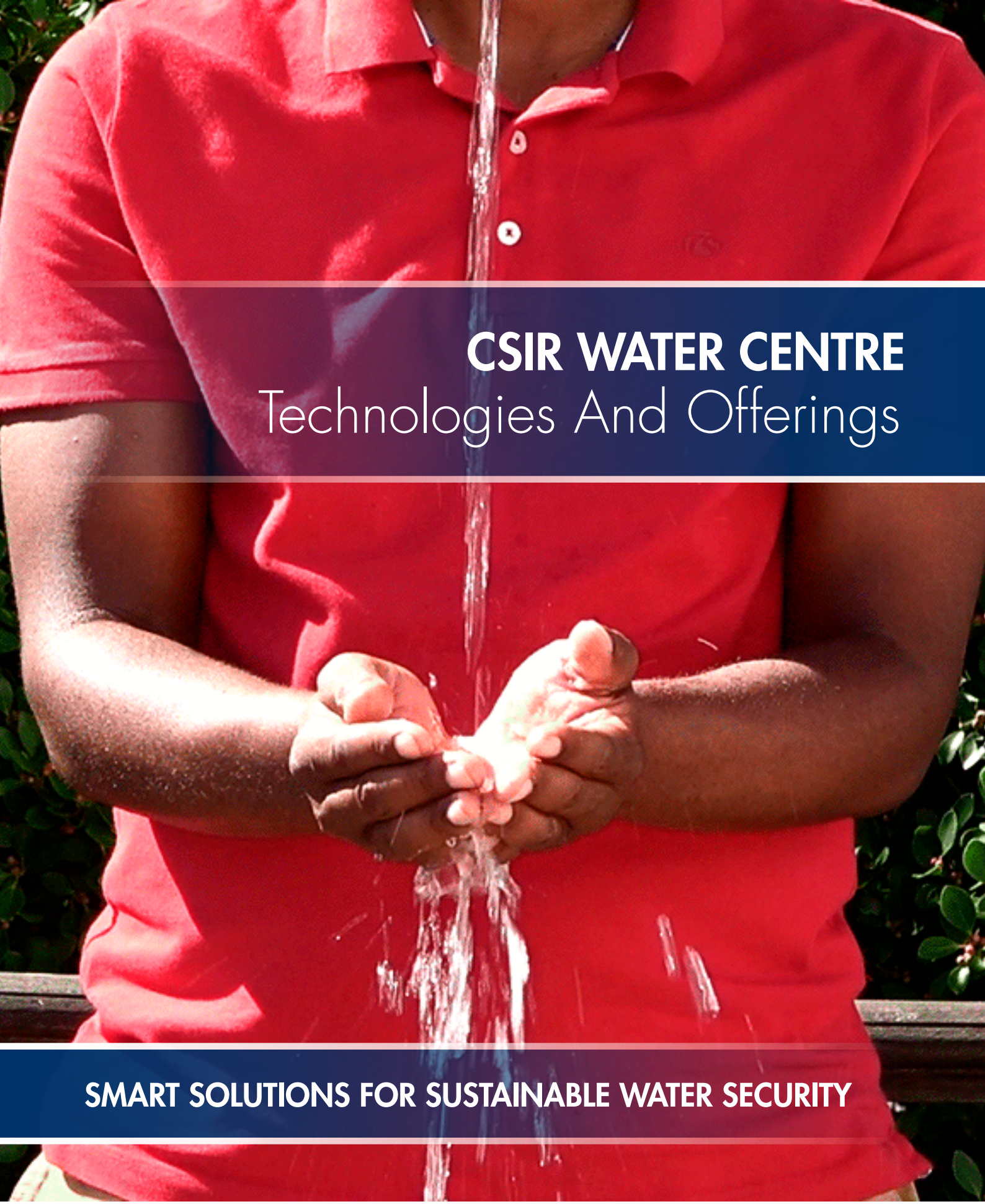
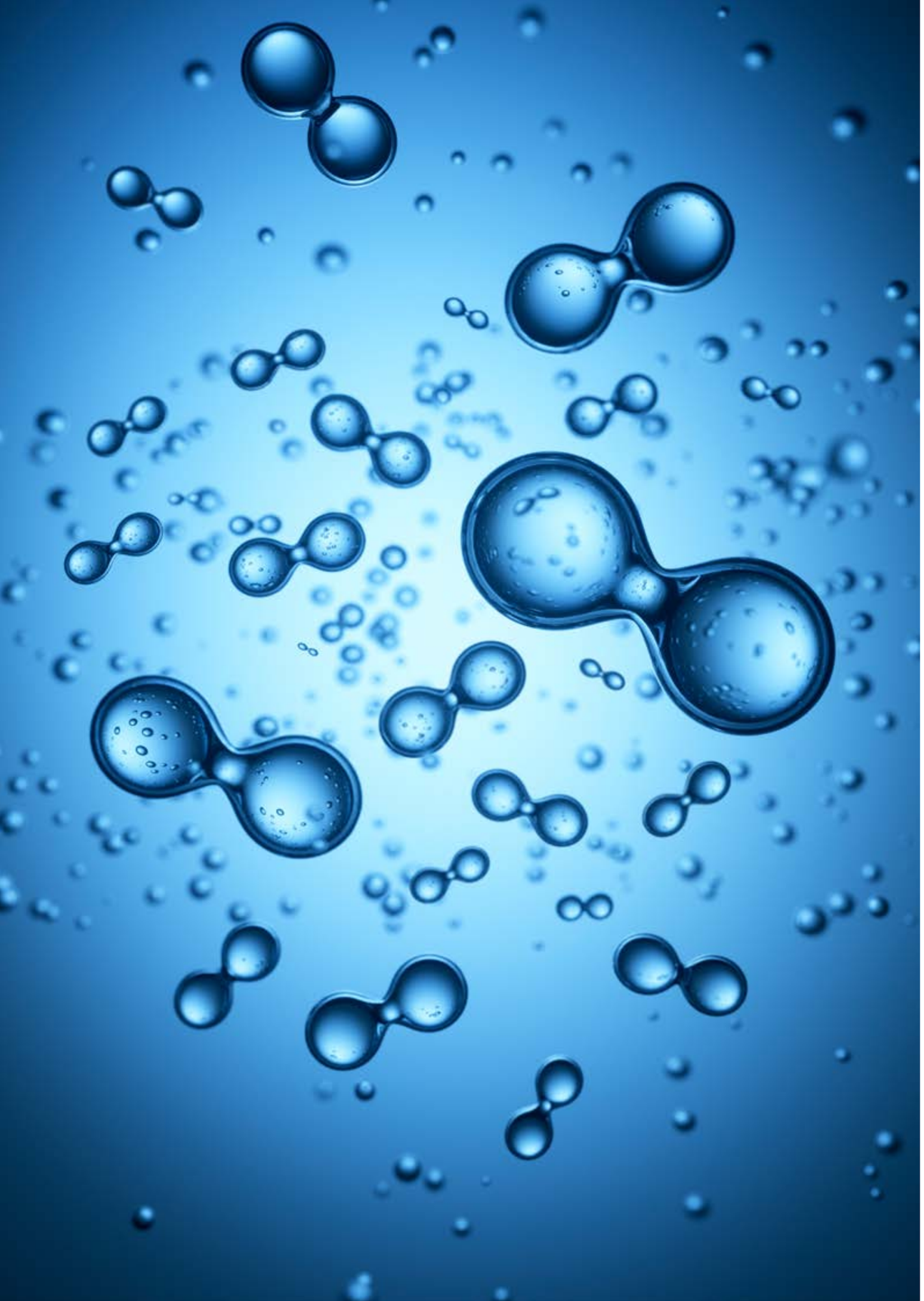


CSIR WATER CENTRE
Technologies And Offerings

SMART SOLUTIONS FOR SUSTAINABLE WATER SECURITY

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

CSIR
Touching lives through innovation



Contents

SMART WATER ANALYTICS AND SOLUTIONS (continued)

Water Centre Identity

Overview

- **Envisaged impact:** Reliable, Efficient and Functional water and wastewater service delivery, in the interest of economic development, through the development and refinement of smart water use and infrastructure technologies for Public and Private Sectors.
- **SA Water Challenges being addressed include:** Water Shortage, poor water planning and accountability, lack of sound infrastructure operation and maintenance, dwindling water resources, deteriorating water quality, outdated and high-cost water treatment technologies, emerging water pollutants, lack of access into alternative water resources and lack of key domain skills.

Strategic Objectives

- **Development of software tools that will improve water resources resilience**, thus ensuring availability of water with good quality against the backdrop of climate change impact and other stressors such as trade-offs within the Food-Water-Energy nexus.
- I**mprove water management systems** through contribution towards policy review and development of tools and techniques that will reduce the cost of water service delivery and promote equitable and smart water use. Ensure improved water testing methods, purification, water and wastewater treatment and access to alternative water resources
(Support water mix).
- **Development of fit for purpose technologies** for the development and optimization of smart and robust water and wastewater infrastructure with concomitant improved operation and maintenance.

Focus Offerings

- **Smart Water Use:** Focusing on the provision of knowledge, innovation, technology development, skills and services to support water mix and improve water supply and demand management through effective water resources planning. Including, Water use auditing.
- **Smart Water and Wastewater Infrastructure:** Focusing on the innovation and development of comprehensive water infrastructure lifecycle solutions (design, operation and performance management) with a specific focus on raw water reticulation, potable water distribution networks, wastewater (incl. industrial and pharmaceutical) networks and water treatment plants. This also include the development of smart Decentralized Wastewater and Point of use/source treatment systems to support Smart Off Grid Water and Wastewater Treatment.
- **Smart Water Analytics and Solutions:** Focusing on the innovative assessment, testing and monitoring of water resources, pathways and effluents quality, and also the development of low-cost (in-situ) technology solutions to mitigate water quality challenges.

Summary of our Focus/Priority Areas: the linearised water value chain

NON EXHAUSTED EXAMPLES

Smart Water Usage

Challenges
- Escalating water tariffs threatening industrial and agricultural development
- Lack of effective Water Planning (i.e Local government)
- Deteriorating Water Resources Quality
- Lack of accurate water accounting
- Water demand outstripping supply due to over-reliance on surface water (Lack of sufficient Water mix)

Distinguishing Capabilities
- Comprehensive Water Resource Assessment: site visit and modelling
- Groundwater Quality Modelling
  - Assessment technology/equipment
    - 1st publication record and Benchmark study

Smart Water and Wastewater Infrastructure

Challenges
- Water losses due to dilapidated infrastructure
- Dysfunctional WWTWs;
- Marginalized communities still not serviced
- AMD threat on water resources

Distinguishing Capabilities
- Mobile, cost effective and simple water and WWTWs
- Continuous improvement, support and training on our products
- Value add with manufacturing cluster (manufacturing membranes)

Smart Water Analytics and Solutions

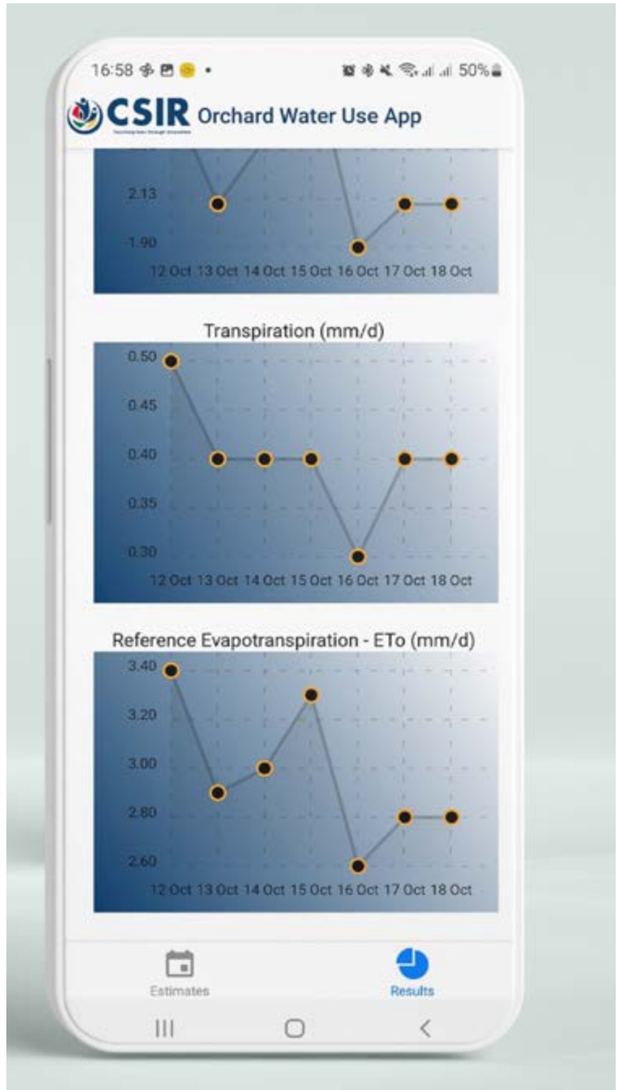
Challenges
- Poor drinking water and wastewater management (incl. recycle)
- Adherence to Environmental regulations by Industries
- Non-Compliance with SANS 241
- Lack of specialised testing skills and facilities

Distinguishing Capabilities
- Specialized water quality analysis: viruses, ecotoxicity, emerging and non-conventional water pollutants; Persistent Organic Pollutants (POPs), Pharmaceuticals and Nano-Pollutants.

SMART WATER USE TECHNOLOGIES

Smart Water Use App

Landing Page: Orchard Details



Outputs: In graphical

Outputs: In tabular format

SCHEMATIC REPRESENTATION OF THE APPLICATION

Inputs

Location ID

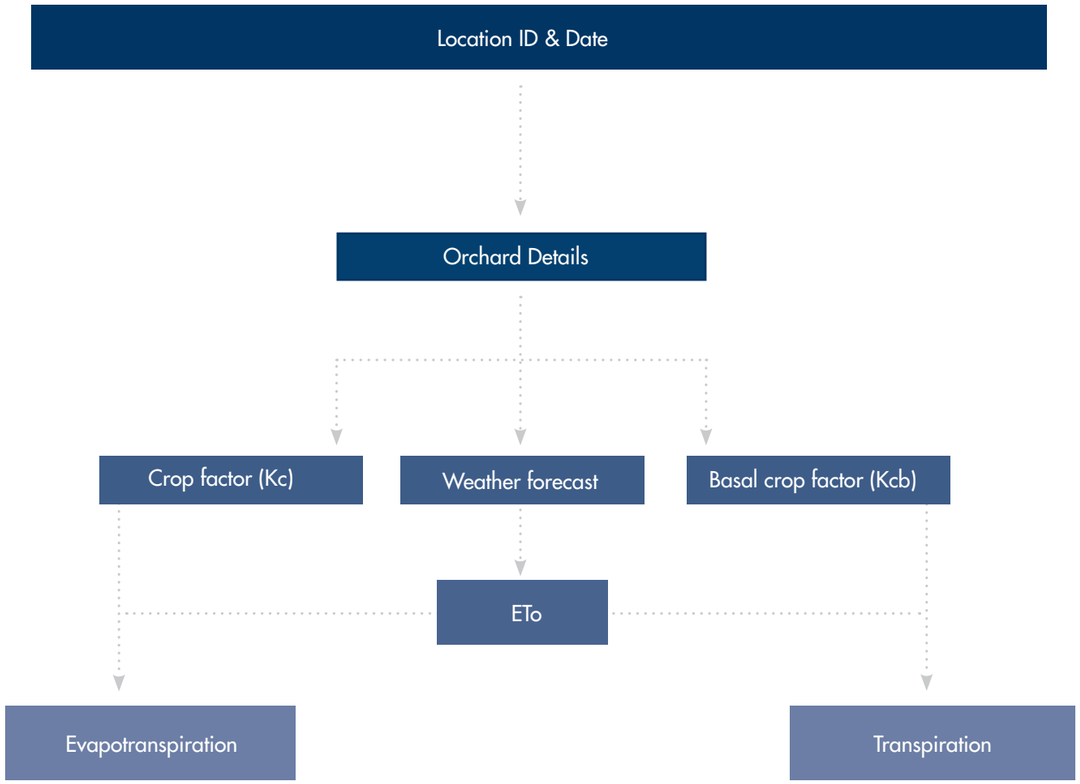
- Orchard coordinates

Orchard details

- Fractional vegetation cover
- Average tree height
- Soil type
- Irrigation system
- Cover crop status

Online weather forecasts

- DarkSky (www.darksky.net)



BACKGROUND: THE PROBLEM/CHALLENGE TO BE SOLVED

Farmers do not have scientifically proven tools that use accurate state-of-the-art platforms to forecast the water requirements of their crops. This information is critical for:

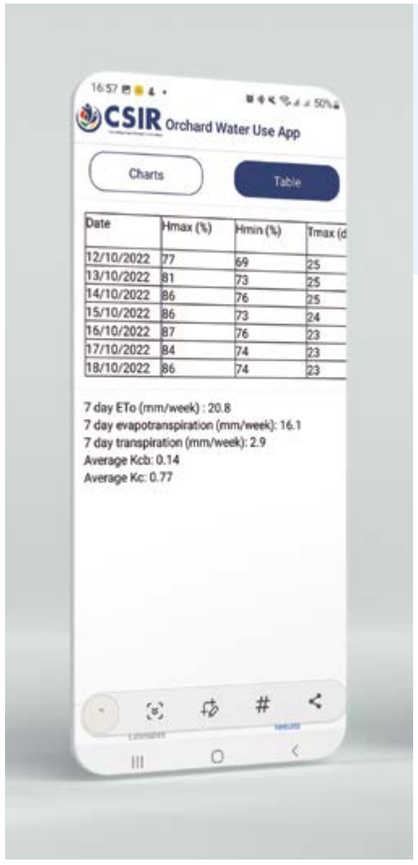
1. Irrigation scheduling (deciding when to irrigate and how much water to apply), and
2. Water allocation planning.

The CSIR-developed smartphone app forecasts the water requirements for apple orchards one to seven days in advance.

The intended users of this app include farm managers, commercial farm owners, irrigation boards and water allocation committees.

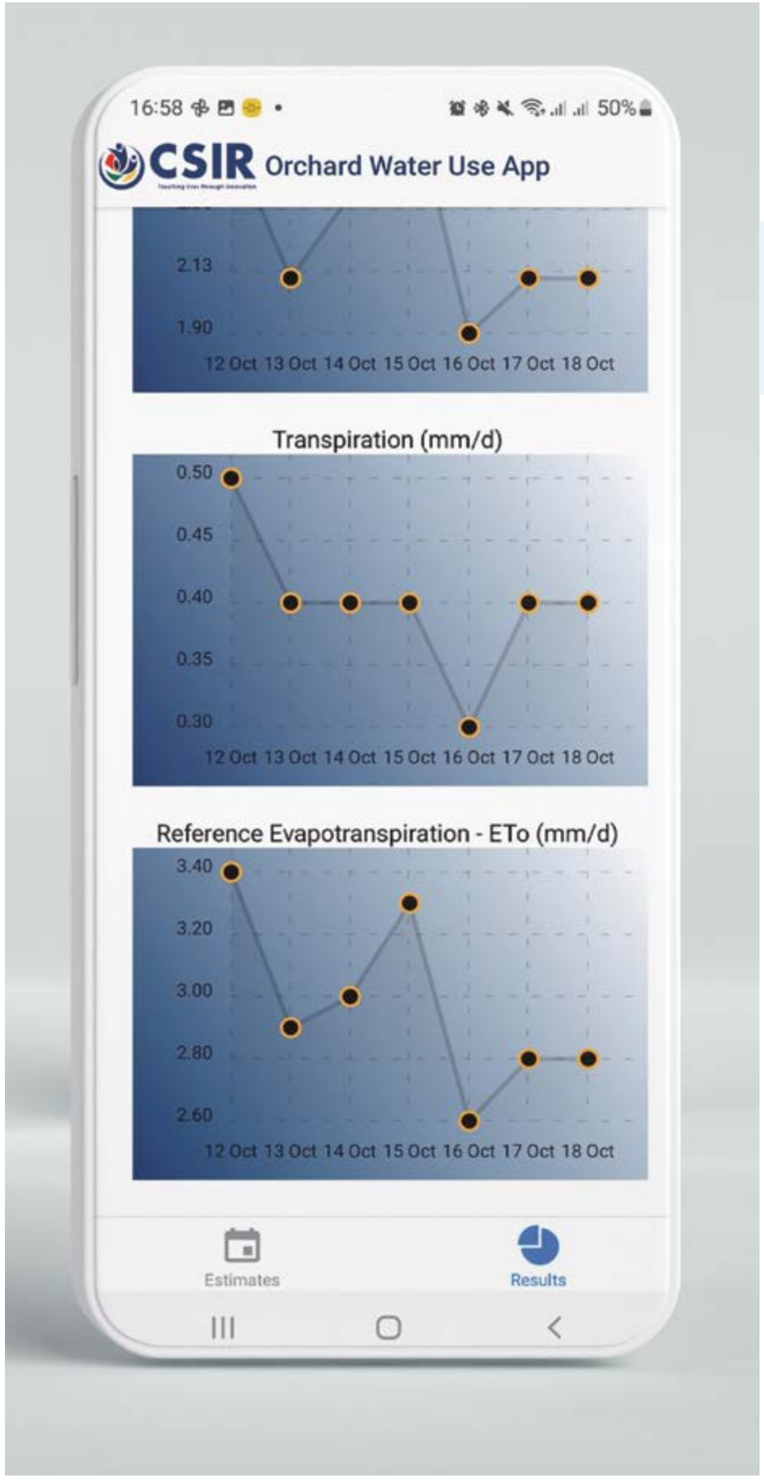
HOW THE SMART WATER USE APP TECHNOLOGY WORKS

Opening Window: Enter



Background calculations.

Then results in tabular format



Results in graphical format

Technology highlights, benefits and limitations

The application was successfully validated in 16 apple orchards and four farms were part of the beta testing of the application. Known benefits include improved irrigation scheduling and water savings.

Technologies currently in use only give farmers atmospheric evaporative demand based on climate data. But the farmer must guess or estimate the crop factor, which is a major source of uncertainty.

The CSIR app calculates both the reference evapotranspiration and the crop factors, thereby directly and accurately providing the crop water requirement forecast.

The app was designed exclusively for use in apple orchards, however, ongoing research is being conducted and more crops will be added.

SUMMARY OF SMART WATER USE APP

Problem

Farmers do not have scientifically proven tools that use accurate state-of-the-art platforms to forecast the water requirements of their crops. Such information is critical for irrigation scheduling and water allocation planning. The tools that farmers currently use only give atmospheric evaporative demand and the irrigation scheduler must guess the crop factor; this leads to major uncertainties and increases chances of over/under irrigation.

Value offering

The CSIR has, over the years, conducted research to quantify the water requirements of irrigated fruit trees. To add value to the huge database of measured water use data, these data were used to develop a smartphone app that can forecast the water requirements of apple orchards. The app uses the internationally acclaimed methods first to forecast the atmospheric evaporative demand. Then, calculates adjustment factors to the reference evapotranspiration, called crop factors, based on readily available information to predict water use, one to seven days in advance.

Competitive advantage

The technologies that the farmers use only give atmospheric evaporative demand based on climate data.
The farmer must guess the crop factor, which is a major source of uncertainty. The CSIR app calculates both the reference evapotranspiration and the crop factors, resulting in a direct and accurate crop water requirement forecast. In addition, the information is split into beneficial water use (transpiration) and non-beneficial water use (orchard floor water use), hence enabling the farmer to identify opportunities to reduce water wastage.

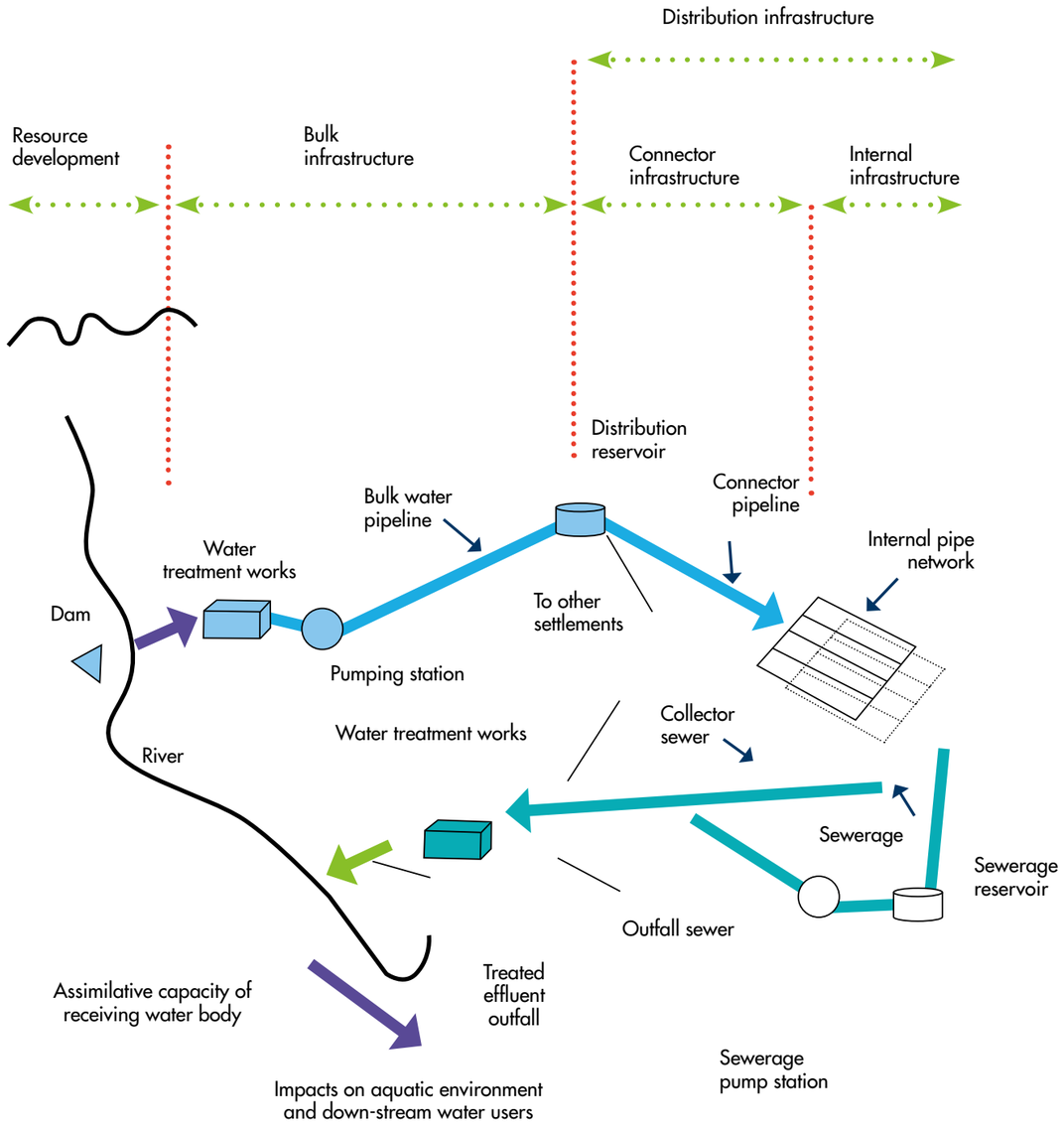
Local Government Skills Forecasting Model

Water And Wastewater Skills Supply/Demand Projection

Background: The problem/challenge to be solved

The Local Government Sector Education and Training Authority (LGSETA) has not been projecting future skills demand or supply in the sector as part of skills planning. The 2013 Sector Skills Plan Update presented an introduction to a proposed skills needs projection model. At the time, the purpose was to present the emerging thinking based on desktop research on skills demand and supply forecasting. It was proposed that the projection model be informed by quantitative analysis as well as qualitative analysis where labour experts, organised labour, academic institutions form part of a panel that would present additional information to inform the proposed projections. In addition, those involved decided that the projection should also be informed by other statistical data.

Model Assumptions



Importantly, the model is not aimed at providing precise numbers of the demand of skills for the sector, rather, it is intended to provide insights about the individuals, job seekers, municipalities, as well as the LGSETA with skills development-related priorities.

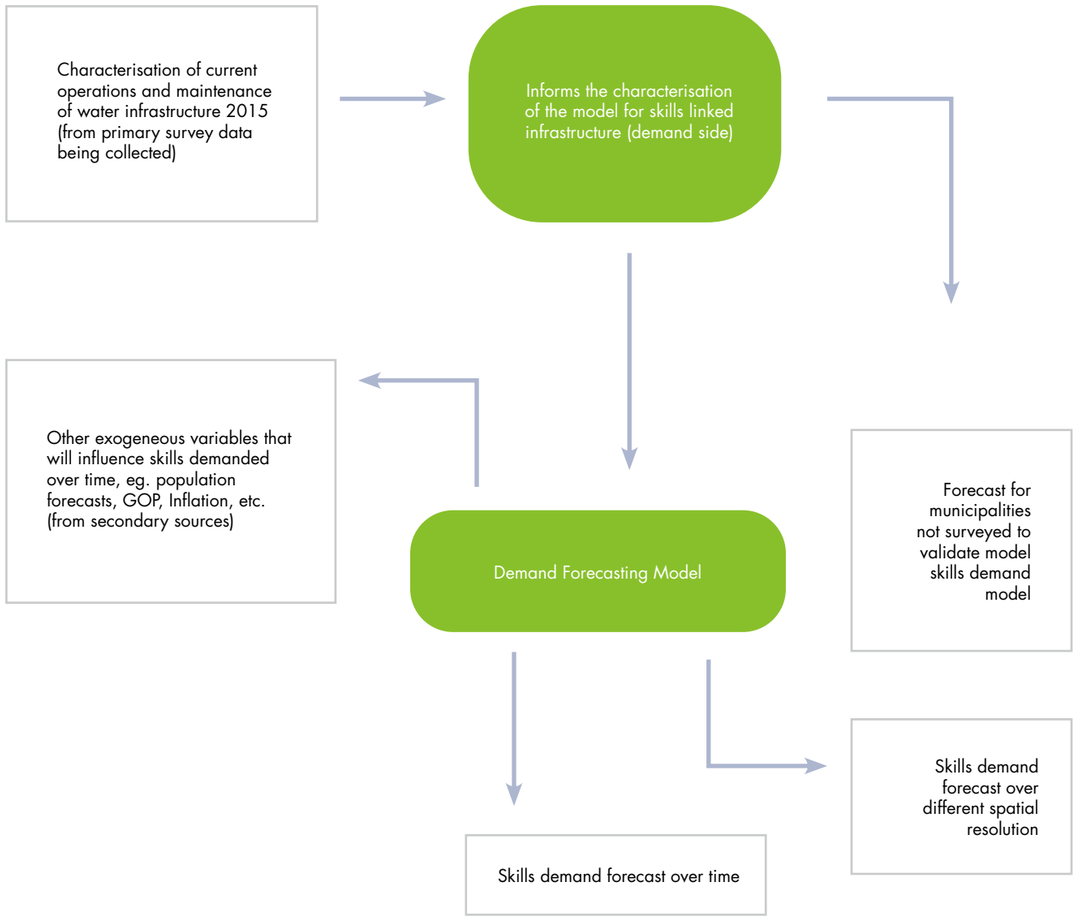
HOW THE LOCAL GOVERNMENT SKILLS FORECASTING MODEL WORKS

Forecasting Model) need to be considered:

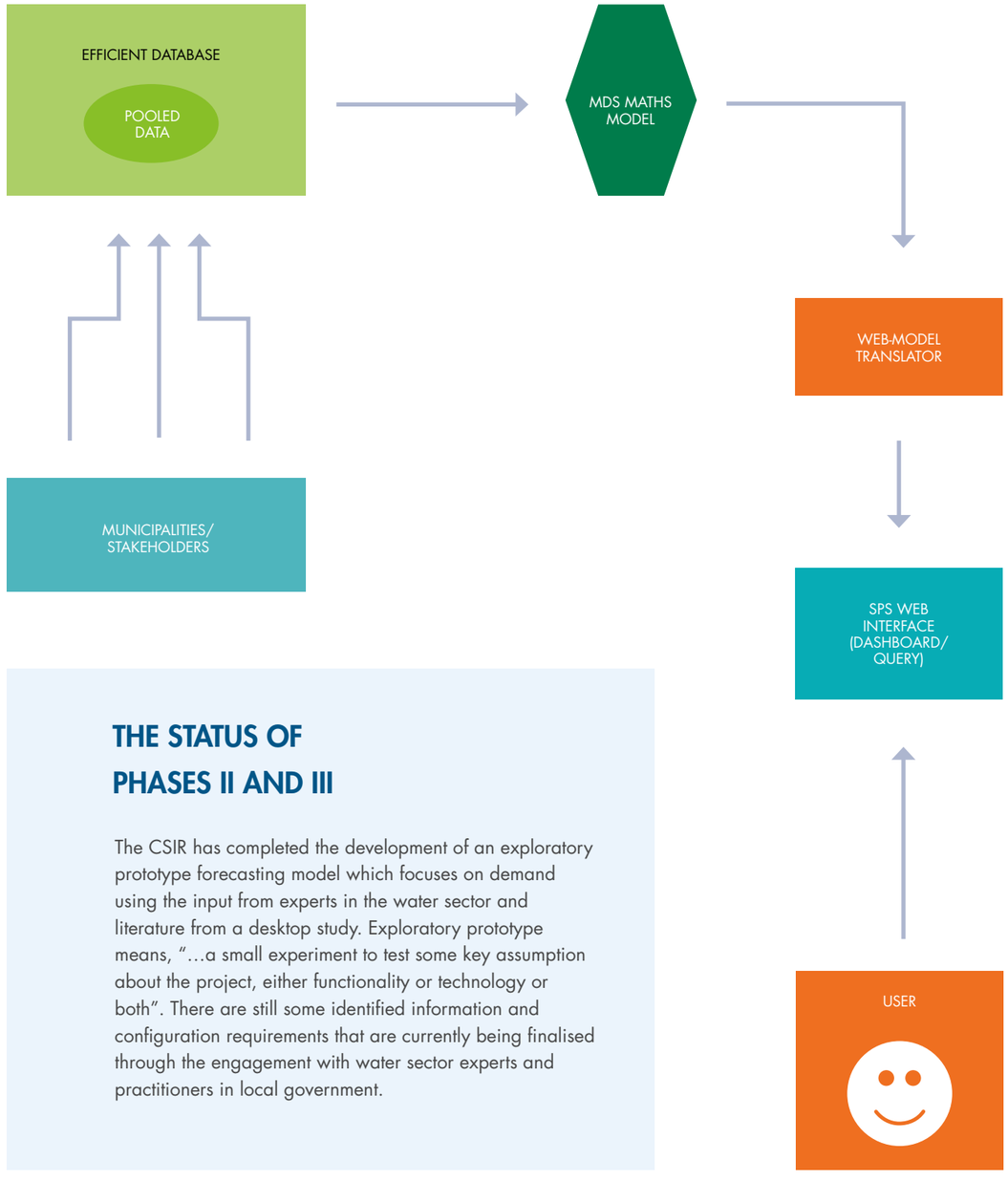
1. The Forecasting Model itself; and
2. The Operating Model which addresses the values proposition and value chain surrounding the model, together with cost and sustainment issues of the Forecasting Model. The Operating Model will exist in a context that has political, economic, social, technological, environmental, and legal dimensions which may change over time, and which will impact skills supply and demand.

Both the Forecasting Model and the Operating Model are inter-dependent and need to be developed simultaneously.

Skills Demand Forecast Model



SKILLS SUPPLY FORECAST MODEL: TO BE DEVELOPED



THE STATUS OF PHASES II AND III

The CSIR has completed the development of an exploratory prototype forecasting model which focuses on demand using the input from experts in the water sector and literature from a desktop study. Exploratory prototype means, "…a small experiment to test some key assumption about the project, either functionality or technology or both". There are still some identified information and configuration requirements that are currently being finalised through the engagement with water sector experts and practitioners in local government.

TECHNOLOGY HIGHLIGHTS, BENEFITS AND LIMITATIONS

- The model development was beset with challenges not fully anticipated during the study planning process.
- However, the pioneering nature of the study in a data-scarce environment required different, more pliable configuration approaches to maintain the level of confidence and value of the model outputs.
- The analytical approach, relying on expert knowledge and national guidelines rather than data, makes the model more robust for all South African municipalities where a lack of data, poor quality data or unreliable data can be a real concern.
- The implementation of a graphical user interface makes the model easier to use and more intuitive to the envisioned end user.
- There is interest in deploying the model in other water sector capacity-poor countries, and the intention to expand the model to include other sectors in local government (waste, electricity/power, transport/ roads).
- Further development of the model is required to ensure more focused attention is given to each individual module. This will include, but is not limited to:
- Addressing finer details on the different relationships that cannot necessarily be addressed when working with the module on a microscopic level; and
- Having more workshops and interactions with experts from each of the relevant departments and not just the planners for each municipality

SUMMARY OF LOCAL GOVERNMENT SKILLS FORECASTING MODEL

Problem/Issue

There has not been a projection of water sector skills demand and supply at local government level to proactively plan water services and performance. This has hampered effective and efficient water services delivery at this level of government.

Value Offering

The projection model provides a common basis to assess the skills requirements and numbers of personnel required to optimally perform the water services functions required at local government level. This also allows for consistent and effective financial and human resources planning across municipalities nationally. Budgets allocated from the fiscus can also be allocated equitably, based on a common system to assess the allocations.

Competitive advantage

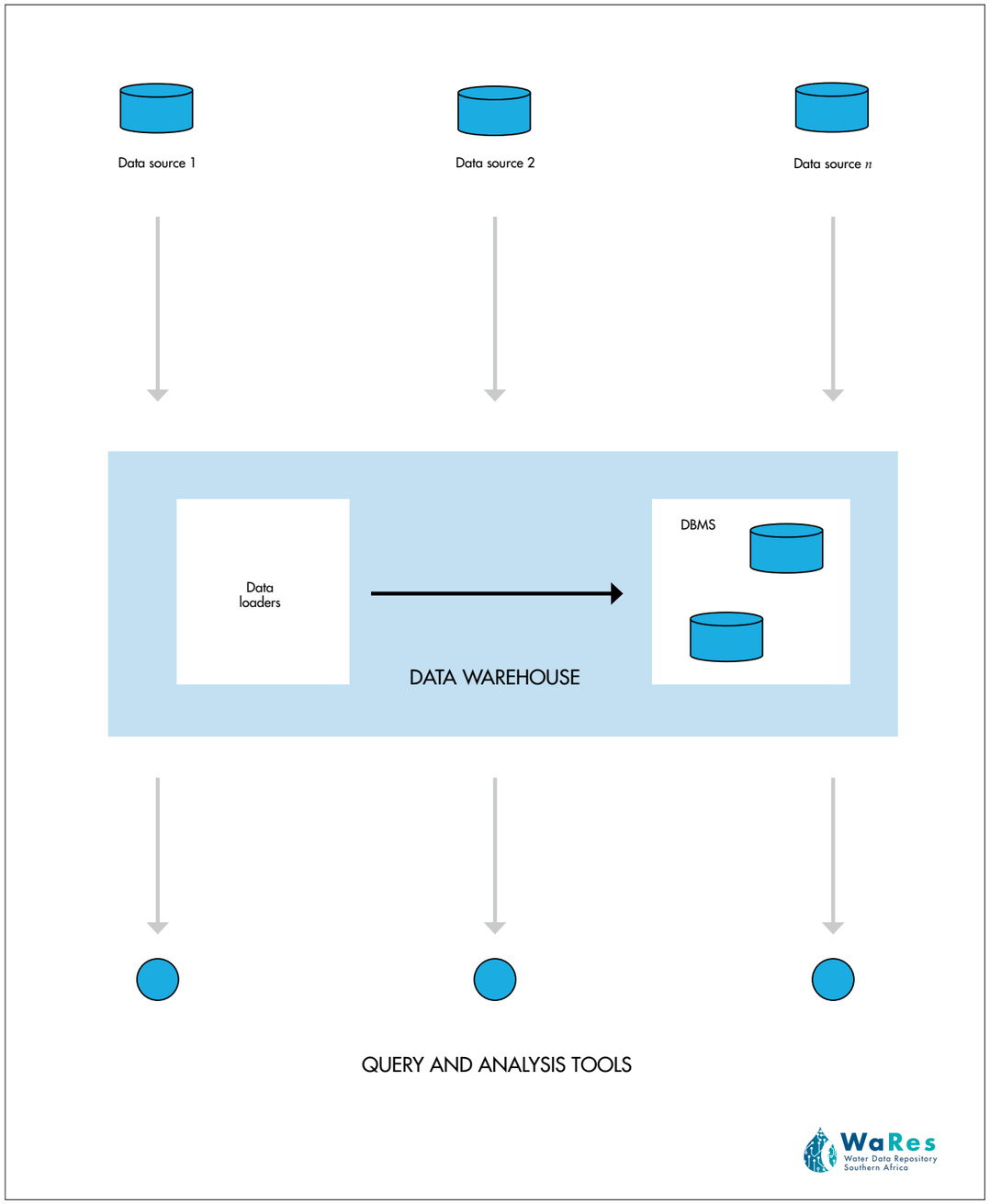
The model has been developed for national and local conditions where data are scarce or lacking. No such model currently exists locally or internationally

Target audience/ stakeholders

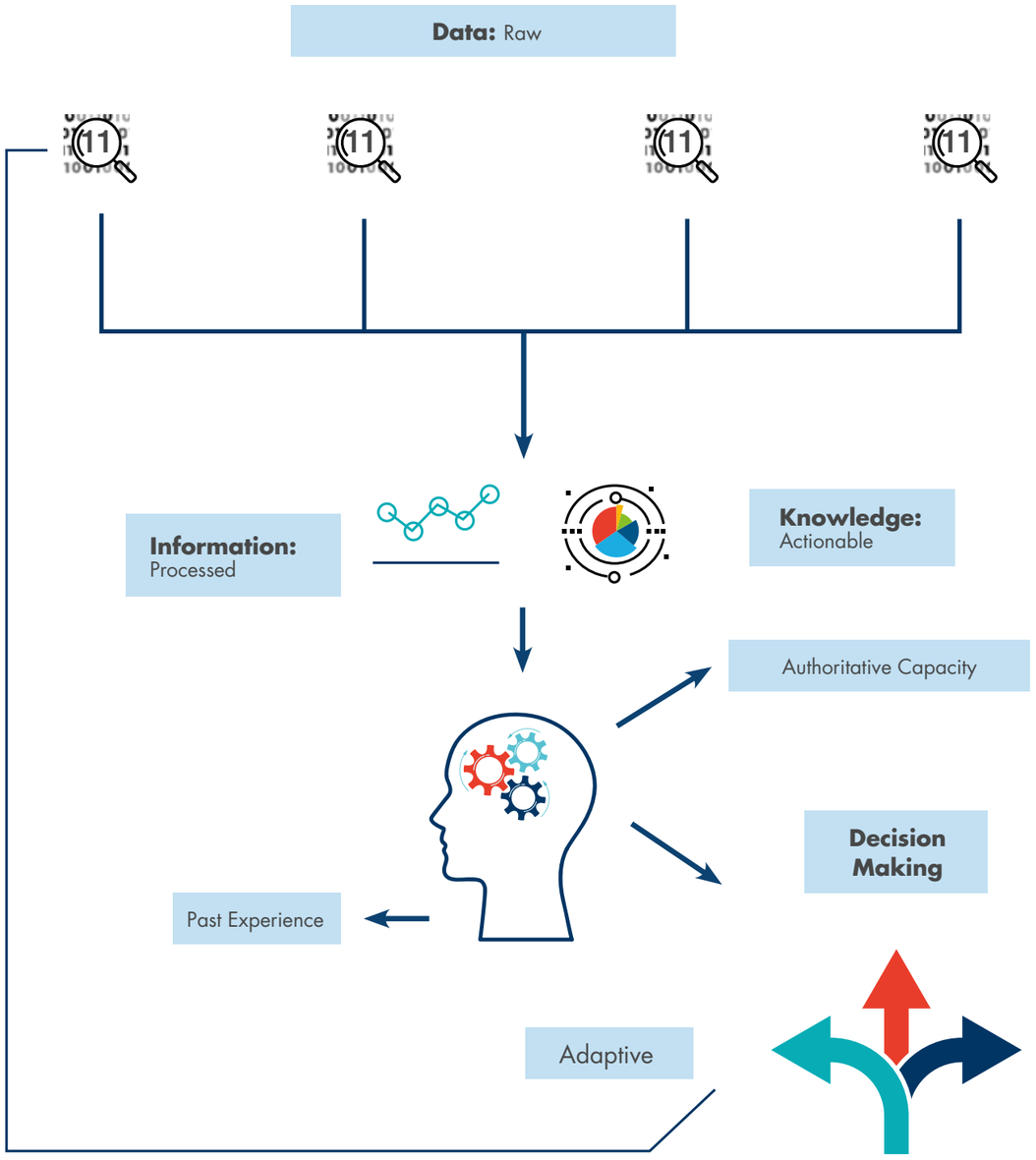
National and local government (municipalities)

THE WATER DATA REPOSITORY

Water data users experience difficulties in identifying and accessing the existing water and water-related datasets. Consequently, only a small share of the datasets produced are used effectively. The data are used for multiple purposes such as planning for sectorial water management, disaster risk reduction, etc. Therefore, there is a need of a wide range of decision-support systems.



The CSIR developed a centralised Water Centre Data Repository in support of the public and private sector to strengthen water security, economic growth and development.



SUMMARY OF WATER DATA REPOSITORY

Problem/Issue

Water data users experience difficulties in identifying and accessing the existing water and water-related datasets. Consequently, only a small share of the datasets produced are used effectively.

Competitive Advantage

The CSIR is a research council and its Water Centre is multidisciplinary. The CSIR is also home to the Centre for High Performance Computing. As such, water-related data are plentiful, verified and backed by experts in the field who are knowledgeable in interpreting the data.

Value Offering

A water curation system to make water data accurate, readily accessible, and fit for purpose, and tools and software to support decisions in water management and development.

SMART WATER ANALYTICS AND SOLUTIONS

SUPPORT SYSTEM FOR INDUSTRIAL BULK WASTEWATER RE-USE

The Decision Support System Tool

A Decision Support System (DSS) was developed to enable municipal and industry partners, and water quality managers to make informed decisions for possible reuse options. It aims to directly assist by linking industrial effluent volumes and quality to fitness for use with specific industries. The tool can determine the suitably of available bulk wastewater for reuse by nearby water consuming industries.

To optimise the local application for this tool, engagements with municipalities and industry stakeholders are crucial to establish:

- The volume of water consumed and waste effluent produced by industry; and
- The fitness for use optimisation based on this information can be used to identify industry partners for effluent re-purposing, with fitting quality parameters.

With inputs from stakeholders, this offering will provide an interface that will be web-based and ultimately digitised as a mobile app, providing bulk water users with a user-friendly, interactive dashboard that indicates the most suitable effluent for reuse within the closest geographical distance of any metro.

Background: Challenges to solve

- Wastewater reuse is a critical potential source of water which is largely untapped in South Africa. Only 14% of water is reused nationally (NWRS, NWSMP, 2018).
- The National Water Safety Management Programme (NWSMP) (2018) indicates that 60% of the country's wastewater is untreated and the continued failure to efficiently address wastewater treatment plants could have devastating consequences for South Africa's people, the environment and economy.
- The CSIR has invested into the development of a DSS that can be used to assist in identifying national water and wastewater reuse potential. Technology application via the DSS will improve water use efficiency and will feed into the circular economy by the repurposing of effluent generated from industry and metropolitan cities.
- Versions 1.0 (Excel), 2.0 Excel integration into digital, and 3.0 (digital/online) of the DSS have been developed from publicly available data gleaned from the Department of Water and Sanitation's Water use Authorisation and Registration Management System, international standards and from various industry scales to evaluate wastewater potential for re-purposing/reuse.

DSS Technology Value Chain

TECHNOLOGY HIGHLIGHTS, BENEFITS AND LIMITATIONS

- The CSIR research outputs and uptake of the DSS by public and private sectors partners have been very positive.
- The DSS system can be used to support government thought leadership that fosters more robust planning and policy formulation, specifically in terms of fit-for-purpose wastewater reuse.
- The CSIR's water reuse programme is extremely important in the South African water value chain and illustrates the key steps of knowledge acquisition and content management, through to the application of the wastewater reuse projects across the country.
- The overall research value further lies in addressing the current water conservation and water demand management challenges faced by industries, water service authorities and municipalities in sound decision-making in relation to bulk water reuse potential within metropolitan cities.
- Due to the DSS's user-friendly design, users of the tool will be able to identify the most suitable strategy for their decision/business case (which will concurrently improve future versions of the CSIR DSS). The application of the DSS tool using actual data obtained from, for example, eThekwini Municipality, is evidence that the DSS is directly applicable.
- The limitations of the current DSS are primarily centered on data availability and acquisition. These limitations validate the need to modify and refine the DSS demonstration prototype and transform it into a more practice-orientated tool. The inclusion of actual water use/effluent production data in the application testing will also aid in further understanding potential shortcomings and inconsistencies in the system.
- Future versions of the DSS will focus on obtaining additional data for each water user that will allow for a more detailed and reliable assessment of fit-for-purpose wastewater reuse options.

SUMMARY OF THE DSS TECHNOLOGY

Problem/Issue

South African estimates indicate that only 14% of wastewater is reused across the country. The South African National Water Resources and Sanitation Master Plan (NWRSMP, 2018) states that a 17% water deficit (or between 2,7–3,8 billion m^3 per annum) is projected and expected by 2030. Therefore, a Water Research, Development and Innovation Roadmap was developed to identify research, development and innovation gaps and opportunities to orientate the sector towards addressing these issues through investments in strategic research, skills development and action plans that shift new smart water solutions into practice. This wastewater reuse research solution supports unpacking the potential for wastewater reuse within metros across South Africa.

Competitive Advantage

This project supports the development of a circular economy in that it supports wastewater beneficiation. The unique aspect of the CSIR and in particular the Water Centre offering is our ability to coherently resolve the main technical feasibility challenges, i.e. integration of large, often diverse data, qualitative risk assessment, and the bioassay assessments. The CSIR is uniquely placed to provide this smart water solution in South Africa.

Value Offering

The application of a fit-for-purpose water and wastewater reuse DSS. This research offering will support the identification of ecological and economic opportunities for infrastructure development by supporting enhanced water security through bulk water reuse within industries. Reuse potential at municipalities and industries have been identified through the development phases of the DSS which has identified and scientifically mapped the volumes of effluent production at bulk industrial producers, nationally. A high-level evaluation of potential for beneficial reuse is the next phase of this research programme. The quality of effluent will be assessed through a qualitative water quality testing and analysis programme which will included, but not be limited to:

- Qualification and quantification of bulk wastewater (municipal and industrial); and
- Integration of technologies of pollutants – determining fitness for use business cases for wastewater reuse.

Target audience/stakeholders

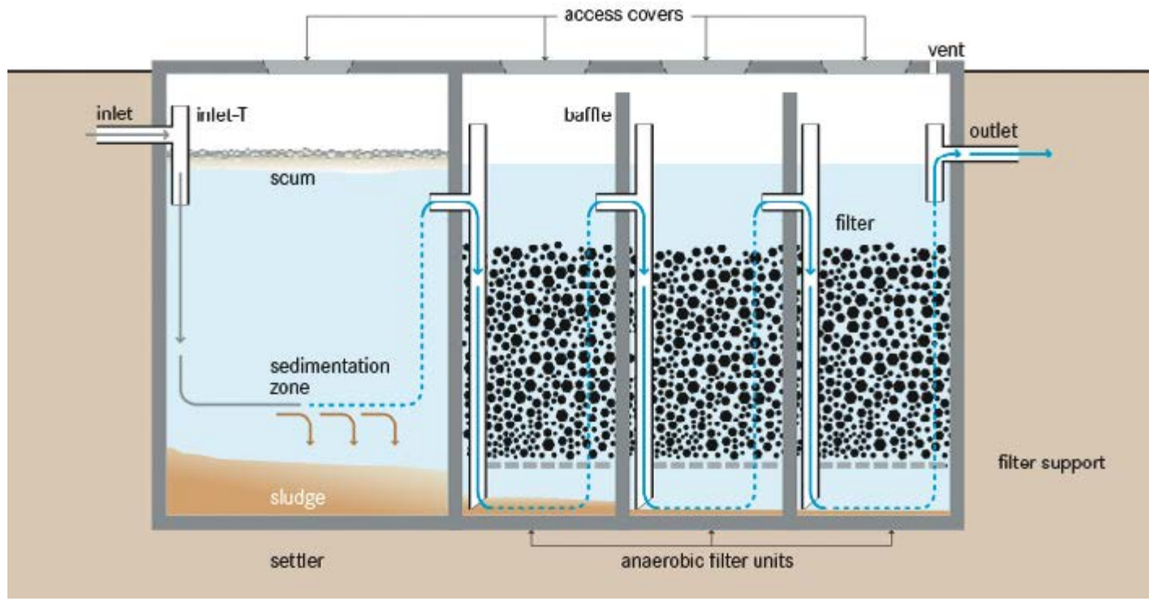
South African Local Government Association, municipalities, industry/ private sector

Decentralised Wastewater Treatment Systems

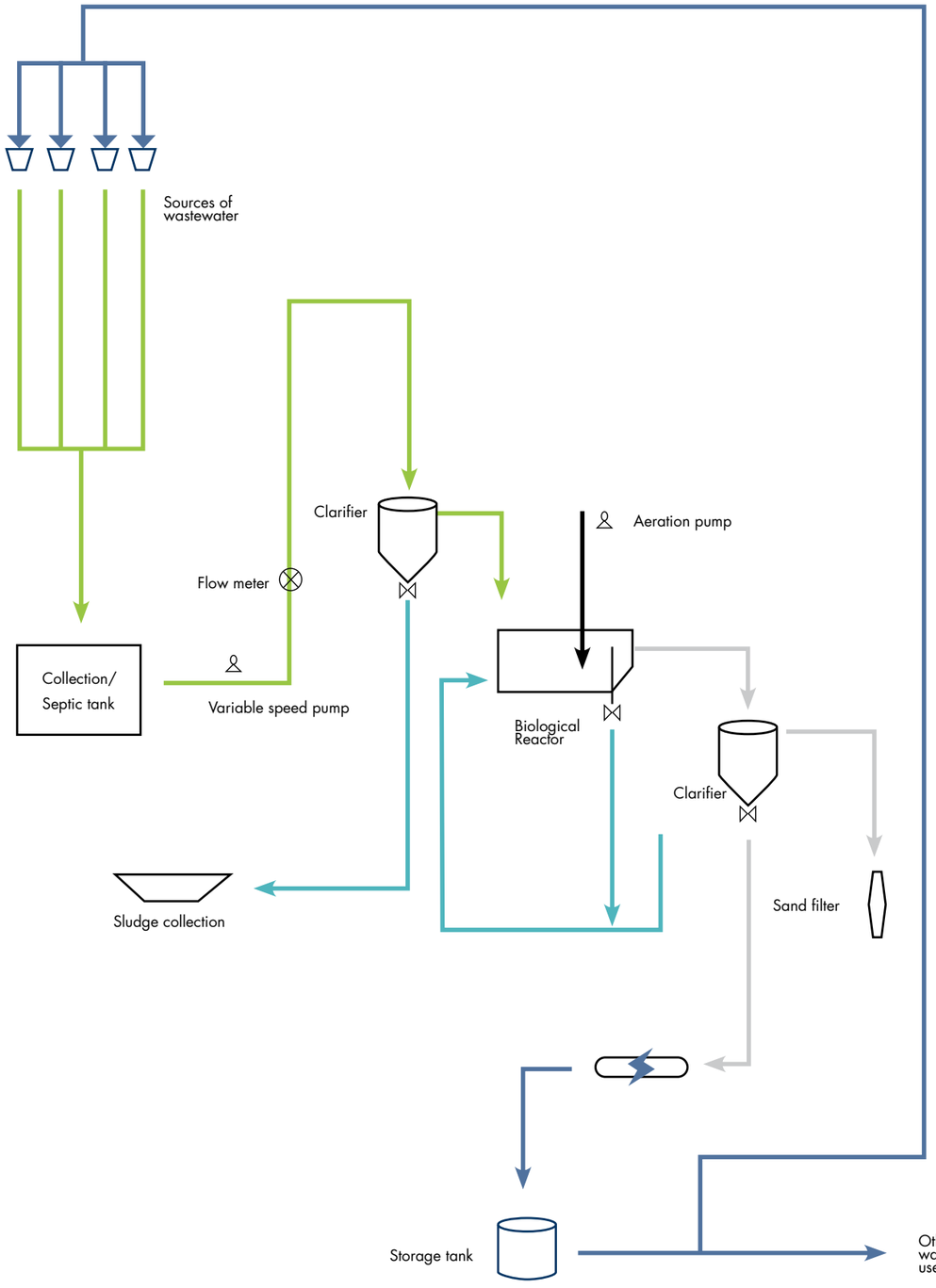
The Decentralised Wastewater Treatment Systems (DEWATS), coupled with chemical free sanitation technology is another of the CSIR's smart water analytic and solution technologies. The CSIR's innovative solution lies in the coupling of the low-cost DEWATS for nutrients and chemical oxygen demand reduction from the domestic wastewater, with the chemical free microbial and organic matter removal technology – an advanced oxidation process. This results in treated wastewater of quality that is fit for different purposes at the point of source, thus reducing water demand and enhancing the circular economy.

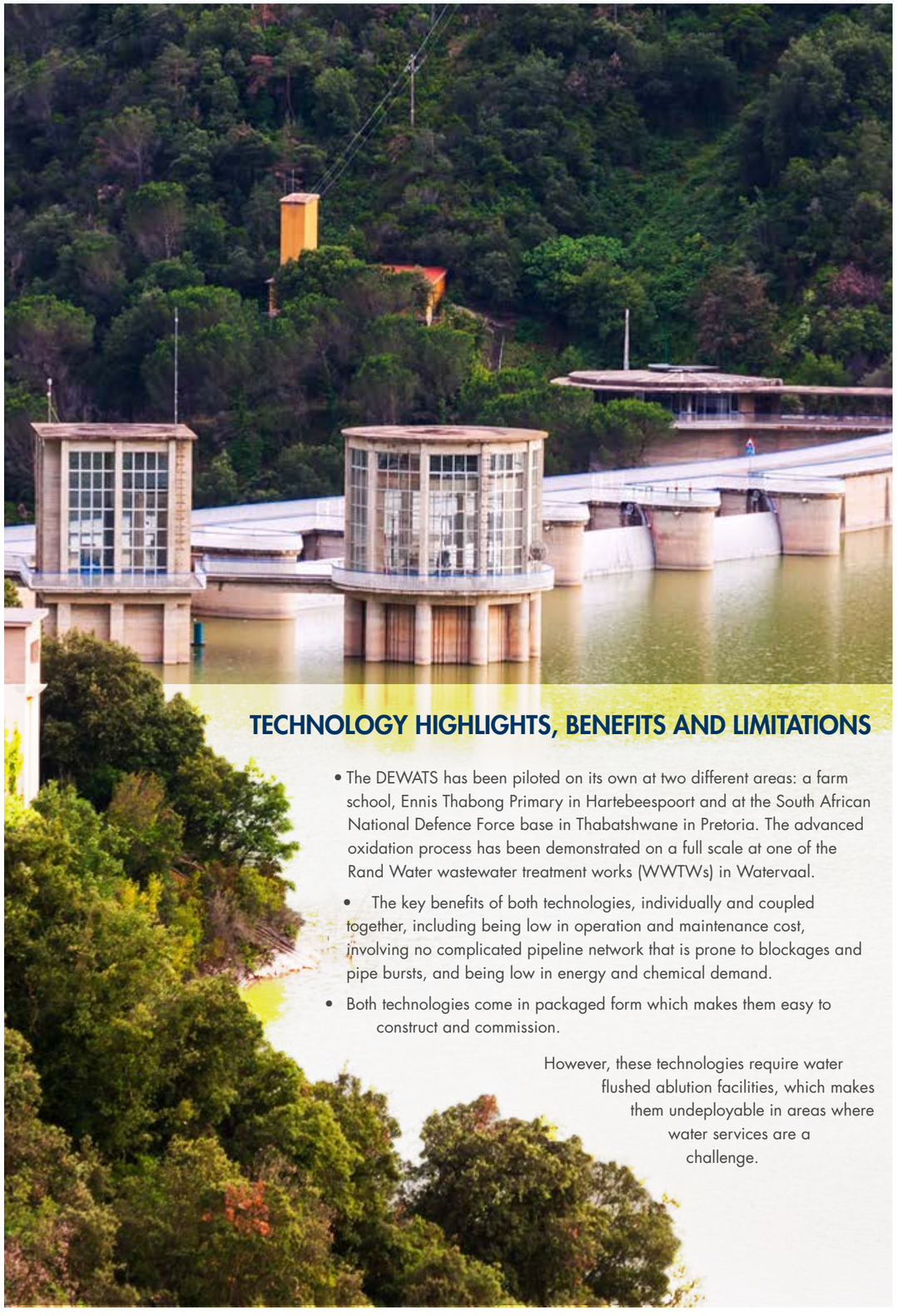
Background

Most of the conventional wastewater treatment processes in South Africa are in a dilapidated state due to high operation and maintenance cost. As a result, these systems no longer meet the required effluent discharge standards. Some municipalities are unable to provide effective wastewater treatment and management processes to small and peri-urban communities due to affordability challenges. The uncontrolled flow of untreated or poorly treated sewage into the environment is a threat to both surface and groundwater resources, as well as human health. If treated to good standard, this effluent can be reused for other purposes such as irrigation, thus contributing to water security and the circular economy. The current low-cost innovative solution has potential use for rural areas, schools, prisons, peri-urban/informal settlements, settlement clusters and industrial parks.



HOW DEWATS TECHNOLOGY WORKS





TECHNOLOGY HIGHLIGHTS, BENEFITS AND LIMITATIONS

- The DEWATS has been piloted on its own at two different areas: a farm school, Ennis Thabong Primary in Hartebeespoort and at the South African National Defence Force base in Thabatshwane in Pretoria. The advanced oxidation process has been demonstrated on a full scale at one of the Rand Water wastewater treatment works (WWTWs) in Watervaal.
- The key benefits of both technologies, individually and coupled together, including being low in operation and maintenance cost, involving no complicated pipeline network that is prone to blockages and pipe bursts, and being low in energy and chemical demand.
- Both technologies come in packaged form which makes them easy to construct and commission.

However, these technologies require water flushed ablution facilities, which makes them undeployable in areas where water services are a challenge.

SUMMARY: DECENTRALISED WASTEWATER TREATMENT SYSTEMS – COUPLED WITH CHEMICAL FREE WATER SANITATION

Problem/Issue

Most of the conventional wastewater treatment plants are currently overloaded with inflows, with some operating above design levels. This is mainly due to high operation and maintenance cost which is also exacerbated by population growth that is exerting pressure on infrastructure demand. This leads to effluents that are poorly treated or not treated at all being discharged into the environment. Discharge of effluents that do not meet the environmentally acceptable levels is detrimental to the water resources, stream, rivers, human health, etc.

Value Offering

Decentralised, modular packaged wastewater treatment systems that can be deployed in small community-based settlements, schools, prisons, industrial parks, rural areas and peri-urban settlements. The effluent can further be treated to a certain level of sanitation, using chemical-free methods, to allow further use for different purposes.

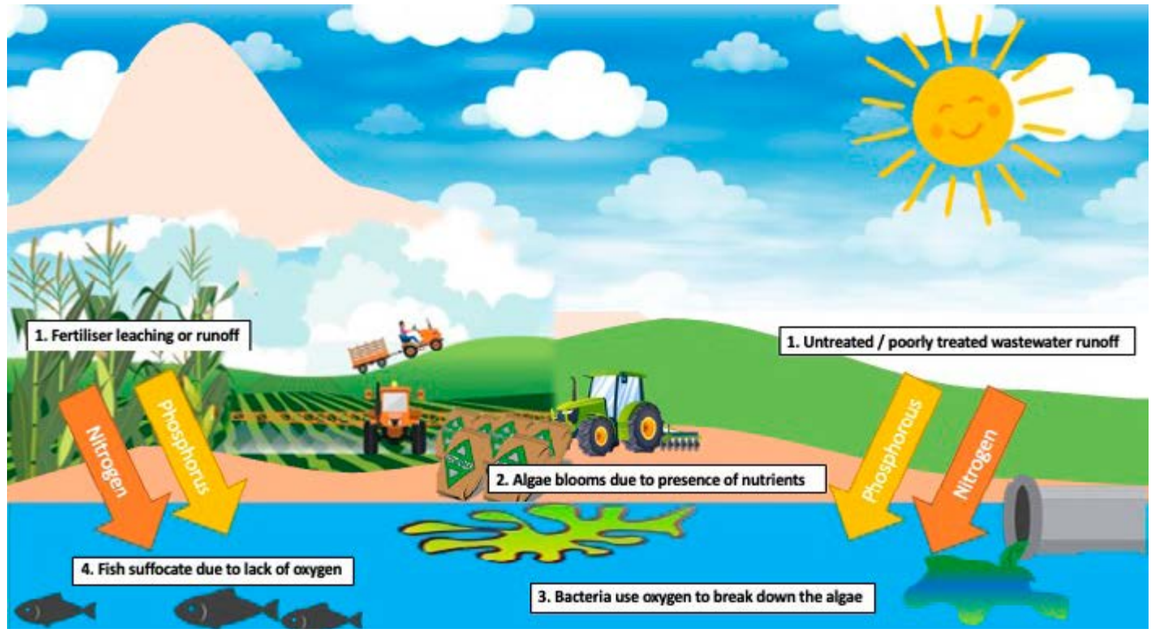
The Technology Offers

- Low energy and chemical use.
- Low capex due to the simplicity of the process plant design and
- Low opex due to low operation and maintenance cost.
- No complicated network pipeline required, thus less prone to
- leakages and pipe bursts.
- Quality of the effluent is more controlled compared to conventional
- WWTWs, thus can be used for different purposes at the point of source leading to reduced water demand and localised circular economy.

Phycoremediation for Ponds Systems

BACKGROUND: THE PROBLEM/CHALLENGE TO BE SOLVED

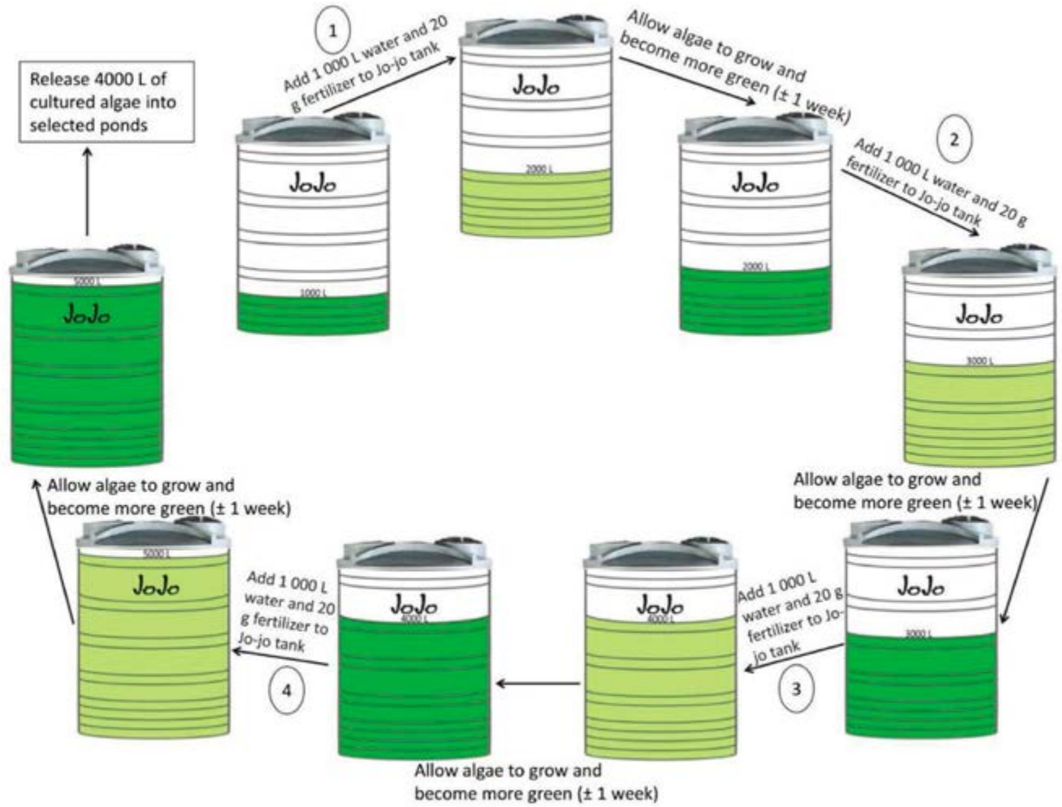
What is Eutrophication?

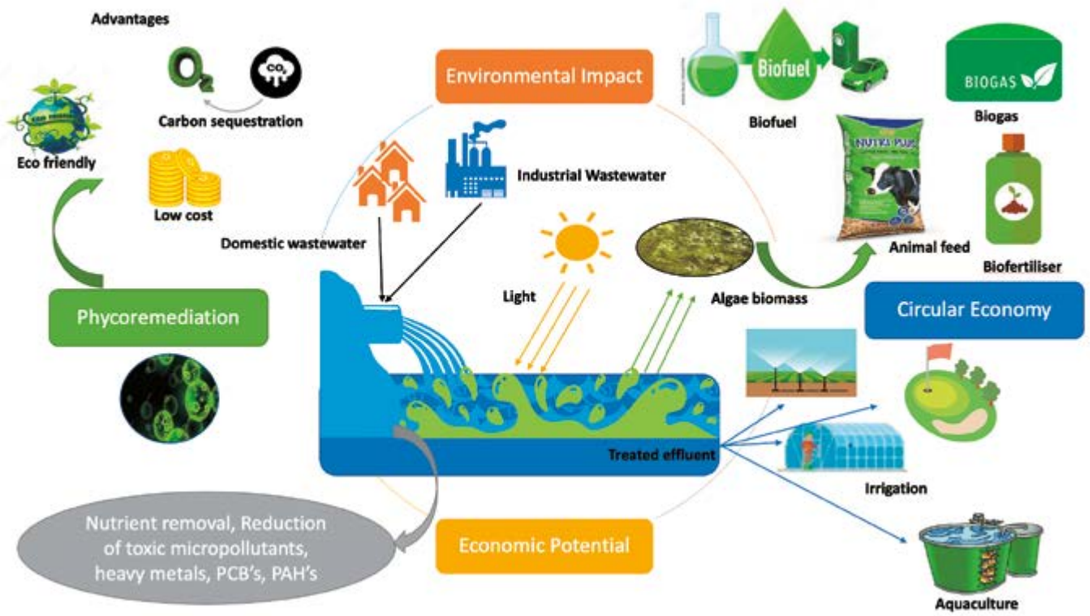


- The Green Drop report highlighted the increase in over-capacitated and poorly maintained wastewater treatment works. It recently reported that R8 billion were needed to upgrade or maintain WWTW.
- Population growth, urban migration, eutrophication and climate change are increasingly adding to the pressure on South Africa's water systems.
- An estimated 40% of domestic wastewater is released untreated to surface water, resulting in nutrient-rich rivers and streams, causing eutrophication.
- Eutrophication has additional impacts on downstream users of the water for agriculture (e.g. export of fruit).
- We need a cost-effective solution for South Africa. Phycoremediation could extend the lifetime of WWTWs.

HOW PHYCOREMEDIATION TECHNOLOGY WORKS

- Microalgae cultured in bioreactors (A)
- Released to ponds (B)
- Uptake of nutrients by algae (B)
- Algae removed (B)
- Improved effluent quality (B)
  - Water available for reuse(e.g. irrigation)
- Algae biomass beneficiation (e.g. fertiliser) (B)





VALUE PROPOSITION

- No electricity needed
- No harmful chemicals added
- No skilled labour required
- Use mainly existing infrastructure
- Apply specific algae consortium
- Reduce operational budget
- Support green economy
- Technology is a mature product offering

SUMMARY OF PHYCOREMEDIATION TECHNOLOGY

Problem/Issue

Wastewater treatment plant upgrade and maintenance backlogs due to over-capacitated treatment works – 40% of effluent from the 864 WWTWs in South Africa (NWSP) released to surface waters is untreated.

Value Offering

The phycoremediation technology decreases eutrophication in rivers receiving domestic wastewater by treating the wastewater with a consortium of algae, specifically cultivated to remove nutrients from the water column.

Competitive advantage

Complete natural treatment technology. Low-cost phycoremediation technology that does not require electricity or skilled workforce. Improve effluent and downstream water quality. Closes the nutrient loop via algae biomass beneficiation.

TECHNOLOGY HIGHLIGHTS, BENEFITS AND LIMITATIONS

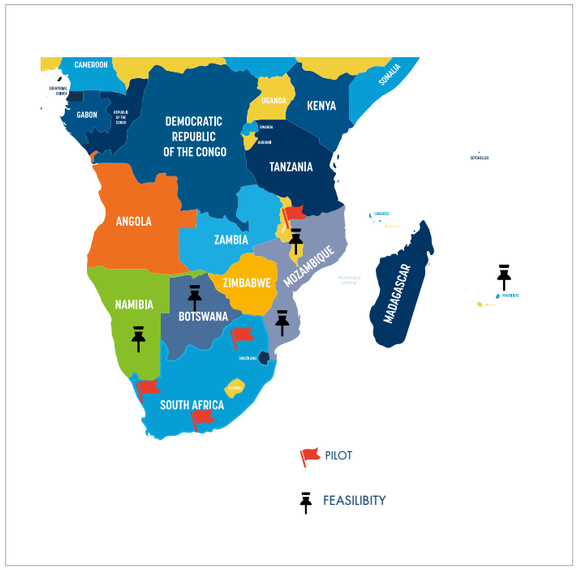
Technology implemented and operational at domestic WWTW:

- Motetema WWTW (Limpopo Province, RSA) – 2015/16
- Brandwacht WWTW (Western Cape, RSA) – 2017/18
- UNIMA WWTW (Zomba, Malawi) – 2021/22

New Project – Bitterfontein WWTW (Western Cape)

Highlights: Nutrient removal efficiencies:

- Nitrogen: 73.1%;
- Phosphates: 74.4%
- Limitations: Algae removal efficiencies, retention time
- Low cost, use mainly existing infrastructure, low maintenance.



Detecting niche waterborne pathogens: Ensuring compliance

South Africa is a water scarce country and this problem is compounded when pollution occurs, further reducing the availability of safe water. The pollutants can be biotic (living) or abiotic (non-living). Abiotic stressors, commonly referred to as "chemicals", can cause significant problems, however, it is widely acknowledged that the biotic pollutants, like pathogenic microbes, have a far greater impact on water safety. Microbes are known as pathogens if they can cause disease, as well as cause morbidity and mortality, far beyond the initial point of contact, due to their infectious nature. The presence of waterborne pathogens negatively impacts water security and is a public health threat. To ensure water safety, the national standard for drinking water quality (SANS 241), stipulates the acceptable limits and risks associated with specific waterborne pathogens.

BACKGROUND: THE PROBLEM OR CHALLENGE TO BE SOLVED

Accurate and reliable analytical methods are required for the detection and quantification of pathogenic microbes in water. However, microbes are diverse, complex and ever changing, resulting in many analytical challenges. The use of indicator organisms, like *E. coli*, helps to circumvent some of the challenges, but they do not provide a detailed representation of all infectious risks. There are scenarios that require specific and in-depth microbial analysis, and the CSIR's Water Centre Microbiology Laboratory is well-equipped to support the water sector with analytical services. The South African national drinking water standard (SANS 241) requires water utilities and drinking water suppliers to monitor for specific viral and protozoan pathogens, and the WC Microbiology Laboratory has extensive experience in the analysis of these determinants. The laboratory is also well positioned to develop new and innovative test methods for emerging pathogens.

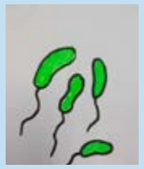
THE OFFERING

Detection of enteric viruses in raw and treated water

The analytical approach utilises ultra-filtration for concentration followed by an infectivity assay on a primate cell-line to detect a wide range of cytopathogenic viruses. Specific viral determinants, like norovirus and enterovirus, can then be identified using molecular detection techniques.

Detection and quantification of *Cryptosporidium* and *Giardia* parasites (protozoan parasites)

Large volumes of water are concentrated using positive pressure filtration followed by antibody-mediated purification and labelling, and finally enumeration using fluorescence microscopy. This approach is still regarded as the 'gold standard' in protozoan parasite detection.



Detection of niche bacterial pathogens like *Salmonella*, *Shigella* and *Vibrio cholerae*

Real-time polymerase chain reaction assays are used to detect the causative agents of serious diseases like typhoid fever and cholera.

HIGHLIGHTS, BENEFITS AND LIMITATIONS

- Offering tests for difficult-to-perform microbial determinants;
- Due to the CSIR's footprint, the service is available nation-wide;
- Protozoan parasite analysis is accredited by the South African National Accreditation System (SANAS), under facility number T0657;
- New methods can be rapidly developed for emerging waterborne pathogens due to the laboratory's proficiency in molecular detection techniques;
- A disadvantage is the cost associated with virus and protozoan parasite testing – the specialist consumables are expensive and influence the price of these tests; and
- Some tests, like the one for viruses, require extensive incubation times that lengthen the duration of the analysis.

SUMMARY: DETECTING NICHE WATERBORNE PATHOGENS

Pathogenic waterborne viruses, parasites and bacteria pose a significant health risk to water users. These microbes are often difficult to detect and quantify, and this requires specific expertise and equipment that are not readily available. The CSIR's Water Centre Microbiology Laboratory has developed the capability and methods to offer a range of niche microbial tests, which include testing for enteric (cytopathogenic) viruses, protozoan parasites and outbreak or epidemic-causing bacteria. The laboratory can also rapidly develop new methods for emerging microbial contaminants, utilising its expertise in molecular detection techniques.

Problem/Issue

Waterborne pathogens create public health problems. Some of these pathogens are difficult to detect and monitor.

Value Offering

The CSIR Water Centre Microbiology Laboratory has developed methods and facilities that detect niche waterborne pathogens. This is offered as a service to the water sector.

Competitive advantage

The CSIR Water Centre Microbiology Laboratory is the only laboratory in the country that can perform virus testing on water samples using primate cell lines.

The laboratory is SANAS accredited for protozoan parasite testing.

The laboratory is well-equipped to perform molecular detection of various pathogens and can develop new methods rapidly, as and when the need arises.

SMART WATER & WASTEWATER INFRASTRUCTURE TECHNOLOGIES

Struvite Recovery Technology (StruRe Technology)

BACKGROUND: THE PROBLEM/CHALLENGE TO BE SOLVED

Municipal wastewater treatment works are responsible for removal of pollutants (organic matter, nutrients, pathogens, etc.) from wastewater prior to safe discharge back into watercourses. Nutrients are removed by being assimilated into sludge in biological nutrient removal (BNR) reactors.

Nutrients are released back into the water during anaerobic digestion (AD) of this sludge. This nutrient slowly precipitates and deposits into pipeline, leading to reduction in pipe diameter and eventually blockages.

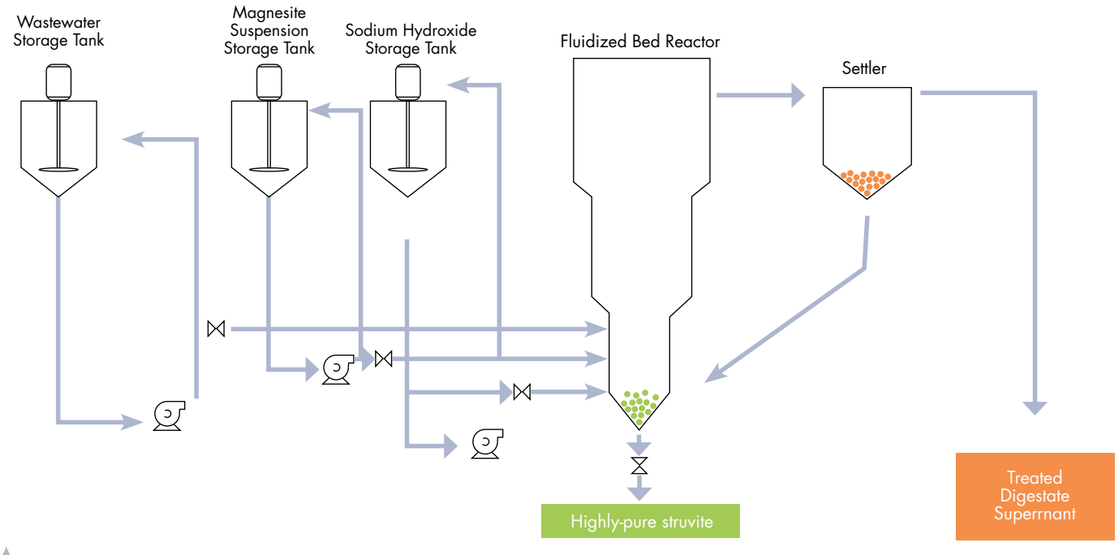
The CSIR has developed a Struvite Recovery Technology for harvesting of struvite from digestate supernatant.

The struvite can be used as agricultural fertilisers, and the technology reduces nutrients in the digestate, reducing the load on the BNR process.

Potential users include	WWTWs with BNR and AD.

HOW STRURE TECHNOLOGY WORKS

Digestate supernatant is mixed with cryptocrystalline magnesite suspension to precipitate struvite in a fluidised bed reactor (FBR). The precipitate collects at the bottom in the settling unit, and are then recycled back to the FBR for producing high-quality struvite.



TECHNOLOGY HIGHLIGHTS, BENEFITS AND LIMITATIONS

Areas/sites of successful deployment:

- 48% struvite purity has been achieved with the technology, where 70% and 90% removal efficiency has been achieved for nitrogen and phosphorus, respectively.
- The CSIR is in the process to deploy the pilot plant to one of the City of Tshwane's or Joburg Water's WWTW.

Novel attributes of this technology:

- The technology uses cryptocrystalline magnesite which is cheaper than conventional magnesium sources (magnesium chloride, magnesium oxide).
- The technology has low operational costs due to a low sodium hydroxide requirement compared to conventional processes.

Some disadvantages/Limitations

- The technology has not been tested under continuous mode of operation.

SUMMARY OF STRUVITE RECOVERY TECHNOLOGY

Problem/Issue

Struvite crystals slowly deposit in pipelines conveying digestate supernatant. This leads to a reduction in pipeline diameters, and if left untreated, the pipe can be blocked. The supernatant stream is concentrated with nutrients and when returned to the head of the works, it increases the load on the BNR process.

Competitive advantage

The technology used cryptocrystalline magnesite which is cheaper than conventional magnesium sources. The magnesite is also basic, lowering sodium hydroxide requirement.

Target audience/stakeholders

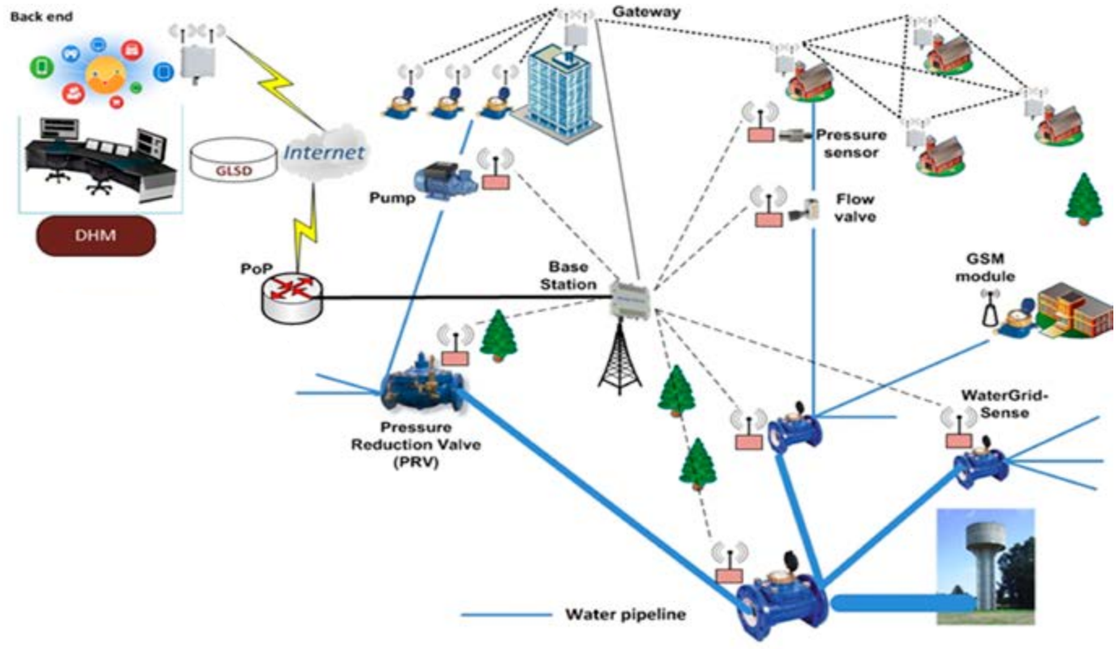
Municipalities and waterboards

Value offering

Struvite recovery technology allows for the removal of nutrients and harvesting high-purity struvite for use as an agricultural fertiliser. Struvite is a slow-release fertiliser, reducing the rate of application, and this will result in financial savings for farmers.

Dynamic Hydraulic Model

The water sector leverages the ICT technology infrastructure and advances in high performance computing (HPC) to create a data-rich platform for the management of water supply and distribution.



Backhaul Network

Long Range TVWS (30Km)

Medium Range M2M (5Km)

Short Range Technologies (802.11,802.15.4)

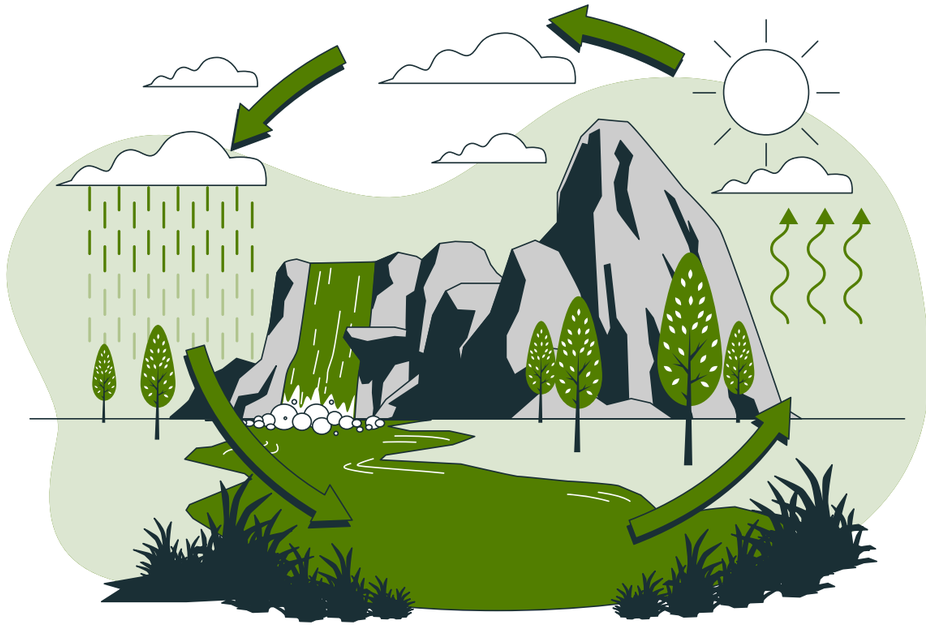
BACKGROUND: THE PROBLEM/CHALLENGE TO BE SOLVED

Water services in South Africa are constrained with an estimated 17% gap in demand and supply projected by 2030 according to the National Water and Sanitation Master Plan (Vol. 2). This is further complicated by; (1) old, dilapidated infrastructure, (2) maintenance backlog, and (3) budget shortfall for new infrastructure.

Water service institutions are losing considerable amounts of potable water annually, about 41% or 1 660 ML/year, as part of Non-Revenue Water (NRW). Priority has been to reduce NRW such as water losses through leaks and unauthorised use of water. The lack of continuous metering, network monitoring and pressure management is one of the main challenges for the water sector in managing losses. Rudimentary methods practiced by water service authorities include reticulation pressure reduction. This, however, works against the fluctuating demand, potentially depriving distant communities of supplies. While addressing NRW, it is also necessary to effectively manage and maintain the reticulation infrastructure by managing supply pressure according to demand. At least, old pipelines will not be subject to unnecessarily high pressure which may increase bust ratio.

The CSIR Water Centre developed the Smart Water Network Management (SWNM) solution to address these issues. The core is the Dynamic Hydraulic Model (DHM) which manages the decision-making according to the demand factor.

Potential users include	Water service providers and water boards.



How DHM technology works

Step 0: Evaluate the project area to determine water network status and telecoms connectivity.

Step 1: A hydraulic model is the foundation of the water distribution network being managed. This is currently modelled in EpaNet baseaAn EpaNet output file is used as input in DHM.

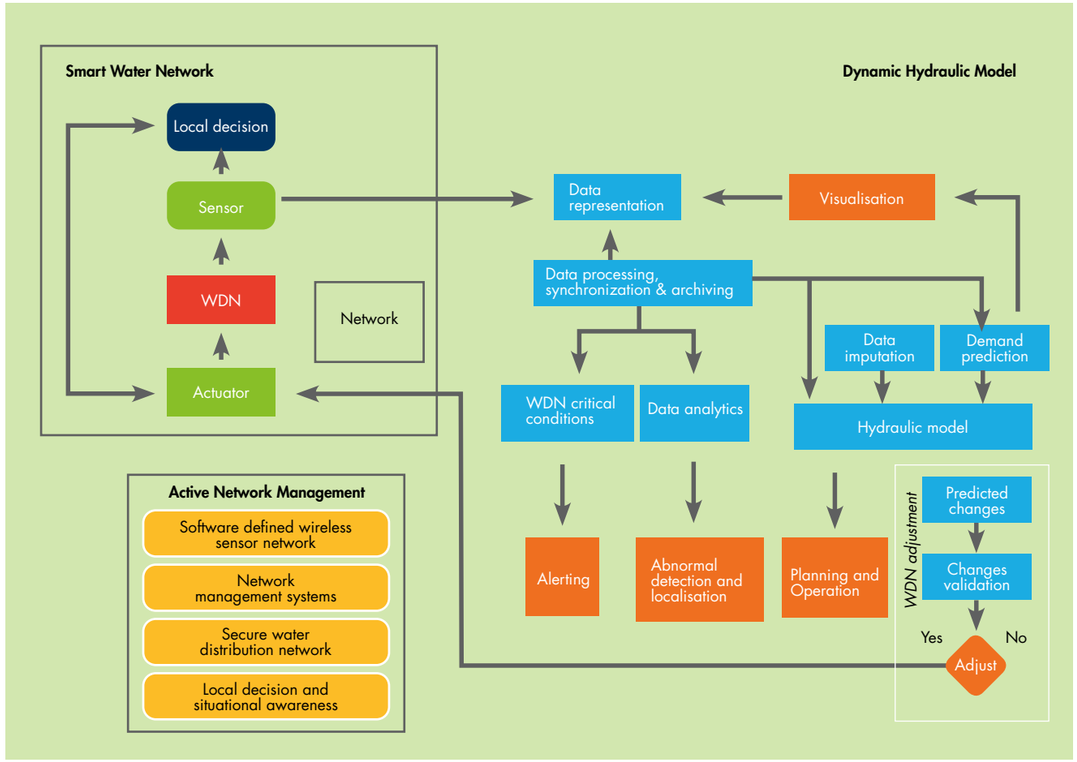
Step 2: Rehabilitate and/or install new water sensors, and commissioning at strategic locations of the water distribution network.

Step 3: Rehabilitate and/or install new water actuators, and commissioning at strategic location(s) of the water distribution network.

Step 4: Install communications network, either linked to or independent from the CSIR mainframe.

Step 5: Deploy the DHM module.

Step 6: Commission and test the smart water network.



- Network status is continuously detected using sensors that relay data to the DHM module via the database. At the database, data authenticity is verified and transferred to the dashboard (visualisation). Information is passed to the DHM to check any anomalies.
- Anomalies are corrected by completing data amputations and relaying message to the actuator for correction.

TECHNOLOGY HIGHLIGHTS, BENEFITS AND LIMITATIONS

DEPLOYMENT

- Partnership with Magalies Water, Valkop
- Deployment and piloting planned for 2022/23

BENEFITS

- Continuous water network metering, monitoring, and pressure management
- Reduction in non-revenue water
- Traceable water metering records (for DWS IWA compliance)
- Reduced manpower for fieldwork

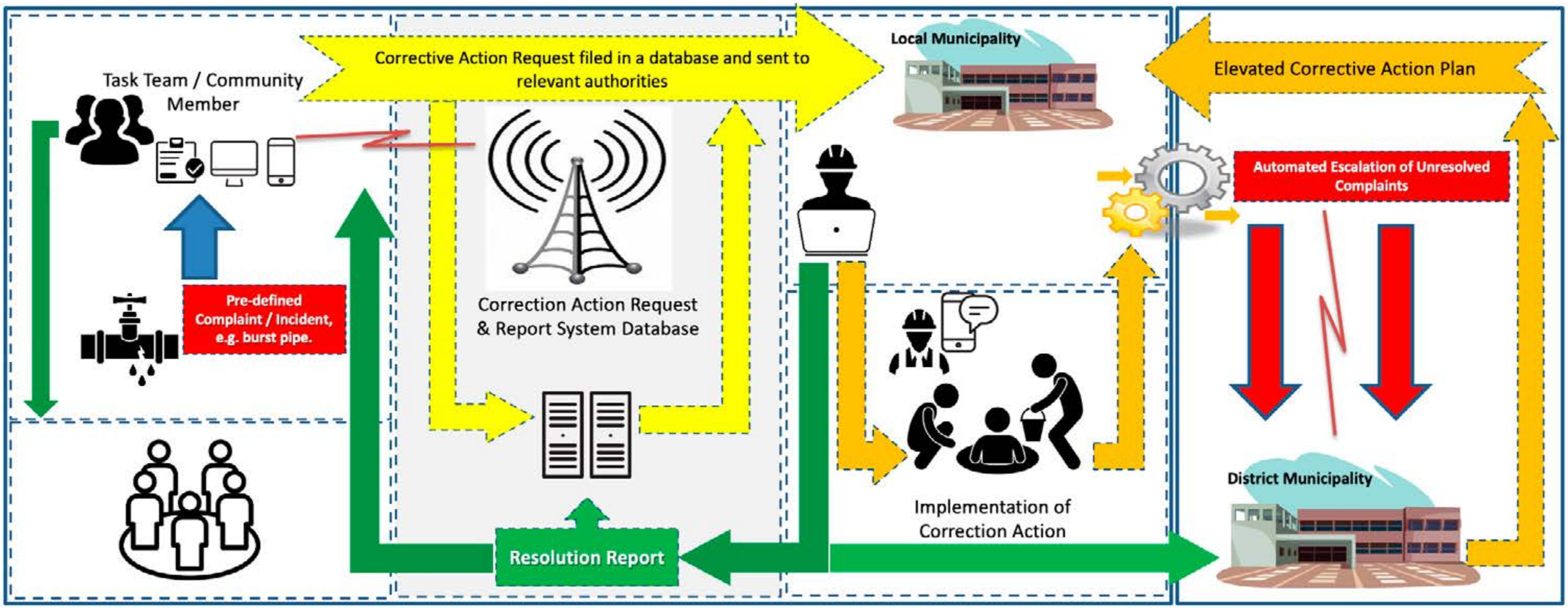
ABOUT SWNM

- Technology leverages the advances in ICT technology infrastructure and high-performance computing to create a data-rich platform for the management of water supply and distribution
- The input file of the distribution, thus hydraulic design, is developed in EpaNat

TECHNOLOGY LIMITATIONS

- Potential high capex input (for network sensors and actuators)

Corrective Action Request and Report System



STAGE 1

COMPLAINT/ INCIDENT

Community / Official identifies an event – either directly via CARRS Mobile-App or through established web-portal centres (i.e. assigned Task Team) – logs an incident on the CARRS platform. Task Team works with other stakeholders/ forums to establish facts, and then files and logs the complaint on the CARRS system. Direct contact feedback is available from assigned Task Team, otherwise via push notifications on the App.

STAGE 2

CARRS DATABASE & FILING

Filed complaints are stored on the CARRS database. CARRS system sends out an electronic message (e-mail or App notifications) to the relevant official at the local municipal office for actioning. Once corrective action has successfully been implemented, official closes the incident on the system.

An automated message is generated for feedback to author of the incident.

STAGE 3

MUNICIPAL INTERVENTION

Municipal official responsible for corrective action draws an implementation plan to resolve the incident and files it on the CARRS system. Normal internal municipal processes are followed to implement corrective action.

Municipal official files a corrective action report at completion. This can be achieved whilst at site or back at municipal offices.

STAGE 4

ESCALATED INTERVENTION

CARRS generates an automated message and escalates unresolved complaints from local municipality to district municipality. District municipality drafts an elevated corrective action plan and employs required resources to implement the corrective action at local municipality

The Corrective Action Request and Report System (CARRS) approach focuses on community-based water services-related incidents reporting, by placing the citizen as a part of the water service provider leveraging on smart phone penetration and modernisation of municipal infrastructure.

BACKGROUND: THE PROBLEM/CHALLENGE TO BE SOLVED

Local government/municipalities face:

- Frequent breakdowns as a result of ageing infrastructure;
- Non-revenue water of 41%;
- Lack of effective and robust incident management systems;
- Poor engagement of municipalities with communities;
- The uneven performance of the public service (non-standardised system of performance within the municipalities); and
- A weak culture of service delivery.

These often result in:

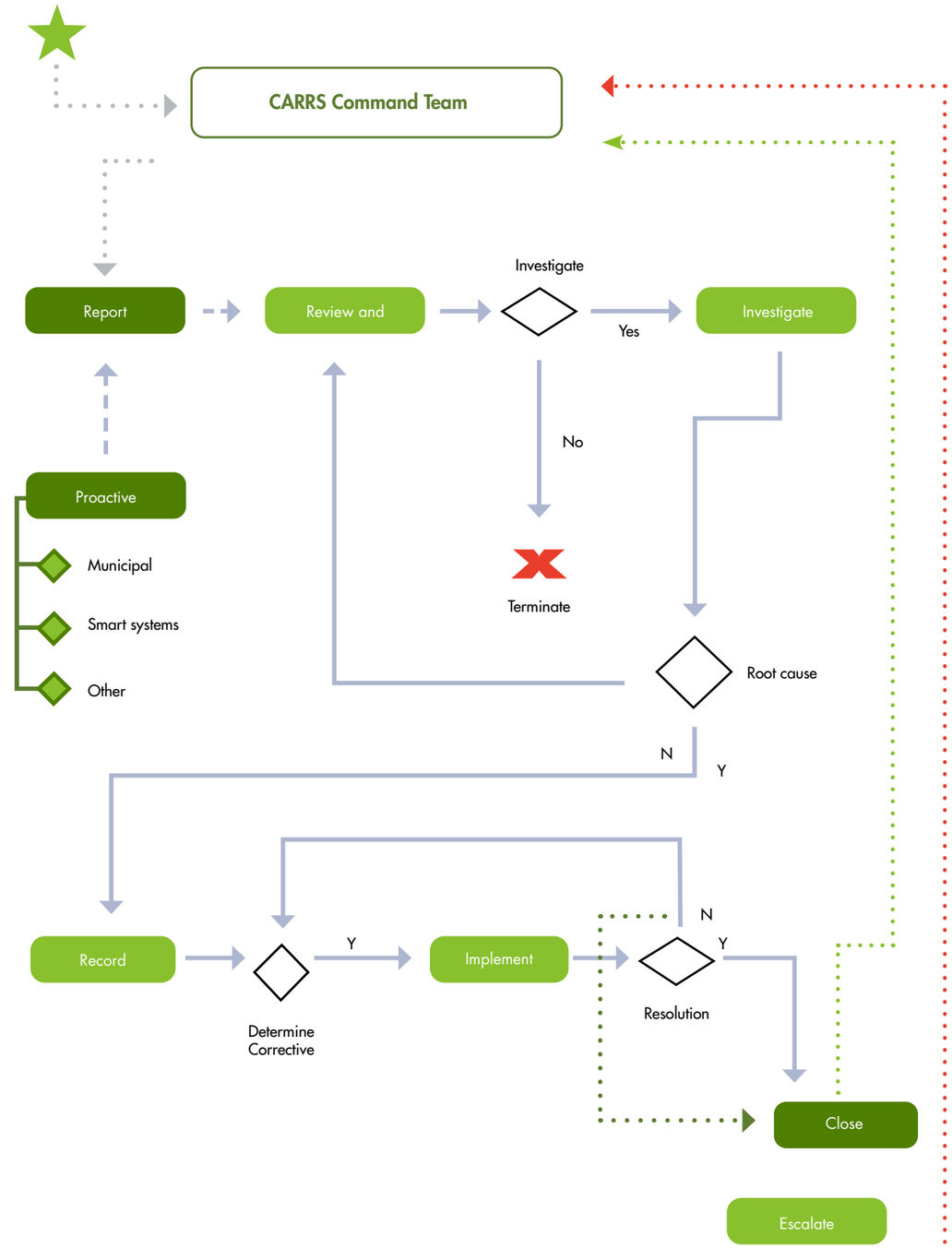
- Inadequate service delivery;
- Poor enforcement of corrective action; and
- An increase in the number of service protests, including violent protests.

Potential users include	Water service authorities

CARRS Rationale:

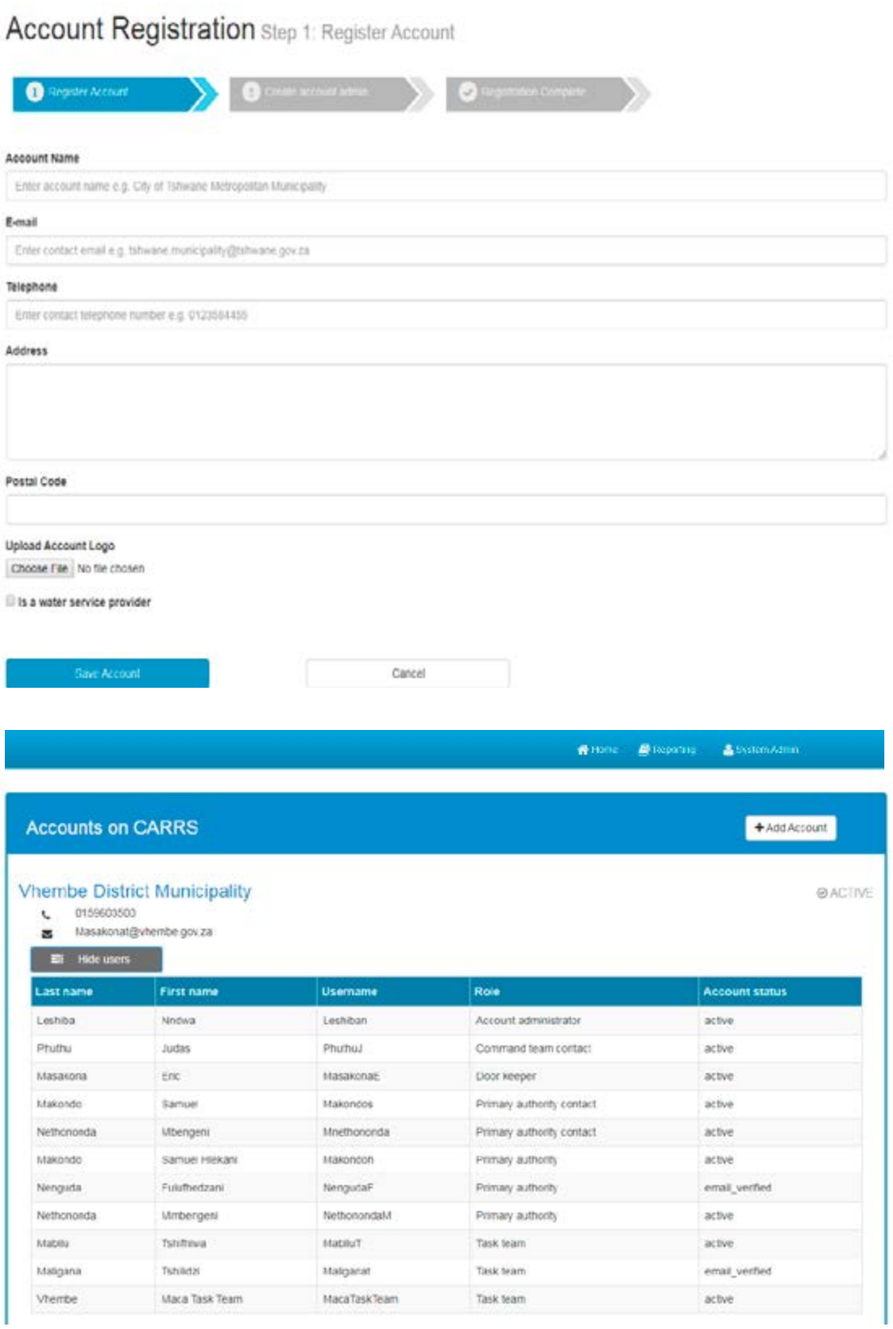
- Possible lower operating cost from **centralised system**
- Reduces municipal **infrastructure and non-revenue water bill**
- Reduced **water losses**
- Indirectly contribute to a **remote assessment** of infrastructure
- Supports in enabling a **sustainable environment**
- Enhanced **customer satisfaction**

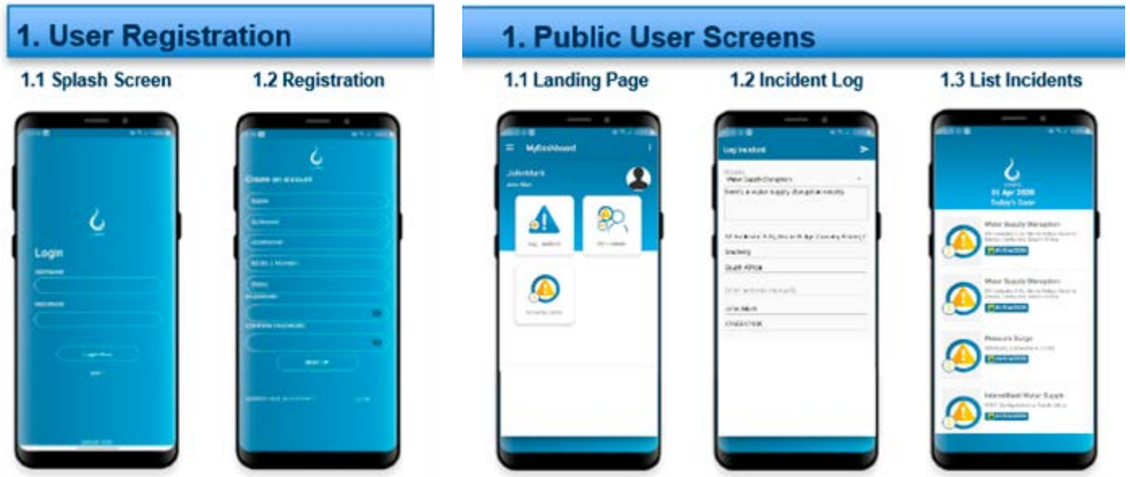
HOW CARRS TECHNOLOGY WORKS:
CARRS INCIDENT MANAGEMENT PROCESS

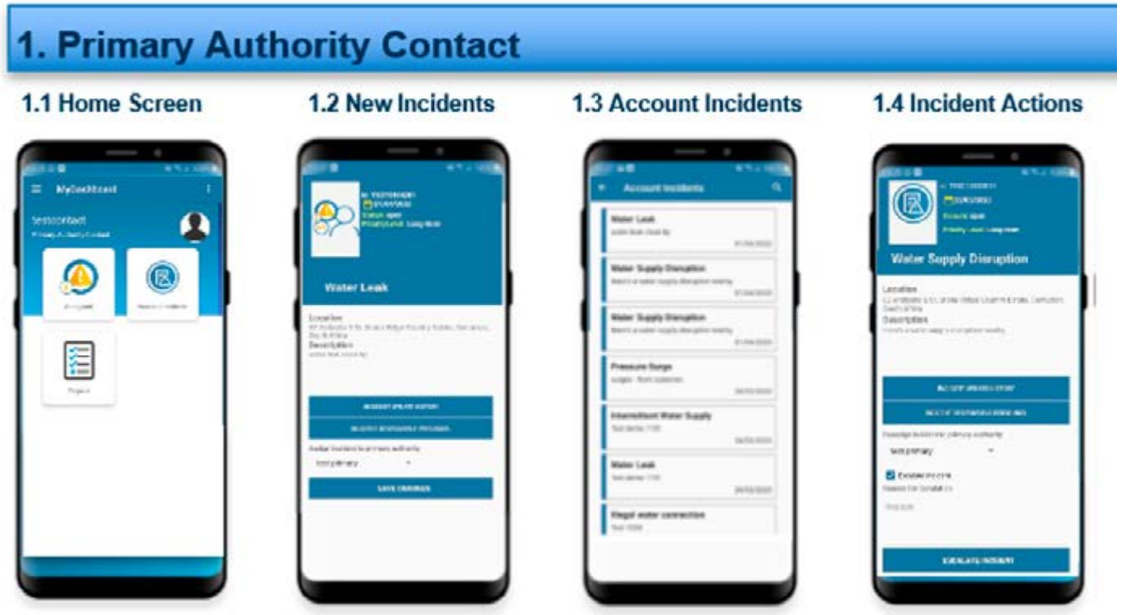


Solutions Platform for CARRS

WEB PLATFORM







SUMMARY OF CARRS

Problem/Issue

Uneven performance in the public service sector and lack of monitoring systems have resulted in poor enforcement of corrective action. Frequent breakdowns as a result of ageing infrastructure, inadequate service delivery, and poor engagement with communities result in communities resorting to unorthodox ways of engaging with authorities, such as violent service delivery protests

Value offering

CSIR has developed a web-based incident management system (CARRS) to assist communities in reporting water service delivery challenges, and for municipalities to timeously respond to the reported challenges.

Competitive advantage

Municipalities respond timeously in addressing reported incidents and communities feel engaged when they see corrective action taken on issues that they reported

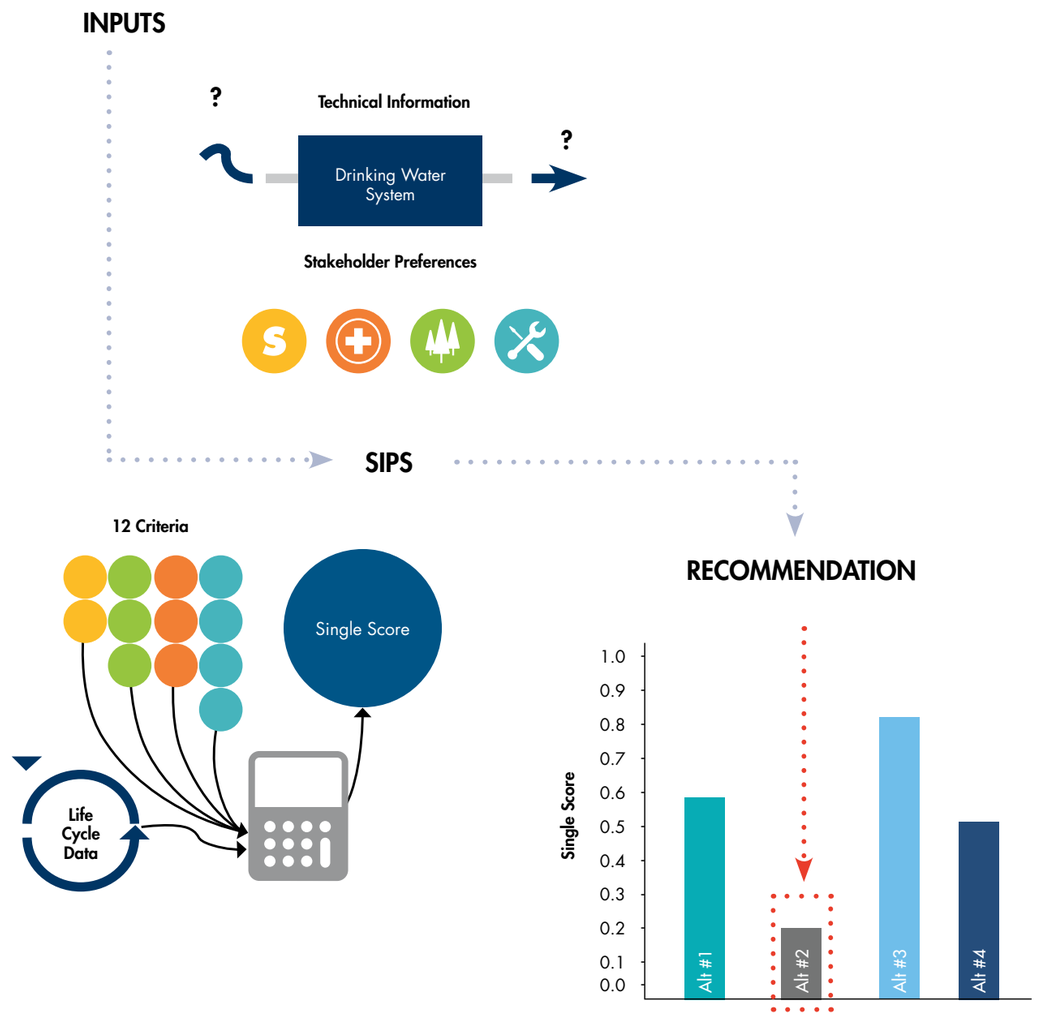
Potential users include

Water service authorities

Small Drinking Water Plant Sustainability Support and Decision-making System

BACKGROUND: THE PROBLEM/CHALLENGE TO BE SOLVED

Decisions about which treatment options are best for a small community of less than 10 000 people can be challenging, especially as regulations become more stringent and source water quality gets worse. Treatment decisions can be particularly difficult due to limited resources (for example, skill and financial constraints) and because sustainable decisions use a variety of economic, environmental and social criteria. Therefore, a user-friendly assessment framework that compares various treatment processes relevant to a wide variety of small drinking water systems, was developed.



TECHNOLOGY HIGHLIGHTS AND BENEFITS

- The Small Drinking Water Plant Sustainability (SIPS) Support and Decision-making System framework was developed by researchers from America based in the University of Colorado, Boulder.
- It was created using Microsoft Excel and includes important criteria in addition to economic (i.e. financial) considerations such as environmental and social factors.
- In collaboration with these researchers, SIPS has been transferred to an easily accessible and much more secure web-based platform. Thus, with the appropriate rights, any person can access the framework and use it to assist them to make better informed small drinking water treatment decisions without fear of accidentally altering any parameters that are not easily protected in Excel.
- In addition to the framework, a SIPS user manual has been further developed and amended to provide the potential user with a clear understanding of the different components of SIPS.
- Thus, with some initial explanations and training, it will be possible for a potential user to, relatively independently, interrogate the SIPS framework and decide for themselves whether it is helpful when they are faced with making small-scale drinking water treatment decisions where additional assistance for informed decision-making is not readily available.

The CSIR Water Centre contributes to the provision of reliable, efficient and functional water and wastewater service delivery, in the interest of economic development, through the development and refinement of smart water use and infrastructure technologies for the public and private sectors. The centre addresses shortcomings in South Africa's water planning and accountability; infrastructure operation and maintenance; water treatment technologies and critical domain skills. It also focuses on dwindling water resources, deteriorating water quality, emerging water pollutants and lack of access to alternative water resources.

Enquiries: RMagoba@csir.co.za

WaterCenterManager@csir.co.za

www.csir.co.za

science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

CSIR
Touching lives through innovation