour and noise emanating from pump stations and sewer infrastructure	no	0.00	
		yes	1.50	
	4.0 Economy		**15.0**	
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	
2	• Are the intersection spacing's and block lengths compatible with maximum manhole spacing's to minimize the number of manholes.	no	0.00	
		yes	1.36	
3	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.36	
4	• Is the percentage of sewer is mid-block sewer >30% of the total length	no	0.00	
		yes	1.36	
5	Av Trench Depth <2m in over total length	no	0.00	
		yes	1.36	
6	• Is the av manhole spacing's >50m	no	0.00	
		yes	1.36	
7	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel, concrete	0.00	
		pvc, hdpe	1.36	
8	• manhole types-	brick	0.00	
		precast	1.36	
9	• Are there long lengths of sewers which cross or adjoin open space or undeveloped land.	yes	0.00	
		no	1.36	
10	• Are there shared trenches >30%	no	0.00	
		yes	1.36	
11	• Are the roads or mid-block erf alignments as straight as possible to reduce sewer reticulation costs and minimize the number of manholes.	no	0.00	
		yes	1.36	
	5.0 FUTURE MAINTENANCE		**10.0**	
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.25	
2	• Are the pipe runs and cables in servitudes that are accessible for maintenance work.	no	0.00	
		yes	1.25	
3	Provisions for future expansion of the system	no	0.00	
		yes	1.25	
4	• Was there a lifecycle cost analysis done of the pipe and materials	no	0.00	
		yes	1.25	
5	Are pipeline susceptible to erosion protected	no	0.00	
		yes	1.25	
6	• Does every erf have a rodding eye in addition of inspection eye	no	0.00	
		yes	1.25	
7	Are all services watertight	no	0.00	
		yes	1.25	
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	1.25	

6.0	**Safety**		**10.0**	
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	
2	Trench Depth >3m in <10% of length	no	0.00	
		yes	1.67	
3	Measures to Reduce the incidence , spreading of diseases by waste	no	0.00	
		yes	1.67	
4	Compatibility with storm water management	no	0.00	
		yes	1.67	
5	Manhole Depth >3m in <10% of length	no	0.00	
		yes	1.67	
6	Position of sewer pipe in relation to water pipe >90% of pipe not <1m away	no	0.00	
		yes	1.67	
7.0	**SOCIAL**		**5.0**	
1	• Does every site have access to sewers	no	0.00	
		yes	1.25	
2	Educational Outreach plan - health and sanitation	no	0.00	
		yes	1.25	
3	Public participation in all stages of the project	no	0.00	
		yes	1.25	
4	Provision of employment to local community >100 person days	no	0.00	
		yes	1.25	
8.0	**RESOURCES**		**10.0**	
1	Conventional use of resources	no	0.00	
		yes	0.91	
2	• Does the development use onsite materials for bedding	no	0.00	
		yes	0.91	
3	• Does the development use onsite materials for backfill	no	0.00	
		yes	0.91	
4	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel, concrete	0.00	
		pvc, hdpe	0.91	
5	• What manhole types are designed for - brick- precast	brick	0.00	
		precast	0.91	
6	• Does the development have pumpstations	yes	0.00	
		no	0.91	
7	does the development have an irrigation system, that the Recycled sewer effluent can be used for irrigation	no	0.00	
		yes	0.91	
8	Does the development attempt to reduce the peak sewer demand (consumption	no	0.00	
		yes	0.91	
9	Is there Sewer attenuation	no	0.00	
		yes	0.91	
10	Was a Detailed investigation of existing services to assess the spare capacity of treatment woks, as well as the feasibility of upgrading undertaken.	no	0.00	
		yes	0.91	
11	Is the Recycled sewage used for fertilizer	no	0.00	
		yes	0.91	
9.0	**CONSTRUCTION**		**5.0**	
1	Sewer Management Plan	no	0.00	
		yes	2.50	
2	Sewer Operational plan	no	0.00	
		yes	2.50	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Date:
Client: xxxxx Compiled by:

INFRASTRUCTURE ELEMENT- WATER			Scoring	
	1.0 LAYOUT EFFECIENCY		**10.0**	**0.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	
2	• Are the land uses which have high water demands and high fire risk located close to the water supply mains for the township	no	0.00	
		yes	1.00	
3	• Are land uses with low water demand located on high ground to minimize the size of mains and the cost of water towers	no	0.00	
		yes	1.00	
4	• Does the layout facilitate laying the water reticulation pipes as a network of linked loops with a balanced loss of water pressure?	no	0.00	
		yes	1.00	
5	Does the layout relate to the water pressure zones	no	0.00	
		yes	1.00	
6	• Are the Bulk service routed on roads or minimum 5m servitudes	no	0.00	
		yes	1.00	
7	Minimal no of dead-ends to ensure flushing/no stagnation	no	0.00	
		yes	1.00	
8	• Did the layout consider the positioning of trees in close proximity of services	no	0.00	
		yes	1.00	
9	• Location & Spacing of Fire hydrants have a minimum overlap of<15% area	no	0.00	
		yes	1.00	
10	• Is adequate space provided for the siting of reservoir, pump stations and maintenance depots, with allowable buffers when required?	no	0.00	
		yes	1.00	
	2.0 FUNCTIONAL EFFICIENCY		**20.0**	
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.33	
2	• Can water loss be reduced by reducing velocity in pipe . Maximum velocity Pressure in the reticulation < 3m/s- leakage	no		
		yes	1.33	
3	Does the design attempt to monitor water supply by metering. Design of systems that both monitor and manage water consumption.	no	0.00	
		yes	1.33	
4	Pressure Management -Is the maximum Pressure in the reticulation< 9 bar-in order to minimise leakage	no	0.00	
		yes	1.33	
5	Water efficient fittings	no	0.00	
		yes	1.33	
6	• Was the layout designed as a network of linked loops to facilitate a balanced loss of water pressure?	no	0.00	
		yes	1.33	
7	Does the design Reduce peak demand with the use of attenuation/bulk reservoirs	no	0.00	
		yes	1.33	
8	Water-Efficient Irrigation & landscaping measures	no	0.00	
		yes	1.33	
9	Use of Roof tank/intermediate storage	no	0.00	
		yes	1.33	
10	Dry Fire Hydrants. suction pipe systems from pond/external source	no	0.00	
		yes	1.33	
11	Low impact Development technologies- Water	no	0.00	
		yes	1.33	
12	Watertight joints/compression type coupling/Seals quality	no	0.00	
		yes	1.33	
13	Efficient water systems design-Optimised flow/velocity in pipe not <0.2m/s	no	0.00	
		yes	1.33	
14	Water hammer analysis undertaken	no	0.00	
		yes	1.33	
15	Water reticulation designed to be self-cleaning	no	0.00	
		yes	1.33	
	3.0 Environmental quality		**15.0**	
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.67	
2	Provisions made to increase Reliability of water source	no	0.00	
		yes	1.67	
3	• Does the design protect existing sources of water within townships for possible use for water supply.	no	0.00	
		yes	1.67	
4	Provision of aesthetic water infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.67	
5	Scour valves positioned for safe discharge- erosion	no	0.00	
		yes	1.67	
6	low-level water audit carried out	no	0.00	
		yes	1.67	
7	Water-Wise Gardening	no	0.00	
		yes	1.67	
8	Separate grey water/ black water-Reticulated recycled water supply	no	0.00	
		yes	1.67	
9	Water quality monitoring measures in place	no	0.00	
		yes	1.67	

	4.0 Economy		**15.0**	
1	Some consideration of economy in the design of the service	no	0.00	
		yes	0.00	
2	• Are high and moderate fire risk categories of development located close to bulk water supply points	no	0.00	
		yes	1.50	
3	• Are <20% of the fittings special fittings, i.e tees/couplings	no	0.00	
		yes	1.50	
4	Use of shared trenches >20% of length	no	0.00	
		yes	1.50	
5	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.50	
6	• Are the air valves , shut off valves in valve rings, compared to brick chambers	no	0.00	
		yes	1.50	
7	• Are there curvilinear roads with small radii, as this increases the cost of water reticulation due to the necessity of providing additional pipe specials, fittings and thrust blocks to anchor all pipes.	yes	0.00	
		no	1.50	
8	Av Trench Depth <1.2m in over total length	no	0.00	
		yes	1.50	
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.50	
10	Pipe material - pvc/hdpe vs. concrete/steel	concrete/steel	0.00	
		pvc/hdpe	1.50	
	5.0 FUTURE MAINTENANCE		**15.0**	
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.00	
2	Valves/Meters located in convenient positions- Outside properties	no	0.00	
		yes	1.25	
3	Are the valves located in convenient positions.> 80% at intersections	no	0.00	
		yes	1.25	
4	Are >80% of the bulk services placed in the most accessible locations such as roads?	no	0.00	
		yes	1.25	
5	Positioning of trees - proximity of services	no	0.00	
		yes	1.25	
6	Flexible type coupling to permit ease in repair	no	0.00	
		yes	1.25	
7	Are all services watertight	no	0.00	
		yes	1.25	
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	1.25	
9	Are the corrodible pipes protected	no	0.00	
		yes	1.25	
10	Uniform type of fittings compared to non standard fittings	no	0.00	
		yes	1.25	
11	Leak Detection devices in reticulation	no	0.00	
		yes	1.25	
12	Provisions for future expansion of the system	no	0.00	
		yes	1.25	
	6.0 Safety		**10.0**	
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	
2	<10% of length >3m Trench Depth	no	0.00	
		yes	1.67	
3	• Is the high and moderate fire risk developments located close to bulk water supply points	no	0.00	
		yes	1.67	
4	• Is there supply capacity is compatible with the development's fire fighting requirements	no	0.00	
		yes	1.67	
5	Fire risk -High/medium or low	High/medium	0.00	
		low	1.67	
6	Pressure on pipeline<9bar	no	0.00	
		yes	1.67	
	7.0 SOCIAL		**5.0**	
1	Is end user provided with access to free basic services, in terms of demand	no	0.00	
		yes	1.00	
2	Educational Outreach plan - water conservation	no	0.00	
		yes	1.00	
3	• Are the standpipes located in convenient positions along walkways	no	0.00	
		yes	1.00	
4	• Will vehicular access to other parts of the residential area be blocked during the repair of services	yes	0.00	
		no	1.00	
5	Provision of employment to local community >100 person days	no	0.00	
		yes	1.00	

	8.0 RESOURCES		**10.0**	
1	Conventional use of resources	no	0.00	
		yes	1.00	
2	•Water demand management measures - Does the design attempt to reduce the potable water consumption by building occupants. Reduced demand	yes	1.00	
		no	0.00	
3	Can the pump duty points/velocities in pipelines be reduced or optimised	yes	0.00	
		no	1.00	
4	Zone and bulk smart metering	yes	1.00	
		no	0.00	
5	Use of onsite materials for Bedding	no	0.00	
		yes	1.00	
6	Use of Present & future water consumption figures	no	0.00	
		yes	1.00	
7	Does the design attempt to use water efficient appliances and fittings	no	0.00	
		yes	1.00	
8	Use of Recycled materials	no	0.00	
		yes	1.00	
9	• Does the design attempt to reduce the consumption of potable water for landscape irrigation is sourced from non-potable water (e.g. rainwater, Recycled water effluent for irrigation)	no	0.00	
		yes	1.00	
10	Was there a detailed investigation of existing services to assess the spare capacity of watermains, as well as the feasibility of upgrading	no	0.00	
		yes	1.00	
	9.0 CONSTRUCTION		**5.0**	
1	Water Operational Plan		0.00	
			5.00	

APPENDIX 4: Detailed Green Infrastructure Rating report

THE GREEN TOWNSHIP DESIGN MODEL

Project Title:
Client: xxxxx

Date:
Compiled by:

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	ROADS	STORMWATER	SEWER	WATER
		40%	20%	20%	20%
1.0 LAYOUT EFFICIENCY	10%	0	0	0	0
		10	*10*	*10*	*10*
2.0 FUNCTIONAL EFFICIENCY	20%	0	0	0	0
		20	*20*	*20*	*20*
3.0 ENVIRONMENTAL QUALITY	15%	0	0	0	0
		15	*15*	*15*	*15*
4.0 ECONOMY	15%	0	0	0	0
		15	*15*	*15*	*15*
5.0 FUTURE MAINTENANCE	10%	0	0	0	0
		10	*10*	*10*	*15*
6.0 SAFETY	10%	0	0	0	0
		10	*10*	*10*	*10*
7.0 SOCIAL	5%	0	0	0	0
		5	*5*	*5*	*5*
8.0 RESOURCES	10%	0	0	0	0
		10	*10*	*10*	*10*
9.0 CONSTRUCTION	5%	0	0	0	0
		5	*5*	*5*	*5*
TOTAL PTS.		*100*	*100*	*100*	*105*
WEIGHTED PTS. ACHIEVED		*0.0*	*0.0*	*0.0*	*0.0*
WEIGHTED PTS. AVAILABLE		*13.0*	*13.0*	*13.0*	*13.5*
TOTAL ACHIEVED		*0.0*	*0.0*	*0.0*	*0.0*
TOTAL AVAILABLE		*100.0*	*100.0*	*100.0*	*100.0*

SCORE	0	PLATINUM	Best solution to the environment- Benchmark performance

SCORE	GREEN GOALS	
0-24	Minimal interventions were undertaken- compliance based on regulations	Bronze
25-49	Some considerations for environment- Applied conventional practice	SILVER
50-74	Restricted damage to the environment with innovation and new technologies	GOLD
75-100	Best solution to the environment- Benchmark performance	PLATINUM

APPENDIX 5: Construction Eco Analysis report

CONSTRUCTION ECO-ANALYSIS REPORT

PROJECT NAME:	CLIENT:	YES(1)	NO(0)
Enhance Material Recyclability			
1	Are local materials and product suppliers used?		
2	Is recycled Materials used		
3	Is there a formal Site Recycling Plan that is established, implemented, and maintained?		
4	Can products or services be combined to reduce overall materials intensity?		
Environmental Training Plan			
5	Is there training of subcontractors and field personnel on environmental issues?		
Quality Management System			
6	Is there a formal construction Quality Control Plan which contains items to be monitored, testing to be done (including testing standards, frequency and when corrective action is required?		
Construction Stormwater Management			
7	Are there devices installed to improve the Runoff Quality and runoff flow control?		
8	Are there erosion and sediment control measures installed?		
Site Ecological			
9	Is more than 40% of the Site Vegetation affected?		
10	Are there habitat restoration plans in place?		
11	Is ecological connectivity maintained?		
Pollution Prevention Plan (Erosion, Sediment and Materials Pollution Control)			
12	Reduction of air pollution– Are there attempts to reduce air emissions from road and non-road construction equipment		
13	Is there a Hazardous materials management plan in place?		
14	Is there communication meetings for jobsite housekeeping practices for the contractor any for subcontractors on issues such as Littering and good housekeeping .		
Waste Management Plan			
15	Can packaging be reduced or eliminated?		
16	Can waste be reused on site or transported elsewhere for reuse?		
17	Does the Waste Management Plan cover the ffg- Type of construction waste, Expected (or actual) tonnage, Destination of waste, Responsible party for hauling/ disposal site		
Noise Mitigation Plan			
18	Establish, implement, and maintain a formal Noise Mitigation Plan during construction for the prime contractor. Responsible party for noise mitigation activities, contact information. Project location and distance to closest receptor of noise. List of proposed construction activities		
	TOTAL		

APPENDIX 6: Case Study 1: Green Goal Report

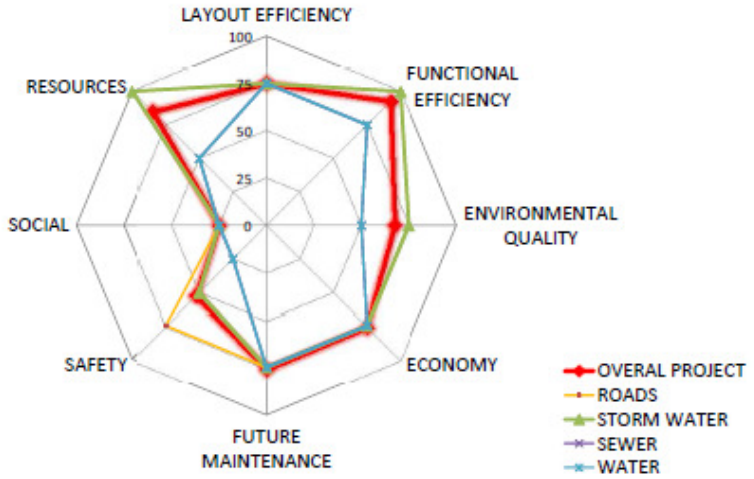
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Blueberry Hills- High Income Private Development
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROOP

CIVIL INFRASTRUCTURE GREEN GOAL REPORT

PERFORMANCE CATEGORIES	ROADS	40%	STORM WATER	30%	SEWER	20%	WATER	10%	Weighted Infrastructure
1 LAYOUT EFFICIENCY	Best solution to the environment	75	Best solution to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	10%
2 FUNCTIONAL EFFICIENCY	Best solution to the environment	100	Best solution to the environment	100	Restricted damage to the environment	75	Restricted damage to the environment	75	20%
3 ENVIRONMENTAL QUALITY	Restricted damage to the environment	75	Restricted damage to the environment	75	Some considerations for environment	50	Some considerations for environment	50	15%
4 ECONOMY	Best solution to the environment	75	Best solution to the environment	75	Best solution to the environment	75	Best solution to the environment	75	15%
5 FUTURE MAINTENANCE	Restricted damage to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	Some considerations for environment	75	10%
6 SAFETY	Restricted damage to the environment	75	Some considerations for environment	50	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	10%
7 SOCIAL	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	5%
8 RESOURCES	Best solution to the environment	100	Best solution to the environment	100	Some considerations for environment	50	Restricted damage to the environment	50	10%
9 CONSTRUCTION	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	5%
WEIGHTED SCORE		31		22.5		11.8		5.88	100%



SCORE	71	GOLD	Restricted damage to the environment

RANGE OF SUSTAINABLE DEVELOPMENT GOALS			
Sustainable goal for development	Range of implementation choices	Status	Score
Best solution to the environment	Set new performance benchmark through new technological developments	PLATINUM	75 -100
Restricted damage to the environment	Doing what is achievable- through innovation and risk taking with new systems and technologies	GOLD	50 - 74
Some considerations for environment	Apply conventional and current state-of-practice	SILVER	25 - 49
Minimal interventions to be undertaken	Achieve compliance based on regulations	Bronze	0 - 24

APPENDIX 7: Case Study 1: Preliminary Green Infrastructure Rating Report

THE GREEN TOWNSHIP DESIGN MODEL

PRELIMINARY GREEN INFRASTRUCTURE RATING ANALYSIS

INFRASTRUCTURE ELEMENTS

ROADS		40%	SEWER		20%
	Pts Av	Pts Ach		Pts Av	Pts Ac
PC: LAYOUT EFFICIENCY	8	8		8	6
Typical service layout configuration	1	1	Typical service layout configuration	1	1
landscaping and all public utilities	1	1	Layout promote midblock sewer> 30% midblock	1	1
Promote concept of green streets	1	1	<10% of length of Sewer pipeline in floodline	1	1
Ecological Connectivity-Open spaces and circulation system	1	1	Avoidance of pumpstations	1	
layout facilitates economical subdivision and min. intersections	1	1	Alternative Route alignments	1	1
Design the internal street layout to inhibit through-traffic	1	1	Catchment planning	1	
Increased diversity in road reserve through distinction between si	1	1	Contour layout planning	1	1
Roads aligned with natural topography	1	1	Sewer lines planned one catchment at a time	1	1
RESOURCES	7	4		7	5
Alternative Surfacing technologies -Permeable pav/Grass blocks	1		Backfill - non commercial source	1	1
Tree conservation <1tree/ha removed	1	1	Use of onsite materials for Bedding	1	
Re-Use of Pavement Layerworks	1	1	Manhole sealed in the floodline	1	1
Alt Transportation Options such as bicycles, light rail, NMT	1		Pipe material - use of pvc/hdpe vs. /concrete/steel	1	1
Earthworks- balanced -Cut / Fill <20% spoil	1	1	The avoidance of the use of pumpstations	1	1
Use of Recycled materials	1		Use of Recycled materials	1	
Conventional use of resources	1	1	Conventional use of resources	1	1
ENVIRONMENT QUALITY	8	6		8	7
Some consideration for reducing envir impact. in the design	1	1	Some consideration for reducing envir impact. in the desi	1	1
Minimal of valley crossings < 1/km	1	1	<20% pipeline positioned in the flood plains	1	1
ramps and paving	1	1	manholes, outlets, fittings	1	1
Erosion control measures @ all outlets	1	1	Measures to control factors governing odour and noise	1	1
Landscaping: Use of Water efficient plantings	1		Provision for protecting surface & sub surface water bodi	1	1
Clearing and grading (Site Vegetation) limited to road footprint or	1	1	Flood protection of pumpstation and pipeline	1	1
Noise reduction through Quiet Pavement, traffic reduction on inte	1		Is the development density < the environmental capacity	1	1
Habitat Restoration	1	1	Waste effluent quality monitoring measures	1	
FUNCTIONALITY EFFICIENCY	11	7		11	7
Conventional systems that achieve minimum compliance	1	1	Conventional systems that achieve minimum compliance	1	1
Use of Drainage and storage functions of roads	1	1	Primary greywater reuse	1	1
Use of Pedestrian / bicycle paths	1	1	Oil/grease/grit separators	1	1
Is the av. road grad/m <5%/m	1	1	Onsite sewage disposal-Recycle/composting	1	
Innovation- eg. Use of Permeable pavements	1		Secondary greywater reuse	1	
Low impact Development technologies- roads	1		Low impact Development technologies- Sewer	1	
automatic right of way on higher order roads	1	1	Nutrient resource recovery & reuse	1	
Parking ratios/codes/parking lots	1	1	Avoid Flat gradients (20% that is <1: 100)- stagnation	1	1
Use of street furniture for a positive contribution to area	1		Are the manholes that are in the 1:100 yr. floodline seale	1	1
Roadway system design to be self-cleaning	1	1	Sanitation system design to have self-cleaning velocity	1	1
Additional lanes at major intersections-reduce peak quantity	1		Sewer attenuation-reduce peak quantity	1	1
FUTURE MAINTENANCE	8	6		8	7
Some consideration of maintenance in the design of the service	1	1	Some consideration of maintenance in the design of the	1	1
Maintenance of grass- pioneer grass used	1	1	Provisions for future expansion of the system	1	1
Bank slopes must be gentle >1:1.75	1	1	Are pipeline susceptible to erosion protected	1	1
Pavement lifecycle design >20yrs	1	1	Service aligned with road/property boundary>80%	1	1
Site Vegetation-low water	1	1	Services watertight	1	1
Alternative access for the repair of services	1		Easy access and room for the repair	1	1
Type of trees planted allows for minimal leaves to fall	1		Erf have a rodding eye	1	1
Street marking- high quality luminous paint	1	1	Pipe loading in all areas checked	1	
ECONOMY	7	6		7	6
Some consideration of economy in the design of the service	1	1	Some consideration of economy in the design of the serv	1	1
Most economic system/service for target market	1	1	Most economic system/service for target market	1	1
Minimized the number of road intersections	1	1	Av Trench Depth <2m in over total length	1	1
Are narrower, shorter streets used	1	1	Av. manhole spacing >50m	1	1
Too Curvilinear roads increases no of manholes	1	1	Use of shared trenches> 30%	1	1
Conduct Life-Cycle Cost Analyses	1		erf alignments as straight as possible to reduce sewer m	1	
Is the area devoted to streets minimal- min road widths/reserves	1	1	Pipe material - pvc/concrete/hdpe.	1	1
SAFETY	7	6		5	5
Some consideration of safety in the design of the service	1	1	Some consideration of safety in the design of the service	1	1
Traffic calming measures	1	1	<10% of length >3m Trench Depth	1	1
Signage and pedestrian friendliness	1	1	Position in relation to water pipe >1m away	1	1
the street is designed as a safe and unique public space	1	1	Compatibility with storm water management	1	1
Segregate pedestrians, cyclists and vehicles where traffic speeds/volumes high	1	1	Measures to reduce the incidence ,spreading of diseases by waste	1	1
Road safety Audit	1				
Safe Intersection-site distance, sidewalks, crosswalks, other inter	1	1			
SOCIAL	8	4		4	3
neighbourhoods	1		ERF access to sewers	1	1
Educational Outreach plan - road safety - to community	1		Educational Outreach plan -awareness on Health and sa	1	
Public participation in all stages of the project	1	1	Public participation in all stages of the project	1	1
Public transport facilities and provision of street furniture	1	1	Provision of employment to local community >100 perso	1	1
Universal access-layout cater for disabled-Wheelchairs and elde	1	1			
Provision of employment to local community >100 person days	1	1			
Measures to preserve Cultural Heritage	1				
Provision of social amenities to the community	1				
CONSTRUCTION EFFICIENCY	6	2		1	0
Environmental management Process, plan and training	1	1	Sewer Management Plan	1	
Site Waste management plan	1				
Pavement Management System	1				
Quality Management System	1	1			
Site maintenance plan	1				
Equipment Emissions Reduction Plan	1				
WEIGHTED SCORES	100	72		100	77.33

Best solution to the environment- Benchmark performance through new technological developments	77

THE GREEN TOWNSHIP DESIGN MODEL

PRELIMINARY GREEN INFRASTRUCTURE RATING ANALYSIS

STORMWATER		30%	WATER	10%	100%	Weighted
	Pts Av	Pts Ach		Pts Av	Pts Ach	
	8	8		8	7	10%
Typical service layout configuration	1	1	Typical service layout configuration	1	1	
Use of Green corridors-Natural drainage paths	1	1	Pipe route alignment- looped network efficiency	1	1	
stormwater pipeline in floodline <10% of total length	1	1	Water pipeline in floodline <10% of total length of pipe	1	1	
Multipurpose Attenuation facilities-for retarding sw	1	1	Location & Spacing of Fire hydrants have a minimum overlap	1	1	
land use intensities matched to landscape tolerances for sw	1	1	layout relate to the water pressure zones	1		
SWMP initiated at start of planning for land uses	1	1	Minimal no of dead-ends to ensure flushing/no stagnation	1	1	
servitudes for safe, acceptable points of discharge.	1	1	land uses-high demands & fire risk close to water supply	1	1	
Reduced SW concentration & hydrological impact	1	1	Bulk service routed on roads or minimum 5m servitudes	1	1	
	7	5		7	5	10%
Pipe material - use of pvc/hdpe vs. /concrete/steel	1	1	Water demand management measures	1		
Use of onsite materials for Bedding	1	1	Zone and bulk smart metering	1	1	
Manhole types- brick/precast	1		Use of onsite materials for Bedding	1	1	
Rain water harvesting and Reuse	1	1	Use of Present & future water consumption figures	1	1	
Runoff quantity control	1	1	Promote use Water Efficient fixtures/Appliances	1	1	
Recycled materials to construct of SW channels/manholes/	1		Rain water harvesting	1		
Conventional use of resources	1	1	Conventional use of resources	1	1	
	8	7		7	3	15%
Some consideration for reducing envir impact. in the design	1	1	Some consideration for reducing envir impact. in the design	1	1	
Post Development < Predev Flow	1	1	Protect against water contamination	1	1	
manholes, outlets, fittings	1	1	manholes, outlets, fittings that is not obtrusive	1		
Recharge rates maintained	1	1	low-level water audits	1		
Protection measures of wetlands- stagnant water	1	1	Scour valves positioned for safe discharge- erosion	1	1	
Runoff quality-Constructed Wetlands/filters	1		Reticulated recycled water supply	1		
Minimize soil erosion; by good vegetation along the water co	1	1	Water-Wise Gardening	1		
Increased roughness of drainage way to decrease the veloci	1	1				
	11	9		11	7	20%
Conventional systems that achieve minimum compliance	1	1	Conventional systems that achieve minimum compliance	1	1	
Quality control at source-from residential rooftop by disconn	1		Water-Efficient Irrigation & landscaping measures	1		
SW attenuation-reduce peak quantity	1	1	Use of Roof tank/intermediate storage	1		
Stormwater Management Plan	1	1	Pressure Management as part of design-Balanced loss/increa	1	1	
Bioretention swales/ponds/infiltration berms	1	1	Dry Fire Hydrants. suction pipe systems from pond	1		
Low impact Development technologies- SW	1	1	Water efficient fittings	1	1	
Erosion control(Geotextile/cells, gabions)	1	1	water attenuation-reduce peak quantity	1		
Sediment control- Silt fences/Stilling basin	1		Watertight joints/compression type coupling/Seals quality	1	1	
Is the av. channel grad/m <5%/m-high velocities	1	1	Efficient water systems design-Optimised flow/velocity in pipe	1	1	
Use of roads & parking to control drainage & storage	1	1	Water reticulation design to be self-cleaning	1	1	
Are channels lined -earth,-grass, concrete, grass	1	1	Water hammer analysis	1	1	
	8	7		8	7	10%
Some consideration of maintenance in the design of the ser	1	1	Some consideration of maintenance in the design of the servic	1	1	
Is the design-manholes, pipes and catchpits sized for maint	1	1	Sleeves used where pipes cross the road	1	1	
Flood plain accessible	1	1	Services Watertight joints/Seals quality	1	1	
Pipe loading in all areas checked	1		Positioning of trees - proximity of services	1	1	
Stormwater system design to be self-cleaning	1	1	Isolation Valves/Meters located in convenient positions @ 90%	1	1	
Easy access and room for the repair of services	1	1	Easy access and room for the repair of services	1	1	
Positioning of trees in close proximity of services > 20m	1	1	Leak Detection devices in retic.	1		
Inlet/outlet design to reduce blockages	1	1	Provisions for future expansion of the system	1	1	
	8	7		8	8	15%
Some consideration of economy in the design of the service	1	1	Some consideration of economy in the design of the service	1	1	
Most economic system/service for target market	1	1	Most economic system/service for target market	1	1	
Non structural controls	1	1	Use of shared trenches >20%	1	1	
Use of shared trenches >20%	1	1	Max. hydrants, airvalve spacing av spacing- 200m	1	1	
Av. manhole spacing >50m	1	1	Av Trench Depth <1.2m in over total length	1	1	
Multipurpose stormwater facilities	1		Conduct Life-Cycle Cost Analyses	1	1	
Pipe material - pvc/concrete/hdpe.	1	1	Pipe material - pvc/concrete/hdpe.	1	1	
Av Trench Depth <2m in over total length	1	1	Are the air valves , shut off valves in valve rings	1	1	
	6	5		6	6	10%
Some consideration of safety in the design of the service	1	1	Some consideration of safety in the design of the service	1	1	
<10% of length >3m Trench Depth	1	1	<10% of length >3m Trench Depth	1	1	
Velocity /depth of stormwater flowing	1	1	Supply sufficient for fire fighting requirements	1	1	
Safe discharge routes	1	1	Fire risk -High/medium or low	1	1	
Design accommodates various storm frequencies	1	1	located close to bulk water supply points	1	1	
Flood warning signs	1		Pressure on pipeline<9bar	1	1	
	6	5		4	2	5%
convenience- minor system designed for high-frequency sto	1	1	Provision of employment to local community >100 person day	1	1	
Education and awareness- Rainwater harvesting	1		Educational Outreach plan - water conservation	1		
Public participation in all stages of the project	1	1	Public participation in all stages of the project	1	1	
No Inconvenience of overland flow and Temporary storage f	1	1	Standpipes located in convenient positions along walkways.	1		
Is access to river walks and open spaces	1	1				
Provision of employment to local community >100 person da	1	1				
	2	1		1	0	5%
Pre construction Stormwater Management Plan	1	1	Water Operational plan	1		
Siltation control with Sand and hessian bags or Silt fences	1					
	100	84.81		100	74.34	77
Best solution to the environment- Benchmark performance through new technological developments				PLATINUM		77

APPENDIX 8: Case Study 1: Detailed Green Infrastructure Rating Analysis Report

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Blueberry Hills- High Income Private Development
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SARO

INFRASTRUCTURE ELEMENT- ROADS			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**9.4**
1	Typical service layout configuration	no	0.00	
		yes	0.63	0.63
2	Does the layout promote concept of greenstreets	no	0.00	
		yes	0.63	0.63
3	Does the layout facilitate economical subdivisions, with the use of shared road infrastructure	no	0.00	
		yes	0.63	0.63
4	• Layout integrates the circulation system with dwellings, landscaping and all public utilities	no	0.00	
		yes	0.63	0.63
5	• the percentage township area devoted to roads, parking and footways <30% of total area	no	0.00	
		yes	0.63	0.63
6	• Is there minimum interruption from access movements, intersections, to achieve good mobility, Access road >100m apart	no	0.00	
		yes	0.63	0.63
7	• Provide public transport routes which minimize operating costs while satisfying user requirements for convenience	no	0.00	
		yes	0.63	
8	• Provide reserve widths and alignments which cater for all road users, for services for landscaping, in the most economical way.	no	0.00	
		yes	0.63	0.63
9	• Relate the spacing and layout of intersections to the probable vehicle type, the volume and direction of movement	no	0.00	
		yes	0.63	0.63
10	• Ecological Connectivity-Open spaces and circulation system-integral part of the open space system and appropriate landscaping provided for	no	0.00	
		yes	0.63	0.63
11	• Are short-distance links (<1km) between adjacent neighbourhoods	no	0.00	
		yes	0.63	0.63
12	• Does the road hierarchy requirements provide automatic right-of-way for traffic on higher order roads. additional lanes at intersections provided for to reduce peak traffic with minimum interruption	no	0.00	
		yes	0.63	0.63
13	Design the internal street layout to inhibit through-traffic	no	0.00	
		yes	0.63	0.63
14	• Garages and urban collectors located away from residents, to minimize nuisance to residents from noise, dust and fumes	no	0.00	
		yes	0.63	0.63
15	• Develop the road aligned to the natural topography	no	0.00	
		yes	0.63	0.63
16	• Increase diversity in road reserve. Design and make distinction between sidewalk zone, cycle areas, pedestrian area, refuse areas, planters, lighting, etc.	no	0.00	
		yes	0.63	0.63
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**15.0**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.00	1.00
2	The use of Innovative design techniques, such as the use geogrids to reduce layer thickness, increase pavement life, bearing capacity, differential settlement, etc.	no	0.00	
		yes	1.00	
3	The use of Low impact Development technologies on roads	no	0.00	
		yes	1.00	1.00
4	Are the street furniture well designed items, and placed so as to make a positive contribution to the total street picture	no	0.00	
		yes	1.00	1.00
5	Are there cycle lanes	no	0.00	
		yes	1.00	
6	Are there special details for the design of all road elements, including kerbing, channelling, ramps and different types of paving eg. Brick paving compared to concrete and asphalt as it creates	no	0.00	
		yes	1.00	1.00
7	Are landscaping and trees used to reduce the impact of large areas of asphalt	no	0.00	
		yes	1.00	1.00
8	Is the potential drainage function of roads maximized by co-ordinating their layouts with the drainage systems.	no	0.00	
		yes	1.00	1.00
9	• Where appropriate, are the medians-<1.5m for safety	no	0.00	
		yes	1.00	1.00
10	• Is the maximum road crown slope(4%)-operation problem driving, wear of vehicles <20% of the total road length	no	0.00	
		yes	1.00	1.00
11	• Is the minimum road crown slope(2%) - prevents sediment loading <5% of the total road length	no	0.00	
		yes	1.00	1.00
12	• Additional lanes at major intersections-reduce peak quantity	no	0.00	
		yes	1.00	
13	• Is the average road grad/m less than 5%/m	no	0.00	
		yes	1.00	1.00
14	• Are parking areas provided (according to Parking ratios/codes) where road will be well trafficked and where appropriate consist of grass blocks, gravel, paving to give it a softer park like image	no	0.00	
		yes	1.00	1.00

	Pedestrian routes			
15	• Do the pedestrian routes minimize walking distances and encourage pedestrian use	no	0.00	
		yes	1.00	1.00
16	• Are there pedestrian facilities (such as sidewalks and crossings)	no	0.00	
		yes	1.00	1.00
17	The project layout promotes walking and discourages the use of vehicles.	no	0.00	
		yes	1.00	
	Bus stops			
18	• Are bus bays provided at major bus stops to minimize delays to other traffic	no	0.00	
		yes	1.00	1.00
19	• Provide shelter against rain, sun, wind as well as benches or a space for resting or eating while waiting for transportation and signage integrated with shelters	no	0.00	
		yes	1.00	
20	• Are gradients designed appropriate to the mode/s of transport using the bus route-<6%	no	0.00	
		yes	1.00	1.00
	3.0 Environmental quality		**15.0**	**11.8**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.07	1.07
2	Noise reduction through Quiet Pavement, traffic reduction on internal streets	no	0.00	
		yes	1.07	1.07
3	• Use of surfacing on roads - Concrete vs. asphalt increases volumetric heat capacities, lower air temperatures	no	0.00	
		yes	1.07	
4	Habitat Restoration measures used	no	0.00	
		yes	1.07	1.07
5	• Provide aesthetic kerbing, channelling, pedestrian refuges, ramps and paving	no	0.00	
		yes	1.07	1.07
6	• Permeable road surface/parking lots -grass blocks- selection of surfacing that has a reduced environmental impact relative to available alternatives.	no	0.00	
		yes	1.07	
7	Does the project layout provides a safe, convenient and attractive environment for walking.	no	0.00	
		yes	1.07	1.07
8	• Preserve natural features such as gullies, outcrops, marshes and existing trees, shrubs and hedges in the layout to create interest, variety and surprise in the vistas along the and along the	no	0.00	
		yes	1.07	1.07
9	Are erosion control measures used in the design of earthworks on steep areas, such as the use of sand bags or Hessian sheets, rehabilitation of exposed soil areas, soil is protected from the	no	0.00	
		yes	1.07	1.07
10	Clearing and grading (Site Vegetation) - road footprint/topsoil removed <50% of road reserve	no	0.00	
		yes	1.07	1.07
11	• Is a variety of access street forms provided to avoid monotony	no	0.00	
		yes	1.07	1.07
12	would there be stock piling of soil or any other materials near a watercourse	yes	0.00	
		no	1.07	1.07
13	Landscaping: Use of Water efficient plantings	yes	0.00	
		no	1.07	
14	Are areas sensitive to erosion such as near water supply points and edges of slopes being developed.	yes	0.00	
		no	1.07	1.07
	4.0 Economy		**15.0**	**15.0**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	1.36
2	Most economic system/service for target market	no	0.00	
		yes	1.36	1.36
3	• Can the number of road intersections be minimized through layout configuration	yes	0.00	
		no	1.36	1.36
4	Are the roads too Curvilinear roads- increased no of manholes, kerb lengths	yes	0.00	
		no	1.36	1.36
5	• Are the public transport routes optimized;	no	0.00	
		yes	1.36	1.36
6	• Are the widths of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
7	• Is the alignment of roadways utilise the maximum criteria in order to reduce earthworks, in with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
8	• Is the pavement foundation design of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.36	1.36
10	Earthworks- balanced-Cut / Fill <1000m3 spoil	no	0.00	
		yes	1.36	1.36
11	• Can the total length and cost of internal roads be minimized	yes	0.00	
		no	1.36	1.36

	5.0 FUTURE MAINTENANCE		10.0	9.0
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.00	1.00
2	• Acceptable pioneer grasses(cynodindactolin) and reeds where applicable	no	0.00	
		yes	1.00	1.00
3	Type of trees planted allows for minimal leaves to fall and clog up drains	no	0.00	
		yes	1.00	
4	Landscaping: Use of Water efficient plantings	no	0.00	
		yes	1.00	1.00
5	• -Bank slopes must be gentle to allow access for maintenance >1:1.75	no	0.00	
		yes	1.00	1.00
6	• Life span of the road pavement >20 years	no	0.00	
		yes	1.00	1.00
7	• Street marking- high quality luminous paint	no	0.00	
		yes	1.00	1.00
8	Alternative access for the repair of road or road closure	no	0.00	
		yes	1.00	1.00
9	High quality Street signage - minimal maintenance >2m from trees/shrubs	no	0.00	
		yes	1.00	1.00
10	Are there subsurface water drainage systems in 80% of cuts >2m to protect road pavements - minimal maintenance of road layerworks	no	0.00	
		yes	1.00	1.00
	6.0 SAFETY		**10.0**	**8.0**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	0.67	0.67
2	Adequate sight distances at intersections, horizontal curves and crests are commensurate with operating speeds	no	0.00	
		yes	0.67	0.67
3	• Universal access at Intersections-designed to be safe for pedestrians and vehicles. This includes sidewalks, crosswalks, traffic signals and other intersection treatment	no	0.00	
		yes	0.67	0.67
4	• Inhibit through-traffic in internal streets/neighbourhoods	no	0.00	
		yes	0.67	0.67
5	• Segregate pedestrians, cyclists and vehicles where traffic is concentrated or speeds and volumes are high	no	0.00	
		yes	0.67	
6	Traffic calming measures used such as Speed humps, chicanes, street narrowing devices, change in the surface colour or texture, in the immediate vicinity of homes.	no	0.00	
		yes	0.67	0.67
7	• Provide access points to multiple units dwellings only at selected points to control and concentrate traffic	no	0.00	
		yes	0.67	0.67
8	• Provide turning spaces which avoid the need for vehicles to reverse over long distances.	no	0.00	
		yes	0.67	0.67
9	• Are there pedestrian crossings and sidewalks with adequate signage	no	0.00	
		yes	0.67	0.67
10	Road safety Audit undertaken	no	0.00	
		yes	0.67	
11	• Provide mutual visibility between pedestrians and moving vehicles with traffic on main roads;	no	0.00	
		yes	0.67	0.67
12	• is there a potential conflict areas between roads users, pedestrian and cyclists	yes	0.00	
		no	0.67	0.67
13	• Design soft mounds, and plant trees to separate pedestrian from buildings and road	no	0.00	
		yes	0.67	0.67
14	Convenience- Traffic-generating facilities located near entrances to residential areas or adjacent to higher order roads	no	0.00	
		yes	0.67	
15	Are the pedestrian system and parking areas located where they will be overlooked by dwellings or passing traffic and well-lit after dark for greater security	no	0.00	
		yes	0.67	0.67

7.0	**SOCIAL**		**5.0**	**3.1**
1	Does the road contribute to development of previously underdeveloped areas	no	0.00	
		yes	0.63	0.63
2	Educational Outreach plan - road safety	no	0.00	
		yes	0.63	
3	• Ensure that pedestrian crossings on distributor roads are convenient to use	no	0.00	
		yes	0.63	0.63
4	• Minimize distances of pedestrian routes <15min walking time;	no	0.00	
		yes	0.63	
5	Provision of social amenities to the community	no	0.00	
		yes	0.63	
6	• Does the layout cater for disabled and Wheelchairs and elders that may want to sit down	no	0.00	
		yes	0.63	0.63
7	Provision of employment to local community >100 person days	no	0.00	
		yes	0.63	0.63
8	Use of Public transport facilities and provision of street furniture	no	0.00	
		yes	0.63	0.63
8.0	**RESOURCES**		**10.0**	**5.6**
1	Conventional use of resources	no	0.00	
		yes	1.11	1.11
2	Use of Recycled road materials in the layerworks	no	0.00	
		yes	1.11	
3	Is the Kerbing cast insitu or precast	precast	0.00	
		insitu	1.11	
4	Design initiatives that increase the facilitate reused building materials, Recycled materials and	no	0.00	
		yes	1.11	1.11
5	Tree conservation- no of trees <10/ha	no	0.00	
		yes	1.11	1.11
6	Earthworks spoiled- <20%	no	0.00	
		yes	1.11	1.11
7	Promoting Alternative Transportation Options such as bicycles, light rail, Non Motorized Transport	no	0.00	
		yes	1.11	
8	Use of alternative Surfacing other than hot mix asphalt, such as Permeable pave/Grass blocks/porous concrete	no	0.00	
		yes	1.11	
9	Reuse existing materials onsite to minimise materials consumption	no	0.00	
		yes	1.11	1.11
9.0	**CONSTRUCTION**		**5.0**	**2.1**
1	Environmental management Process, plan and training	no	0.00	
		yes	0.71	0.71
2	Site Waste management plan	no	0.00	
		yes	0.71	
3	Pavement Management System	no	0.00	
		yes	0.71	
4	Quality Management System	no	0.00	
		yes	0.71	0.71
5	Site maintenance plan	no	0.00	
		yes	0.71	
6	Equipment Emissions Reduction Plan	no	0.00	
		yes	0.71	
7	• Stockpiles <1000m3 (Hugh stockpiles create dust in wind)	no	0.00	
		yes	0.71	0.71

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Blueberry Hills- High Income Private Development
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAR

INFRASTRUCTURE ELEMENT- STORMWATER

			Scoring	
1.0 LAYOUT EFFECIENCY			**10.0**	**8.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	1.00
2	• Does the layout consider hydrological concerns with regards to sw runoff and relationship to plot size, type of land use	no	0.00	
		yes	1.00	
3	• Does the layout plan take into account the natural drainage paths(Stream patterns), areas subject to flooding	no	0.00	
		yes	1.00	1.00
4	• Are the land use intensities matched to landscape tolerances for swmp	no	0.00	
		yes	1.00	1.00
5	are the stormwater facilities Integrated with recreation areas;	no	0.00	
		yes	1.00	1.00
6	• Does the swmp use open spaces for retarding or stormwater evaporation ponds to remove partially treated water	no	0.00	
		yes	1.00	1.00
7	is the length of Storm water services located in special servitudes and not located in road reserve <10% of total length	no	0.00	
		yes	1.00	
8	stormwater pipeline in floodline <10% of total length	no	0.00	
		yes	1.00	1.00
9	• Does the layout reduce the hydrological impact of the development by reducing stormwater concentration	no	0.00	
		yes	1.00	1.00
10	• Was the mdp initiated at start of planning for land uses	no	0.00	
		yes	1.00	1.00
2.0 FUNCTIONAL EFFECIENCY			**20.0**	**14.81**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	0.74	0.74
2	• Provision of surface water management system to ensure that the ultimate flow from the development does not result in any negative impacts on downstream properties or watercourse and is managed within the overall site	no	0.00	
		yes	0.74	0.74
3	• Has the Master drainage plans been prepared, in collaboration with adjoining communities and authorities, for the existing and future development of the entire catchments	no	0.00	
		yes	0.74	0.74
4	Is >70% of the road designed for sheetflow	no	0.00	
		yes	0.74	0.74
5	Is the maximum velocity <3m/s	no	0.00	
		yes	0.74	0.74
6	<10% of roads have a maximum road gradient >12%	no	0.00	
		yes	0.74	0.74
7	• What is the minimum road crown slope- <2%- sediment	no	0.00	
		yes	0.74	0.74
8	Is the maximum road crown slope- <3%-operation problem driving, ware of vehicles	no	0.00	
		yes	0.74	0.74
9	• Are the potential drainage and storage functions of roads, roadside channels used	no	0.00	
		yes	0.74	0.74
10	Is >50% of the road gradients <2% - used for retarding stormwater run-off	no	0.00	
		yes	0.74	0.74
11	• Is the post development limited to predevelopment	no	0.00	
		yes	0.74	0.74
12	• Is the roadside channels designed to prevent erosion	no	0.00	
		yes	0.74	0.74
13	• Is the stormwater flow depths < 0.5m	no	0.00	
		yes	0.74	
14	• Inlet- are the backwater effects designed for	no	0.00	
		yes	0.74	
15	• are the inlets/pond have swing type grids or are self cleansing to prevent blockages	no	0.00	
		yes	0.74	
16	Quality control at the source-from residential rooftop by disconnecting downpipe, Rain Barrels, soakaway- Prevent pollutant dumping	no	0.00	
		yes	0.74	
17	• Does the reticulation limit runoff volumes with the use of bioswales filtering pollution	no	0.00	
		yes	0.74	0.74
18	• Does the reticulation limit volumes with the use of retention basin	no	0.00	
		yes	0.74	0.74
19	Are velocities reduced with the use of Check dams	no	0.00	
		yes	0.74	0.74
20	• Does the reticulation limit runoff volumes with the use of Porous parking surfaces	no	0.00	
		yes	0.74	
21	• In areas where the subsoil and water table are suitable, does the design the surfaces of storage areas allow for the re-charging of the underground water.	no	0.00	
		yes	0.74	0.74
22	Are flood plains and watercourses protected from erosion with Gabions, dissipaters, Reno mattress, stilling basins, Check weir, Riprap protection, Energy reduction, Drop structures, Rip rap basins,	no	0.00	
		yes	0.74	0.74

23	• Are there measures to prevent underground conduits from silting up	no	0.00	
		yes	0.74	
24	• Are channels lined -earth,-grass, concrete, grass	no	0.00	
		yes	0.74	0.74
25	• Is the average channel slopes -<5%	no	0.00	
		yes	0.74	0.74
26	• Are the stormwater outlet structures designed to decrease flow velocity by the use of velocity dissipaters	no	0.00	
		yes	0.74	0.74
27	Sediment control- Silt fences/Stilling basin	no	0.00	
		yes	0.74	
	3.0 ENVIROMENTAL QUALITY		**15.0**	**12.7**
	Erosion control measures			
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.15	1.15
2	• Protection of environmentally sensitive areas;	no	0.00	
		yes	1.15	1.15
3	• Predevelopment ground water Recharge rates are maintained;	no	0.00	
		yes	1.15	1.15
4	SW pipes steeper than 1:3 <10% of the total length	no	0.00	
		yes	1.15	1.15
5	• Consolidate waterways and open space requirements;	no	0.00	
		yes	1.15	1.15
6	• Minimize soil erosion; by good vegetation along the water courses	no	0.00	
		yes	1.15	1.15
7	• Buffer zone>25m between hard and watercourse areas	no	0.00	
		yes	1.15	1.15
8	• Rehabilitation of exposed soil areas to ensure soil protection	no	0.00	
		yes	1.15	
9	• Removal of vegetation on steep areas	yes	0.00	
		no	1.15	1.15
10	Protection measures of wetlands- stagnant water- may become health hazards-Is there a potential of Nutrient enrichment- eutrophication	no	0.00	
		yes	1.15	
11	SW quality treatment with the use storage facilities, Constructed Wetlands/filters	no	0.00	
		yes	1.15	1.15
12	• Increased roughness of the channel or drainage way to decrease the velocity	no	0.00	
		yes	1.15	1.15
13	• Subsurface disposal is not to close to point of rainfall >200m	no	0.00	
		yes	1.15	1.15
	4.0 ECONOMY		**15.0**	**15.0**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.67	1.67
2	• What type of system is being used	>50% piped	0.00	
		<50% piped	1.67	1.67
3	The use of non-structural control as in relation to structural control of SW.	no	0.00	
		yes	1.67	1.67
4	• Does the reticulation have multipurpose stormwater facilities	no	0.00	
		yes	1.67	1.67
5	• Does the SWMP provide a few, large areas for retaining stormwater, rather than many smaller areas which are more problematic to maintain.	no	0.00	
		yes	1.67	1.67
6	• Does the SWMP attempt to align open drainage systems with natural drainage systems, to minimize the cost of earthworks and pipe works.	no	0.00	
		yes	1.67	1.67
7	• Are the manhole spaced at an the Av. manhole spacing >50m	no	0.00	
		yes	1.67	1.67
8	Is there >30% of shared trenches in relation to separate trenches	no	0.00	
		yes	1.67	1.67
9	Trench Depth <10% of length >3m	no	0.00	
		yes	1.67	1.67
	5.0 FUTURE MAINTENANCE		**10.0**	**7.3**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.67	0.67
2	• Are there any services placed in a location that is not easily accessible by public fo rmaintence	yes	0.00	
		no	0.67	0.67
3	• Was the mdp prepared in collaboration with authorizes for future developments	no	0.00	
		yes	0.67	0.67
4	• Is the flood plain accessible to public for maintenance	no	0.00	
		yes	0.67	0.67
5	• Is the design-manholes, pipes and catchpits sized for maintenance	no	0.00	
		yes	0.67	0.67
6	• Are the bulk services routed on roads or minimum 5m servitudes	no	0.00	
		yes	0.67	0.67
7	• Pipe loading in all areas checked	no	0.00	
		yes	0.67	

8	• If services are in midblock, is a 5m building line imposed	no	0.00	
		yes	0.67	0.67
9	• Is due regard for positioning of trees in close proximity of services > 20m	no	0.00	
		yes	0.67	0.67
10	• Are sleeves used where pipes cross the road	no	0.00	
		yes	0.67	0.67
11	• Are the pipes susceptable to erosion protected	no	0.00	
		yes	0.67	
12	• Are the open drains in in >6% lined	no	0.00	
		yes	0.67	0.67
13	• pipes across road >100D	no	0.00	
		yes	0.67	
14	- is there an acceptable pioneer grass (cynodindactolin) and reeds established where applicable	no	0.00	
		yes	0.67	
15	• Does the Inlet structures designed to reduce clogging, self cleansing, not designed to overflow	no	0.00	
		yes	0.67	0.67
	6.0 SAFETY		**10.0**	**8.0**
	Aim- Risk of loss of life and significant damage to properties from the run off from the exception heavy			
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.00	1.00
2	• Does the drainage system manage the planned development for the upstream areas, for storms ranging from frequent to rare events?	no	0.00	
		yes	1.00	1.00
3	• Are there safe discharge routes provided for stormwater overland flow. Would the overflow from storage areas protect the downstream property from being inundated,	no	0.00	
		yes	1.00	1.00
4	• In areas susceptible to flooding, is the velocity and/or depth of stormwater flowing in or across streets is within safe limits, with particular attention to potential traffic hazard on higher speed roads.	no	0.00	
		yes	1.00	1.00
5	• Are storms >1:20 yr frequencies accommodated within the design;	no	0.00	
		yes	1.00	
6	•-are the elevation of infrastructure & buildings above the 100yr floodline	no	0.00	
		yes	1.00	1.00
7	• are the manhole covers sealing in flood sensitive areas	no	0.00	
		yes	1.00	1.00
8	• are the any building that have Installation of pumps for stormwater	yes	0.00	
		no	1.00	1.00
9	<10% of length >3m Trench Depth	no	0.00	
		yes	1.00	1.00
10	are there flood warning signs informing public of approaching hazards	no	0.00	
		yes	1.00	
	7.0 SOCIAL		**5.0**	**1.7**
1	• Are the minor system designed for high-frequency storms; so that there is no inconvenience of overland flow routes	no	0.00	
		yes	0.83	
2	• Are the temporary storage areas for stormwater in places where the water would not cause inconvenience during or immediately after storms.	no	0.00	
		yes	0.83	0.83
3	• Is access to river walks and open spaces allowed;	no	0.00	
		yes	0.83	
4	Education and awareness- Rainwater harvesting	no	0.00	
		yes	0.83	
5	Public participation in all stages of the project	no	0.00	
		yes	0.83	
6	• Provision of employment to local community >100 person days	no	0.00	
		yes	0.83	0.83
	8.0 RESOURCES		**10.0**	**7.8**
1	Conventional use of resources	no	0.00	
		yes	1.11	1.11
2	• Use of onsite materials for bedding	no	0.00	
		yes	1.11	1.11
3	• Use of onsite materials for backfill	no	0.00	
		yes	1.11	1.11
4	Runoff quantity control measures	no	0.00	
		yes	1.11	1.11
5	Rain water harvesting and Reuse -recycled stormwater for irrigation	no	0.00	
		yes	1.11	
6	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc,	1.11	
7	Does the sytem recharge groundwater	no	0.00	
		yes	1.11	1.11
8	• manhole types-	brick	0.00	
		precast	1.11	1.11
9	Recycled materials to construct of SW channels	no	0.00	
		yes	1.11	1.11
	9.0 CONSTRUCTION		**5.0**	**1.7**
1	Pre construction Stormwater Management Plan	no	0.00	
		yes	1.67	
2	Education and awareness- Rainwater harvesting	no	0.00	
		yes	1.67	
3	Minimize erosion and control siltation with Sand and hessian bags or Silt fences	no	0.00	
		yes	1.67	1.67

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Blueberry Hills- High Income Private Development
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROC

INFRASTRUCTURE ELEMENT- SEWER

			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**8.9**
1	Typical service layout configuration	no	0.00	
		yes	1.11	1.11
2	• Can pumpstations be avoided through the layout reorientation	no	0.00	
		yes	1.11	
3	• Does the layout promote midblock sewer	no	0.00	
		yes	1.11	1.11
4	• Are alternative sewer layouts considered;	no	0.00	
		yes	1.11	1.11
5	Are the Bulk service routed on roads or minimum 5m servitudes If services are in midblock, a 5m building line imposed	no	0.00	
		yes	1.11	1.11
6	Is there a Sewer Catchment Management Plan been done	no	0.00	
		yes	1.11	1.11
7	<10% of total length of Sewer pipeline in floodline	no	0.00	
		yes	1.11	1.11
8	• Is the development Phased in one catchment at a time	no	0.00	
		yes	1.11	1.11
9	Did the layout consider the positioning of trees in close proximity of services >20m	no	0.00	
		yes	1.11	1.11
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**14.1**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.18	1.18
2	• Does the development contain a grey / black water water reuse system	no	0.00	
		yes	1.18	
3	• Does the development contain Secondary greywater reuse	no	0.00	
		yes	1.18	
4	• Are sewers designed to gradients which are steep enough to ensure adequate velocity for self-cleansing	no	0.00	
		yes	1.18	1.18
5	use of Oil/grease/grit separators	no	0.00	
		yes	1.18	1.18
6	• Does the development attempt to minimize discharge to the municipal sewerage system through sewer attenuation	no	0.00	
		yes	1.18	1.18
7	Does the system attempt Nutrient resource recovery & reuse by Recycle/composting	no	0.00	
		yes	1.18	
8	Are there a potential areas >30% of length that are flat (1: 100) that can result in stagnation	yes	0.00	
		no	1.18	
9	Innovative wastewater technology	no	0.00	
		yes	1.18	1.18
10	• Was the Geotechnical conditions taken into account in the design	no	0.00	
		yes	1.18	1.18
11	• Does the Soil profile have good permeability	no	0.00	
		yes	1.18	1.18
12	Are the manholes that are in the 1:100 yr. floodline sealed	no	0.00	
		yes	1.18	1.18
13	• Does the evapotranspiration area in case of an overflow fall within the site	no	0.00	
		yes	1.18	
14	• Does the evapotranspiration area in case of an overflow fall within the wetland	yes	0.00	
		no	1.18	1.18
15	• Is the av. topography >12%-steep slope problematic for sewage	yes	0.00	
		no	1.18	1.18
16	Are there Soakaway/Sewer lines positioned <7.5m from drink water source	yes	0.00	
		no	1.18	1.18
17	• Soakaway/Sewer lines positioned >5m from water table	no	0.00	
		yes	1.18	1.18

3.0	**Environmental quality**		**15.0**	**12.0**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.50	1.50
2	Design a layout which minimizes nuisance to residents, provides attractive and healthy living conditions, and benefits the environment	no	0.00	
		yes	1.50	1.50
3	Provision for protecting surface & sub surface water bodies from sewage	no	0.00	
		yes	1.50	1.50
4	Provision of aesthetic sewer infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.50	1.50
5	• Are <10% of sewerpipline positioned in the flood plains;	no	0.00	
		yes	1.50	1.50
6	• Is the receiving sewer purification works clear >500m flood plains;	no	0.00	
		yes	1.50	1.50
7	• Is there Erosion protection provided near water course	no	0.00	
		yes	1.50	1.50
8	Waste effluent quality monitoring measures in place	no	0.00	
		yes	1.50	
9	• Are there measures taken to Minimize the obtrusiveness of pumping stations, sewer infrastructure and their environs	no	0.00	
		yes	1.50	1.50
10	• Are there measures taken to control factors governing odour and noise emanating from pump stations and sewer infrastructure	no	0.00	
		yes	1.50	
4.0	**Economy**		**15.0**	**12.3**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	1.36
2	• Are the intersection spacing's and block lengths compatible with maximum manhole spacing's to minimize the number of manholes.	no	0.00	
		yes	1.36	1.36
3	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.36	1.36
4	• Is the percentage of sewer is mid-block sewer >30% of the total length	no	0.00	
		yes	1.36	
5	Av Trench Depth <2m in over total length	no	0.00	
		yes	1.36	1.36
6	• Is the av manhole spacing's >50m	no	0.00	
		yes	1.36	1.36
7	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc, hdpe	1.36	1.36
8	• manhole types-	brick	0.00	
		precast	1.36	1.36
9	• Are there long lengths of sewers which cross or adjoin open space or undeveloped land.	yes	0.00	
		no	1.36	1.36
10	• Are there shared trenches >30%	no	0.00	
		yes	1.36	
11	• Are the roads or mid-block erf alignments as straight as possible to reduce sewer reticulation costs and minimize the number of manholes.	no	0.00	
		yes	1.36	1.36
5.0	**FUTURE MAINTENANCE**		**10.0**	**8.8**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.25	1.25
2	• Are the pipe runs and cables in servitudes that are accessible for maintenance work.	no	0.00	
		yes	1.25	1.25
3	Provisions for future expansion of the system	no	0.00	
		yes	1.25	1.25
4	• Was there a lifecycle cost analysis done of the pipe and materials	no	0.00	
		yes	1.25	
5	Are pipeline susceptible to erosion protected	no	0.00	
		yes	1.25	1.25
6	• Does every erf have a rodding eye in addition of inspection eye	no	0.00	
		yes	1.25	1.25
7	Are all services watertight	no	0.00	
		yes	1.25	1.25
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	1.25	1.25

6.0	**Safety**		**10.0**	**5.0**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	1.67
2	Trench Depth >3m in <10% of length	no	0.00	
		yes	1.67	
3	Measures to Reduce the incidence , spreading of diseases by waste	no	0.00	
		yes	1.67	
4	Compatibility with storm water management	no	0.00	
		yes	1.67	1.67
5	Manhole Depth >3m in <10% of length	no	0.00	
		yes	1.67	
6	Position of sewer pipe in relation to water pipe >90% of pipe not <1m away	no	0.00	
		yes	1.67	1.67
7.0	**SOCIAL**		**5.0**	**3.8**
1	• Does every site have access to sewers	no	0.00	
		yes	1.25	1.25
2	Educational Outreach plan - health and sanitation	no	0.00	
		yes	1.25	
3	Public participation in all stages of the project	no	0.00	
		yes	1.25	1.25
4	Provision of employment to local community >100 person days	no	0.00	
		yes	1.25	1.25
8.0	**RESOURCES**		**10.0**	**6.4**
1	Conventional use of resources	no	0.00	
		yes	0.91	0.91
2	• Does the development use onsite materials for bedding	no	0.00	
		yes	0.91	
3	• Does the development use onsite materials for backfill	no	0.00	
		yes	0.91	0.91
4	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc, hdpe	0.91	0.91
5	• What manhole types are designed for - brick- precast	brick	0.00	
		precast	0.91	0.91
6	• Does the development have pumpstations	yes	0.00	
		no	0.91	
7	does the development have an irrigation system, that the Recycled sewer effluent can be used for irrigation	no	0.00	
		yes	0.91	
8	Does the development attempt to reduce the peak sewer demand (consumption	no	0.00	
		yes	0.91	0.91
9	Is there Sewer attenuation	no	0.00	
		yes	0.91	0.91
10	Was a Detailed investigation of existing services to assess the spare capacity of treatment woks, as well as the feasibility of upgrading undertaken.	no	0.00	
		yes	0.91	0.91
11	Is the Recycled sewage used for fertilizer	no	0.00	
		yes	0.91	
9.0	**CONSTRUCTION**		**5.0**	**2.5**
1	Sewer Management Plan	no	0.00	
		yes	2.50	2.50
2	Sewer Operational plan	no	0.00	
		yes	2.50	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Blueberry Hills- High Income Private Development
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROC

INFRASTRUCTURE ELEMENT- WATER

			Scoring	
	1.0 LAYOUT EFFECIENCY		**10.0**	**8.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	1.00
2	• Are the land uses which have high water demands and high fire risk located close to the water supply mains for the township	no	0.00	
		yes	1.00	1.00
3	• Are land uses with low water demand located on high ground to minimize the size of mains and the cost of water towers	no	0.00	
		yes	1.00	1.00
4	• Does the layout facilitate laying the water reticulation pipes as a network of linked loops with a balanced loss of water pressure?	no	0.00	
		yes	1.00	1.00
5	Does the layout relate to the water pressure zones	no	0.00	
		yes	1.00	
6	• Are the Bulk service routed on roads or minimum 5m servitudes	no	0.00	
		yes	1.00	1.00
7	Minimal no of dead-ends to ensure flushing/no stagnation	no	0.00	
		yes	1.00	1.00
8	• Did the layout consider the positioning of trees in close proximity of services	no	0.00	
		yes	1.00	1.00
9	• Location & Spacing of Fire hydrants have a minimum overlap of<15% area	no	0.00	
		yes	1.00	
10	• Is adequate space provided for the siting of reservoir, pump stations and maintenance depots, with allowable buffers when required?	no	0.00	
		yes	1.00	1.00
	2.0 FUNCTIONAL EFFICIENCY		**20.0**	**13.3**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.33	1.33
2	• Can water loss be reduced by reducing velocity in pipe . Maximum velocity Pressure in the reticulation < 3m/s-leakage	no		
		yes	1.33	1.33
3	Does the design attempt to monitor water supply by metering. Design of systems that both monitor and manage water consumption.	no	0.00	
		yes	1.33	1.33
4	Pressure Management -Is the maximum Pressure in the reticulation< 9 bar-in order to minimise leakage	no	0.00	
		yes	1.33	1.33
5	Water efficient fittings	no	0.00	
		yes	1.33	1.33
6	• Was the layout designed as a network of linked loops to facilitate a balanced loss of water pressure?	no	0.00	
		yes	1.33	1.33
7	Does the design Reduce peak demand with the use of attenuation/bulk reservoirs	no	0.00	
		yes	1.33	
8	Water-Efficient Irrigation & landscaping measures	no	0.00	
		yes	1.33	
9	Use of Roof tank/intermediate storage	no	0.00	
		yes	1.33	
10	Dry Fire Hydrants. suction pipe systems from pond/external source	no	0.00	
		yes	1.33	
11	Low impact Development technologies- Water	no	0.00	
		yes	1.33	
12	Watertight joints/compression type coupling/Seals quality	no	0.00	
		yes	1.33	1.33
13	Efficient water systems design-Optimised flow/velocity in pipe not <0.2m/s	no	0.00	
		yes	1.33	1.33
14	Water hammer analysis undertaken	no	0.00	
		yes	1.33	1.33
15	Water reticulation designed to be self-cleaning	no	0.00	
		yes	1.33	1.33
	3.0 Environmental quality		**15.0**	**6.7**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.67	1.67
2	Provisions made to increase Reliability of water source	no	0.00	
		yes	1.67	
3	• Does the design protect existing sources of water within townships for possible use for water supply.	no	0.00	
		yes	1.67	1.67
4	Provision of aesthetic water infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.67	1.67
5	Scour valves positioned for safe discharge- erosion	no	0.00	
		yes	1.67	1.67
6	low-level water audit carried out	no	0.00	
		yes	1.67	

7	Water-Wise Gardening	no	0.00	
		yes	1.67	
8	Separate grey water/ black water-Reticulated recycled water supply	no	0.00	
		yes	1.67	
9	Water quality monitoring measures in place	no	0.00	
		yes	1.67	
	4.0 Economy		**15.0**	**15.0**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	0.00	1.50
2	• Are high and moderate fire risk categories of development located close to bulk water supply points	no	0.00	
		yes	1.50	1.50
3	• Are <20% of the fittings special fittings, i.e tees/couplings	no	0.00	
		yes	1.50	1.50
4	Use of shared trenches >20% of length	no	0.00	
		yes	1.50	1.50
5	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.50	1.50
6	• Are the air valves , shut off valves in valve rings, compared to brick chambers	no	0.00	
		yes	1.50	1.50
7	• Are there curvilinear roads with small radii, as this increases the cost of water reticulation due to the necessity of providing additional pipe specials, fittings and thrust blocks to anchor all pipes.	yes	0.00	
		no	1.50	1.50
8	Av Trench Depth <1.2m in over total length	no	0.00	
		yes	1.50	1.50
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.50	1.50
10	Pipe material - pvc/hdpe vs. concrete/steel	concrete/st	0.00	
		pvc/hdpe	1.50	1.50
	5.0 FUTURE MAINTENANCE		**10.0**	**9.2**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.00	0.83
2	Valves/Meters located in convenient positions- Outside properties	no	0.00	
		yes	0.83	0.83
3	Are the valves located in convenient positions.> 80% at intersections	no	0.00	
		yes	0.83	0.83
4	Are >80% of the bulk services placed in the most accessible locations such as roads?	no	0.00	
		yes	0.83	0.83
5	Positioning of trees - proximity of services	no	0.00	
		yes	0.83	0.83
6	Flexible type coupling to permit ease in repair	no	0.00	
		yes	0.83	0.83
7	Are all services watertight	no	0.00	
		yes	0.83	0.83
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	0.83	0.83
9	Are the corrodible pipes protected	no	0.00	
		yes	0.83	0.83
10	Uniform type of fittings compared to non standard fittings	no	0.00	
		yes	0.83	0.83
11	Leak Detection devices in reticulation	no	0.00	
		yes	0.83	
12	Provisions for future expansion of the system	no	0.00	
		yes	0.83	0.83
	6.0 Safety		**10.0**	**10.0**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	1.67
2	<10% of length >3m Trench Depth	no	0.00	
		yes	1.67	1.67
3	• Is the high and moderate fire risk developments located close to bulk water supply points	no	0.00	
		yes	1.67	1.67
4	• Is there supply capacity is compatible with the development's fire fighting requirements	no	0.00	
		yes	1.67	1.67
5	Fire risk -High/medium or low	High/medi	0.00	
		low	1.67	1.67
6	Pressure on pipeline<9bar	no	0.00	
		yes	1.67	1.67

	7.0 SOCIAL		**5.0**	**5.0**
1	Is end user provided with access to free basic services, in terms of demand	no	0.00	
		yes	1.00	1.00
2	Educational Outreach plan - water conservation	no	0.00	
		yes	1.00	1.00
3	• Are the standpipes located in convenient positions along walkways	no	0.00	
		yes	1.00	1.00
4	• Will vehicular access to other parts of the residential area be blocked during the repair of services	yes	0.00	
		no	1.00	1.00
5	Provision of employment to local community >100 person days	no	0.00	
		yes	1.00	1.00
	8.0 RESOURCES		**10.0**	**7.0**
1	Conventional use of resources	no	0.00	
		yes	1.00	1.00
2	•Water demand management measures - Does the design attempt to reduce the potable water consumption by building occupants. Reduced demand	yes	1.00	1.00
		no	0.00	
3	Can the pump duty points/velocities in pipelines be reduced or optimised	yes	0.00	
		no	1.00	1.00
4	Zone and bulk smart metering	yes	1.00	
		no	0.00	
5	Use of onsite materials for Bedding	no	0.00	
		yes	1.00	
6	Use of Present & future water consumption figures	no	0.00	
		yes	1.00	1.00
7	Does the design attempt to use water efficient appliances and fittings	no	0.00	
		yes	1.00	1.00
8	Use of Recycled materials	no	0.00	
		yes	1.00	1.00
9	• Does the design attempt to reduce the consumption of potable water for landscape irrigation is sourced from non-potable water (e.g. rainwater, Recycled water effluent for irrigation)	no	0.00	
		yes	1.00	1.00
10	Was there a detailed investigation of existing services to assess the spare capacity of watermains, as well as the feasibility of upgrading	no	0.00	
		yes	1.00	1.00
	9.0 CONSTRUCTION		**5.0**	**0.0**
1	Water Operational Plan		0.00	
			5.00	

APPENDIX 9: Case Study 1: Detailed Green Infrastructure Rating report

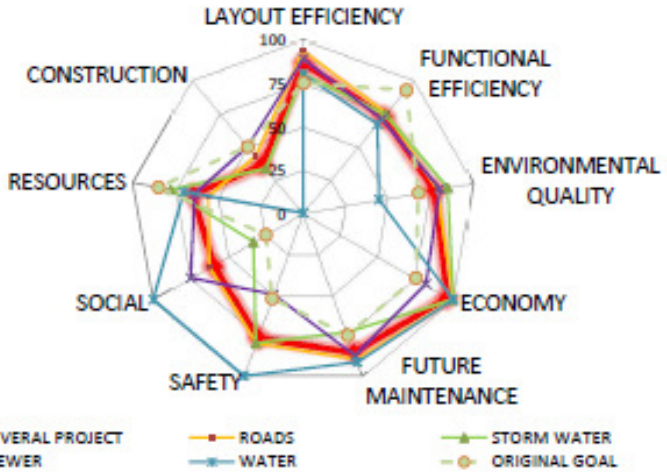
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Blueberry Hills- High Income Private Development
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROOP

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	INFRASTRUCTURE ELEMENTS				
		ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	30%	20%	10%	
1.0 LAYOUT EFFICIENCY	10%	9	8	9	8	Points. Achieved
		10	10	10	10	Points. Available
2.0 FUNCTIONAL EFFICIENCY	20%	15	15	14	13	Points. Achieved
		20	20	20	20	Points. Available
3.0 ENVIRONMENTAL QUALITY	15%	12	13	12	7	Points. Achieved
		15	15	15	15	Points. Available
4.0 ECONOMY	15%	15	15	12	15	Points. Achieved
		15	15	15	15	Points. Available
5.0 FUTURE MAINTENANCE	10%	9	7	9	9	Points. Achieved
		10	10	10	10	Points. Available
6.0 SAFETY	10%	8	8	5	10	Points. Achieved
		10	10	10	10	Points. Available
7.0 SOCIAL	5%	3	2	4	5	Points. Achieved
		5	5	5	5	Points. Available
8.0 RESOURCES	10%	6	8	6	7	Points. Achieved
		10	10	10	10	Points. Available
9.0 CONSTRUCTION	5%	2	2	3	0	Points. Achieved
		5	5	5	5	Points. Available
TOTAL PTS.		100	100	100	100	Scoring
WEIGHTED PTS. ACHIEVED		10.5	10.4	9.7	9.6	
WEIGHTED PTS. AVAILABLE		13.0	13.0	13.0	13.0	
TOTAL ACHIEVED		80.6	80.0	74.4	73.7	
TOTAL AVAILABLE		100.0	100.0	100.0	100.0	



SCORE	78	PLATINUM	Best solution to the environment- Benchmark performance

SCORE	GREEN GOALS	
0-24	Minimal interventions were undertaken- compliance based on regulations	Bronze
25-49	Some considerations for environment- Applied conventional practice	SILVER
50-74	Restricted damage to the environment with innovation and new technolog	GOLD
75-100	Best solution to the environment- Benchmark performance	PLATINUM

APPENDIX 10: Case Study 2: Green Goal Report

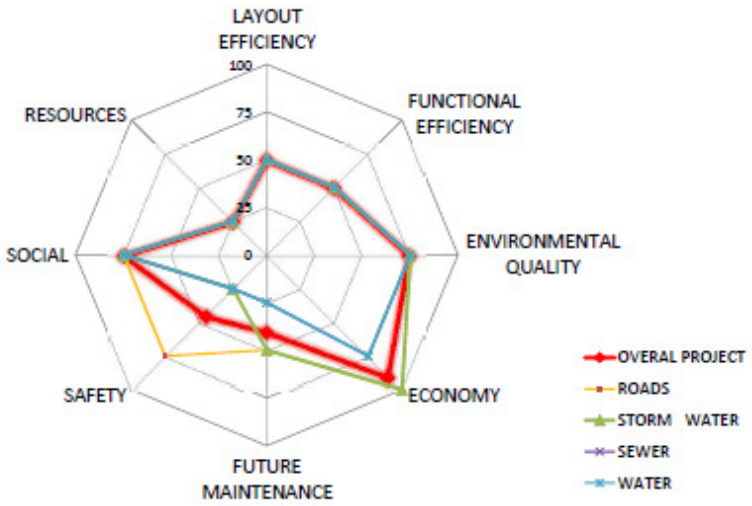
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sihahlala-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROOP

CIVIL INFRASTRUCTURE GREEN GOAL REPORT

PERFORMANCE CATEGORIES	ROADS	40%	STORM WATER	20%	SEWER	20%	WATER	20%	Weighted Infrastructure
1 LAYOUT EFFICIENCY	Some considerations for environment	50	Some considerations for environment	50	Some considerations for environment	50	Some considerations for environment	50	10%
2 FUNCTIONAL EFFICIENCY	Some considerations for environment	50	Some considerations for environment	50	Some considerations for environment	50	Some considerations for environment	50	20%
3 ENVIRONMENTAL QUALITY	Restricted damage to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	10%
4 ECONOMY	Best solution to the environment	100	Best solution to the environment	100	Restricted damage to the environment	75	Restricted damage to the environment	75	15%
5 FUTURE MAINTENANCE	Some considerations for environment	50	Some considerations for environment	50	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	10%
6 SAFETY	Restricted damage to the environment	75	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	10%
7 SOCIAL	Restricted damage to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	Restricted damage to the environment	75	10%
8 RESOURCES	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	10%
9 CONSTRUCTION	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	5%
WEIGHTED SCORE		24		12		10.8		10.8	100%



SCORE	58	GOLD	Restricted damage to the environment

RANGE OF SUSTAINABLE DEVELOPMENT GOALS			
Sustainable goal for development	Range of implementation choices	Status	Score
Best solution to the environment	Set new performance benchmark through new technological developments	PLATINUM	75 -100
Restricted damage to the environment	Doing what is achievable- through innovation and risk taking with new systems and technologies	GOLD	50 - 74
Some considerations for environment	Apply conventional and current state-of-practice	SILVER	25 - 49
Minimal interventions to be undertaken	Achieve compliance based on regulations	Bronze	0 - 24

APPENDIX 11: Case Study 2: Preliminary Green Infrastructure Rating Report

THE GREEN TOWNSHIP DESIGN MODEL

PRELIMINARY GREEN INFRASTRUCTURE RATING ANALYSIS

INFRASTRUCTURE ELEMENTS

ROADS		40%	SEWER		20%
	Pts Av	Pts Ach		Pts Av	Pts Ac
PC: LAYOUT EFFICIENCY	8	7		8	6
Typical service layout configuration	1	1	Typical service layout configuration	1	1
landscaping and all public utilities	1	1	Layout promote midblock sewer> 30% midblock	1	1
Promote concept of green streets	1	1	<10% of length of Sewer pipeline in floodline	1	1
Ecological Connectivity-Open spaces and circulation system	1	1	Avoidance of pumpstations	1	
layout facilitates economical subdivision and min. intersections	1	1	Alternative Route alignments	1	1
Design the internal street layout to inhibit through-traffic	1	1	Catchment planning	1	
Increased diversity in road reserve through distinction between si	1		Contour layout planning	1	1
Roads aligned with natural topography	1	1	Sewer lines planned one catchment at a time	1	1
RESOURCES	7	3		7	5
Alternative Surfacing technologies -Permeable pav/Grass blocks	1		Backfill - non commercial source	1	1
Tree conservation <1tree/ha removed	1	1	Use of onsite materials for Bedding	1	
Re-Use of Pavement Layerworks	1		Manhole sealed in the floodline	1	1
Alt Transportation Options such as bicycles, light rail, NMT	1		Pipe material - use of pvc/hdpe vs. /concrete/steel	1	1
Earthworks- balanced -Cut / Fill <20% spoil	1	1	The avoidance of the use of pumpstations	1	1
Use of Recycled materials	1		Use of Recycled materials	1	
Conventional use of resources	1	1	Conventional use of resources	1	1
ENVIRONMENT QUALITY	8	4		8	4
Some consideration for reducing envir impact. in the design	1	1	Some consideration for reducing envir impact. in the des	1	1
Minimal of valley crossings < 1/km	1	1	<20% pipeline positioned in the flood plains	1	1
ramps and paving	1		manholes, outlets, fittings	1	
Erosion control measures @ all outlets	1	1	Measures to control factors governing odour and noise	1	
Landscaping: Use of Water efficient plantings	1		Provision for protecting surface & sub surface water bodi	1	1
Clearing and grading (Site Vegetation) limited to road footprint or	1		Flood protection of pumpstation and pipeline	1	1
Noise reduction through Quiet Pavement, traffic reduction on inte	1		Is the development density < the environmental capacity	1	
Habitat Restoration	1	1	Waste effluent quality monitoring measures	1	
FUNCTIONALITY EFFICIENCY	11	6		11	3
Conventional systems that achieve minimum compliance	1	1	Conventional systems that achieve minimum compliance	1	1
Use of Drainage and storage functions of roads	1	1	Primary greywater reuse	1	
Use of Pedestrian / bicycle paths	1		Oil/grease/grit separators	1	
Is the av. road grad/m <5%/m	1	1	Onsite sewage disposal-Recycle/composting	1	
Innovation- eg. Use of Permeable pavements	1		Secondary greywater reuse	1	
Low impact Development technologies- roads	1		Low impact Development technologies- Sewer	1	
automatic right of way on higher order roads	1	1	Nutrient resource recovery & reuse	1	
Parking ratios/codes/parking lots	1	1	Avoid Flat gradients (20% that is <1: 100)- stagnation	1	
Use of street furniture for a positive contribution to area	1		Are the manholes that are in the 1:100 yr. floodline seale	1	1
Roadway system design to be self-cleaning	1	1	Sanitation system design to have self-cleaning velocity	1	1
Additional lanes at major intersections-reduce peak quantity	1		Sewer attenuation-reduce peak quantity	1	
FUTURE MAINTENANCE	8	3		8	7
Some consideration of maintenance in the design of the service	1	1	Some consideration of maintenance in the design of the s	1	1
Maintenance of grass- pioneer grass used	1	1	Provisions for future expansion of the system	1	1
Bank slopes must be gentle >1:1.75	1		Are pipeline susceptible to erosion protected	1	1
Pavement lifecycle design >20yrs	1		Service aligned with road/property boundary>80%	1	1
Site Vegetation-low water	1		Services watertight	1	1
Alternative access for the repair of services	1		Easy access and room for the repair	1	1
Type of trees planted allows for minimal leaves to fall	1		Erf have a rodding eye	1	1
Street marking- high quality luminous paint	1	1	Pipe loading in all areas checked	1	
ECONOMY	7	5		8	5
Some consideration of economy in the design of the service	1	1	Some consideration of economy in the design of the serv	1	1
Most economic system/service for target market	1	1	Most economic system/service for target market	1	1
Minimized the number of road intersections	1		Av Trench Depth <2m in over total length	1	1
Are narrower, shorter streets used	1	1	Av. manhole spacing >50m	1	
Too Curvilinear roads increases no of manholes	1	1	Use of shared trenches> 30%	1	1
Conduct Life-Cycle Cost Analyses	1		erf alignments as straight as possible to reduce sewer m	1	
Is the area devoted to streets minimal- min road widths/reserves	1	1	Pipe material - pvc/concrete/hdpe.	1	1
				1	
SAFETY	7	6		5	3
Some consideration of safety in the design of the service	1	1	Some consideration of safety in the design of the service	1	1
Traffic calming measures	1	1	<10% of length >3m Trench Depth	1	1
Signage and pedestrian friendliness	1	1	Position in relation to water pipe >1m away	1	1
the street is designed as a safe and unique public space	1	1	Compatibility with storm water management	1	
Segregate pedestrians, cyclists and vehicles where traffic speeds/volumes high	1	1	Measures to reduce the incidence ,spreading of diseases by waste	1	
Road safety Audit	1				
Safe Intersection-site distance, sidewalks, crosswalks, other inte	1	1			
SOCIAL	8	4		4	3
neighbourhoods	1		ERF access to sewers	1	1
Educational Outreach plan - road safety - to community	1		Educational Outreach plan -awareness on Health and sa	1	
Public participation in all stages of the project	1	1	Public participation in all stages of the project	1	1
Public transport facilities and provision of street furniture	1	1	Provision of employment to local community >100 perso	1	1
Universal access-layout cater for disabled-Wheelchairs and elde	1	1			
Provision of employment to local community >100 person days	1	1			
Measures to preserve Cultural Heritage	1				
Provision of social amenities to the community	1				
CONSTRUCTION EFFICIENCY	6	2		1	0
Environmental management Process, plan and training	1	1	Sewer Management Plan	1	
Site Waste management plan	1				
Pavement Management System	1				
Quality Management System	1	1			
Site maintenance plan	1				
Equipment Emissions Reduction Plan	1				
WEIGHTED SCORES	8.15	4.75		7.45	4.15
WEIGHTED SCORES	100	58		100	55.7

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THE GREEN TOWNSHIP DESIGN MODEL

PRELIMINARY GREEN INFRASTRUCTURE RATING ANALYSIS

STORMWATER		20%	WATER	20%	100%	Weighted
	Pts Av	Pts Ach		Pts Av	Pts Act	
0	8	6	0	8	5	10%
Typical service layout configuration	1	1	Typical service layout configuration	1	1	
Use of Green corridors-Natural drainage paths	1	1	Pipe route alignment- looped network efficiency	1	1	
stormwater pipeline in floodline <10% of total length	1	1	Water pipeline in floodline <10% of total length of pipe	1	1	
Multipurpose Attenuation facilities-for retarding sw	1	1	Location & Spacing of Fire hydrants have a minimum overlap	1		
land use intensities matched to landscape tolerances for sw	1		layout relate to the water pressure zones	1		
SWMP initiated at start of planning for land uses	1		Minimal no of dead-ends to ensure flushing/no stagnation	1	1	
servitudes for safe, acceptable points of discharge.	1	1	land uses-high demands & fire risk close to water supply	1		
Reduced SW concentration & hydrological impact	1	1	Bulk service routed on roads or minimum 5m servitudes	1	1	
	7	3		7	4	10%
Pipe material - use of pvc/hdpe vs. /concrete/steel	1		Water demand management measures	1		
Use of onsite materials for Bedding	1	1	Zone and bulk smart metering	1		
Manhole types- brick/precast	1		Use of onsite materials for Bedding	1	1	
Rain water harvesting and Reuse	1		Use of Present & future water consumption figures	1	1	
Runoff quantity control	1	1	Promote use Water Efficient fixtures/Appliances	1	1	
Recycled materials to construct of SW channels/manholes/	1		Rain water harvesting	1		
Conventional use of resources	1	1	Conventional use of resources	1	1	
	8	6		7	3	10%
Some consideration for reducing envir impact. in the design	1	1	Some consideration for reducing envir impact. in the design	1	1	
Post Development < Predev Flow	1	1	Protect against water contamination	1	1	
manholes, outlets, fittings	1		manholes, outlets, fittings that is not obtrusive	1		
Recharge rates maintained	1	1	low-level water audits	1		
Protection measures of wetlands- stagnant water	1	1	Scour valves positioned for safe discharge- erosion	1	1	
Runoff quality-Constructed Wetlands/filters	1		Reticulated recycled water supply	1		
Minimize soil erosion; by good vegetation along the water co	1	1	Water-Wise Gardening	1		
Increased roughness of drainage way to decrease the veloci	1	1				
	11	8		11	6	20%
Conventional systems that achieve minimum compliance	1	1	Conventional systems that achieve minimum compliance	1	1	
Quality control at source-from residential rooftop by disconn	1		Water-Efficient Irrigation & landscaping measures	1		
SW attenuation-reduce peak quantity	1	1	Use of Roof tank/intermediate storage	1		
Stormwater Management Plan	1	1	Pressure Management as part of design-Balanced loss/increa	1	1	
Bioretention swales/ponds/infiltration berms	1		Dry Fire Hydrants. suction pipe systems from pond	1		
Low impact Development technologies- SW	1	1	Water efficient fittings	1	1	
Erosion control(Geotextile/cells, gabions)	1	1	water attenuation-reduce peak quantity	1		
Sediment control- Silt fences/Stilling basin	1		Watertight joints/compression type coupling/Seals quality	1	1	
Is the av. channel grad/m <5%/m-high velocities	1	1	Efficient water systems design-Optimised flow/velocity in pipe	1	1	
Use of roads & parking to control drainage & storage	1	1	Water reticulation design to be self-cleaning	1	1	
Are channels lined -earth,-grass, concrete, grass	1	1	Water hammer analysis	1		
	8	6		8	6	10%
Some consideration of maintenance in the design of the ser	1	1	Some consideration of maintenance in the design of the servic	1	1	
Is the design-manholes, pipes and catchpits sized for maint	1	1	Sleeves used where pipes cross the road	1	1	
Flood plain accessible	1	1	Services Watertight joints/Seals quality	1	1	
Pipe loading in all areas checked	1		Positioning of trees - proximity of services	1	1	
Stormwater system design to be self-cleaning	1	1	Isolation Valves/Meters located in convenient positions @ 90%	1	1	
Easy access and room for the repair of services	1	1	Easy access and room for the repair of services	1	1	
Positioning of trees in close proximity of services > 20m	1	1	Leak Detection devices in retic.	1		
Inlet/outlet design to reduce blockages	1		Provisions for future expansion of the system	1		
	8	7		8	6	15%
Some consideration of economy in the design of the service	1	1	Some consideration of economy in the design of the service	1	1	
Most economic system/service for target market	1	1	Most economic system/service for target market	1	1	
Non structural controls	1	1	Use of shared trenches >20%	1		
Use of shared trenches >20%	1	1	Max. hydrants, airvalve spacing av spacing- 200m	1	1	
Av. manhole spacing >50m	1	1	Av Trench Depth <1.2m in over total length	1	1	
Multipurpose stormwater facilities	1	1	Conduct Life-Cycle Cost Analyses	1		
Pipe material - pvc/concrete/hdpe.	1		Pipe material - pvc/concrete/hdpe.	1	1	
Av Trench Depth <2m in over total length	1	1	Are the air valves , shut off valves in valve rings	1	1	
	6	3		6	6	10%
Some consideration of safety in the design of the service	1	1	Some consideration of safety in the design of the service	1	1	
<10% of length >3m Trench Depth	1	1	<10% of length >3m Trench Depth	1	1	
Velocity /depth of stormwater flowing	1		Supply sufficient for fire fighting requirements	1	1	
Safe discharge routes	1	1	Fire risk -High/medium or low	1	1	
Design accommodates various storm frequencies	1		located close to bulk water supply points	1	1	
Flood warning signs	1		Pressure on pipeline<9bar	1	1	
	6	4		4	2	10%
convenience- minor system designed for high-frequency sto	1	1	Provision of employment to local community >100 person day	1	1	
Education and awareness- Rainwater harvesting	1		Educational Outreach plan - water conservation	1		
Public participation in all stages of the project	1	1	Public participation in all stages of the project	1	1	
No Inconvenience of overland flow and Temporary storage f	1		Standpipes located in convenient positions along walkways.	1		
Is access to river walks and open spaces	1	1				
Provision of employment to local community >100 person da	1	1				
	2	1		1	0	5%
Pre construction Stormwater Management Plan	1	1	Water Operational plan	1		
Siltation control with Sand and hessian bags or Silt fences	1					
	7.8	5.5		7.45	4.7	100%
	100	70.51		100	63.1	62
Restricted damage to the environment with some innovation and new technologies				GOLD		62

APPENDIX 12: Case Study 2: Detailed Green Infrastructure Rating Analysis Report

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sihahlala-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAR

INFRASTRUCTURE ELEMENT- ROADS			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**8.8**
1	Typical service layout configuration	no	0.00	
		yes	0.63	0.63
2	Does the layout promote concept of greenstreets	no	0.00	
		yes	0.63	0.63
3	Does the layout facilitate economical subdivisions, with the use of shared road infrastructure	no	0.00	
		yes	0.63	0.63
4	• Layout integrates the circulation system with dwellings, landscaping and all public utilities	no	0.00	
		yes	0.63	0.63
5	• the percentage township area devoted to roads, parking and footways <30% of total area	no	0.00	
		yes	0.63	0.63
6	• Is there minimum interruption from access movements, intersections, to achieve good mobility, Access road >100m apart	no	0.00	
		yes	0.63	0.63
7	• Provide public transport routes which minimize operating costs while satisfying user requirements for convenience	no	0.00	
		yes	0.63	
8	• Provide reserve widths and alignments which cater for all road users, for services for landscaping, in the most economical way.	no	0.00	
		yes	0.63	0.63
9	• Relate the spacing and layout of intersections to the probable vehicle type, the volume and direction of movement	no	0.00	
		yes	0.63	0.63
10	• Ecological Connectivity-Open spaces and circulation system-integral part of the open space system and appropriate landscaping provided for	no	0.00	
		yes	0.63	0.63
11	• Are short-distance links (<1km) between adjacent neighbourhoods	no	0.00	
		yes	0.63	0.63
12	• Does the road hierarchy requirements provide automatic right-of-way for traffic on higher order roads. additional lanes at intersections provided for to reduce peak traffic with minimum interruption	no	0.00	
		yes	0.63	0.63
13	Design the internal street layout to inhibit through-traffic	no	0.00	
		yes	0.63	0.63
14	• Garages and urban collectors located away from residents, to minimize nuisance to residents from noise, dust and fumes	no	0.00	
		yes	0.63	0.63
15	• Develop the road aligned to the natural topography	no	0.00	
		yes	0.63	0.63
16	• Increase diversity in road reserve. Design and make distinction between sidewalk zone, cycle areas, pedestrian area, refuse areas, planters, lighting, etc.	no	0.00	
		yes	0.63	
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**15.0**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.00	1.00
2	The use of Innovative design techniques, such as the use geogrids to reduce layer thickness, increase pavement life, bearing capacity, differential settlement, etc.	no	0.00	
		yes	1.00	
3	The use of Low impact Development technologies on roads	no	0.00	
		yes	1.00	1.00
4	Are the street furniture well designed items, and placed so as to make a positive contribution to the total street picture	no	0.00	
		yes	1.00	1.00
5	Are there cycle lanes	no	0.00	
		yes	1.00	
6	Are there special details for the design of all road elements, including kerbing, channelling, ramps and different types of paving.eg. Brick paving compared to concrete and asphalt as it creates	no	0.00	
		yes	1.00	1.00
7	Are landscaping and trees used to reduce the impact of large areas of asphalt	no	0.00	
		yes	1.00	1.00
8	Is the potential drainage function of roads maximized by co-ordinating their layouts with the drainage systems.	no	0.00	
		yes	1.00	1.00
9	• Where appropriate, are the medians-<1.5m for safety	no	0.00	
		yes	1.00	1.00
10	• Is the maximum road crown slope(4%)-operation problem driving, wear of vehicles <20% of the total road length	no	0.00	
		yes	1.00	1.00
11	• Is the minimum road crown slope(2%) - prevents sediment loading <5% of the total road length	no	0.00	
		yes	1.00	1.00
12	• Additional lanes at major intersections-reduce peak quantity	no	0.00	
		yes	1.00	
13	• Is the average road grad/m less than 5%/m	no	0.00	
		yes	1.00	1.00
14	• Are parking areas provided (according to Parking ratios/codes) where road will be well trafficked and where appropriate consist of grass blocks, gravel, paving to give it a softer park like image	no	0.00	
		yes	1.00	

	Pedestrian routes			
15	• Do the pedestrian routes minimize walking distances and encourage pedestrian use	no	0.00	
		yes	1.00	1.00
16	• Are there pedestrian facilities (such as sidewalks and crossings)	no	0.00	
		yes	1.00	1.00
17	The project layout promotes walking and discourages the use of vehicles.	no	0.00	
		yes	1.00	1.00
	Bus stops			
18	• Are bus bays provided at major bus stops to minimize delays to other traffic	no	0.00	
		yes	1.00	1.00
19	• Provide shelter against rain, sun, wind as well as benches or a space for resting or eating while waiting for transportation and signage integrated with shelters	no	0.00	
		yes	1.00	
20	• Are gradients designed appropriate to the mode/s of transport using the bus route <6%	no	0.00	
		yes	1.00	1.00
	3.0 Environmental quality		**15.0**	**8.6**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.07	1.07
2	Noise reduction through Quiet Pavement, traffic reduction on internal streets	no	0.00	
		yes	1.07	1.07
3	• Use of surfacing on roads - Concrete vs. asphalt increases volumetric heat capacities, lower air temperatures	no	0.00	
		yes	1.07	
4	Habitat Restoration measures used	no	0.00	
		yes	1.07	1.07
5	• Provide aesthetic kerbing, channelling, pedestrian refuges, ramps and paving	no	0.00	
		yes	1.07	
6	• Permeable road surface/parking lots -grass blocks- selection of surfacing that has a reduced environmental impact relative to available alternatives.	no	0.00	
		yes	1.07	
7	Does the project layout provides a safe, convenient and attractive environment for walking.	no	0.00	
		yes	1.07	1.07
8	• Preserve natural features such as gullies, outcrops, marshes and existing trees, shrubs and hedges in the layout to create interest, variety and surprise in the vistas along the and along the	no	0.00	
		yes	1.07	1.07
9	Are erosion control measures used in the design of earthworks on steep areas, such as the use of sand bags or Hessian sheets, rehabilitation of exposed soil areas, soil is protected from the	no	0.00	
		yes	1.07	1.07
10	Clearing and grading (Site Vegetation) - road footprint/topsoil removed <50% of road reserve	no	0.00	
		yes	1.07	
11	• Is a variety of access street forms provided to avoid monotony	no	0.00	
		yes	1.07	
12	would there be stock piling of soil or any other materials near a watercourse	yes	0.00	
		no	1.07	1.07
13	Landscaping: Use of Water efficient plantings	yes	0.00	
		no	1.07	
14	Are areas sensitive to erosion such as near water supply points and edges of slopes being developed.	yes	0.00	
		no	1.07	1.07
	4.0 Economy		**15.0**	**12.3**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	1.36
2	Most economic system/service for target market	no	0.00	
		yes	1.36	1.36
3	• Can the number of road intersections be minimized through layout configuration	yes	0.00	
		no	1.36	
4	Are the roads too Curvilinear roads- increased no of manholes, kerb lengths	yes	0.00	
		no	1.36	1.36
5	• Are the public transport routes optimized;	no	0.00	
		yes	1.36	1.36
6	• Are the widths of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
7	• Is the alignment of roadways utilise the maximum criteria in order to reduce earthworks, in with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
8	• Is the pavement foundation design of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.36	
10	Earthworks- balanced-Cut / Fill <20% spoil	no	0.00	
		yes	1.36	1.36
11	• Can the total length and cost of internal roads be minimized	yes	0.00	
		no	1.36	1.36

	5.0 FUTURE MAINTENANCE		**10.0**	**5.0**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.00	1.00
2	• Acceptable pioneer grasses(cynodindactolin) and reeds where applicable	no	0.00	
		yes	1.00	1.00
3	Type of trees planted allows for minimal leaves to fall and clog up drains	no	0.00	
		yes	1.00	
4	Landscaping: Use of Water efficient plantings	no	0.00	
		yes	1.00	
5	• -Bank slopes must be gentle to allow access for maintenance >1:1.75	no	0.00	
		yes	1.00	1.00
6	• Life span of the road pavement >20 years	no	0.00	
		yes	1.00	
7	• Street marking- high quality luminous paint	no	0.00	
		yes	1.00	1.00
8	Alternative access for the repair of road or road closure	no	0.00	
		yes	1.00	
9	High quality Street signage - minimal maintenance >2m from trees/shrubs	no	0.00	
		yes	1.00	1.00
10	Are there subsurface water drainage systems in 80% of cuts >2m to protect road pavements - minimal maintenance of road layerworks	no	0.00	
		yes	1.00	
	6.0 SAFETY		**10.0**	**8.0**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	0.67	0.67
2	Adequate sight distances at intersections, horizontal curves and crests are commensurate with operating speeds	no	0.00	
		yes	0.67	0.67
3	• Universal access at Intersections-designed to be safe for pedestrians and vehicles. This includes sidewalks, crosswalks, traffic signals and other intersection treatment	no	0.00	
		yes	0.67	0.67
4	• Inhibit through-traffic in internal streets/neighbourhoods	no	0.00	
		yes	0.67	0.67
5	• Segregate pedestrians, cyclists and vehicles where traffic is concentrated or speeds and volumes are high	no	0.00	
		yes	0.67	
6	Traffic calming measures used such as Speed humps, chicanes, street narrowing devices, change in the surface colour or texture, in the immediate vicinity of homes.	no	0.00	
		yes	0.67	0.67
7	• Provide access points to multiple units dwellings only at selected points to control and concentrate traffic	no	0.00	
		yes	0.67	0.67
8	• Provide turning spaces which avoid the need for vehicles to reverse over long distances.	no	0.00	
		yes	0.67	0.67
9	• Are there pedestrian crossings and sidewalks with adequate signage	no	0.00	
		yes	0.67	0.67
10	Road safety Audit undertaken	no	0.00	
		yes	0.67	
11	• Provide mutual visibility between pedestrians and moving vehicles with traffic on main roads;	no	0.00	
		yes	0.67	0.67
12	• is there a potential conflict areas between roads users, pedestrian and cyclists	yes	0.00	
		no	0.67	0.67
13	• Design soft mounds, and plant trees to separate pedestrian from buildings and road	no	0.00	
		yes	0.67	0.67
14	Convenience- Traffic-generating facilities located near entrances to residential areas or adjacent to higher order roads	no	0.00	
		yes	0.67	
15	Are the pedestrian system and parking areas located where they will be overlooked by dwellings or passing traffic and well-lit after dark for greater security	no	0.00	
		yes	0.67	0.67
	7.0 SOCIAL		**5.0**	**3.8**
1	Does the road contribute to development of previously underdeveloped areas	no	0.00	
		yes	0.63	0.63
2	Educational Outreach plan - road safety	no	0.00	
		yes	0.63	
3	• Ensure that pedestrian crossings on distributor roads are convenient to use	no	0.00	
		yes	0.63	0.63
4	• Minimize distances of pedestrian routes <15min walking time;	no	0.00	
		yes	0.63	0.63
5	Provision of social amenities to the community	no	0.00	
		yes	0.63	
6	• Does the layout cater for disabled and Wheelchairs and elders that may want to sit down	no	0.00	
		yes	0.63	0.63
7	Provision of employment to local community >100 person days	no	0.00	
		yes	0.63	0.63
8	Use of Public transport facilities and provision of street furniture	no	0.00	
		yes	0.63	0.63

	8.0 RESOURCES		10.0	4.4
1	Conventional use of resources	no	0.00	
		yes	1.11	1.11
2	Use of Recycled road materials in the layerworks	no	0.00	
		yes	1.11	
3	Is the Kerbing cast insitu or precast	precast	0.00	
		insitu	1.11	
4	Design initiatives that increase the facilitate reused building materials, Recycled materials and	no	0.00	
		yes	1.11	1.11
5	Tree conservation- no of trees <10/ha	no	0.00	
		yes	1.11	1.11
6	Earthworks- balanced -Cut / Fill <20% spoil	no	0.00	
		yes	1.11	1.11
7	Promoting Alternative Transportation Options such as bicycles, light rail, Non Motorized Transport	no	0.00	
		yes	1.11	
8	Use of alternative Surfacing other than hot mix asphalt, such as Permeable pave/Grass blocks/porous concrete	no	0.00	
		yes	1.11	
9	Reuse existing materials onsite to minimise materials consumption	no	0.00	
		yes	1.11	
	9.0 CONSTRUCTION		**5.0**	**2.1**
1	Environmental management Process, plan and training	no	0.00	
		yes	0.71	0.71
2	Site Waste management plan	no	0.00	
		yes	0.71	
3	Pavement Management System	no	0.00	
		yes	0.71	
4	Quality Management System	no	0.00	
		yes	0.71	0.71
5	Site maintenance plan	no	0.00	
		yes	0.71	
6	Equipment Emissions Reduction Plan	no	0.00	
		yes	0.71	
7	• Stockpiles <1000m3 (Hugh stockpiles create dust in wind)	no	0.00	
		yes	0.71	0.71

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sihahlala-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SARC

INFRASTRUCTURE ELEMENT- STORMWATER

			Scoring	
1.0 LAYOUT EFFECIENCY			**10.0**	**6.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	1.00
2	• Does the layout consider hydrological concerns with regards to sw runoff and relationship to plot size, type of land use	no	0.00	
		yes	1.00	
3	• Does the layout plan take into account the natural drainage paths(Stream patterns), areas subject to flooding	no	0.00	
		yes	1.00	1.00
4	• Are the land use intensities matched to landscape tolerances for swmp	no	0.00	
		yes	1.00	
5	are the stormwater facilities Integrated with recreation areas;	no	0.00	
		yes	1.00	1.00
6	• Does the swmp use open spaces for retarding or stormwater evaporation ponds to remove partially treated water	no	0.00	
		yes	1.00	1.00
7	is the length of Storm water services located in special servitudes and not located in road reserve <10% of total length	no	0.00	
		yes	1.00	
8	stormwater pipeline in floodline <10% of total length	no	0.00	
		yes	1.00	1.00
9	• Does the layout reduce the hydrological impact of the development by reducing stormwater concentration	no	0.00	
		yes	1.00	1.00
10	• Was the mdp initiated at start of planning for land uses	no	0.00	
		yes	1.00	
2.0 FUNCTIONAL EFFECIENCY			**20.0**	**12.59**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	**0.74**	**0.74**
2	• Provision of surface water management system to ensure that the ultimate flow from the development does not result in any negative impacts on downstream properties or watercourse and is managed within the overall site	no	0.00	
		yes	**0.74**	**0.74**
3	• Has the Master drainage plans been prepared, in collaboration with adjoining communities and authorities, for the existing and future development of the entire catchments	no	0.00	
		yes	**0.74**	**0.74**
4	Is >70% of the road designed for sheetflow	no	0.00	
		yes	**0.74**	**0.74**
5	Is the maximum velocity <3m/s	no	0.00	
		yes	**0.74**	**0.74**
6	<10% of roads have a maximum road gradient >12%	no	0.00	
		yes	**0.74**	**0.74**
7	• What is the minimum road crown slope- <2%- sediment	no	0.00	
		yes	**0.74**	**0.74**
8	Is the maximum road crown slope- <3%-operation problem driving, ware of vehicles	no	0.00	
		yes	**0.74**	**0.74**
9	• Are the potential drainage and storage functions of roads, roadside channels used	no	0.00	
		yes	**0.74**	**0.74**
10	Is >50% of the road gradients <2% - used for retarding stormwater run-off	no	0.00	
		yes	**0.74**	**0.74**
11	• Is the post development limited to predevelopment	no	0.00	
		yes	**0.74**	**0.74**
12	• Is the roadside channels designed to prevent erosion	no	0.00	
		yes	**0.74**	**0.74**
13	• Is the stormwater flow depths < 0.5m	no	0.00	
		yes	**0.74**	
14	• Inlet- are the backwater effects designed for	no	0.00	
		yes	**0.74**	
15	• are the inlets/pond have swing type grids or are self cleansing to prevent blockages	no	0.00	
		yes	**0.74**	**0.74**
16	Quality control at the source-from residential rooftop by disconnecting downpipe, Rain Barrels, soakaway-Prevent pollutant dumping	no	0.00	
		yes	**0.74**	
17	• Does the reticulation limit runoff volumes with the use of bioswales filtering pollution	no	0.00	
		yes	**0.74**	
18	• Does the reticulation limit volumes with the use of retention basin	no	0.00	
		yes	**0.74**	
19	Are velocities reduced with the use of Check dams	no	0.00	
		yes	**0.74**	
20	• Does the reticulation limit runoff volumes with the use of Porous parking surfaces	no	0.00	
		yes	**0.74**	
21	• In areas where the subsoil and water table are suitable, does the design the surfaces of storage areas allow for the re-charging of the underground water.	no	0.00	
		yes	**0.74**	
22	Are flood plains and watercourses protected from erosion with Gabions, dissipaters, Reno mattress, stilling basins, Check weir, Riprap protection, Energy reduction, Drop structures, Rip rap basins,	no	0.00	
		yes	**0.74**	**0.74**
23	• Are there measures to prevent underground conduits from silting up	no	0.00	
		yes	**0.74**	**yes**

24	• Are channels lined -earth,-grass, concrete, grass	no	0.00	
		yes	0.74	0.74
25	• Is the average channel slopes -<5%	no	0.00	
		yes	0.74	0.74
26	• Are the stormwater outlet structures designed to decrease flow velocity by the use of velocity dissipaters	no	0.00	
		yes	0.74	0.74
27	Sediment control- Silt fences/Stilling basin	no	0.00	
		yes	0.74	
	3.0 ENVIROMENTAL QUALITY		**15.0**	**9.2**
	Erosion control measures			
1	Some consideration for reducing envir impact. In the design	no	0.00	
		yes	1.15	1.15
2	• Protection of environmentally sensitive areas;	no	0.00	
		yes	1.15	1.15
3	• Predevelopment ground water Recharge rates are maintained;	no	0.00	
		yes	1.15	1.15
4	SW pipes steeper than 1:3 <10% of the total length	no	0.00	
		yes	1.15	1.15
5	• Consolidate waterways and open space requirements;	no	0.00	
		yes	1.15	1.15
6	• Minimize soil erosion; by good vegetation along the water courses	no	0.00	
		yes	1.15	1.15
7	• Buffer zone>25m between hard and watercourse areas	no	0.00	
		yes	1.15	
8	• Rehabilitation of exposed soil areas to ensure soil protection	no	0.00	
		yes	1.15	
9	• Removal of vegetation on steep areas	yes	0.00	
		no	1.15	
10	Protection measures of wetlands- stagnant water- may become health hazards-Is there a potential of Nutrient enrichment- eutrophication	no	0.00	
		yes	1.15	
11	SW quality treatment with the use storage facilities, Constructed Wetlands/filters	no	0.00	
		yes	1.15	
12	• Increased roughness of the channel or drainage way to decrease the velocity	no	0.00	
		yes	1.15	1.15
13	• Subsurface disposal is not to close to point of rainfall >200m	no	0.00	
		yes	1.15	1.15
	4.0 ECONOMY		**15.0**	**13.3**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.67	1.67
2	• What type of system is being used	>50% piped	0.00	
		<50% piped	1.67	1.67
3	The use of non-structural control as in relation to structural control of SW.	no	0.00	
		yes	1.67	1.67
4	• Does the reticulation have multipurpose stormwater facilities	no	0.00	
		yes	1.67	
5	• Does the SWMP provide a few, large areas for retaining stormwater, rather than many smaller areas which are more problematic to maintain.	no	0.00	
		yes	1.67	1.67
6	• Does the SWMP attempt to align open drainage systems with natural drainage systems, to minimize the cost of earthworks and pipe works.	no	0.00	
		yes	1.67	1.67
7	• Are the manhole spaced at an the Av. manhole spacing >50m	no	0.00	
		yes	1.67	1.67
8	Is there >30% of shared trenches in relation to separate trenches	no	0.00	
		yes	1.67	1.67
9	Trench Depth <10% of length >3m	no	0.00	
		yes	1.67	1.67
	5.0 FUTURE MAINTENANCE		**10.0**	**7.3**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.67	0.67
2	• Are there any services placed in a location that is not easily accessible by public fo rmaintence	yes	0.00	
		no	0.67	0.67
3	• Was the mdp prepared in collaboration with authorizes for future developments	no	0.00	
		yes	0.67	0.67
4	• Is the flood plain accessible to public for maintenance	no	0.00	
		yes	0.67	0.67
5	• Is the design-manholes, pipes and catchpits sized for maintenance	no	0.00	
		yes	0.67	0.67
6	• Are the bulk services routed on roads or minimum 5m servitudes	no	0.00	
		yes	0.67	0.67
7	• Pipe loading in all areas checked	no	0.00	
		yes	0.67	
8	• If services are in midblock, is a 5m building line imposed	no	0.00	
		yes	0.67	0.67
9	•Positioning of trees in close proximity of services > 20m	no	0.00	
		yes	0.67	0.67

10	• Are sleeves used where pipes cross the road	no	0.00	
		yes	0.67	0.67
11	• Are the pipes susceptable to erosion protected	no	0.00	
		yes	0.67	
12	• Are the open drains in in >6% lined	no	0.00	
		yes	0.67	0.67
13	• pipes across road >100D	no	0.00	
		yes	0.67	
14	- is there an acceptable pioneer grass (cynodindactoiln) and reeds established where applicable	no	0.00	
		yes	0.67	
15	• Does the inlet structures designed to reduce clogging, self cleansing, not designed to overflow	no	0.00	
		yes	0.67	0.67
	6.0 SAFETY		**10.0**	**6.0**
	Aim- Risk of loss of life and significant damage to properties from the run off from the exception heavy			
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.00	1.00
2	• Does the drainage system manage the planned development for the upstream areas, for storms ranging from frequent to rare events?	no	0.00	
		yes	1.00	
3	• Are there safe discharge routes provided for stormwater overland flow. Would the overflow from storage areas protect the downstream property from being inundated,	no	0.00	
		yes	1.00	1.00
4	• In areas susceptible to flooding, is the velocity and/or depth of stormwater flowing in or across streets is within safe limits, with particular attention to potential traffic hazard on higher speed roads.	no	0.00	
		yes	1.00	
5	• Are storms >1:20 yr frequencies accommodated within the design;	no	0.00	
		yes	1.00	
6	•-are the elevation of infrastructure & buildings above the 100yr floodline	no	0.00	
		yes	1.00	1.00
7	• are the manhole covers sealing in flood sensitive areas	no	0.00	
		yes	1.00	1.00
8	• are the any building that have installation of pumps for stormwater	yes	0.00	
		no	1.00	1.00
9	<10% of length >3m Trench Depth	no	0.00	
		yes	1.00	1.00
10	are there flood warning signs informing public of approaching hazards	no	0.00	
		yes	1.00	
	7.0 SOCIAL		**5.0**	**0.8**
1	• Are the minor system designed for high-frequency storms; so that there is no inconvenience of overland flow routes	no	0.00	
		yes	0.83	
2	• Are the temporary storage areas for stormwater in places where the water would not cause inconvenience during or immediately after storms.	no	0.00	
		yes	0.83	
3	• Is access to river walks and open spaces allowed;	no	0.00	
		yes	0.83	
4	Education and awareness- Rainwater harvesting	no	0.00	
		yes	0.83	
5	Public participation in all stages of the project	no	0.00	
		yes	0.83	
6	• Provision of employment to local community >100 person days	no	0.00	
		yes	0.83	0.83
	8.0 RESOURCES		**10.0**	**5.6**
1	Conventional use of resources	no	0.00	
		yes	1.11	1.11
2	• Use of onsite materials for bedding	no	0.00	
		yes	1.11	
3	• Use of onsite materials for backfill	no	0.00	
		yes	1.11	1.11
4	Runoff quantity control measures	no	0.00	
		yes	1.11	1.11
5	Rain water harvesting and Reuse -recycled stormwater for irrigation	no	0.00	
		yes	1.11	
6	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc,	1.11	
7	Does the sytem recharge groundwater	no	0.00	
		yes	1.11	1.11
8	• manhole types-	brick	0.00	
		precast	1.11	
9	Recycled materials to construct of SW channels	no	0.00	
		yes	1.11	1.11
	9.0 CONSTRUCTION		**5.0**	**1.7**
1	Pre construction Stormwater Management Plan	no	0.00	
		yes	1.67	
2	Education and awareness- Rainwater harvesting	no	0.00	
		yes	1.67	
3	Minimize erosion and control siltation with Sand and hessian bags or Silt fences	no	0.00	
		yes	1.67	1.67

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sihahlala-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SARO

INFRASTRUCTURE ELEMENT- SEWER			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**8.9**
1	Typical service layout configuration	no	0.00	
		yes	1.11	1.11
2	• Can pumpstations be avoided through the layout reorientation	no	0.00	
		yes	1.11	1.11
3	• Does the layout promote midblock sewer	no	0.00	
		yes	1.11	1.11
4	• Are alternative sewer layouts considered;	no	0.00	
		yes	1.11	1.11
5	Are the Bulk service routed on roads or minimum 5m servitudes If services are in midblock, a 5m building line imposed	no	0.00	
		yes	1.11	1.11
6	Is there a Sewer Catchment Management Plan been done	no	0.00	
		yes	1.11	
7	<10% of total length of Sewer pipeline in floodline	no	0.00	
		yes	1.11	1.11
8	• Is the development Phased in one catchment at a time	no	0.00	
		yes	1.11	1.11
9	Did the layout consider the positioning of trees in close proximity of services >20m	no	0.00	
		yes	1.11	1.11
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**10.6**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.18	1.18
2	• Does the development contain a grey / black water water reuse system	no	0.00	
		yes	1.18	
3	• Does the development contain Secondary greywater reuse	no	0.00	
		yes	1.18	
4	• Are sewers designed to gradients which are steep enough to ensure adequate velocity for self-cleansing	no	0.00	
		yes	1.18	1.18
5	use of Oil/grease/grit separators	no	0.00	
		yes	1.18	
6	• Does the development attempt to minimize discharge to the municipal sewerage system through sewer attenuation	no	0.00	
		yes	1.18	
7	Does the system attempt Nutrient resource recovery & reuse by Recycle/composting	no	0.00	
		yes	1.18	
8	Are there a potential areas >30% of length that are flat (1: 100) that can result in stagnation	yes	0.00	
		no	1.18	1.18
9	Innovative wastewater technology	no	0.00	
		yes	1.18	
10	• Was the Geotechnical conditions taken into account in the design	no	0.00	
		yes	1.18	1.18
11	• Does the Soil profile have good permeability	no	0.00	
		yes	1.18	1.18
12	Are the manholes that are in the 1:100 yr. floodline sealed	no	0.00	
		yes	1.18	1.18
13	• Does the evapotranspiration area in case of an overflow fall within the site	no	0.00	
		yes	1.18	
14	• Does the evapotranspiration area in case of an overflow fall within the wetland	yes	0.00	
		no	1.18	
15	• Is the av. topography >12%-steep slope problematic for sewage	yes	0.00	
		no	1.18	1.18
16	Are there Soakaway/Sewer lines positioned <7.5m from drink water source	yes	0.00	
		no	1.18	1.18
17	• Soakaway/Sewer lines positioned >5m from water table	no	0.00	
		yes	1.18	1.18
3.0	**Environmental quality**		**15.0**	**6.0**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.50	1.50
2	Design a layout which minimizes nuisance to residents, provides attractive and healthy living conditions, and benefits the environment	no	0.00	
		yes	1.50	1.50
3	Provision for protecting surface & sub surface water bodies from sewage	no	0.00	
		yes	1.50	1.50
4	Provision of aesthetic sewer infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.50	
5	• Are <10% of sewerpipline positioned in the flood plains;	no	0.00	
		yes	1.50	
6	• Is the receiving sewer purification works clear >500m flood plains;	no	0.00	

		yes	1.50	
7	• Is there Erosion protection provided near water course	no	0.00	
		yes	1.50	1.50
8	Waste effluent quality monitoring measures in place	no	0.00	
		yes	1.50	
9	• Are there measures taken to Minimize the obtrusiveness of pumping stations, sewer infrastructure and their environs	no	0.00	
		yes	1.50	
10	• Are there measures taken to control factors governing odour and noise emanating from pump stations and sewer infrastructure	no	0.00	
		yes	1.50	
	4.0 Economy		**15.0**	**12.3**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	1.36
2	• Are the intersection spacing's and block lengths compatible with maximum manhole spacing's to minimize the number of manholes.	no	0.00	
		yes	1.36	1.36
3	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.36	1.36
4	• Is the percentage of sewer is mid-block sewer >30% of the total length	no	0.00	
		yes	1.36	
5	Av Trench Depth <2m in over total length	no	0.00	
		yes	1.36	1.36
6	• Is the av manhole spacing's >50m	no	0.00	
		yes	1.36	
7	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc, hdpe	1.36	1.36
8	• manhole types-	brick	0.00	
		precast	1.36	1.36
9	• Are there long lengths of sewers which cross or adjoin open space or undeveloped land.	yes	0.00	
		no	1.36	1.36
10	• Are there shared trenches >30%	no	0.00	
		yes	1.36	1.36
11	• Are the roads or mid-block erf alignments as straight as possible to reduce sewer reticulation costs and minimize the number of manholes.	no	0.00	
		yes	1.36	1.36
	5.0 FUTURE MAINTENANCE		**10.0**	**6.3**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.25	1.25
2	• Are the pipe runs and cables in servitudes that are accessible for maintenance work.	no	0.00	
		yes	1.25	1.25
3	Provisions for future expansion of the system	no	0.00	
		yes	1.25	
4	• Was there a lifecycle cost analysis done of the pipe and materials	no	0.00	
		yes	1.25	
5	Are pipeline susceptible to erosion protected	no	0.00	
		yes	1.25	1.25
6	• Does every erf have a rodding eye in addition of inspection eye	no	0.00	
		yes	1.25	1.25
7	Are all services watertight	no	0.00	
		yes	1.25	1.25
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	1.25	
	6.0 Safety		**10.0**	**8.3**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	1.67
2	Trench Depth >3m in <10% of length	no	0.00	
		yes	1.67	1.67
3	Measures to Reduce the incidence , spreading of diseases by waste	no	0.00	
		yes	1.67	
4	Compatibility with storm water management	no	0.00	
		yes	1.67	1.67
5	Manhole Depth >3m in <10% of length	no	0.00	
		yes	1.67	1.67
6	Position of sewer pipe in relation to water pipe >90% of pipe not <1m away	no	0.00	
		yes	1.67	1.67

7.0	**SOCIAL**		**5.0**	**3.8**
1	• Does every site have access to sewers	no	0.00	
		yes	1.25	1.25
2	Educational Outreach plan - health and sanitation	no	0.00	
		yes	1.25	
3	Public participation in all stages of the project	no	0.00	
		yes	1.25	1.25
4	Provision of employment to local community >100 person days	no	0.00	
		yes	1.25	1.25
8.0	**RESOURCES**		**10.0**	**6.4**
1	Conventional use of resources	no	0.00	
		yes	0.91	0.91
2	• Does the development use onsite materials for bedding	no	0.00	
		yes	0.91	0.91
3	• Does the development use onsite materials for backfill	no	0.00	
		yes	0.91	0.91
4	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc, hdpe	0.91	0.91
5	• What manhole types are designed for - brick- precast	brick	0.00	
		precast	0.91	0.91
6	• Does the development have pumpstations	yes	0.00	
		no	0.91	
7	does the development have an irrigation system, that the Recycled sewer effluent can be used for irrigation	no	0.00	
		yes	0.91	
8	Does the development attempt to reduce the peak sewer demand (consumption	no	0.00	
		yes	0.91	0.91
9	Is there Sewer attenuation	no	0.00	
		yes	0.91	
10	Was a Detailed investigation of existing services to assess the spare capacity of treatment woks, as well as the feasibility of upgrading undertaken.	no	0.00	
		yes	0.91	0.91
11	Is the Recycled sewage used for fertilizer	no	0.00	
		yes	0.91	
9.0	**CONSTRUCTION**		**5.0**	**2.5**
1	Sewer Management Plan	no	0.00	
		yes	2.50	2.50
2	Sewer Operational plan	no	0.00	
		yes	2.50	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sihahlala-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAR

	INFRASTRUCTURE ELEMENT- WATER			Scoring
	1.0 LAYOUT EFFICIENCY		**10.0**	**6.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	1.00
2	• Are the land uses which have high water demands and high fire risk located close to the water supply mains for the township	no	0.00	
		yes	1.00	1.00
3	• Are land uses with low water demand located on high ground to minimize the size of mains and the cost of water towers	no	0.00	
		yes	1.00	1.00
4	• Does the layout facilitate laying the water reticulation pipes as a network of linked loops with a balanced loss of water pressure?	no	0.00	
		yes	1.00	1.00
5	Does the layout relate to the water pressure zones	no	0.00	
		yes	1.00	
6	• Are the Bulk service routed on roads or minimum 5m servitudes	no	0.00	
		yes	1.00	1.00
7	Minimal no of dead-ends to ensure flushing/no stagnation	no	0.00	
		yes	1.00	
8	• Did the layout consider the positioning of trees in close proximity of services	no	0.00	
		yes	1.00	
9	• Location & Spacing of Fire hydrants have a minimum overlap of<15% area	no	0.00	
		yes	1.00	
10	• Is adequate space provided for the siting of reservoir, pump stations and maintenance depots, with allowable buffers when required?	no	0.00	
		yes	1.00	1.00
	2.0 FUNCTIONAL EFFICIENCY		**20.0**	**13.3**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.33	1.33
2	• Can water loss be reduced by reducing velocity in pipe . Maximum velocity Pressure in the reticulation < 3m/s-leakage	no		
		yes	1.33	1.33
3	Does the design attempt to monitor water supply by metering. Design of systems that both monitor and manage water consumption.	no	0.00	
		yes	1.33	1.33
4	Pressure Management -Is the maximum Pressure in the reticulation< 9 bar-in order to minimise leakage	no	0.00	
		yes	1.33	1.33
5	Water efficient fittings	no	0.00	
		yes	1.33	1.33
6	• Was the layout designed as a network of linked loops to facilitate a balanced loss of water pressure?	no	0.00	
		yes	1.33	1.33
7	Does the design Reduce peak demand with the use of attenuation/bulk reservoirs	no	0.00	
		yes	1.33	
8	Water-Efficient Irrigation & landscaping measures	no	0.00	
		yes	1.33	
9	Use of Roof tank/intermediate storage	no	0.00	
		yes	1.33	
10	Dry Fire Hydrants. suction pipe systems from pond/external source	no	0.00	
		yes	1.33	
11	Low impact Development technologies- Water	no	0.00	
		yes	1.33	
12	Watertight joints/compression type coupling/Seals quality	no	0.00	
		yes	1.33	1.33
13	Efficient water systems design-Optimised flow/velocity in pipe not <0.2m/s	no	0.00	
		yes	1.33	1.33
14	Water hammer analysis undertaken	no	0.00	
		yes	1.33	1.33
15	Water reticulation designed to be self-cleaning	no	0.00	
		yes	1.33	1.33
	3.0 Environmental quality		**15.0**	**5.0**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.67	1.67
2	Provisions made to increase Reliability of water source	no	0.00	
		yes	1.67	
3	• Does the design protect existing sources of water within townships for possible use for water supply.	no	0.00	
		yes	1.67	1.67
4	Provision of aesthetic water infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.67	
5	Scour valves positioned for safe discharge- erosion	no	0.00	
		yes	1.67	1.67
6	low-level water audit carried out	no	0.00	
		yes	1.67	

7	Water-Wise Gardening	no	0.00	
		yes	1.67	
8	Separate grey water/ black water-Reticulated recycled water supply	no	0.00	
		yes	1.67	
9	Water quality monitoring measures in place	no	0.00	
		yes	1.67	
	4.0 Economy		**15.0**	**12.0**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	0.00	1.50
2	• Are high and moderate fire risk categories of development located close to bulk water supply points	no	0.00	
		yes	1.50	1.50
3	• Are <20% of the fittings special fittings, i.e tees/couplings	no	0.00	
		yes	1.50	1.50
4	Use of shared trenches >20% of length	no	0.00	
		yes	1.50	
5	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.50	1.50
6	• Are the air valves , shut off valves in valve rings, compared to brick chambers	no	0.00	
		yes	1.50	1.50
7	• Are there curvilinear roads with small radii, as this increases the cost of water reticulation due to the necessity of providing additional pipe specials, fittings and thrust blocks to anchor all pipes.	yes	0.00	
		no	1.50	1.50
8	Av Trench Depth <1.2m in over total length	no	0.00	
		yes	1.50	1.50
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.50	
10	Pipe material - pvc/hdpe vs. concrete/steel	concret	0.00	
		pvc/hdp	1.50	1.50
	5.0 FUTURE MAINTENANCE		**15.0**	**11.3**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.00	1.25
2	Valves/Meters located in convenient positions- Outside properties	no	0.00	
		yes	1.25	1.25
3	Are the valves located in convenient positions.> 80% at intersections	no	0.00	
		yes	1.25	1.25
4	Are >80% of the bulk services placed in the most accessible locations such as roads?	no	0.00	
		yes	1.25	1.25
5	Positioning of trees - proximity of services	no	0.00	
		yes	1.25	1.25
6	Flexible type coupling to permit ease in repair	no	0.00	
		yes	1.25	1.25
7	Are all services watertight	no	0.00	
		yes	1.25	1.25
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	1.25	1.25
9	Are the corrodible pipes protected	no	0.00	
		yes	1.25	
10	Uniform type of fittings compared to non standard fittings	no	0.00	
		yes	1.25	1.25
11	Leak Detection devices in reticulation	no	0.00	
		yes	1.25	
12	Provisions for future expansion of the system	no	0.00	
		yes	1.25	
	6.0 Safety		**10.0**	**10.0**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	1.67
2	<10% of length >3m Trench Depth	no	0.00	
		yes	1.67	1.67
3	• Is the high and moderate fire risk developments located close to bulk water supply points	no	0.00	
		yes	1.67	1.67
4	• Is there supply capacity is compatible with the development's fire fighting requirements	no	0.00	
		yes	1.67	1.67
5	Fire risk -High/medium or low	High/m	0.00	
		low	1.67	1.67
6	Pressure on pipeline<9bar	no	0.00	
		yes	1.67	1.67

	7.0 SOCIAL		**5.0**	**3.0**
1	Is end user provided with access to free basic services, in terms of demand	no	0.00	
		yes	1.00	1.00
2	Educational Outreach plan - water conservation	no	0.00	
		yes	1.00	
3	• Are the standpipes located in convenient positions along walkways	no	0.00	
		yes	1.00	
4	• Will vehicular access to other parts of the residential area be blocked during the repair of services	yes	0.00	
		no	1.00	1.00
5	Provision of employment to local community >100 person days	no	0.00	
		yes	1.00	1.00
	8.0 RESOURCES		**10.0**	**5.0**
1	Conventional use of resources	no	0.00	
		yes	1.00	1.00
2	•Water demand management measures - Does the design attempt to reduce the potable water consumption by building occupants. Reduced demand	yes	1.00	
		no	0.00	
3	Can the pump duty points/velocities in pipelines be reduced or optimised	yes	0.00	
		no	1.00	1.00
4	Zone and bulk smart metering	yes	1.00	
		no	0.00	
5	Use of onsite materials for Bedding	no	0.00	
		yes	1.00	1.00
6	Use of Present & future water consumption figures	no	0.00	
		yes	1.00	1.00
7	Does the design attempt to use water efficient appliances and fittings	no	0.00	
		yes	1.00	1.00
8	Use of Recycled materials	no	0.00	
		yes	1.00	
9	• Does the design attempt to reduce the consumption of potable water for landscape irrigation is sourced from non-potable water (e.g. rainwater, Recycled water effluent for irrigation)	no	0.00	
		yes	1.00	
10	Was there a detailed investigation of existing services to assess the spare capacity of watermains, as well as the feasibility of upgrading	no	0.00	
		yes	1.00	1.00
	9.0 CONSTRUCTION		**5.0**	**0.0**
1	Water Operational Plan		0.00	
			5.00	

APPENDIX 13: Case Study 2: Detailed Green Infrastructure Rating report

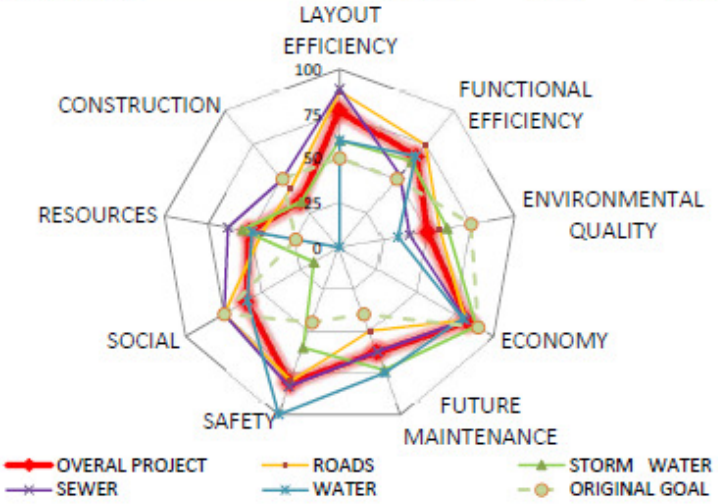
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sihahlala-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROOP

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	20%	20%	20%	
1.0 LAYOUT EFFICIENCY	10%	9	6	9	6	Pts. Achieved
		10	10	10	10	Pts. Available
2.0 FUNCTIONAL EFFICIENCY	20%	15	13	11	13	Pts. Achieved
		20	20	20	20	Pts. Available
3.0 ENVIRONMENTAL QUALITY	10%	9	9	6	5	Pts. Achieved
		15	15	15	15	Pts. Available
4.0 ECONOMY	15%	12	13	12	12	Pts. Achieved
		15	15	15	15	Pts. Available
5.0 FUTURE MAINTENANCE	10%	5	7	6	11	Pts. Achieved
		10	10	10	15	Pts. Available
6.0 SAFETY	10%	8	6	8	10	Pts. Achieved
		10	10	10	10	Pts. Available
7.0 SOCIAL	10%	4	1	4	3	Pts. Achieved
		5	5	5	5	Pts. Available
8.0 RESOURCES	10%	4	6	6	5	Pts. Achieved
		10	10	10	10	Pts. Available
9.0 CONSTRUCTION	5%	2	2	3	0	Pts. Achieved
		5	5	5	5	Pts. Available
TOTAL PTS.		100	100	100	105	
WEIGHTED PTS. ACHIEVED		8.8	8.1	8.0	8.5	
WEIGHTED PTS. AVAILABLE		12.5	12.5	12.5	13.0	
TOTAL ACHIEVED		70.4	64.8	64.3	65.3	
TOTAL AVAILABLE		100.0	100.0	100.0	100.0	



SCORE	67	GOLD	Restricted damage to the environment with innovation and new technologies

SCORE	GREEN GOALS	
0-24	Minimal interventions were undertaken- compliance based on regulations	Bronze
25-49	Some considerations for environment- Applied conventional practice	SILVER
50-74	Restricted damage to the environment with innovation and new technolog	GOLD
75-100	Best solution to the environment- Benchmark performance	PLATINUM

APPENDIX 14: Case Study 3: Green Goal Report

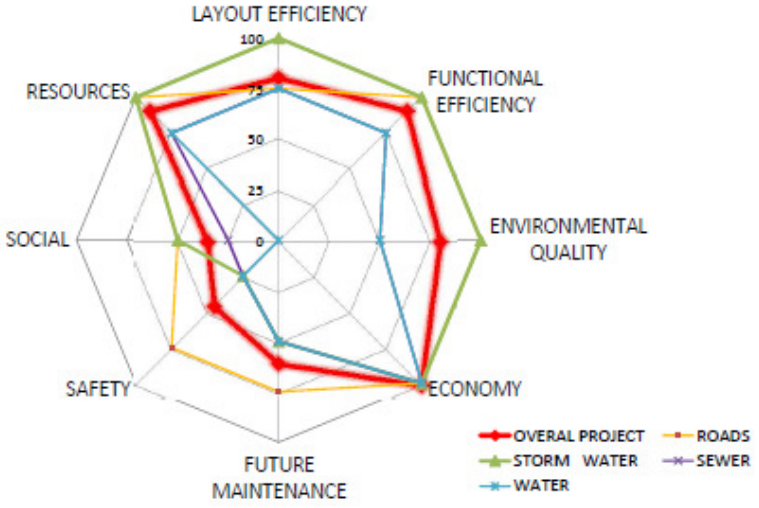
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Bloemfontien Industrial Park | Date: 04 April 2013

Client: xxxxx | Compiled by: SHIAN SAROOP

CIVIL INFRASTRUCTURE GREEN GOAL REPORT

PERFORMANCE CATEGORIES	ROADS	40%	STORM WATER	20%	SEWER	20%	WATER	20%	Weighted Infrastructure
1 LAYOUT EFFICIENCY	Restricted damage to the environment	75	Best solution to the environment	100	Restricted damage to the environment	75	Restricted damage to the environment	75	10%
2 FUNCTIONAL EFFICIENCY	Best solution to the environment	100	Best solution to the environment	100	Restricted damage to the environment	75	Restricted damage to the environment	75	20%
3 ENVIRONMENTAL QUALITY	Best solution to the environment	100	Best solution to the environment	100	Some considerations for environment	50	Some considerations for environment	50	15%
4 ECONOMY	Best solution to the environment	100	Best solution to the environment	100	Best solution to the environment	100	Best solution to the environment	100	15%
5 FUTURE MAINTENANCE	Restricted damage to the environment	75	Some considerations for environment	50	Some considerations for environment	50	Some considerations for environment	50	10%
6 SAFETY	Restricted damage to the environment	75	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	Minimum interventions to be undertaken	25	10%
7 SOCIAL	Some considerations for environment	50	Some considerations for environment	50	Minimum interventions to be undertaken	25	No interventions to be undertaken	0	10%
8 RESOURCES	Best solution to the environment	100	Best solution to the environment	100	Restricted damage to the environment	75	Restricted damage to the environment	75	10%
9 CONSTRUCTION	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	0%
WEIGHTED SCORE		35		16.5		12.5		12	100%



SCORE	76	PLATINUM	Best solution to the environment

RANGE OF SUSTAINABLE DEVELOPMENT GOALS

Sustainable goal for development	Range of implementation choices	Status	Score
Best solution to the environment	Set new performance benchmark through new technological developments	PLATINUM	75 -100
Restricted damage to the environment	Doing what is achievable- through innovation and risk taking with new systems and technologies	GOLD	50 - 74
Some considerations for environment	Apply conventional and current state-of-practice	SILVER	25 - 49
Minimal interventions to be undertaken	Achieve compliance based on regulations	Bronze	0 - 24

APPENDIX 15: Case Study 3: Preliminary Green Infrastructure Rating Report

THE GREEN TOWNSHIP DESIGN MODEL

PRELIMINARY GREEN INFRASTRUCTURE RATING ANALYSIS

INFRASTRUCTURE ELEMENTS

ROADS		40%	SEWER		20%
	Pts Av	Pts Ach		Pts Av	Pts Ac
PC: LAYOUT EFFICIENCY	8	8		8	7
Typical service layout configuration	1	1	Typical service layout configuration	1	1
landscaping and all public utilities	1	1	Layout promote midblock sewer> 30% midblock	1	1
Promote concept of green streets	1	1	<10% of length of Sewer pipeline in floodline	1	1
Ecological Connectivity-Open spaces and circulation system	1	1	Avoidance of pumpstations	1	
layout facilitates economical subdivision and min. intersections	1	1	Alternative Route alignments	1	1
Design the internal street layout to inhibit through-traffic	1	1	Catchment planning	1	1
Increased diversity in road reserve through distinction between si	1	1	Contour layout planning	1	1
Roads aligned with natural topography	1	1	Sewer lines planned one catchment at a time	1	1
RESOURCES	7	4		7	4
Alternative Surfacing technologies -Permeable pav/Grass blocks,	1		Backfill - non commercial source	1	1
Tree conservation <1tree/ha removed	1	1	Use of onsite materials for Bedding	1	
Re-Use of Pavement Layerworks	1	1	Manhole sealed in the floodline	1	1
Alt Transportation Options such as bicycles, light rail, NMT	1		Pipe material - use of pvc/hdpe vs. /concrete/steel	1	1
Earthworks- balanced -Cut / Fill <20% spoil	1	1	The avoidance of the use of pumpstations	1	0
Use of Recycled materials	1		Use of Recycled materials	1	
Conventional use of resources	1	1	Conventional use of resources	1	1
ENVIRONMENT QUALITY	8	8		8	4
Some consideration for reducing envir impact. in the design	1	1	Some consideration for reducing envir impact. in the desi	1	1
Minimal of valley crossings < 1/km	1	1	<20% pipeline positioned in the flood plains	1	0
ramps and paving	1	1	manholes, outlets, fittings	1	0
Erosion control measures @ all outlets	1	1	Measures to control factors governing odour and noise	1	0
Landscaping: Use of Water efficient plantings	1	1	Provision for protecting surface & sub surface water bodi	1	1
Clearing and grading (Site Vegetation) limited to road footprint or	1	1	Flood protection of pumpstation and pipeline	1	1
Noise reduction through Quiet Pavement, traffic reduction on inte	1	1	Is the development density < the environmental capacity	1	0
Habitat Restoration	1	1	Waste effluent quality monitoring measures	1	1
FUNCTIONALITY EFFICIENCY	11	8		11	5
Conventional systems that achieve minimum compliance	1	1	Conventional systems that achieve minimum compliance	1	1
Use of Drainage and storage functions of roads	1	1	Primary greywater reuse	1	0
Use of Pedestrian / bicycle paths	1	1	Oil/grease/grit separators	1	1
Is the av. road grad/m <5%/m	1	1	Onsite sewage disposal-Recycle/composting	1	
Innovation- eg. Use of Permeable pavements	1		Secondary greywater reuse	1	
Low impact Development technologies- roads	1		Low impact Development technologies- Sewer	1	
automatic right of way on higher order roads	1	1	Nutrient resource recovery & reuse	1	
Parking ratios/codes/parking lots	1	1	Avoid Flat gradients (20% that is <1: 100)- stagnation	1	0
Use of street furniture for a positive contribution to area	1		Are the manholes that are in the 1:100 yr. floodline sealed	1	1
Roadway system design to be self-cleaning	1	1	Sanitation system design to have self-cleaning velocity	1	1
Additional lanes at major intersections-reduce peak quantity	1	1	Sewer attenuation-reduce peak quantity	1	1
FUTURE MAINTENANCE	8	8		8	7
Some consideration of maintenance in the design of the service	1	1	Some consideration of maintenance in the design of the s	1	1
Maintenance of grass- pioneer grass used	1	1	Provisions for future expansion of the system	1	1
Bank slopes must be gentle >1:1.75	1	1	Are pipeline susceptible to erosion protected	1	1
Pavement lifecycle design >20yrs	1	1	Service aligned with road/property boundary>80%	1	1
Site Vegetation-low water	1	1	Services watertight	1	1
Alternative access for the repair of services	1	1	Easy access and room for the repair	1	1
Type of trees planted allows for minimal leaves to fall	1	1	Erf have a rodding eye	1	1
Street marking- high quality luminous paint	1	1	Pipe loading in all areas checked	1	
ECONOMY	7	6		7	6
Some consideration of economy in the design of the service	1	1	Some consideration of economy in the design of the serv	1	1
Most economic system/service for target market	1	1	Most economic system/service for target market	1	1
Minimized the number of road intersections	1	1	Av Trench Depth <2m in over total length	1	
Are narrower, shorter streets used	1	1	Av. manhole spacing >50m	1	1
Too Curvilinear roads increases no of manholes	1	1	Use of shared trenches> 30%	1	1
Conduct Life-Cycle Cost Analyses	1		erf alignments as straight as possible to reduce sewer ml	1	1
Is the area devoted to streets minimal- min road widths/reserves	1	1	Pipe material - pvc/concrete/hdpe.	1	1
SAFETY	7	6		5	4
Some consideration of safety in the design of the service	1	1	Some consideration of safety in the design of the service	1	1
Traffic calming measures	1	1	<10% of length >3m Trench Depth	1	
Signage and pedestrian friendliness	1	1	Position in relation to water pipe >1m away	1	1
the street is designed as a safe and unique public space	1	1	Compatibility with storm water management	1	1
Segregate pedestrians, cyclists and vehicles where traffic speeds/volumes high	1	1	Measures to reduce the incidence ,spreading of diseases by waste	1	1
Road safety Audit	1				
Safe Intersection-site distance, sidewalks, crosswalks, other inter	1	1			
SOCIAL	8	4		4	3
neighbourhoods	1		ERF access to sewers	1	1
Educational Outreach plan - road safety - to community	1		Educational Outreach plan -awareness on Health and sa	1	
Public participation in all stages of the project	1	1	Public participation in all stages of the project	1	1
Public transport facilities and provision of street furniture	1	1	Provision of employment to local community >100 persor	1	1
Universal access-layout cater for disabled-Wheelchairs and elder	1	1			
Provision of employment to local community >100 person days	1	1			
Measures to preserve Cultural Heritage	1				
Provision of social amenities to the community	1				
CONSTRUCTION EFFICIENCY	6	2		1	1
Environmental management Process, plan and training	1	1	Sewer Management Plan	1	1
Site Waste management plan	1				
Pavement Management System	1				
Quality Management System	1	1			
Site maintenance plan	1				
Equipment Emissions Reduction Plan	1				
WEIGHTED SCORES	100	81		100	65.33

Best solution to the environment- Benchmark performance through new technological developments	76

THE GREEN TOWNSHIP DESIGN MODEL

PRELIMINARY GREEN INFRASTRUCTURE RATING ANALYSIS

STORMWATER		20%	WATER	20%	100%	Weighted
	Pts Av	Pts Ach		Pts Av	Pts Ach	
	8	8		8	8	10%
Typical service layout configuration	1	1	Typical service layout configuration	1	1	
Use of Green corridors-Natural drainage paths	1	1	Pipe route alignment- looped network efficiency	1	1	
stormwater pipeline in floodline <10% of total length	1	1	Water pipeline in floodline <10% of total length of pipe	1	1	
Multipurpose Attenuation facilities-for retarding sw	1	1	Location & Spacing of Fire hydrants have a minimum overlap	1	1	
land use intensities matched to landscape tolerances for sw	1	1	layout relate to the water pressure zones	1	1	
SWMP initiated at start of planning for land uses	1	1	Minimal no of dead-ends to ensure flushing/no stagnation	1	1	
servitudes for safe, acceptable points of discharge.	1	1	land uses-high demands & fire risk close to water supply	1	1	
Reduced SW concentration & hydrological impact	1	1	Bulk service routed on roads or minimum 5m servitudes	1	1	
	7	5		7	5	10%
Pipe material - use of pvc/hdpe vs. /concrete/steel	1	1	Water demand management measures	1		
Use of onsite materials for Bedding	1	1	Zone and bulk smart metering	1	1	
Manhole types- brick/precast	1		Use of onsite materials for Bedding	1	1	
Rain water harvesting and Reuse	1	1	Use of Present & future water consumption figures	1	1	
Runoff quantity control	1	1	Promote use Water Efficient fixtures/Appliances	1	1	
Recycled materials to construct of SW channels/manholes/	1		Rain water harvesting	1		
Conventional use of resources	1	1	Conventional use of resources	1	1	
	8	8		7	3	15%
Some consideration for reducing envir impact. in the design	1	1	Some consideration for reducing envir impact. in the design	1	1	
Post Development < Predev Flow	1	1	Protect against water contamination	1	1	
manholes, outlets, fittings	1	1	manholes, outlets, fittings that is not obtrusive	1		
Recharge rates maintained	1	1	low-level water audits	1		
Protection measures of wetlands- stagnant water	1	1	Scour valves positioned for safe discharge- erosion	1	1	
Runoff quality-Constructed Wetlands/filters	1	1	Reticulated recycled water supply	1		
Minimize soil erosion; by good vegetation along the water co	1	1	Water-Wise Gardening	1		
Increased roughness of drainage way to decrease the veloc	1	1				
	11	9		11	7	20%
Conventional systems that achieve minimum compliance	1	1	Conventional systems that achieve minimum compliance	1	1	
Quality control at source-from residential rooftop by disconr	1		Water-Efficient Irrigation & landscaping measures	1		
SW attenuation-reduce peak quantity	1	1	Use of Roof tank/intermediate storage	1		
Stormwater Management Plan	1	1	Pressure Management as part of design-Balanced loss/increa	1	1	
Bioretention swales/ponds/infiltration berms	1	1	Dry Fire Hydrants. suction pipe systems from pond	1		
Low impact Development technologies- SW	1	1	Water efficient fittings	1	1	
Erosion control(Geotextile/cells, gabions)	1	1	water attenuation-reduce peak quantity	1		
Sediment control- Silt fences/Stilling basin	1	1	Watertight joints/compression type coupling/Seals quality	1	1	
Is the av. channel grad/m <5%/m-high velocities	1	1	Efficient water systems design-Optimised flow/velocity in pipe	1	1	
Use of roads & parking to control drainage & storage	1	0	Water reticulation design to be self-cleaning	1	1	
Are channels lined -earth,-grass, concrete, grass	1	1	Water hammer analysis	1	1	
	8	4		8	7	10%
Some consideration of maintenance in the design of the ser	1	1	Some consideration of maintenance in the design of the servic	1	1	
Is the design-manholes, pipes and catchpits sized for maint	1	1	Sleeves used where pipes cross the road	1	1	
Flood plain accessible	1	1	Services Watertight joints/Seals quality	1	1	
Pipe loading in all areas checked	1	0	Positioning of trees - proximity of services	1	1	
Stormwater system design to be self-cleaning	1	1	Isolation Valves/Meters located in convenient positions @ 90%	1	1	
Easy access and room for the repair of services	1	0	Easy access and room for the repair of services	1	1	
Positioning of trees in close proximity of services > 20m	1	0	Leak Detection devices in retic.	1		
Inlet/outlet design to reduce blockages	1	0	Provisions for future expansion of the system	1	1	
	8	7		8	8	15%
Some consideration of economy in the design of the service	1	1	Some consideration of economy in the design of the service	1	1	
Most economic system/service for target market	1	1	Most economic system/service for target market	1	1	
Non structural controls	1	1	Use of shared trenches >20%	1	1	
Use of shared trenches >20%	1	1	Max. hydrants, airvalve spacing av spacing- 200m	1	1	
Av. manhole spacing >50m	1	1	Av Trench Depth <1.2m in over total length	1	1	
Multipurpose stormwater facilities	1	1	Conduct Life-Cycle Cost Analyses	1	1	
Pipe material - pvc/concrete/hdpe.	1	1	Pipe material - pvc/concrete/hdpe.	1	1	
Av Trench Depth <2m in over total length	1		Are the air valves , shut off valves in valve rings	1	1	
	6	4		6	5	10%
Some consideration of safety in the design of the service	1	1	Some consideration of safety in the design of the service	1	1	
<10% of length >3m Trench Depth	1		<10% of length >3m Trench Depth	1	0	
Velocity /depth of stormwater flowing	1	1	Supply sufficient for fire fighting requirements	1	1	
Safe discharge routes	1	1	Fire risk -High/medium or low	1	1	
Design accommodates various storm frequencies	1	1	located close to bulk water supply points	1	1	
Flood warning signs	1		Pressure on pipeline<9bar	1	1	
	6	5		4	2	5%
convenience- minor system designed for high-frequency sto	1	1	Provision of employment to local community >100 person days	1	1	
Education and awareness- Rainwater harvesting	1		Educational Outreach plan - water conservation	1		
Public participation in all stages of the project	1	1	Public participation in all stages of the project	1	1	
No Inconvenience of overland flow and Temporary storage f	1	1	Standpipes located in convenient positions along walkways.	1		
Is access to river walks and open spaces	1	1				
Provision of employment to local community >100 person da	1	1				
	2	1		1	1	5%
Pre construction Stormwater Management Plan	1	1	Water Operational plan	1	1	
Siltation control with Sand and hessian bags or Silt fences	1					
	100	81.65		100	75	76
Best solution to the environment- Benchmark performance through new technological developments				PLATINUM		76

APPENDIX 16: Case Study 3: Detailed Green Infrastructure Rating Analysis Report

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Bloemfontien Industrial Park
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAR

INFRASTRUCTURE ELEMENT- ROADS			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**8.8**
1	Typical service layout configuration	no	0.00	
		yes	0.63	0.63
2	Does the layout promote concept of greenstreets	no	0.00	
		yes	0.63	0.63
3	Does the layout facilitate economical subdivisions, with the use of shared road infrastructure	no	0.00	
		yes	0.63	0.63
4	• Layout integrates the circulation system with dwellings, landscaping and all public utilities	no	0.00	
		yes	0.63	0.63
5	• the percentage township area devoted to roads, parking and footways <30% of total area	no	0.00	
		yes	0.63	0.63
6	• Is there minimum interruption from access movements, intersections, to achieve good mobility, Access road >100m apart	no	0.00	
		yes	0.63	0.63
7	• Provide public transport routes which minimize operating costs while satisfying user requirements for convenience	no	0.00	
		yes	0.63	
8	• Provide reserve widths and alignments which cater for all road users, for services for landscaping, in the most economical way.	no	0.00	
		yes	0.63	0.63
9	• Relate the spacing and layout of intersections to the probable vehicle type, the volume and direction of movement	no	0.00	
		yes	0.63	0.63
10	• Ecological Connectivity-Open spaces and circulation system-integral part of the open space system and appropriate landscaping provided for	no	0.00	
		yes	0.63	0.63
11	• Are short-distance links (<1km) between adjacent neighbourhoods	no	0.00	
		yes	0.63	
12	• Does the road hierarchy requirements provide automatic right-of-way for traffic on higher order roads. additional lanes at intersections provided for to reduce peak traffic with minimum interruption	no	0.00	
		yes	0.63	0.63
13	Design the internal street layout to inhibit through-traffic	no	0.00	
		yes	0.63	0.63
14	• Garages and urban collectors located away from residents, to minimize nuisance to residents from noise, dust and fumes	no	0.00	
		yes	0.63	0.63
15	• Develop the road aligned to the natural topography	no	0.00	
		yes	0.63	0.63
16	• Increase diversity in road reserve. Design and make distinction between sidewalk zone, cycle areas, pedestrian area, refuse areas, planters, lighting, etc.	no	0.00	
		yes	0.63	0.63
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**15.0**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.00	1.00
2	The use of Innovative design techniques, such as the use geogrids to reduce layer thickness, increase pavement life, bearing capacity, differential settlement, etc.	no	0.00	
		yes	1.00	
3	The use of Low impact Development technologies on roads	no	0.00	
		yes	1.00	1.00
4	Are the street furniture well designed items, and placed so as to make a positive contribution to the total street picture	no	0.00	
		yes	1.00	1.00
5	Are there cycle lanes	no	0.00	
		yes	1.00	
6	Are there special details for the design of all road elements, including kerbing, channelling, ramps and different types of paving.eg. Brick paving compared to concrete and asphalt as it creates	no	0.00	
		yes	1.00	1.00
7	Are landscaping and trees used to reduce the impact of large areas of asphalt	no	0.00	
		yes	1.00	1.00
8	Is the potential drainage function of roads maximized by co-ordinating their layouts with the drainage systems.	no	0.00	
		yes	1.00	1.00
9	• Where appropriate, are the medians-<1.5m for safety	no	0.00	
		yes	1.00	1.00
10	• Is the maximum road crown slope(4%)-operation problem driving, wear of vehicles <20% of the total road length	no	0.00	
		yes	1.00	1.00
11	• Is the minimum road crown slope(2%) - prevents sediment loading <5% of the total road length	no	0.00	
		yes	1.00	1.00
12	• Additional lanes at major intersections-reduce peak quantity	no	0.00	
		yes	1.00	1.00
13	• Is the average road grad/m less than 5%/m	no	0.00	
		yes	1.00	1.00
14	• Are parking areas provided (according to Parking ratios/codes) where road will be well trafficked and where appropriate consist of grass blocks, gravel, paving to give it a softer park like image	no	0.00	
		yes	1.00	

	Pedestrian routes			
15	• Do the pedestrian routes minimize walking distances and encourage pedestrian use	no	0.00	
		yes	1.00	1.00
16	• Are there pedestrian facilities (such as sidewalks and crossings)	no	0.00	
		yes	1.00	1.00
17	The project layout promotes walking and discourages the use of vehicles.	no	0.00	
		yes	1.00	
	Bus stops			
18	• Are bus bays provided at major bus stops to minimize delays to other traffic	no	0.00	
		yes	1.00	1.00
19	• Provide shelter against rain, sun, wind as well as benches or a space for resting or eating while waiting for transportation and signage integrated with shelters	no	0.00	
		yes	1.00	
20	• Are gradients designed appropriate to the mode/s of transport using the bus route-<6%	no	0.00	
		yes	1.00	1.00
	3.0 Environmental quality		**15.0**	**12.9**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.07	1.07
2	Noise reduction through Quiet Pavement, traffic reduction on internal streets	no	0.00	
		yes	1.07	1.07
3	• Use of surfacing on roads - Concrete vs. asphalt increases volumetric heat capacities, lower air temperatures	no	0.00	
		yes	1.07	
4	Habitat Restoration measures used	no	0.00	
		yes	1.07	1.07
5	• Provide aesthetic kerbing, channelling, pedestrian refuges, ramps and paving	no	0.00	
		yes	1.07	1.07
6	• Permeable road surface/parking lots -grass blocks- selection of surfacing that has a reduced environmental impact relative to available alternatives.	no	0.00	
		yes	1.07	
7	Does the project layout provides a safe, convenient and attractive environment for walking.	no	0.00	
		yes	1.07	1.07
8	• Preserve natural features such as gullies, outcrops, marshes and existing trees, shrubs and hedges in the layout to create interest, variety and surprise in the vistas along the and along the	no	0.00	
		yes	1.07	1.07
9	Are erosion control measures used in the design of earthworks on steep areas, such as the use of sand bags or Hessian sheets, rehabilitation of exposed soil areas, soil is protected from the	no	0.00	
		yes	1.07	1.07
10	Clearing and grading (Site Vegetation) - road footprint/topsoil removed <50% of road reserve	no	0.00	
		yes	1.07	1.07
11	• Is a variety of access street forms provided to avoid monotony	no	0.00	
		yes	1.07	1.07
12	would there be stock piling of soil or any other materials near a watercourse	yes	0.00	
		no	1.07	1.07
13	Landscaping: Use of Water efficient plantings	yes	0.00	
		no	1.07	1.07
14	Are areas sensitive to erosion such as near water supply points and edges of slopes being developed.	yes	0.00	
		no	1.07	1.07
	4.0 Economy		**15.0**	**13.6**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	1.36
2	Most economic system/service for target market	no	0.00	
		yes	1.36	1.36
3	• Can the number of road intersections be minimized through layout configuration	yes	0.00	
		no	1.36	1.36
4	Are the roads too Curvilinear roads- increased no of manholes, kerb lengths	yes	0.00	
		no	1.36	1.36
5	• Are the public transport routes optimized;	no	0.00	
		yes	1.36	
6	• Are the widths of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
7	• Is the alignment of roadways utilise the maximum criteria in order to reduce earthworks, in with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
8	• Is the pavement foundation design of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.36	1.36
10	Earthworks- balanced-Cut / Fill <1000m3 spoil	no	0.00	
		yes	1.36	1.36
11	• Can the total length and cost of internal roads be minimized	yes	0.00	
		no	1.36	1.36

	5.0 FUTURE MAINTENANCE		10.0	8.0
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.00	1.00
2	• Acceptable pioneer grasses(cynodindactolin) and reeds where applicable	no	0.00	
		yes	1.00	1.00
3	Type of trees planted allows for minimal leaves to fall and clog up drains	no	0.00	
		yes	1.00	
4	Landscaping: Use of Water efficient plantings	no	0.00	
		yes	1.00	1.00
5	• -Bank slopes must be gentle to allow access for maintenance >1:1.75	no	0.00	
		yes	1.00	1.00
6	• Life span of the road pavement >20 years	no	0.00	
		yes	1.00	
7	• Street marking- high quality luminous paint	no	0.00	
		yes	1.00	1.00
8	Alternative access for the repair of road or road closure	no	0.00	
		yes	1.00	1.00
9	High quality Street signage - minimal maintenance >2m from trees/shrubs	no	0.00	
		yes	1.00	1.00
10	Are there subsurface water drainage systems in 80% of cuts >2m to protect road pavements - minimal maintenance of road layerworks	no	0.00	
		yes	1.00	1.00
	6.0 SAFETY		**10.0**	**8.7**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	0.67	0.67
2	Adequate sight distances at intersections, horizontal curves and crests are commensurate with operating speeds	no	0.00	
		yes	0.67	0.67
3	• Universal access at Intersections-designed to be safe for pedestrians and vehicles. This includes sidewalks, crosswalks, traffic signals and other intersection treatment	no	0.00	
		yes	0.67	0.67
4	• Inhibit through-traffic in internal streets/neighbourhoods	no	0.00	
		yes	0.67	0.67
5	• Segregate pedestrians, cyclists and vehicles where traffic is concentrated or speeds and volumes are high	no	0.00	
		yes	0.67	0.67
6	Traffic calming measures used such as Speed humps, chicanes, street narrowing devices, change in the surface colour or texture, in the immediate vicinity of homes.	no	0.00	
		yes	0.67	0.67
7	• Provide access points to multiple units dwellings only at selected points to control and concentrate traffic	no	0.00	
		yes	0.67	0.67
8	• Provide turning spaces which avoid the need for vehicles to reverse over long distances.	no	0.00	
		yes	0.67	0.67
9	• Are there pedestrian crossings and sidewalks with adequate signage	no	0.00	
		yes	0.67	0.67
10	Road safety Audit undertaken	no	0.00	
		yes	0.67	
11	• Provide mutual visibility between pedestrians and moving vehicles with traffic on main roads;	no	0.00	
		yes	0.67	0.67
12	• is there a potential conflict areas between roads users, pedestrian and cyclists	yes	0.00	
		no	0.67	0.67
13	• Design soft mounds, and plant trees to separate pedestrian from buildings and road	no	0.00	
		yes	0.67	0.67
14	Convenience- Traffic-generating facilities located near entrances to residential areas or adjacent to higher order roads	no	0.00	
		yes	0.67	
15	Are the pedestrian system and parking areas located where they will be overlooked by dwellings or passing traffic and well-lit after dark for greater security	no	0.00	
		yes	0.67	0.67
	7.0 SOCIAL		**5.0**	**3.1**
1	Does the road contribute to development of previously underdeveloped areas	no	0.00	
		yes	0.63	0.63
2	Educational Outreach plan - road safety	no	0.00	
		yes	0.63	
3	• Ensure that pedestrian crossings on distributor roads are convenient to use	no	0.00	
		yes	0.63	0.63
4	• Minimize distances of pedestrian routes <15min walking time;	no	0.00	
		yes	0.63	
5	Provision of social amenities to the community	no	0.00	
		yes	0.63	
6	• Does the layout cater for disabled and Wheelchairs and elders that may want to sit down	no	0.00	
		yes	0.63	0.63
7	Provision of employment to local community >100 person days	no	0.00	
		yes	0.63	0.63
8	Use of Public transport facilities and provision of street furniture	no	0.00	
		yes	0.63	0.63

	8.0 RESOURCES		10.0	5.6
1	Conventional use of resources	no	0.00	
		yes	1.11	1.11
2	Use of Recycled road materials in the layerworks	no	0.00	
		yes	1.11	
3	Is the Kerbing cast insitu or precast	precast	0.00	
		insitu	1.11	
4	Design initiatives that increase the facilitate reused building materials, Recycled materials and	no	0.00	
		yes	1.11	1.11
5	Tree conservation- no of trees <10/ha	no	0.00	
		yes	1.11	1.11
6	Earthworks- balanced -Cut / Fill <20% spoil	no	0.00	
		yes	1.11	1.11
7	Promoting Alternative Transportation Options such as bicycles, light rail, Non Motorized Transport	no	0.00	
		yes	1.11	
8	Use of alternative Surfacing other than hot mix asphalt, such as Permeable pave/Grass blocks/porous concrete	no	0.00	
		yes	1.11	
9	Reuse existing materials onsite to minimise materials consumption	no	0.00	
		yes	1.11	1.11
	9.0 CONSTRUCTION		**5.0**	**2.1**
1	Environmental management Process, plan and training	no	0.00	
		yes	0.71	0.71
2	Site Waste management plan	no	0.00	
		yes	0.71	
3	Pavement Management System	no	0.00	
		yes	0.71	
4	Quality Management System	no	0.00	
		yes	0.71	0.71
5	Site maintenance plan	no	0.00	
		yes	0.71	
6	Equipment Emissions Reduction Plan	no	0.00	
		yes	0.71	
7	• Stockpiles <1000m3 (Hugh stockpiles create dust in wind)	no	0.00	
		yes	0.71	0.71

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Bloemfontien Industrial Park
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SARO

INFRASTRUCTURE ELEMENT- STORMWATER			Scoring	
1.0 LAYOUT EFFECIENCY			**10.0**	**8.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	1.00
2	• Does the layout consider hydrological concerns with regards to sw runoff and relationship to plot size, type of land use	no	0.00	
		yes	1.00	
3	• Does the layout plan take into account the natural drainage paths(Stream patterns), areas subject to flooding	no	0.00	
		yes	1.00	1.00
4	• Are the land use intensities matched to landscape tolerances for swmp	no	0.00	
		yes	1.00	1.00
5	are the stormwater facilities Integrated with recreation areas;	no	0.00	
		yes	1.00	1.00
6	• Does the swmp use open spaces for retarding or stormwater evaporation ponds to remove partially treated water	no	0.00	
		yes	1.00	1.00
7	is the length of Storm water services located in special servitudes and not located in road reserve <10% of total length	no	0.00	
		yes	1.00	
8	stormwater pipeline in floodline <10% of total length	no	0.00	
		yes	1.00	1.00
9	• Does the layout reduce the hydrological impact of the development by reducing stormwater concentration	no	0.00	
		yes	1.00	1.00
10	• Was the mdp initiated at start of planning for land uses	no	0.00	
		yes	1.00	1.00
2.0 FUNCTIONAL EFFECIENCY			**20.0**	**16.30**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	0.74	0.74
2	• Provision of surface water management system to ensure that the ultimate flow from the development does not result in any negative impacts on downstream properties or watercourse and is managed within the overall site	no	0.00	
		yes	0.74	0.74
3	• Has the Master drainage plans been prepared, in collaboration with adjoining communities and authorities, for the existing and future development of the entire catchments	no	0.00	
		yes	0.74	0.74
4	Is >70% of the road designed for sheetflow	no	0.00	
		yes	0.74	0.74
5	Is the maximum velocity <3m/s	no	0.00	
		yes	0.74	0.74
6	<10% of roads have a maximum road gradient >12%	no	0.00	
		yes	0.74	0.74
7	• What is the minimum road crown slope- <2%- sediment	no	0.00	
		yes	0.74	0.74
8	Is the maximum road crown slope- <3%-operation problem driving, ware of vehicles	no	0.00	
		yes	0.74	0.74
9	• Are the potential drainage and storage functions of roads, roadside channels used	no	0.00	
		yes	0.74	0.74
10	Is >50% of the road gradients <2% - used for retarding stormwater run-off	no	0.00	
		yes	0.74	0.74
11	• Is the post development limited to predevelopment	no	0.00	
		yes	0.74	0.74
12	• Is the roadside channels designed to prevent erosion	no	0.00	
		yes	0.74	0.74
13	• Is the stormwater flow depths < 0.5m	no	0.00	
		yes	0.74	0.74
14	• Inlet- are the backwater effects designed for	no	0.00	
		yes	0.74	
15	• are the inlets/pond have swing type grids or are self cleansing to prevent blockages	no	0.00	
		yes	0.74	0.74
16	Quality control at the source-from residential rooftop by disconnecting downpipe, Rain Barrels, soakaway-Prevent pollutant dumping	no	0.00	
		yes	0.74	
17	• Does the reticulation limit runoff volumes with the use of bioswales filtering pollution	no	0.00	
		yes	0.74	0.74
18	• Does the reticulation limit volumes with the use of retention basin	no	0.00	
		yes	0.74	0.74
19	Are velocities reduced with the use of Check dams	no	0.00	
		yes	0.74	0.74
20	• Does the reticulation limit runoff volumes with the use of Porous parking surfaces	no	0.00	
		yes	0.74	
21	• In areas where the subsoil and water table are suitable, does the design the surfaces of storage areas allow for the re-charging of the underground water.	no	0.00	
		yes	0.74	0.74
22	Are flood plains and watercourses protected from erosion with Gabions, dissipaters, Reno mattress, stilling basins, Check weir, Riprap protection, Energy reduction, Drop structures, Rip rap basins,	no	0.00	
		yes	0.74	0.74

23	• Are there measures to prevent underground conduits from silting up	no	0.00	
		yes	0.74	
24	• Are channels lined -earth,-grass, concrete, grass	no	0.00	
		yes	0.74	0.74
25	• Is the average channel slopes -<5%	no	0.00	
		yes	0.74	0.74
26	• Are the stormwater outlet structures designed to decrease flow velocity by the use of velocity dissipaters	no	0.00	
		yes	0.74	0.74
27	Sediment control- Silt fences/Stilling basin	no	0.00	
		yes	0.74	
	3.0 ENVIROMENTAL QUALITY		**15.0**	**12.7**
	Erosion control measures			
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.15	1.15
2	• Protection of environmentally sensitive areas;	no	0.00	
		yes	1.15	1.15
3	• Predevelopment ground water Recharge rates are maintained;	no	0.00	
		yes	1.15	1.15
4	SW pipes steeper than 1:3 <10% of the total length	no	0.00	
		yes	1.15	1.15
5	• Consolidate waterways and open space requirements;	no	0.00	
		yes	1.15	1.15
6	• Minimize soil erosion; by good vegetation along the water courses	no	0.00	
		yes	1.15	1.15
7	• Buffer zone>25m between hard and watercourse areas	no	0.00	
		yes	1.15	1.15
8	• Rehabilitation of exposed soil areas to ensure soil protection	no	0.00	
		yes	1.15	
9	• Removal of vegetation on steep areas	yes	0.00	
		no	1.15	1.15
10	Protection measures of wetlands- stagnant water- may become health hazards-Is there a potential of Nutrient enrichment- eutrophication	no	0.00	
		yes	1.15	
11	SW quality treatment with the use storage facilities, Constructed Wetlands/filters	no	0.00	
		yes	1.15	1.15
12	• Increased roughness of the channel or drainage way to decrease the velocity	no	0.00	
		yes	1.15	1.15
13	• Subsurface disposal is not to close to point of rainfall >200m	no	0.00	
		yes	1.15	1.15
	4.0 ECONOMY		**15.0**	**13.3**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.67	1.67
2	• What type of system is being used	>50% piped	0.00	
		<50% piped	1.67	1.67
3	The use of non-structural control as in relation to structural control of SW.	no	0.00	
		yes	1.67	1.67
4	• Does the reticulation have multipurpose stormwater facilities	no	0.00	
		yes	1.67	1.67
5	• Does the SWMP provide a few, large areas for retaining stormwater, rather than many smaller areas which are more problematic to maintain.	no	0.00	
		yes	1.67	1.67
6	• Does the SWMP attempt to align open drainage systems with natural drainage systems, to minimize the cost of earthworks and pipe works.	no	0.00	
		yes	1.67	1.67
7	• Are the manhole spaced at an the Av. manhole spacing >50m	no	0.00	
		yes	1.67	1.67
8	Is there >30% of shared trenches in relation to separate trenches	no	0.00	
		yes	1.67	
9	Trench Depth <10% of length >3m	no	0.00	
		yes	1.67	1.67
	5.0 FUTURE MAINTENANCE		**10.0**	**8.0**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.67	0.67
2	• Are there any services placed in a location that is not easily accessible by public fo rmaintence	yes	0.00	
		no	0.67	0.67
3	• Was the mdp prepared in collaboration with authorizes for future developments	no	0.00	
		yes	0.67	0.67
4	• Is the flood plain accessible to public for maintenance	no	0.00	
		yes	0.67	0.67
5	• Is the design-manholes, pipes and catchpits sized for maintenance	no	0.00	
		yes	0.67	
6	• Are the bulk services routed on roads or minimum 5m servitudes	no	0.00	
		yes	0.67	0.67

7	• Pipe loading in all areas checked	no	0.00	
		yes	0.67	
8	• If services are in midblock, is a 5m building line imposed	no	0.00	
		yes	0.67	0.67
9	• Is due regard for positioning of trees in close proximity of services > 20m	no	0.00	
		yes	0.67	0.67
10	• Are sleeves used where pipes cross the road	no	0.00	
		yes	0.67	0.67
11	• Are the pipes susceptable to erosion protected	no	0.00	
		yes	0.67	0.67
12	• Are the open drains in in >6% lined	no	0.00	
		yes	0.67	
13	• pipes across road >100D	no	0.00	
		yes	0.67	0.67
14	- is there an acceptable pioneer grass (cynodindactolin) and reeds established where applicable	no	0.00	
		yes	0.67	0.67
15	• Does the Inlet structures designed to reduce clogging, self cleansing, not designed to overflow	no	0.00	
		yes	0.67	0.67
	6.0 SAFETY		**10.0**	**7.0**
	Aim- Risk of loss of life and significant damage to properties from the run off from the exception heavy			
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.00	1.00
2	• Does the drainage system manage the planned development for the upstream areas, for storms ranging from frequent to rare events?	no	0.00	
		yes	1.00	1.00
3	• Are there safe discharge routes provided for stormwater overland flow. Would the overflow from storage areas protect the downstream property from being inundated,	no	0.00	
		yes	1.00	1.00
4	• In areas susceptible to flooding, is the velocity and/or depth of stormwater flowing in or across streets is within safe limits, with particular attention to potential traffic hazard on higher speed roads.	no	0.00	
		yes	1.00	1.00
5	• Are storms >1:20 yr frequencies accommodated within the design;	no	0.00	
		yes	1.00	
6	•-are the elevation of infrastructure & buildings above the 100yr floodline	no	0.00	
		yes	1.00	1.00
7	• are the manhole covers sealing in flood sensitive areas	no	0.00	
		yes	1.00	1.00
8	• are the any building that have Installation of pumps for stormwater	yes	0.00	
		no	1.00	1.00
9	<10% of length >3m Trench Depth	no	0.00	
		yes	1.00	
10	are there flood warning signs informing public of approaching hazards	no	0.00	
		yes	1.00	
	7.0 SOCIAL		**5.0**	**4.2**
1	• Are the minor system designed for high-frequency storms; so that there is no inconvenience of overland flow routes	no	0.00	
		yes	0.83	0.83
2	• Are the temporary storage areas for stormwater in places where the water would not cause inconvenience during or immediately after storms.	no	0.00	
		yes	0.83	0.83
3	• Is access to river walks and open spaces allowed;	no	0.00	
		yes	0.83	0.83
4	Education and awareness- Rainwater harvesting	no	0.00	
		yes	0.83	
5	Public participation in all stages of the project	no	0.00	
		yes	0.83	0.83
6	• Provision of employment to local community >100 person days	no	0.00	
		yes	0.83	0.83

	8.0 RESOURCES		**10.0**	**5.6**
1	Conventional use of resources	no	0.00	
		yes	1.11	1.11
2	• Use of onsite materials for bedding	no	0.00	
		yes	1.11	1.11
3	• Use of onsite materials for backfill	no	0.00	
		yes	1.11	1.11
4	Runoff quantity control measures	no	0.00	
		yes	1.11	1.11
5	Rain water harvesting and Reuse -recycled stormwater for irrigation	no	0.00	
		yes	1.11	
6	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc, hdpe	1.11	
7	Does the sytem recharge groundwater	no	0.00	
		yes	1.11	1.11
8	• manhole /headwall types-	brick	0.00	
		precast	1.11	
9	Recycled materials to construct of SW channels/manholes/headwalls	no	0.00	
		yes	1.11	
	9.0 CONSTRUCTION		**5.0**	**3.3**
1	Pre construction Stormwater Management Plan	no	0.00	
		yes	1.67	1.67
2	Education and awareness- Rainwater harvesting	no	0.00	
		yes	1.67	
3	Minimize erosion and control siltation with Sand and hessian bags or Silt fences	no	0.00	
		yes	1.67	1.67

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Bloemfontien Industrial Park
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROO

INFRASTRUCTURE ELEMENT- SEWER			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**7.8**
1	Typical service layout configuration	no	0.00	
		yes	1.11	1.11
2	• Can pumpstations be avoided through the layout reorientation	no	0.00	
		yes	1.11	
3	• Does the layout promote midblock sewer	no	0.00	
		yes	1.11	1.11
4	• Are alternative sewer layouts considered;	no	0.00	
		yes	1.11	1.11
5	Are the Bulk service routed on roads or minimum 5m servitudes If services are in midblock, a 5m building line imposed	no	0.00	
		yes	1.11	1.11
6	Is there a Sewer Catchment Management Plan been done	no	0.00	
		yes	1.11	1.11
7	<10% of total length of Sewer pipeline in floodline	no	0.00	
		yes	1.11	
8	• Is the development Phased in one catchment at a time	no	0.00	
		yes	1.11	1.11
9	Did the layout consider the positioning of trees in close proximity of services >20m	no	0.00	
		yes	1.11	1.11
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**12.9**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.18	1.18
2	• Does the development contain a grey / black water water reuse system	no	0.00	
		yes	1.18	
3	• Does the development contain Secondary greywater reuse	no	0.00	
		yes	1.18	
4	• Are sewers designed to gradients which are steep enough to ensure adequate velocity for self-cleansing	no	0.00	
		yes	1.18	1.18
5	use of Oil/grease/grit separators	no	0.00	
		yes	1.18	1.18
6	• Does the development attempt to minimize discharge to the municipal sewerage system through sewer attenuation	no	0.00	
		yes	1.18	1.18
7	Does the system attempt Nutrient resource recovery & reuse by Recycle/composting	no	0.00	
		yes	1.18	
8	Are there a potential areas >30% of length that are flat (1: 100) that can result in stagnation	yes	0.00	
		no	1.18	
9	Innovative wastewater technology	no	0.00	
		yes	1.18	1.18
10	• Was the Geotechnical conditions taken into account in the design	no	0.00	
		yes	1.18	1.18
11	• Does the Soil profile have good permeability	no	0.00	
		yes	1.18	1.18
12	Are the manholes that are in the 1:100 yr. floodline sealed	no	0.00	
		yes	1.18	1.18
13	• Does the evapotranspiration area in case of an overflow fall within the site	no	0.00	
		yes	1.18	
14	• Does the evapotranspiration area in case of an overflow fall within the wetland	yes	0.00	
		no	1.18	
15	• Is the av. topography >12%-steep slope problematic for sewage	yes	0.00	
		no	1.18	1.18
16	Are there Soakaway/Sewer lines positioned <7.5m from drink water source	yes	0.00	
		no	1.18	1.18
17	• Soakaway/Sewer lines positioned >5m from water table	no	0.00	
		yes	1.18	1.18

	3.0 Environmental quality		**15.0**	**7.5**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.50	1.50
2	Design a layout which minimizes nuisance to residents, provides attractive and healthy living conditions, and benefits the environment	no	0.00	
		yes	1.50	1.50
3	Provision for protecting surface & sub surface water bodies from sewage	no	0.00	
		yes	1.50	
4	Provision of aesthetic sewer infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.50	
5	• Are <10% of sewerpipline positioned in the flood plains;	no	0.00	
		yes	1.50	
6	• Is the receiving sewer purification works clear >500m flood plains;	no	0.00	
		yes	1.50	
7	• Is there Erosion protection provided near water course	no	0.00	
		yes	1.50	1.50
8	Waste effluent quality monitoring measures in place	no	0.00	
		yes	1.50	1.50
9	• Are there measures taken to Minimize the obtrusiveness of pumping stations, sewer infrastructure and their environs	no	0.00	
		yes	1.50	1.50
10	• Are there measures taken to control factors governing odour and noise emanating from pump stations and sewer infrastructure	no	0.00	
		yes	1.50	
	4.0 Economy		**15.0**	**10.9**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	1.36
2	• Are the intersection spacing's and block lengths compatible with maximum manhole spacing's to minimize the number of manholes.	no	0.00	
		yes	1.36	1.36
3	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.36	1.36
4	• Is the percentage of sewer is mid-block sewer >30% of the total length	no	0.00	
		yes	1.36	
5	Av Trench Depth <2m in over total length	no	0.00	
		yes	1.36	
6	• Is the av manhole spacing's >50m	no	0.00	
		yes	1.36	1.36
7	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc, hdpe	1.36	1.36
8	• manhole types-	brick	0.00	
		precast	1.36	1.36
9	• Are there long lengths of sewers which cross or adjoin open space or undeveloped land.	yes	0.00	
		no	1.36	1.36
10	• Are there shared trenches >30%	no	0.00	
		yes	1.36	
11	• Are the roads or mid-block erf alignments as straight as possible to reduce sewer reticulation costs and minimize the number of manholes.	no	0.00	
		yes	1.36	1.36
	5.0 FUTURE MAINTENANCE		**10.0**	**8.8**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.25	1.25
2	• Are the pipe runs and cables in servitudes that are accessible for maintenance work.	no	0.00	
		yes	1.25	1.25
3	Provisions for future expansion of the system	no	0.00	
		yes	1.25	1.25
4	• Was there a lifecycle cost analysis done of the pipe and materials	no	0.00	
		yes	1.25	
5	Are pipeline susceptible to erosion protected	no	0.00	
		yes	1.25	1.25
6	• Does every erf have a rodding eye in addition of inspection eye	no	0.00	
		yes	1.25	1.25
7	Are all services watertight	no	0.00	
		yes	1.25	1.25
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	1.25	1.25
	6.0 Safety		**10.0**	**5.0**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	1.67
2	Trench Depth >3m in <10% of length	no	0.00	
		yes	1.67	
3	Measures to Reduce the incidence , spreading of diseases by waste	no	0.00	
		yes	1.67	
4	Compatibility with storm water management	no	0.00	
		yes	1.67	1.67
5	Manhole Depth >3m in <10% of length	no	0.00	

		yes	1.67	
6	Position of sewer pipe in relation to water pipe >90% of pipe not <1m away	no	0.00	
		yes	1.67	1.67
7.0	**SOCIAL**		**5.0**	**3.8**
1	• Does every site have access to sewers	no	0.00	
		yes	1.25	1.25
2	Educational Outreach plan - health and sanitation	no	0.00	
		yes	1.25	
3	Public participation in all stages of the project	no	0.00	
		yes	1.25	1.25
4	Provision of employment to local community >100 person days	no	0.00	
		yes	1.25	1.25
8.0	**RESOURCES**		**10.0**	**5.5**
1	Conventional use of resources	no	0.00	
		yes	0.91	0.91
2	• Does the development use onsite materials for bedding	no	0.00	
		yes	0.91	0.91
3	• Does the development use onsite materials for backfill	no	0.00	
		yes	0.91	
4	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc, hdpe	0.91	0.91
5	• What manhole types are designed for - brick- precast	brick	0.00	
		precast	0.91	0.91
6	• Does the development have pumpstations	yes	0.00	
		no	0.91	
7	does the development have an irrigation system, that the Recycled sewer effluent can be used for irrigation	no	0.00	
		yes	0.91	
8	Does the development attempt to reduce the peak sewer demand (consumption	no	0.00	
		yes	0.91	
9	Is there Sewer attenuation	no	0.00	
		yes	0.91	0.91
10	Was a Detailed investigation of existing services to assess the spare capacity of treatment woks, as well as the feasibility of upgrading undertaken.	no	0.00	
		yes	0.91	0.91
11	Is the Recycled sewage used for fertilizer	no	0.00	
		yes	0.91	
9.0	**CONSTRUCTION**		**5.0**	**2.5**
1	Sewer Management Plan	no	0.00	
		yes	2.50	2.50
2	Sewer Operational plan	no	0.00	
		yes	2.50	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Bloemfontien Industrial Park
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SARC

INFRASTRUCTURE ELEMENT- WATER			Scoring	
	1.0 LAYOUT EFFECIENCY		**10.0**	**8.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	1.00
2	• Are the land uses which have high water demands and high fire risk located close to the water supply mains for the township	no	0.00	
		yes	1.00	1.00
3	• Are land uses with low water demand located on high ground to minimize the size of mains and the cost of water towers	no	0.00	
		yes	1.00	1.00
4	• Does the layout facilitate laying the water reticulation pipes as a network of linked loops with a balanced loss of water pressure?	no	0.00	
		yes	1.00	1.00
5	Does the layout relate to the water pressure zones	no	0.00	
		yes	1.00	
6	• Are the Bulk service routed on roads or minimum 5m servitudes	no	0.00	
		yes	1.00	1.00
7	Minimal no of dead-ends to ensure flushing/no stagnation	no	0.00	
		yes	1.00	1.00
8	• Did the layout consider the positioning of trees in close proximity of services	no	0.00	
		yes	1.00	1.00
9	• Location & Spacing of Fire hydrants have a minimum overlap of<15% area	no	0.00	
		yes	1.00	
10	• Is adequate space provided for the siting of reservoir, pump stations and maintenance depots, with allowable buffers when required?	no	0.00	
		yes	1.00	1.00
	2.0 FUNCTIONAL EFFICIENCY		**20.0**	**13.3**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.33	1.33
2	• Can water loss be reduced by reducing velocity in pipe . Maximum velocity Pressure in the reticulation < 3m/s- leakage	no		
		yes	1.33	1.33
3	Does the design attempt to monitor water supply by metering. Design of systems that both monitor and manage water consumption.	no	0.00	
		yes	1.33	1.33
4	Pressure Management -Is the maximum Pressure in the reticulation< 9 bar-in order to minimise leakage	no	0.00	
		yes	1.33	1.33
5	Water efficient fittings	no	0.00	
		yes	1.33	1.33
6	• Was the layout designed as a network of linked loops to facilitate a balanced loss of water pressure?	no	0.00	
		yes	1.33	1.33
7	Does the design Reduce peak demand with the use of attenuation/bulk reservoirs	no	0.00	
		yes	1.33	
8	Water-Efficient Irrigation & landscaping measures	no	0.00	
		yes	1.33	
9	Use of Roof tank/intermediate storage	no	0.00	
		yes	1.33	
10	Dry Fire Hydrants. suction pipe systems from pond/external source	no	0.00	
		yes	1.33	
11	Low impact Development technologies- Water	no	0.00	
		yes	1.33	
12	Watertight joints/compression type coupling/Seals quality	no	0.00	
		yes	1.33	1.33
13	Efficient water systems design-Optimised flow/velocity in pipe not <0.2m/s	no	0.00	
		yes	1.33	1.33
14	Water hammer analysis undertaken	no	0.00	
		yes	1.33	1.33
15	Water reticulation designed to be self-cleaning	no	0.00	
		yes	1.33	1.33

	3.0 Environmental quality		**15.0**	**6.7**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.67	1.67
2	Provisions made to increase Reliability of water source	no	0.00	
		yes	1.67	
3	• Does the design protect existing sources of water within townships for possible use for water supply.	no	0.00	
		yes	1.67	1.67
4	Provision of aesthetic water infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.67	1.67
5	Scour valves positioned for safe discharge- erosion	no	0.00	
		yes	1.67	1.67
6	low-level water audit carried out	no	0.00	
		yes	1.67	
7	Water-Wise Gardening	no	0.00	
		yes	1.67	
8	Separate grey water/ black water-Reticulated recycled water supply	no	0.00	
		yes	1.67	
9	Water quality monitoring measures in place	no	0.00	
		yes	1.67	
	4.0 Economy		**15.0**	**12.0**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	0.00	1.50
2	• Are high and moderate fire risk categories of development located close to bulk water supply points	no	0.00	
		yes	1.50	
3	• Are <20% of the fittings special fittings, i.e tees/couplings	no	0.00	
		yes	1.50	1.50
4	Use of shared trenches >20% of length	no	0.00	
		yes	1.50	1.50
5	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.50	1.50
6	• Are the air valves , shut off valves in valve rings, compared to brick chambers	no	0.00	
		yes	1.50	1.50
7	• Are there curvilinear roads with small radii, as this increases the cost of water reticulation due to the necessity of providing additional pipe specials, fittings and thrust blocks to anchor all pipes.	yes	0.00	
		no	1.50	1.50
8	Av Trench Depth <1.2m in over total length	no	0.00	
		yes	1.50	1.50
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.50	
10	Pipe material - pvc/hdpe vs. concrete/steel	concrete/	0.00	
		pvc/hdpe	1.50	1.50
	5.0 FUTURE MAINTENANCE		**10.0**	**9.2**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.00	0.83
2	Valves/Meters located in convenient positions- Outside properties	no	0.00	
		yes	0.83	0.83
3	Are the valves located in convenient positions.> 80% at intersections	no	0.00	
		yes	0.83	0.83
4	Are >80% of the bulk services placed in the most accessible locations such as roads?	no	0.00	
		yes	0.83	0.83
5	Positioning of trees - proximity of services	no	0.00	
		yes	0.83	0.83
6	Flexible type coupling to permit ease in repair	no	0.00	
		yes	0.83	0.83
7	Are all services watertight	no	0.00	
		yes	0.83	0.83
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	0.83	0.83
9	Are the corrodible pipes protected	no	0.00	
		yes	0.83	0.83
10	Uniform type of fittings compared to non standard fittings	no	0.00	
		yes	0.83	0.83
11	Leak Detection devices in reticulation	no	0.00	
		yes	0.83	
12	Provisions for future expansion of the system	no	0.00	
		yes	0.83	0.83

	6.0 Safety		**10.0**	**6.7**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	1.67
2	<10% of length >3m Trench Depth	no	0.00	
		yes	1.67	1.67
3	• Is the high and moderate fire risk developments located close to bulk water supply points	no	0.00	
		yes	1.67	
4	• Is there supply capacity is compatible with the development's fire fighting requirements	no	0.00	
		yes	1.67	1.67
5	Fire risk -High/medium or low	High/med	0.00	
		low	1.67	
6	Pressure on pipeline<9bar	no	0.00	
		yes	1.67	1.67
	7.0 SOCIAL		**5.0**	**3.0**
1	Is end user provided with access to free basic services, in terms of demand	no	0.00	
		yes	1.00	1.00
2	Educational Outreach plan - water conservation	no	0.00	
		yes	1.00	
3	• Are the standpipes located in convenient positions along walkways	no	0.00	
		yes	1.00	
4	• Will vehicular access to other parts of the residential area be blocked during the repair of services	yes	0.00	
		no	1.00	1.00
5	Provision of employment to local community >100 person days	no	0.00	
		yes	1.00	1.00
	8.0 RESOURCES		**10.0**	**5.0**
1	Conventional use of resources	no	0.00	
		yes	1.00	1.00
2	•Water demand management measures - Does the design attempt to reduce the potable water consumption by building occupants. Reduced demand	yes	1.00	1.00
		no	0.00	
3	Can the pump duty points/velocities in pipelines be reduced or optimised	yes	0.00	
		no	1.00	1.00
4	Zone and bulk smart metering	yes	1.00	
		no	0.00	
5	Use of onsite materials for Bedding	no	0.00	
		yes	1.00	
6	Use of Present & future water consumption figures	no	0.00	
		yes	1.00	1.00
7	Does the design attempt to use water efficient appliances and fittings	no	0.00	
		yes	1.00	1.00
8	Use of Recycled materials	no	0.00	
		yes	1.00	
9	• Does the design attempt to reduce the consumption of potable water for landscape irrigation is sourced from non-potable water (e.g. rainwater, Recycled water effluent for irrigation)	no	0.00	
		yes	1.00	
10	Was there a detailed investigation of existing services to assess the spare capacity of watermains, as well as the feasibility of upgrading	no	0.00	
		yes	1.00	1.00
	9.0 CONSTRUCTION		**5.0**	**0.0**
1	Water Operational Plan	no	0.00	
		yes	5.00	

APPENDIX 17: Case Study 3: Detailed Green Infrastructure Rating report

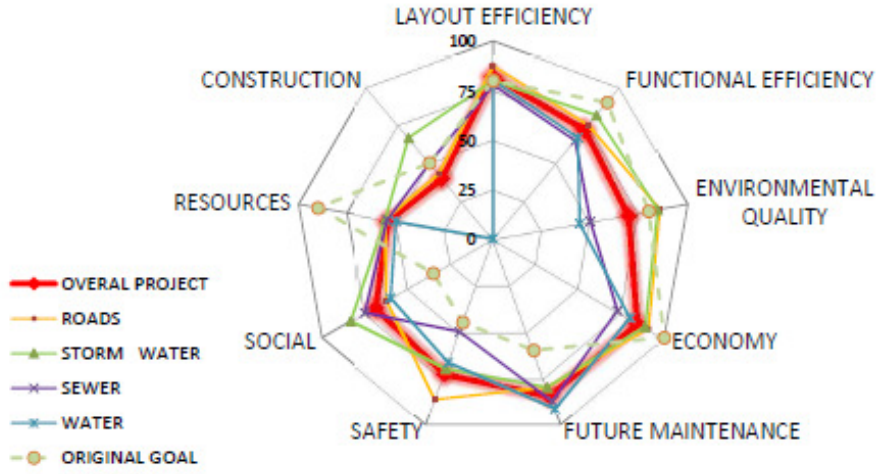
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Bloemfontien Industrial Park
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROOP

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	20%	20%	20%	
1.0 LAYOUT EFFICIENCY	10%	9	8	8	8	Pts. Achieved
		10	10	10	10	Pts. Available
2.0 FUNCTIONAL EFFICIENCY	20%	15	16	13	13	Pts. Achieved
		20	20	20	20	Pts. Available
3.0 ENVIRONMENTAL QUALITY	15%	13	13	8	7	Pts. Achieved
		15	15	15	15	Pts. Available
4.0 ECONOMY	15%	14	13	11	12	Pts. Achieved
		15	15	15	15	Pts. Available
5.0 FUTURE MAINTENANCE	10%	8	8	9	9	Pts. Achieved
		10	10	10	10	Pts. Available
6.0 SAFETY	10%	9	7	5	7	Pts. Achieved
		10	10	10	10	Pts. Available
7.0 SOCIAL	5%	3	4	4	3	Pts. Achieved
		5	5	5	5	Pts. Available
8.0 RESOURCES	10%	6	6	5	5	Pts. Achieved
		10	10	10	10	Pts. Available
9.0 CONSTRUCTION	5%	2	3	3	0	Pts. Achieved
		5	5	5	5	Pts. Available
TOTAL PTS.		100	100	100	100	
WEIGHTED PTS. ACHIEVED		10.3	10.4	8.4	8.5	
WEIGHTED PTS. AVAILABLE		13.0	13.0	13.0	13.0	
TOTAL ACHIEVED		79.5	80.0	64.3	65.4	
TOTAL AVAILABLE		100.0	100.0	100.0	100.0	



SCORE	74	GOLD	Restricted damage to the environment with innovation and new technologies

SCORE	GREEN GOALS	
0-24	Minimal interventions were undertaken- compliance based on regulations	Bronze
25-49	Some considerations for environment- Applied conventional practice	SILVER
50-74	Restricted damage to the environment with innovation and new technologie	GOLD
75-100	Best solution to the environment- Benchmark performance	PLATINUM

APPENDIX 18: Case Study 4: Green Goal Report

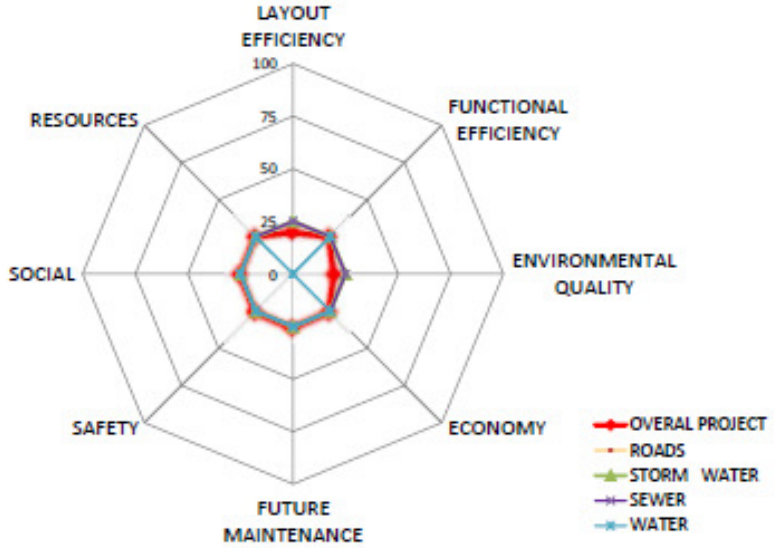
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sunnyside-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROOP

CIVIL INFRASTRUCTURE GREEN GOAL REPORT

PERFORMANCE CATEGORIES	ROADS	40%	STORM WATER	20%	SEWER	20%	WATER	20%	Weighted Infrastructure
1 LAYOUT EFFICIENCY	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	No interventions to be undertaken	0	10%
2 FUNCTIONAL EFFICIENCY	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	20%
3 ENVIRONMENTAL QUALITY	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	No interventions to be undertaken	0	10%
4 ECONOMY	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	15%
5 FUTURE MAINTENANCE	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	10%
6 SAFETY	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	10%
7 SOCIAL	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	10%
8 RESOURCES	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	10%
9 CONSTRUCTION	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	Minimal interventions to be undertaken	25	5%
WEIGHTED SCORE		9.5		4.75		4.75		3.8	100%



SCORE	23	Bronze	Minimal interventions to be undertaken

RANGE OF SUSTAINABLE DEVELOPMENT GOALS			
Sustainable goal for development	Range of implementation choices	Status	Score
Best solution to the environment	Set new performance benchmark through new technological developments	PLATINUM	75 -100
Restricted damage to the environment	Doing what is achievable- through innovation and risk taking with new systems and technologies	GOLD	50 - 74
Some considerations for environment	Apply conventional and current state-of-practice	SILVER	25 - 49
Minimal interventions to be undertaken	Achieve compliance based on regulations	Bronze	

APPENDIX 19: Case Study 4: Preliminary Green Infrastructure Rating Report

INFRASTRUCTURE ELEMENTS						
ROADS		**40%**	**SEWER**		**20%**	
	Pts Av	**Pts Ach**		**Pts Av**	**Pts Ac**	
PC: LAYOUT EFFICIENCY	8	2		8	1	
Typical service layout configuration	1	1	Typical service layout configuration	1	1	
landscaping and all public utilities	1		Layout promote midblock sewer> 30% midblock	1		
Promote concept of green streets	1		<10% of length of Sewer pipeline in floodline	1		
Ecological Connectivity-Open spaces and circulation system	1		Avoidance of pumpstations	1		
layout facilitates economical subdivision and min. intersections	1	1	Alternative Route alignments	1		
Design the internal street layout to inhibit through-traffic	1		Catchment planning	1		
Increased diversity in road reserve through distinction between s	1		Contour layout planning	1		
Roads aligned with natural topography	1		Sewer lines planned one catchment at a time	1		
RESOURCES	7	1		7	1	
Alternative Surfacing technologies -Permeable pav/Grass blocks	1		Backfill - non commercial source	1		
Tree conservation <1tree/ha removed	1		Use of onsite materials for Bedding	1		
Re-Use of Pavement Layerworks	1		Manhole sealed in the floodline	1		
Alt Transportation Options such as bicycles, light rail, NMT	1		Pipe material - use of pvc/hdpe vs. /concrete/steel	1		
Earthworks- balanced -Cut / Fill <20% spoil	1		The avoidance of the use of pumpstations	1		
Use of Recycled materials	1		Use of Recycled materials	1		
Conventional use of resources	1	1	Conventional use of resources	1	1	
ENVIRONMENT QUALITY	8	1		8	1	
Some consideration for reducing envir impact. in the design	1	1	Some consideration for reducing envir impact. in the des	1	1	
Minimal of valley crossings < 1/km	1		<20% pipeline positioned in the flood plains	1		
ramps and paving	1		manholes, outlets, fittings	1		
Erosion control measures @ all outlets	1		Measures to control factors governing odour and noise	1		
Landscaping: Use of Water efficient plantings	1		Provision for protecting surface & sub surface water bodi	1		
Clearing and grading (Site Vegetation) limited to road footprint o	1		Flood protection of pumpstation and pipeline	1		
Noise reduction through Quiet Pavement, traffic reduction on int	1		Is the development density < the environmental capacity	1		
Habitat Restoration	1		Waste effluent quality monitoring measures	1		
FUNCTIONALITY EFFICIENCY	11	1		11	1	
Conventional systems that achieve minimum compliance	1	1	Conventional systems that achieve minimum compliance	1	1	
Use of Drainage and storage functions of roads	1		Primary greywater reuse	1		
Use of Pedestrian / bicycle paths	1		Oil/grease/grit separators	1		
Is the av. road grad/m <5%/m	1		Onsite sewage disposal-Recycle/composting	1		
Innovation- eg. Use of Permeable pavements	1		Secondary greywater reuse	1		
Low impact Development technologies- roads	1		Low impact Development technologies- Sewer	1		
automatic right of way on higher order roads	1		Nutrient resource recovery & reuse	1		
Parking ratios/codes/parking lots	1		Avoid Flat gradients (20% that is <1: 100)- stagnation	1		
Use of street furniture for a positive contribution to area	1		Are the manholes that are in the 1:100 yr. floodline seale	1		
Roadway system design to be self-cleaning	1		Sanitation system design to have self-cleaning velocity	1		
Additional lanes at major intersections-reduce peak quantity	1		Sewer attenuation-reduce peak quantity	1		
FUTURE MAINTENANCE	8	1		7	1	
Some consideration of maintenance in the design of the service	1	1	Some consideration of maintenance in the design of the	1	1	
Maintenance of grass- pioneer grass used	1		Provisions for future expansion of the system	1		
Bank slopes must be gentle >1:1.75	1		Are pipeline susceptible to erosion protected	1		
Pavement lifecycle design >20yrs	1		Service aligned with road/property boundary>80%	1		
Site Vegetation-low water	1		Services watertight	1		
Alternative access for the repair of services	1		Easy access and room for the repair	1		
Type of trees planted allows for minimal leaves to fall	1		Erf have a rodding eye	1		
Street marking- high quality luminous paint	1					
ECONOMY	7	2		7	1	
Some consideration of economy in the design of the service	1	1	Some consideration of economy in the design of the serv	1	1	
Most economic system/service for target market	1	1	Most economic system/service for target market	1		
Minimized the number of road intersections	1		Av Trench Depth <2m in over total length	1		
Are narrower, shorter streets used	1		Av. manhole spacing >50m	1		
Too Curvilinear roads increases no of manholes	1		Use of shared trenches> 30%	1		
Conduct Life-Cycle Cost Analyses	1		erf alignments as straight as possible to reduce sewer m	1		
Is the area devoted to streets minimal- min road widths/reserves	1		Pipe material - pvc/concrete/hdpe.	1		
SAFETY	7	1		5	1	
Some consideration of safety in the design of the service	1	1	Some consideration of safety in the design of the service	1	1	
Traffic calming measures	1		<10% of length >3m Trench Depth	1		
Signage and pedestrian friendliness	1		Position in relation to water pipe >1m away	1		
the street is designed as a safe and unique public space	1		Compatibility with storm water management	1		
Segregate pedestrians, cyclists and vehicles where traffic speeds/volumes high	1		Measures to reduce the incidence ;spreading of diseases by waste	1		
Road safety Audit	1					
Safe Intersection-site distance, sidewalks, crosswalks, other inte	1					
SOCIAL	8	2		4	1	
neighbourhoods	1		ERF access to sewers	1		
Educational Outreach plan - road safety - to community	1		Educational Outreach plan -awareness on Health and sa	1		
Public participation in all stages of the project	1	1	Public participation in all stages of the project	1		
Public transport facilities and provision of street furniture	1		Provision of employment to local community >100 perso	1	1	
Universal access-layout cater for disabled-Wheelchairs and elde	1					
Provision of employment to local community >100 person days	1	1				
Measures to preserve Cultural Heritage	1					
Provision of social amenities to the community	1					
CONSTRUCTION EFFICIENCY	6	0		1	0	
Environmental management Process, plan and training	1		Sewer Management Plan	1		
Site Waste management plan	1					
Pavement Management System	1					
Quality Management System	1					
Site maintenance plan	1					
Equipment Emissions Reduction Plan	1					
WEIGHTED SCORES	100	15		100	12.86	
Minimal interventions to be undertaken- Achieve compliance based on regulations				23		

STORMWATER		20%	WATER	20%	100%	Weighted
	Pts Av	Pts Ach		Pts Av	Pts Ach	
	8	1		8	4	10%
Typical service layout configuration	1	1	Typical service layout configuration	1	1	
Use of Green corridors-Natural drainage paths	1		Pipe route alignment- looped network efficiency	1		
stormwater pipeline in floodline <10% of total length	1		Water pipeline in floodline <10% of total length of pipe	1	1	
Multipurpose Attenuation facilities-for retarding sw	1		Location & Spacing of Fire hydrants have a minimum overlap	1	1	
land use intensities matched to landscape tolerances for sw	1		layout relate to the water pressure zones	1		
SWMP initiated at start of planning for land uses	1		Minimal no of dead-ends to ensure flushing/no stagnation	1		
servitudes for safe, acceptable points of discharge.	1		land uses-high demands & fire risk close to water supply	1		
Reduced SW concentration & hydrological impact	1		Bulk service routed on roads or minimum 5m servitudes	1	1	
	7	1		7	3	10%
Pipe material - use of pvc/hdpe vs. /concrete/steel	1		Water demand management measures	1		
Use of onsite materials for Bedding	1		Zone and bulk smart metering	1		
Manhole types- brick/precast	1		Use of onsite materials for Bedding	1	1	
Rain water harvesting and Reuse	1		Use of Present & future water consumption figures	1	1	
Runoff quantity control	1		Promote use Water Efficient fixtures/Appliances	1		
Recycled materials to construct of SW channels/manholes/	1		Rain water harvesting	1		
Conventional use of resources	1	1	Conventional use of resources	1	1	
	8	1		7	3	10%
Some consideration for reducing envir impact. in the design	1	1	Some consideration for reducing envir impact. in the design	1	1	
Post Development < Predev Flow	1		Protect against water contamination	1	1	
manholes, outlets, fittings	1		manholes, outlets, fittings that is not obtrusive	1		
Recharge rates maintained	1		low-level water audits	1		
Protection measures of wetlands- stagnant water	1		Scour valves positioned for safe discharge- erosion	1	1	
Runoff quality-Constructed Wetlands/filters	1		Reticulated recycled water supply	1		
Minimize soil erosion; by good vegetation along the water c	1		Water-Wise Gardening	1		
Increased roughness of drainage way to decrease the veloc	1					
	11	2		11	2	20%
Conventional systems that achieve minimum compliance	1	1	Conventional systems that achieve minimum compliance	1	1	
Quality control at source-from residential rooftop by discon	1		Water-Efficient Irrigation & landscaping measures	1		
SW attenuation-reduce peak quantity	1		Use of Roof tank/intermediate storage	1		
Stormwater Management Plan	1		Pressure Management as part of design-Balanced loss/increa	1		
Bioretention swales/ponds/infiltration berms	1		Dry Fire Hydrants. suction pipe systems from pond	1		
Low impact Development technologies- SW	1		Water efficient fittings	1		
Erosion control(Geotextile/cells, gabions)	1		water attenuation-reduce peak quantity	1		
Sediment control- Silt fences/Stilling basin	1		Watertight joints/compression type coupling/Seals quality	1		
Is the av. channel grad/m <5%/m-high velocities	1		Efficient water systems design-Optimised flow/velocity in pipe	1		
Use of roads & parking to control drainage & storage	1		Water reticulation design to be self-cleaning	1	1	
Are channels lined -earth,-grass, concrete, grass	1	1	Water hammer analysis	1		
	8	2		8	1	10%
Some consideration of maintenance in the design of the ser	1	1	Some consideration of maintenance in the design of the servi	1	1	
Is the design-manholes, pipes and catchpits sized for main	1		Sleeves used where pipes cross the road	1		
Flood plain accessible	1	1	Services Watertight joints/Seals quality	1		
Pipe loading in all areas checked	1		Positioning of trees - proximity of services	1		
Stormwater system design to be self-cleaning	1		Isolation Valves/Meters located in convenient positions @ 90	1		
Easy access and room for the repair of services	1		Easy access and room for the repair of services	1		
Positioning of trees in close proximity of services > 20m	1		Leak Detection devices in retic.	1		
Inlet/outlet design to reduce blockages	1		Provisions for future expansion of the system	1		
	8	2		8	3	15%
Some consideration of economy in the design of the service	1	1	Some consideration of economy in the design of the service	1	1	
Most economic system/service for target market	1		Most economic system/service for target market	1		
Non structural controls	1		Use of shared trenches >20%	1		
Use of shared trenches >20%	1		Max. hydrants, airvalve spacing av spacing- 200m	1		
Av. manhole spacing >50m	1		Av Trench Depth <1.2m in over total length	1		
Multipurpose stormwater facilities	1		Conduct Life-Cycle Cost Analyses	1		
Pipe material - pvc/concrete/hdpe.	1		Pipe material - pvc/concrete/hdpe.	1	1	
Av Trench Depth <2m in over total length	1	1	Are the air valves , shut off valves in valve rings	1	1	
	6	1		6	5	10%
Some consideration of safety in the design of the service	1	1	Some consideration of safety in the design of the service	1	1	
<10% of length >3m Trench Depth	1		<10% of length >3m Trench Depth	1	1	
Velocity /depth of stormwater flowing	1		Supply sufficient for fire fighting requirements	1		
Safe discharge routes	1		Fire risk -High/medium or low	1	1	
Design accommodates various storm frequencies	1		located close to bulk water supply points	1	1	
Flood warning signs	1		Pressure on pipeline<9bar	1	1	
	6	2		4	1	5%
convenience- minor system designed for high-frequency sto	1		Provision of employment to local community >100 person day	1	1	
Education and awareness- Rainwater harvesting	1		Educational Outreach plan - water conservation	1		
Public participation in all stages of the project	1		Public participation in all stages of the project	1		
No Inconvenience of overland flow and Temporary storage	1		Standpipes located in convenient positions along walkways.	1		
Is access to river walks and open spaces	1	1				
Provision of employment to local community >100 person da	1	1				
	2	1		1	0	5%
Pre construction Stormwater Management Plan	1	1	Water Operational plan	1		
Siltation control with Sand and hessian bags or Silt fences	1					
	100	19.33		100	34.5	23
Minimal interventions to be undertaken- Achieve compliance based on regulations					Bronze	23

APPENDIX 20: Case Study 4: Detailed Green Infrastructure Rating Analysis Report

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sunnyside-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SARC

INFRASTRUCTURE ELEMENT- ROADS			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**1.3**
1	Typical service layout configuration	no	0.00	
		yes	0.63	0.63
2	Does the layout promote concept of greenstreets	no	0.00	
		yes	0.63	
3	Does the layout facilitate economical subdivisions, with the use of shared road infrastructure	no	0.00	
		yes	0.63	0.63
4	• Layout integrates the circulation system with dwellings, landscaping and all public utilities	no	0.00	
		yes	0.63	
5	• the percentage township area devoted to roads, parking and footways <30% of total area	no	0.00	
		yes	0.63	
6	• Is there minimum interruption from access movements, intersections, to achieve good mobility, Access road >100m apart	no	0.00	
		yes	0.63	
7	• Provide public transport routes which minimize operating costs while satisfying user requirements for convenience	no	0.00	
		yes	0.63	
8	• Provide reserve widths and alignments which cater for all road users, for services for landscaping, in the most economical way.	no	0.00	
		yes	0.63	
9	• Relate the spacing and layout of intersections to the probable vehicle type, the volume and direction of movement	no	0.00	
		yes	0.63	
10	• Ecological Connectivity-Open spaces and circulation system-integral part of the open space system and appropriate landscaping provided for	no	0.00	
		yes	0.63	
11	• Are short-distance links (<1km) between adjacent neighbourhoods	no	0.00	
		yes	0.63	
12	• Does the road hierarchy requirements provide automatic right-of-way for traffic on higher order roads. additional lanes at intersections provided for to reduce peak traffic with minimum interruption	no	0.00	
		yes	0.63	
13	Design the internal street layout to inhibit through-traffic	no	0.00	
		yes	0.63	
14	• Garages and urban collectors located away from residents, to minimize nuisance to residents from noise, dust and fumes	no	0.00	
		yes	0.63	
15	• Develop the road aligned to the natural topography	no	0.00	
		yes	0.63	
16	• Increase diversity in road reserve. Design and make distinction between sidewalk zone, cycle areas, pedestrian area, refuse areas, planters, lighting, etc.	no	0.00	
		yes	0.63	
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**3.0**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.00	1.00
2	The use of Innovative design techniques, such as the use geogrids to reduce layer thickness, increase pavement life, bearing capacity, differential settlement, etc.	no	0.00	
		yes	1.00	
3	The use of Low impact Development technologies on roads	no	0.00	
		yes	1.00	
4	Are the street furniture well designed items, and placed so as to make a positive contribution to the total street picture	no	0.00	
		yes	1.00	
5	Are there cycle lanes	no	0.00	
		yes	1.00	
6	Are there special details for the design of all road elements, including kerbing, channelling, ramps and different types of paving.eg. Brick paving compared to concrete and asphalt as it creates	no	0.00	
		yes	1.00	
7	Are landscaping and trees used to reduce the impact of large areas of asphalt	no	0.00	
		yes	1.00	
8	Is the potential drainage function of roads maximized by co-ordinating their layouts with the drainage systems.	no	0.00	
		yes	1.00	
9	• Where appropriate, are the medians-<1.5m for safety	no	0.00	
		yes	1.00	
10	• Is the maximum road crown slope(4%)-operation problem driving, wear of vehicles <20% of the total road length	no	0.00	
		yes	1.00	
11	• Is the minimum road crown slope(2%) - prevents sediment loading <5% of the total road length	no	0.00	
		yes	1.00	
12	• Additional lanes at major intersections-reduce peak quantity	no	0.00	
		yes	1.00	
13	• Is the average road grad/m less than 5%/m	no	0.00	
		yes	1.00	
14	• Are parking areas provided (according to Parking ratios/codes) where road will be well trafficked and where appropriate consist of grass blocks, gravel, paving to give it a softer park like image	no	0.00	
		yes	1.00	

	Pedestrian routes			
15	• Do the pedestrian routes minimize walking distances and encourage pedestrian use	no	0.00	
		yes	1.00	
16	• Are there pedestrian facilities (such as sidewalks and crossings)	no	0.00	
		yes	1.00	
17	The project layout promotes walking and discourages the use of vehicles.	no	0.00	
		yes	1.00	
	Bus stops			
18	• Are bus bays provided at major bus stops to minimize delays to other traffic	no	0.00	
		yes	1.00	1.00
19	• Provide shelter against rain, sun, wind as well as benches or a space for resting or eating while waiting for transportation and signage integrated with shelters	no	0.00	
		yes	1.00	
20	• Are gradients designed appropriate to the mode/s of transport using the Bus route (<6%)	no	0.00	
		yes	1.00	1.00
	3.0 Environmental quality		**15.0**	**3.2**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.07	1.07
2	Noise reduction through Quiet Pavement, traffic reduction on internal streets	no	0.00	
		yes	1.07	1.07
3	• Use of surfacing on roads - Concrete vs. asphalt increases volumetric heat capacities, lower air temperatures	no	0.00	
		yes	1.07	
4	Habitat Restoration measures used	no	0.00	
		yes	1.07	
5	• Provide aesthetic kerbing, channelling, pedestrian refuges, ramps and paving	no	0.00	
		yes	1.07	
6	• Permeable road surface/parking lots -grass blocks- selection of surfacing that has a reduced environmental impact relative to available alternatives.	no	0.00	
		yes	1.07	
7	Does the project layout provides a safe, convenient and attractive environment for walking.	no	0.00	
		yes	1.07	
8	• Preserve natural features such as gullies, outcrops, marshes and existing trees, shrubs and hedges in the layout to create interest, variety and surprise in the vistas along the and along the streets.	no	0.00	
		yes	1.07	
9	Are erosion control measures used in the design of earthworks on steep areas, such as the use of sand bags or Hessian sheets, rehabilitation of exposed soil areas, soil is protected from the	no	0.00	
		yes	1.07	
10	Clearing and grading (Site Vegetation) - road footprint/topsoil removed <50% of road reserve	no	0.00	
		yes	1.07	
11	• Is a variety of access street forms provided to avoid monotony	no	0.00	
		yes	1.07	
12	would there be stock piling of soil or any other materials near a watercourse	yes	0.00	
		no	1.07	
13	Landscaping: Use of Water efficient plantings	yes	0.00	
		no	1.07	
14	Are areas sensitive to erosion such as near water supply points and edges of slopes being developed.	yes	0.00	
		no	1.07	1.07
	4.0 Economy		**15.0**	**8.2**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	1.36
2	Most economic system/service for target market	no	0.00	
		yes	1.36	1.36
3	• Can the number of road intersections be minimized through layout configuration	yes	0.00	
		no	1.36	
4	Are the roads too Curvilinear roads- increased no of manholes, kerb lengths	yes	0.00	
		no	1.36	
5	• Are the public transport routes optimized;	no	0.00	
		yes	1.36	
6	• Are the widths of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
7	• Is the alignment of roadways utilise the maximum criteria in order to reduce earthworks, in with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
8	• Is the pavement foundation design of roadways the minimum commensurate with the desired speed and expected volume and composition of traffic	no	0.00	
		yes	1.36	1.36
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.36	
10	Earthworks- balanced-Cut / Fill <1000m3 spoil	no	0.00	
		yes	1.36	
11	• Can the total length and cost of internal roads be minimized	yes	0.00	
		no	1.36	1.36

	5.0 FUTURE MAINTENANCE		**10.0**	**1.0**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.00	1.00
2	• Acceptable pioneer grasses(cynodindactolin) and reeds where applicable	no	0.00	
		yes	1.00	
3	Type of trees planted allows for minimal leaves to fall and clog up drains	no	0.00	
		yes	1.00	
4	Landscaping: Use of Water efficient plantings	no	0.00	
		yes	1.00	
5	• -Bank slopes must be gentle to allow access for maintenance >1:1.75	no	0.00	
		yes	1.00	
6	• Life span of the road pavement >20 years	no	0.00	
		yes	1.00	
7	• Street marking- high quality luminous paint	no	0.00	
		yes	1.00	
8	Alternative access for the repair of road or road closure	no	0.00	
		yes	1.00	
9	High quality Street signage - minimal maintenance >2m from trees/shrubs	no	0.00	
		yes	1.00	
10	Are there subsurface water drainage systems in 80% of cuts >2m to protect road pavements - minimal maintenance of road layerworks	no	0.00	
		yes	1.00	
	6.0 SAFETY		**10.0**	**1.3**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	0.67	0.67
2	Adequate sight distances at intersections, horizontal curves and crests are commensurate with operating speeds	no	0.00	
		yes	0.67	
3	• Universal access at Intersections-designed to be safe for pedestrians and vehicles. This includes sidewalks, crosswalks, traffic signals and other intersection treatment	no	0.00	
		yes	0.67	
4	• Inhibit through-traffic in internal streets/neighbourhoods	no	0.00	
		yes	0.67	
5	• Segregate pedestrians, cyclists and vehicles where traffic is concentrated or speeds and volumes are high	no	0.00	
		yes	0.67	
6	Traffic calming measures used such as Speed humps, chicanes, street narrowing devices, change in the surface colour or texture, in the immediate vicinity of homes.	no	0.00	
		yes	0.67	
7	• Provide access points to multiple units dwellings only at selected points to control and concentrate traffic	no	0.00	
		yes	0.67	
8	• Provide turning spaces which avoid the need for vehicles to reverse over long distances.	no	0.00	
		yes	0.67	0.67
9	• Are there pedestrian crossings and sidewalks with adequate signage	no	0.00	
		yes	0.67	
10	Road safety Audit undertaken	no	0.00	
		yes	0.67	
11	• Provide mutual visibility between pedestrians and moving vehicles with traffic on main roads;	no	0.00	
		yes	0.67	
12	• is there a potential conflict areas between roads users, pedestrian and cyclists	yes	0.00	
		no	0.67	
13	• Design soft mounds, and plant trees to separate pedestrian from buildings and road	no	0.00	
		yes	0.67	
14	Convenience- Traffic-generating facilities located near entrances to residential areas or adjacent to higher order roads	no	0.00	
		yes	0.67	
15	Are the pedestrian system and parking areas located where they will be overlooked by dwellings or passing traffic and well-lit after dark for greater security	no	0.00	
		yes	0.67	
	7.0 SOCIAL		**5.0**	**2.5**
1	Does the road contribute to development of previously underdeveloped areas	no	0.00	
		yes	0.63	0.63
2	Educational Outreach plan - road safety	no	0.00	
		yes	0.63	
3	• Ensure that pedestrian crossings on distributor roads are convenient to use	no	0.00	
		yes	0.63	
4	• Minimize distances of pedestrian routes <15min walking time;	no	0.00	
		yes	0.63	
5	Provision of social amenities to the community	no	0.00	
		yes	0.63	
6	• Does the layout cater for disabled and Wheelchairs and elders that may want to sit down	no	0.00	
		yes	0.63	0.63
7	Provision of employment to local community >100 person days	no	0.00	
		yes	0.63	0.63
8	Use of Public transport facilities and provision of street furniture	no	0.00	
		yes	0.63	0.63

	8.0 RESOURCES		10.0	2.2
1	Conventional use of resources	no	0.00	
		yes	1.11	1.11
2	Use of Recycled road materials in the layerworks	no	0.00	
		yes	1.11	
3	Is the Kerbing cast insitu or precast	precast	0.00	
		insitu	1.11	
4	Design initiatives that increase the facilitate reused building materials, Recycled materials and	no	0.00	
		yes	1.11	
5	Tree conservation- no of trees <10/ha	no	0.00	
		yes	1.11	
6	Earthworks- balanced -Cut / Fill <20% spoil	no	0.00	
		yes	1.11	
7	Promoting Alternative Transportation Options such as bicycles, light rail, Non Motorized Transport	no	0.00	
		yes	1.11	
8	Use of alternative Surfacing other than hot mix asphalt, such as Permeable pave/Grass blocks/porous concrete	no	0.00	
		yes	1.11	
9	Reuse existing materials onsite to minimise materials consumption	no	0.00	
		yes	1.11	1.11
	9.0 CONSTRUCTION		**5.0**	**0.7**
1	Environmental management Process, plan and training	no	0.00	
		yes	0.71	0.71
2	Site Waste management plan	no	0.00	
		yes	0.71	
3	Pavement Management System	no	0.00	
		yes	0.71	
4	Quality Management System	no	0.00	
		yes	0.71	
5	Site maintenance plan	no	0.00	
		yes	0.71	
6	Equipment Emissions Reduction Plan	no	0.00	
		yes	0.71	
7	• Stockpiles <1000m3 (Hugh stockpiles create dust in wind)	no	0.00	
		yes	0.71	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sunnyside-Low Cost Housing Project | Date: 04 April 2013
Client: xxxxx | Compiled by: SHIAN S

	INFRASTRUCTURE ELEMENT- STORMWATER		Scoring	
	1.0 LAYOUT EFFECIENCY		**10.0**	**1.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	1.00
2	• Does the layout consider hydrological concerns with regards to sw runoff and relationship to plot size, type of land use	no	0.00	
		yes	1.00	
3	• Does the layout plan take into account the natural drainage paths(Stream patterns), areas subject to flooding	no	0.00	
		yes	1.00	
4	• Are the land use intensities matched to landscape tolerances for swmp	no	0.00	
		yes	1.00	
5	are the stormwater facilities Integrated with recreation areas;	no	0.00	
		yes	1.00	
6	• Does the swmp use open spaces for retarding or stormwater evaporation ponds to remove partially treated water	no	0.00	
		yes	1.00	
7	is the length of Storm water services located in special servitudes and not located in road reserve <10% of total length	no	0.00	
		yes	1.00	
8	stormwater pipeline in floodline <10% of total length	no	0.00	
		yes	1.00	
9	• Does the layout reduce the hydrological impact of the development by reducing stormwater concentration	no	0.00	
		yes	1.00	
10	• Was the mdp initiated at start of planning for land uses	no	0.00	
		yes	1.00	
	2.0 FUNCTIONAL EFFECIENCY		**20.0**	**1.48**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	**0.74**	**0.74**
2	• Provision of surface water management system to ensure that the ultimate flow from the development does not result in any negative impacts on downstream properties or watercourse and is managed within the overall site	no	0.00	
		yes	**0.74**	
3	• Has the Master drainage plans been prepared, in collaboration with adjoining communities and authorities, for the existing and future development of the entire catchments	no	0.00	
		yes	**0.74**	
4	Is >70% of the road designed for sheetflow	no	0.00	
		yes	**0.74**	
5	Is the maximum velocity <3m/s	no	0.00	
		yes	**0.74**	
6	<10% of roads have a maximum road gradient >12%	no	0.00	
		yes	**0.74**	
7	• What is the minimum road crown slope- <2%- sediment	no	0.00	
		yes	**0.74**	
8	Is the maximum road crown slope- <3%-operation problem driving, ware of vehicles	no	0.00	
		yes	**0.74**	
9	• Are the potential drainage and storage functions of roads, roadside channels used	no	0.00	
		yes	**0.74**	
10	Is >50% of the road gradients <2% - used for retarding stormwater run-off	no	0.00	
		yes	**0.74**	
11	• Is the post development limited to predevelopment	no	0.00	
		yes	**0.74**	**0.74**
12	• Is the roadside channels designed to prevent erosion	no	0.00	
		yes	**0.74**	
13	• Is the stormwater flow depths < 0.5m	no	0.00	
		yes	**0.74**	
14	• Inlet- are the backwater effects designed for	no	0.00	
		yes	**0.74**	
15	• are the inlets/pond have swing type grids or are self cleansing to prevent blockages	no	0.00	
		yes	**0.74**	
16	Quality control at the source-from residential rooftop by disconnecting downpipe, Rain Barrels, soakaway-Prevent pollutant dumping	no	0.00	
		yes	**0.74**	
17	• Does the reticulation limit runoff volumes with the use of bioswales filtering pollution	no	0.00	
		yes	**0.74**	
18	• Does the reticulation limit volumes with the use of retention basin	no	0.00	
		yes	**0.74**	
19	Are velocities reduced with the use of Check dams	no	0.00	
		yes	**0.74**	
20	• Does the reticulation limit runoff volumes with the use of Porous parking surfaces	no	0.00	
		yes	**0.74**	
21	• In areas where the subsoil and water table are suitable, does the design the surfaces of storage areas allow for the re-charging of the underground water.	no	0.00	
		yes	**0.74**	
22	Are flood plains and watercourses protected from erosion with Gabions, dissipaters, Reno mattress, stilling basins, Check weir, Riprap protection, Energy reduction, Drop structures, Rip rap basins,	no	0.00	
		yes	**0.74**	

23	• Are there measures to prevent underground conduits from silting up	no	0.00	
		yes	0.74	
24	• Are channels lined -earth,-grass, concrete, grass	no	0.00	
		yes	0.74	
25	• Is the average channel slopes -<5%	no	0.00	
		yes	0.74	
26	• Are the stormwater outlet structures designed to decrease flow velocity by the use of velocity dissipaters	no	0.00	
		yes	0.74	
27	Sediment control- Silt fences/Stilling basin	no	0.00	
		yes	0.74	
	3.0 ENVIROMENTAL QUALITY		**15.0**	**1.2**
	Erosion control measures			
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.15	1.15
2	• Protection of environmentally sensitive areas;	no	0.00	
		yes	1.15	
3	• Predevelopment ground water Recharge rates are maintained;	no	0.00	
		yes	1.15	
4	SW pipes steeper than 1:3 <10% of the total length	no	0.00	
		yes	1.15	
5	• Consolidate waterways and open space requirements;	no	0.00	
		yes	1.15	
6	• Minimize soil erosion; by good vegetation along the water courses	no	0.00	
		yes	1.15	
7	• Buffer zone>25m between hard and watercourse areas	no	0.00	
		yes	1.15	
8	• Rehabilitation of exposed soil areas to ensure soil protection	no	0.00	
		yes	1.15	
9	• Removal of vegetation on steep areas	yes	0.00	
		no	1.15	
10	Protection measures of wetlands- stagnant water- may become health hazards-Is there a potential of Nutrient enrichment- eutrophication	no	0.00	
		yes	1.15	
11	SW quality treatment with the use storage facilities, Constructed Wetlands/filters	no	0.00	
		yes	1.15	
12	• Increased roughness of the channel or drainage way to decrease the velocity	no	0.00	
		yes	1.15	
13	• Subsurface disposal is not to close to point of rainfall >200m	no	0.00	
		yes	1.15	
	4.0 ECONOMY		**15.0**	**1.7**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.67	1.67
2	• What type of system is being used	>50% piped	0.00	
		<50% piped	1.67	
3	The use of non-structural control as in relation to structural control of SW.	no	0.00	
		yes	1.67	
4	• Does the reticulation have multipurpose stormwater facilities	no	0.00	
		yes	1.67	
5	• Does the SWMP provide a few, large areas for retaining stormwater, rather than many smaller areas which are more problematic to maintain.	no	0.00	
		yes	1.67	
6	• Does the SWMP attempt to align open drainage systems with natural drainage systems, to minimize the cost of earthworks and pipe works.	no	0.00	
		yes	1.67	
7	• Are the manhole spaced at an the Av. manhole spacing >50m	no	0.00	
		yes	1.67	
8	Is there >30% of shared trenches in relation to separate trenches	no	0.00	
		yes	1.67	
9	Trench Depth <10% of length >3m	no	0.00	
		yes	1.67	
	5.0 FUTURE MAINTENANCE		**10.0**	**1.3**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.67	0.67
2	• Are there any services placed in a location that is not easily accessible by public fo rmaintence	yes	0.00	
		no	0.67	
3	• Was the mdp prepared in collaboration with authorizes for future developments	no	0.00	
		yes	0.67	
4	• Is the flood plain accessible to public for maintenance	no	0.00	
		yes	0.67	
5	• Is the design-manholes, pipes and catchpits sized for maintenance	no	0.00	
		yes	0.67	
6	• Are the bulk services routed on roads or minimum 5m servitudes	no	0.00	
		yes	0.67	

7	• Pipe loading in all areas checked	no	0.00	
		yes	0.67	
8	• If services are in midblock, is a 5m building line imposed	no	0.00	
		yes	0.67	
9	• Is due regard for positioning of trees in close proximity of services > 20m	no	0.00	
		yes	0.67	
10	• Are sleeves used where pipes cross the road	no	0.00	
		yes	0.67	
11	• Are the pipes susceptable to erosion protected	no	0.00	
		yes	0.67	
12	• Are the open drains in in >6% lined	no	0.00	
		yes	0.67	
13	• pipes across road >100D	no	0.00	
		yes	0.67	0.67
14	- is there an acceptable pioneer grass (cynodindactolin) and reeds established where applicable	no	0.00	
		yes	0.67	
15	• Does the Inlet structures designed to reduce clogging, self cleansing, not designed to overflow	no	0.00	
		yes	0.67	
	6.0 SAFETY		**10.0**	**1.0**
	Aim- Risk of loss of life and significant damage to properties from the run off from the exception heavy			
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.00	1.00
2	• Does the drainage system manage the planned development for the upstream areas, for storms ranging from frequent to rare events?	no	0.00	
		yes	1.00	
3	• Are there safe discharge routes provided for stormwater overland flow. Would the overflow from storage areas protect the downstream property from being inundated.	no	0.00	
		yes	1.00	
4	• In areas susceptible to flooding, is the velocity and/or depth of stormwater flowing in or across streets is within safe limits, with particular attention to potential traffic hazard on higher speed roads.	no	0.00	
		yes	1.00	
5	• Are storms >1:20 yr frequencies accommodated within the design;	no	0.00	
		yes	1.00	
6	•-are the elevation of infrastructure & buildings above the 100yr floodline	no	0.00	
		yes	1.00	
7	• are the manhole covers sealing in flood sensitive areas	no	0.00	
		yes	1.00	
8	• are the any building that have Installation of pumps for stormwater	yes	0.00	
		no	1.00	
9	<10% of length >3m Trench Depth	no	0.00	
		yes	1.00	
10	are there flood warning signs informing public of approaching hazards	no	0.00	
		yes	1.00	
	7.0 SOCIAL		**5.0**	**0.8**
1	• Are the minor system designed for high-frequency storms; so that there is no inconvenience of overland flow routes	no	0.00	
		yes	0.83	
2	• Are the temporary storage areas for stormwater in places where the water would not cause inconvenience during or immediately after storms.	no	0.00	
		yes	0.83	
3	• Is access to river walks and open spaces allowed;	no	0.00	
		yes	0.83	
4	Education and awareness- Rainwater harvesting	no	0.00	
		yes	0.83	
5	Public participation in all stages of the project	no	0.00	
		yes	0.83	
6	• Provision of employment to local community >100 person days	no	0.00	
		yes	0.83	0.83
	8.0 RESOURCES		**10.0**	**2.2**
1	Conventional use of resources	no	0.00	
		yes	1.11	1.11
2	• Use of onsite materials for bedding	no	0.00	
		yes	1.11	
3	• Use of onsite materials for backfill	no	0.00	
		yes	1.11	1.11
4	Runoff quantity control measures	no	0.00	
		yes	1.11	
5	Rain water harvesting and Reuse -recycled stormwater for irrigation	no	0.00	
		yes	1.11	
6	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc,	1.11	
7	Does the sytem recharge groundwater	no	0.00	
		yes	1.11	
8	• manhole types-	brick	0.00	
		precast	1.11	
9	Recycled materials to construct of SW channels	no	0.00	
		yes	1.11	
	9.0 CONSTRUCTION		**5.0**	**0.0**
1	Pre construction Stormwater Management Plan	no	0.00	
		yes	1.67	
2	Education and awareness- Rainwater harvesting	no	0.00	
		yes	1.67	
3	Minimize erosion and control siltation with Sand and hessian bags or Silt fences	no	0.00	
		yes	1.67	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sunnyside-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAR

INFRASTRUCTURE ELEMENT- SEWER			Scoring	
1.0	**LAYOUT EFFICIENCY**		**10.0**	**3.3**
1	Typical service layout configuration	no	0.00	
		yes	1.11	1.11
2	• Can pumpstations be avoided through the layout reorientation	no	0.00	
		yes	1.11	
3	• Does the layout promote midblock sewer	no	0.00	
		yes	1.11	1.11
4	• Are alternative sewer layouts considered;	no	0.00	
		yes	1.11	
5	Are the Bulk service routed on roads or minimum 5m servitudes If services are in midblock, a 5m building line imposed	no	0.00	
		yes	1.11	
6	Is there a Sewer Catchment Management Plan been done	no	0.00	
		yes	1.11	
7	<10% of total length of Sewer pipeline in floodline	no	0.00	
		yes	1.11	
8	• Is the development Phased in one catchment at a time	no	0.00	
		yes	1.11	1.11
9	Did the layout consider the positioning of trees in close proximity of services >20m	no	0.00	
		yes	1.11	
2.0	**FUNCTIONAL EFFICIENCY**		**20.0**	**1.2**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.18	1.18
2	• Does the development contain a grey / black water water reuse system	no	0.00	
		yes	1.18	
3	• Does the development contain Secondary greywater reuse	no	0.00	
		yes	1.18	
4	• Are sewers designed to gradients which are steep enough to ensure adequate velocity for self-cleansing	no	0.00	
		yes	1.18	
5	use of Oil/grease/grit separators	no	0.00	
		yes	1.18	
6	• Does the development attempt to minimize discharge to the municipal sewerage system through sewer attenuation	no	0.00	
		yes	1.18	
7	Does the system attempt Nutrient resource recovery & reuse by Recycle/composting	no	0.00	
		yes	1.18	
8	Are there a potential areas >30% of length that are flat (1: 100) that can result in stagnation	yes	0.00	
		no	1.18	
9	Innovative wastewater technology	no	0.00	
		yes	1.18	
10	• Was the Geotechnical conditions taken into account in the design	no	0.00	
		yes	1.18	
11	• Does the Soil profile have good permeability	no	0.00	
		yes	1.18	
12	Are the manholes that are in the 1:100 yr. floodline sealed	no	0.00	
		yes	1.18	
13	• Does the evapotranspiration area in case of an overflow fall within the site	no	0.00	
		yes	1.18	
14	• Does the evapotranspiration area in case of an overflow fall within the wetland	yes	0.00	
		no	1.18	
15	• Is the av. topography >12%-steep slope problematic for sewage	yes	0.00	
		no	1.18	
16	Are there Soakaway/Sewer lines positioned <7.5m from drink water source	yes	0.00	
		no	1.18	
17	• Soakaway/Sewer lines positioned >5m from water table	no	0.00	
		yes	1.18	
3.0	**Environmental quality**		**15.0**	**1.5**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.50	1.50
2	Design a layout which minimizes nuisance to residents, provides attractive and healthy living conditions, and benefits the environment	no	0.00	
		yes	1.50	
3	Provision for protecting surface & sub surface water bodies from sewage	no	0.00	
		yes	1.50	
4	Provision of aesthetic sewer infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.50	
5	• Are <10% of sewerpipline positioned in the flood plains;	no	0.00	
		yes	1.50	

6	• Is the receiving sewer purification works clear >500m flood plains;	no	0.00	
		yes	1.50	
7	• Is there Erosion protection provided near water course	no	0.00	
		yes	1.50	
8	Waste effluent quality monitoring measures in place	no	0.00	
		yes	1.50	
9	• Are there measures taken to Minimize the obtrusiveness of pumping stations, sewer infrastructure and their environs	no	0.00	
		yes	1.50	
10	• Are there measures taken to control factors governing odour and noise emanating from pump stations and sewer infrastructure	no	0.00	
		yes	1.50	
4.0	**Economy**		**15.0**	**4.1**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	1.36	1.36
2	• Are the intersection spacing's and block lengths compatible with maximum manhole spacing's to minimize the number of manholes.	no	0.00	
		yes	1.36	
3	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.36	
4	• Is the percentage of sewer is mid-block sewer >30% of the total length	no	0.00	
		yes	1.36	
5	Av Trench Depth <2m in over total length	no	0.00	
		yes	1.36	
6	• Is the av manhole spacing's >50m	no	0.00	
		yes	1.36	
7	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc,	1.36	
8	• manhole types-	brick	0.00	
		precast	1.36	1.36
9	• Are there long lengths of sewers which cross or adjoin open space or undeveloped land.	yes	0.00	
		no	1.36	
10	• Are there shared trenches >30%	no	0.00	
		yes	1.36	1.36
11	• Are the roads or mid-block erf alignments as straight as possible to reduce sewer reticulation costs and minimize the number of manholes.	no	0.00	
		yes	1.36	
5.0	**FUTURE MAINTENANCE**		**10.0**	**1.3**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	1.25	1.25
2	• Are the pipe runs and cables in servitudes that are accessible for maintenance work.	no	0.00	
		yes	1.25	
3	Provisions for future expansion of the system	no	0.00	
		yes	1.25	
4	• Was there a lifecycle cost analysis done of the pipe and materials	no	0.00	
		yes	1.25	
5	Are pipeline susceptible to erosion protected	no	0.00	
		yes	1.25	
6	• Does every erf have a rodding eye in addition of inspection eye	no	0.00	
		yes	1.25	
7	Are all services watertight	no	0.00	
		yes	1.25	
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	1.25	
6.0	**Safety**		**10.0**	**1.7**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	1.67
2	Trench Depth >3m in <10% of length	no	0.00	
		yes	1.67	
3	Measures to Reduce the incidence , spreading of diseases by waste	no	0.00	
		yes	1.67	
4	Compatibility with storm water management	no	0.00	
		yes	1.67	
5	Manhole Depth >3m in <10% of length	no	0.00	
		yes	1.67	
6	Position of sewer pipe in relation to water pipe >90% of pipe not <1m away	no	0.00	
		yes	1.67	

7.0	**SOCIAL**		**5.0**	**3.8**
1	• Does every site have access to sewers	no	0.00	
		yes	1.25	1.25
2	Educational Outreach plan - health and sanitation	no	0.00	
		yes	1.25	
3	Public participation in all stages of the project	no	0.00	
		yes	1.25	1.25
4	Provision of employment to local community >100 person days	no	0.00	
		yes	1.25	1.25
8.0	**RESOURCES**		**10.0**	**3.6**
1	Conventional use of resources	no	0.00	
		yes	0.91	0.91
2	• Does the development use onsite materials for bedding	no	0.00	
		yes	0.91	
3	• Does the development use onsite materials for backfill	no	0.00	
		yes	0.91	0.91
4	Pipe material - use of pvc/hdpe vs. /concrete/steel	steel,	0.00	
		pvc,	0.91	0.91
5	• What manhole types are designed for - brick- precast	brick	0.00	
		precast	0.91	0.91
6	• Does the development have pumpstations	yes	0.00	
		no	0.91	
7	does the development have an irrigation system, that the Recycled sewer effluent can be used for irrigation	no	0.00	
		yes	0.91	
8	Does the development attempt to reduce the peak sewer demand (consumption	no	0.00	
		yes	0.91	
9	Is there Sewer attenuation	no	0.00	
		yes	0.91	
10	Was a Detailed investigation of existing services to assess the spare capacity of treatment woks, as well as the feasibility of upgrading undertaken.	no	0.00	
		yes	0.91	
11	Is the Recycled sewage used for fertilizer	no	0.00	
		yes	0.91	
9.0	**CONSTRUCTION**		**5.0**	**0.0**
1	Sewer Management Plan	no	0.00	
		yes	2.50	
2	Sewer Operational plan	no	0.00	
		yes	2.50	

THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sunnyside-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAR

	INFRASTRUCTURE ELEMENT- WATER			Scoring
	1.0 LAYOUT EFFECIENCY		**10.0**	**1.0**
1	Typical service layout configuration	no	0.00	
		yes	1.00	1.00
2	• Are the land uses which have high water demands and high fire risk located close to the water supply mains for the township	no	0.00	
		yes	1.00	
3	• Are land uses with low water demand located on high ground to minimize the size of mains and the cost of water towers	no	0.00	
		yes	1.00	
4	• Does the layout facilitate laying the water reticulation pipes as a network of linked loops with a balanced loss of water pressure?	no	0.00	
		yes	1.00	
5	Does the layout relate to the water pressure zones	no	0.00	
		yes	1.00	
6	• Are the Bulk service routed on roads or minimum 5m servitudes	no	0.00	
		yes	1.00	
7	Minimal no of dead-ends to ensure flushing/no stagnation	no	0.00	
		yes	1.00	
8	• Did the layout consider the positioning of trees in close proximity of services	no	0.00	
		yes	1.00	
9	• Location & Spacing of Fire hydrants have a minimum overlap of<15% area	no	0.00	
		yes	1.00	
10	• Is adequate space provided for the siting of reservoir, pump stations and maintenance depots, with allowable buffers when required?	no	0.00	
		yes	1.00	
	2.0 FUNCTIONAL EFFICIENCY		**20.0**	**1.3**
1	Conventional systems that achieve minimum compliance	no	0.00	
		yes	1.33	1.33
2	• Can water loss be reduced by reducing velocity in pipe . Maximum velocity Pressure in the reticulation < 3m/s- leakage	no		
		yes	1.33	
3	Does the design attempt to monitor water supply by metering. Design of systems that both monitor and manage water consumption.	no	0.00	
		yes	1.33	
4	Pressure Management -Is the maximum Pressure in the reticulation< 9 bar-in order to minimise leakage	no	0.00	
		yes	1.33	
5	Water efficient fittings	no	0.00	
		yes	1.33	
6	• Was the layout designed as a network of linked loops to facilitate a balanced loss of water pressure?	no	0.00	
		yes	1.33	
7	Does the design Reduce peak demand with the use of attenuation/bulk reservoirs	no	0.00	
		yes	1.33	
8	Water-Efficient Irrigation & landscaping measures	no	0.00	
		yes	1.33	
9	Use of Roof tank/intermediate storage	no	0.00	
		yes	1.33	
10	Dry Fire Hydrants. suction pipe systems from pond/external source	no	0.00	
		yes	1.33	
11	Low impact Development technologies- Water	no	0.00	
		yes	1.33	
12	Watertight joints/compression type coupling/Seals quality	no	0.00	
		yes	1.33	
13	Efficient water systems design-Optimised flow/velocity in pipe not <0.2m/s	no	0.00	
		yes	1.33	
14	Water hammer analysis undertaken	no	0.00	
		yes	1.33	
15	Water reticulation designed to be self-cleaning	no	0.00	
		yes	1.33	
	3.0 Environmental quality		**15.0**	**1.7**
1	Some consideration for reducing envir impact. in the design	no	0.00	
		yes	1.67	1.67
2	Provisions made to increase Reliability of water source	no	0.00	
		yes	1.67	
3	• Does the design protect existing sources of water within townships for possible use for water supply.	no	0.00	
		yes	1.67	
4	Provision of aesthetic water infrastructure elements, manholes, outlets, fittings	no	0.00	
		yes	1.67	
5	Scour valves positioned for safe discharge- erosion	no	0.00	
		yes	1.67	
6	low-level water audit carried out	no	0.00	
		yes	1.67	

7	Water-Wise Gardening	no	0.00	
		yes	1.67	
8	Separate grey water/ black water-Reticulated recycled water supply	no	0.00	
		yes	1.67	
9	Water quality monitoring measures in place	no	0.00	
		yes	1.67	
	4.0 Economy		**15.0**	**4.5**
1	Some consideration of economy in the design of the service	no	0.00	
		yes	0.00	1.50
2	• Are high and moderate fire risk categories of development located close to bulk water supply points	no	0.00	
		yes	1.50	
3	• Are <20% of the fittings special fittings, i.e tees/couplings	no	0.00	
		yes	1.50	
4	Use of shared trenches >20% of length	no	0.00	
		yes	1.50	
5	• Is the level of service the most economical system for the target market	no	0.00	
		yes	1.50	
6	• Are the air valves , shut off valves in valve rings, compared to brick chambers	no	0.00	
		yes	1.50	
7	• Are there curvilinear roads with small radii, as this increases the cost of water reticulation due to the necessity of providing additional pipe specials, fittings and thrust blocks to anchor all pipes.	yes	0.00	
		no	1.50	
8	Av Trench Depth <1.2m in over total length	no	0.00	
		yes	1.50	1.50
9	Conduct Life-Cycle Cost Analyses	no	0.00	
		yes	1.50	
10	Pipe material - pvc/hdpe vs. concrete/steel	concret	0.00	
		pvc/hdp	1.50	1.50
	5.0 FUTURE MAINTENANCE		**15.0**	**3.8**
1	Some consideration of maintenance in the design of the service	no	0.00	
		yes	0.00	1.25
2	Valves/Meters located in convenient positions- Outside properties	no	0.00	
		yes	1.25	1.25
3	Are the valves located in convenient positions.> 80% at intersections	no	0.00	
		yes	1.25	
4	Are >80% of the bulk services placed in the most accessible locations such as roads?	no	0.00	
		yes	1.25	1.25
5	Positioning of trees - proximity of services	no	0.00	
		yes	1.25	
6	Flexible type coupling to permit ease in repair	no	0.00	
		yes	1.25	
7	Are all services watertight	no	0.00	
		yes	1.25	
8	Are sleeves should be used where pipes cross the road	no	0.00	
		yes	1.25	
9	Are the corrodible pipes protected	no	0.00	
		yes	1.25	
10	Uniform type of fittings compared to non standard fittings	no	0.00	
		yes	1.25	
11	Leak Detection devices in reticulation	no	0.00	
		yes	1.25	
12	Provisions for future expansion of the system	no	0.00	
		yes	1.25	
	6.0 Safety		**10.0**	**3.3**
1	Some consideration of safety in the design of the service	no	0.00	
		yes	1.67	1.67
2	<10% of length >3m Trench Depth	no	0.00	
		yes	1.67	1.67
3	• Is the high and moderate fire risk developments located close to bulk water supply points	no	0.00	
		yes	1.67	
4	• Is there supply capacity is compatible with the development's fire fighting requirements	no	0.00	
		yes	1.67	
5	Fire risk -High/medium or low	High/m	0.00	
		low	1.67	
6	Pressure on pipeline<9bar	no	0.00	
		yes	1.67	

	7.0 SOCIAL		**5.0**	**2.0**
1	Is end user provided with access to free basic services, in terms of demand	no	0.00	
		yes	1.00	1.00
2	Educational Outreach plan - water conservation	no	0.00	
		yes	1.00	
3	• Are the standpipes located in convenient positions along walkways	no	0.00	
		yes	1.00	
4	• Will vehicular access to other parts of the residential area be blocked during the repair of services	yes	0.00	
		no	1.00	
5	Provision of employment to local community >100 person days	no	0.00	
		yes	1.00	1.00
	8.0 RESOURCES		**10.0**	**0.0**
1	Conventional use of resources	no	0.00	
		yes	1.00	
2	•Water demand management measures - Does the design attempt to reduce the potable water consumption by building occupants. Reduced demand	yes	1.00	
		no	0.00	
3	Can the pump duty points/velocities in pipelines be reduced or optimised	yes	0.00	
		no	1.00	
4	Zone and bulk smart metering	yes	1.00	
		no	0.00	
5	Use of onsite materials for Bedding	no	0.00	
		yes	1.00	
6	Use of Present & future water consumption figures	no	0.00	
		yes	1.00	
7	Does the design attempt to use water efficient appliances and fittings	no	0.00	
		yes	1.00	
8	Use of Recycled materials	no	0.00	
		yes	1.00	
9	• Does the design attempt to reduce the consumption of potable water for landscape irrigation is sourced from non-potable water (e.g. rainwater, Recycled water effluent for irrigation)	no	0.00	
		yes	1.00	
10	Was there a detailed investigation of existing services to assess the spare capacity of watermains, as well as the feasibility of upgrading	no	0.00	
		yes	1.00	
	9.0 CONSTRUCTION		**5.0**	**0.0**
1	Water Operational Plan		0.00	
			5.00	

APPENDIX 21: Case Study 4: Detailed Green Infrastructure Rating report

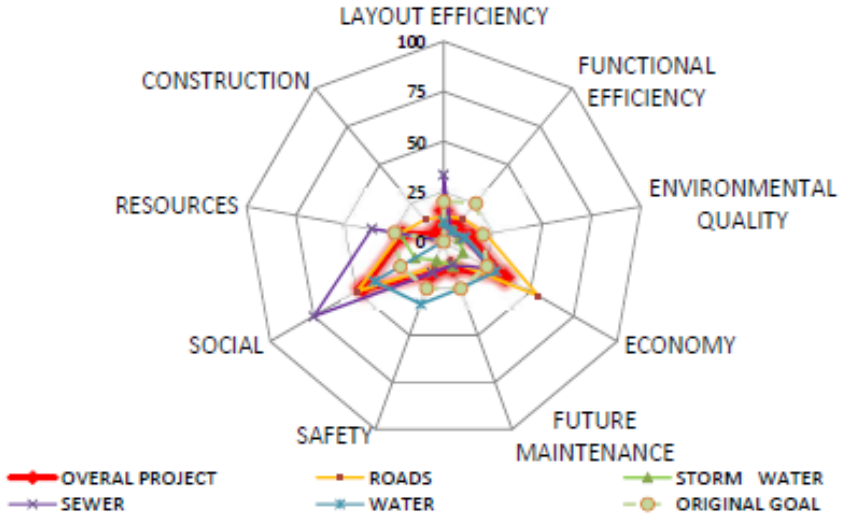
THE GREEN TOWNSHIP DESIGN MODEL

Project Title: Sunnyside-Low Cost Housing Project
Client: xxxxx

Date: 04 April 2013
Compiled by: SHIAN SAROOP

GREEN INFRASTRUCTURE ECO RATING REPORT

PERFORMANCE CATEGORIES	Category Weighting	ROADS	STORMWATER	SEWER	WATER	Infrastructure Weighting
		40%	20%	20%	20%	
1.0 LAYOUT EFFICIENCY	10%	1	1	3	1	Pts. Achieved
		10	*10*	*10*	*10*	Pts. Available
2.0 FUNCTIONAL EFFICIENCY	20%	3	1	1	1	Pts. Achieved
		20	*20*	*20*	*20*	Pts. Available
3.0 ENVIRONMENTAL QUALITY	10%	3	1	2	2	Pts. Achieved
		15	*15*	*15*	*15*	Pts. Available
4.0 ECONOMY	15%	8	2	4	5	Pts. Achieved
		15	*15*	*15*	*15*	Pts. Available
5.0 FUTURE MAINTENANCE	10%	1	1	1	4	Pts. Achieved
		10	*10*	*10*	*15*	Pts. Available
6.0 SAFETY	10%	1	1	2	3	Pts. Achieved
		10	*10*	*10*	*10*	Pts. Available
7.0 SOCIAL	5%	3	1	4	2	Pts. Achieved
		5	*5*	*5*	*5*	Pts. Available
8.0 RESOURCES	10%	2	2	4	0	Pts. Achieved
		10	*10*	*10*	*10*	Pts. Available
9.0 CONSTRUCTION	5%	1	0	0	0	Pts. Achieved
		5	*5*	*5*	*5*	Pts. Available
TOTAL PTS.		*100*	*100*	*100*	*105*	
WEIGHTED PTS. ACHIEVED		*2.9*	*1.3*	*2.2*	*2.0*	
WEIGHTED PTS. AVAILABLE		*12.3*	*12.3*	*12.3*	*12.8*	
TOTAL ACHIEVED		*23.6*	*10.3*	*17.8*	*15.8*	
TOTAL AVAILABLE		*100.0*	*100.0*	*100.0*	*100.0*	



SCORE	18	Bronze	Minimal interventions were undertaken- compliance based on regulations

SCORE	GREEN GOALS	
0-24	Minimal interventions were undertaken- compliance based on regulations	Bronze
25-49	Some considerations for environment- Applied conventional practice	SILVER
50-74	Restricted damage to the environment with innovation and new technologies	GOLD
75-100	Best solution to the environment- Benchmark performance	PLATINUM

APPENDIX 22: List of Publications and Conference Presentations

Journal Publications

Journal of the Institution of Municipal Engineering of Southern Africa

Saroop, S. H. and Allopi, D. 2012. Greener townships: Towards softer solutions on infrastructure projects. *Journal of the Institution of Municipal Engineering of Southern Africa*, 37(4), 23-25.

Journal of the South African Institution of Civil Engineers

Saroop, S. H. and Allopi, D. 2011. The need to implement green technology on municipal infrastructure projects. *Journal of the South African Institution of Civil Engineers*, 19(9), 43.

Journal of the Institution of Municipal Engineering of Southern Africa

Allopi, D. and Saroop, S. H. 2014. Designing infrastructure projects with the use of eco efficient sustainable criteria. *Journal of the Institution of Municipal Engineering of Southern Africa*, 39(12).

International Journal of Chemical & Environmental Engineering, 2013

Saroop, S. H. and Allopi, D. 2013. Designing environmentally sound engineering solutions on infrastructure projects. *International Journal of Chemical & Environmental Engineering,* 4(6), 411-413.

International Journal of Science and Technology

Saroop, S. H. and Allopi, D. 2014. Developing eco sensitive infrastructure solutions with the use of sustainability criteria. *International Journal of Science and Technology,* 3(2), 121-126.

American International Journal of Research in Science, Technology, Engineering & Mathematics

Saroop, S. H. and Allopi, D. 2015. Measuring infrastructure sustainability with the use of eco efficient performance criteria. *American International Journal of Research in Science, Technology, Engineering & Mathematics*, 9(3), 323-327.

International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences

Saroop, S. H. and Allopi, D. 2015. Developing a Green Infrastructure Tool for implementing environmental friendly township services. *International Journal of Innovative Research in Engineering & Multidisciplinary Physical Sciences*, (Accepted).

International Journal of Sustainable Development and Planning

Saroop, S. H. and Allopi, D. 2015. The use of eco efficient criteria in the design of infrastructure projects. *International Journal of International Journal of Sustainable Development and Planning*, (Accepted)

Conference Presentations

International Renewable Energy and Environment Conference, 2011

Saroop, S. H. and Allopi, D. 2011. Environmentally sound infrastructure solutions on projects. *Proceedings of the International Renewable Energy and Environment Conference,* 24-26 June 2011, Kuala Lumpur, Malaysia.

Southern African Transport Conference, 2012

Saroop, S. H. and Allopi, D. 2012. Establishing a green rating system on civil engineering infrastructure projects. *Proceedings of the Southern African Transport Conference,* 9-12 July 2012, Pretoria.

International Conference on Sustainable Development and Planning, 2013

Saroop, S. H. and Allopi, D. 2013. Enhancing sustainable infrastructure with the aid of the Green Infrastructure Toolkit. *Proceedings of the 6th International Conference on Sustainable Development and Planning 2013 (SDP13) Conference,* May 27-29, Kos, Greece

Southern African Planning Conference, 2014

Saroop, S. H. and Allopi, D. 2014. Enhancing environmentally quality settlements through eco sensitive infrastructure interventions. *Proceedings of the Southern African Planning Conference, 2014,* Durban.

Southern African Transport Conference, 2014

Saroop, S. H. and Allopi, D. 2014. Conceptual framework of environmental Sustainable interventions with the use of green infrastructure design criteria on projects. *Proceedings of the Southern African Transport Conference, 2014,* 9-12 July 2014, Pretoria

Institution of Municipal Engineering of Southern Africa Conference, 2015

Saroop, S. H. and Allopi, D. 2015. Designing eco efficient infrastructure projects with the use of sustainable criteria and greener engineering solutions. *Proceedings of the Institution of Municipal Engineering of Southern Africa Conference, 2015,* 27-29 October 2015, Cape Town.