FUTURE INVESTMENT REQUIREMENTS AND ECONOMIC IMPACT FOR WASTEWATER TREATMENT WORKS IN SOUTH AFRICA

Dineo Makate, Christian Griffiths, Bernice Macquela, Valmak Mathebula, Charity Mogotsi, and Jackie Crafford

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Future Investment Requirements and Economic Impact for Wastewater Treatment Works in South Africa

Report to the
Water Research Commission

prepared by

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EXECUTIVE SUMMARY

The state of municipal wastewater treatment works (WWTW) is crucial for South Africa as it provides a barrier to the spread of diseases including several other benefits. However, many of the WWTW are operated beyond design capacity. The 2022 Department of Water and Sanitation (DWS) Green Drop (GD) assessment indicated that 39% of municipal WWTW are in a critical state and treatment plants have generally moved into a more vulnerable risk rating over a period of 8 years. This regress is mostly associated with increased effluent quality failures and design capacity being exceeded.

Non-compliance of WWTW has detrimental effects on catchments and it impacts direct water users while also making downstream treatment for potable purposes more expensive. With the combined demands from population growth and sanitation pathway migration to improved levels of sanitation, it is inevitable that WWTW needs to either be upgraded or have new ones built as a matter of urgency.

The responsibility for expanding/building WWTW lies with the Water Services Authorities (WSAs). However, WSAs do not have cost-reflective tariffs, which results in under-recovery of revenue and a lack of budgeting for future infrastructure. With funds being an ongoing challenge for WSAs and the Government, upgrading or building new infrastructure will require proper financial planning.

The main aim of the project was therefore to develop tools that can be used to plan for future WWTW infrastructure, in order to support sustainable wastewater services in the sector. To achieve this, the specific objectives included:

- Developing WWTW and WSA spatial database, with each WWTW location and required additional WWTW capacity determined as the basis for infrastructure investment planning.
- Quantify the level of investment required for WWTW infrastructure up to 2050.
- Assessing the levels of WWTW tariffs needed to sustain investment liability.
- Assessing the economic benefits of WWTW on the economy.

In order to achieve these objectives, data on WWTW performance was collected from all GD reports (2009, 2011, 2014, 2022) and sanitation pathway per WSA, separated per income group (i.e. rural and urban). Three future scenarios up to 2050 were then developed and demonstrated a trend in migration to urban areas and an upgrade in the sanitation ladder.

Based on WWTW information from GD reports, and coordinates collected, a KML file of WWTW was developed. The information hosted by the database include: (i) design and operational capacity, (ii) liquid and sludge treatment type, (iii) name of the river being discharged to, and (iv) Cumulative Risk Rating (CRR).

WSA sanitation pathway information collected was utilized to inform additional capacity required for WWTW up to 2050 per scenario. The output was displayed spatially, together with WWTW information.

The forecasted capacity required from WWTW was then used to calculate investment requirements for upgrading/building WWTW per scenario. The investments included Capital Expenditure (CAPEX) and Operational Expenditure (OPEX) requirements. The CAPEX for the infrastructure was calculated to be R9 billion for the low range and R21.4 billion for the high range. The low-range CAPEX only considers conventional treatment technologies, and high-range CAPEX accommodates, additional capacity required as a result of growth in industries, and better treatment technologies (e.g. biogas) in urban WSAs.

Discounted Cash flow (DCF), which is a financial tool was developed to: (i) derive total funding required with interests to be paid, (ii) test current tariffs to see whether the investment will be recovered, (iii) test different combinations of debt and equity financing and (iv) forecast tariff structure that would ensure financial sustainability covering CAPEX and OPEX of the developments.

The dashboard in the financial tool allows for quick analysis to be made and is one of the key outputs of the tool. First, a user can input their current charge next to the item "Charge at 2026" and view the Internal Rate of Return (IRR). Next, a user can set the amount of debt financing they want to use to fund the investment and view the result on the IRR. Lastly, after setting the desired debt and equity combination, a user can perform a goal-seek function to derive a charge that achieves a desired IRR. This can then help in setting the charge that recovers all the costs.

To assess the economic benefits of investing in WWTW, the Social Accounting Matrix (SAM) methodology was employed. This method demonstrates the advantages of specific scenarios or inputs on the economy, including the additional goods and services produced and the resulting increased benefits across various sectors. The method is an effective tool to illustrate the broader impact of the investments, leading to higher Gross Domestic Product (GDP) and increased employment.

The output sheet of the economic model shows the result of the CAPEX and OPEX monetary injections in terms of direct (i.e. money that is injected into one industry, such as construction) and indirect benefits (i.e. money that is spent by employees in the construction industry, as a result of the initial injection). It also shows what these combined effects mean for GDP and employment growth when the money moves through the economy. For example, a CAPEX scenario where R3,2 billion is invested into WWTW would result in a R986 million increase in GPD and an additional R513 increase in employee compensation. This then builds a business case for investing in WWTW because it shows a 30% increase in the economy. The output further highlights the primary (e.g. mining) and secondary (e.g. manufacturing) industries that benefit the most from the CAPEX and OPEX investment injections.

Environmental benefits from investing in WWTW were also determined and this was through determining ecosystem services provided as a result of improved effluent.

The three tools developed (i.e. spatial database, financial tool, and economic tool) are therefore powerful planning tools based on the following.

- The WWTW and WSA spatial database: useful decision-making tool that can be used to plan for future WWTW capacity requirements.
- The financial model: a tool that the WSA can use to determine CAPEX requirements for either upgrade or newly built infrastructure, including the determination of tariff required to pay back any loan or investment, also taking into consideration OPEX costs.
- The economic model: a tool for demonstrating the economic benefits of investing in WWTW infrastructure, and this can be part of the WSA's business plan.

Since these tools have been developed on different scales, i.e. spatial database (WSA level), and financial and economic tool (national level), it is recommended that the financial and economic tools be further refined to a WSA level for improved local relevance. This is due to WSAs having different financial standing and economic status. The integration will mean that WSAs will be able to visualize projections on WWTW that need to be upgraded, investment requirements and the economic benefits to emanate from the investments. The integration should also be further demonstrated in a variety of WSAs of different economic status to understand its applicability and potential replication.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY..... i

Acknowledgements..... iii

List of Tables vii

List of Figures vii

List of Acronyms..... viii

1 Introduction 1

1.1 Background 1

2 Wastewater Treatment Works Infrastructure: Spatial Data base and Future WWTW Capacity Requirements..... 2

2.1 Overview 2

2.2 Methodology..... 2

2.2.1 WWTW spatial database..... 2

2.2.2 Additional Capacity of WWTW 3

2.2.3 Conditions for upgrading/building WWTW Infrastructure 5

2.3 Results and Discussion 6

3 Wastewater Treatment Works Infrastructure: Investments Requirements 9

3.1 Overview 9

3.2 Methodology..... 9

3.2.1 Cost of Building and Operating WWTW Infrastructure 9

3.2.2 Determining multi-year increase of Capacity 9

3.2.3 Discounted Cash Flow Model Development..... 9

3.2.4 Capital Expenditure (CAPEX) sheet 11

3.2.5 Operating Expenditure (OPEX) sheet..... 12

3.2.6 Financing Sheet 12

3.3 Results and Discussion 12

3.3.1 Cost of upgrading/building WWTW infrastructure..... 12

3.3.2 Investment requirements 13

4 Wastewater Treatment Works Infrastructure: Economic Benefits 15

4.1 Overview 15

4.2 Development of Economic Tool..... 15

4.2.1 Construction of the Input-Output Model 15

4.2.2 Multipliers and impact estimation..... 17

4.3 Results and Discussion 18

4.3.1 Economic Impact of CAPEX..... 18

5 Conclusions and Recommendations..... 21

6 References 23
7 APPENDIX A: Scenario Development 26
7.1.1 Baseline scenario without additional measures (**WOM**) 26
7.1.2 Baseline scenario with existing measures (**WEM**) 27
7.1.3 Baseline scenario with additional measures (**WAM**) 28
7.1.4 Forecast Additional WWTW Capacity 28
8 Appendix B: Spatial Data base 30
9 Appendix C: Financial Tool 36
10 Appendix D: Economic Tool 39
10.1 Final Demand: 41
10.1.1 Total Effect on GDP 41
10.1.2 Total Effect on Compensation of employees: 42
10.1.3 Net Exports 42
10.1.4 Industry and SAM Multipliers: 43

LIST OF TABLES

Table 4-1: Definitions of direct and indirect impact Source: Prime Africa own compilation 16
Table 4-2: Breakdown of Capital Expenditure 18
Table 4-3: Low Range: Economic impact of CAPEX for WOM Scenario.. 19
Table 7-1:Data sources and policies that guided the development of sanitation pathways scenarios26
Table 7-2: Annual percentage increase of households connected to the sewer system 29
Table 10-1: Low Range: Economic impact of OPEX for WOM Scenario... 41
Table 10-2: Industries contributing the most to total GDP. 42
Table 10-3: Industries contributing the most to compensation of employees. 42
Table 10-4: The Industries affected by the CAPEX costs and their multipliers.................................. 43

LIST OF FIGURES

Figure 2-1: WWTW Spatial dataset of displaying information per WWTW 7
Figure 2-2: Volume of Upgrading/building WWTWs for 2025,2035,2045 per WSA 8
Figure 3-1: Discounted Cash Flow Model architecture.. 10
Figure 3-2: Example of cumulated kilolitres treated. 11
Figure 3-3: CAPEX required for 2025, 2035 and 2045 in each WSA 12
Figure 4-1: Illustrative Input-Output Table (Sporri et al., 2007) 16
Figure 8-1: Number of households per sanitation pathways separated by rural and urban areas...... 30
Figure 8-2: WWTW information per WSA for the year 2022.. 31
Figure 8-3: Development of scenarios of households connected to sewer 32
Figure 8-4: Required capacity of WWTWs for the year 2025 per scenario 33
Figure 8-5: Example of WWTW information in “WWTW” KML file 34
Figure 8-6: Example of overcapacity per scenario displayed in decade 35
Figure 9-1: Income statement example.. 36
Figure 9-2: Extract from Statement of Financial Position 37
Figure 9-3: Extract of cashflow waterfall 38
Figure 10-1: Summary Tab of CAPEX and OPEX costs as well as their industry multipliers. 39
Figure 10-2: Output sheet of all CAPEX and OPEX costs from 2025 40
Figure 10-3: Total BOP Excel sheet showing the sum of Net Export and Direct Export effects for OPEX. 43

LIST OF ACRONYMS

AFDB	African Development Bank
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
CAPEX	Capital Expenditure
CICES	Common International Classification of Ecosystem Services
CIV	Collective Investment Vehicles
CMA	Catchment Management Agencies
CoGTA	Department of Cooperative Governance and Traditional Affairs
CRR	Cumulative Risk Rating
DAF	Dissolved air flotation
DBSA	Development Bank of Southern Africa
DCF	Discounted Cash Flow
DFFE	Department of Forestry, Fisheries and the Environment
DFI	Development Finance Institution
DFO	Design Finance, and Operate
DM	District Municipality
DPW	Department of Public Works
DWS	Department of Water and Sanitation
FISIM	Financial intermediation Services Indirectly Measured
FOG	Fats, oils, and greases
GD	Green Drop
GDP	Gross Domestic Product
GVA	Gross Value Added
IDP	Integrated Development Plan
IF	Infrastructure Fund
IFC	International Finance Corporation
IPBES	The International Panel on Biodiversity and Ecosystem Services
IRR	Internal Rate of Return
KML	Keyhole Markup Language
LCA	Life-cycle Assessment
LCC	Life-cycle Costing
LM	Local Municipality
LOC	Line of Credit
MEA	Millennium Ecosystem Assessment
MIG	Municipal infrastructure grants
MLD	Mega litres per Day
MM	Metropolitan Municipality
NDP	National Development Plan
NT	National Treasury
NWSKS	National Water Services Knowledge System
OPEX	Operational Expenditure
PAT	Progress Assessment Tool

PAYE	Pay As You Earn
PPI	Public Private Infrastructure
PPP	Public-Private Partnership
QGIS	Quantum Geographic Information System
Q-SAM	Quasi-Social Accounting Matrix
RBC	Rotating biological contractors
RBIG	Regional Bulk Infrastructure Grant
RDP	Reconstruction and Development Programme
RQO	Resource Quality Objectives
RRR	Resource Recovery and Reuse
SDGs	Sustainable Development Goals
SME	Small Medium Enterprise
SPV	Special Purpose Vehicles
StatsSA	Statistics South Africa
TEEB	The Economics of Ecosystems and Biodiversity
VAT	Value-Added Tax
VBA	Visual Basic for Applications
WAM	With Additional Measures
WCWDM	Water Conservation and Water Demand Management
WDCS	Waste Discharge Charge System
WEM	With Existing Measures
WOM	Without Measures
WSA	Water Service Authority
WSDP	Water Service Development Plan
WSIG	Water Services Infrastructure Grant
WWTW	Wastewater Treatment Works

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1 INTRODUCTION

1.1 Background

The state of Wastewater Treatment Works (WWTW) in South Africa is deteriorating and most of them are operating at levels that exceed design capacity. The 2022 Green Drop (GD) assessment, which is a Department of Water and Sanitation (DWS) incentive-based initiative, indicated that 39% of municipal WWTW are in critical state (DWS, 2022) compared to 29% for the previous GD assessment, which was done in the year 2013 (DWS, 2013). The GD risk analysis measured as Cumulative Risk Rating (CRR) focusing specifically on the WWTW function (i.e. design capacity, operational flow, technical capacity and effluent quality) indicated a national relapse from 2013 to 2021, with WWTW generally moving into a more vulnerable risk rating over the past eight years. This regress is mostly associated with increased effluent quality failures, and design capacity being exceeded. One of the suggestions from the CRR analysis is the expansion and upgrading of existing plants which are hydraulically overloaded or approaching their design lifespan. Furthermore, it is common cause that additional WWTW would need to be built where new city and town expansions are planned to cater for population growth.

The deterioration of the quality of water resource as a result of untreated or partially treated effluent has a significant impact on socio-economic development because it poses risks to downstream ecosystems and people who rely on the river as a drinking water source, and commercial water users.

Municipalities do not have a cost reflective tariff and that results in under-recovery of revenue. More importantly, no provision is made for development of new infrastructure.

The DWS, though they are involved in building of WWTWs through administering grants such as Regional Infrastructure Grant (RBIG), they do not have a mandate or a policy that talks about upgrading these plants and the responsibility lies with Water Services Authorities (WSAs) through their Water Service Development Plans (WSDPs). These municipal plans work in isolation and do not speak to the overall national strategic plans. There is therefore a need to foresight the investment required to upgrade/build infrastructure. This will help decision makers in the wastewater sector to properly plan their infrastructure projects.

The main aim of the project was therefore to develop a strategy that can be used to plan for future WWTW infrastructure, in order to provide sustainable wastewater services in the sector. To address this aim, the specific objectives of this study are therefore as follows:

- Develop a spatial database, with each WWTW located, as a basis for infrastructure investment planning for WWTWs
- Quantify the level of investment required in WWTWs over 25 years (informed by the spatial database)
- Assess the levels of WWTW tariffs needed for investment liability
- Assess the economic benefits of WWTWs on the economy.

2 WASTEWATER TREATMENT WORKS INFRASTRUCTURE: SPATIAL DATA BASE AND FUTURE WWTW CAPACITY REQUIREMENTS

2.1 Overview

This section provides feedback on the WWTW spatial database developed. The purpose of the spatial tool was to display WWTW information (i.e. treatment technology, design and operational capacity, river being discharged into) and to understand additional capacity WWTW requirement in the country up to. Spatial planning evaluates WWTWs capacity in context with the surrounding population and its growth until 2050.

In order to forecast additional WWTW required per WSA, as a result of population growth, firstly, sanitation pathways were identified, and households were separated by rural and urban settlement. The DWS Directorate: National Water Services Knowledge System (NWSKS) reports on different sanitation pathways in each WSA per income group. The data source uses Statistics SA population data as a baseline. The data collected was from the year 2000 to 2021.

Three future scenarios were developed: (a) baseline (WOM); (b) baseline with existing mitigation measures (WEM); and (c) baseline with additional measures (WAM). The purpose of the scenarios was to quantify additional WWTW capacity required as a result of different sanitation migration situations (e.g. migration to urban areas and improved sanitation pathway).

2.2 Methodology

2.2.1 WWTW spatial database

WWTW spatial database was developed through the collection of DWS Green Drop data and WWTW coordinates, which the process is described in the sections below.

2.2.1.1 Green Drop Data

Green Drop data was used to collect WWTWs information in each WSA. The data included design capacity; operational flow; liquid treatment type; and sludge treatment type. The data was collected from 2011 GD report, 2014 GD PAT; 2022 GD report; and on the DWS IRIS.

2022 GD design capacity information was used, and design capacity on the IRIS was also used for quality control.

Operational flow of WWTWs for all GD reports was analysed and it was observed that some WWTWs that record incoming flow, have shown decreasing flow between 2011 and 2021, which indicates that the sewer networks are not operating optimally and there is potential raw sewage leaking into the water resource. To determine operational flow, the GD assessment that had higher flow for a specific WWTW was used. Design capacity was used as operational capacity, for WWTW that do not record incoming flows.

The liquid treatment type and sludge treatment type were identified per WWTW, and the liquid treatment type included biological filters (trickling filter); Biological nutrient removal (BNR); Rotating biological contractors (RBC); mechanical aeration; ponds systems (aerobic/oxidation ponds; anaerobic ponds /facultative ponds, and maturation ponds), while the sludge treatment types included solar drying beds; aerobic/anaerobic digester; sludge lagoon; gravity thickener; Dissolved Air Flotation (DAF) thickener; and belt press dewatering.

2.2.1.2 WWTW Coordinates

As the output of the database must be displayed spatially, WWTW coordinates were collected from various sources. The coordinates were then plotted on QGIS, and it was shown that some coordinates were not correct as they were either in a wrong province or outside the country. Those identified misplaced coordinates were then corrected through identifying the plants on Google Maps.

2.2.1.2.1 Verification process of WWTW coordinates

To verify location of all WWTWs, there was an extensive quality control process. This was done by inserting collected coordinates of each WWTW on Google Earth pro, and if a plant is not displayed in the given location, coordinates were adjusted by looking at the surrounding area and also searching for the plant on Google Maps.

2.2.2 Additional Capacity of WWTW

In determining additional volume of incoming flow as a result of increased population, two options were investigated:

1. Observe historical operational flow of WWTWs: Obtain operational flow of WWTWs from 2011 GD; 2014 GD PAT; and 2022 GD, and use percentage increase in flow to forecast additional volume until 2050.
2. Population growth: collect additional number of households on sewer (including septic tank users). Determine additional flow through calculating basic volume of household per month (6 kl) and assume 70% of the volume ends up in the sewer.

The first option had gaps and as a result, the second option was used. The concern with the first option was that some WWTWs do not measure incoming flow, and also in some instances, operational flow does not increase over time, which might be due to leaks in the sewer networks.

2.2.2.1 Sanitation Pathway data source

Domestic wastewater pathways in South Africa comprise sewer, pit latrines, septic tanks and bucket systems and none.

The DWS Directorate: National Water Services Knowledge System (NWSKS) reports on different sanitation pathways in each WSA. The data is also reported per rural and urban population distribution. The data source uses Statistics South Africa population data as a baseline. The data on NWSKS was available for year 1994 to 2021 but collected for the year 2000-2021. The data in the NWSKS were collected per household. The data provides the number of households within a settlement per sanitation type. The following are the categories of sanitation types provided:

1. Flush toilet (connected to sewage system)
2. Flush toilet (with septic tank)
3. Chemical toilet
4. Pit latrine with ventilation (VIP)
5. Pit latrine without ventilation
6. Bucket
7. No Sanitation.

To determine number of households that will have an impact on capacity of WWTWs, the following sanitation pathways were selected as their volumes end up in the sewer system:

- Flush toilets

- Septic tank
- Bucket
- Chemical toilets

2.2.2.2 Scenario Development

The methodology of the scenarios was guided by historical trends per sanitation pathways, StatsSA and United Nations Department of Economic and Social Affairs Population Dynamics (UN, 2019) projections, and South African sanitation pathways target which states 100% population having sanitation above RDP level (DWS, 2018).

The implicit growth rates within each income segment sanitation pathway were computed and used as the basis for population growth. The median population projection presented by the World Population Projection 2019 of the UN Department of Economics and Social Affairs was used as the most likely case for population growth up to the year 2035.

The migration between income groups was implicitly calculated along with the migration between sanitation pathways in this study. The data were grouped into sanitation pathway by income group, producing eight unique groups:

1. Rural None;
2. Rural Pit Latrine;
3. Rural Septic Tank;
4. Rural Sewer;
5. Urban None;
6. Urban Pit Latrine;
7. Urban Septic Tank;
8. Urban Sewer.

The historical population growth rate for each grouping was calculated for the baseline scenario, then proportionally adjusted to ensure consistency while being constrained by the expected total population in 2050. This growth rate can be taken as a single number being representative of the net migration encompassing both income group and sanitation pathway, as it encompasses the rate of change in each grouping individually.

Where different rates of change were calculated for the various scenarios, the relevant policies (which related to sanitation pathways trajectories rather than income grouping trajectories), along with historical trends and expert judgement, were used to adjust the rates of change in each of these groupings to reflect the likely effects of the targeted policies, while once again maintaining internal consistency with regards to the total population.

Please see Appendix A for detailed analysis of scenario development.

2.2.3 Conditions for upgrading/building WWTW Infrastructure

Conditions were done in order to determine whether the WSA needs to upgrade and with which treatment technology.

Conditions for WSAs that are Local Municipality (LM) and Metropolitan Municipality (MM):

1. If WSA in 2050 is >1.0 Ml/day over capacity, we upgrade
2. Only Ponds:
   a. If they only have ponds, and they need upgrade less than 2 MLD = upgrade ponds
   b. If they only have ponds, and they need upgrade more than 2 MLD = build a new pond
3. Activated sludge, trickling filter and Ponds
   a. If they have activated sludge and pond but upgrade is less than 1 MLD=upgrade ponds
   b. If they have activated sludge and pond but upgrade is more than 1 MLD but less than 10 MLD=upgrade 1 activated sludge
   c. If they have activated sludge and pond but upgrade is more than 10 MLD and less than 100 ML=upgrade 2 activated sludge
   d. If they have activated sludge and pond but upgrade is more than 100 MLD=upgrade 3 activated sludge maximum

District Municipality (DM) conditions were separated as these WSA consist of several towns and as a result upgrades/building must take that into consideration.

Conditions for DM:

1. Consider LM and MM conditions, but the upgrade amount must be divided equally to their LMs.
2. Prioritise the plant with the highest overcapacity or utilisation.

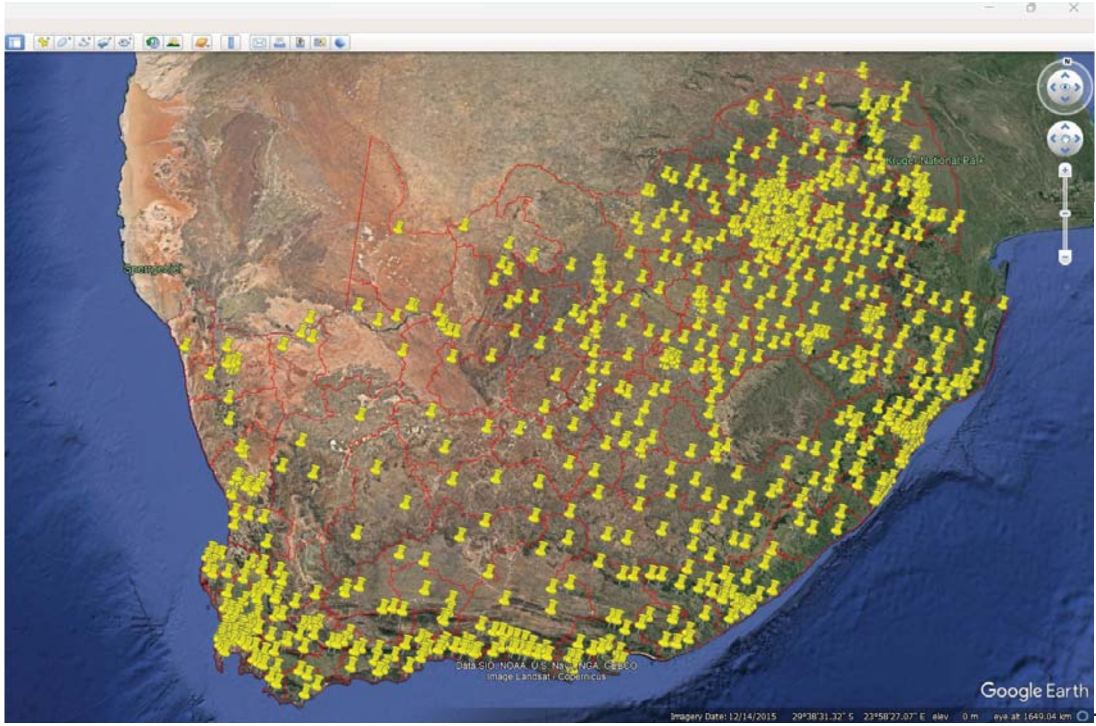
Additional measures were done to assess whether WSAs will be able to afford the developments required. This was done by looking at 2020-2022 financial reports of all WSAs. The analysis included looking at revenue collected from the customers, and OPEX budget for sanitation. The insights gained from the assessment indicated that in the rural municipalities, a high percentage of their income comes from grants, and they do not collect much revenue from their customers. These insights showed that we cannot recommend expensive developments in such WSAs.

2.3 Results and Discussion

WWTW KML was developed to spatially show information of each WWTW as show in Figure 2-1. WSA KML was also developed to display required capacity of WWTWs to service the growing population as shown in Appendix B.

Additional capacity of WWTW per WSA were quantified together with type of treatment technology as shown in Figure 2-2. The data shows that South Africa needs to increase capacity of WWTW by 755 MLD, from 40 WSA, with municipalities in Gauteng accounting for 78% of the total volume. The information was useful in determining funds required for infrastructure development.

Please find the additional WWTW capacity required up to 2050 per scenario in Appendix B.



WSA_Plant:PROVINCE	Free State (FS)
WSA_Plant:Municipal Name	Maqhaka Local Municipality
WSA_Plant:Plant Name	Koppies
WSA_Plant:Design Capacity	3,1
WSA_Plant:Operational Capacity	2
WSA_Plant:Liquid Treatment type	activated sludge
WSA_Plant:Sludge Treatment	solar drying beds
WSA_Plant:Discharge source	Renoster River
WSA_Plant:latitude	-27.2541667
WSA_Plant:longitude	27.571667

Figure 2-1: WWTW Spatial dataset of displaying information per WWTW

WSA	Plant type WOM 2025	2035	2045	Capacity Required: Upgrade by 2025 - WOM (MLD)	Upgrade by 2035 - WOM (MLD)	Upgrade by 2045- WOM (MLD)
Kouga Local Municipality	Upgrade activated sludge	Upgrade activated sludge	Upgrade activated sludge	5,55	4,16	4,16
Koukamma Local Municipality				-	-	-
Makana Local Municipality	Belmont Valley - biologica filters	Activated sludge		2,01	3,02	-
Ndlambe Local Municipality	Kenton on Sea Ekuphumleni - activated sludge	Build new pond	Build new pond	2,48	1,86	1,86
Nelson Mandela Bay Metropolitan Municip				-	-	-
OR Thambo Municipality				-	-	-
Sunday's River Valley Local Municipality	Upgrade pond	Upgrade pond	Upgrade pond	0,73	0,54	0,54
Dihlabeng Lacal Municipality				-	-	-
Kopanong Local Municipality	Upgrade 1 pond	Upgrade 1 pond	Upgrade 1 pond	0,66	0,50	0,50
Letsemeng Local Municipality	Upgrade 1 pond	Upgrade 1 pond	Upgrade 1 pond	0,44	0,33	0,33
Mafube Local Municipality				-	-	-
Malutu-A-Phofung Local Municipality	Upgrade activated sludge	Upgrade activated sludge	-	1,70	2,55	-
Mangaung Local Municipality	upgrade 1 activated sludge	upgrade 1 activated sludge	upgrade 1 activated sludge	12,51	9,38	9,38
Mantsopa Local Municipality				-	-	-
Masilonyana Local Municipality	Upgrade activated sludge	Upgrade pond	Upgrade pond	1,07	0,80	0,80
Matjabeng Local Municipality	upgrade activated sludge	-	-	1,10	-	-
Metsimaholo Locala Municipality	Deneysville-Refengkgotso	Oranjeville	-	1,93	2,90	-
Maqhaka Local Municipality				-	-	-
Nala Local Municipality	upgrade all now	0	0	2,12	-	-
Ngwathe Local Municipality				-	-	-
Nketoana Local Municipality				-	-	-
Phumelela Local Municipality	activated sludge	0	0	1,35	-	-
Sesotho Local Municipality	Upgrade activated sludge	Upgrade activated sludge	Upgrade activated sludge	5,30	3,97	3,97
Tokologong				-	-	-
Tswelopele Local Municipality	activated sludge	-	-	1,20	-	-

Figure 2-2: Volume of Upgrading/building WWTWs for 2025,2035,2045 per WSA

3 WASTEWATER TREATMENT WORKS INFRASTRUCTURE: INVESTMENTS REQUIREMENTS

3.1 Overview

This section provides feedback on determination of CAPEX and OPEX required for upgrading/building WWTWs as a result of required additional capacity up to 2050. As CAPEX require large amounts of money upfront, it was important to identify how these developments will be funded. The section therefore explores different funding mechanisms. The financial tool developed shows best combination of:

- What debt and equity will be
- What total debt service cost will be.
- What Internal Rate of Return (IRR) will be for different combination of debt and equity.

3.2 Methodology

3.2.1 Cost of Building and Operating WWTW Infrastructure

Predominant wastewater treatment technologies are ponds, activated sludge (variations thereof), and biofilters for effluent treatment and solar drying beds, sludge lagoons/ponds, anaerobic digesters, and belt press dewatering for sludge treatment. CAPEX and OPEX data for activated sludge treatment technology was collected from an ongoing WRC project (C2022/2023-00873: A Full Cost Recovery Model for Financing Wastewater Infrastructure and Operation). Benchmark costs for other treatment technologies was used in brownfield scenarios and for greenfield scenarios.

3.2.2 Determining multi-year increase of Capacity

As there are currently WWTWs that are operating at overcapacity and will be very expensive to increase their capacities all at once, it is recommended that WSAs should increase their capacities in stages. The recommended increment stages are 40% for the year 2025; 30% for 2035; and 30% for 2045. For WSAs that needed minimal upgrades the upgrades were recommended for the year 2025. As it is cheaper per MLD to increase WWTW by high volume.

3.2.3 Discounted Cash Flow Model Development

The Discounted Cash Flow (DCF) model presents a high-level financial analysis for the investment required in wastewater treatments in South Africa under three scenarios: WOM, WEM and WAM. The DCF model allows WSAs to derive and forecast a structure of tariff that would ensure financial sustainability covering the capital and operating expenses of developments.

Each scenario has its own set of financial statements which includes the income statement, a statement of financial position and a cash flow statement. A cashflow waterfall is also shown following the three financial statements. The cash flow waterfall is a more concise cash flow statement as it displays the cash flows in the order in which they occur. It also provides an indication of the cash available for debt service, which is a key metric to assess credit worthiness. The three financial statements and the cashflow waterfall are used in calculating the Internal Rate of Return (IRR) of the investment in wastewater treatment under the different scenarios. The type of financing used (namely debt or equity) and the tariff charged for wastewater treatment ultimately impacts this IRR.

Figure 3-1 shows the architecture of the DCF model. The construction inputs sheet and the assumptions sheet provide a lot of the inputs for the entire model and so changing numbers in this sheet can configure the entire model. Each scenario has the same number of sheets and follows the same process and ends with the financial analysis and financial statements.

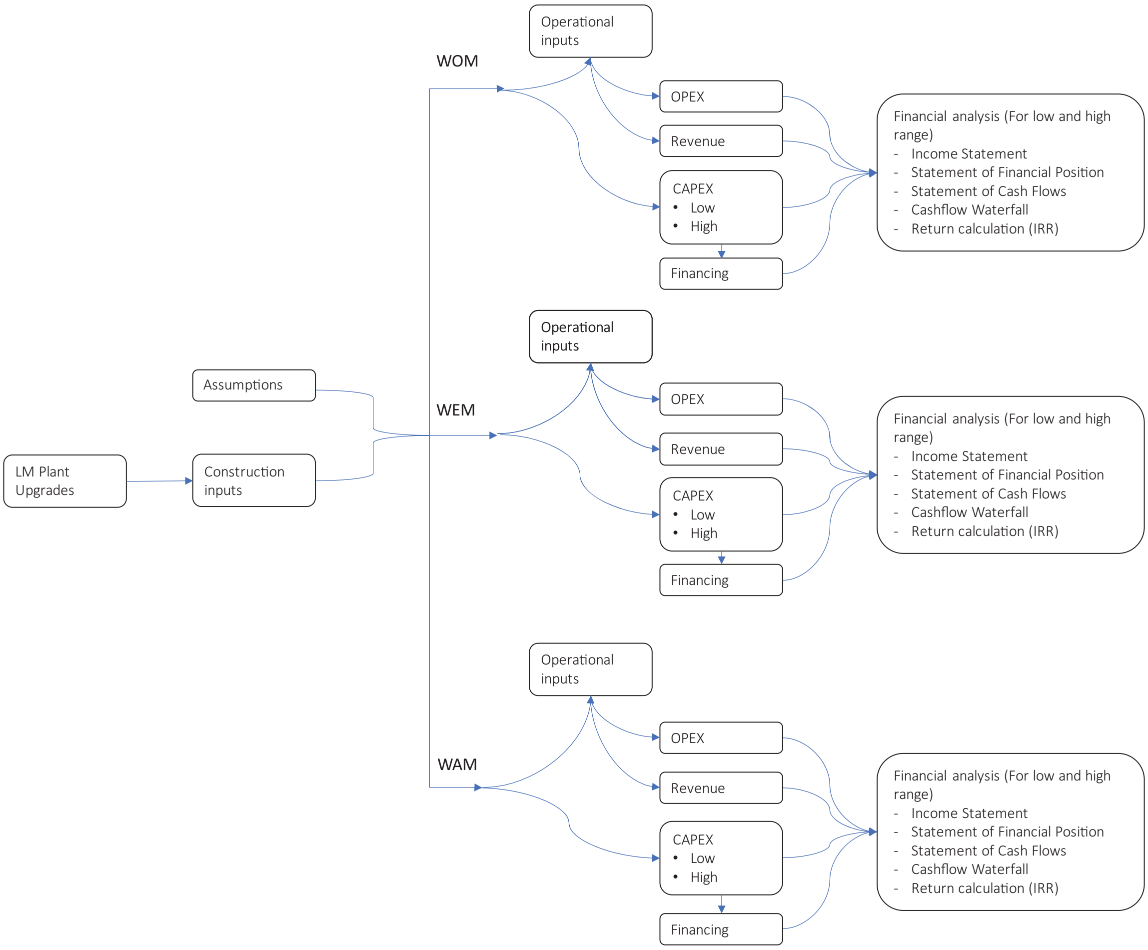


Figure 3-1: Discounted Cash Flow Model architecture

3.2.3.1 Dashboard Sheet

The dashboard is an important sheet in the beginning of the workbook, as one toggles different combinations of debt and equity to see what the impact on IRR will be. One can also compare the IRR with the charge and be able to easily tell whether the charge is too low (i.e. the revenue is not covering all the costs). After toggling the different options one can scroll to the financial statements tab in each scenario to view the results.

In the dashboard under each scenario there are two tables (the low range table and the high range table) and two graphs (the low range graph and the high range graph). In the tables, one can toggle the different financing options and view the results. The graphs allow one to see the movement in revenue and total costs (operating costs, depreciation and debt service costs).

3.2.3.2 Assumptions Sheet

The DCF model has been constructed based on several assumptions and they include:

- Economic assumptions such as annual inflation rates and value added tax (VAT). This is to ensure information in the financial statements are in nominal terms.
- Financial assumptions such as interest rates on debt, the period of the debt and dividend pay-out ratios in the case of equity financing. Please note that the dividend pay-out ratio is the percentage of net income that is paid out in the form of dividend to equity investors.
- Other assumptions such as days in the year and the useful life of assets.
- OPEX assumptions such as the costs in rands per kilolitre for different levels of plant capacity (in MLD).
- Working capital assumptions such as the days sales outstanding which is used to calculate the accounts receivable balance. Please note that the accounts receivables refers to debtors, who are customers that have been invoiced but have not yet paid over the cash.

3.2.3.3 Construction Input Sheet

The construction inputs sheet shows the amount of additional capacity (in MLD) each WSA will need to upgrade in 2025, 2035 and 2045 under each of the three scenarios. The capital expenditure (in rand amounts) is then calculated for these upgrades.

3.2.3.4 Operational Input Sheet

The operational inputs sheet for each scenario uses the capacity added for 2025, 2035 and 2045 and calculates the kilolitres (kl) treated every year from 2025 to 2050. There is a cumulative trend occurring because each build stage adds additional kilolitres treated on top of the previous build. An example of this step up is shown in *Figure 3-2*. The cumulated effect is highlighted in green. This sheet then also sums up the kilolitres treated every year for all the WSAs.

	A–E	F	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1	**WRC Foresight Wastewater Treatment Works Plan**		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
2	**Financial model**														
3	**Operational inputs worksheet**														
260	Metsimaholo Locala Municipality														
261	Capacity added 2025	MLD		1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93
262	Portion treated	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
263	**Amount treated**	**kl**		**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**
264	Capacity added 2035	MLD												2.90	2.90
265	Portion treated	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
266	**Amount treated**	**kl**												**1,057,103**	**1,057,103**
267	Capacity added 2045	MLD													
268	Portion treated	%													
269	**Amount treated**	**kl**													
270	**Total treated**	**Kl**	-	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**704,735**	**1,761,838**	**1,761,838**
271	Mohokare Local Municipality														
272	Capacity added 2025	MLD		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
273	Portion treated	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
274	**Amount treated**	**kl**		**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**
275	Capacity added 2035	MLD												0.75	0.75
276	Portion treated	%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
277	**Amount treated**	**kl**												**274,426**	**274,426**
278	Capacity added 2045	MLD													
279	Portion treated	%													
280	**Amount treated**	**kl**													
281	**Total treated**	**Kl**	-	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**365,902**	**640,328**	**640,328**

Figure 3-2: Example of cumulated kilolitres treated.

3.2.4 Capital Expenditure (CAPEX) sheet

The CAPEX sheet uses the capital expenditures from the construction inputs sheet and calculates a total CAPEX for all the WSAs at 2025, 2035 and 2045 in nominal terms (including VAT and inflation). These amounts are then transferred to the relevant sections in the financial statements and to the financing sheet. Based on the CAPEX, depreciation per year is calculated (using straight-line depreciation) which is then transferred to the income statement. Straight-line depreciation is based on taking the cost of the asset divided by its useful life. In the CAPEX sheet, the accumulated depreciation balance is also calculated, and this is used in calculating the closing balance (net book value) of the asset base in the statement of financial position. The closing balance is cost minus accumulated depreciation.

3.2.5 Operating Expenditure (OPEX) sheet

In the OPEX sheet, the kl treated per year from the operational inputs sheet is multiplied by the operating cost (in R/kl) applicable for the relevant size of the plant upgrade and type of plant (such as activated sludge, trickling filters or ponds) with respect to each WSA. The operating cost is calculated for each WSA requiring upgrades and then summed up for all the WSAs as a whole. This total is transferred to the income statement.

3.2.6 Financing Sheet

The financing sheet uses the nominal capital expenditure for 2025, 2035 and 2045 from the CAPEX sheet. These amounts are then totalled and applied to the financing split of debt and equity. If loans are required then this sheet calculates the interest and principal payments on the loan as well as the balance of the loan at year end for use in the financial statements.

3.3 Results and Discussion

3.3.1 Cost of upgrading/building WWTW infrastructure

An abstract of the CAPEX required to increase WWTW capacity was calculated as shown in Figure 3-3 below. The data shows the total capex is ranging between R4.9 billion-10.6 billion using 2023 value and ranges between R9.5 billion-21.4 billion for value in nominal terms (i.e. including inflation)

Please find the accompanied CAPEX spreadsheet to see the additional volume and CAPEX required per WSA per scenario up to 2050.

	Capacity Required			Capital Expenditure		
WSA	Upgrade by 2025 - WOM	Upgrade by 2035 - WOM	Upgrade by 2045- WOM	Upgrade by 2025 - WOM	Upgrade by 2035 - WOM	Upgrade by 2045 - WOM
	MLD	MLD	MLD	Rands	Rands	Rands
Kouga Local Municipality	5,55	4,16	4,16	R48 340 182	R36 255 137	R36 255 137
Koukamma Local Municipality	-	-	-	R0	R0	R0
Makana Local Municipality	2,01	3,02	-	R30 410 403	R34 229 779	R0
Ndlambe Local Municipality	2,48	1,86	1,86	R28 158 077	R28 305 137	R28 305 137
Nelson Mandela Bay Metropolitan Municip	-	-	-	R0	R0	R0
OR Thambo Municipality	-	-	-	R0	R0	R0
Sunday's River Valley Local Municipality	0,73	0,54	0,54	R6 642 735	R4 982 051	R4 982 051
Dihlabeng Lacal Municipality	-	-	-	R0	R0	R0
Kopanong Local Municipality	0,66	0,50	0,50	R6 087 720	R4 565 790	R4 565 790
Letsemeng Local Municipality	0,44	0,33	0,33	R4 636 445	R3 477 334	R3 477 334
Mafube Local Municipality	-	-	-	R0	R0	R0
Malutu-A-Phofung Local Municipality	1,70	2,55	-	R25 847 107	R28 926 920	R0
Mangaung Local Municipality	12,51	9,38	9,38	R95 221 876	R81 759 709	R81 759 709
Mantsopa Local Municipality	-	-	-	R0	R0	R0
Masilonyana Local Municipality	1,07	0,80	0,80	R9 778 801	R7 334 101	R7 334 101
Matjabeng Local Municipality	1,10	-	-	R21 452 795	R0	R0
Metsimaholo Locala Municipality	1,93	2,90	-	R29 357 925	R32 856 070	R0
Maqhaka Local Municipality	-	-	-	R0	R0	R0
Nala Local Municipality	2,12	-	-	R32 226 062	R0	R0
Ngwathe Local Municipality	-	-	-	R0	R0	R0
Nketoana Local Municipality	-	-	-	R0	R0	R0
Phumelela Local Municipality	1,35	-	-	R26 426 048	R0	R0
Sesotho Local Municipality	5,30	3,97	3,97	R46 180 678	R34 635 508	R34 635 508
Tokologong	-	-	-	R0	R0	R0
Tswelopele Local Municipality	1,20	-	-	R23 351 646	R0	R0

Figure 3-3: CAPEX required for 2025, 2035 and 2045 in each WSA

3.3.2 Investment requirements

Information from all the sheets developed ultimately ends up in the financial statements. The financial statements provide valuable insight on the investment in wastewater treatment works and the type of financing used. One can navigate to key financial indicators in each of the financial statements, such as net income in the income statements, balances for assets, debt and equity in the statements of financial position and cash on hand at the end of the year reflected from the cash flow statement. All this financial information assists in better understanding the investments and allows for long-term financial planning.

Extracts of the income statement, statement of financial position and the cashflow waterfall for the WOM scenario, financed with 100% debt is illustrated in Figure 9-1, Figure 9-2, Figure 9-3 respectively in Appendix C.

3.3.2.1 Revenue and IRR Sheet

Revenue is based on the charge (in rands per kilolitre) and the treated effluent for all the WSAs. This charge needs to be able to cover the OPEX, depreciation and the debt service costs (interest and principal payments). An innovative way of determining this charge is by using the IRR. One can solve for the charge by setting a desirable IRR (an IRR that exceeds the cost of capital). For example, the interest rate on debt is around 11%. One can then solve for the charge that would return an IRR of 12%, exceeding the interest rate ensuring that the debt service costs are covered. The purpose of using the IRR is to determine the charge that ensures the charge covers operating costs, depreciation, and any debt service costs. It also allows some cash reserves to be built up over time. Building up cash reserves has several benefits, including having cash available to fund future capital expenditure. Cash reserves can also be used to make higher principal payments on debt to reduce the interest expense and it can cover any working capital fluctuations that may occur in future.

3.3.2.2 Discounted Cash Flow

3.3.2.2.1 Financed with 100 percent debt

If one runs a scenario (under the WOM) where the capital expenditure is financed with 100% debt – in the "Dashboard sheet" in the DCF model one can type 100% into the white cell next to the label debt for both the low range and the high range. A goal seek function can then be used to set the IRR at 0.12 (12%) by solving for the charge. Once this function is performed it will be evident that the charge needs to be between R10.36 and R15.52. With these charges and 100% debt finance, the results for the low and high ranges should look as follows:

Low Range				**High Range**		
Total CAPEX – Nominal		**R9,810,085,219**		**Total CAPEX – Nominal**		**R21,425,290,346**
Financing				**Financing**		
Debt	%	100%		Debt	%	100%
Equity	%	0%		Equity	%	0%
Total debt service costs	R	**R13,529,842,393**		**Total debt service costs**	R	**R28,908,735,910**
Tariff				**Tariff**		
Charge at 2026	R/kl	10.36		Charge at 2026	R/kl	15.52
Interest rate on debt	%	11.08%		**Interest rate on debt**	%	11.08%
Return				**Return**		
IRR	%	**12.00%**		IRR	%	**12.00%**

3.3.2.2.2 Financed with 20% equity and 80% debt

If we used the charges determined above (R10.36-R15.52) and ran a scenario where the capital expenditure is financed with 20% equity and 80% debt – in the “Dashboard sheet” in the DCF model one can type 80% into the white cell next to the label debt for both the low range and the high range. It will then be evident that the IRR is around 18%. Which is the kind of returns equity investors look for. This shows how using a combination of debt and equity can generate greater return on investment. If we only wanted to generate the 12% IRR, a goal seek function can be used to set the IRR at 0.12 (12%) and solving for the charge. Once this function is performed it will be evident that the charge needs to be between R9.28/kl and R13.17/kl. Slightly less than the charges determined above due to the lower amount of debt that must be repaid. With these charges and 20% equity and 80% debt finance, the results for the low and high ranges should look as follows:

Low Range		
Total CAPEX – Nominal		**R9,810,085,219**
Financing		
Debt	%	80%
Equity	%	20%
Total debt service costs	**R**	**R10,187,125,764**
Tariff		
Charge at 2026	R/kl	9.28
Interest rate on debt	%	11.08%
Return		
IRR	%	**12.04%**

High Range		
Total CAPEX – Nominal		**R21,425,290,346**
Financing		
Debt	%	80%
Equity	%	20%
Total debt service costs	**R**	**R21,608,220,907**
Tariff		
Charge at 2026	R/kl	13.17
Interest rate on debt	%	11.08%
Return		
IRR	%	**12.01%**

Please find the accompanied DCF spreadsheet to see detailed analysis of how WWTWs can be financed.

4 WASTEWATER TREATMENT WORKS INFRASTRUCTURE: ECONOMIC BENEFITS

4.1 Overview

This section provides feedback on the economic tool developed. The purpose of the tool is to give insights into the role of WWTWs in the economy and this is done to make decision makers aware of the impact the state of WWTWs has on the economy.

The analysis demonstrates GDP and compensation to employees due to CAPEX and OPEX required for upgrading/ building WWTWs as a result of population growth up to 2050.

4.2 Development of Economic Tool

To assess the economic benefits of investing in WWTWs, a quasi-social accounting matrix (Q-SAM) was employed. This method demonstrates the advantages of specific scenarios or inputs on the economy, including the additional goods and services produced and the resulting increase in salaries and wages across various sectors. By utilizing an input-output model of the South African economy, this approach becomes an effective tool to illustrate the broader impact of the project, leading to higher GDP and increased employment.

The Q-SAM analysis can also assist policymakers in identifying key sectors that might experience significant growth and investment opportunities, thereby creating a ripple effect of economic development. By utilizing the Q-SAM approach, decision-makers can therefore gain valuable insights into any economic benefits of investing in WWTWs, making informed choices that positively influence the overall prosperity of the South African economy.

4.2.1 Construction of the Input-Output Model

An input-output table is a way to represent economic accounts of a country or region, showing how different industries produce and trade goods and services among themselves. These transactions are recorded in a matrix, organized by both the source and destination of the flows (OECD, 2006). In an input-output analysis, we use this table to measure the effects of changes in the final demand for a product within an industry or sector (Surugiu, 2009). An example of an input-output table is shown in Figure 4-1.

The table typically arranges inputs in columns and outputs in rows (Sporri et al., 2007). "Intermediate demand (Z)" shows transactions between production sectors, while "final demand (y)" includes household consumption and international trade. To extend the input-output table, labour and capital factors, as well as government contributions, were incorporated, creating a quasi-social accounting matrix (Q-SAM). The Q-SAM is a square matrix that represents transactions between income rows and expenditure columns for various sector accounts. In a SAM's square format, the total receipts must equal the total payments for each account (Van Deventer & Davies, 2019). The Q-SAM is useful for assessing the socio-economic impact of external changes on the national economy.

In this study, we use the Q-SAM to examine the impact of CAPEX and OPEX on the overall economy of South Africa. The Q-SAM model utilized the Leontief matrix algebra framework to calculate multipliers. Leontief matrix algebra is a mathematical framework employed in economics to analyse input-output relationships between various sectors of an economy, studying their interdependence The model estimates the direct and indirect effects of economic growth and displays the overall impact on GDP and compensation for employees of both the direct and indirect effects. The direct and indirect effects are defined in Table 4-1.

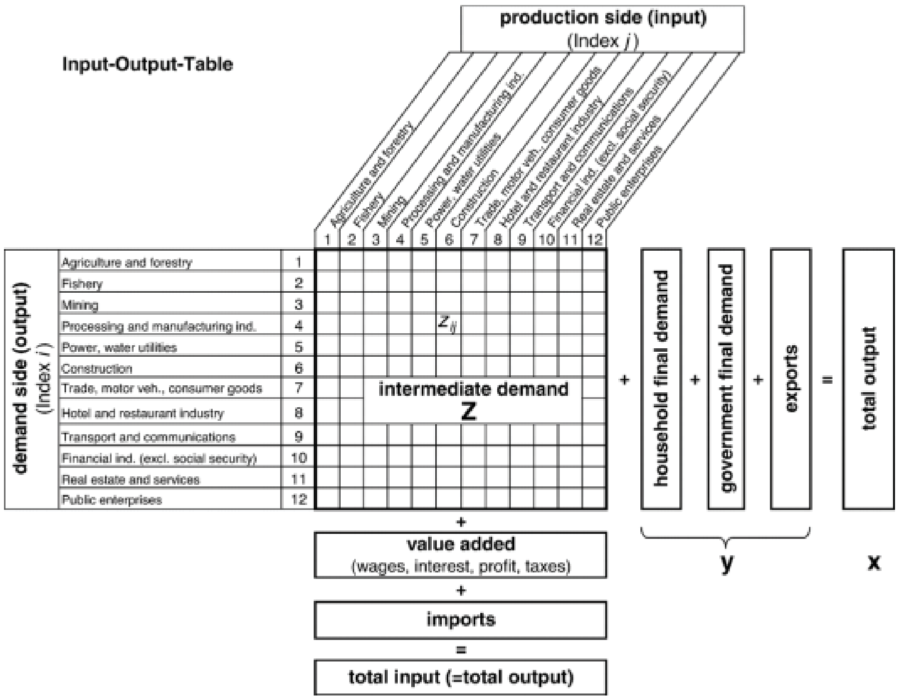


Figure 4-1: Illustrative Input-Output Table (Sporri et al., 2007)

Table 4-1: Definitions of direct and indirect impact Source: Prime Africa own compilation

GDP (Economic Growth)	
Direct Impact	**Indirect Impact**
The direct economic impact is the change in economic activities that are directly related to the Capital and Operational expenditures going into the economy	The indirect economic impact seeks to capture the ripple effect to the host economy (e.g. additional money spent in the region by saying an increase in eco-tourism) Indirect impact, also known as the multiplier effect, includes the spending of revenues in the local economy.
Compensation to Employees	
Direct Impact	**Indirect Impact**
Total employment created / destroyed directly based on the capital and operational expenditures going into the economy.	Indirect employment is the total of jobs created/destroyed based on the capital and operational expenditures going into the economy. For example, Local businesses that provide goods and services to the eco-tourism sector increase / decrease the number of their employees as eco-tourism is on the rise/fall, thus creating a multiplier of employment

In summary, the construction of the economic tool involves several steps to understand the impact of certain costs on the economy:

- First, we calculate the percentage of the final demand that contributes to the total output (GDP). This final demand represents the actual amount that enters the economy.
- Next, we determine how much value is added to the economy when we put an amount into a specific sector, considering factors like CAPEX and OPEX values. This helps us understand the value each sector adds to the total output.
- Supply and Use tables published by StatsSA in 2023 for the year 2019 were used to construct an input-output table. Using the input-output table, we calculate industry multipliers using Leontief matrix algebra. These multipliers allow us to estimate the direct and indirect economic benefits of different scenarios.
- The model focuses on sectors in the economy that are affected by specific costs, such as machinery costs in construction. We identify these sectors as the first step.
- Once the affected sectors are identified, we introduce the cost amount as an injection into the economy. By using the final demand percentages of each sector, we calculate the total final demand, which represents the actual amount that enters the economy from the injection.
- To assess the overall impact of the cost injection on GDP and employment compensation, we use production multipliers and income effect multipliers of various sectors.

Our model helps us understand how different costs affect the economy by analysing specific sectors and their contributions to the total output and value-added. By using industry multipliers, we can estimate the economic benefits of various scenarios and their impact on GDP and employment.

4.2.2 Multipliers and impact estimation

The Leontief inverse matrix was used to calculate the output multiplier, the income multiplier, and the income effects (D'Hernoncourt, Cordier and Hadley, 2011)

- The multiplier of the output of a given industry can be defined as the sum of all the outputs of each national industry necessary for the realization of an additional production unit.
- The income multiplier indicates the increase in employment income as a result of a change in employment income of one Rand for each industry.
- The income multiplier shows the impact on employment income across the economy resulting from an increase of one unit of final demand for industry output.

4.3 Results and Discussion

4.3.1 Economic Impact of CAPEX

4.3.1.1 Economic Sectors Impacted

The financial model's predicted Low Range and High Range CAPEX expenses have been split between the economic sectors affected. The purpose of doing this was to illustrate the economic implications of both the low range and high range expenses more clearly. The CAPEX expenses related to upgrading WWTWs are displayed in table 4-2 below.

- Mechanical assets are all the machinery costs associated with the upgrading/building, therefore industries using mechanical equipment are those that are impacted. Due to the segmentation of those sectors, the four sectors for machinery bear an equal share of the cost of mechanical assets.
- The electrical machinery sector was matched with electrical assets.
- Civil assets are the costs associated with building; these costs include steel, concrete, and any other sectors involved in building. The amount was split amongst the six sectors equally.
- Instrumentation refers to the observation, measurement, and control tools and equipment utilized in plants. Consequently, both the general machinery and electrical machinery sectors are impacted.
- Design fees include the expenditures of professionals who work on both the design and implementation of structures. Since professional services (such as architectural and engineering services) are provided in support of building projects, this has an impact on the other business activities sector.

Please find the accompanied Economic Model spreadsheet to see detailed economic impact of investing in WWTWs as a result of population growth per scenario (i.e. WOM, WEM, WAM) up to 2050.

Table 4-2: Breakdown of Capital Expenditure

Types of Capital expenditure	Sectors Impacted
Mechanical Assets	Engines, turbines, pumps, compressors, bearings and gears
	Lifting, handling equipment
	Other general machinery
	Special-purpose machinery
Electrical Assets	Electrical machinery
Civil Assets	Basic Iron, Steel
	Iron, steel products
	Structural metal, tanks and reservoirs
	Plaster, lime, cement
	Concrete, cement, plaster
	Construction services
Instrumentation	Other general machinery
	Electrical machinery
Design Fees	Other business activities

4.3.1.2 Impact of CAPEX on South African Economy

In Table 4-3 4-3, an overview of the CAPEX investments' implications on GDP, employment, and net exports is presented for the years 2025, 2035, and 2045. Looking at the results, the CAPEX investment in WWTW during 2025 is forecasted to yield significant outcomes, contributing a total effect of R986 million to the GDP, along with a noteworthy impact of R513 million on the compensation of employees. Further insights into the ramifications of OPEX, Net Exports, and detailed information on the associated multipliers can be found in Section 10 of the Appendix. This section delves deeper into the economic results, providing a better understanding of the broader implications of the investments analysed.

Table 4-3: Low Range: Economic impact of *CAPEX for WOM Scenario*

WOM				
CAPEX – Low Range		2025	2035	2045
Indicator	Unit	Economic Effect		
CAPEX Input	Million R	3,273	3,585	4,259
Final demand	Million R	825	905	1,120
Total Effect GDP	Million R	986	1,087	1,325
Total Effect Compensation of employees	Million R	513	566	690
Net Exports	Million R	183	201	248

4.3.1.3 Economic Impact of not Investing in WWTWs

The effluent quality of WWTWs affects all people in the society as well as the economy in a number of ways. The discharge of poorly treated or untreated wastewater into the environment reduces the ability of the environment to provide the benefits on which society depends, negatively affecting the availability of clean water for urban, agricultural and industrial use. Pathogens carried by improperly treated wastewater leads to infant mortality or morbidity as well as increased absenteeism from the work force, decreasing national productivity (Van Vuuren, 2010). The national press noted that poor water quality threatens the export market for irrigated produce. Farmers from an irrigation scheme have been warned by the EU Regulator to attend to water quality or risk losing these export opportunities supporting this economy. Thus, there are social and economic reasons, in addition to the regulatory requirements, to improve the performance of wastewater treatment works.

The consequences of not investing in WWTW infrastructure also increases human health risk, increases the cost of water treatment downstream, reduces property value, decreases tourism and has many other economic damage costs. Critically, it also reduces availability of fresh water, an effective water loss that South Africa cannot afford.

According to capacity required by 2050, the modelled output shows that South Africa needs to increase capacity of WWTW by 755 MLD, from 40 WSAs, with municipalities in Gauteng accounting 78% of the total volume. Brownfield and greenfield developments are thus important as the effluent water quality will affect production of primary (i.e. agriculture and mining) and secondary sectors (i.e. manufacturing) in the economy. These sectors contribute the following to GDP:

- Agriculture: 3%
- Mining: 8%
- Manufacturing: 13%

The primary sector contributes 6.4% to total employment and secondary sector contributes 11.5% of total employment.

Mitigating the water pollution is more costly than investing in maintaining the condition of WWTWs (e.g. 20 MLD reverse osmosis can cost approx. R250 million, excluding OPEX). Implementing Waste Discharge Charge System (WDCS) as a result of not investing in WWTWs will imply that budget must be set aside in developing rehabilitation programmes across the country such as artificial wetlands, reverse osmosis etc., which must be implemented by Catchment Management Agencies (CMAs) to meet Resource Quality Objectives (RQOs).

5 CONCLUSIONS AND RECOMMENDATIONS

Most South African wastewater treatment plants have been performing poorly in recent years with some operating above their design capacities. This often results in partially treated and sometimes raw wastewater being discharged into water courses and the environment. Untreated or poorly treated effluent degrades natural ecosystems, increases human health risk, increases the cost of water treatment downstream, reduces property value, and has many other economic damage costs. Critically, it also reduces the availability of fresh water, an effective water loss that South Africa cannot afford.

Understanding the treatment demand projections, together with its investment requirements could be used as valuable tools in the planning and financing of wastewater capital infrastructure and operation.

In this assignment, we developed three tools required to foresight WWTWs investment plan in South Africa:

- Spatial data base
- Financial tool
- Economic tool

The spatial database had information of domestic and DPW WWTWs, and this information included the following for the year 2022:

- design capacity
- operational capacity
- liquid treatment technology
- sludge treatment technology
- name of the river being discharged into
- GD score
- WWTW coordinates

In order to determine capacity requirements of WWTWs in the next three decades, sanitation pathways per WSA were then collected and also displayed spatially. Three Scenarios were developed by analysing historical trends per sanitation pathway and per income group (i.e. rural and urban) in each WSA. The output was the determination of additional capacity required per WSA up to 2050. Additional analysis was done to determine either brown or green field development, together with the type of treatment technology.

Discounted cash flow model was developed with CAPEX and OPEX requirements per WSA as inputs. Each scenario had its own financial statements which included:

- Income statement
- Statement of financial position
- Cash flow waterfall: a concise cash flow statement as it displays the cash flows in the order in which they occur. It also provides an indication of the cash available for debt service, which is a key metric to assess credit worthiness.

The outputs of the model were calculating:

- Rate of return

- Tariff charge
- The optimum combination of debt and equity

The economic model was developed to assess the economic benefits of investing in WWTWs and also an awareness for investment purposes. This was done through QSAM: Social Accounting Matrix: Input-output model that can illustrate the impact of investment, leading to higher GDP and increased employment. The output of the model was to determine GDP and compensation to employees as a result of investing in WWTWs. The model showed that if the country injects R 3.3 billion, the GDP effect will be R986 million and R 513 million to labour.

Environmental benefits from investing in WWTWs was also determined and this was through determining ecosystem services provided.

Our key conclusions are as follows:

- The spatial data is a powerful tool that can be utilise by WSAs/Government to determine future capacity of WWTWs.
- The financial model developed is a tool that a WSA can use to determine CAPEX required to upgrade/build their WWTWs and depending on whether the funds will come from debt or equity, they can also determine the tariff needed to pay back the loan/investors and also considering OPEX costs.
- Economic model is a tool that can be used to demonstrate to investors/Government the economic benefits as a result of investing in WWTWs, which can be part of the WSA's business plan.
- Investing in WWTWs has numerous benefits besides economic benefits and providing sanitation service to the people, and this can be demonstrated through determining ecosystem services to be provided as a result of effluent that is complying with the water use licence.

The tools developed were displayed on different levels:

- WWTW data base: plant level
- Sanitation pathway projection: WSA level
- Financial model: National level
- Economic model: National level

For further work, it is therefore recommended that the tools be integrated on a WSA level. This integration will mean that WSAs will be able to see their own projections, number of WWTWs they need to upgrade, CAPEX required, and economic benefits from the investments. The integration should be tested on at least two WSAs (i.e. MM and rural LM) with different economic status, to demonstrate its applicability.

Furthermore, the evidence suggests that the WWTW upgrades will need to be financed using some combination of debt and equity. This usually takes place in a Public-Private-Partnership (PPP) structure and so the PPP model will be an essential component in the funding of these upgrades. The Water Partnership Office, implemented by the DBSA, is a programme which seeks to accelerate water and sanitation infrastructure delivery across South Africa. There is also a Private Sector Participation Model (PSPM) within the DBSA specifically focussing on Water and Sanitation. It is therefore worth investigation how the tools developed in this WRC report can be integrated or further developed with the PSPM in the DBSA under guidance from the Water Partnership Office.

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7 APPENDIX A: SCENARIO DEVELOPMENT

The scenarios were developed by observing historical data of sanitation pathways per income group; migration from rural to urban over the years; and migration up the sanitation ladder. Post identifying the historical trend, three scenarios were developed which included, baseline scenario; DWS master plan scenario (100% population with sanitation level above RDP level); and additional mitigation measure scenario (i.e. more households connected to the sewer system).

The three scenarios developed as shown in Table 7-1 included:

1. Baseline without mitigation measures (**WOM):** Historical data on households per sanitation pathways per income group (i.e. rural and urban), and the data was for the years 2000-2017. Besides the historical trend, the baseline scenario used the most recent United Nations population dynamics figures to project population to 2050.

2. Baseline with existing mitigation measures **(WEM):** This scenario incorporated targets the Government has set towards sanitation services, balanced with socio-economic development goals, through their policies (e.g. Department of Water and Sanitation Master Plan).

3. Baseline with additional measures (**WAM**): This scenario was a build-up from the previous scenario but including ambitious mitigation strategies such as migrating more people onto the sewer system.

Table 7-1: Data sources and policies that guided the development of sanitation pathways scenarios

Sanitation pathway Scenarios			
Scenario	**Forecast principles**	**Relevant Policies**	**Data sources and notes**
Baseline without mitigation measures (**WOM**)	Population growth increases to 2050 as projected by historical data	N/A	Historical trends based on existing data, constrained by StatsSA and UN projections
	Migration between grouping income segment and sanitation pathway	N/A	Historical trends based on existing data, constrained by StatsSA and UN projections
Baseline with existing mitigation measures (**WEM**)	Achieve Water and Sanitation Master Plan goal: 100% of population having sanitation above RDP level (0% of population with no sanitation)	Water and Sanitation Master Plan	N/A
Baseline with additional measures (**WAM**)	WEM + Migrate double baseline % of pit latrine people to flush toilets	Water and Sanitation Master Plan	N/A

7.1.1 Baseline scenario without additional measures (WOM)

The data was split between Pit Latrines, None, Septic tanks, and Sewer per income group. The data used to forecast to 2050 was based on the observed historical trends. The data used for the observation was from 2000-2017. Sanitation pathways per income also considered population migration from rural to urban areas.

The following approach was used to determine migration percentages and population growth per sanitation pathway per income group:

1. Rural-None: observed population increase of this sanitation pathway; and migration to pit latrine
2. Rural-Pit Latrine: observed population increase of this sanitation pathway; and migration to septic tanks
3. Rural-Septic Tank: observed population growth of this sanitation pathway; and migration from pit latrine users
4. Rural-Sewer: observed population growth of this sanitation pathway; and migration from pit latrines
5. Urban-None: observed population increase of this sanitation pathway; and migration to sewer system
6. Urban-Pit Latrine: observed population increase of this sanitation pathway; and migration to sewer system and septic tank
7. Urban-Septic Tank: observed population increase of this sanitation pathway; and migration from pit latrine
8. Urban-Sewer: observed population increase of this sanitation pathway; and migration from none and pit latrine.

7.1.2 Baseline scenario with existing measures (WEM)

The WOM scenario with addition of Water and Sanitation Master Plan, which has a target of 100% population with sanitation above RDP level by 2030. Population with no sanitation in rural migrated to pit latrines and population with no sanitation in urban low migrated to sewer system.

The following approach was used to determine migration percentages and population growth per sanitation pathway per income group:

1. Rural None and bucket: all users are migrated to pit latrines
2. Rural Pit Latrine: users increase as population with no sanitation are connected, with addition to baseline trend. Reduction of users as they migrate to septic tank
3. Rural Septic Tank: baseline trend, with addition of migration of pit latrine users
4. Rural Sewer: users followed baseline trend
5. Urban None: all users are migrated to sewer
6. Urban Pit Latrine: users followed baseline trend, and reduction of users as they migrate to septic tank and sewer
7. Urban Septic Tank: users followed baseline trend, with addition to migration from pit latrine
8. Urban Sewer: users followed baseline, with addition to migration from pit latrine.

7.1.3 Baseline scenario with additional measures (WAM)

The WAM scenario considered double the percentage change of baseline pathway migration. The observed data indicated that people are moving from pit latrines to sewer and septic tank; septic tank to sewer system, as well as between different income groups for the years between 2000-2017.

The following approach was used to determine migration percentages and population growth per sanitation pathway per income group:

1. Rural None: all users are migrated to pit latrines
2. Rural Pit Latrine: users decrease as more people are migrating to sewer and septic tank
3. Rural Septic Tank: baseline trend, with addition of migration of pit latrine users
4. Rural Sewer: users followed baseline trend with addition to more migration of pit latrine users
5. Urban None: all users are migrated to sewer
6. Urban Pit Latrine: users followed baseline trend, and reduction of users as they migrate to septic tank and sewer
7. Urban Septic Tank: users followed baseline trend, with addition to migration from pit latrine
8. Urban Sewer: users followed baseline, with addition to migration from pit latrine.

7.1.4 Forecast Additional WWTW Capacity

In determining additional volume of incoming flow in each scenario as a result of increased population, two options were investigated:

1. Observe historical operational flow of WWTWs: Obtain operational flow of WWTWs from 2011 GD; 2014 GD PAT; and 2022 GD, and use percentage increase in flow to forecast additional volume until 2050.
2. Population growth: collect additional number of households on sewer per scenario (including septic tank users). Determine additional flow through calculating basic volume of household per month (6 kl) and assume 70% of the volume ends up in the sewer.

The first option had gaps and as a result, the second option was used. The concern with the first option was that some WWTWs do not measure incoming flow, and also in some instances, operational flow does not increase, which might be due to leaks in the sewer networks.

To determine number of households that will have an impact on capacity of WWTWs, the following sanitation pathways were selected as their volumes end up in the sewer system:

- Flush toilets
- Septic tank
- Bucket
- Chemical toilets

The calculated percentages as shown in Table 7-2 below were used to determine annual increase in households per income group being connected to the sewer.

Table 7-2: Annual percentage increase of households connected to the sewer system

Sanitation pathway	Income group	scenario	Principle	Annual percentage increase of households on sewer system
Flush toilets + septic tank + chemical toilets	Rural	WOM	• Population growth increases to 2050 as projected by historical data (2000-2017) • People migrate from rural to urban • Migration up the sanitation ladder (migration of pit latrine to septic)	0.32
		WEM	• WOM + achieve Water and Sanitation Master Plan goal: 100% of population have sanitation above RDP level (0% of population with no sanitation) • Migration up the sanitation ladder	1.85
		WAM	• WEM + Migrate double baseline % of pit latrine people to flush toilets	2.92
	Urban	WOM	• Population growth increases to 2050 as projected by historical data (2000-2017) • People migrate to urban areas • Migration up the sanitation ladder (migration of pit latrine to sewer)	2.51
		WEM	• WOM + achieve Water and Sanitation Master Plan goal: 100% of population have sanitation above RDP level (0% of population with no sanitation)	2.32
		WAM	• WEM + Migrate double baseline % of pit latrine people to flush toilets	3.14

8 APPENDIX B: SPATIAL DATA BASE

The figures below are the results of the spatial database

A	B	F	G	H	L	M	N	O	P	Q	R	S	T	U	V	
Province	Municipal Name	Rural HH	Urban HH	Total HH	Rural Households with Access to RDP Level Sanitation	Urban Households with Access to RDP Level Sanitation	Total Households with Access to RDP Level Sanitation	Rural Flush toilet (connected to sewerage system) Households	Urban Flush toilet (connected to sewerage system) Households	Total Flush toilet (connected to sewerage system) Households	Rural Flush toilet (with septic tank) Households	urban Flush toilet (with septic tank) Households	Total Flush toilet (with septic tank) Households	Rural Chemical toilet Households	Urban Chemical toilet Households	Tot Che toil Hou
Eastern Cape(EC)	Alfred Nzo District Municipality	207 855	13 385	221 240	170 921	10 923	181 844	8 839	478	9 317	418	60	478	22 675	1 653	
Eastern Cape(EC)	Amathole District Municipality	188 454	1 182	189 636	130 507	5 646	136 153	334 337	1 106	335 443	2 541	-	2 541	24 594	1 227	
Eastern Cape(EC)	Blue Crane Local Municipality	1 992	6 960	8 952	1 760	7 192	8 952	1 688	6 898	8 586	35	146	181	24 594	1 227	
Eastern Cape(EC)	Buffalo City Metropolitan Municipa	95 044	134 454	229 498	94 943	133 617	228 560	75 421	112 410	187 831	3 571	4 508	8 079	73	565	
Eastern Cape(EC)	Chris Hani District Municipality	136 813	4 211	141 024	88 212	36 425	124 637	29 734	31 380	61 114	2 063	1 320	3 383	12 503	2 142	
Eastern Cape(EC)	Dr Beyer Naude Local Municipality	235	18 571	18 806	235	18 571	18 806	235	17 956	18 191	-	502	502	-	-	
Eastern Cape(EC)	Joe Gqabi District Municipality	51 481	34 987	86 468	33 397	28 533	61 930	6 289	20 300	26 589	2 320	1 790	4 110	10 637	3 412	
Eastern Cape(EC)	Kouga Local Municipality	898	31 053	31 951	794	27 144	27 938	768	25 803	26 571	19	991	1 010	9	497	
Eastern Cape(EC)	Koukamma Local Municipality	189	10 325	10 514	189	10 296	10 485	166	9 028	9 194	23	1 182	1 205	-	-	
Eastern Cape(EC)	Makana Local Municipality	46	20 533	20 579	46	72 180	72 226	46	18 442	18 488	-	170	170	-	883	
Eastern Cape(EC)	Ndlambe Local Municipality	171	18 701	18 872	153	16 116	16 269	128	12 656	12 784	17	2 300	2 317	-	-	
Eastern Cape(EC)	Nelson Mandela Bay Metropolitan	1 407	332 610	334 017	1 407	332 610	334 017	1 381	323 438	324 819	26	9 112	9 138	-	-	
Eastern Cape(EC)	OR Thambo Municipality	333 131	41 310	374 441	226 529	27 819	254 348	17 578	5 257	22 835	335	234	569	56 583	7 450	
Eastern Cape(EC)	Sunday's River Valley Local Municip	63	15 550	15 613	63	11 523	11 586	63	11 103	11 166	-	298	298	-	-	
Free State	Dihlabeng Lacal Municipality	1 902	49 560	51 462	1 673	43 637	45 310	1 573	41 085	42 658	54	1 378	1 432	168	4 317	
Free State	Kopanong Local Municipality	3 251	16 977	20 228	3 201	16 882	20 083	2 836	14 890	17 726	334	1 887	2 221	12	7	
Free State	Letsemeng Local Municipality	2 584	12 764	15 348	2 394	11 816	14 210	2 020	9 064	11 084	248	1 236	1 484	125	619	
Free State	Mafube Local Municipality	997	19 590	20 587	846	16 630	17 476	835	16 427	17 262	11	186	197	-	-	
Free State	Malutu-A-Phofung Local Municipali	50 233	82 818	133 051	29 157	47 924	77 081	15 846	25 991	41 837	1 135	1 853	2 988	8 795	14 241	
Free State	Mangaung Local Municipality	7 375	284 285	291 660	7 037	251 867	258 904	5 936	207 464	213 400	186	6 477	6 663	237	23 003	
Free State	Mantsopa Local Municipality	1 205	17 413	18 618	1 131	16 373	17 504	1 131	15 683	16 814	1 131	289	1 420	1 131	215	
Free State	Masilonyana Local Municipality	1 637	22 039	23 676	1 495	20 137	21 632	1 469	19 838	21 307	13	156	169	20	270	
Free State	Matjabeng Local Municipality	2 494	161 357	163 851	2 228	144 111	146 339	2 214	143 295	145 509	7	434	441	133	8 518	

Sanitation pathways | Green drop plant data

Figure 8-1: Number of households per sanitation pathways separated by rural and urban areas

Province	Municipal Name	Plant Name	Liquid Treatment Type	Sludge Treatment	Discharge Source	Design Capacity (Ml/day)	Operational Capacity (Ml/day)	Latitude	Longitude
Eastern Cape(EC)	Alfred Nzo District Municipality	Mt Ayliff	activated sludge	anaerobic digestion	Mzintlava River	1,4	0,83	-30.8137	29.3447
Eastern Cape(EC)	Alfred Nzo District Municipality	Mount Frere	activated sludge	anaerobic digestion	Chapoti River	2	0,76	-30.88921	29.041
Eastern Cape(EC)	Alfred Nzo District Municipality	Matatiele	activated sludge	sludge lagoon/pond	Khoapa Stream -Tyinirha Rive	2	0,83	-30.32856	28.7999
Eastern Cape(EC)	Alfred Nzo District Municipality	Cedarville	aerated ponds	sludge lagoon/pond	Wetland	0,7	0,65	-30.38059444	29.05131389
Eastern Cape(EC)	Alfred Nzo District Municipality	Bizana	aerated ponds	non specified	Ledeke dam-Mtamvuna	0,28	0,28	-30.845	29.8741667
Eastern Cape(EC)	Alfred Nzo District Municipality	Ntabankulu	evaporation Ponds	non specified	No discharge	0,5	0,5	-30.962158589049086	29.305443198527264
Eastern Cape(EC)	Amathole District Municipality	Adelaide	activated sludge	solar drying beds	Koonap River	1,8	0,68	-32.6927778	26.2958333
Eastern Cape(EC)	Amathole District Municipality	Amabele	biologica filters	solar drying beds	No discharge	0,05	0,13	-32.67195529540895	27.536935941041282
Eastern Cape(EC)	Amathole District Municipality	Bedford	aerated pond	sludge lagoon	Irrigated to golf course	0,5	0,6	-32.685833	26.106111
Eastern Cape(EC)	Amathole District Municipality	Butterworth	biologica filters & activate	anaerobic digestion	Gcuwa	6	5,23	-32.32916667	28.190556
Eastern Cape(EC)	Amathole District Municipality	Cathcart	activated sludge	solar drying beds	Thorn River	1	0,54	-32.30941169788268	27.155918805134597
Eastern Cape(EC)	Amathole District Municipality	Cintsa	aerated pond	non specified	no discharge	0,3	0,15	-32.8158333	28.102222
Eastern Cape(EC)	Amathole District Municipality	Dutywa	aerated pond	sludge lagoon	Gxakaxha	1,1	1,1	-32.1016667	28.3141667
Eastern Cape(EC)	Amathole District Municipality	Fort Beaufort	activated sludge & SRB	solar drying beds	Kat River	2,7	2,49	-32.78427514118975	26.648370726524142
Eastern Cape(EC)	Amathole District Municipality	Kei Mouth	maturation ponds	non specified	No discharge	0,7	0,69	-32.7	28.3627778
Eastern Cape(EC)	Amathole District Municipality	Keiskammahoek	activated sludge	non specified	Keiskamma	0,7	1,56	-32.69142436094026	27.142563534719407
Eastern Cape(EC)	Amathole District Municipality	Komga	activated sludge	solar drying beds	Kei	0,63	0,52	-32.58416667	27.87527778
Eastern Cape(EC)	Amathole District Municipality	MiddleDrift	activated sludge	solar drying beds	Keiskamma	0,33	0,22	-32.81076750465781	26.994008066926245
Eastern Cape(EC)	Amathole District Municipality	Peddie	activated sludge	solar drying beds	Keiskamma	0,3	1,1	-33.20430584462503	27.131453273015065
Eastern Cape(EC)	Amathole District Municipality	Seymour	activated sludge	solar drying beds	Gesi	0,25	0,25	-32.542062708388265	26.766026419045197
Eastern Cape(EC)	Amathole District Municipality	Stutterhein	activated sludge	solar drying beds	Cumakala	3	2,92	-32.57059628675352	27.43501072883585
Eastern Cape(EC)	Blue Crane Local Municipality	Cookhouse	anaerated ponds/ fuclutativ	non specified	Little Orange fish River	0,47	0,47	-32.737339012181955	25.792428238093073
Eastern Cape(EC)	Blue Crane Local Municipality	Pearston	anaerated ponds/ fuclutativ	non specified	Little Orange fish River	1	1	-32.58929970220123	25.147476896004402
Eastern Cape(EC)	Blue Crane Local Municipality	Somerset East	anaerated ponds/ fuclutativ	non specified	Little Orange fish River	2,5	1,4	-32.74052843051025	25.584686616666175
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Amalinds/ Centr	biologica filters	solar drying beds	Buffalo River	5	6,5	-33.0080556	27.85666667
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Berlin	biologica filters	Anaerated digester	Nahoon River	2	0,68	-32.84111111	27.61916667
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Breidbach	aerated ponds/oxidation pc	has never been disluc	Irrigation	1,6	2,8	-32.90167	27.440833
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Bhisho	aerated ponds/oxidation pc	non specified	Irrigation	2	1,7	-32.8452778	27.46
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Dimbaza	activated sludge & extended aeration & sludge la		Mdizeni Stream	7,7	8,47	-32.85361	27.234722
Eastern Cape(EC)	Buffalo City Metropolitan Munic	East Bank	activated sludge	Sludge disposal in the	Sea & irrigation	40	26	-32.996168586486526	27.94377290212887
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Gonubie	activated sludge	sludge lagoon	Sea	18	18	-32.958212	27.992651
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Kayser's Beach	evaporation Pond (no efflu	non specified	Zero discharge	0,8	0,16	-33.20361	27.593889
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Kidds Beach	evaporation Pond (no efflu	non specified	Mcantsi River	0,4	0,6	-33.13861	27.686389
Eastern Cape(EC)	Buffalo City Metropolitan Munic	Mdantsane	biologica filters	anaerobic digestion	Buffalo River	24	12,48	-32.96611	27.71

Sanitation pathways | Green drop plant data

Figure 8-2: WWTW information per WSA for the year 2022

Rural

Year	Area Classification	Urbanisation	Sanitation type	Population	Increament difference
2000	National	Rural	Sewer	5 160 344	
2001	National	Rural	Sewer	5 287 758	2%
2002	National	Rural	Sewer	5 433 443	3%
2003	National	Rural	Sewer	5 760 220	6%
2004	National	Rural	Sewer	6 086 997	6%
2005	National	Rural	Sewer	6 357 051	4%
2006	National	Rural	Sewer	6 610 036	4%
2007	National	Rural	Sewer	6 911 157	5%
2008	National	Rural	Sewer	7 217 145	4%
2009	National	Rural	Sewer	7 644 289	6%
2010	National	Rural	Sewer	7 771 780	2%
2011	National	Rural	Sewer	6 095 325	-22%
2012	National	Rural	Sewer	6 697 408	10%
2013	National	Rural	Sewer	7 125 819	6%
2014	National	Rural	Sewer	7 331 969	3%
2015	National	Rural	Sewer	7 380 204	1%
2016	National	Rural	Sewer	7 253 313	-2%
2017	National	Rural	Sewer	7 125 686	-2%
2018	National	Rural	Sewer	7 416 543	4%
2019	National	Rural	Sewer	7 707 401	4%
2020	National	Rural	Sewer	8 010 131	4%
2021	National	Rural	Sewer	8 324 733	4%

Urban

Year	Area Classification	Urbanisation	Sanitation type	Population	Increament difference
2000	National	Urban	Sewer	17 792 776	
2001	National	Urban	Sewer	18 633 674	5%
2002	National	Urban	Sewer	19 843 866	6%
2003	National	Urban	Sewer	20 245 910	2%
2004	National	Urban	Sewer	20 647 955	2%
2005	National	Urban	Sewer	21 053 727	2%
2006	National	Urban	Sewer	21 452 092	2%
2007	National	Urban	Sewer	21 478 308	0%
2008	National	Urban	Sewer	21 705 652	1%
2009	National	Urban	Sewer	22 111 215	2%
2010	National	Urban	Sewer	23 184 415	5%
2011	National	Urban	Sewer	24 712 745	7%
2012	National	Urban	Sewer	25 547 113	3%
2013	National	Urban	Sewer	26 314 520	3%
2014	National	Urban	Sewer	27 018 053	3%
2015	National	Urban	Sewer	27 668 431	2%
2016	National	Urban	Sewer	28 268 213	2%
2017	National	Urban	Sewer	28 810 376	2%
2018	National	Urban	Sewer	30 790 449	7%
2019	National	Urban	Sewer	31 966 437	4%
2020	National	Urban	Sewer	33 223 247	4%
2021	National	Urban	Sewer	34 528 060	4%

Scenario	Rural	Urban
WOM	0,32%	2,51%
WEM	1,85%	2,32%
WAM	2,92%	3,14%

Figure 8-3: Development of scenarios of households connected to sewer

A	B	P	Q	R	Y	Z	QC	QD	QE	QF	QG	QH	QI	QJ	QK	QL	QM	QN	QO	QP	QQ
														2050							
								Rural	Urban												
							WOM	0,32%	2,51%												
							WEM	1,85%	2,32%												
							WAM	2,92%	3,14%												
Province	Municipal Name	Rural HH on sewerage system	Urban HH on sewerage system	Total HH on sewerage system	Design capacity	Operational capacity	WOM Rural	WOM Urban	Additional Volume of wastewater Ml per day	operational capacity / design capacity	2050 WOM: Over Capacity (Ml/day)	WEM rural	WEM urban	Additional Volume of wastewater Ml per day	operational capacity / design capacity	2050 WEM: Over Capacity (Ml/day	WAM Rural	WAM Urban	Additional Volume of wastewater Ml per day	operational capacity / design capacity	2050 WAM: Over Capacity (Ml/day)
Eastern Cape(E	Alfred Nzo District Muni	32 113	2 206	34 319	7	3	49 965	3 778	0,92	58%		54 645	4 289	3,45	95%		73 955	5 403	6,25	135%	2,43
Eastern Cape(E	Amathole District Muni	361 988	2 333	364 321	19	18	566 640	3 996	6,70	129%	5,53	615 976	4 535	35,93	280%	34,75	833 647	5 714	66,24	436%	65,07
Eastern Cape(E	Blue Crane Local Munici	26 317	8 271	34 588	4	3	41 432	14 166	1,20	103%	0,10	44 782	16 079	3,66	164%	2,56	60 607	20 259	6,44	235%	5,34
Eastern Cape(E	Buffalo City Metropolita	79 065	117 483	196 548	175	106	119 010	201 210	15,20	69%		134 541	228 389	22,74	74%		182 084	287 763	36,82	82%	
Eastern Cape(E	Chris Hani District Muni	45 233	34 943	80 176	48	106	68 054	59 846	5,45	235%	64,07	76 971	67 930	8,93	242%	67,54	104 170	85 589	14,81	254%	73,43
Eastern Cape(E	Dr Beyer Naude Local M	235	18 458	18 693	9	7	370	31 613	1,86	95%		400	35 883	2,39	101%	0,07	541	45 211	3,67	115%	1,35
Eastern Cape(E	Joe Gqabi District Muni	19 324	25 689	45 013	19	20	26 805	43 997	4,36	128%	5,29	32 883	49 940	5,10	132%	6,02	44 503	62 923	8,07	147%	9,00
Eastern Cape(E	Kouga Local Municipalit	858	29 670	30 528	17	26	1 323	50 815	3,01	172%	11,98	1 460	57 679	3,87	177%	12,84	1 976	72 674	5,94	189%	14,91
Eastern Cape(E	Koukamma Local Munic	189	10 210	10 399	5	2	262	17 486	1,07	59%		322	19 848	1,20	61%		435	25 008	1,82	75%	
Eastern Cape(E	Makana Local Municipal	46	19 618	19 664	9	12	73	33 599	1,96	158%	5,10	78	38 138	2,57	164%	5,71	106	48 052	3,95	180%	7,08
Eastern Cape(E	Ndlambe Local Municipa	145	15 054	15 199	9	14	202	25 783	1,59	169%	6,34	247	29 265	1,68	170%	6,43	334	36 873	2,53	180%	7,28
Eastern Cape(E	Nelson Mandela Bay M	1 407	332 550	333 957	205	158	2 177	569 550	33,49	93%		2 394	646 483	42,80	98%		3 240	814 547	65,56	109%	18,48
Eastern Cape(E	OR Thambo Municipalit	78 888	13 188	92 076	32	21	123 833	22 587	2,59	73%		134 240	25 638	9,47	95%		181 677	32 303	16,98	118%	5,91
Eastern Cape(E	Sunday's River Valley Lo	63	13 068	13 131	5	5	99	22 381	1,31	140%	1,87	107	25 404	1,69	148%	2,24	145	32 009	2,59	168%	3,14
Free State	Dihlabeng Lacal Municip	1 837	47 895	49 732	32	25	2 811	82 029	4,88	92%		3 126	93 109	6,32	97%		4 231	117 314	9,72	107%	2,35
Free State	Kopanong Local Municip	3 191	16 784	19 975	8		4 504	28 746	1,99	24%		5 430	32 628	2,27	27%		7 349	41 111	3,50	42%	
Free State	Letsemeng Local Munici	2 430	11 124	13 554	9		3 440	19 052	1,34	16%		4 135	21 625	1,54	18%		5 596	27 247	2,38	28%	
Free State	Mafube Local Municipal	990	19 467	20 457	12	6	1 543	33 341	1,97	70%		1 685	37 844	2,64	76%		2 280	47 682	4,09	88%	

Flush+Bucket+Chemical+Septic

Accessibility: Good to go — Display Settings

Figure 8-4: Required capacity of WWTWs for the year 2025 per scenario

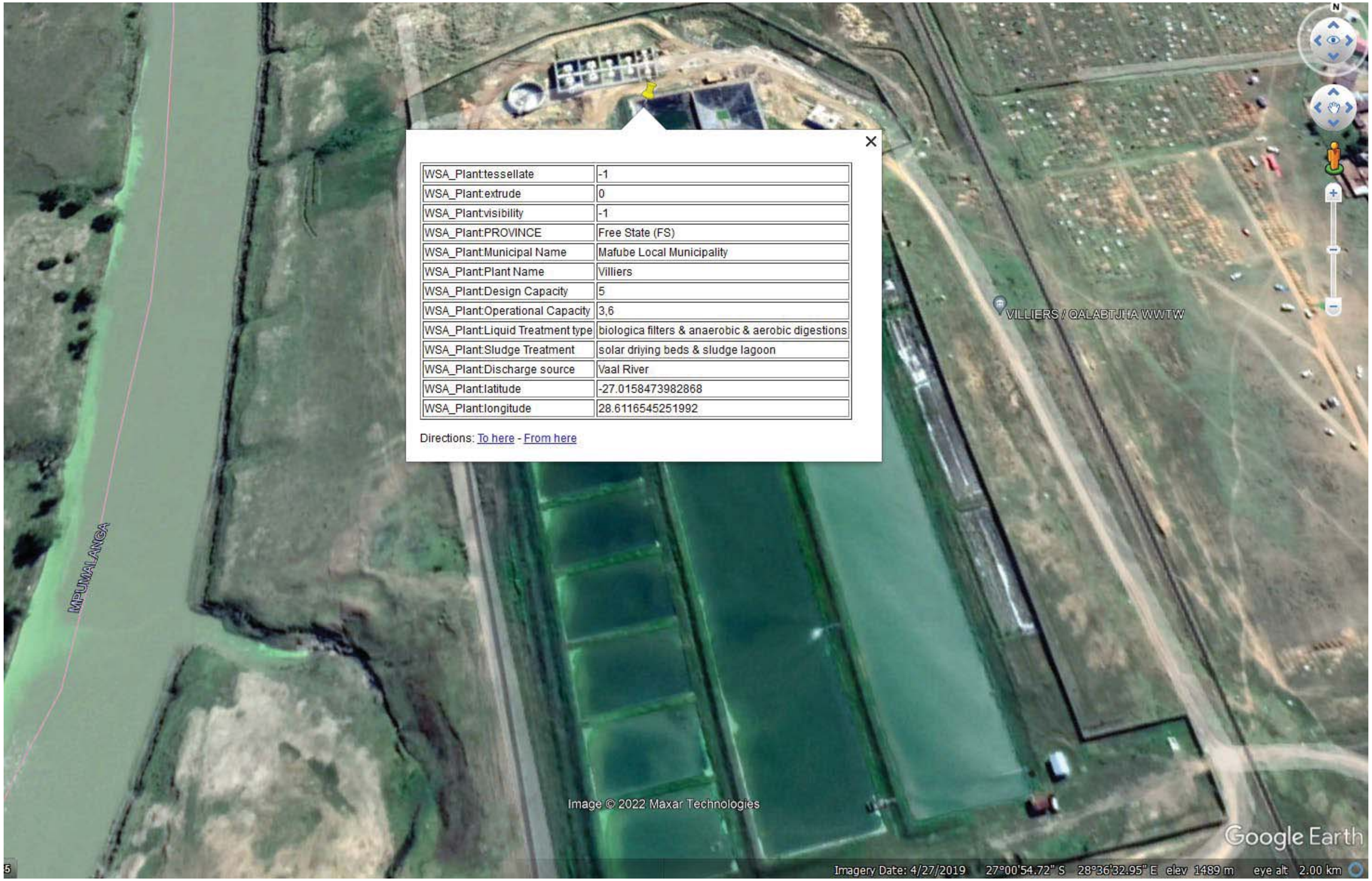

Figure 8-5: Example of WWTW information in "WWTW" KML file

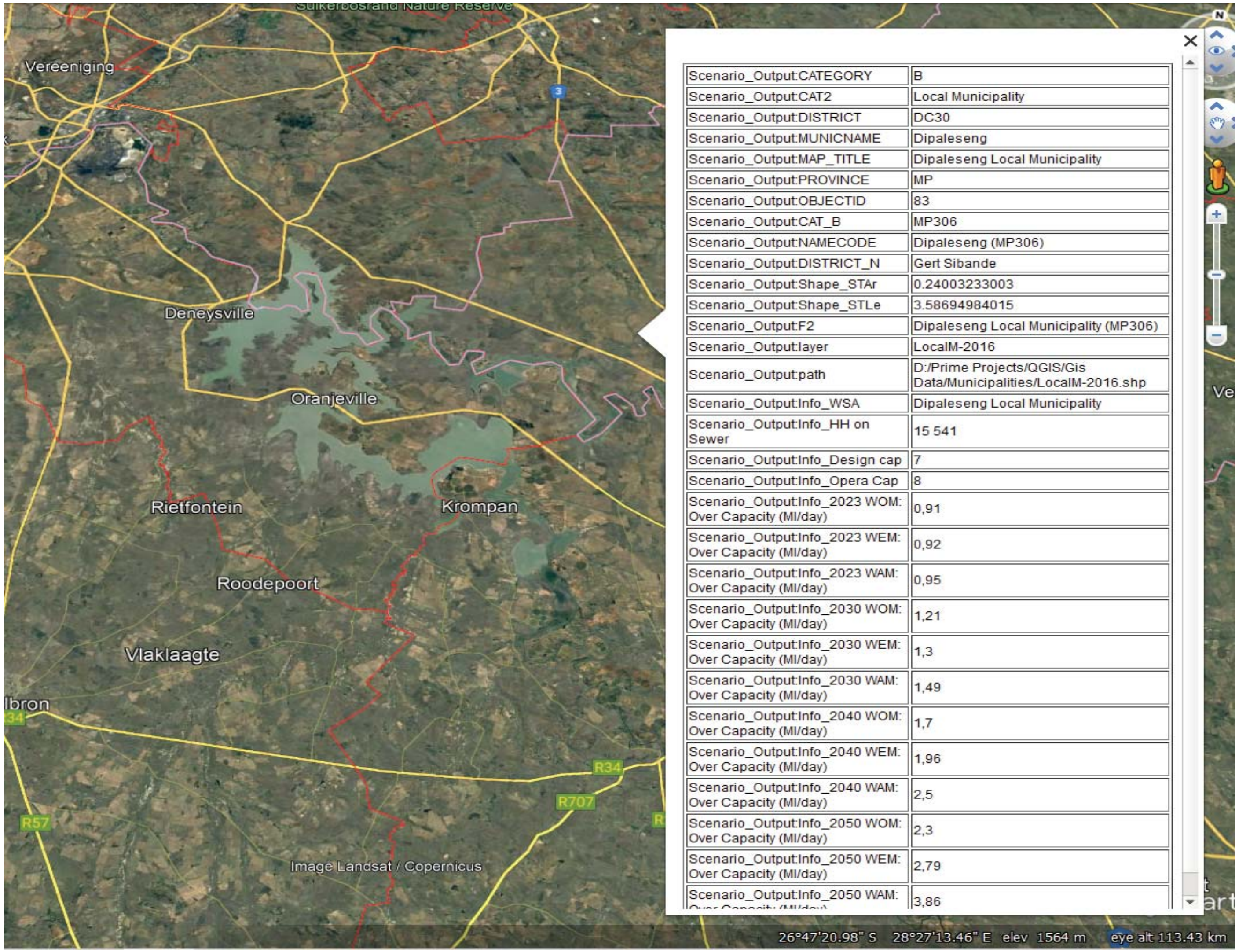

Figure 8-6: Example of overcapacity per scenario displayed in decade

9 APPENDIX C: FINANCIAL TOOL

	A–F	G	H	O	P	Q	R	S	T	U	V	W
1	**WRC Foresight Wastewater Treatment Works Plan**	Calendar year		2024	2025	2026	2027	2028	2029	2030	2031	2032
2	**Financial model**	Operations year										
3												
4												
5												
6			Sum									
7	**Income Statement - Nominal**											
8												
9	**Nominal Revenue**		94,334,387,460	-	-	1,259,070,467	1,315,728,638	1,374,936,426	1,436,808,566	1,501,464,951	1,569,030,874	1,639,637,263
10	Sewerage and sanitation charges			-	-	1,259,070,467	1,315,728,638	1,374,936,426	1,436,808,566	1,501,464,951	1,569,030,874	1,639,637,263
11												
12	**Operating Expenses**		(51,543,129,147)	-	-	(680,044,048)	(710,646,030)	(742,625,101)	(776,043,231)	(810,965,176)	(847,458,609)	(885,594,247)
13												
14												
15	**Earnings before interest, tax, depreciation and amortisation (EBITDA)**			-	-	579,026,419	605,082,608	632,311,325	660,765,335	690,499,775	721,572,265	754,043,017
16												
17	Depreciation			-	-	(280,842,095)	(280,842,095)	(280,842,095)	(280,842,095)	(280,842,095)	(280,842,095)	(280,842,095)
18												
19	**Net Finance Cost**		(5,908,928,682)	-	-	(311,173,041)	(292,636,016)	(272,045,088)	(249,172,686)	(223,766,021)	(195,544,298)	(164,195,609)
20	Finance Income											
21	Finance cost			-	-	(311,173,041)	(292,636,016)	(272,045,088)	(249,172,686)	(223,766,021)	(195,544,298)	(164,195,609)
22												
23	**Net Income before Tax**			-	-	**(12,988,717)**	**31,604,497**	**79,424,142**	**130,750,554**	**185,891,659**	**245,185,872**	**309,005,313**
24												
25	**Taxation**	-		-	-	-	-	-	-	-	-	-
26	Income tax expense											
27												
28	**Net Income after Tax**			-	-	**(12,988,717)**	**31,604,497**	**79,424,142**	**130,750,554**	**185,891,659**	**245,185,872**	**309,005,313**
29												
30	**Dividends**		-	-	-	-	-	-	-	-	-	-
31												
32	**Retained Income for the Year**			-	-	**(12,988,717)**	**31,604,497**	**79,424,142**	**130,750,554**	**185,891,659**	**245,185,872**	**309,005,313**
33												
34	**Opening Retained Income**			-	-	-	**(12,988,717)**	**18,615,781**	**98,039,923**	**228,790,477**	**414,682,136**	**659,868,008**
35												
36	**Closing Retained Income**			-	-	**(12,988,717)**	**18,615,781**	**98,039,923**	**228,790,477**	**414,682,136**	**659,868,008**	**968,873,321**

Figure 9-1: Income statement example

	A–F	G	H		O	P	Q	R	S	T	U	V	W
1	**WRC Foresight Wastewater Treatment Works Plan**	Calendar year			2024	2025	2026	2027	2028	2029	2030	2031	2032
2	**Financial model**	Operations year											
3													
4													
5													
38	**Statement of Financial Position**												
39													
40	**ASSETS**												
41													
42	**Non-current assets**			-	-	2,808,420,947	2,527,578,852	2,246,736,758	1,965,894,663	1,685,052,568	1,404,210,473	1,123,368,379	842,526,284
43	Infrastructure Assets												
44	Cost			0	0	2,808,420,947	2,808,420,947	2,808,420,947	2,808,420,947	2,808,420,947	2,808,420,947	2,808,420,947	2,808,420,947
45	Accumulated depreciation			0	0	0	(280,842,095)	(561,684,189)	(842,526,284)	(1,123,368,379)	(1,404,210,473)	(1,685,052,568)	(1,965,894,663)
46	Closing Net Book Value			0	0	2,808,420,947	2,527,578,852	2,246,736,758	1,965,894,663	1,685,052,568	1,404,210,473	1,123,368,379	842,526,284
47													
48	**Current Assets**			-	0	0	100,551,707	227,159,603	380,996,216	563,286,839	775,311,902	1,018,409,455	1,293,977,759
49	Receivables			0	0	0	103,485,244	108,142,080	113,008,473	118,093,855	123,408,078	128,961,442	134,764,707
50	Debt Service Reserve Account												
51	Cash			0	0	0	(2,933,537)	119,017,523	267,987,743	445,192,984	651,903,824	889,448,013	1,159,213,053
52													
53	**Total Assets**			-	-	2,808,420,947	2,628,130,559	2,473,896,360	2,346,890,879	2,248,339,407	2,179,522,375	2,141,777,833	2,136,504,043
54													
55	**LIABILITIES AND EQUITY**												
56													
57	**Long Tem Liabilities**			0	0	2,808,420,947	2,641,119,276	2,455,280,580	2,248,850,956	2,019,548,930	1,764,840,239	1,481,909,826	1,167,630,722
58	Term Loan			0	0	2,808,420,947	2,641,119,276	2,455,280,580	2,248,850,956	2,019,548,930	1,764,840,239	1,481,909,826	1,167,630,722
59													
60	**Current Liabilities**			0	0	0	0	0	0	0	0	0	0
61	Payables												
62													
63	**Total liabilities**			*0*	*0*	*2,808,420,947*	*2,641,119,276*	*2,455,280,580*	*2,248,850,956*	*2,019,548,930*	*1,764,840,239*	*1,481,909,826*	*1,167,630,722*
64													
65	**Share Capital**			0	0	0	0	0	0	0	0	0	0
66	Share Capital			0	0	0	0	0	0	0	0	0	0
67													
68	**Retained earnings**			0	0	0	(12,988,717)	18,615,781	98,039,923	228,790,477	414,682,136	659,868,008	968,873,321

Figure 9-2: Extract from Statement of Financial Position

	F	G	H		O	P	Q	R	S	T	U	V	W
1	**WRC Foresight Wastewater Treatment Works Plan**	Calendar year			2024	2025	2026	2027	2028	2029	2030	2031	2032
2	**Financial model**	Operations year											
3													
4													
5													
120	**Cashflow Waterfall**												
121													
122	**Revenue**			-	-	-	1,259,070,467	1,315,728,638	1,374,936,426	1,436,808,566	1,501,464,951	1,569,030,874	1,639,637,263
123	Sewerage and sanitation charges			-	-	-	1,259,070,467	1,315,728,638	1,374,936,426	1,436,808,566	1,501,464,951	1,569,030,874	1,639,637,263
124													
125	**Operating Expenses**			-	-	-	(680,044,048)	(710,646,030)	(742,625,101)	(776,043,231)	(810,965,176)	(847,458,609)	(885,594,247
126													
127	**EBITDA**			-	-	-	**579,026,419**	**605,082,608**	**632,311,325**	**660,765,335**	**690,499,775**	**721,572,265**	**754,043,017**
128													
129	Net changes in working capital			-	-	-	(103,485,244)	(4,656,836)	(4,866,394)	(5,085,381)	(5,314,223)	(5,553,364)	(5,803,265
130	Capital expenditure			-	-	(2,808,420,947)	-	-	-	-	-	-	-
131													
132	**Cash available after investment**			-	-	**(2,808,420,947)**	**475,541,175**	**600,425,772**	**627,444,932**	**655,679,954**	**685,185,551**	**716,018,901**	**748,239,752**
133													
134	Equity drawdown			-	-	-	-	-	-	-	-	-	-
135	Debt drawdown			-	-	2,808,420,947	-	-	-	-	-	-	-
136													
137	**Cash available after financing**			-	-	-	**475,541,175**	**600,425,772**	**627,444,932**	**655,679,954**	**685,185,551**	**716,018,901**	**748,239,752**
138													
139	Interest income			-	-	-	-	-	-	-	-	-	-
140													
141	**Cash flow available for debt service**			-	-	-	**475,541,175**	**600,425,772**	**627,444,932**	**655,679,954**	**685,185,551**	**716,018,901**	**748,239,752**
142													
143	Finance cost		(5,908,928,682)	-	-	-	(311,173,041)	(292,636,016)	(272,045,088)	(249,172,686)	(223,766,021)	(195,544,298)	(164,195,609
144	Principal repayment		(7,248,321,128)	-	-	-	(167,301,671)	(185,838,696)	(206,429,624)	(229,302,026)	(254,708,691)	(282,930,414)	(314,279,103
145													
146	Income tax paid			-	-	-	-	-	-	-	-	-	-
147													
148	**Cash flow available for dividend distribution**			-	-	-	**(2,933,537)**	**121,951,060**	**148,970,220**	**177,205,242**	**206,710,839**	**237,544,189**	**269,765,040**
149	Dividends paid to shareholders		-	-	-	-	-	-	-	-	-	-	-
150	Dividend tax		-	-	-	-	-	-	-	-	-	-	-

Figure 9-3: Extract of cashflow waterfall

10 APPENDIX D: ECONOMIC TOOL

The total economic effects for both CAPEX and OPEX are shown in the sheet below

CAPEX - Low Range		WOM			WEM			WAM		
		2025	2035	2045	2025	2035	2045	2025	2035	2045
Indicator	Unit	Economic Effect								
CAPEX Input	Million R	3,273	3,585	4,259	3727	4024	4722	3970	4576	5233
Final demand	Million R	825	905	1,120	955	1,020	1,251	1,007	1,151	1,378
Total Effect GDP	Million R	986	1,087	1,325	1126	1232	1488	1210	1395	1644
Total Effect Compensation of employees	Million R	513	566	690	586	641	774	630	725	855
Net Exports	Million R	183	201	248	210	227	278	224	256	307

CAPEX - High Range		WOM			WEM			WAM		
		2025	2035	2045	2025	2035	2045	2025	2035	2045
Indicator	Unit	Economic Effect								
CAPEX Input	Million R	5,413	5805	9015	6236	6412	9958	6531	7173	11139
Final demand	Million R	1,423	1,514	2,351	1,688	1,676	2,603	1,736	1,872	2,907
Total Effect GDP	Million R	1643	1753	2722	1887	1965	3052	1981	2198	3414
Total Effect Compensation of employees	Million R	852	909	1412	981	1019	1582	1028	1139	1769
Net Exports	Million R	319	340	528	375	379	588	388	423	657

OPEX - Low Range		WOM			WEM			WAM		
		After 2025	After 2035	After 2045	After 2025	After 2035	After 2045	After 2025	After 2035	After 2045
Indicator	Unit	Economic Effect								
OPEX Input	Million R	873	2133	4045	1003	2435	4601	1031	2567	4798
Final demand	Million R	49	119	240	58	141	286	65	149	300
Total Effect GDP	Million R	63	153	297	73	178	346	78	188	361
Total Effect Compensation of employees	Million R	31	73	142	35	85	165	38	90	173
Net Exports	Million R	10	23	49	11	28	59	13	30	62

CAPEX Industries	Industry Multiplier	SAM Multiplier
Stone	4.66	5.87
Iron and steel	4.91	6.01
Casting of metals	4.83	6.15
Structural metal	4.77	5.87
Other fabricated metal	4.72	5.96
General purpose machinery	4.27	5.41
Special purpose machinery	4.10	5.15
Computing machinery	4.17	5.43
Electric motors	3.93	4.95
Other electric	3.60	4.49
Other electric components	4.10	5.13
Site preparation	4.37	5.64
Civil Engineering	4.45	5.60
Building Installation	3.60	4.51
Building Completion	4.26	5.25
Architectural and engineering	5.17	6.80
Advertising	5.35	6.94
Other business activities	5.24	6.85

OPEX Industries	Industry Multiplie	SAM Multiplier
Electricity	4.87	6.11
Water	4.70	6.04
Basic chemicals	3.54	4.32
Other chemicals	3.95	4.91
Other business activities	5.24	6.85
Monetary intermediation	5.01	6.71
Other financial	5.15	6.78

Figure 10-1: Summary Tab of CAPEX and OPEX costs as well as their industry multipliers.

A	B	C	D	E	F	G	H	I	J	K	L
	Inflation Factor		1.00	1.05	1.09	1.14	1.19	1.25	1.30	1.36	1.42
	Year		**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
	Low Range										
	CAPEX Input					**3,272,893,047**					
	OPEX Input						**662,771,239**	**825,933,546**	**863,100,556**	**901,940,081**	**942,527,385**
	Interest						**210,361,400**	**210,361,400**	**210,361,400**	**210,361,400**	**210,361,400**
		Final Demand				825,444,887	49,034,257	58,474,264	61,105,606	63,855,358	66,728,849
		Total GDP Effect				986,046,531	63,248,034	75,424,457	78,818,558	82,365,393	86,071,836
		Total Compensation to employment				513,319,079	30,527,675	36,404,820	38,043,037	39,754,973	41,543,947
WOM		Balance of payments				182,649,265	9,565,535	11,407,078	11,920,397	12,456,815	13,017,371
	High Range										
	CAPEX Input					**5,412,966,677**					
	OPEX Input						**662,771,239**	**825,933,546**	**863,100,556**	**901,940,081**	**942,527,385**
	Interest						**425,646,460**	**425,646,460**	**425,646,460**	**425,646,460**	**425,646,460**
		Final Demand				1,423,179,395	54,142,712	67,471,670	70,507,895	73,680,750	76,996,384
		Total GDP Effect				1,643,164,064	75,946,002	94,642,536	98,901,450	103,352,016	108,002,856
		Total Compensation to employment				852,334,160	36,987,768	46,093,489	48,167,696	50,335,242	52,600,328
		Balance of payments				319,395,373	9,768,315	9,768,315	9,768,315	9,768,315	9,768,315
	Low Range										
	CAPEX Input					**3,726,581,152**					
	OPEX Input						**764,867,491**	**799,286,528**	**835,254,422**	**872,840,871**	**912,118,710**
	Interest						**238,559,797**	**238,559,797**	**238,559,797**	**238,559,797**	**238,559,797**
		Final Demand				954,576,548	57,529,247	60,118,063	62,823,375	65,650,427	68,604,697
		[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 10-2: Output sheet of all CAPEX and OPEX costs from 2025

10.1 Final Demand:

The OPEX inputs are calculated for the years after the upgrades, which means the years after 2025 (2026-2035), 2035 (2036-2045), and 2045 (2046-2050). For the year 2026, the OPEX input will be R873 million, including the interest payable for the finance loans. This amount will lead to a final demand of R49 million. Meaning the amount that actually goes into the economy is R49 million. Similarly for the year 2036 the OPEX input will have a final demand of R119 million and the OPEX input for 2046 will have a final demand of R240 million.

The OPEX input is calculated for a year because the SAM depicts the consequences of a value over a year. For the following years, this input amount will be adjusted for inflation to reflect the nominal amounts entering the economy.

10.1.1 Total Effect on GDP

Table 10-1: Low Range: Economic impact of OPEX for WOM Scenario

			WOM	
OPEX – Low Range		**After 2025**	**After 2035**	**After 2045**
Indicator	Unit	Economic Effect		
OPEX Input	Million R	873	2133	4045
Final demand	Million R	49	119	240
Total Effect GDP	Million R	63	153	297
Total Effect Compensation of employees	Million R	31	73	142
Net Exports	Million R	10	23	49

The entire impact of the OPEX input on GDP for 2026 under the WOM scenario depicted in Table 10-1 will be R63 million. This stems from both the direct industries that are impacted and the ripple effects of the R63 million's indirect purchases and economic activities. Similarly for the year 2036, the OPEX Input will result in a R153 million total effect on GDP, and the R4 billion spent in 2045 will result in a R297 million effect on GDP.

These effects are smaller than the CAPEX effects because the CAPEX expenses shock many businesses, including the machinery and building industries. The multiplier effect of OPEX costs on the economy is less because they are more related to day-to-day operations, but they still have a sizable impact.
The top three industries contributing significantly to the total GDP are electricity, households, and monetary intermediation. Electricity adds R7 million to the GDP due to its crucial role in powering day-to-day operations, boosting overall production in the economy. Households play a vital role as well, being substantial contributors to the GDP. Additionally, the monetary intermediation sector, which

includes the banking industry, benefits from OPEX inputs and interest payments, further contributing to the GDP growth.

Table 10-2: Industries contributing the most to total GDP.

Industry	Unit	Effect
Basic chemicals	Million R	2.11
Other chemicals	Million R	2.58
Electricity	Million R	7.14
Monetary Intermediation	Million R	5.82
Real estate activities with own or leased property	Million R	2.34
Legal and accounting	Million R	2.16
Other business activities	Million R	2.07
Informal, illicit, non-profit, and households	Million R	4.03

10.1.2 Total Effect on Compensation of employees:

In 2026, the OPEX input leads to a R31 million increase in employee compensation, which accounts for 61% of the final demand amount. This increase represents additional salaries, wages, and possibly new job opportunities created throughout the economy due to the OPEX.

Similarly, in 2036, the OPEX input will result in a R73 million increase in employee compensation, while in 2046, it will lead to a R142 million increase in employee compensation.

Table 10-3 shows the industries contributing the most to the R31 million compensation for employment. Similar to GDP, the main beneficiaries of increased employment are the electricity, monetary intermediation (banking), and household industries. The employment multiplier of the monetary intermediation sector allows it to have a more substantial effect on compensation for employment compared to the electricity industry.

Table 10-3: Industries contributing the most to compensation of employees.

Industry	Unit	Effect
Basic chemicals	Million R	1.22
Other chemicals	Million R	1.37
Electricity	Million R	2.44
Monetary Intermediation	Million R	3.11
Legal and accounting	Million R	1.21
Other business activities	Million R	1.57
Education	Million R	1.55
Informal, illicit, non-profit, and households	Million R	1.72

10.1.3 Net Exports

The OPEX input for 2026 will result in a Net export effect for the whole economy of R9.57 million. There will also be a change in direct exports of R51 million as shown in Figure 10-3. For 2036 there will be a net export effect of R23 million and for 2045 there'll be a net export effect of R49 million. A total change in direct exports is also shown in the excel sheet just to show the export changes in the sectors directly affected by the OPEX input.

A	B	C	D	E	F	G
		2026 - WOM				
Code	Economic sector	Indirect effect (change in production)	Exports	Imports	Net exports	Change in direct exports
I111	Provincial government	0.28	-	-	-	-
I112	Local government	0.44	-	-	-	-
I113	Education	2.16	-	-	-	-
I114	Human health	2.06	-	-	-	-
I115	Veterinary	0.14	-	-	-	-
I116	Social work	0.07	-	-	-	-
I117	Sewage and refuse	0.13	-	-	-	-
I118	Professional	0.09	-	-	-	-
I119	Membership	0.18	-	-	-	-
I120	Entertainment	0.29	-	-	-	-
I121	Museums	0.04	-	-	-	-
I122	Recreational	0.68	-	-	-	-
I123	Other services	0.10	-	-	-	-
I124	Informal, illicit, non-profit, and households	7.02	-	-	-	-
D1	Compensation of employees					
	Gross operation surplus/mixed income					
			BoP (Total effect):		9.57	51.38

Figure 10-3: Total BOP Excel sheet showing the sum of Net Export and Direct Export effects for OPEX.

10.1.4 Industry and SAM Multipliers:

The industries affected by OPEX costs are shown in Table 10-4, along with their respective industry and SAM multipliers.

Table 10-4: The Industries affected by the CAPEX costs and their multipliers.

OPEX Industries	Industry Multiplier	SAM Multiplier
Electricity	4.87	6.11
Water	4.70	6.04
Basic chemicals	3.54	4.32
Other chemicals	3.95	4.91
Other business activities	5.24	6.85
Monetary intermediation	5.01	6.71
Other financial	5.15	6.78