CITY OF BULAWAYO | 2017

WATER AND SANITATION LOCAL ACTION PLAN

ICLEI Local Governments for Sustainability

SURE WATER 4 AFRICA
SUSTAINABLE • URBAN • RESILIENT

Full Project Title: Sustainable Urban Resilient Water for Africa: Developing Local Climate Solutions

Abbreviated Project Title: SURe Water 4 Africa: Developing LoCS

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FOREWORD

The City of Bulawayo is proud to have been one of the six implementing local authorities for the "Sustainable Urban Resilient Water for Africa: Developing Local Climate Solutions" (SURe Water 4 Africa: Developing LoCS) project. We were very excited to participate in the project that sought to strengthen local government planning and action for urban water management in the context of climate change.

Bulawayo is located in a drought-prone region and our water shortage problems are perennial with weather patterns characterised by low rainfall compounded by seasonal annual droughts. The El Niño and LA Niña effects together with climate change have affected the rainfall patterns in the region. This has called upon the City and the citizens to adopt resilient strategies in a bid to optimise the water supply for the City in each season. Water conservation has become a culture and way of life in Bulawayo with the Council and citizens recognising that water is a finite resource that needs to be conserved. Water restrictions date as far back as the early 1890s and the City has implemented water rationing permanently since 1984. It has been Council's role to try and stretch the limited resources to balance access to water for domestic purposes with that for industrial use. Council is continually investigating new water sources to support progress and sustainable development in Bulawayo.

Industrialisation and urbanisation, while an inevitable part of the 21st century, have increased climate change and global warming. To compound this, environmental problems encountered are usually multi-faceted. Various ills such as our over-dependence on hydro-carbon fuels, littering, water and air pollution, deforestation and greenhouse gas emissions plague any modern city. My vision is of a Bulawayo that is free from all these. It is a vision of a City that meets the Sustainable Development Goal (SDG) Six of providing our residents with clean water and sanitation as well as SGD 11, which is the creation of sustainable cities and communities. We aim to provide residents, visitors and investors with a sustainable city that features an efficient mass transit system dependent on clean renewable energies, such as electric trams and buses servicing high traffic routes. This should alleviate traffic congestion as more people choose public mass transit systems. We aspire to achieve a low greenhouse gas emission index. Our streets should be clean and litter-free. We further envision clean general city environs in which people can enjoy fresh air, in well-maintained public parks and gardens. I envision the future of Bulawayo as a place where every resident has ready access to clean, affordable potable water and an efficient wastewater reticulation system that releases high quality wastewater into water courses. My wish is that of an economically thriving Bulawayo replete with prosperity and the associated ambience.

The earth and its atmosphere are our home and we must therefore maintain it in a sustainable manner. It is our duty to restore the balance of its ecosystems for the sake of our environmental welfare and health.

COUNCILLOR
MARTIN K MOYO
Mayor: Bulawayo

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ICLEI-Local Governments for Sustainability is the ICLEI-Local Governments for Sustainability is the leading global network of over 1,500 cities, towns and regions committed to building a sustainable urban future. By helping our members to become sustainable, low-carbon, ecomobile, resilient, biodiverse, resource-efficient, healthy and happy, with a green economy and smart infrastructure, we impact over 25% of the global urban population in over 85 countries.

ICLEI envisions a world of sustainable cities that confront the realities of urbanization, adapt to economic and demographic trends and prepare for the impacts of climate change and other urban challenges. This is why ICLEI unites local and subnational governments in creating positive change through collective learning, exchange and capacity development.

At ICLEI Africa, we serve our African members from our offices based in Cape Town, South Africa, where we work with cities and regions across 23 sub-Saharan African countries. Our work is conducted by a dynamic and passionate team of professionals who work with cities to ensure a more sustainable future. Key thematic areas include urban planning, infrastructure, water and sanitation, climate change and energy, and nature-based solutions. The projects underpinning these themes are designed to strengthen local leadership and promote good governance, foster innovative partnerships and enable new finance options. For more information visit www.africa.iclei.org.

SURE WATER 4 AFRICA: DEVELOPING LOCS

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Sustainable Urban Resilient (SURe) Water for Africa: Developing Local Climate Solutions is a 54 month project funded by the European Commission, which aims to contribute to climate change adaptation, and foster resilient, urban water planning at the local government level.

The project focuses on promoting urban well-being and resilient cities through addressing the nexus of climate change and water, in particular droughts and floods, while identifying priority adaptation measures to assist the most vulnerable sectors within the participating cities.

The project has three objectives:

1. To improve understanding of current and projected climate change risks associated with flooding and drought and to develop capacity amongst policy- and decision-makers to apply such knowledge to influence their decision making processes.
2. To strengthen and/or develop local action plans integrating urban water management with flooding and drought intervention frameworks.
3. To strengthen local, national and regional knowledge management and to facilitate information sharing on the water/climate change and urban development nexus.

The project has been implemented in the following six countries located in the Southern African Development Community (SADC) region: Botswana, Malawi, Namibia, South Africa, Zambia and Zimbabwe.

AWASLA

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The Africa Water and Sanitation Local Authorities (AWASLA) Network is a dynamic, interactive and dedicated pan-African network for African local governments and their associated institutions engaged in all aspects of the urban water cycle (water supply, sanitation, storm and wastewater management). AWASLA provides a unique platform to enable local governments to exchange knowledge and best practices, consider emerging challenges and innovations and explore collaborative action. These aims are geared towards seeking a paradigm shift for more sustainable, resilient and equitable urban water and sanitation practices in Africa.

AWASLA aims to:

- Promote knowledge exchange
- Develop and enhance capacity
- Facilitate connections
- Empower advocacy

AWASLA is open to all African local and sub-national governments (and their associations) that are committed to achieving more sustainable and effective urban water and sanitation management practices in African cities.

Regional and international organisations, non-governmental organisations, research institutions and individuals who wish to exchange knowledge and best practices for urban water and sanitation in Africa can participate as network associates. For more information visit **www.awasla.org**.

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LIST OF ACRONYMS AND ABBREVIATIONS

AfDB	African Development Bank
AWASLA	Africa Water and Sanitation Local Authorities (AWASLA) Network
BCC	Bulawayo City Council
CBA	Cost Benefit Analysis
CBD	Central Business District
CBO	Community Based Organisations
CMIP	Coupled Model Intercomparison Project
CoB	City of Bulawayo
DJF	Dec-Jan-Feb
DTI	Department of Trade and Industry
EC	European Commission
EMA	Environmental Management Agency
EWS	eThekwini Water & Sanitation
GCM	Global Climate Models
ICLEI	ICLEI-Local Governments for Sustainability
ICLEI Africa	ICLEI-Local Governments for Sustainability-Africa
LAP	Local Action Plans
LoCS	Local Climate Solutions
MoU	Memorandum of Understanding
NGO	Non-Governmental Organisation
O&M	Operations and Maintenance
RCP	Representative Concentration Patterns
SADC	Southern African Development Community
SDG	Sustainable Development Goal
SMART Goal	Specific, Measurable, Achievable, Realistic and Time-orientated Goal
SURe Water 4 Africa: Developing LoCS	Sustainable Urban Resilient Water for Africa: Developing Local Climate Solutions Project
WWAP	World Water Assessment Programme
WWTW	Wastewater Treatment Works
ZINARA	Zimbabwe National Road Administration
ZINWA	Zimbabwe National Water Authority

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1 | WATER AND CLIMATE

Climate change has severe indirect and direct physical, social, environmental and economic impacts on cities worldwide. These are anticipated to be experienced with greater intensity in the developing world, particularly in sub-Saharan Africa in the near future. Some of the changes that have begun to manifest are:

- Changes in rainfall and precipitation patterns (flooding and drought)
- Increases in temperature
- Increasing frequency and intensity of storm surges or extreme events
- Increasing average global sea levels due to melting glaciers and thermal expansion (permanent and non-permanent inundation)
- Changes in wind speed

The impact of climate change on water resources and infrastructure is particularly profound. It is well recognised that freshwater is linked to all aspects of human development and well-being. Its availability is the single largest major natural limit to economic growth, given that all other sectors are dependent on its secure supply. Water resources are globally scarce, with Cities increasingly resorting to extreme measures to establish water security. It is therefore particularly important for them to implement more efficient water management practices. To this end, proactive planning is essential for the promotion of sustainable development.

Superimposed on these existing scarcities and supply challenges, are the impacts of current climate variability and climate change. There is growing realisation that the impacts of climate change in Africa will be experienced by means of floods, droughts or extreme rainfall events – and their cross-cutting impacts – and this is translating into recognition that Cities need to adopt and implement integrated and innovative water management strategies. It is increasingly imperative that the infrastructure designs, daily operations and long term planning of Cities and water utilities explicitly take climate change impacts into account.

In addition to existing scarcities and climate change impacts, by 2045 the world's urban population is expected to surpass six billion people, with much of this growth occurring in Africa. It is anticipated that the continent's urban populations will rise by almost 50% by 2030. This means that half of the people who will be living in Africa's cities in 20 years' time have yet to arrive and that most of that growth is anticipated to take place in informal settlements (Jacobsen *et al.,* 2013).

Shaping sustainable cities can only be achieved by adopting measures that ensure effective water management and improve access to clean and safe water in Africa's cities. A sustainable and secure supply of water can act as a key catalyst to unlock Africa's development potential. Such an approach has the potential to create a ripple effect and nudge the continent towards a leading role in meeting the ambitious United Nations 2030 Agenda for Sustainable Development Goals (SDGs) of *inter alia* eradicating poverty, and promoting access to energy and reliable supplies of water as well as adequate sanitation. The 2017 World Water Development Report lends impetus to this approach by stating that "*sub-Saharan Africa can address the strong growth in water demand that is expected for 2030 and meet SDG Six, provided it starts addressing its current water challenges now and embraces the opportunities that improved wastewater management can provide.*" (WWAP, 2017)

It is clear that although our cities face a myriad of sustainability challenges both now and in the future, none are more critical than the threat posed to the continent's water resources and delivery thereof. Water is pivotal to both social and economic development, and will be THE defining resource in our urban futures as it will determine how and where we live, our economic successes and failures, and our growth. It will ultimately shape the cities of the future. Africa's development and sustainability trajectory is without doubt entwined with the choices its leaders make in respect to its water resources.

2 | SURE WATER 4 AFRICA

The Sustainable Urban Resilient (SURe) Water for Africa: Developing Local Climate Solutions project aimed to contribute to climate change adaptation measures, and foster resilient urban water planning at the local government level in Africa. The project, funded by the European Commission, focussed on six cities, in six countries in sub-Saharan Africa, as indicated in Figure 1 below.

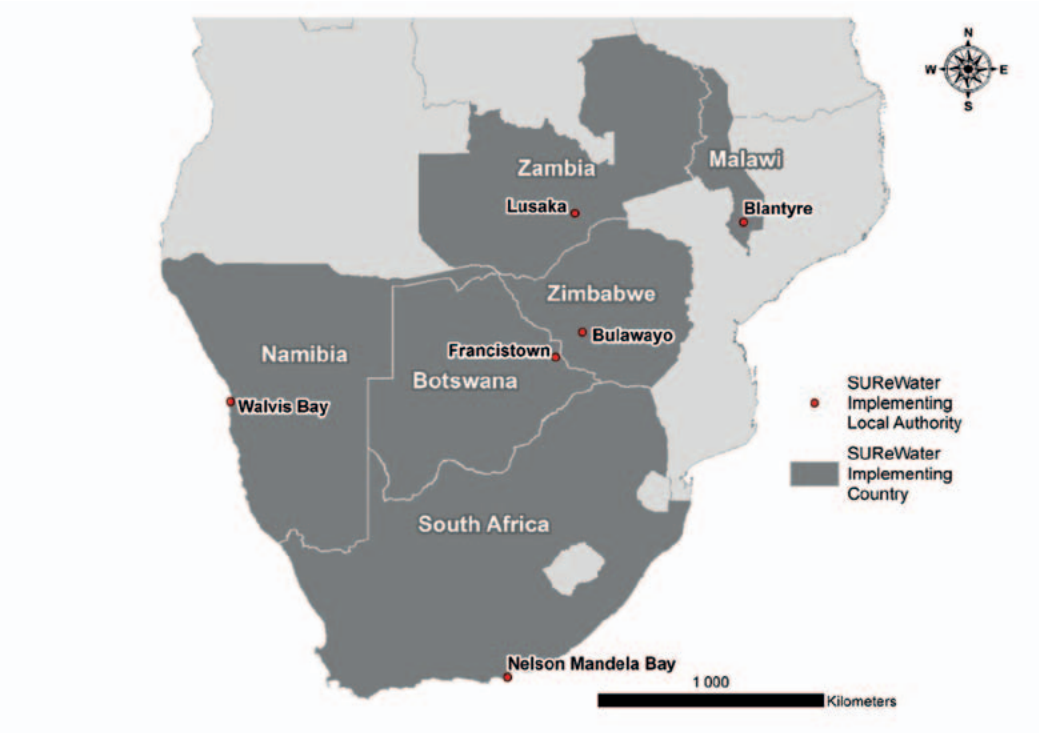

FIGURE 1: SURe Water 4 Africa: Developing Local Climate Solutions implementing local authorities and countries (***Spatial data source:*** *maplibrary.org*)

Its main output was the development of a tailor-made water and sanitation Local Action Plan (LAP) for each implementing local authority. These were aimed at strengthening, developing and institutionalising integrated flooding and drought interventions by identifying a number of low-regret adaptation options.

Central to the development of the LAPs was the adoption of a participatory approach to engagement within the cities. The following role players actively contributed to the development of the plans: *inter alia* local decision makers (councillors and traditional leaders that can influence/direct policy), local technical staff, community representatives, water utilities, water users' associations, national government, universities, Community Based Organisations (CBOs) and Non-Governmental Organisations (NGOs).

To improve access to water, sanitation and climate change data at the local level and contribute to the identification of key intervention focus areas, the LAPs were underpinned by the following technical components:

- A Climate Systems Analysis, which provided an analysis of local temperature and precipitation trends to better grasp long term changes and actively contribute to future planning
- A Risk Assessment, which provided an overview of each city's water and sanitation infrastructure, highlighting capacity, operation and maintenance status, as well as key recommendations

2 SURE WATER 4 AFRICA *(continued)*

- The Resilient Africa Tool, developed by ICLEI Africa to guide the cities through the identification of sector risks and viable local adaptation options for urban water and sanitation. It also assessed the priority, feasibility and key stakeholders who would be needed to effectively implement the identified adaptation interventions.
- A Cost Benefit Analysis, which was commissioned for three of the six cities, which aimed to investigate the costs of action and inaction for selected water and sanitation adaptation options outlined in the local action plan.
- A series of Finance Mechanism papers to identify funding pathways for urban water, sanitation and climate change

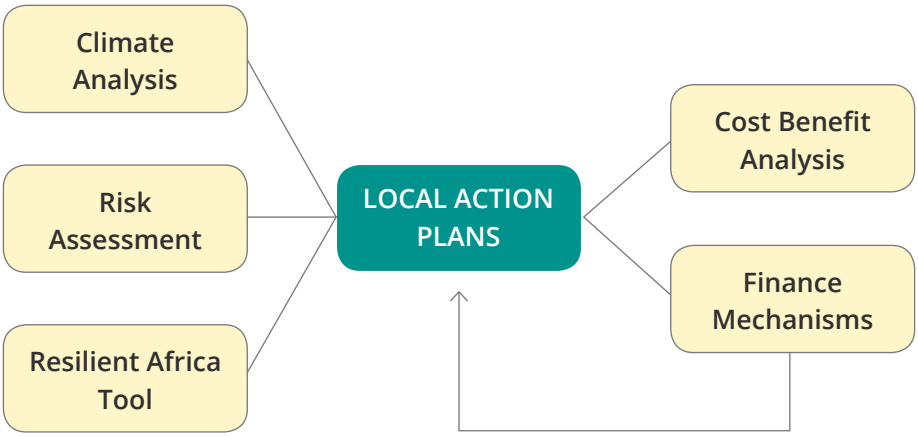

FIGURE 2: Overview of the key components of the SURe Water 4 Africa: Developing LoCS project (*ICLEI Africa, 2015*)

The LAPs are anticipated to assist in mitigating the risk of damage and impacts caused by storms, floods and droughts, thereby building more resilient cities and contributing to the following:

At the policy level:
- Improved integration and co-ordination between technical and political role-players' in each city
- Improved understanding and capacity in respect to climate change and its links to urban water and sanitation
- Identification of tangible, low-regret adaptation options which can be implemented at the local level

At the technical level:
- Improved integration and co-ordination of key stakeholders and relevant departments
- Enhanced knowledge and capacity in respect to climate change and its links to urban water and sanitation
- Peer to peer exchange of best practice and knowledge
- Exposure to innovative solutions and practices
- Reduced risk to infrastructure and operations

At the socio-economic level:
- Improved dialogue and co-ordination between the key stakeholders and citizens resulting in improved sustainability of actions
- Improved operation and maintenance of existing infrastructure, as well as planning for the projected impacts of climate change to reduce the need for large scale (reactionary) allocation of funds following a climate related extreme event
- Affordable adaptation options that can be implemented locally without requiring large scale investment
- Identification of large scale interventions which would require external support and funding

The time is *now* for African Cities to show bold and decisive leadership that nurtures innovation so as to ensure that water resources and usage is sustainably and effectively managed.

3 | CITY OF BULAWAYO

Bulawayo is located in the Matabeleland region, 439 km south-west of Harare and 110 km from the Botswana border (Figure 3). After Harare, it is the second largest city in Zimbabwe. Bulawayo has long been and is still regarded as the industrial and business capital of Zimbabwe and is home to the National Railways of Zimbabwe due to its strategic position near Botswana and South Africa.

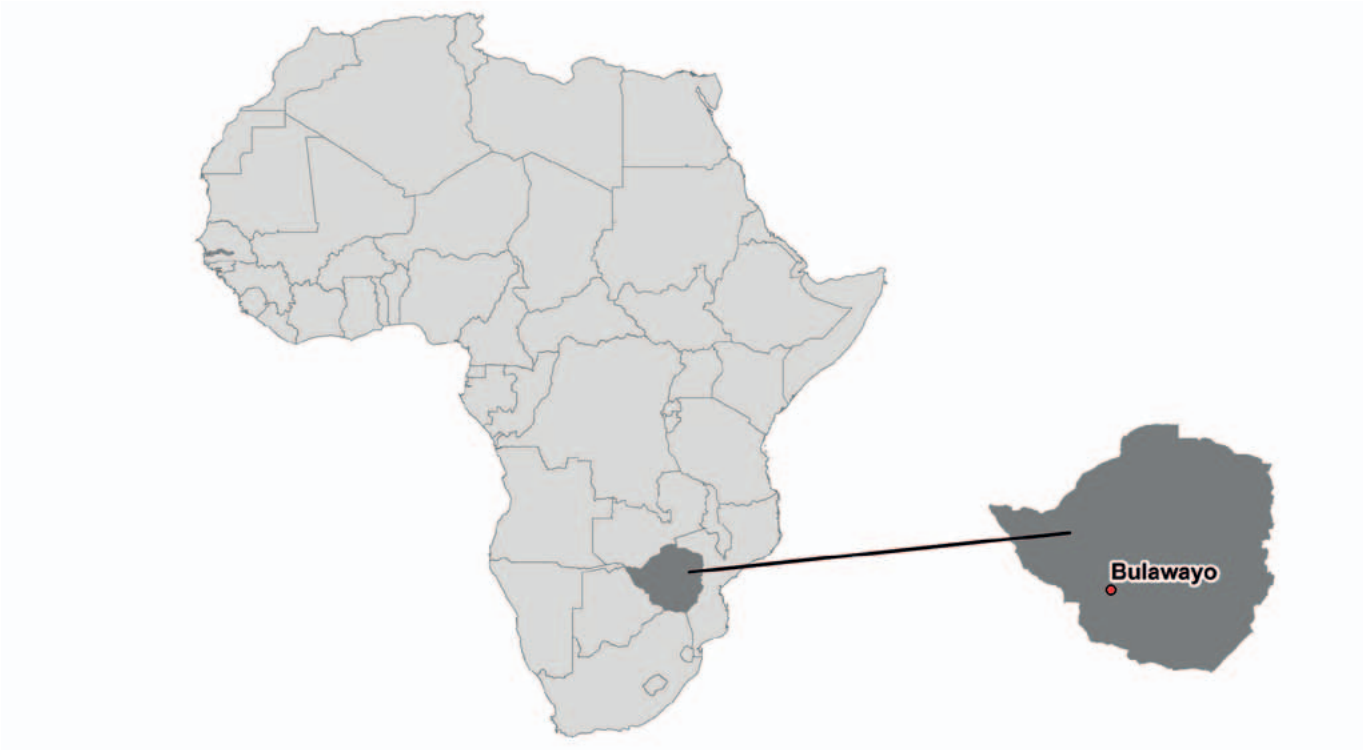

FIGURE 3: Location of Zimbabwe within Africa (left) and Bulawayo in Zimbabwe (right)

Before the collapse of Zimbabwe's rail infrastructure, Bulawayo sustained a burgeoning economy for the country due to its strategic location and extensive road and rail network to main cities in the country, and to neighbouring countries (Mbohwa, 2008).

Bulawayo is also the closest to the main tourist resorts in Zimbabwe, namely Hwange National Park, Matopos National Park and Victoria Falls.

3.1 POPULATION

The population of Bulawayo has remained very constant at between 620 000 and 670 000 since 1992.

The total population as per the 2012 national census was estimated at 653 337 (City of Bulawayo, 2012).

3.2 LAND USE

The City of Bulawayo has extensive industrial areas, with tanneries, foundries, engineering firms, breweries, textile companies, abattoirs, pharmaceutical companies, soft drink manufacturers, dairy processors, machining and fabrication companies, all of which were supported by its extensive rail and road systems (Mangore, 2004). Most of these are currently dormant as a result of Zimbabwe's economic challenges.

3.3 FLOODS

Bulawayo is located on a plateau marking the Highveld that serves as a watershed between the Zambezi and Limpopo Rivers. It is elevated, meaning that water generally tends to flow away from the city, either to the south towards the Limpopo, or to the north towards the Zambezi. Due to the topography of the terrain and absence of large rivers, floods are not considered a major threat. Localised flooding ('ponding') does however occur as a result of poor stormwater drainage.

3.4 DROUGHT

Bulawayo has a subtropical climate with average maximum temperatures ranging from 21°C in winter to 30°C in summer. The city lies in a region that is characterised by low rainfall, averaging 588mm per annum, with the hot summer temperatures accelerating evaporation and transpiration (Mabiza et al., 2008). Bulawayo has a history of water shortages dating back to the 1920s when water rationing was introduced. Stringent water restrictions were imposed in 1938–1943, 1947, 1951, 1953, 1968, 1971–1973, 1983 and 1990 and water rationing was imposed in the following years: 1949, 1984, 1987 and 1991 (Moyo et.al., 2007). However, rationing limits tend to change, as they are reviewed according to the availability of water at any given time. The most severe water rationing campaign was imposed in January 1992 at the height of a devastating drought which affected all of southern Africa (Sokwanele, 2004).

FIGURE 4: Jaiva Arts presents a play on water conservation, anti-littering and anti-vandalism, health, hygiene and gender and social inclusion as part of a road show.

3.4 DROUGHT *(continued)*

Bulawayo has a history of prudent water resource management and longstanding water restriction measures. Water resource management efficiency is achieved by a combination of efforts by the Bulawayo City Council (BCC) and residents. Gumbo et al., 2003 states that BCC developed a Water Loss Reduction Plan in 2000. The plan defines clear methodologies for monitoring and evaluating water use in the city. There have been a number of campaigns to inform residents about the water situation and encourage them to save it and support the City's efficient water usage programmes. These campaigns have made it relatively manageable for the City to enforce water demand management measures, such as water rationing and banning the use of hosepipes.

FIGURE 5: A Master of Ceremonies presents information on water conservation, anti-littering and anti-vandalism, health, hygiene, gender and social inclusion at Lozikeyi Primary School in Pumula Ward 8.

3.5 WATER SUPPLY

Bulawayo derives its water from the following six dams, which are situated to the south-east of the city (Figure 6):

- Umzingwane Dam (capacity of 42 million m^3 and a yield of 35.3 Mℓ/day)
- Inyankuni Dam (capacity of 74 million m^3 and a yield of 20.8 Mℓ/day)
- Upper and Lower Ncema Dams (capacity of 63 million m^3 and a yield of 42.5 Mℓ/day)
- Insiza Dam (capacity of 173 million m^3 and a yield of 33.7 Mℓ/day)
- Mtshabezi Dam

The total yield from the dams and city boreholes is estimated at 148 Mℓ/day sustainable yield which falls below the current constrained peak season demand of 156 Mℓ/day.

The challenges of inadequate human and financial resources, treatment capacity, old and obsolete infrastructure (pump stations, pipelines, reservoirs, etc.) have constrained the City's delivery of water services (WAMTechnology, 2014).

These are compounded by old sanitation infrastructure and infrastructure disintegration. The City's flows to the wastewater treatment works were calculated at 89 Mℓ/day. However, only 33 Mℓ/day were received at the treatment works due to pipe blockages, broken main lines and non-operational pumps. A site visit undertaken during the course of the SURe Water 4 Africa: Developing LoCs project showed that pump stations were out of order, although manhole covers were found to be in place. Furthermore, urban drainage infrastructure was not functional due to blocked channels and culverts.

Figure 8 below shows the Primary Clarifier at Ncema which was not operational at the time of the site visit in 2014 and was in need of repairs. Figure 9 depicts localised flooding due to water seepage from the broken underground water pipeline.

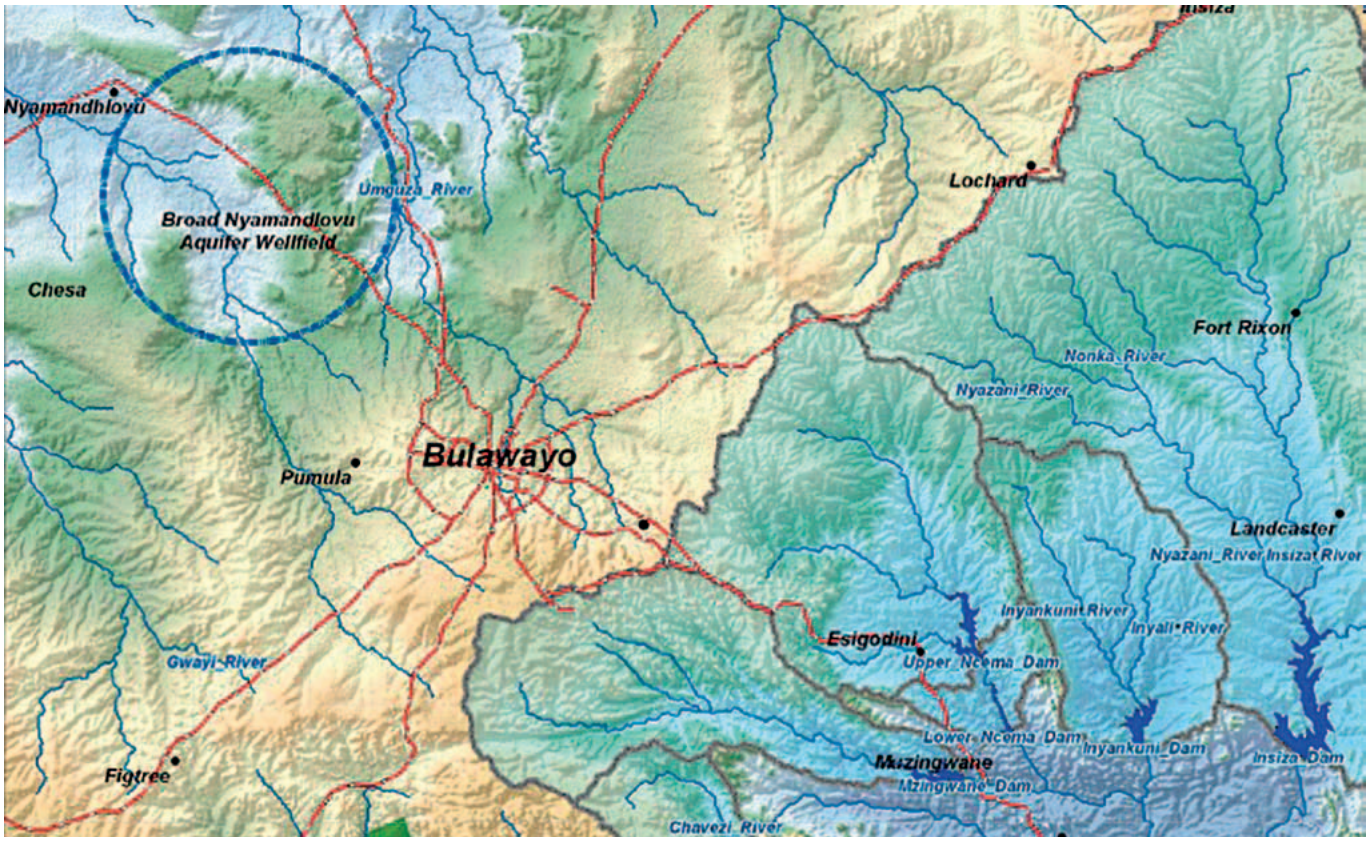

FIGURE 6: City of Bulawayo dams and groundwater supply (Ncube, 2017)

3.5 WATER SUPPLY *(continued)*

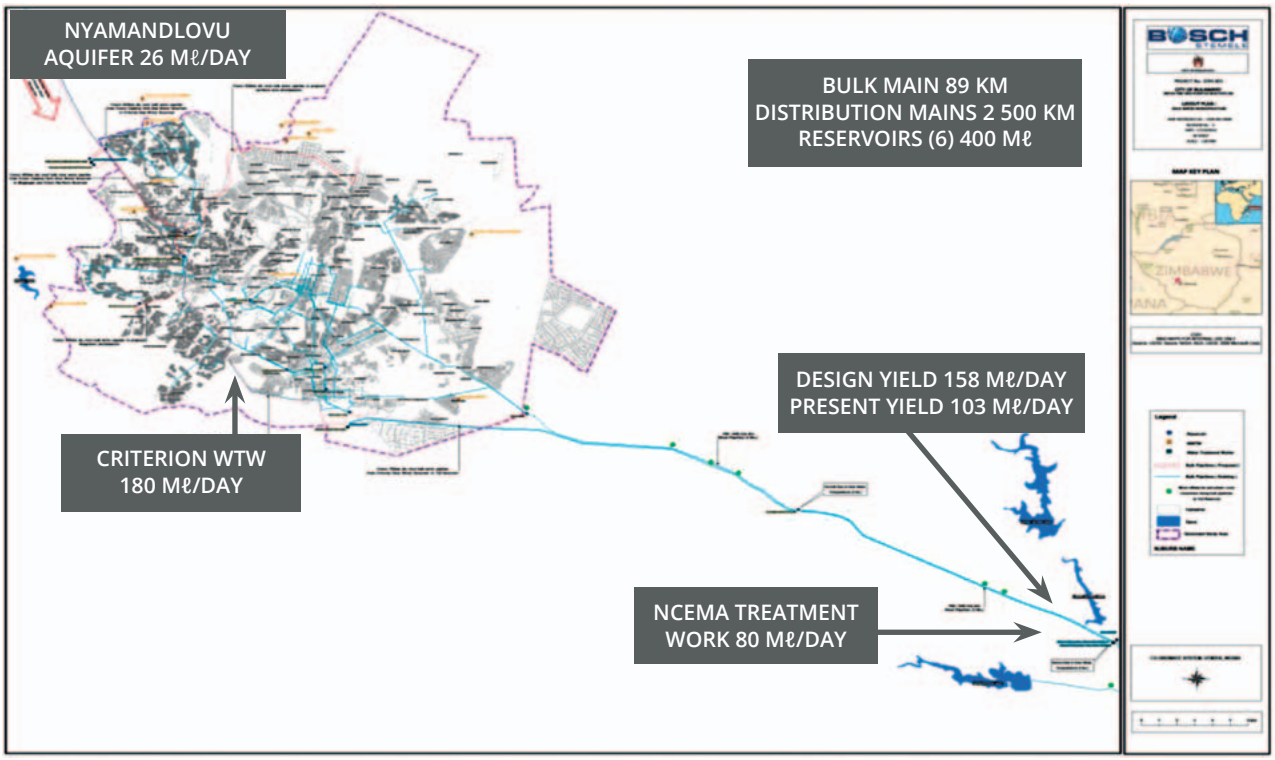

FIGURE 7: Bulawayo's water supply system (Dube, 2013)

FIGURE 8: Primary Clarifier at Ncema, which is in need of rehabilitation.

FIGURE 9: Leakages at the Inyankuni-Ncema Pipeline result in localised flooding.

Bulawayo has sister or twin city status with eThekwini Municipality in Durban, South Africa. This arrangement seeks to provide a common platform for constructive engagement and collective project design on various issues relating to urban development and service delivery. Water, sanitation and environmental management are two of the 12 issues listed in the Memorandum of Understanding (MoU), signed by the two local authorities in 2011. In terms of the MoU, the cities have agreed to work on improving the state of water service delivery in Bulawayo. eThekwini shared its experiences and expertise in with respect to how it has planned for, and is delivering efficient and sustainable water services. The partnership was strengthened by the deployment of engineers from eThekwini to the BCC to assist with the rehabilitation of water and sewer infrastructure in 2010. The engagement enabled the BCC to emerge as the first City to produce a Water and Wastewater Master Plan in Zimbabwe (Cobiti, 2013).

4 | POLICY OVERVIEW

Bulawayo City Council (BCC) is the sole supplier of water to the city, which it does via its Engineering Services Department. This department is further divided into Roads, Town Planning and Water Services. The latter comprises the Water Supply (potable water supply, treatment and wastewater treatment), Water Distribution (water supply and sewage) and Electro-mechanical Divisions (Bulawayo City Council, 2000). Water and sanitation service tariffs are regulated and costs are increased in line with usage. The City's current pricing of water service delivery to residents is guided by the rising block tariff structure that was adopted in 1992. This was implemented as a tool to curb excessive water demand in the commercial and domestic sector with basic consumption limited to 600 litres per household per day or 18 kl per month (Sibanda, 2002). The rising block tariff structure has also accelerated efficiency and equity (fairness) of distribution.

FIGURE 10: Bulawayo CIty, Zimbabwe

5 | CLIMATE CHANGE

The section on climate change and climate modelling has been adapted from a report prepared by the University of Cape Town's Climate Systems Analysis Group (Blamey et al., 2014) as part of the SURe Water project.

5.1 INTRODUCTION

The City of Bulawayo receives most of its rainfall (around 600 mm per year) during the summer period spanning November to February. Average summer temperatures range between 25°C and 30°C as shown in Figure 11 below (Blamey et al., 2014). Very little or no rainfall is experienced during the cooler winter months (May – August).

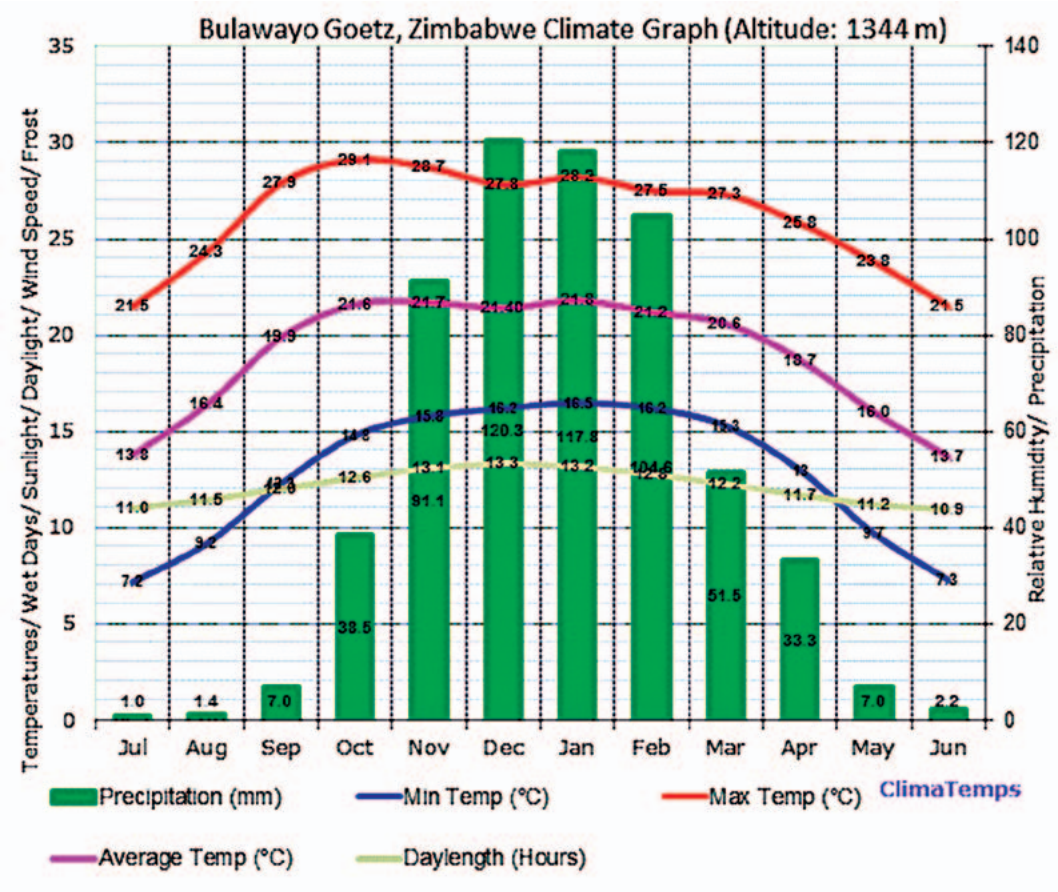

FIGURE 11: Bulawayo's average weather conditions (*Source:* http://www.bulawayo-goetz.climatemps.com/)

5.2 CLIMATE PROJECTIONS

The Representative Concentration Pathways (RCP) 8.5 scenario from the Coupled Model Intercomparison Project (CMIP) 5 models were selected for the climate analysis. It must be borne in mind that Global Climate Models (GCMs) contain a very low resolution, which is why the projections presented are very coarse and focus on the entire country (and do not zoom in to Bulawayo for a finer resolution) (Blamey et al., 2014).

An example of the model output's low resolution can be viewed in some panels (e.g. the BNU-ESM or CanESM2 model), with roughly four grid points from the model used to describe Zimbabwe's regional climate. As a result, these types of models often do not resolve rainfall patterns in areas with strong topography or around large water area's which could significantly influence local climate patterns (Blamey et al., 2014).

5.2.1 Rainfall

There is no consensus among the climate models on the future direction of changes in rainfall patterns for Zimbabwe. Some models indicate an increase in rainfall over the entire country (six models) while the other models project a decrease in rainfall (five models). This is unlike other countries for which some models consistently show an increase in one region and a decrease in another. Most climate models agree on a decreases in rainfall across the country in the spring months (September to November) (Figure 12) although there is no consensus among the models on projected rainfall patterns for (Blamey et al., 2014).

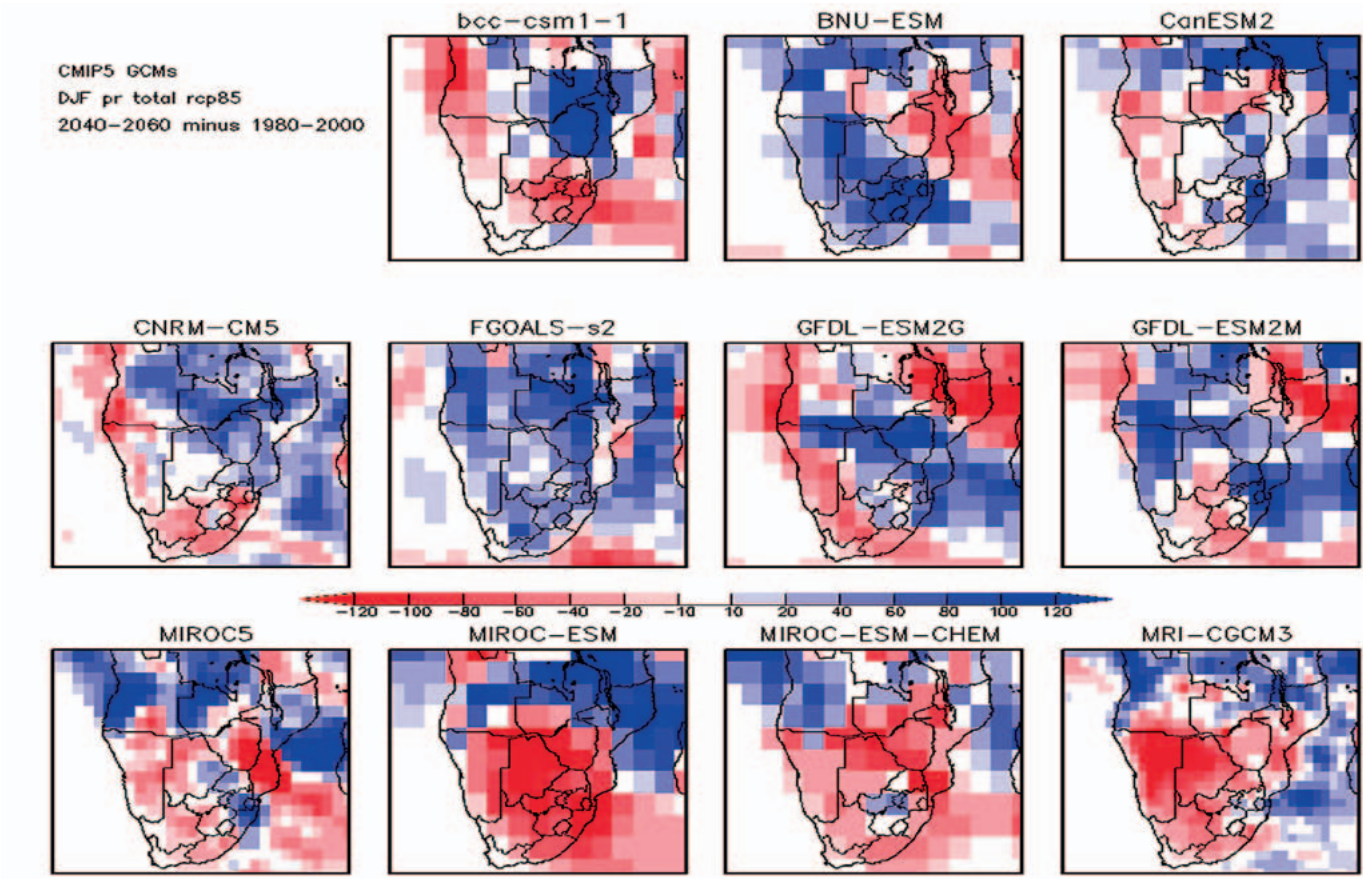

FIGURE 12: GCM projections DJF (summer) total average rainfall anomaly (mm) between the 2040–2060 and 1980–2000 periods (red colours indicate less rainfall, blue indicates an increase). These are from models (name is on top of each fig. panel) run with RCP8.5 (***Source:*** *Blamey et al., 2014*)

5.2.2 Temperature

Most climate models project an increase in summer maximum temperatures of between 1.0° C and 2.5°C by mid-century. Greatest temperature changes are projected for the months of September to November (Figure 13 below) (Blamey et al., 2014). Minimum temperatures are also projected to increase by between 1°C and 2°C in all seasons, with some models again projecting even higher minimum temperatures (Figure 14 on page 20).

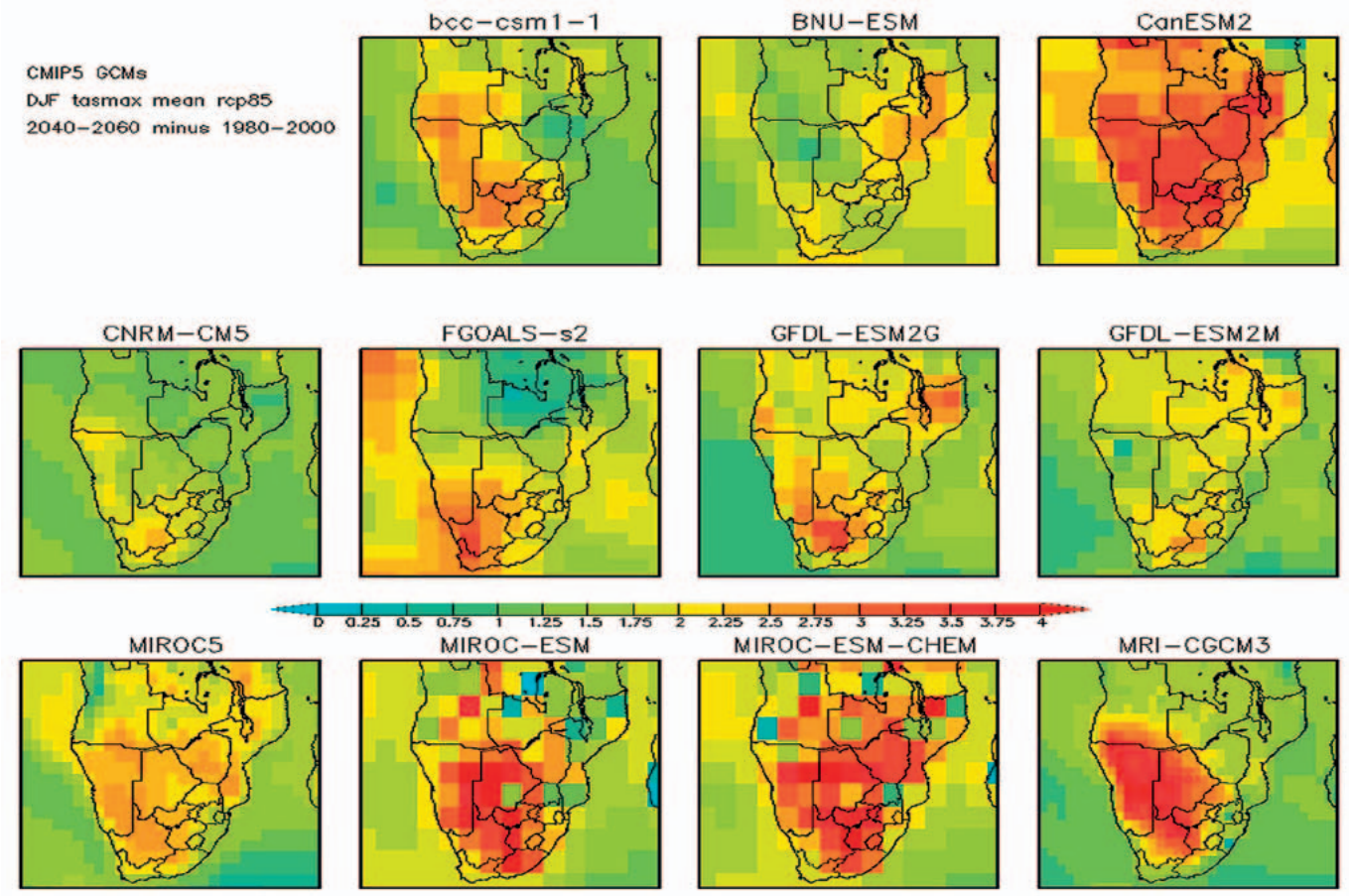

FIGURE 13: GCM projections of changes in average DJF (summer) maximum temperature (in °C) between the 2040–2060 and 1980–2000 periods (light blue being less change, while red is a higher increase in temperature). These are from models (name is on top of each figure panel) run with RCP 8.5 model scenario. (***Source:*** *Blamey et al, 2014*)

5.2 CLIMATE PROJECTIONS *(continued)*

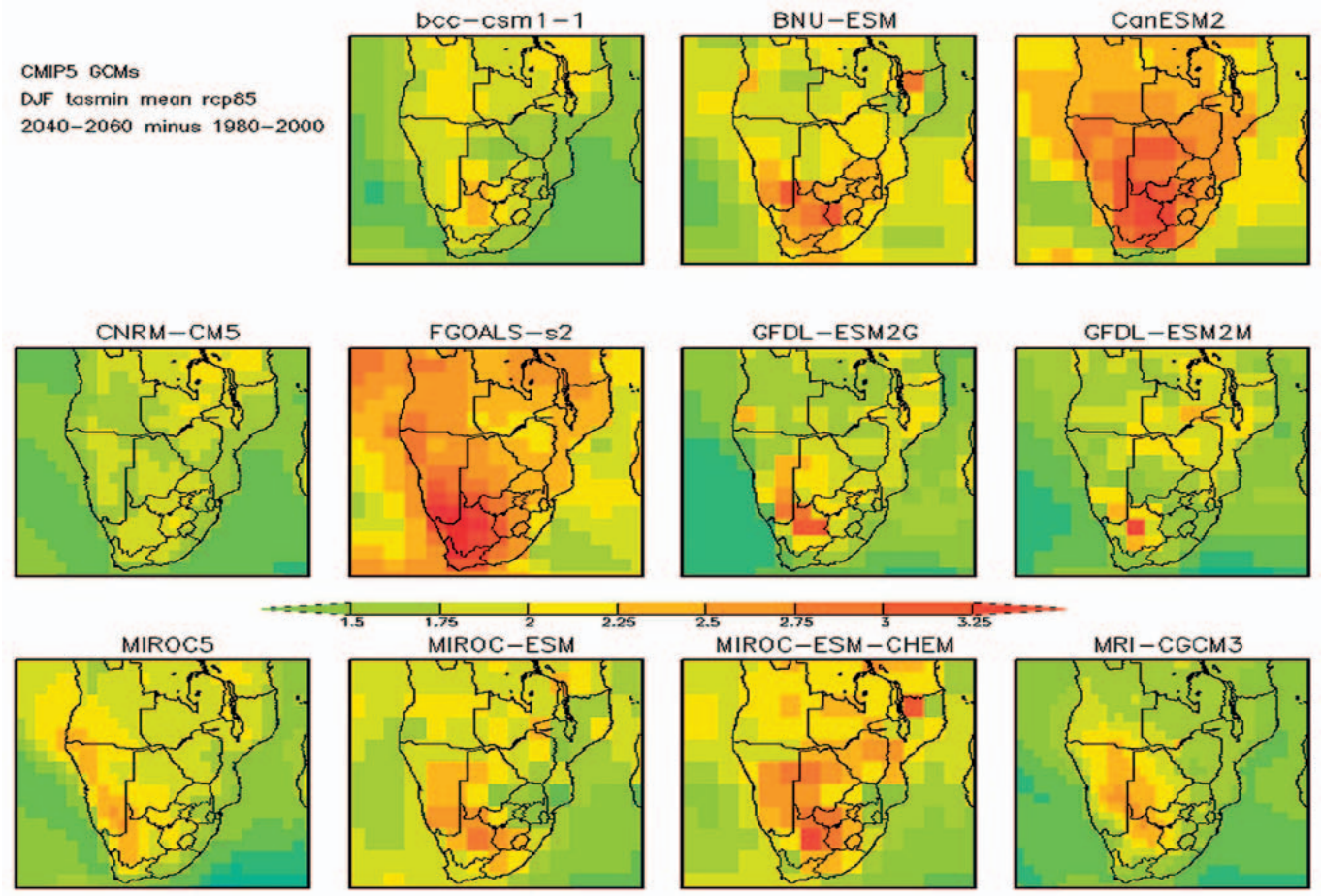

FIGURE 14: GCM projections of changes in average DJF (summer) minimum temperature (in °C) between the 2040–2060 and 1980–2000 periods. These are from models (name is on top of each figure panel) run with RCP8.5 scenario. (***Source:*** *Blamey et al., 2014*)

FIGURE 15: Umzingwane Dam (decommissioned) 5.32% capacity, December 2016

5.3 CHANGES IN EXTREME WEATHER

Weather/climate extremes are generally defined as the occurrence of an event that has a climate variable (or variables) that is above or below a threshold value either at the upper or lower ends of the observed range (Blamey et al., 2014). Climate extremes may be the result of a combination of weather patterns or events that are only extreme on an accumulative level and not on an individual scale (e.g. a drought). Other external factors such as topography, population density, vegetation may also trigger occurrence of exacerbate impact of floods and other hazardous events. It would therefore be irresponsible to assign risk probabilities to changes in these events from an assessment that confines itself to the climate variables.

Extreme events weather events, particularly rainfall events, are harder to simulate than changes in the mean climate, largely because GCMs are low resolution parameterised versions of the real climate and may thus fail to capture important mechanisms such as intense and localised convective rainfall (Blamey et al., 2014).

5.3.1 Changes in extreme rainfall

Changes in extreme rainfall are somewhat difficult to estimate due to the abovementioned problems in simulating extreme atmospheric conditions. A review of the literature on extreme events indicates that it is very likely that heavy rainfall events will increase globally in the future, both in frequency and in contribution to annual rainfall (Seneviratne et al., 2012). However, these findings contain large uncertainties and model biases in projections of changes in heavy rainfall for some regions. Southern Africa is one of these.

5.3.2 Changes in extreme temperature

In regions with sufficient data, there is evidence to suggest that there has already been an increase in temperature extremes over the past few decades. However, confidence in the change in historical trends in temperature extremes across Africa is low to medium based on regional variation (Seneviratne et al., 2012). Some projections indicate considerable warming in the second half of the twenty first century. This could influence the frequency and intensity of temperature extremes although the magnitude of the change is primarily determined by the choice of future emissions pathways. (Seneviratne et al., 2012).

6 | RISK ASSESSMENT SUMMARY

As part of the SURe Water 4 Africa project, WAMTechnology cc, conducted a Risk and Vulnerability Assessment of Bulawayo in 2014. The main components comprised a broad evaluation of the Cities water and sanitation infrastructure with a more detailed assessment of one focal community called Pumula. All infrastructures observed during the site visit were captured photographically to provide a snapshot of its condition. These images were then utilized in the development of the city and community maps to provide a real time indication of the current status of Bulawayo's water and sanitation services.

6.1 URBAN WATER RISK

Bulawayo has a number of factors that influence the City's ability to sustain the supply of potable water, putting it in a moderate risk category. As water demand is increasingly exceeding supply, it is vital to make improvements to reverse this trend. Due to the fact that Bulawayo is often affected by droughts, it is imperative that the City proactively plans for efficient management of its water supply (WAMTechnology, 2014). The site assessments of its water supply facilities revealed that aging and deficient infrastructure caused severe water losses, thus severely restricting the City's capacity to deliver water. In addition, at water treatment works facilities, large volumes of water were found to be lost in the treatment process due to ageing infrastructure. The age, condition and operations of Bulawayo's infrastructure are thus significant risk factors.

The assessment examined the hazardous events that could impact water supply for the community of Pumula. These events were ranked according to significance of impact. Results of the risk assessment indicated that the major hazards which may affect the supply and quality of potable water were related to socio economic issues (i.e. people have to collect water due to water cut-off, resulting in reduced supplies and storage in open containers) in addition to the challenges related to the large infrastructure (i.e. condition, capacity and operation). The results are summarised in Figure 16.

This section will focus on results from the detailed assessment in the location of Pumula. All households in the location have access to the water network, and 90% of the households sampled within the community either have house connections or yard standpipes. However, the water pressure is extremely low due to the high levels of stress on the system caused by the large number of water consumers. 72% of surveyed households in this community reported that they experienced regular problems with water quality and supply. Further the assessment also revealed that households that did not make, or were unable to make payment to the City had their water disconnected, forcing them to rely on community standpipes or hand pumps from boreholes (WAMTechnology, 2014). It is worth noting that of 72 boreholes in Bulawayo, only 11 were operational at the time of the assessment. 85% of residents reported that they had not experienced detrimental health effects due to the water quality, while the remaining 15% surveyed mentioned that they had at some point experienced illness or diarrhoea.

PROJECT	BULAWAYO: ZIMBABWE										
EVENT CATEGORY	POTABLE WATER SUPPLY										
	Droughts	Floods	High precipitation	Infrastructure: Age	Infrastructure: Capacity	Infrastructure: Condition	Infrastructure: O & M	Power supply	Socio economic situation	Theft and vandalism	**Total**
Water supply: Distribution network				9	6	12	12		15	4	**58**
Water supply: Household connections				2	6	6	4		15	6	**39**
Water supply: Standpipes			2	2		6	1		15	6	**32**
Water supply: Treated Water Storage				6	9	9	9			8	**41**
Water supply: Water Abstraction	15	6		9	6	6	9	16		4	**71**
Water supply: Water treatment		6		8	16	12	9	16	6	4	**77**
Total	**15**	**12**	**2**	**36**	**43**	**51**	**44**	**32**	**51**	**32**	**318**

FIGURE 16: Identified hazards and degree of impact related to the Supply of Potable Water for Pumula (***Source:*** *WAMTechnology, 2014*)

6.1 URBAN WATER RISK *(continued)*

FIGURE 17: There is one standpipe per yard and one outside toilet per yard. Residents take turns to fetch water using buckets and water containers and to use the toilet facility. (***Source:*** *WAMTechnology, 2014*)

The City implements stringent water rationing measures in drought periods and as recently as 2014, water was provided for only three days per week to the community. Boreholes tend to dry up at a faster rate in droughts than the distribution network, leaving low income families who depend on communal hand pumps especially susceptible to these fluctuations. It is therefore possible to conclude that socio-economic factors play a significant role in access to water (WAMTechnology, 2014).

6.2 SANITATION AND HEALTH RISK: SUMMARY

Bulawayo and the community of Pumula were judged to be at moderate risk with regards to sanitation and public health. It was noted that Bulawayo had an extensive sewage reticulation network, and the entire community of Pumula was connected to the sewer network. Despite its broad scope, a number of challenged were identified in respect to wastewater reticulation in the city and the community. The sewage system's infrastructure was notably old, which hinders its efficiency and creates sanitation related hazards. Other issues included blocked pipes, broken main lines and non-operational pump stations. As a result of the aging reticulation system, sewage lines that cross waterways often leak. This causes pollution to the waterways and poses health risks to residents (WAMTechnology, 2014).

Infrastructure at the community level (i.e. Pumula) was also insufficient to meet demand. While all manholes were covered during the site visit, they were in a state of deterioration; it was furthermore reported that they are often stolen, creating safety and health risks. In many households, the standpipe used for drinking, cooking, and washing is situated next to the toilet, which presents a sub-optimal hygiene situation.

The collection and management of refuse in the community was noted as satisfactory with household refuse being regularly collected and taken to the Richmond Landfill.

6.3 TANGIBLE THREATS

The effects of climate change may increase or intensify natural hazards in Bulawayo. In conjunction with increasing pressure on city infrastructure, these may further challenge the City's ability to supply adequate potable water and maintain sanitary conditions.

6.4 DROUGHTS

Bulawayo has a record of extreme droughts, and climate change could very well increase their frequency and length. This creates numerous hardships for households, which have to manage cooking, cleaning and drinking from a very limited supply of water. In addition, a reduced water supply creates public health challenges (WAMTechnology, 2014). For example, in a drought, people are more likely to conserve their water supply, using open containers for storage. This increases the risk of water-borne diseases, to which infants and the elderly are particularly vulnerable. Droughts also have severely negative effects on agriculture, resulting in a significant threat to food supply and economic security for households.

7 | WATER AND SANITATION LOCAL ACTION PLAN

FIGURE 18: Community in groups identifying and prioritising adaptation options.

The SURe Water 4 Africa: Developing LoCS project provided an opportunity for the City of Bulawayo to engage representatives from key departments to review the available options to build climate resilience in its long term planning for water and sanitation services.

These iterative meetings provided an enabling environment for stakeholders to review the *status quo* of Bulawayo's water and sanitation services and infrastructure and afforded them a systemic overview of the system going forward. It was stressed that this should be done in a manner that would optimise available human and capital resources.

All goals were developed goals within the 'Specific, Measurable, Achievable, Realistic and Time-orientated' (SMART) framework and in line with the Water and Wastewater Master Plan. The table which follows presents the prioritised adaptation options clustered under the relevant SMART goal, of which there are five.

FIGURE 19: Bulawayo City Council staff members attending SURe Water 4 Africa project Workshop Series 1.

WATER AND WASTEWATER MASTER PLAN

The City has a twinning agreement with eThekwini Municipality in Durban, South Africa to share and exchange knowledge and good practices driven towards promoting sustainability. As a result, members of staff from eThekwini Water and Sanitation (EWS) visited the City of Bulawayo at the end of 2009 to assess its water and wastewater systems.

This assessment showed that:

- The original water and wastewater infrastructure planned for the City was well constructed
- This water and wastewater infrastructure had deteriorated and was in dire need of rehabilitation and upgrading
- Operations and maintenance resources were not coping under the circumstances
- Institutional and cost recovery for water and wastewater services needed to be improved urgently and concurrently with the infrastructure remedies

It recommended that the City of Bulawayo develop a Water and Wastewater Master Plan.

Funding was then sought from the Department of Trade and Industry (DTI) in South Africa to undertake a water and wastewater master planning study for the City of Bulawayo.

The DTI approved funding of 55% of the costs for the study with the remaining 45% being counter-funded by City of Bulawayo.

A master plan was drafted with priority actions to improve the water and wastewater infrastructure and service in the city. The underlying priority for this plan was to ensure feasibility in implementation given the available human, capital and infrastructure resources, and implementation was staggered in three phases as follows:

- An immediate action plan aimed at interventions to be implemented by CoB in the short term, in order to remedy priority problem areas
- A short mid-term action plan for improving water and wastewater services within a five year period
- A medium to long term plan with a 20 year horizon, aimed at creating and delivering viable and sustainable water and wastewater services

The plan also includes planning for rehabilitation, renewal and upgrading of water and wastewater infrastructure, including associated operational and maintenance requirements as well as institutional aspects linked to cost recovery.

TABLE 1 BULAWAYO WATER AND SANITATION LOCAL ACTION PLAN

SECTOR RISK	ADAPTATION OPTION	VARIABLE ADDRESSED	STRATEGY/ACTION	STAKEHOLDERS	FEASIBILITY	PRIORITY
GOAL 1: Ensure adequate Potable Water Supply						
Water shortages	Water Conservation	Drought	• Limit water use by rationing water allocations • Introduce water-shedding (limit access of water to limited number of days per week) • Influence City Policy on water saving measures including use of retrofits and installation of flow limiters for high water users who are not paying for it	• Bulawayo City Council – Engineering Services and Financial Services departments • Zimbabwe National Water Authority • Ministry of Local Government, Public Works and National Housing • Non-Governmental Organisations (NGOs) and civil society organisations	Feasible, but limited funding available	High
Inadequate Water Supply	Exploiting additional water sources	Drought	• Exploit new groundwater resources north-west of the city by engaging consultants to undertake a feasibility study	• Bulawayo City Council – Engineering Services Department • Zimbabwe National Water Authority • Ministry of Local Government, Public Works and National Housing • NGOs and civil society organisations	Feasible, but limited funding available	High
	Infrastructure upgrade	Drought	• Do a bulk systems upgrade to convey more water to the city • Insiza Dam has water during droughts but pipelines to convey it have capacity limitations and should be supplemented	• Bulawayo City Council – Engineering Services Department • Zimbabwe National Water Authority • Ministry of Local Government, Public Works and National Housing • NGOs and civil society organisations	Feasible, but limited funding available. A pipeline levy was introduced but the funding was later redirected to the resuscitation of Nyamandlovu boreholes	

continued

TABLE 1 BULAWAYO WATER AND SANITATION LOCAL ACTION PLAN

SECTOR RISK	ADAPTATION OPTION	VARIABLE ADDRESSED	STRATEGY/ACTION	STAKEHOLDERS	FEASIBILITY	PRIORITY
GOAL 1: Ensure adequate Potable Water Supply						
Water shortages	Use of recycled water for industrial use	Drought	• Quantify the industries that are capable of using recycled water and rehabilitate recycled water infrastructure	• Industrial consumers • Bulawayo City Council – Engineering Services and Finance departments • Zimbabwe National Water Authority • Ministry of Local Government, Public Works and National Housing	Feasible provided an assessment confirms the need	Medium
Erratic water supply	Community education and engagement	Drought	• Develop stakeholder engagement programmes • Share information and improve storage • Implement awareness campaigns to encourage water reuse through bucket system	• Bulawayo City Council – Engineering Services Department • Zimbabwe National Water Authority • Ministry of Local Government, Public Works and National Housing • NGOs and civil society organisations • Development Banks e.g. AfDB • Consumers (water users)	Feasible. There are AfDB funded roadshows as part of their project on water conservation and public health and hygiene Education	
Infrastructure damage	Improve Infrastructure	Drought	• Install controlling devices to minimise water bursts i.e. air release valves • Throttle system valves to manage pressure	• Bulawayo City Council – Engineering Services and Financial Services departments • Consumers (water users)	Feasible but there is limited funding	
Water hoarding	Community engagement and sensitising residents	Drought	• Develop stakeholder engagement programmes such as road-shows and school campaigns • Improve information sharing with stakeholders by means of media e.g. print, social media	• Bulawayo City Council – Engineering Services, Public Relations departments • Consumers (water users)	Feasible but awareness campaigns need sustainable budget allocation. Messages to be shared regularly. Seasonal trends have been identified – water hoarding peaks in summer and in drought periods	

continued

TABLE 1 BULAWAYO WATER AND SANITATION LOCAL ACTION PLAN

SECTOR RISK	ADAPTATION OPTION	VARIABLE ADDRESSED	STRATEGY/ACTION	STAKEHOLDERS	FEASIBILITY	PRIORITY
GOAL 2: Increase Water Security						
Environmental degradation/ pollution due to clogging of sewer pipes and overflows	Household water reuse	Drought	• Consider use of reclaimed water for flushing toilets	• Bulawayo City Council • NGOs • Financiers & Development banks (e.g. AfDB)	Partial funding available from BCC's budget & AfDB – 1/6 sewer catchments covered	High
	Dragging and rodding of sewer pipelines	Drought	• Develop a planned maintenance programme to clean sewer pipes	• Bulawayo City Council • Community	AfDB has procured equipment that will be used to assist in the dragging of the pipes (usual O & M). City will implement planned maintenance programme	High
	Infrastructure improvement	Flooding	• Raise sewer manholes, install sand traps and plan a maintenance schedule	• Bulawayo City Council – Engineering Services Department • Community members • Downstream water users • Environmental Management Agencies (EMA) • NGOs and civil society organisations • AfDB • Consumers (water users)	Feasible with funding	High
Aquifer over exploitation	Monitor groundwater extraction	Drought	Assess aquifer discharge and recharge potential	• Bulawayo City Council – Engineering Services Department • Zimbabwe National Water Authority • Ministry of Local Government, Public Works and National Housing • NGOs and civil society organisations	Feasible with funding	Medium

continued

TABLE 1 BULAWAYO WATER AND SANITATION LOCAL ACTION PLAN

SECTOR RISK	ADAPTATION OPTION	VARIABLE ADDRESSED	STRATEGY/ACTION	STAKEHOLDERS	FEASIBILITY	PRIORITY
GOAL 2: Increase Water Security						
Increased levels of siltation (City supplying dams -Insiza, Nyankuni, Upper and Lower Ncema, Mzingwane and Mtshabezi)	Good practices in upstream catchment management–mining and agriculture	Flooding	• Technical support in sound catchment management practices	• Bulawayo City Council • ZINWA • Catchment and sub-catchment councils • Esigodini Rural District Council • Farmers and miners	Feasible but requires financial and human resources as well as outreach work to sensitise various stakeholders	Medium
High evaporation rates from dams	Reduce surface water exposure	Drought	• Explore public-private partnerships to use floating solar panels for power generation	• Public private partnerships (BCC and private sector) • Bulawayo City Council – Engineering Services Department • Community • NGOs and civil society organisations	Not feasible	Low
Old borehole infrastructure	Regular maintenance of boreholes	Drought	• The 338 boreholes in and around the city need operation and maintenance plans and funding	• Community • Bulawayo City Council – Engineering Services and Operation & Maintenance (O&M)	Feasible with planned operation and maintenance	High
Boreholes not adequately managed and maintained	Building capacity of community to maintain boreholes	Drought	• Develop maintenance manual for boreholes and train and equip community	• Bulawayo City Council – Engineering Services Department • Councillors • Water point user committees – responsible for minor repairs and maintenance of boreholes	Feasible	Medium

continued

TABLE 1 BULAWAYO WATER AND SANITATION LOCAL ACTION PLAN

SECTOR RISK	ADAPTATION OPTION	VARIABLE ADDRESSED	STRATEGY/ACTION	STAKEHOLDERS	FEASIBILITY	PRIORITY
GOAL 2: Increase Water Security						
Address long term water security by introducing policy reforms	Infrastructure development	Drought and flooding	• Develop and adopt building standards that incorporate rainwater harvesting into the design	• Community • Bulawayo City Council – Engineering Services & Housing departments	Feasible but requires strong enforcement plan	High
Water Shortages	Water policy	Drought	• Develop a new Bulawayo City Council Water Policy	• Bulawayo City Council • Zimbabwe National Water Authority • Ministry of Local Government, Public Works and National Housing • NGOs and civil society organisations	Feasible	High
GOAL 3: Efficiently reduce non-revenue water loss						
Water losses due to pipe bursts, meter reading errors & leaks as a result of aged infrastructure and lack of adequate maintenance	Infrastructure rehabilitation	Drought	• Replace and upgrade network • Rehabilitate network by installing PRVs, scour valves etc. • Replace meters to bill residents on correct water usage	• Bulawayo City Council • NGOs • Development Banks (e.g. AfDB) • Stakeholders	Partial funding available from BCC's budget & AfDB – 5% coverage	High
Illegal water use	Customer/ community engagement	Drought	• Conduct feasibility studies • Implement public awareness campaigns on existing Council policy concerning illegal water usage • Introduce an amnesty for customers who declare their illegal water connections	• Community • Bulawayo City Council – Public Relations, Engineering Services & Finance departments	Feasible	High

continued

TABLE 1 BULAWAYO WATER AND SANITATION LOCAL ACTION PLAN

SECTOR RISK	ADAPTATION OPTION	VARIABLE ADDRESSED	STRATEGY/ACTION	STAKEHOLDERS	FEASIBILITY	PRIORITY
GOAL 4: Increase public awareness						
Blockages of stormwater drainage system	Infrastructure maintenance	Flooding	• Educate residents on how to clear storm drains Continue engagement with them • Conduct cleaning campaigns to clear stormwater drains	• Community • Bulawayo City Council – Public Relations, Engineering Services, Roads & Financial Services departments	Feasible	High
High morbidity (high occurrence of water-borne diseases	Prevent or prepare for disease outbreaks	Flooding and drought	• Raise public preparedness and awareness by means of communication campaigns • Disaster preparedness plans • Encourage homeowners to create weep holes on walls surrounding their properties	• Community • Bulawayo City Council – Health, Engineering Services, Public Relations departments • Ministry of Health, Maternity and Child welfare	Feasible	Medium
High water consumption	Reuse of water at household level	Drought	• Increase awareness and education on the reuse of water for agriculture and irrigation purposes at household level. (Not currently widespread/only a few doing it.)	• Community • Bulawayo City Council – Health, Engineering Services, Public Relations departments	Feasible	High
Goal 5: Increasing resilience of water and sanitation infrastructure to climate change						
Damaged stormwater drainage and road network infrastructure	Infrastructure improvement	Flooding	• Clear drains and repair roads using more adaptive materials	• Bulawayo City Council – Engineering Services, Roads, Public Relations departments • ZINARA • Community	Feasible, however more resources are required to supplement inconsistency in funding from ZINARA	High
Damage to residential, key industrial and municipal infrastructure	Clearing and repairing/ upgrading of storm drains	Flooding	• Construct additional stormwater drainage infrastructure	• Bulawayo City Council – Engineering Services, Roads departments • Civil society organisations • National Government • NGOs • ZINARA	Feasible – ZINARA funding insufficient	Medium

8 | COST BENEFIT ANALYSIS

8.1 INTRODUCTION

Fourth Element Consulting was appointed to undertake a Cost Benefit Analysis (CBA) for the SUReWater project cities of Walvis Bay, Lusaka and Bulawayo. The section which follows provides a summary of the CBA findings for each of them. The text has been adapted from the full CBA report, after Dunsmore (2017).

Applying CBA techniques to municipal capital investment decisions in order to support and inform infrastructure development decisions requires the right kind of data (Dunsmore, 2017). CBAs initially start with available data, and in most cases the focus is on capital cost that has been prepared for infrastructure projects. Each of the three participating Cities identified a number of projects that may support resilience to climate change. The projects were largely at a very preliminary level with limited scale and detail, and as such both costs and benefits have been difficult to quantify (Dunsmore, 2017). The approach was then adapted as follows:

- List and prioritise the projects identified by each City (prioritisation was based largely on whether the City would need funding to implement the project)
- Review each project for its potential contribution to climate adaptation and the number of beneficiaries

The CBA was then used to motivate for implementation funding or a more detailed study to further refine the outcomes.

As indicated above, the detail of the CBA is adapted to available data. For this reason early CBA studies in cities are often qualitative, and only become more quantitative over time as the data requirements are understood and collected. The CBAs in this study are therefore largely qualitative (Dunsmore, 2017). The first attempts at applying CBAs almost always highlights a lack of data; the gaps identified thus far should therefore be seen as a positive step toward developing a process of applying CBAs to infrastructure project decision making.

9 | BULAWAYO

Since the 1930s the city of Bulawayo has experienced drought almost every decade, each typically lasting one to three years (Ncube, pers. comm., 2017, cited in Dunsmore, 2017). As a result, the city has adapted a strong water conservation mentality and household consumption levels were below normal at the time of the survey in 2014 (RHDV, 2014, cited in Dunsmore, 2017). Economic growth has been very slow and population growth may be negative depending on which source is used (ZimStats, 2012, cited in Dunsmore, 2017), which means that the demand for water is likely to be stable. Nevertheless, the city continues to experience water shortages, with the result that most of the proposed climate adaptation options/schemes are linked to drought mitigation and water management measures (Dunsmore, 2017).

The suburb of Pumula is the focus of the adaptation options/schemes identified in this report. Located west of the Bulawayo Central Business District (CBD), it is one of the most densely populated areas in the city, and home to almost 70 000 residents in over 14 200 households (Dunsmore, 2017).

Bulawayo City Council (BCC) has proposed the following three adaptation options/schemes, which are summarised below:

1. **Improving storm drainage**. While the risk assessment undertaken by WAMTechnology in 2014 indicates that storm related flooding is not perceived as a particularly significant issue by the communities concerned, the storm drains are generally in a poor condition and properties will in future be at risk of intense and more storm rainfall events. To prepare for this, the adaptation plan is to clean and upgrade local storm drains.
2. **Improve the performance of water networks**. A previous report on a water mains renewals plan for Bulawayo highlights not only the need for pipe replacement and pressure management in particular, but general network monitoring and control as a whole. There are very high water losses in the city networks, and in Pumula in particular. The benefits of any additional water resource development projects will be severely reduced with these losses in the receiving networks.
3. **Recycling wastewater for non-potable uses**. There is potential to restore the currently derelict water treatment plant at the Thorngrove Wastewater Treatment Works (WWTW) that was used to supply non-potable water to the local power station. The intention is to widen the use of recycled water such that demand on fresh water resources is reduced. The scheme will have to include the refurbishment of the WWTW which is only partly functional at present, and this will be in addition to rehabilitating the existing water treatment plant.

Table 2 summarises the cost: benefit ratio of the above, where a favourable ratio (✓) is one where the value of the benefits exceeds the cost of the adaptation option/scheme. On the other hand, a negative ratio (✗) is one where the cost of the proposed adaption option/scheme exceeds the value of the benefits. Low confidence in the information used to calculate the cost: benefit ratio is indicated by '?'.

TABLE 2 COST: BENEFIT RATIO OF SCHEMES PROFILED FOR BULAWAYO CITY COUNCIL

SCHEME	SCENARIO	$\frac{\$ \text{ COSTS}}{\$ \text{ BENEFITS}} = ?$	✓ OR ✗	OUTSTANDING POTENTIAL COST OR BENEFIT DATA
Clearing, repairing and upgrading storm drains in Pumula	Municipal cleaning rates	$\frac{\$6.9 \text{ million}}{?} > 1$	?	Flood relief benefits are unmeasured.
	Community cleaning rates	$\frac{\$4.8 \text{ million}}{\$4.0 \text{ million} + ?} < 1?$	✓	Flood relief benefits are unmeasured.
Water network rehabilitation in Pumula	Pipe replacement programme	$\frac{\$6.0 \text{ million} + ?}{?} < 1$	✓	Additional costs may include: • Pressure management (PRV) costs • Supply upgrade • Potential benefits include: • Community health improvements • Potable water treatment costs • Avoided costs of new water resource development
Repair of sewer lines and pump station in Pumula	Pumula pump station no. 1	$\frac{\$2.6 \text{ million} + ?}{> \$1 \text{ million fines} + \text{environmental} + \text{community benefits}} < 1?$	✓	Unmeasured costs include fill length of sewer network to be cleaned and/or repaired. Unmeasured benefits include: • Improved community health benefits • Reduced cost of water treatment • Impacts on downstream communities and water users • Ecological benefits
Rehabilitating Thorngrove WWTW to produce recycled water		$\frac{\$5.5 \text{ million} + ?}{?} < 1?$	✓?	Unmeasured costs: • Sewer outfall rehabilitation • Rehabilitation and extension of recycled water reticulation system • Unmeasured benefits include: • Avoided stream pollution fines • Avoided increased treatment costs of polluted stream flow • Avoided cost of new water resource development project(s) • Greater resilience of municipality to droughts • Sales income from customers • Improved economic benefit to potential customers

The main outcomes of the table are summarised as follows:

i. The drain clearing and expansion CBA shows that there is potential benefit to both the City and the community. It is expected that with further investigation, the community participation scheme will show a very favourable cost: benefit ratio (i.e. lower than 1). Incidentally, community participation in general and in management of stormwater systems is increasingly being adopted by developed countries as one of their sustainable drainage measures (Dunsmore, 2017).
ii. The provision of reliable basic water supply, water saving and the protection of the environment and water resources against pollution generally do not need CBAs to justify action. However, running the CBA process can be useful in identifying all the costs and benefits, even if some of these are difficult to assign economic value to (Dunsmore, 2017).
iii. The Thorngrove project is a good example to illustrate how CBA can significantly improve decision making for investment. Although the premise of the scheme is intuitively strong, there is insufficient information to ascertain whether this is the best option for saving potable water supplies in the short term. For example:
    a. Would the water savings be more than the Pumula pipe replacement programme at a potentially similar cost?
    b. Is protecting water resources against pollution more important than securing potable supplies in the short term?

It is worth considering that by addressing some of the outstanding data gaps, a detailed CBA may in fact show that all these projects are critical investments and that a budget of ±USD $20 million would provide a very important step in reducing the vulnerability of the water and sanitation sector and actively contribute to improving climate resilience (Dunsmore, 2017). Maintenance and operations must be ensured to secure the benefits and to preserve the investment value (Dunsmore, 2017).

FIGURE 20: Thorngrove Wastewater Treatment Works (WWTW).

CONCLUSION

Through the development of the water and sanitation local action plan (LAP) a number of key recommendations were identified to support Cities in the identification and prioritisation of local adaptation options and the development of sustainable and resilient urban water and sanitation infrastructure including *inter alia*:

- Developing creative partnerships with local universities and other research institutions to develop capacity and tap into technical expertise and knowledge. This is potentially a win-win situation as students and academics gain valuable experience, while local authorities can invest in well qualified and experienced water engineers and in multidisciplinary planning teams.
- Re-use of water, wastewater and stormwater is considered by many experts as the defining solution for the African continent in shifting towards improved sustainability and resilience for our urban centres in terms of water and sanitation service delivery. New technologies could allow local authorities and utilities to re-imagine the way we use our finite water resources and assist in adapting to some of the projected impacts of climate change in the region such as increasing water scarcity, droughts and intense rainfall events.
- Cities in Africa must prioritise their influence and drive the narrative around water in their planning efforts as this will change the way African citizens regard and relate to water resources. A paradigm shift is needed in this respect in order to slow the continent's ever-growing demand for water. Another way of achieving this is to price water correctly; such that access to water for basic needs is not restricted, but that over-exploitation and unsustainable extraction is discouraged. This needs to work hand in hand with exploring and implementing decentralised approaches to infrastructure design and a concerted effort in reducing non-revenue water lost from the system.
- Cities should consider the role of nature-based solutions to complement or replace hard infrastructure to store and/or purify water in and around urban and peri-urban areas. Examples include healthy wetlands (both natural and manmade (constructed)). The costs of such interventions tend to be significantly less than large infrastructure projects.
- Data is key to all current and future planning and its collection and monitoring, especially early-warning systems, can improve communities' ability to reduce their vulnerability to flooding and droughts. It can also serve local authorities in planning for improved disaster risk management at the local level and future infrastructure development.

It is anticipated that it will inform the City of Bulawayo's long term vision of providing resilient and sustainable water and sanitation services to residents. The project adopted a highly participatory approach, engaging a variety of key stakeholders. Methods included one on one interviews and focused group discussions with City of Bulawayo technical personnel, workshops with both the City of Bulawayo technical personnel and Community members from Pumula. The engagements challenged participants to think strategically in identifying solutions and opportunities to respond to their local challenges. To this end, Sustainable Development Goal (SDG) Six (Ensure availability and sustainable management of water and sanitation for all) and (SDG) 11 (Make cities and human settlements inclusive, safe, resilient and sustainable) were instrumental in informing the priority areas and SMART goals for the city. These are:

- Ensure adequate potable water supply
- Increase water security
- Efficiently reduce non-revenue water
- Increase public awareness on the wise use of water and increase resilience of water and sanitation infrastructure to climate change

Efforts were made to ensure that the goals were aligned to the City of Bulawayo's strategic vision as indicated in its Water and Wastewater Master Plan. High level political buy-in to the project has been key in ensuring the City's commitment to and successful engagement with the project. Furthermore, the City of Bulawayo is in the early stages of developing a Climate Strategy which will build upon the LAP and seek to align it to its Water and Wastewater Master Plan.

The next phase is for the City to seek ways of operationalising the actions set out in the LAP. An option being considered is to engage development aid agencies/funders/financiers in a project preparation phase to ensure that proposed projects are well conceptualised, feasible, appropriate and that they can be successfully implemented.

It is hoped that the City will be able to use the LAP as a point of reference as they engage with relevant stakeholders in mobilising resources to implement the actions in the plan.

GLOSSARY

Aquifer: An aquifer is an underground layer of permeable rock through which water is able to pass. It fills with permeated water from precipitation such as rain or snow, and acts as a reservoir for groundwater.

Borehole: A deep, narrow hole made in the ground to locate and utilise ground water.

Drought: "A sustained and regionally extensive occurrence of below average natural water availability, which can thus be characterised as a deviation from normal conditions of variables such as precipitation, soil moisture, groundwater and streamflow" (Tallaksen & van Lanen., 2004).

Flooding (Flash): Flooding that begins between three to six hours following a heavy rainfall event (National Weather Service., 2017).

Non-potable water: "Water that has not been examined or properly treated and is thus not approved by appropriate authorities as being safe for human consumption" (Oilgae., 2017).

Non-revenue water: "Water that has been produced and is 'lost' before it reaches the customer. Losses can be real losses (through leaks, sometimes also referred to as physical losses) or apparent losses (for example through theft or metering inaccuracies)" (Frauendorfer & Liemberger., 2010).

Potable water: Water that has been purified, monitored and tested and declared suitable and safe for human consumption

Retrofit: "Add (a component) to something that did not have it when manufactured" (English Oxford Dictionary., 2017a).

SADC: "The Southern African Development Community (SADC) is a Regional Economic Community comprising 15 Member States: Angola, Botswana, Democratic Republic of Congo, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe. Established in 1992, SADC is committed to Regional Integration and poverty eradication within Southern Africa through economic development and ensuring peace and security" (SADC., 2017).

Standpipe: A potable water delivery system that is usually placed outside a residential dwelling for single or communal use.

GLOSSARY

Stormwater: Surface water that is present in abnormal quantity resulting from heavy, often intense periods of precipitation such as rain or snow. It can be held on the surface, stored in reservoirs and lakes, permeate into soil or through rock and be stored as ground water, present as run-off or stay on surface as in ponding (often seen areas with poor drainage systems or following intense rainfall events) (English Oxford Dictionary., 2017b).

Sustainable development: Meeting the (human) development needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development., 1987).

Sustainable Development Goals: "The Sustainable Development Goals (SDGs) are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity.

"The 17 goals build on the successes of the Millennium Development Goals, while including new areas such as climate change, economic inequality, innovation, sustainable consumption, peace and justice, among other priorities. The goals are interconnected – often the key to success in one will involve tackling issues more commonly associated with another" (UNDP., 2017).

Topography: Surface features of an area of land. Topographic features can include mountains, hills, rivers and lakes *inter alia* most often depicted on maps

Wastewater: Water for which the quality has been often negatively impacted due to human related activities such as water that has been used in the home, in a business, for agriculture or as part of an industrial process (English Oxford Dictionary., 2017c).

Water harvesting: "Rainwater harvesting is the collection, filtering, storage and distribution of rainwater. It can be used for irrigation, as an emergency supply of water or a complete off-the grid system. It can be stored in water tanks or reservoirs" (Rainwater Harvesting., 2017).

Weather or climate extremes: The occurrence of an event that has a climate variable (or variables) that is above or below a threshold value either at the upper of lower ends of the observed range (Blamey *et al*., 2014)

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Nesisa Mpofu: Senior Public Relations Officer, City of Bulawayo

Kwanele G Dube: Acting Senior Engineer; Strategic Planning & Research Unit, City of Bulawayo

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Tserayi Machinda: Urban Council Association of Zimbabwe (UCAZ)

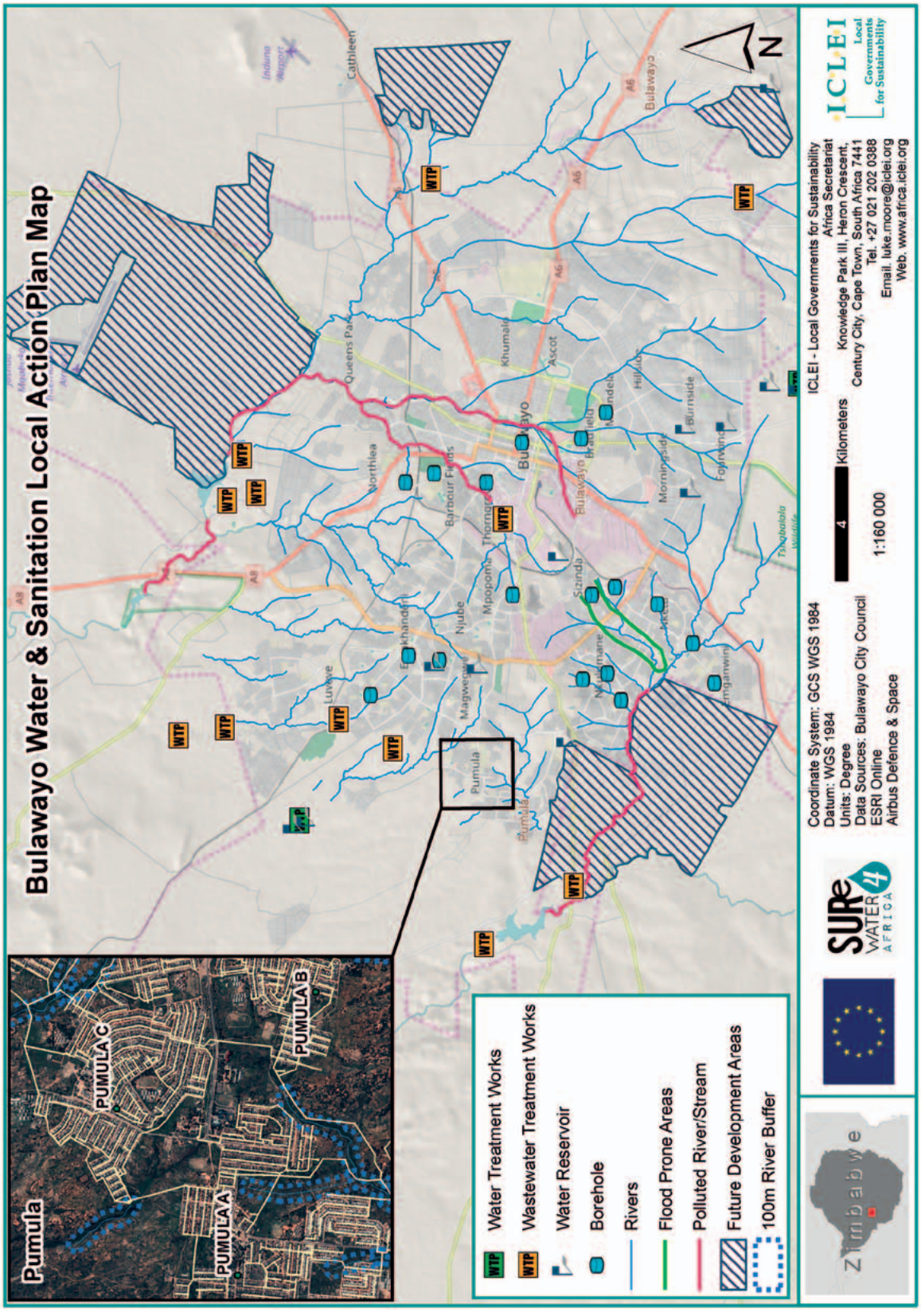
Community members who attended the SURe Water project workshops as listed in the table below.

NAME	ORGANISATION REPRESENTED
Admire Chirikure	Apostolic Church
Agnes Anderson	Women of Zimbabwe Arise/ WOZA
Bryton Sigola	Intern Isilwane Y.C
Dumiso Khumalo	Community member
Felix A.P.	Chairperson Resident Association
Innocent Ndlovu	Community Action Team (CAT)
Innocent Nduoru	Bulawayo Progressive Residents Association (BPRA)
Johannes Sithole	Bulawayo Progressive Residents Association (BPRA)
John Gwiriri	Community Based Planning
Jonathan Ndlovu	Secretary for Development
Luino Francis Dube	Community member
Luwo Francis Dube	Zibuthe (Community based planning)
Maina Dube	Home Based Care (HBC)
Mankazana Moyo	Community Based Organisation (CBO)
Mbarengwa Resocce	Local Reporter
Mhinah Dube	Community member
Micheal M.L. Mhlanga	Child Protection Com Secretary

NAME	ORGANISATION REPRESENTED
Ndumiso Khumalo	Recreation Officer
Nhlanhla Dube	Bulawayo Progressive Residents Association (BPRA)
Nhlanhla Moyo	Bulawayo Progressive Residents Association (BPRA)
Ntando Moyo	Home Based Care (HBC)
Oswell Moyo	Chronicle Reporter
Pambano Ndebele Felix	Teachers
Pastor Shenje	Interfaith Churches
Paul Goremuchehe	Vendors
Qyton Zana	Councillor
Sebastian Baloyi	Ward Aids Committee (WAC)
Senzeni Mhlanga	People living with disabilities
Sichelesile Mahlangu	Case Care
Solomon Tshabangu	Bulawayo Residents Association (BURA) (Old Pumula)
Stanford Mhlanga	Bulawayo Residents Association (BURA) (East Pumula)
Vigie Jele	Community Health Worker
Vivian Mhlanga	Radio Dialogue

APPENDICES

APPENDIX 1 BULAWAYO WATER AND SANITATION LOCAL ACTION PLAN MAP (ICLEI Africa, 2017)



APPENDICES

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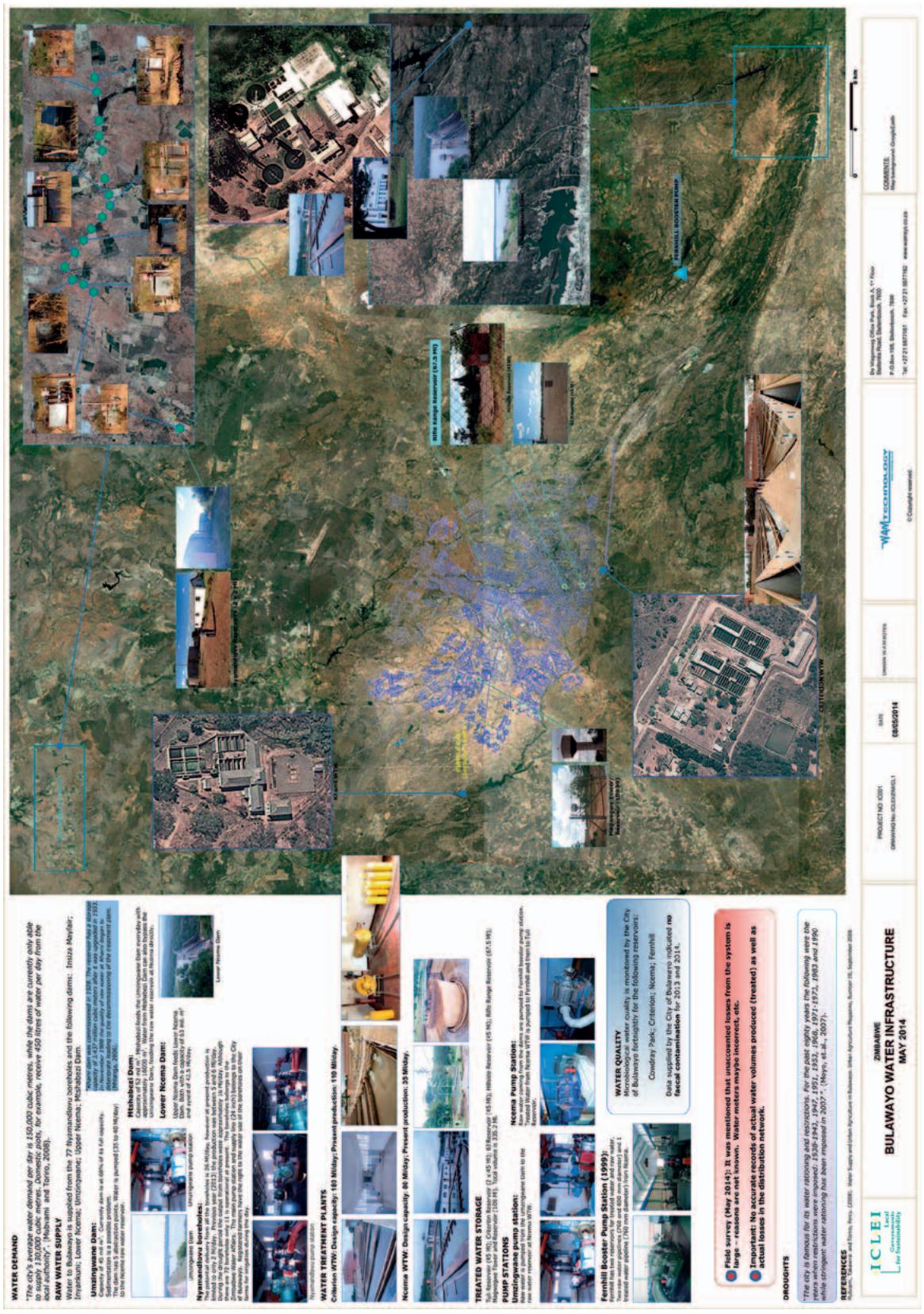

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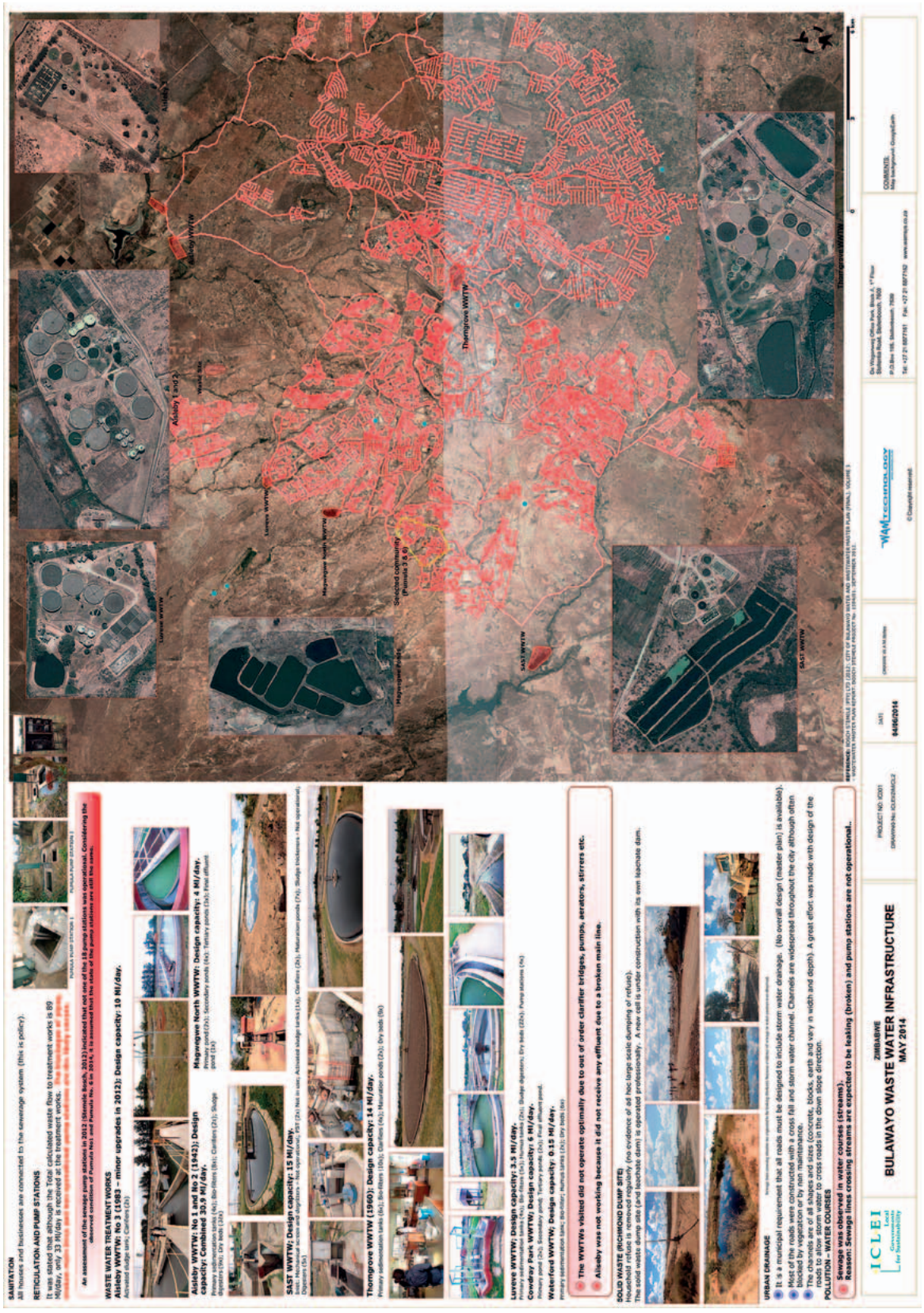

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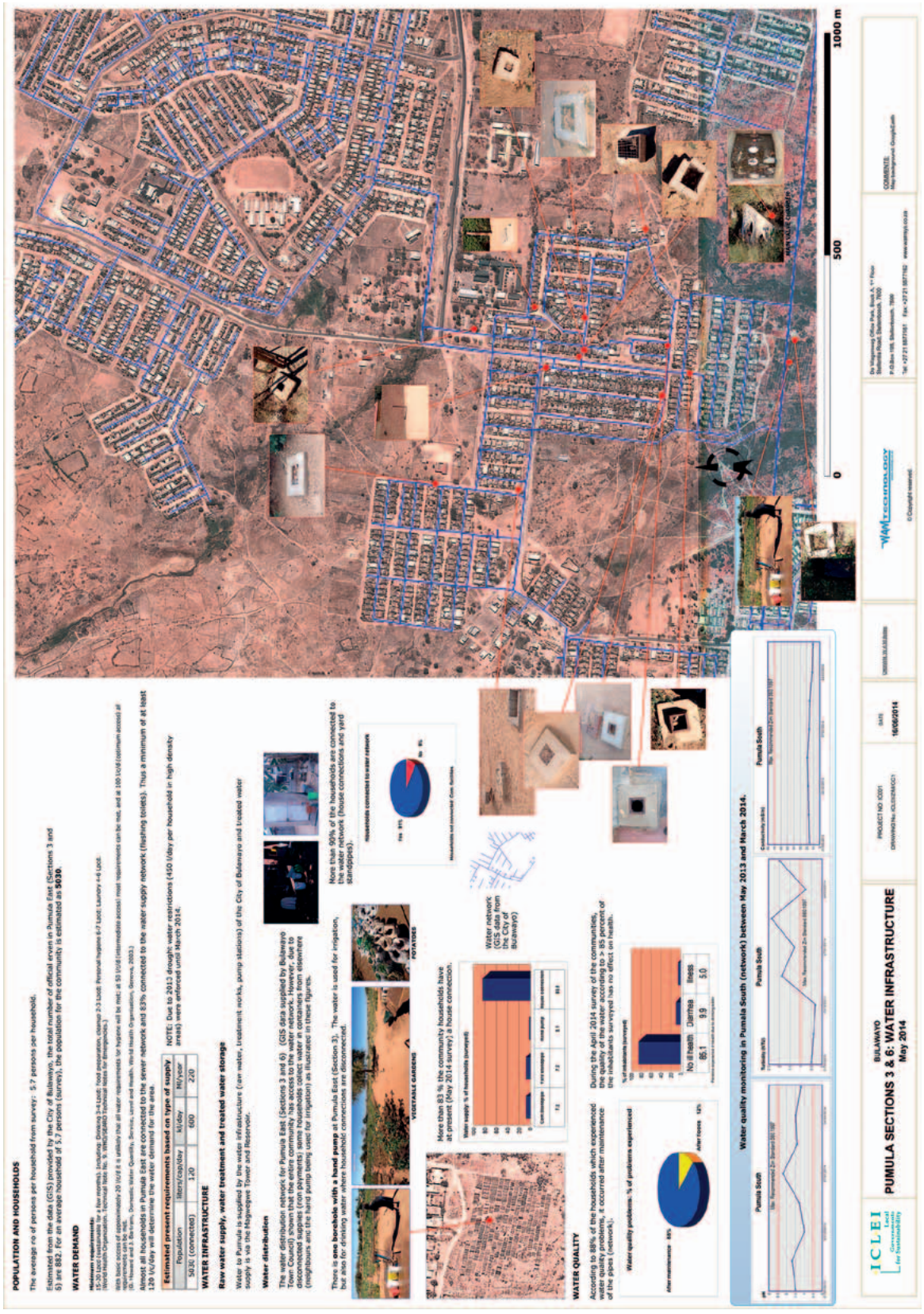

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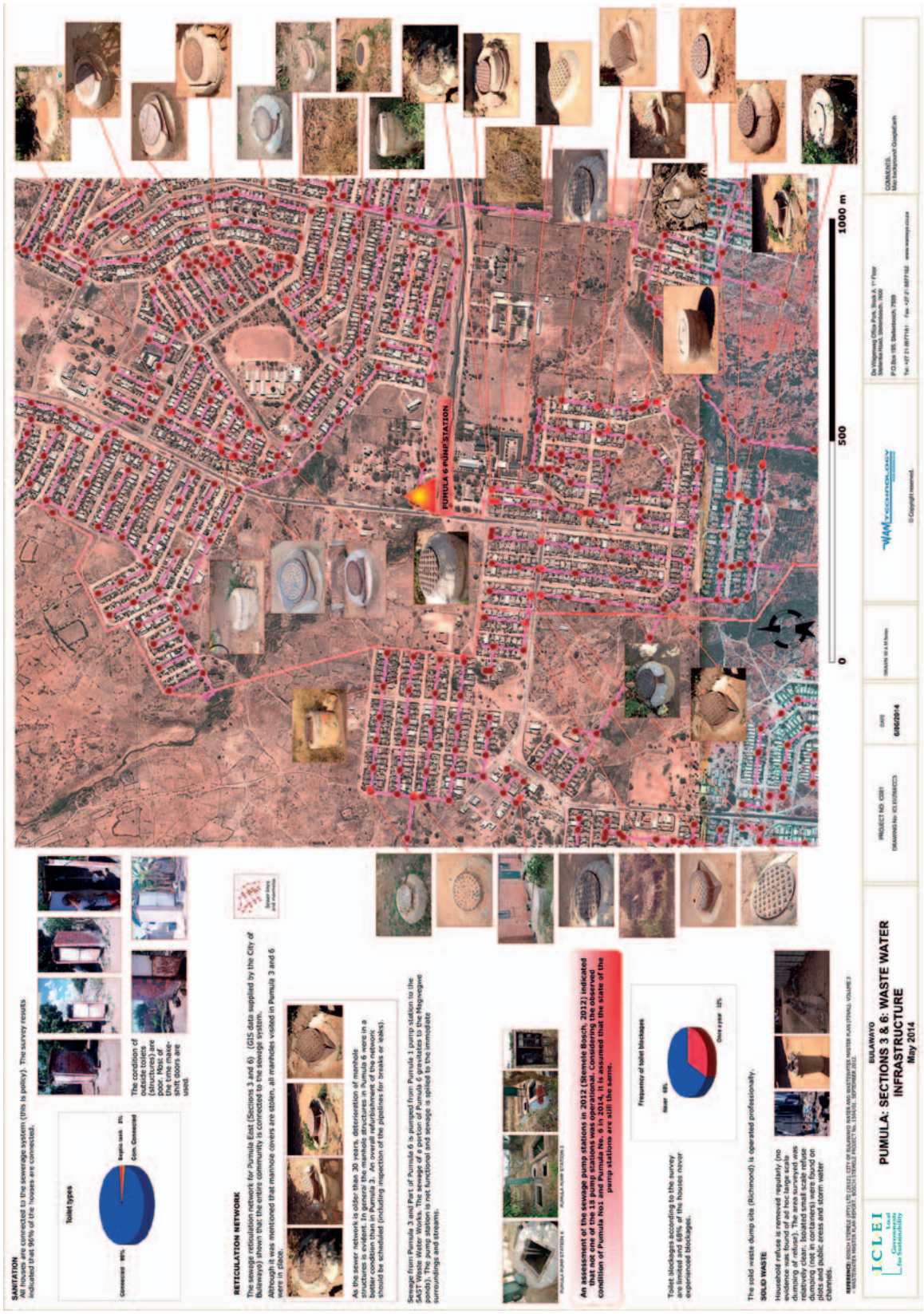

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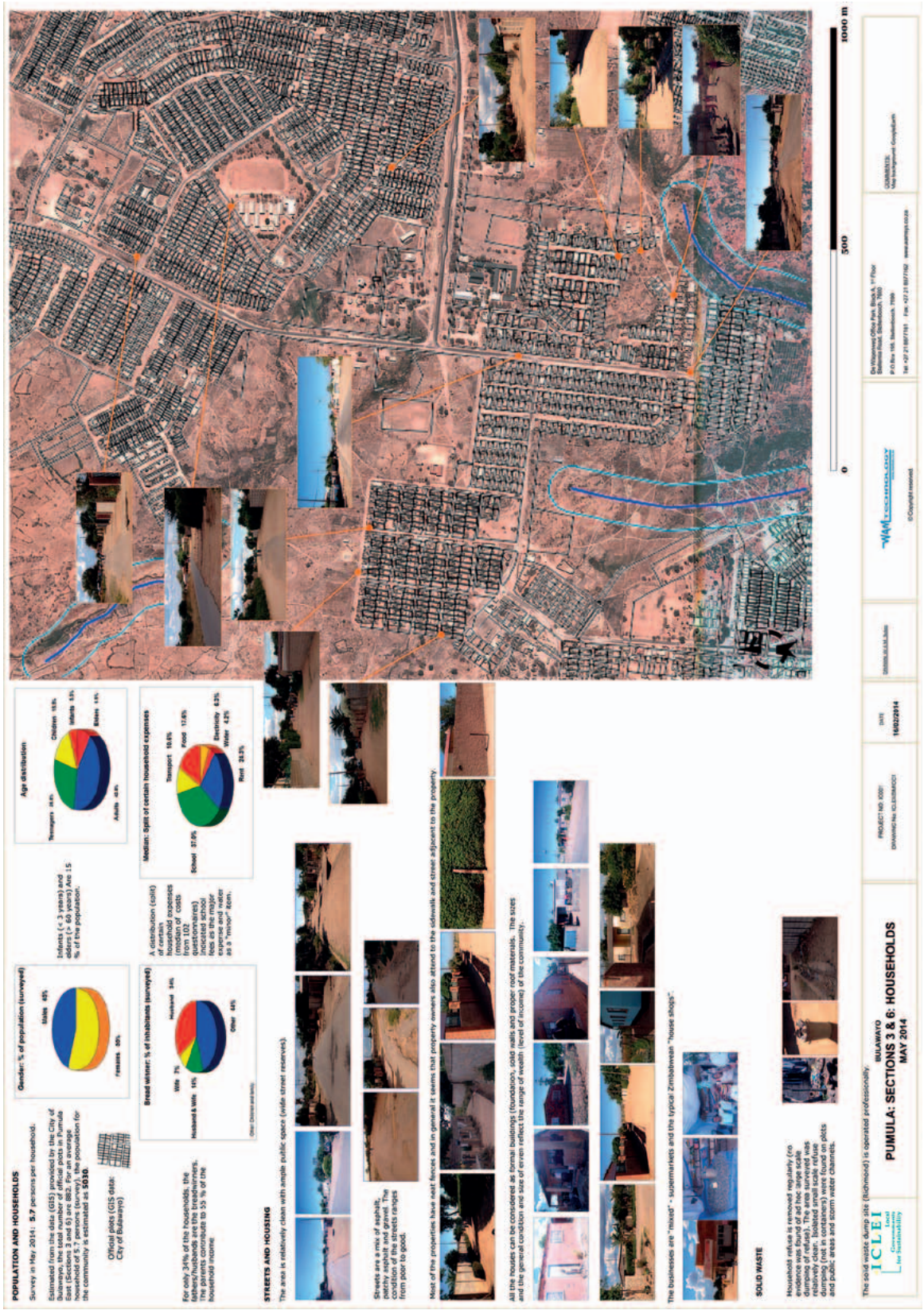
APPENDIX 6 PUMULA HOUSEHOLD OVERVIEW (WAMTechnology, 2014)



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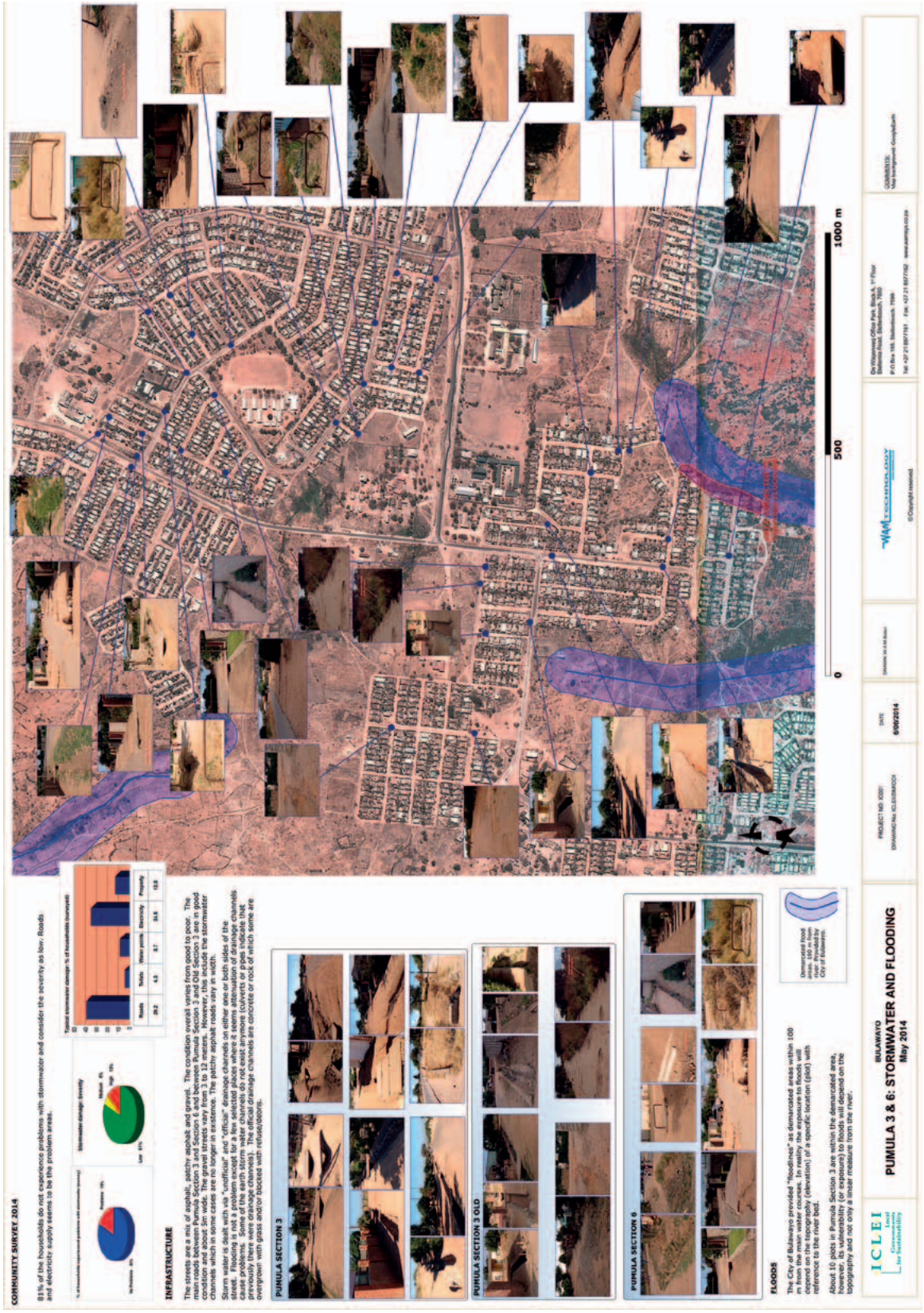
APPENDIX 7 PUMULA URBAN DRAINAGE (WAMTechnology, 2014)



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