Utility measurement requirements: SASOL 1 site as case study

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It all starts here ™

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Abstract

Clean water has become a scarce and pricey commodity. Companies, governments and the public are realising more and more the importance of efficient and effective water use and the conservation of South Africa's natural water resources. Governments are implementing conservation and usage laws while companies are trying to get as much use out of their water while staying within the law. This dissertation focusses on the potable water measuring and billing practices taking place on the SASOL 1 site. A field study, interviews and questionnaires were used to gather the relevant data which was subsequently compiled into a Stakeholder Requirement Statement. The latter is a description of the ideal system that would meet all the requirements for measuring potable water and billing customers on the SASOL 1 site.

Keywords

Utilities, water metering, water balance, billing, stakeholder requirement statement.

Table of Contents

Acknowledgments ... **ii**

Abstract ... **iii**

Keywords ... **iv**

Table of Contents ... **v**

List of figures ... **x**

List of tables ... **xi**

Nomenclature ... **xii**

Chapter 1: Introduction ... **1**

1.1 Water ... **1**

1.2 South Africa ... **1**

1.3 SASOL ... **1**

1.4 Metsimaholo ... **2**

1.5 Energy Measurement ... **3**

1.6 Research Problem ... **4**

1.7 Research Objectives ... **4**

1.8 Dissertation Overview ... **4**

Chapter 2: Literature survey ... **6**

2.1 Reporting ... **6**

2.1.1 Sustainable Development Report ... 6

2.1.2 United Nations Global Water Mandate 7

2.1.3 Carbon Disclosure Project 8

2.2 Current System 9

2.3 South African Regulations 10

2.4 SANS 10306 11

2.5 International regulations 12

2.6 International Industrial best practices 14

2.7 Water balance 15

2.8 Savings 19

2.9 Incentive 22

2.10 Implementation 22

2.11 SASOL metering requirements 23

Chapter 3: Empirical investigation 25

3.1 Research Objectives 25

3.1.1 RO1: Investigate how the billing process is being done at the end of each month. 25

3.1.2 RO2: Investigate the hardware that is being used to measure the water consumption of clients. 27

3.1.3 RO3: Investigate if any SASOL specifications exist that are applicable to water billing. 27

3.1.4 RO4: Research industry best practices for drinking water billing. 28

3.1.5 RO5: Gather stakeholder requirements for the billing/measuring system through semi-structured interviews and a questionnaire. 28

3.2 Stakeholder Requirement Statement 30

3.2.1 Information gathering 30

3.2.2 Stakeholder needs identification 31

3.2.3 Envisioning and evaluation 31

3.2.4 Requirements Specifications/Statement 31

Chapter 4: Results and Findings 33

4.1 Water billing cycle 33

4.2 Metering Hardware 34

4.2.1 Analogue vs. digital 35

4.2.2 Meter connectivity 35

4.2.3 Flooding 36

4.2.4 Electricity Supply 36

4.2.5 Network connection 37

4.2.6 Condition of meters 37

4.3 Consumer Metering 38

4.4 SASOL Specifications 38

4.5 Water Balance 39

4.6 Results from questionnaire 42

4.7 Interviews 43

4.7.1 Current system: Effectiveness 43

4.7.2 Requirements: Scope of measurement 43

4.7.3 Accuracy 44

4.7.4 Data availability 44

4.7.5 Automatic Meter Reading 44

Chapter 5: Discussion and interpretation 45

5.1 Discussion of results 45

5.2 Stakeholder Requirement Statement 46

5.2.1 Independence 46

5.2.2 Verification 46

5.3 Conclusion 47

Chapter 6: Conclusions and Recommendations 48

6.1 Conclusions 48

6.2 Recommendations 49

6.3 Recommendations: Further research work 51

List of References 52

Appendix A: Data sheet for water meter information 56

Appendix B: The completed data sheets for all the meters visited 57

Appendix C: Positions of the main municipal water meters 70

Appendix D: Municipal water consumers and their usage during May 2013 71

Appendix E: Clients being billed 74

Appendix F: Leak sizes and loss rates 76

Appendix G: Questionnaire 77

Appendix H: Interviewer guide for data flow during billing process 79

Appendix I: SRS review feedback..... 80

List of figures

Figure 1: An example of an overall facility or process block diagram 17

Figure 2: The effect of control boundaries (Blair, n.d.) 18

Figure 3: Cost Per Meter Read (Ascend Group Inc.) 21

Figure 4: Process for user requirements analysis (Maguire & Bevan, 2002)..... 30

Figure 5: Analogue vs. digital 35

Figure 6: Meter Connectivity 35

Figure 7: Meters Flooded 36

Figure 8: Electricity available within 20m..... 36

Figure 9: Wired network connection available nearby 37

Figure 10: Condition of meters 37

Figure 11: SASOL 1 site water balance 39

Figure 12: Water balance block diagram – Energy Measurement..... 41

Figure 13: Questionnaire data 42

Figure 14: Positions of the main municipality meters. 70

List of tables

Table 1: Metsimaholo Heavy Industries water tariff 2

Table 2: Annual average inflation rates (Statistics South Africa, 2013) 2

Table 3: Losses associated with leaks (AUD Metering, 2012) 24

Table 4: Identified stakeholders 42

Table 5: Replies on Question 6 43

Table 6: Municipal water consumers and their usage during May 2013 71

Table 7: Leak sizes and loss rates at 500 kPa (SANS 10306) 76

Nomenclature

AMR – Automatic Meter Reading

BU – Business Unit

CIS – Customer Information System

DWAF – Department of Water Affairs and Forestry

E, G&D - Energy Generation and Distribution

GRI – Global Reporting Initiative

KPI – Key Performance Indicators

MDM – Meter Data Management

POTW - Publicly Owned Treatment Works

RO – Research Objective

RP – Research Problem

SANS – South African National Standards

SASOL – Suid-Afrikaanse Steenkool en Olie

SGEPP – SASOL Gas Engine Power Plant

SRS - Stakeholder Requirement Statement

UAW – Unaccounted for Water

WSA – Water Service Authority

Chapter 1: Introduction

1.1 Water

Water is life. Without it all life on earth will perish. Although 70% of the earth's surface is covered with water only about 3% is fresh water of which less than 1% is available for use by people. (Rand Water, 2013)

1.2 South Africa

South Africa's annual rainfall is well below the world's average. According to the Department of Water and Environmental Affairs, the demand for water will outstrip supply in Gauteng by 2013 and in the whole of South Africa by 2025. Building new dams and pumping water from areas with an abundant supply is extremely expensive. It is much more cost effective to use the water which is already available more wisely and efficiently. To encourage water savings the price of water from municipalities are on the increase. This will have a big impact on users especially on industries which use a lot of water, like SASOL for example.

1.3 SASOL

SASOL is an alternative fuels and chemicals company. It was formed in 1950 in Sasolburg (SASOL 1) and has subsequently expanded to Secunda (SASOL 2). Currently they have operations in 38 countries throughout the world. (Sasol, 2011)

SASOL 1 is divided into different business units (BUs). These BUs operate as independent businesses. The aim of this is to let each BU take responsibility for its own profitability. Although all money spend between BUs stay in SASOL, each BU is responsible for its own budget. It is therefore necessary to quantify all inputs and outputs for each BU to enable calculation of expenses and profits.

The problem faced by the BUs is that because of the relative inexpensiveness of utilities (including water) in the past, it was not measured. Therefore little or no utility measurement infrastructure exists on the SASOL 1 site. With the price of water on the increase this will have to change to let users know how much they are using and/or wasting and where savings can be attained.

1.4 Metsimaholo

SASOL purchases its potable water from the Metsimaholo municipality in Sasolburg. The water tariffs have been on the increase for the last couple of years as shown in Table 1. (Metsimaholo, 2012)

Table 1: Metsimaholo Heavy Industries water tariff

Financial Year	Percentage increase on previous years tariff
2010/2011	8
2011/2012	8
2012/2013	6
2013/2014	7

Table 2: Annual average inflation rates (Statistics South Africa, 2013)

Year	Annual average inflation (%)
2009	7.1
2010	4.3
2011	5.0
2012	5.6
2013	5.9 (Up to September)

From Table 1 and Table 2 it can be seen that the increase in water price is not just keeping up with inflation. The increases are a percentage or two higher than the inflation rate for that same year. The real price of water has been on the increase for at least the last four years.

Rand Water who supplies the Metsimaholo municipality with water has done an assessment of their infrastructure. It revealed that capital must urgently be spent to ensure the company's ability to supply water in the long run. To fund the R705 million infrastructure upgrade the bulk tariff rates will increase with 9.5% from 1 July

2013. Approximately 71% of the Metsimaholo municipality's water is supplied by Rand Water. The rest of the water is treated at the municipalities own aging treatment plants which are being upgraded in terms of a 5-year plan according to their budget. The increase in Rand Waters' rates contributes to approximately 48% of the Municipality's water input cost.

The National Treasury has also advised municipalities to review their rates and insure that water tariff structures are cost reflective by 2014. This imply that the tariff must include the cost of maintenance and renewal of infrastructure. (Metsimaholo Local Municipality, 2013)

When taking Rand Water's infrastructure improvements, the National Treasury's advice to municipalities, Metsimaholo's own upgrades and the water tariff increase trend into consideration, there is no way that the price of water will decrease in the foreseeable future in order for companies to be ignorant about their water usage.

1.5 Energy Measurement

Energy Measurement forms part of SASOL Infrachem. This business unit's function is to measure all electricity usage on the SASOL 1 site. This is already being done from the main electrical incomers down to client level, with an accuracy of more than 99%.

Energy Measurement's scope has been expanded to include all utilities (electricity, steam and water). This has been done, because the BU already has the data infrastructure and network capacity and the importance of these measurements are being realised. Some steam usage measurements have already been implemented, but potable water usage measurements are still outstanding except for one clamp on, test meter on the main supply from the municipality. The water measurements that are currently taking place are done by the business unit, Water and Waste, and are done by hand. This leads us to the research problem investigated in this dissertation.

1.6 Research Problem

Water usage on the SASOL 1 site is either not measured or poorly measured. The trend of increasing real cost of water necessitates proper and accurate measurement, so that its usage can be better managed. Research is therefore needed to determine and formally document the requirements for a water measurement and billing system.

1.7 Research Objectives

The research scope will include only the potable water on the SASOL 1 site. To make the research more manageable it was broken down into different research objectives:

1. Investigate how the current billing process is being done at the end of each month.
2. Investigate the hardware that is being used to measure the water consumption of clients.
3. Investigate if any SASOL specifications exist that are applicable to water billing.
4. Research industry best practices for potable water billing.
5. Gather stakeholder requirements for the billing/measuring system through structured interviews and a questionnaire.
6. Compile the requirements in a Stakeholder Requirement Statement and verify that the requirements have indeed been correctly solicited and documented.

1.8 Dissertation Overview

The dissertation will take on the following structure:

The findings of the literature study are reported in Chapter 2. This includes research into local and international regulations and standards and SASOL specifications for water metering. Different solutions and systems which can be used for industrial water metering were also investigated and their strengths and weaknesses noted.

In Chapter 3 the experimental designs and work done to reach the research objectives are described. The way information was gathered, how interviews were

structured and held and how the Stakeholder Requirement Statement was compiled and verified are provided.

Chapter 4 presents the findings and data gathered from the interviews, questionnaires and investigations.

The discussion on the data from the previous chapter is noted in Chapter 5. The Stakeholder Requirement Statement and its verification is also presented.

With clean water becoming scarcer on a worldwide scale and its cost constantly on the rise, it is unacceptable for any individual or company to be ignorant of their water usage. This research will expose the status of potable water measurement and its management on the SASOL 1 site. The results will allow the company to focus on areas where improvements will have the greatest impact and will be of benefit to the company and the environment.

Chapter 2: Literature survey

Chapter 2 is an investigation of literature and previous studies to determine what research have already been done in the field of utility measuring systems. These findings will be used to make this research relevant without duplicating work already done.

The literature study will look at what types of consumption or environmental reporting is already being done by SASOL and why it is being done. The current water metering setup at SASOL will then be investigated. Different environmental laws exist throughout the world as will be seen in the section on International regulations. The research will then investigate what laws and regulations are relevant and applicable to SASOL in South Africa and what industrial best practices are being followed by others in the industry. Water balance functioning and benefits are investigated.

Finally the literature survey will focus on what types of savings can be attained from a well-managed metering system and how personnel can be motivated to buy in to it. Problems that might be experienced during the implementation of such a system are investigated and research is done on the existence of any SASOL specific metering specifications that needs to be adhered to.

2.1 Reporting

2.1.1 Sustainable Development Report

SASOL publishes a yearly Sustainable Development report which covers all SASOL's business activities. It reviews the management approach and performance relating to social, economic and environmental issues that impact the long-term success of the business, as well as the economies and communities in which they operate and the natural environment. (SASOL, 2012)

In this report water usage and other water-related issues are reported in terms of the GRI (Global Reporting Initiative) indicators. The GRI indictors allow companies to report on sustainability as a way to become more sustainable and contribute to sustainable development. (GRI, 2013)

In the report it is stated that demonstrating responsible water stewardship is a key priority for SASOL. During 2013 SASOL also launched a group-wide initiative called: “Sasol Water Sense: Protect, Share, Save” to promote and improve water stewardship practices throughout SASOL.

This initiative and the yearly sustainable reporting should instil confidence in SASOL’s commitment to protect the environment. SASOL also focusses on water conservation on its own with the Global Water Mandate.

2.1.2 United Nations Global Water Mandate

SASOL has endorsed the United Nations Global Compact CEO Water Mandate, which is a public-private initiative aimed at assisting companies in the development, implementation and disclosure of water sustainability policies and practices. The mandate presents a comprehensive approach to corporate water stewardship and is a voluntary initiative developed to inspire business to positively contribute to sustainable water resource management.

The six focus areas of the UN Global Compact CEO Water Mandate are (Water Sense, 2013), (United Nations Global Compact, 2011):

- Direct operations:
  SASOL should know how they use water in the direct production of their good and set targets and use technologies for sustainable water usage.
- Catchment management:
  SASOL should encourage and help their suppliers to improve their water conservation, quality monitoring, waste-water treatment and recycling practices.
- Collective action :
  SASOL should support the work of existing water initiatives and build closer ties with civil society organizations on regional and local levels to ensure water sustainable practices keep expanding.
- Public policy
  SASOL should contribute to government regulations and work with policy makers to drive the water sustainability agenda.

- Community engagement
  SASOL should contribute to the community with water-resource education, awareness campaigns and work with public authorities to develop water infrastructure.
- Transparency
  SASOL should always be transparent in dealings with government and other public authorities on water issues and report their progress on water sustainability improvement projects.

SASOL follows these guidelines as evident in their community projects, awareness campaigns (Water Wise) and the reporting they are doing in the Sustainable Development Report and the Carbon Disclosure Project.

2.1.3 Carbon Disclosure Project

The Carbon Disclosure Project (CDP) is, according to their website, an international, not-for-profit organization providing the only global system for companies and cities to measure, disclose, manage and share vital environmental information.

SASOL, as the only representative from the Energy sector in the South African sample, has demonstrated leading practice by setting quantitative water efficiency targets which are monitored by water related key performance indicators (KPI's) for their larger and most water intensive business units.

The 2011 Carbon Disclosure Project Report shows that most companies are measuring their total water withdrawals but that little external verification is being done to ensure the quality of the measurements. This means that the readings can be inaccurate if the companies do not have any internal verification system of their own in place. The report also discloses that SASOL is concerned with its water consumption, but are only measuring their larger and most water intensive business units. (CDP, 2011)

SASOL's public image and their stakeholder's confidence are improved and strengthened by these reports. It portrays an image of a company which cares for the environment, taking responsibility for their actions and are not ashamed to

publish these reports. The image a company reflects can and do have a big effect on how people perceive the company. This has an effect on the company's share price and finally its profits.

Reports must be filled with data which are gathered somewhere. An investigation was done into the system currently at work in the Water & Waste Section at the SASOL 1 site.

2.2 Current System

Water and Waste is a section which functions under Water Management and are responsible for the whole process of supplying potable water to the site.

The water distribution system at SASOL 1 has been expanded throughout the years as the factory grew, resulting in a complex system with various tie-ins. Old and new equipment is used side by side.

In the factory there are different types of water and effluent streams. The streams are kept separate to prevent effluents with higher pollution levels from contaminating those streams which are less dirty.

There are two water streams entering the Sasol 1 site. These are the:

- Potable water and
- River water.

The municipal water is bought from the local Metsimaholo municipality in Sasolburg. It enters the SASOL 1 site at a central place and is distributed from there as drinking water to the various sections throughout the factory. In case of an emergency it can also be used in the production process on SASOL 1.

The river water (raw water) is pumped from the Vaal River and is processed before it is used.

The cleaning process consists of various stages. Depending on the quality of the water, the water is added earlier or later in the process. The more steps that are required to get the water within specification the more expensive it becomes.

The first step in the cleaning process is the flocculation of the water through flocculation filters which removes suspended particles from the water. The flocculated water is then filtered through sand filters to clean it further. The flocculated water is used as cooling water in some plants. The rest of the filtered water is treated at the Demineralization plant where salts are removed from the water.

This Demineralized water ("Demin water" for short) is then used in boilers where steam is made. After the steam has lost its energy it condensates and flows into a Condensate stream.

An example where research resulted in the system being upgraded to be more water efficient (and save money) occurred some three years ago. A project was launched to recover condensate after research done by the Technical Group Infrachem showed that a lot of money is wasted on condensate that was being flushed into the effluent system. (Karen, 2013)

The project enabled the Demineralization plant to recover condensate from the plants and save money by reducing the load on the Demineralization plant. If the condensate that is recovered is still within specification it is mixed with the Demin water and sent to the boilers again.

Projects and modifications are not only done to save on costs but also to avoid fines and stay within the regulations of the law.

2.3 South African Regulations

In South Africa there are certain regulations under the Water Services Act which must be complied with by water users. Under Section 9: Norms & Standards for Quality Water Services, every organization releasing effluent into a water body must have a license to do so from the Department of Water Affairs & Forestry. This license will state the exact types and maximum levels of pollutants that may be present in the effluent. (DWAF, 1997) This implies that the organizations releasing the effluent into a body of water must have some means of measuring the quality of their effluent to ensure they do not exceed the permitted pollutant levels and to avoid fines.

The regulation also has a section covering losses and unaccounted for water (UAW). UAW is the difference between the water flowing into and out of a network which cannot be attributed to a certain loss, as determined by a water balance.

2.4 SANS 10306

The South African National Standard for the management of potable water in distribution systems (SANS 10306) gives extensive guidelines on how to manage a potable water system. It focusses on water services authorities (WSA) and the distribution of potable water to entire cities and districts. The information is just as relevant and the concepts can be applied to small distributors like the SASOL Water & Waste section.

According to the standard every WSA, large or small, shall compile, implement and comply with a water management program to investigate and evaluate the magnitude of the water losses, to identify the main contributing factors and to prepare a strategic plan for implementing water loss management. (SANS, 2010, p. 17)

The standard also states that unaccounted-for water (which includes all physical and non-physical losses for the entire water supply and distribution system), forms a significant component of water conservation.

Water must be realistically priced to cover the real cost of the water and to cover the real value of the water. The final price of the water charged to consumers must be a balance between the cost and the value, plus an amount to generate a trading surplus to use for future works. (SANS, 2010, p. 18)

If the price of water does not reflect the true value of the commodity and if the supply area is not fully metered, it becomes extremely difficult to encourage conservation programs according to SANS 10306.

It is the water services authority's responsibility to ensure they have the following in place (to name just a few):

- manpower,
- infrastructure,

- metering and
- maintenance.

The standard goes into great depths explaining how an UAW committee should be implemented to ensure the water conservation goals of the water services authority is reached.

The following are relevant: (SANS, 2010, p. 21)

- Comprehensive and up-to-date information pertaining to the water distribution system is essential for the effective functioning of the UAW committee.
- Key metering/monitoring positions shall be identified and meters installed over a period of two to five years to make it financially possible.
- Realistic goals, targets and time frames must be formulated.
- The required policy is universal metering (i.e. individual metering of all consumers).

The standard acknowledge that universal (individual) metering is not always practical or economical but that in such cases some sort of zone or block metering must still be installed.

A procedure to account for water is also given - which can be used to develop a company specific procedure.

The standard also recommends hand-held electronic meter reading terminals or automatic meter reading (AMR) devices for their better accuracy and time savings.

2.5 International regulations

In the United States of America it is now law that “all Federal buildings shall, for the purposes of efficient use of energy and reduction in the cost of electricity used in such buildings be metered … to the maximum extent practicable.” It must also be considered to meter (where cost-effective) water usage. (U.S. Department of Energy, 2011)

From this Metering Best Practices Guidelines, it is highlighted that metering by itself does not have any saving (or very little) as a result. The important thing is that the

meters present data which can be used to cut on expenses. The data can be used to:

- Reduce energy/utility use;
- Reduce energy/utility costs;
- Improve overall building operations;
- Improve equipment operations.

How the metered data is used is critical to a successful metering program. Depending on the type of data collected, this data can enable the following practices and functions:

- Verification of utility bills
- Comparison of utility rates
- Proper allocation of costs or billing of reimbursable tenants
- Demand response or load shedding when purchasing electricity under time-based rates
- Measurement and verification of energy project performance
- Benchmarking building energy use
- Identifying operational efficiency improvement opportunities and retrofit project opportunities
- Usage reporting and tracking in support of establishing and monitoring utility budgets and costs, and in developing annual agency energy reports.

This correlates with the article “Is Smart Metering smart enough for Africa?” published in the official magazine of the Institute of Municipal Engineering of Southern Africa which states that “collecting vast amounts of system data is in itself pointless – the value is in the management of the data” (Berg, 2013)

From the previous sources it is clear that metering must be done to comply with legal requirements and to be an environmentally responsible entity. It is also clear that metering must not be done just for the sake of gathering data but to enable the business to monitor its consumptions and to become more efficient with less waste.

The price of municipal water is on the rise. The reasons for this are: municipalities were undercharging their clients; all meters were not being read; some meters are inaccurate or broken and losses through pipe leaks. This resulted in a lack of funds and maintenance suffered. To keep on supplying water the aging systems need to be upgraded, repaired and maintained. The funds for this will ultimately come from the users/clients.

2.6 International Industrial best practices

The Federation of Canadian Municipalities and National Research Council have during the last few years released a number of InfraGuides. These are reports on best practices in the industry for various topics. Of interest to this research were the following guides: (a) Water and Sewer Rates: Full Cost Recovery and (b) Potable Water: Establishing a Metering Plan to Account for Water Use and Loss.

“This study notes that on average over the past decade, water use has been over 70% higher when consumers are billed a flat rate rather than a volume-based rate. Recent case studies in Canada have shown that metering alone could reduce water consumption by 10–38%.” (FCM & CNRC, 2006)

This extract confirms that people will be less wasteful when they are paying pro-rata for the volume they use opposed to people paying a fixed rate. For this to work consumers must have confidence in the system and people who are determining how much they have used. Too many utilities are still making use of manual readings or estimates. The manual reading of meters (also known as Sneaker-net Data Collection) is:

“A largely outdated, yet still practiced, method of manual meter reading involving writing down or keying in to a hand recorder the metered data. This data collection practice is inefficient, inaccurate, and discouraged in most applications”, according to the guideline: Metering Best Practices. (U.S. Department of Energy, 2011)

The use of electronic or smart meters has become more widespread as prices have decreased and the technology was proved. The water meter manufacturer Sensus defines a smart water network as follows:

A smart water network is a fully integrated set of products, solutions and systems that enable water utilities to: (Sensus, 2012)

- Remotely and continuously monitor and diagnose problems, pre-emptively prioritize and manage maintenance issues, and remotely control and optimize all aspects of the water distribution network using data-driven insights
- Comply transparently and confidently with regulatory and policy requirements on water quality and conservation
- Provide water customers with the information and tools they need to make informed choices about their behaviours and water usage patterns

According to a whitepaper by Sensus titled “Water 20/20: Bringing Smart Water Networks into Focus” utility companies worldwide can benefit from implementing smart systems into their water networks. The benefits include: Improved leakage and pressure management, strategic prioritization and allocation of capital expenditures, streamlined network operations and maintenance and streamlined water quality monitoring.

But efficient meter or smart metering cannot be implemented without a roll-out strategy. Where to measure? How many meters? A good place to start is with a water balance.

2.7 Water balance

Judging by the amount of reporting being done by SASOL it is apparent that the attitude towards environmental conservation and water conservation is one of caring and realizing the role the industrial sector plays and the effect they have on the environment.

A recent document from the SASOL 1 intranet states that a water bailiff has been appointed:

A “Water Bailiff” has since been appointed on site, tasked with ensuring that the water baseline is not exceeded. According to Johan Meyer (who is the Business Track Manager of the Technical Group Infrachem) that means constant measuring and monitoring to enable focused management of the water baseline. (Karen, 2013)

This “constant measuring and monitoring” must be qualified further to determine if it is effective.

The following questions should be answered:

- Where are the meters?
- How are the readings collected?
- How often are the readings collected?
- What is being done with the readings?

To gain valuable plant knowledge and to develop an understanding of how water is used throughout the factory a water balance must be done. A water balance can also indicate where inefficiencies are within the water system, according to a report by Thomas Blair. (Blair, n.d.)

In its simplest form, a water balance is:

Water in = Water out.

To conduct a successful water balance enough planning should be done:

- What are the objectives?
- What data is available?
- What is unknown?
- What are the data collection needs?
- How will the data gaps be filled?

After these questions have been answered satisfactorily a block diagram can be used to set-up a process flow that shows water in and water out.

A block diagram is an invaluable tool used to conduct a water balance. It shows the known and unknown flows into and out of a facility. It can be used during information gathering and data gap filling to explain to personnel exactly what flow you are interested in and if your current information is correct. If a data gap will not cause a significant error in the overall water balance it may be disregarded.

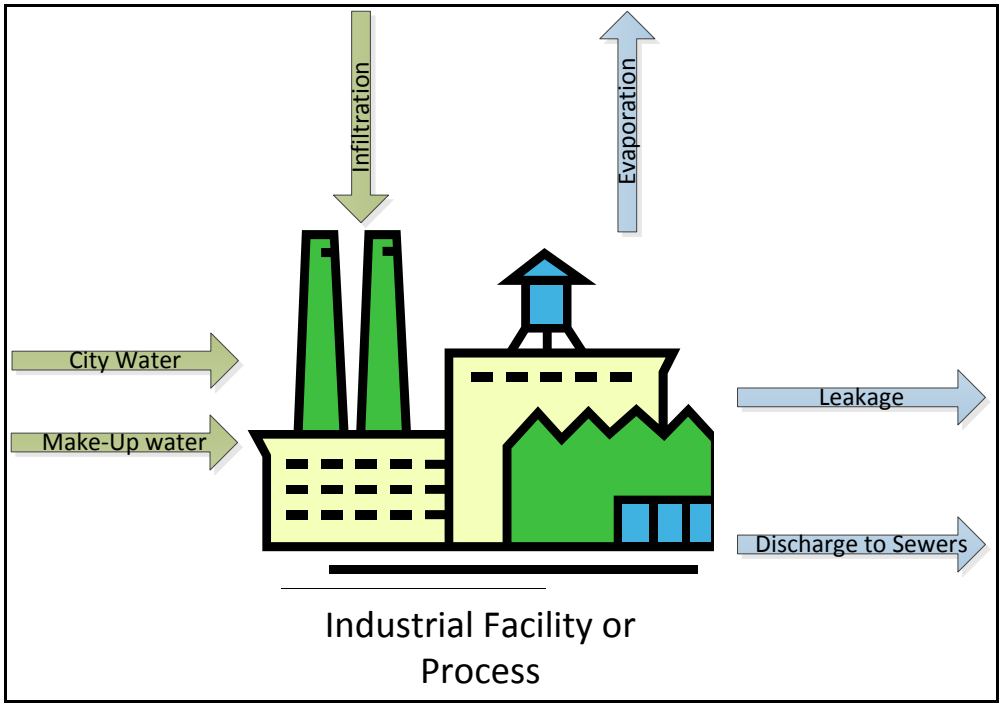

Figure 1: An example of an overall facility or process block diagram

A good place to start with a block diagram is a set of thorough, recent, accurate pipe layout drawings and process flow diagrams. Unfortunately at many industrial facilities, recent and accurate drawings and diagrams are not available. Thorough field work will then have to be done to gather all the required information for the water balance.

Once the process is well understood and the data gaps have been filled as much as possible, the water balance proceeds to the evaluation stage. By drawing control boundaries across processes or equipment, the unknowns at the control boundaries can be discovered and solved (Blair, n.d.).

Depending on what questions need to be answered the control boundaries can be changed.

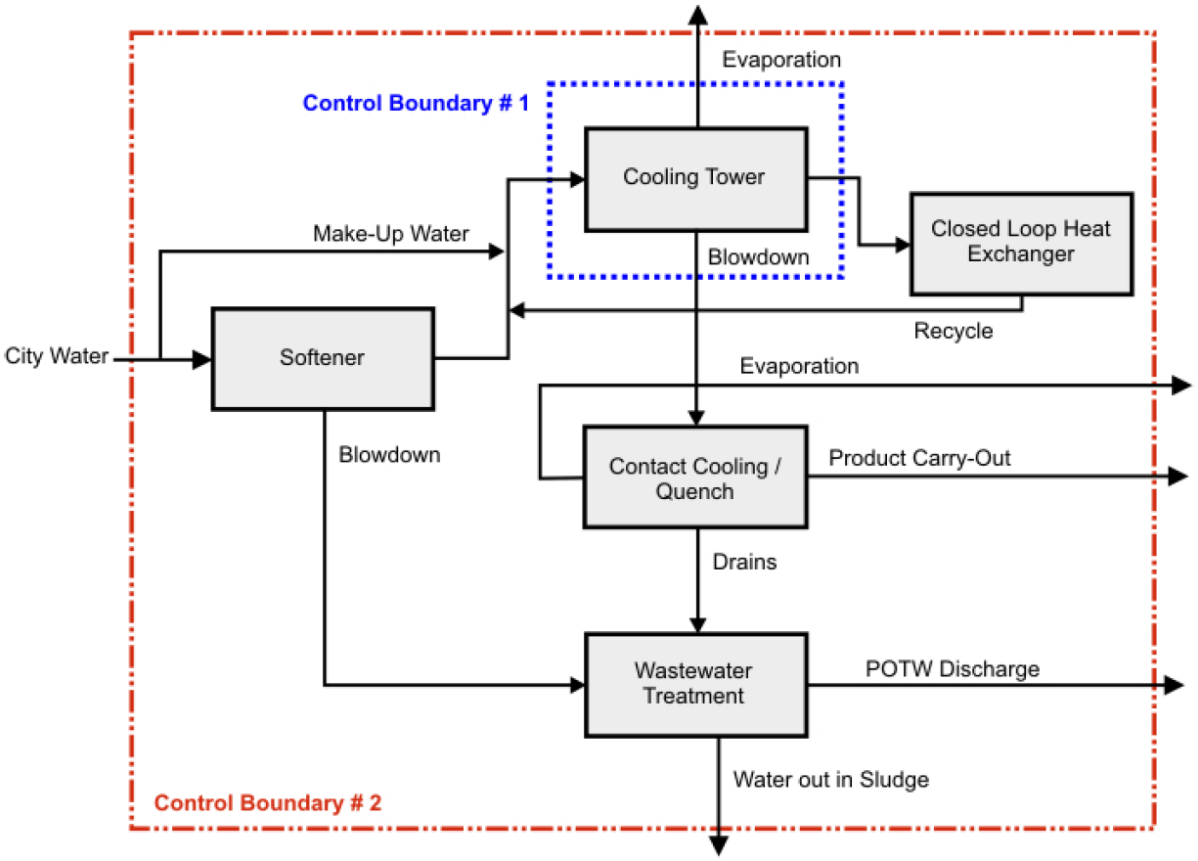

Figure 2: The effect of control boundaries (Blair, n.d.)

The example in Figure 2 shows that Control Boundary #1 is specific to the Cooling Tower, and the balance requires four quantities:

1. water in,
2. evaporation,
3. blow-down, and
4. water out.

Control Boundary #2, on the other hand, is for the overall system, and the balance requires:

1. water in,
2. evaporation (from 2 sources),
3. product water carry-out,
4. POTW (publicly owned treatment works) discharge, and
5. water out in sludge production.

By breaking down the overall system into its various components, fewer variables are introduced, and solving for unknowns gets easier.

A completed water balance can then be used for “what-if” scenarios to determine the impact of changes or modifications to the system. The water balance allows a plant to look at water conservation, wastewater segregation, waste minimization, regulatory compliance, automation control, and ways to improve operations and maintenance.

An accurate water balance allows management to make informed decisions regarding their water system and can result in savings.

2.8 Savings

According to a study done by the Water Conservation Group in Australia (Hauber-Davidson, 2008) it is possible for large water users to obtain economical savings by implementing an integrated water measurement system, or parts of it. To realise any savings it is necessary to know when, where and how water is used, and for what purpose (J Sturman, 2004).

This can only be done by having water meters in place. These meters must be accurate and installed at least at the main site feed. For a better understanding of the usage sub metering can be done at all the downstream clients. The metering data must also be readily available to be of use. This can be done via a smart metering system that periodically transmits the consumption data to a server.

The goal of smart meters is not to collect huge amounts of data, but to make it available in a useful form to the consumers. The implementation of a smart metering system will have a big increase in data being collected and as mentioned previously it is pointless to collect vast amounts of system data and not manage it. To this end a Meter Data Management System must be used by trained personnel to demonstrate benefits for consumers.

According to U.S. Department of Energy’s metering best practices, the primary variables that impact the cost-effectiveness of meters are:

- The annual utility cost of the building being metered

- The cost to purchase and install the meter and associated hardware
- Expected savings resulting from the productive use of data, typically in the range of 2% to 10%, but sometimes higher depending on how the metered data are used
- Site economic criteria – usually payback period.

There are other costs that should be considered in any cost-benefit analysis such as: maintenance cost on a per meter basis, as well as cost for maintaining the collected data and any analysis results, as well as ancillary cost such as meter calibration activities. (U.S. Department of Energy, 2011)

Implementing a Smart Metering system has a high initial cost. Some of the not so apparent expenses include the following according to a whitepaper report by Oracle Utilities (Oracle, 2009):

- Add technology and infrastructure to implement and support smart meters and the huge volumes of data they generate. When implementing a Smart Metering System the company must be prepared for a big increase in data inflow. Up to 180 times more data can be expected. This will have an effect on the infrastructure and hardware necessary to handle the data load (Vespi & O'Keeffe, 2012)
- Modify or replace the customer information system (CIS).
- Expand asset tracking to include such things as smart meter communication capability and software and firmware versions.
- Expand or obtain software to view and analyse the usage data by various utility business and operating functions.
- Obtain or expand middleware and messaging software to reliably handle communications between applications, alerts from field devices, and various data communications methods.
- Upgrade or acquire additional hardware to store and process interval usage data.
- Educate customers about the meter replacement project, including its anticipated costs and benefits.

- Retrain existing staff to install and maintain the smart meters and new infrastructure.

According to a study by the Ascend Group a fully implemented Automatic Meter Reading (AMR) system's cost per meter read is almost 50% less expensive than the Water Industry Average.

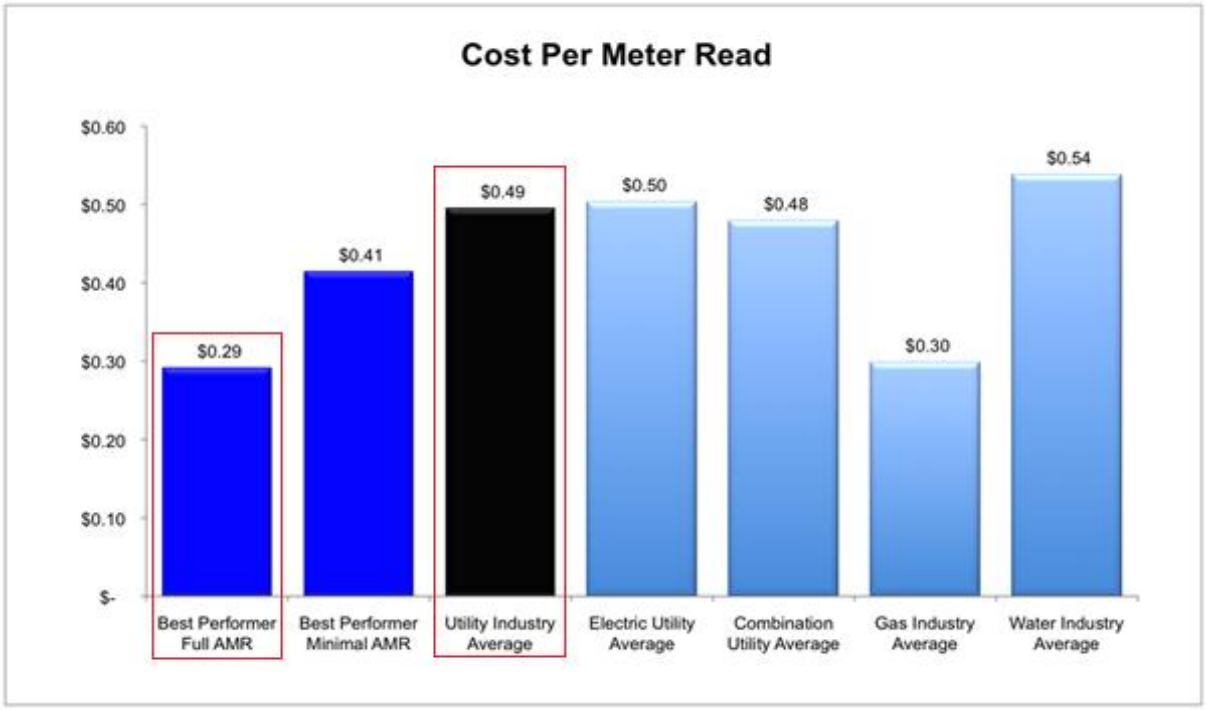

Figure 3: Cost Per Meter Read (Ascend Group Inc.)

The study highlighted the following characteristics of a Best Performer: (Ascent Group, Inc., 2011)

- Use AMR Strategically – to address inaccessible meters, unsafe meter locations, high turnover premises, and other high-read cost meters.
- Continually Optimize Routes – to maximize productivity and reduce costs.
- Implement Clear and Concise Measures of Meter Reader Performance – give employees a clear idea of job expectations and performance.
- Encourage High Performance through Incentives and Rewards – encourage the right behaviour through incentive programs and/or informal or formal reward programs.

- Train and Equip Meter Readers – provide employees with the tools, safety equipment, clothing, and training to do the job right the first time.

2.9 Incentive

Some of these characteristics are more applicable to utility companies and municipalities, but the principles still apply to the BU responsible to measure the water usage of the other BUs on the SASOL 1 site. With the industries high focus on the safety of their employees and the environment, the usage of AMR to reach unsafe meter locations will be a natural decision. An incentive program can also be implemented with the goal being to obtain an accurate water balance. The criteria for the incentive can be the percentage of water that is unaccounted for. The goal can be for example that the deviation between the water purchased and the water sold/used must be under 5%. This principle is already being used by the Energy Measurement department for the electricity billing with a deviation figure of less than 1%.

2.10 Implementation

It is clear that to calculate whether a metering project will be cost-effective, more than just the initial price of the meters must be considered. Enough information must also be gathered regarding current utility costs and metering practices to make an accurate calculation possible. The problem is that intangible benefits like easier operation and safer meter data gathering is difficult to implement into a calculation.

According to interviews held by Oracle with 151 North American senior-level utility executives in April 2012, who have at least one smart metering system implemented, companies must give attention to the following when moving to or using Smart Metering (Vespi & O'Keeffe, 2012):

- Prepare for new data sources that impact operations & service
- Realign processes and systems to take advantage of data insight
- Determine how to best use newly collected data
- Identify and hire new skills to accelerate intelligence delivery
- Define and roll out an enterprise information strategy
- Establish clear roles; enable collaboration and sharing

- Prepare for the change – using data across the enterprise
- Leverage meter data management (MDM) to increase utility effectiveness
- Use data to enhance operations

From the interviews it is clear that the collection of data should not be the main priority, but how it is used. The systems and people who are needed to analyse the data must be invested into.

Research done by Sensus showed that a “Lack of a strong business case” was one of the main reasons that smart water systems are not being implemented. (Sensus, 2012)

According to their research one can expect an average of 3.5% savings on the baseline cost for utilities who implement a smart water system, thanks to the leakage and pressure management feature it offers.

In addition, approximately 39 percent and 43 percent of respondents said the cost of communications infrastructure and automatic/smart meters, respectively, were prohibitively high.

2.11 SASOL metering requirements

The water meters on the SASOL 1 site are used to bill clients for their usage. The SASOL Sastech specification states the following (Sasol Technology, 2012):

6.6 Electricity and water consumption measurement

*6.6.1 Plant electricity consumption is **measured** monthly by SASOL Infrachem Electrical Distribution.*

*6.6.2 Plant water usage is **calculated** monthly by the Infrachem Water and Waste Department.*

It seems that measured water consumption is not required and that a calculated value will do.

An automated electronic system will result in more accurate readings than the manual reading method or calculations currently used. A study done by the Department of Watershed Management in the City of Atlanta into meter and billing accuracy with their automated water metering concluded that water usage data are accurately transmitted from the meters to the Automated Meter Reader (AMR) handheld device. In 100% of the cases where there was a mismatch between the visual and electronic readings of the meters, there was an explanation. In 47% of the cases where the mismatch was large it was because the system made an estimate of the reading. This is the result of new data not being fed into the system. (Meter and Billing Accuracy Assessment Project Team, 2011)

An automated system can also help in the detection of leaks. Even a small leak can result in large water losses. The price per kilo litre is according to the 2013/2014 budget of the Metsimaholo municipality for heavy industries.

Table 3: Losses associated with leaks (AUD Metering, 2012)

Size of leak (inch)	Losses per month (litre)	Financial Loss (@R14.33/kl)
1/16	95000	R 1361
1/8	380 000	R 5445
3/16	830 000	R 11 894
¼	1 500 000	R 21 495

If a big ¼'leak goes undetected for a year it can result in up to R 257 940.00 of wasted money (see Appendix F: Leak sizes and loss rates).

The literature study shows that an industrial user of water in South Africa should have some form of metering system in place. SASOL does have metering in place and are reporting on their water consumption, but is this adequate?

To answer this question an investigation was done to determine the efficiency and accuracy of the metering system and how it is managed. The design of the research instruments used during the investigation is discussed in the following chapter.

Chapter 3: Empirical investigation

3.1 Research Objectives

For research to be meaningful it must be well structured and therefor planning is of the utmost importance. To do the research certain tools must be developed with which data can be collected.

The goal of the research is to find a solution to the research problem. To make the research more manageable and to ensure all aspects are covered, a number of research objectives were compiled. The outcome of the research will be combined in a Stakeholder Requirement Statement for the potable water metering and billing system.

Each Research Objective will be listed separately and a description given why it was necessary and the planning and investigation that were done to reach it.

3.1.1 RO1: Investigate how the billing process is being done at the end of each month.

3.1.1.1 Data flow

The typical flow of data in a generic water billing cycle is as follows:

- All the water meters are read (electronically or manually) and the information is stored.
- The readings are sent to a central point (server or administrator) for processing.
- The processed data are sent to the clients in the form of monthly bills.

The outcome of this research objective was to see how the billing cycle is managed at SASOL 1: Water and Waste. The first step was to identify the role players in this process and schedule interviews with them.

Semi-structured interviews were used to interview the role players. Semi-structured interviews are a valuable tool when detailed information needs to be collected from a

few sources. The interview does not consist of fixed questions, but rather of topics that need to be covered in any order the interviewer deems fit.

An interview sheet was developed to guide the interviewer and to ensure that all the topics were covered. See Appendix H: Interviewer guide for data flow during billing process.

The interviews were held with a number of people to enable cross correlation of the data and to identify similarities and discrepancies in the data.

The manner in which data flows through a system has an effect on the systems efficiency and performance. With enough information from the interviews it was possible to draw a conclusion on how data flows through the Water & Waste sections during the billing process. This makes it possible to identify unnecessary delays or other inefficiencies which can be rectified.

3.1.1.2 Data collection

The way meter readings are collected has an impact on the whole billing cycle. To investigate how the meter readings are collected the meter reader was accompanied during his meter reading trip. During the meter reading the collection of the primary data for the billing system takes place. If any inaccuracies or delays occur here it will have a negative effect on the rest of the process.

The researcher went with the meter reader and witnessed the collection of the readings. Notes were made regarding the following:

- Number of meters read
- Method of reading
- Method of documenting readings

3.1.1.3 System overview

To be able to better understand the billing cycle and make recommendations for it, it was necessary to understand how it fits into the bigger system of water and waste water supply and management.

This high level information on the system was gathered through an interview with the water bailiff. The semi-structured interview approach was again used and the following topics were covered:

- Overview of the water system on SASOL 1
- The potable water system
- Billing
- Consumption information
- Expansion

3.1.2 RO2: Investigate the hardware that is being used to measure the water consumption of clients.

The accuracy of the meter readings is irrelevant when the readings originate from faulty or inaccurate equipment. For this reason a thorough investigation into the condition of the meters was done.

To this end a data sheet was compiled (see Appendix A) to be used during the meter reading trip to ensure all the necessary information is gathered from the meters and that it is being done in a consistent manner. The researcher filled in a copy of the data sheet for each meter that was visited during the meter reading trip. Each meter was visually inspected and the information noted in the relevant spaces on the data sheet.

It is very important that the water meters are in a good, working condition. If the meters are inaccurate or faulty, the data on which the whole billing system runs will be flawed and the system worthless.

3.1.3 RO3: Investigate if any SASOL specifications exist that are applicable to water billing.

Specifications are the culmination of years of experience and by following their recommendations many pitfalls can be avoided. If a specification exist for water metering and billing it will be used during the design of a new system or as a guideline during modifications and upgrades.

The SASOL Sastech department, who are the custodians of the specifications, was contacted via email to enquire if such specification exists.

The SASOL Intranet Knowledge Online is a database where specifications and other useful information on previous projects or lessons learned are stored. The database was accessed and searched for a water metering and billing specification, but it returned no relevant results. The following keywords (and combinations thereof) were used during the search:

- Potable water
- Water/utility metering
- Water/utility measurements
- Billing

3.1.4 RO4: Research industry best practices for drinking water billing.

Best practices are not specifications per se, but rather guidelines on a certain method or system. It is also a way of ensuring that experience is not lost (when experienced personnel retires) but documented and preserved for future use.

If best practices exist for water metering and billing it will be wise to use them when decisions regarding SASOL's water system needs to be made.

Databases and company web sites were included in this search which was done through both the search functionality provided by the North West University's Library web site and a popular internet search engine.

3.1.5 RO5: Gather stakeholder requirements for the billing/measuring system through semi-structured interviews and a questionnaire.

The goal of the interviews and questionnaire was to gather stakeholder's opinions and expectations of the water measuring and billing system. Stakeholders were identified by studying the organograms from the Water & Waste and Energy Measurement sections.

3.1.5.1 Interviews

Based on the research by Litkowski a semi-structured interview was most suited for this research. This is because the respondents' opinions can be explored and interesting relevant issues can be clarified. Questions can also be rephrased or explained if there is any uncertainty on what is asked. (Litkowski, 1991)

When doing semi-structured interviews there are no fixed questions. The interviewer rather asks questions pertaining to predetermined themes or subjects. In this way the interviewer can concentrate on subjects on which the interviewee is an expert.

In the semi-structured interviews, on the requirements for the water metering and billing system, the interviewer focused on the following subjects:

- The effectiveness of the current metering and billing system
- The scope of measurement
- The accuracy of measurement
- Thoughts on an electronic measurement system
- Consumption data availability

Interviews only would not have given enough information, therefore a questionnaire was also used.

3.1.5.2 Questionnaire

The questionnaire (Appendix G) was developed to gauge the stakeholder's perception of the current metering and billing system. The questions were formulated so as not to imply a right or wrong answer. The questions focussed on how the stakeholders perceived the accuracy, necessity and reliability of the current system and what their perceptions were of an electronic metering system.

The information gathered through the interviews and questionnaires was then used to develop a stakeholder requirement statement.

3.2 Stakeholder Requirement Statement

A Stakeholder Requirement Statement (SRS) is a collection of all the requirements for a certain system, for example the water metering and billing system. The SRS gives details on what properties a system must have to satisfy the needs of the systems stakeholders.

To develop a SRS, information had to be gathered from stakeholders of the system. Their needs were then identified together with the system elements which will satisfy them and the requirements were listed following the guidelines from the System Engineering Handbook. (INCOSE, 2004)

In this case, semi-structured interviews were held to obtain the stakeholder requirements.

Maguire and Bevan mention different methods of performing a user requirement analysis. (Maguire & Bevan, 2002) By choosing the appropriate methods and following these, the process shown in Figure 4 was completed.

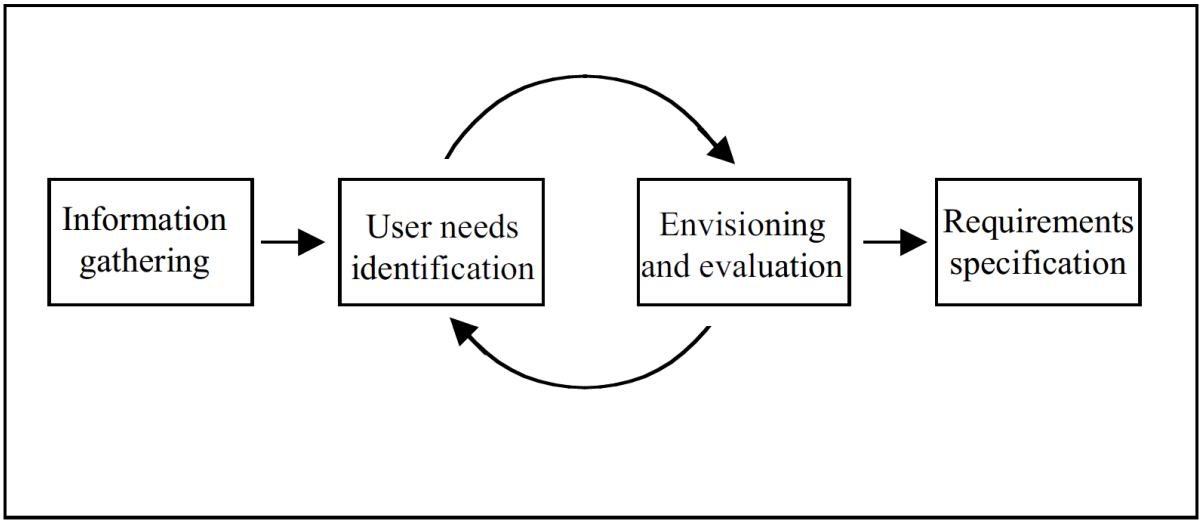

Figure 4: Process for user requirements analysis (Maguire & Bevan, 2002)

3.2.1 Information gathering

The information gathering phase started with a stakeholder analysis. This was to ensure that all relevant stakeholders were considered. The recognised stakeholders

were the manager and foremen from Water & Waste and the Manager of Energy Measurement.

A field study and observation were then done to understand the metering and billing functions in context. Although time consuming the benefit of actually seeing what is done, first hand, made it worthwhile.

3.2.2 Stakeholder needs identification

The stakeholders' needs identification phase consisted of three components to ensure completeness. A survey was done to determine the preferences and concerns of the stakeholders. A weakness of this method is that it lacks in depth comments, but a general idea of the stakeholders' perception can still be formed. See Appendix G for the full questionnaire.

To get more in depth information, interviews were held with the relevant stakeholders. This was done via a semi-structured interview to ensure that the necessary topics received attention, but still allow some leeway in the questioning. The interview was structured according to the guidelines published in Using Structured Interviewing Techniques (Litkowski, 1991).

Finally existing systems were analysed to see what is available on the market and what the popular trends are.

3.2.3 Envisioning and evaluation

An initial set of requirements were drawn up from data gathered during the first steps of the stakeholder requirement analysis. This was presented to the stakeholders for comments and feedback. The stakeholders' feedback on the initial requirements was used to verify and refine the requirements.

3.2.4 Requirements Specifications/Statement

After the stakeholder's feedback was implemented the final requirement statement was developed. The final document includes the design goals and requirements for each part of the system.

Chapter 4: Results and Findings

In the previous chapter the research tools that were developed for and used during the data collection process were discussed. Chapter 4 presents the data from the different investigations.

4.1 Water billing cycle

The BU currently responsible for the measuring and billing of SASOL 1 municipal water users is Water & Waste. They buy water from the local Metsimaholo municipality and then sell it to the users/clients on site. At the end of each month each client is billed according his usage.

Inquiries were made to identify the employees who are part of the water billing system. Three key players were identified consisting of an administrator, a foreman and a process operator. These persons were individually interviewed. The administrator responsible for compiling the water usage file at the end of each month was interviewed and the file she compiles was studied. After several interviews with the administrator, foreman and operator the current practices followed during the metering and billing cycle were reconstructed.

Currently the following actions take place at the end of each month:

1. The main water meters on the site are read by either the foreman or he instructs a plant operator to do it.
2. The readings are taken by hand and noted on a sheet.
3. Some clients read their own meters and e-mail the readings to the foreman.
4. Some clients' usage are not metered but is kept each month on an agreed/estimated value.
5. The foreman sends the e-mailed and gathered information to the administrator near the end of the month.
6. The administrator receives the usage data from the responsible foreman. This can be on any date close to the end of the month. If she does not get the data she must remind him to send it.

7. After the administrator received the data she completes a spread sheet. If the usage of a client for the month differs notably from the previous month, she investigates the reason. It can be the result of a pipe burst, the plant can be in a shut-down or the reading could have been taken incorrectly.
8. The administrator is instructed by the foreman to amend some of the estimated readings to balance the water supplied with the water consumed.
9. The clients are billed for their usage.

4.2 Metering Hardware

At the end of July 2013 the researcher accompanied the water meter reader during his meter reading journey. This was done to analyse how accurate and consistent the readings are done. A datasheet was completed with details on the condition of each meter (see Appendix B: The completed data sheets for all the meters visited).

A graphic summary of the information on the metering hardware follows.

4.2.1 Analogue vs. digital

The meters were categorised into two groups, namely analogue and digital meters. Out of the 15 meters visited only one was a digital meter.

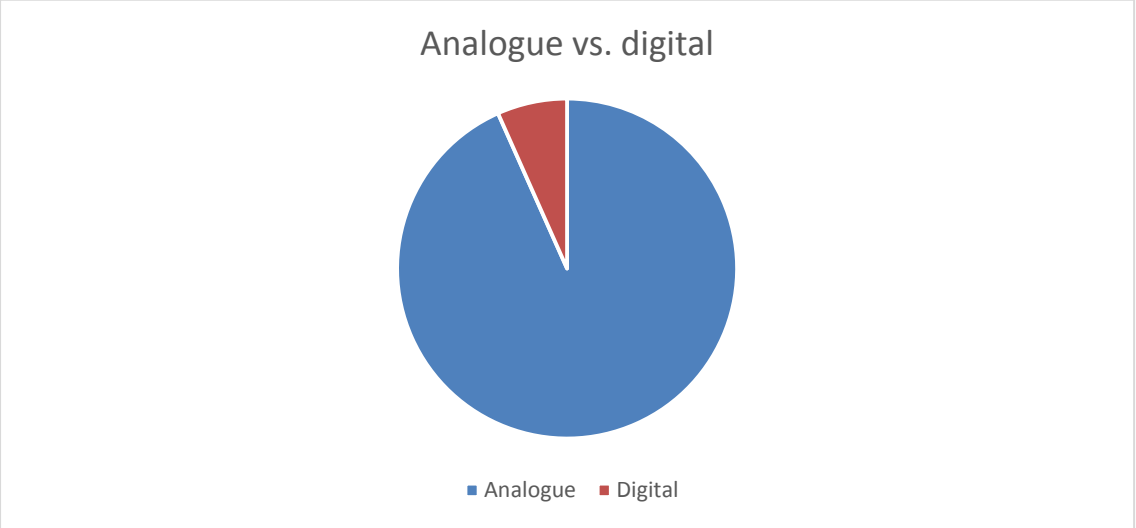

Figure 5: Analogue vs. digital

4.2.2 Meter connectivity

It was noted whether the water meter had any output ports (pulse output) through which the consumption data could be sent other than the main display.

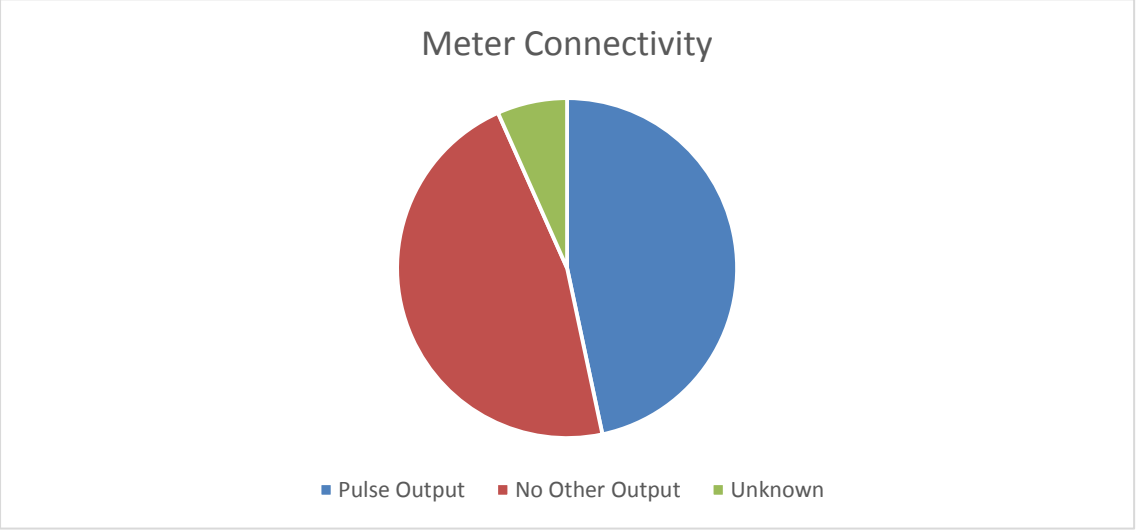

Figure 6: Meter Connectivity

4.2.3 Flooding

If the meter was flooded it was noted.

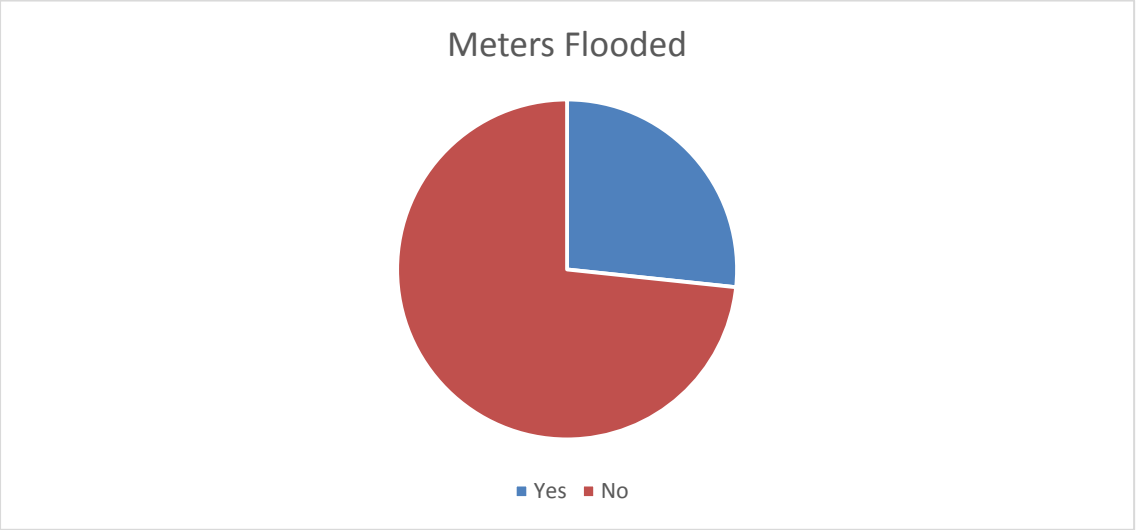

Figure 7: Meters Flooded

4.2.4 Electricity Supply

It was noted whether an electricity supply was available within 20m from the meter.

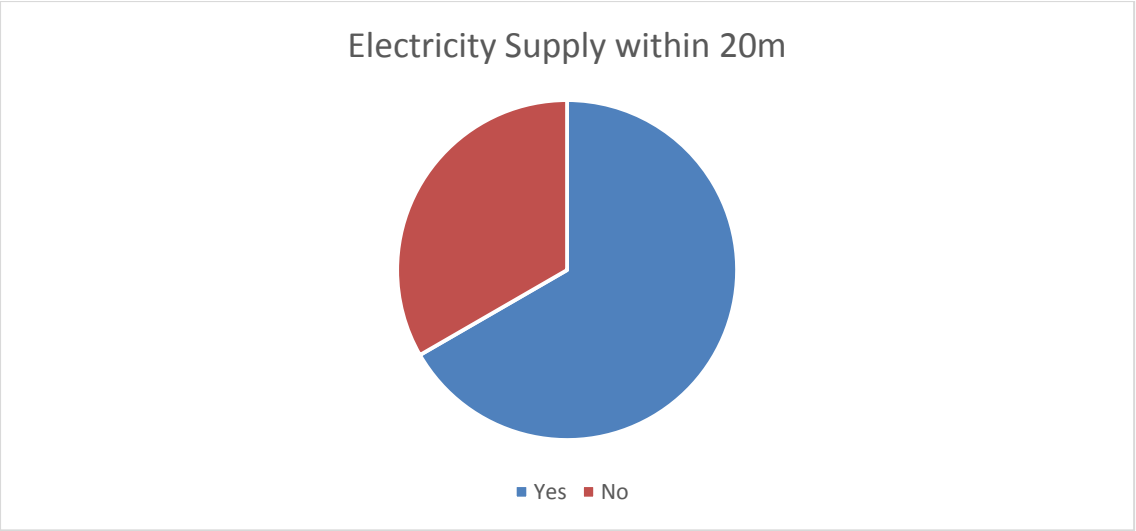

Figure 8: Electricity available within 20m

4.2.5 Network connection

It was determined whether the meter is within range of an access point to the computer network on site.

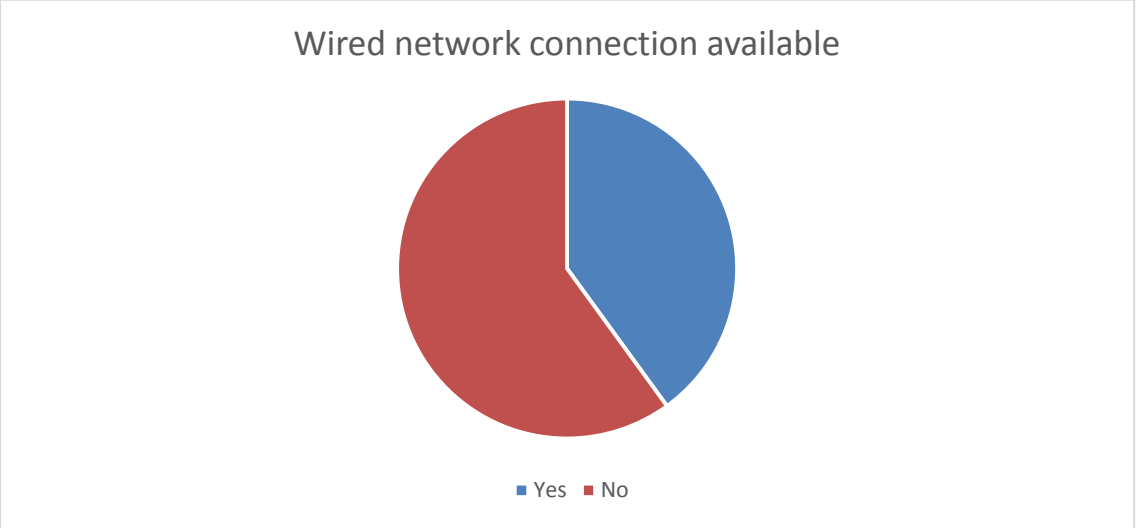

Figure 9: Wired network connection available nearby

4.2.6 Condition of meters

The condition of the meter was rated on its physical appearance.

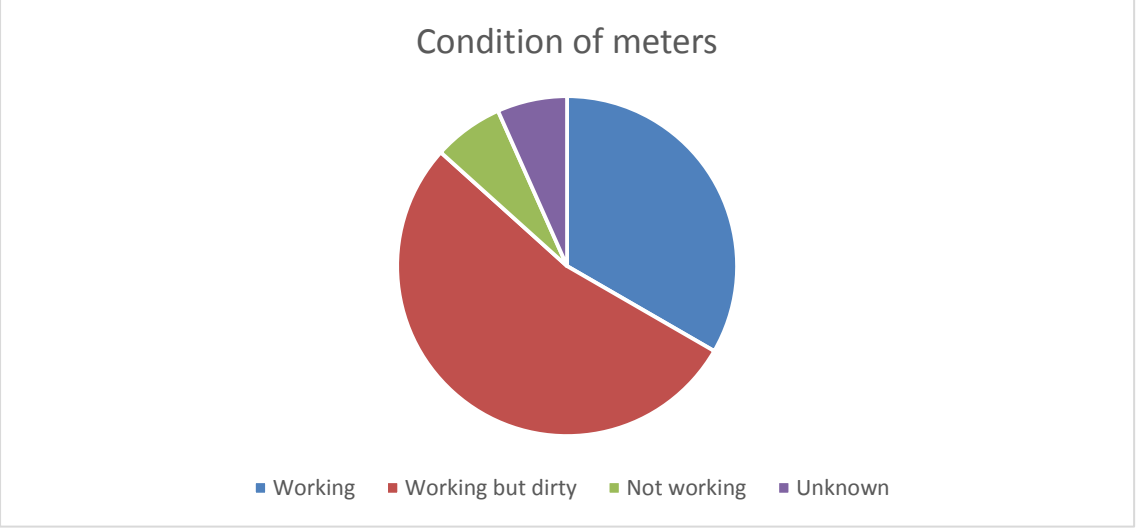

Figure 10: Condition of meters

4.3 Consumer Metering

A list was compiled of all the clients/consumers on the SASOL 1 site who are billed for their water usage at the end of each month. The list is a combination from the monthly water consumer file from Water & Waste and the consumer data on the electronic financial system. (See Appendix D & E)

Of these 46 consumers only the SGEPP - Potable meter (which is a new installation) was read at the end of the month. Four of these consumers send their usage for the month via e-mail to the relevant foreman.

The main water meters measuring potable water from the municipality are the following (see Appendix C: Positions of the main municipal water meters for the location of the meters on a map):

- SASOL 1 Main Meter
- SASOL 1 Ring feed
- SASOL Solvents Building
- Clock Station SASOL 1
- Bio works
- SASOL 1 Res 2
- SASOL1 Power station 2 Main
- SASOL1 Power station 2 Bypass

All these meters (8) were visited and the readings of 7 were taken by hand. The Clock Station SASOL 1 meter was inaccessible, due to it being covered by dirt after civil work in its vicinity.

4.4 SASOL Specifications

The search for a specification was fruitless, except for one result. The only mention of potable water measuring is found in the SASOL Specification: Monitoring and measurement of products, processes or services within Sasol Technology.

This specification specifies that plant water consumption will be *calculated* by the Infrachem Water and Waste Department.

4.5 Water Balance

The goal of the water metering system is to hold each water user accountable for the water they consume. If sufficient water meters are installed in the water network the water flowing into the system will be equal to the amount flowing out of the system.

What is needed is a water balance for the whole SASOL 1 site:

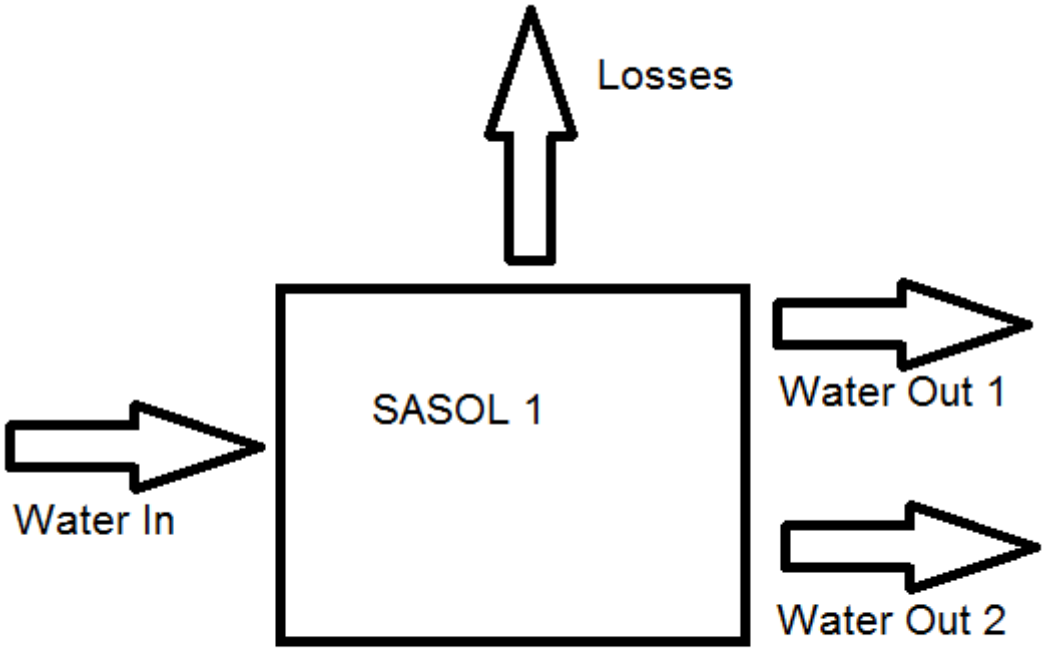

Figure 11: SASOL 1 site water balance

To get to this a water balance must be done for each logical section on the site. Here follows a water balance for the office buildings of the Energy Measurement section.

This section consists of the following water-using elements:

- Bathroom 1
    - Toilet
    - Basin
    - Urinal
    - Shower
- Bathroom 2
    - Toilet
    - Basin
- Bathroom 3
    - Toilet
    - Urinal
    - Basin
- Kitchen 1
    - Basin
    - Hydroboil
    - Water cooler
- Kitchen 2
    - Basin
    - Hydroboil
- Outside
    - Spray irrigation
    - Outside taps x2

In a block diagram the data looks as follows:

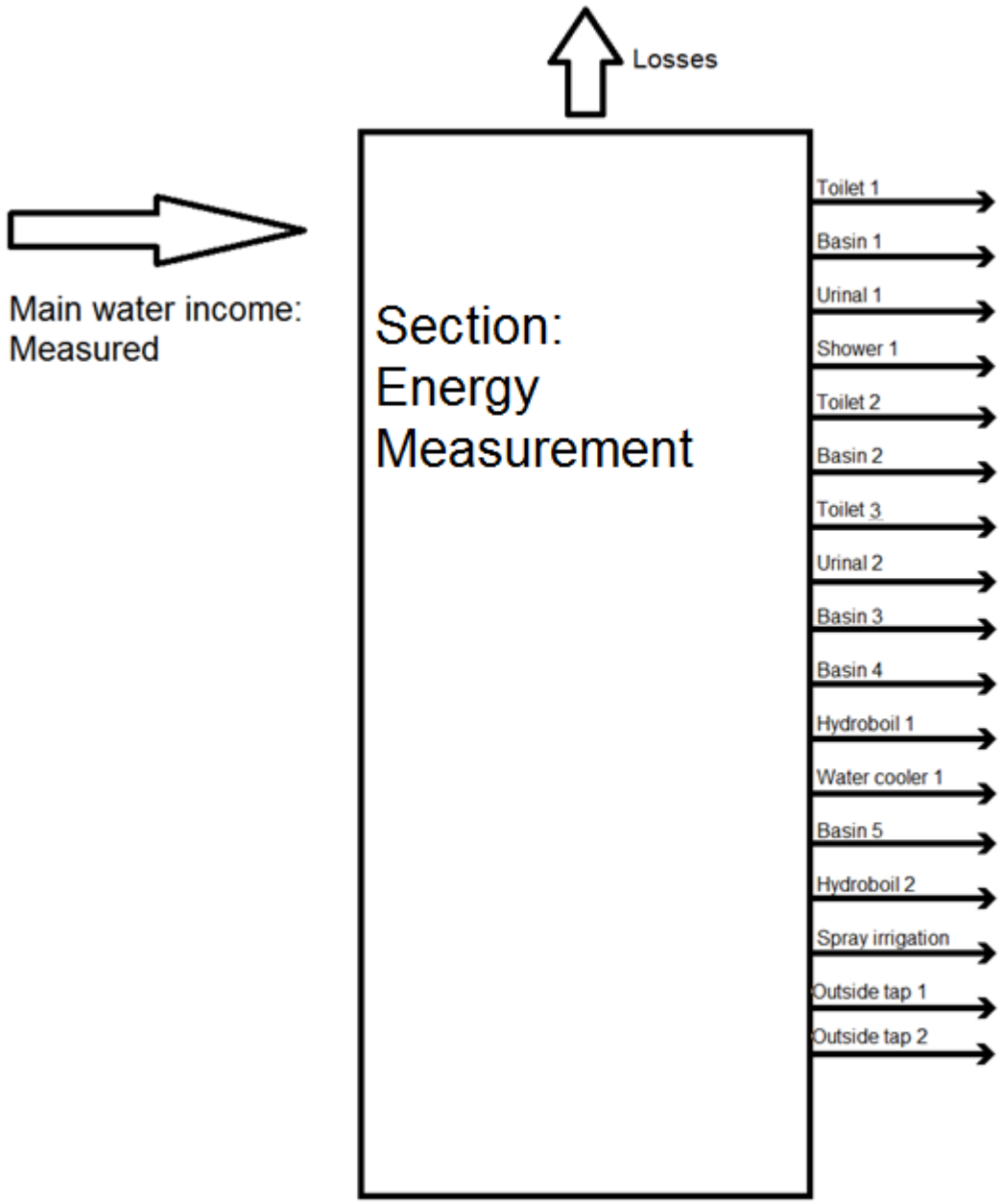

Figure 12: Water balance block diagram – Energy Measurement

The main water income is metered. There are no meters installed on the outflows. Therefore these values will have to be estimated or calculated.

To get to the full site's water balance a water balance must be compiled for each user's facilities, according to the above example. All the balances can then be added to get the full site picture.

4.6 Results from questionnaire

The questionnaire was developed to determine how the stakeholders in the Water & Waste section perceive the metering and billing system. The stakeholder identification process identified the following stakeholders:

Table 4: Identified stakeholders

Section	Stakeholders
Water & Waste	Line manager, foremen, operators and administrators.
Energy Measurement	Line manager, system engineers and system administrators.
Other	Clients being billed for potable water usage

From the group of stakeholders a sample of six were chosen randomly to complete the questionnaire. The data gathered through the questionnaire are graphically displayed next. Refer to Appendix G: Questionnaire for the full set of questions.

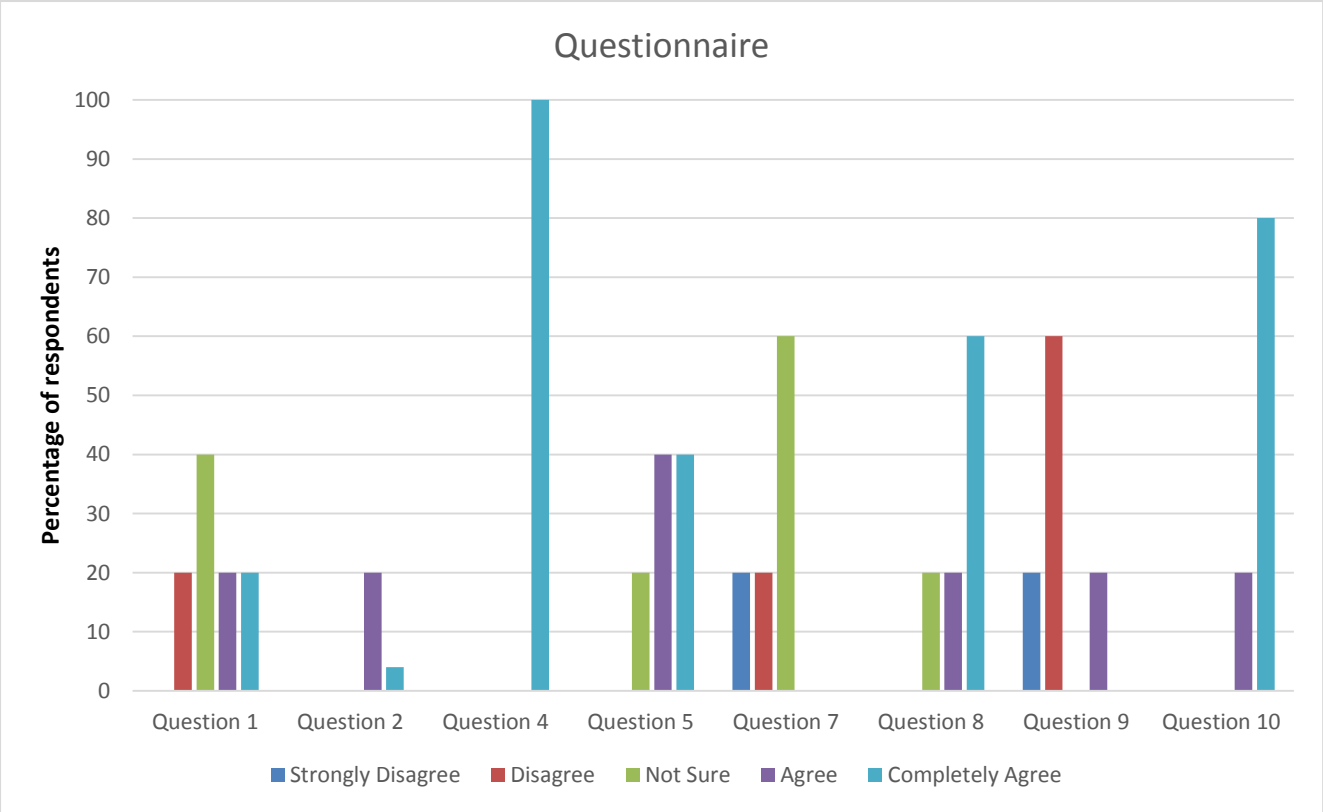

Figure 13: Questionnaire data

Question 3 of the questionnaire asked what will be an acceptable level of unaccounted for water. All the respondents gave an answer of less that 5%.

The replies on Question 6's "At what intervals should consumption data be available":

Table 5: Replies on Question 6

Reply	Percentage of replies
Daily	40
Weekly	20
Real-time	40

4.7 Interviews

Interviews were held with the line manager of Energy Measurement and the manager currently responsible for the billing and measuring of the potable water.

The relevant information from the interviews is listed below:

4.7.1 Current system: Effectiveness

On the effectiveness of the current system both persons commented that it is not very effective, because only the main incoming water is measured and about 10% of the clients. Consumption readings are only available once a month and leaks can only be visibly detected.

4.7.2 Requirements: Scope of measurement

When asked, to what extent metering must take place, the first interviewee replied that the main incoming water must be measured as well as the main tie off points. Thereafter the clients with the largest consumption can also be metered. When asked to clarify his statement he explained that human consumption need not be measured (because it is such a small percentage of the total consumption) only where municipal water is used in the process of the factory.

The other interviewee agreed that the main incoming water must be measured and that each BU's consumption must also be measured, because management of the system is not possible without having meters at each client.

4.7.3 Accuracy

The interviewees were asked what the maximum deviation on the metering system can be. One answer was 5%. The other replied that a water balance must be done to see how accurate the system is and then it must be improved on from there.

4.7.4 Data availability

Data must at least be available monthly for billing purposes, but if any type of water management needs to be done daily or hourly data will be a requirement.

4.7.5 Automatic Meter Reading

Both interviewees reply positively to the implementation of an automatic meter reading system. They stated that it is necessary if water management needs to be done, it will eliminate human error during meter readings and it will make financial sense by saving on water being wasted due to undetected leaks and misuse.

Chapter 5: Discussion and interpretation

5.1 Discussion of results

From the field study, the questionnaire responses and the interviews one fact remained consistent: the current way of measuring the consumption of potable water and billing the users are inaccurate and inconsistent.

The field study showed that the water meters are not being maintained and that only a very small amount of meters are being read compared to the amount of clients being billed. The readings are also being done by hand, which are known to be prone to human error. This was confirmed by both the literature and one of the interviews. The questionnaire also showed that the stakeholders are unsure about the effectiveness of the current system but all of the respondents are sure that an AMR system will be better.

The stakeholder requirements are in line with the SANS 10306 requirements and more than what the SASOL specifications require. This can possibly lead to funding problems if an AMR system was to be implemented. A recent test with a non-intrusive, electronic flow meter showed large amounts of water flow during weekends and after-hours, which could point to mismanaged water or leaks. From a financial point of view, installing the meters will make sense if the savings that can be obtained are more than the cost of implementing the meters.

The interviews showed that the maintenance department only reacts on leaks if it is reported by users. They have no other way of detecting leaks. A system with leak detection will solve this and lead to savings and more user satisfaction according to the literature.

According to the SANS 10306 specifications and other literature the only way to manage leaks and other UAW is through rolling out a metering system. The literature also showed that conservation efforts and user savings are only possible if consumptions are known. To know where to install meters a water balance will have to be done. This will also show what the percentage of UAW is and where additional metering is required.

5.2 Stakeholder Requirement Statement

5.2.1 Independence

From the questionnaire data and the information gathered during the interviews a Stakeholder Requirement Statement was developed. This shows the requirements from the different stakeholders for the potable water billing and metering system. The SRS was developed to be an independent document. This decision was made to enable the stakeholders to verify the content and requirements contained in the SRS on its own.

5.2.2 Verification

The first version of the SRS was circulated to the stakeholders for feedback (see Appendix I: SRS review feedback). The feedback was considered and the SRS was changed to include relevant feedback. The feedback also served as verification of the SRS – proofing its accuracy and relevancy.

The verified SRS is presented next. It serves as a consolidation of the experimental findings and good water management practices that were identified as part of the literature review.

Stakeholder Requirement Statement

For the potable water metering and billing system on the SASOL 1 site

This document addresses the requirements of the potable water metering and billing system on the SASOL 1 site. The requirements are divided into five sections, one section for each of the identified classes of stakeholders.

1.1 Definitions:

- Critical spares - spares which without the system will not be able to operate as usual.
- Non-critical spare – spares which the system can operate without, but not for an indefinite period of time.

1.2 Stakeholder Requirements

1.2.1 Management

a. The system will supply hourly consumption data.
b. Consumption data will be available through a web interface.
c. The system will have customizable alarm capabilities.
d. The system will have leak detection functionality.

1.2.2 Maintenance Department

a. The water meters will be installed in easily accessible areas.
b. Documentation will be supplied describing maintenance procedures on the hardware of the system.
c. Training will be supplied on the maintenance requirements of the hardware.
d. Critical spares will be available on site.
e. Non-critical spares will be available for delivery within 24 hours from the order being placed.
f. The system will be expandable with more meter points.

1.2.3 System Engineers

a. The system will be supplied with the software necessary to run it.
b. The system will consist of individual meters installed at key points.
c. The system will be compatible with repeater towers extending its wireless reach.
d. The system will not interfere with other wireless equipment used on site.
e. The longest time period between the transmissions of consumption data will be an hour.
f. The meters will be able to run from batteries.
g. The batteries will have a lifetime of at least 2 years.
h. On-site system support will be provided by the system integrator.

1.2.4 Administrators

a. The system will store the logged consumption values in such a manner that it is accessible to the ecWIN data management software being used by Energy Measurement.
b. On-site software support will be provided for the system software.
c. Training will be provided to use the system software.

1.2.5 Clients

a. The system will provide a professional looking consumption report for each month.
b. The system will provide a web-based interface accessible by clients.
c. The web-based interface will provide the ability to draw up customizable reports.
d. The web-based interface will provide a customizable dashboard.
e. The dashboard must be customizable with regards to what parameter is displayed, the layout of the dashboard and the measuring units.
f. The system will allow the client to draw reports
g. These reports will be customizable with regards to: time span of report, data to display and manner of display.

1.3 Additional documentation

The system will comply with the following specifications and standards:

a. SASOL specification SP-70-01, Revision 9, Design specification for control systems
b. SASOL specification SP-70-39, Revision 2, Control and instrument equipment numbering and identification
c. SASOL specification SP-70-49, Revision 2, General specification for process telemetry systems
d. SASOL specification SP-90-31, Revision 3, Units of measurement
e. SANS 10306:2010 Edition 1.1 South African National Standard: The management of potable water in distribution systems
f. SANS 1529-1:2006 Edition 2.3 South African National Standard: Water meters for cold potable water Part 1: Metrological characteristics of mechanical water meters of nominal bore not exceeding 100 mm
g. SANS 1529-9:2008 Edition 2.1 South African National Standard: Water meters for cold potable water Part 9: Requirements for electronic indicators used with mechanical water meters, electronic water meters and electronic prepayment water measuring systems

5.3 Conclusion

The SRS addresses the research problem by presenting the findings of the literature review and the experimental work combined in a formally documented list of requirements. The conclusions that were reached throughout the research are presented next, together with the recommendations that are made.

Chapter 6: Conclusions and Recommendations

6.1 Conclusions

The research has brought the following to light:

- The investigation into the current billing process showed that it is inefficient and based on unreliable data.
- It showed that the reading of the water meters are being done by hand and this can lead to errors in the data. The majority of clients (about 90%) are being billed on an estimated consumption value and not on a measured value.
- The investigation into the hardware being used to measure consumption showed that the installed meters are poorly maintained and/or old and that the amount of meters being read on site is insufficient to perform an accurate water balance.
- Without a water balance the amount of unaccounted for water cannot be determined.
- The South African National Standards require that sufficient metering be installed on a potable water supply to determine and reduce unaccounted for water.
- Currently leaks are only detected visually and repaired after it is reported, which results in great water and financial losses.
- The SRS which was developed includes all the requirements from the stakeholders in the water metering and billing process.

6.2 Recommendations

These recommendations follow on the previous findings.

- The SRS must be used as a high level plan to develop and implement a site wide potable water metering system, which can be used for billing, water management and leak detection
- The system should be based on Automatic Meter Reading technology.
  Automatic Meter Reading or AMR systems are the preferred technology on which the water metering and billing system should be based.
  This type of system will consist of smart meters which are installed at the necessary points as indicated by a site-wide water balance. The meters can communicate via cable or wireless technology, but the field study showed that many of the meters are too far away from the physical network to make the wired option viable. For the sake of uniformity all the meters will be of the wireless type.
  A wireless repeater module can be installed on a tower or high structure to ensure reliable communication to even the furthest meters.
- Consumption data will be sent from the water meters to a central server.
  Energy Measurement, which must take ownership of the water metering, have an existing server room and data capacity to handle the water consumption data. A server with sufficient processing power and storage will be allocated to run the water consumption data collection program. An existing data management package, currently being used for the electricity data, will be used to manage the water consumption data.
- The benefit of using the current data management package is that the system administrators are familiar with it and additional training will not be necessary.
- Consumption data will be available on an hourly basis.
  The questionnaire showed that more than half of the respondents feel that weekly or daily data is sufficient. The literature and the interviews indicated the need for water management which requires at least hourly data. This will provide information quick enough to detect leaks and react on it in a timely manner.

- The main water feed from the municipality, the main tie-off points, the biggest consumers and all places where potable water are used in the process will be measured.

  It is highly unlikely that all potable water users' consumption will ever be measured, due to it not being financially viable. Municipal water is expensive therefor the main consumers must be metered. The quickest results can be obtained by installing meters for the 20% of users that are responsible for 80% of the usage.
- Implementing the system will be time consuming, because it is not always possible to close water supplies, which will be necessary if inline meters are to be installed. An alternative will be to install non-intrusive, clamp on meters that work on ultrasonic principles. This has been done for one supply, as a test, and proofed successful.
- Meters will be installed until the difference between the water coming into the factory and the measured water being used is less than 5%.

  The initial water balance will not be within the 5% limit, because of the lack of client side metering. After meters have been installed to the main clients and usage data collected, another water balance must be done. This will show where metering are still lacking, which must then be rectified. This process of doing a water balance, identifying points to be measured and installing meters will be followed until the UAW is within requirements.
- The system will have leak detection functionality.

  If the system is set up to gather consumption data on an hourly basis it will be able to detect leaks in the water network. Sudden high consumption values could indicate a burst pipe if no order for a valve to be opened has been given. Furthermore constant consumption during night times when there should be no flow could indicate a leak. The system must be configured to send out a report to the water maintenance department whenever a leak or burst pipe is detected.
- The management of the AMR system will differ significantly from the current system. The role of the administrator will change to that of data administrator. The person who did the meter readings will be trained to inspect the smart readers on a monthly basis or when a communication failure is detected. A

maintenance plan for the smart meters will need to be implemented with one of the tasks in it the replacement of the smart meters' batteries on a periodical basis.

- Standard Operating Procedures will have to be developed for maintaining the smart meters and performing maintenance tasks on it.
- All stakeholders need to be informed via an information sheet or information session about the new system, its functioning and its advantages. Clients will have to be informed that their billing statements might look different and that they will be paying for actual consumption.
- Water saving initiatives can be launched to assist clients in reducing their usage – the usage which they will be able to track accurately through the new system.

6.3 Recommendations: Further research work

- Develop a water balance for the SASOL 1 site.
- Perform a cost-benefit analysis (against the SRS) to determine which manufacturers AMR solution will be most suitable for this environment.

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Appendix A: Data sheet for water meter information

Water meter information sheet			
			Date
Description			
Manufacturer			
Model			
Type	Analogue	Digital	
Does the meter have any form of output other than the main display?			
Is the meter location flooded or are there signs of previous flooding?			
Is there an electricity supply nearby and how far?			
Is the meter easily accessible?			
What length of cable should be used if an antenna is attached to get it into the open?			
In what condition is the meter?			
General comments			

Appendix B: The completed data sheets for all the meters visited

Water meter information sheet	
	Date 31 July 2013
Description	Sasol One Ring feed.
Manufacturer	George Kent
Model	
Type	Analogue / Digital
Does the meter have any form of output other than the main display?	No
Is the meter location flooded or are there signs of previous flooding?	No.
Are there an electricity supply nearby and how far?	10m away from a lamp pole.
Is the meter easily accessible?	Yes, via stairs.
Is the meter close to a network access point?	No.
How long cable should be used if an antenna is attached to get it into the open?	± 5m to the roof of the structure.
In what condition is the meter?	Working, but dirty.
General comments	

Water meter information sheet

Date 31 July 2013

Description: Sasol Students Building.

Manufacturer: Unknown

Model:

Type: (Analogue) / Digital

Does the meter have any form of output other than the main display?

No.

Is the meter location flooded or are there signs of previous flooding?

No.

Are there an electricity supply nearby and how far?

Yes. 5m. to the nearest offices.

Is the meter easily accessible?

No, it is situated between 2 fences

Is the meter close to a network access point?

The office will have a network point.

How long cable should be used if an antenna is attached to get it into the open?

It is on ground level, in the open ± 2 m.

In what condition is the meter?

Dirty, covered with earth. Working.

General comments

Water meter information sheet

Date 31 July 2013

Description	Sasol One Clock station
Manufacturer	Unknown
Model	
Type	? Analogue / Digital
Does the meter have any form of output other than the main display?	
Is the meter location flooded or are there signs of previous flooding?	
Are there an electricity supply nearby and how far?	
Is the meter easily accessible?	
Is the meter close to a network access point?	
How long cable should be used if an antenna is attached to get it into the open?	
In what condition is the meter?	
General comments	Recent constructions near the meter caused the hole housing it to collapse burying it under 0,5m of ground.

Water meter information sheet

Date 31 July 2013.

Description	Venco Park Main. & Bypass
Manufacturer	Elster & Elster Kent.
Model	
Type	Analogue / Digital

Does the meter have any form of output other than the main display?

Main: No Bypass: Yes, pulse output

Is the meter location flooded or are there signs of previous flooding?

Yes, a leaking valve is flooding the area continuously.

Are there an electricity supply nearby and how far?

16m. to a lamppole.

Is the meter easily accessible?

Yes, but the flooding is making it more difficult.

Is the meter close to a network access point?

No.

How long cable should be used if an antenna is attached to get it into the open?

About 5m to reach the roof of the structure.

In what condition is the meter?

Working but dirty.

General comments

Water meter information sheet

Date 31 July 2013.

Description	Sasol Solvents. Chemcity.
Manufacturer	ABB Kent
Model	
Type	(Analogue) Digital

Does the meter have any form of output other than the main display?

~~Yes~~ No, but it was retrofitted with a pulse output unit.

Is the meter location flooded or are there signs of previous flooding?

No.

Are there an electricity supply nearby and how far?

Yes, 3 m to a junction box.

Is the meter easily accessible?

Moderately, it is in a small hole.

Is the meter close to a network access point?

~~No~~ Yes, 3m to a junction box.

How long cable should be used if an antenna is attached to get it into the open?

1m

In what condition is the meter?

New meter, but already dirty.

General comments

It was found that this meter was retrofitted with a pulse output unit and cabled to a nearby junction box. This was done without the knowledge of Water systems.

Water meter information sheet

Date	
Description	Sasol Wax Chemcity.
Manufacturer	ABB Kent.
Model	
Type	Analogue / Digital

Does the meter have any form of output other than the main display?

~~Yes~~. No.

Is the meter location flooded or are there signs of previous flooding?

No

Are there an electricity supply nearby and how far?

Yes, 6m to junction box.

Is the meter easily accessible?

Yes, mounted in a large hole.

Is the meter close to a network access point?

Yes, 6m to junction box.

How long cable should be used if an antenna is attached to get it into the open?

2m.

In what condition is the meter?

Good, still new.

General comments

A network cable was installed into the hole housing the meter. It was not connected to the meter in any way.

Water meter information sheet

Date 31 July 2013.

Description	Chem city Truck stop.
Manufacturer	Inversys.
Model	
Type	~~Analogue~~ / Digital
Does the meter have any form of output other than the main display?	No
Is the meter location flooded or are there signs of previous flooding?	No
Are there an electricity supply nearby and how far?	No
Is the meter easily accessible?	Yes
Is the meter close to a network access point?	No
How long cable should be used if an antenna is attached to get it into the open?	~ 3m.
In what condition is the meter?	Dirty, working.
General comments	

Water meter information sheet

Date 31 July 2013

Description: Chemcity Main & Bypass.

Manufacturer: Main: Unknown Bypass: Elster.

Model:

Type: (Analogue) Digital

Does the meter have any form of output other than the main display?

Main: No Bypass: Yes, pulse.

Is the meter location flooded or are there signs of previous flooding?

Yes, ankle deep water.

Are there an electricity supply nearby and how far?

No.

Is the meter easily accessible?

No, Underground, access via manhole.

Is the meter close to a network access point?

No.

How long cable should be used if an antenna is attached to get it into the open?

± 6m.

In what condition is the meter?

Dirty, rusted. Bypass: Not functioning.

General comments

Water meter information sheet

Date 31 July 2013

Description: Trees parking Area.

Manufacturer: Elster.

Model:

Type: ~~Analogue~~ | Digital

Does the meter have any form of output other than the main display?

Yes, pulse output.

Is the meter location flooded or are there signs of previous flooding?

No.

Are there an electricity supply nearby and how far?

Yes, office 1m away.

Is the meter easily accessible?

Yes

Is the meter close to a network access point?

Yes, it is next to a security office.

How long cable should be used if an antenna is attached to get it into the open?

3m to get to the roof of the office.

In what condition is the meter?

Brand new.

General comments

It was found that this meter was fitted with a cable to transmit the usage pulses. The destination of the connection is unknown. This cable was installed without the knowledge of

Water meter information sheet

Date 31 July 2013

Description	Sasol Bio works.
Manufacturer	Elster kent
Model	
Type	Analogue / Digital
Does the meter have any form of output other than the main display?	Yes, pulse output
Is the meter location flooded or are there signs of previous flooding?	No
Are there an electricity supply nearby and how far?	Office. 20m away.
Is the meter easily accessible?	Yes.
Is the meter close to a network access point?	Yes 20m.
How long cable should be used if an antenna is attached to get it into the open?	± 2m.
In what condition is the meter?	New.
General comments	The meter is not inclosed and is susceptible to vandalism.

Water meter information sheet

Date 31 July 2013.

Description	Marius Kriel Hoogenboom.
Manufacturer	ABB Kent.
Model	
Type	(Analogue) Digital
Does the meter have any form of output other than the main display?	Yes ~~ABB~~, it has space for a pulse sensor.
Is the meter location flooded or are there signs of previous flooding?	No.
Are there an electricity supply nearby and how far?	No.
Is the meter easily accessible?	Yes.
Is the meter close to a network access point?	No.
How long cable should be used if an antenna is attached to get it into the open?	± 3 m
In what condition is the meter?	Working, good condition.
General comments	

Water meter information sheet

Date 31 July 2013.

Description	Sasol 1 Main.
Manufacturer	KENT.
Model	
Type	Analogue / Digital
Does the meter have any form of output other than the main display?	No.
Is the meter location flooded or are there signs of previous flooding?	Signs of previous flooding.
Are there an electricity supply nearby and how far?	No, small solar panel ±2m away.
Is the meter easily accessible?	Yes.
Is the meter close to a network access point?	No.
How long cable should be used if an antenna is attached to get it into the open?	± 3m.
In what condition is the meter?	Working, dirty.
General comments	This meter was used to test a system whereby a solar powered logger ~~sent~~ retrieved images from a camera mounted above the meter faceplate. and send it via GPRS to a server:

Water meter information sheet

Date 31 July 2013

Description	SGEPP
Manufacturer	Endress + Hauser.
Model	Promass 80.
Type	Analogue (Digital)

Does the meter have any form of output other than the main display?

Yes, the data is send to a digital transmitter.

Is the meter location flooded or are there signs of previous flooding?

No.

Are there an electricity supply nearby and how far?

Yes, on site.

Is the meter easily accessible?

Yes

Is the meter close to a network access point?

± 10m

How long cable should be used if an antenna is attached to get it into the open?

1m.

In what condition is the meter?

Brand new.

General comments

This is a new installation. A small project is underway to connect the transmitters to the computer network via cable and a logger.

Appendix C: Positions of the main municipal water meters

Figure 14: Positions of the main municipality meters.

Appendix D: Municipal water consumers and their usage during May 2013

Table 6: Municipal water consumers and their usage during May 2013

Consumers:		Final Total (m^3)
Ammonia sulphate		0.00
Afrox		10.00
Ash plant		90.00
Atar handling		70.00
NATURAL GAS AFTER COMPR		120.00
BOM: Rectisol E stream		85.00
BOM: Steam Station 1		900.00
BOM: Water cooling system Air Products		745.00
Blending		400.00
Civil Services - J Steinmann		120.00
Communication		40.00
Contractors on site		0.00
Electrical test		20.00
Fire department		20.00
Gasification safe making		35.00
LAB		450.00
Maintenance planning		150.00
Mechanical Integrity		10.00
Merisol, Cresol		167.00

Personnel		2 828.00
Phenosolvan mechanical		0.00
Process Coordination		5.00
SASCON		300.00
SASOL NITRO: Ammonia Plant		102.00
SASOL NITRO: Ammonia Office		226.00
SASOL NITRO: SMX		2.00
SASOL WAX, Parafin		455.00
SASOL WAX, S1400		4 256.00
SASOL WAX, S1600		3 308.00
SASOL WAX, S2200		2 964.00
SASOL WAX, S4200		2 849.00
SASOL WAX, SSBP		2 841.00
SS2 Boiler feed water		213.00
Sasol Polymers, Monomers		2 219.00
Sastech N&O		3 942.00
Security		180.00
Solvents		600.00
Solvents, Methanol Purification		479.00
Steam Station Mechanical		508.00
Stores		500.00
Technical Training		550.00
Thermal Oxidation		45.00
Turbine workshop		65.00

Cobalt Catalyst Plant (Meercat)		25.00
Sasol New Energy - SGEP		128.00
Water Systems balancing figure		0.00
Water to reservoirs		23 700.00
Bio works		951.50
Lapa's Fine ash		951.50

Appendix E: Clients being billed

The following clients/consumers on the SASOL 1 site get billed each month for their water usage (from Water & Waste's monthly consolidated file):

- Ammonia sulphate
- Afrox
- Ash plant
- Atar handling
- NATURAL GAS AFTER COMPR
- BOM: Rectisol E stream
- BOM: Steam Station 1
- BOM: Water cooling system Air Products
- Blending
- Civil Services - J Steinmann
- Communication
- Contractors on site
- Electrical test
- Fire department
- Gasification safe making
- LAB
- Maintenance planning
- Mechanical Integrity
- Merisol, Cresol
- Personnel
- Phenosolvan mechanical
- Process Coordination
- SASCON
- SASOL NITRO: Ammonia Plant
- SASOL NITRO: Ammonia Office
- SASOL NITRO: SMX
- SASOL WAX, Paraffin
- SASOL WAX, S1400

- SASOL WAX, S1600
- SASOL WAX, S2200
- SASOL WAX, S4200
- SASOL WAX, SSBP
- SS2 Boiler feed water
- SASOL Polymers, Monomers
- Sastech N&O
- Security
- Solvents
- Solvents, Methanol Purification
- Steam Station Mechanical
- Stores
- Technical Training
- Thermal Oxidation
- Turbine workshop
- Cobalt Catalyst Plant (Meercat)
- SASOL New Energy – SGEPP
- SGEPP – Potable

Appendix F: Leak sizes and loss rates

Table 7: Leak sizes and loss rates at 500 kPa (SANS 10306)

1	2	3	4	5	6
Leak sizes and losses					
Equivalent size		**Loss**		**Rate**	
mm	dia.	L/min.	L/h	m^3 per day	m^3 per month
0,5		0,33	20	0,48	14,4
1,0		0,97	58	1,39	41,6
1,5		1,82	110	2,64	79
2,0		3,16	190	4,56	136
2,5		5,09	305	7,30	218
3,0		8,15	490	11,75	351
3,5		11,3	680	16,3	490
4,0		14,8	890	21,4	640
4,5		18,2	1 100	26,4	790
5,0		22,3	1 340	32,0	960
5,5		26,0	1 560	37,4	1 120
6,0		30,0	1 800	43,2	1 300
6,5		34,0	2 050	49,1	1 478
7,0		39,3	2 360	56,8	1 700

Appendix G: Questionnaire

Potable water metering and billing: SASOL 1

This questionnaire aims to collect data on the perception that users have on the potable water metering and billing taking place on the SASOL 1 site.

Please answer the questions honestly. The questionnaire is anonymous. The data will be used statistically for research purposes.

The questions can be answered by ranking it as follows:

- 5: I completely agree
- 4: I agree somewhat
- 3: I am not sure
- 2: I disagree
- 1: I strongly disagree

Questions:

1. The current potable water metering and billing system is working effectively and accurately?

1	2	3	4	5

2. It is necessary that each potable water user's consumption be measured?

1	2	3	4	5

3. What percentage of unaccounted for water (UAW) do you think are acceptable? (The difference between incoming and used water)

%

4. An electronic/automatic water metering system will perform better than the current manual (taking readings by hand) system?

1	2	3	4	5

5. An electronic/automatic water metering system is worth the capital?

1	2	3	4	5

6. At what intervals do you think consumer water consumption data must be available?

Monthly	Weekly	Daily	Real-time

7. Taking water meter readings by hand is accurate enough for billing?

1	2	3	4	5

8. Sub metering of potable water usage, down to each consumer, is important?

1	2	3	4	5

9. It is only important to measure our bulk main potable water (from the municipality)?

1	2	3	4	5

10. Potable water metering is an important function?

1	2	3	4	5

Appendix H: Interviewer guide for data flow during billing process

Interviewer Guide: Billing process – Data flow

- **Introduction**
    - Goal of interview
    - Place in this research
- **Background**
    - Position at SASOL
    - Superiors
    - Peers
- **Tasks**
    - Daily tasks
    - Responsibilities
    - Part played in billing cycle
- **Opinions**
    - Complaints
    - Accuracy of process
    - Concerns with billing process
    - Miscellaneous

Appendix I: SRS review feedback

Stakeholder Requirement Statement

For the potable water metering and billing system on the SASOL 1 site

This document addresses the requirements of the potable water metering and billing system on the SASOL 1 site. The requirements are divided into five sections, one section for each of the identified classes of stakeholders.

Definitions:

- Critical spares - spares which without the system will not be able to operate as usual.
- Non-critical spare – spares which the system can operate without, but not for an indefinite amount of time.

1. **Management**

a. The system will supply hourly consumption data.
b. Consumption data will be available through a web interface.
c. The system will have customizable alarm capabilities.
d. The system will have leak detection functionality.

2. **Maintenance Department**

a. The water meters will be installed in easily accessible areas.
b. Documentation will be supplied describing maintenance procedures on the hardware of the system.
c. Training will be supplied on the maintenance requirements of the hardware.
d. Critical spares will be available on site.
e. Non-critical spares will be available for delivery within 24 hours from the order being placed.
f. The system will be expandable with more meter points.

3. **System Engineers**

a. The system will be supplied with the software necessary to run it.

1

b. The software will be Windows compatible.
c. On-site system support will be provided by the system integrator.
d. The system will consist of individual meters installed at key points.
e. The longest time period between the transmissions of consumption data will be an hour.
f. The system will be compatible with repeater towers extending its wireless reach.
g. The meters will be able to run from batteries.
h. The batteries will have a lifetime of at least 2 years.
i. The system will not interfere with other wireless equipment used on site.

4. Administrators

a. The system will store the logged consumption values in such a manner that it is accessible to the ecWIN data management software being used by Energy Measurement.
b. On-site software support will be provided for the system software.
c. Training will be provided to use the system software.

5. Clients

a. The system will provide a professional looking consumption report for each month.
b. The system will provide a web-based interface accessible by clients.
c. The web-based interface will provide the ability to draw up customizable reports.
d. The web-based interface will provide a customizable dashboard.
e. The dashboard must be customizable with regards to what parameter is displayed, the layout of the dashboard and the measuring units.

6. Additional requirements

Rather: system information allow for leak detection, via deviation calculations.

The listed requirements included in this SRS for the water meter and billing system at the SASOL 1 site, with the inclusion of my additional requirements on page 3, are accurate and complete.

Name D. VELDHAGEN Signature

Designation Manager Energy Management Date 5/11/2013

6. Additional requirements

Group items of the same heading/item together
No 4. Administration.

The listed requirements included in this SRS for the water meter and billing system at the SASOL 1 site, with the inclusion of my additional requirements on page 3, are accurate and complete.

Name B. Lamprecht Signature

Designation System Admin Date 5/11/2013.

6. **Additional requirements**

* THE DATA ON THE ECLIPS MANAGEMENT SYSTEM WILL HAVE TO BE AVAILABLE/LINKED TO THE ODS SYSTEM AS WELL. THE AVAILABLE DATA IS NOT ONLY USED FOR STANDARD REPORTING FROM ECLIPS BUT ALSO IN OTHER ACTIONS FOR OTHER DEPARTMENTS NOT LINKED TO ECLIPS.

* WILL THE METERS BE CLAMP ON OR IS THE INTENT TO INSTALL PERMANENT METERING OVER TIME? REASON FOR QUESTION IS THAT THE INTEGRITY OF CLAMP AND METERING MAY BE QUESTIONED FOR BILLING PURPOSES.

The listed requirements included in this SRS for the water meter and billing system at the SASOL 1 site, with the inclusion of my additional requirements on page 3, are accurate and complete.

Name A.A. BOTHA. Signature

Designation PLANNING MANAGER Date 06/11/2013

3

6. **Additional requirements**

None

The listed requirements included in this SRS for the water meter and billing system at the SASOL 1 site, with the inclusion of my additional requirements on page 3, are accurate and complete.

Name DS Makhaulu Signature

Designation Production Manager Date 5/11/2013