Water Footprints for Industry in South Africa

Volume III

Lessons from Industry Case Studies

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Water Footprints for Industry in South Africa. Volume I: Literature Review: Applicability of Water Footprints in South Africa. (WRC Report No. TT 616/14);
Water Footprints for Industry in South Africa. Volume II: Policy and Regulation (WRC Report No. TT 617/14)

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EXECUTIVE SUMMARY

In South Africa and other water-scarce countries, tools which can inform efficiency and raise awareness and create dialogue with people not previously involved in water debates are potentially very useful. Water footprints have the potential to contribute in this way, bringing new and important decision-makers into the water debate in a way that is intuitive and cuts across sectors. Additionally, water footprints create an opportunity for companies to join a global process of disclosure, understand risk and integrate an understanding of water into planning decisions. With this potential, the concept of water footprint has gained significant traction in the past 10 years in the private and public spheres across a variety of sectors. However, water footprint as a tool is still developing and many conceptual and methodological questions remain.

To explore the applicability of water footprints in South Africa, the Water Research Commission has commissioned this project number K5/2099. The purpose of the project is to understand how water footprints may contribute to sustainable management of water in South Africa primarily in the industrial sector, and to explore linkages between water and energy and the concept of water offsetting.

Several reports have been submitted as part of the study. This final deliverable summarises the work carried out to date and highlights the key learning points to be taken away. The final deliverable has been split into three focussed volumes:

- ***Volume I:*** Literature Review
  This volume explores the international experience with water footprints and linkages to carbon footprints and offsetting has been completed as the first deliverable and helped in scoping the project and highlighting key issues which should be addressed.

- ***Volume II:*** Policy and Regulation
  This volume places the water footprinting tool in context with various other water resource management strategies, policies and tools.

- ***Volume III***: Key insights from South African Case Studies
  This volume summarises the key learnings from the South African case studies and makes recommendations for the applicability of water footprinting for the corporate sector.

Presented below is a summary of the findings of each volume:

VOLUME I: LITERATURE REVIEW

The literature review documents the international experience and methods for water footprint, and explores linkages with carbon, energy and offsetting. It also summarises the purposes for which water footprints are being explored in the industrial sector, and highlights questions that must be addressed to use water footprint as a reliable and meaningful indicator.

Water Footprint Methodology and Case Studies

A water footprint is an indicator of freshwater use that considers the direct and indirect water required to produce a product, measured over the full supply chain. A water footprint also considers the origin of the water used, and considers both water quantity and water quality impacts by differentiating between blue-, green- and greywater. The Water Footprint Assessment Manual provides the basic and commonly used water footprint methodology. However, alternative methodologies, such as the life cycle assessment approach which would assign a weighting factor based on water scarcity, are being explored.

Water footprint studies have been completed for a variety of entities, including countries, products, commodities and river basins. The country and river basin footprints focus on informing policy, whereas the product and commodity water footprints focus on understanding supply chain risks. Different potential uses and challenges exist for each type of study.

- ***Country*** – The first water footprint studies focussed on illustrating water flows between countries through trade of industrial and agricultural products. These studies are useful in illustrating virtual water flows into and out of countries. However, the local context of water use must be included to understand the impacts, and challenges arise in framing the water footprint as only one of many environmental, social and economic indicators that must be considered in the context of trade.

- ***Basin*** – Basin-level water footprints have gained focus in recent years, and have been completed for basins including the Nile Basin, the Breede-Overberg River Basin, and several river basins in Spain. Basin water footprints are largely directed to the public sector, with the intent to foster strategic dialogue, inform sector policy and development planning, or inform water allocation. It has, however, proven difficult to sufficiently contextualise the water footprint and to integrate a water footprint with the wide spectrum of public interests or the complex political decision-making processes. Basin-level water footprints have been a useful communication tool for fostering dialogue between diverse sectors.

- ***Product*** – Following country-level water footprints, companies began using water footprints to help understand the footprint of products such as a bottle of Coca-Cola or a cosmetics product. The international review shows that water footprint has different levels of traction for different industries. The food and beverage and textiles sectors are most active with water footprint, as the tool helps to understand significant upstream supply chain risks. Consumer products and the cosmetics, which have significant downstream water implications, are increasingly becoming interested. The chemicals and mining industries have been least active with water footprints. In the studies completed, water footprint is perceived as being useful for understanding supply chain water risk, and for benchmarking and communication. However, there is concern as to whether the greywater footprint is an appropriate representation of water quality. Additionally, understanding the local context of water use, as well as the social, economic and environmental considerations, is critical and difficult task.

- ***Commodity*** – Water footprints have also been studied for global commodities and markets, such as wheat, cotton or biofuels. Commodity water footprints are useful for illustrating virtual water flows through trade between countries, and can help companies understand supply chain risks and make informed decisions. Additionally, commodity water footprints can create transparency and provide information which allows the public to hold companies accountable for supply chain decisions. Again, understanding the local context, including economic and social factors, is critical to understand impacts.

Key Uses and Challenges in the Private Sector

As this project is focussed on the applicability of water footprint to the industrial sector, it is important to understand the key potential uses of water footprint in the private sector and how they may apply in South Africa. Three broad purposes emerge, each having a different level of complexity:

- ***Disclosure and Reporting*** – Using a water footprint as a disclosure and reporting tool, similar to a carbon footprint, is the simplest use of a water footprint because it does not require a full understanding of impacts. The volume of water use is sufficient, without the context of that water use. Water footprint as a disclosure and reporting mechanism is valuable because it presents a more complete picture by considering water use in the supply chain, in addition to direct water use. Reporting can also be used for benchmarking and measuring progress.

- ***Risk Filter*** – Water footprints may be used as a risk filter by understanding supply chain dependencies, and the origin of water used in the supply chain. Using a water footprint as a risk filter is more complex because the impact of water use and the local context of water use must be better understood.

- ***Planning and Decision-Making*** – Water footprints may be able to inform planning, such as decisions regarding where to source supplies or where to build a new manufacturing facility. This is the most complex potential use of water footprints as it requires a full understanding of the environmental, economic and social impacts of a water footprint, and an understanding of opportunity costs and trade-offs.

While water footprints have significant potential to contribute to corporate water management and to integrate water into decision-making, significant questions must still be addressed in order for water footprints to be a reliable and meaningful indicator. Key questions include:

- ***Understanding Impact*** – A water footprint must be rooted in a local context and its local impact understood in order for the water footprint to inform decisions. A meaningful approach to understand impact has not yet been developed, and is a key challenge for the applicability of water footprint.

- ***Water Quality*** – Significant question exists regarding whether representing water quality as a volume of water is meaningful or appropriate. The nature of the water quality impact is lost, as is information which could inform potential responses. Based on the experiences of companies which have explored the use of the greywater component of the footprint, it must be further developed or reconsidered to be useful.

- ***Integrating Complexity and Nuance*** – A water footprint is a number which represents a single consideration. However, the decisions a water footprint is meant to inform are extremely complex and must consider a range of economic, social and environmental considerations. In order for a water footprint to play a role in complex decisions, it must be integrated with the broader context and linked with other considerations.

Offsetting, Carbon and Energy

The differing nature of carbon and water introduces complexities when exploring the potential of water offsetting. Most importantly, it is assumed that carbon emissions have a global impact and may be offset at a global level. Conversely, water is a local resource and must be offset at the local level. Thus, any offsetting effort must track the geographical location of water use through the supply chain and to a point of sale, and must offset in the same geographical location as water use.

While a few water offsetting projects have been initiated, they are still in exploratory stages and many questions arise in these projects. For example, how can geographically-specific offsetting be facilitated, what measures or technologies will be used for offsetting, and what will be the benefit of offsetting? On this last question, a company may offset for good corporate stewardship, or may seek a regulatory benefit such as higher-priority access to water in times of drought.

Finally, water and energy are linked as each is required to provide the other. Additionally, there are often trade-offs between water and energy, where becoming more efficient with one leads to less efficient use of the other. As carbon footprints can represent implications of energy use, carbon footprints and water footprints may be helpful in illustrating and clarifying the connection between water and energy, and understanding trade-offs.

The key potential uses and questions regarding water footprints and offsetting as they apply to the South African industrial sector are framed in this review. A series of case studies on South African companies will be completed to understand the potential of water footprint to contribute to sustainable water resources management and to explore the challenges and questions that must be addressed for water footprints to be a meaningful tool in South Africa. This is further elaborated in Volume II and Volume III.

VOLUME II: POLICY AND REGULATION

Water accounting is a field which has grown considerably in the past few years. Water accounting is carried out by corporates to identify and reduce water-related business risk (and therefore seize opportunities), whether through building competitive advantage, ensuring long-term operational viability, or maintaining and/or improving social license to operate. Water footprinting has been used as one tool through which corporates are able to understand where the majority of their water use (including embedded water use) is situated. Since the development of water footprinting as a water accounting tool, a number of additional tools have been developed which further contribute to a wider understanding of water risks within the context of a particular catchment for example. Water risk tools may have a number of functions which include assessment, disclosure or response to particular water risk concerns. Risk tools may also be focussed internally on corporate concerns, or may have a 'government view' to support regulation. Tools may also play a self-regulatory role when the information is disclosed to competitors for example. This study investigated the applicability of using water footprinting as an accounting method through which water offsetting and neutrality could be achieved.

In response to water-related risks, companies may carry out water offsetting, to negate the impacts of damages done through production. In the case of water, this is further complicated by the spatial and temporal nature of water, which is localised. Offsetting may be required through regulation, or it may be carried out through a form of self-regulation whereby companies try to distinguish themselves from their competitors. Although water offsetting is particularly complex, there are a number of regulatory, social, environmental and business benefits which accrue from carrying out water offsetting. Water offsetting is extensively used to meet a level of water neutrality. Water accounting is required to ensure that the offsetting of water use has been carried out as claimed. Water footprint, as a form of water accounting however, is not the most relevant tool to use. In agriculture for example, the variable water footprints of crops across seasons and regions is too variable to be of use as an exact accounting method.

Water neutrality may be carried out through the use of market mechanisms to offset water use in one region through the investment in water saving or quality improvement in another (nearby) region. This becomes complex however through the recognition of water as a public good, and therefore the commodification of the resource needs to be managed in order to ensure social and environmental requirements are still met. A number of trading mechanisms including payment for ecosystem services, cap and trade and water banking exist through case studies globally. The water offsetting which needs to take place or order to meet neutrality needs to be accounted for. As mentioned previously, water footprint alone cannot be used to determine the volumes of water saved through offsetting measures. Although water footprinting can be used, the footprint needs to be repeated at a number of intervals to gauge the change spatially and temporally.

Therefore, the application of water footprinting to the regulation of water accounting and neutrality is not suggested. Water footprinting is seen as one of many potential alternatives through which water accounting may take place. The decision regarding which tool to use is dependent on the context of the water offset. The National Water Resources Strategy (NWRS 2013) makes mention of the potential for water offsetting to meet neutrality within stressed catchments. However, further investigation is required regarding which accounting mechanisms are best suited to ensure water offsetting is correctly measured.

VOLUME III: KEY INSIGHTS FROM SOUTH AFRICAN CASE STUDIES

The water risks facing private business are growing as the resource becomes increasingly stressed worldwide. Risks include changing water rights, "increasingly stringent water quality regulations, growing community interest and public scrutiny of water-related activities". Business operations are reliant on "healthy water management systems, coherent policies that govern water use, and functioning ecosystems to access water and avoid risk". Internal measures to manage water risks alone (i.e. efforts to reduce water footprints within a company's direct operation and supply chain) cannot eliminate exposure to water risk and uncertainty about water supply. In response to these increasing risks, some businesses have begun to take more "proactive and comprehensive strategic water management actions" and in some cases, reporting these actions to stakeholders and the public.

A range of case studies were conducted to understand the applicability of water footprinting to different sectors using different lenses. The sectors most important to address in case studies include those which are significant water users, have significant water quality implications, and are important to the South African economy. These sectors include:

- ***Agriculture*** – The agricultural sector is the most intensive water user in South Africa in terms of water abstraction and its water footprint. The agricultural sector also plays an important role in the economy by providing rural employment and underpinning much of the economy. The footprint, and the economic and social implications will be important to understand.

- ***Manufacturing*** – The manufacturing sector is the second largest economic sector and has important blue- and greywater implications.

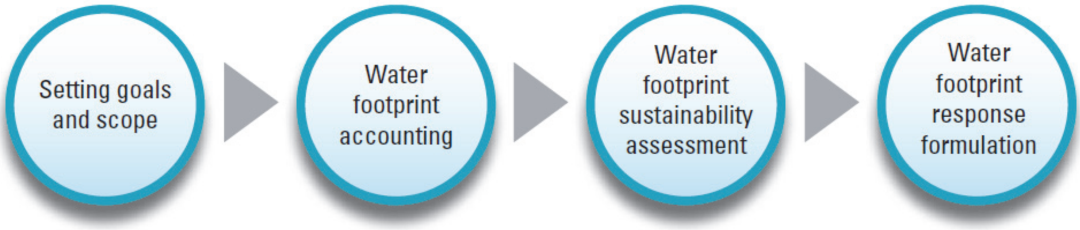
- ***Electricity, gas and water*** – Electricity, gas and water underpin the rest of the economy, and have important blue- and greywater implications. Additionally, the electricity sector offers an opportunity to consider trade-offs between water and energy.

- ***Mining*** – The mining sector is an important economic contributor and has significant water quality implications, for example in the Vaal River system. The greywater footprint with mining will thus be particularly important, and offers an opportunity to consider whether a greywater footprint is an appropriate representation of water quality.

- ***Wholesale and retail*** – Wholesale and retail plays an important role in the economy, including its role in imports and exports. This sector has little direct water use, but is heavily connected to its upstream water footprint for the production of goods and its downstream water footprint from the use of its products. Understanding water risks or opportunities in the supply chain can potentially offer important insights.

Steps to Designing Case Studies

According to the Water Footprint Assessment Manual, a water footprint has the 4 steps shown in the figure below. While these steps provide good guidance for a typical water footprint study, the design of case studies here will diverge slightly from these steps to reflect the project's primary objectives and to stay within the scope of the project.



Purpose

The first step is to identify the purpose or the goal of the water footprint study, as the purpose will determine the scope and methodology of the footprint study.

The 3 potential uses of water footprint which have been discussed are: (1) Reporting and disclosure or internal benchmarking, (2) Understanding supply chain risks or marketing, and (3) Planning and decision-making. Most uses will fall into one of these broad categories. For example, determining the water footprint of upstream supply versus operational processes speaks to understanding supply chain risks, and can be used to determine where to focus water-related efforts to reduce risks.

Identifying the purpose will guide how broad or narrow to make the study, whether to focus on the company or a specific product, and whether to focus on upstream, operational or the downstream footprint.

Scope

Scoping is important to determine the bounds of the study, and to create a study which leads to the intended outcome within the available timeframe and using available resources. The scoping steps should address the following:

- Whether the study will focus on a ***facility, product or company***
- Whether the ***upstream, operational or downstream*** water footprint will be the area of focus, or whether all three will be analysed
- Where to ***truncate the supply chain***, such as whether to consider the footprint of transportation and distribution, or downstream use and disposal of a product
- Whether the study will look only at goods made with ***local*** raw materials, or whether ***imports*** will also be considered. This is important when considering availability and reliability of data.
- Whether the study will include a ***blue-, green- and greywater*** footprint, or whether it will focus on one or two types

The scoping step would normally include whether the study will look at the footprint from a consumption or production perspective. However, the industry focus of this project naturally lends itself toward a production-based approach. A consumption-based approach would be more relevant when determining the footprint of a group of consumers, such as people within a nation.

Methodology for accounting

The starting point for methodology will in most cases be that described in detail in the Water Footprint Assessment Manual. The Manual describes an approach to calculating a blue-, green- and greywater footprint for the following:

- Crop
- Animal product
- Manufactured product
- Commodity
- Consumer or group of consumers
- Nation

For the purposes of the case studies below, the methodologies for crops, animal products, manufactured products and commodities were most relevant.

Questions or Issues to Explore

Questions or issues to explore refers to the methodological and contextual questions which have arisen from the Literature Review and discussion above, such as whether the grey footprint is a good representation of water quality.

In a normal water footprint study, these kinds of questions do not need to be addressed and this step can be left out, unless it is the purpose of the study to do so. These kinds of questions are included in the case study descriptions below because this WRC project is intended to explore water footprint questions through the process of completing case studies.

Sustainability Assessment and Response

The Water Footprint Assessment Manual approach to a water footprint includes a sustainability assessment to understand the environmental, social and economic sustainability of a water footprint. It also includes formulation of a response strategy, which indicates the action that should be taken if a footprint is not deemed sustainable.

These steps will not be comprehensively addressed in the case studies below, as they are in the early stages of development, and are outside the scope of this project. The case studies will, however, summarise the list of responses which have been proposed and may be applicable to the product or industry of analysis.

Using the above design process, the water footprinting tool was applied to the following case studies:

- ☑ Irrigated carrots from the Ceres area, to represent a local irrigated crop
- ☑ Imported beans from Kenya, to represent an imported crop

- ☑ Cheese production in the Western Cape, to represent a livestock-based product with an operational water footprint component
- ☑ Dishwashing detergent produced in Johannesburg, to represent a consumer good with an operational and a downstream water footprint component
- ☑ Manufactured fruit concentrate, to compare the water footprint associated with the growth and processing of different fruits. A comparison was also made between fruits sourced locally and those that are imported.
- ☑ Extraction of coal from a mine, to represent the extractives industry and explore the greywater footprint
- ☑ Combustion of coal to represent the power generation industry
- ☑ Manufacture of products from a chemical facility in the Vaal to highlight the complexities of a large scale chemical plant

Key insights from case studies

Whilst the case studies go into detail about the study itself, the overall learnings are captured below:

Water footprint assessments have rapidly evolved, with several companies and countries having undertaken water footprint assessment. In South Africa, it's mostly large companies with global links that have undertaken water footprint assessment. This could be attributed to the fact that there are still many issues that act as a barrier to the effective uptake of water footprint in South Africa. Some the challenges are related to the following issues broadly:

Institutional, regulatory and policy implications

- The South African water policy does not include the water footprint assessment and its potential for use by large water users. This lack of clarity in the policy framework has created uncertainties in how business should interpret the results of water footprint assessments and its implications on their water use.
- Water footprint assessment methodology places a lot of emphasis on the hydrological aspect, which is a hindrance to effective integration into policy. This is because water footprint assessments are very complex and they are more effective in being used as a metaphor than a metric. There is a need to incorporate economic and ecological aspects of water footprint, to move into a more holistic goal of sustainable development.
- There are different players in the water footprint field, which complicates the issues because of differences in methodological approach (ISO vs WFN). There is need to develop closer alignment of the different initiatives being implemented and align with global processes.
- In many cases there are no clear regulatory framework for disclosure and the reporting of water footprint assessment outcomes, In addition there is no clarity on the application of water footprint tools, for example a company that has undertaken an operational water

footprint might report this as their sole water footprint, even though it does not include their supply chains. Due to the disparity in the application of the water footprint concept, there is a need to agree on an industry wide approach on the application of water footprint approaches. This is partly linked to the fact that some elements of the water footprint such as greenwater are not applicable to some sectors, especially those with no links to agricultural supply chains. For example, for the industrial sector, grey- and bluewater footprints are more pertinent than greenwater footprints.

- Water footprint is a very attractive concept, but it needs to be understood within a specific context. For example labeling of goods and services based on their water footprint can be misleading, because it does not give the full picture.
- Related to water use, companies need to specifically relate their water use efficiency in their annual report. The argument here is that water is at the core of the economy and sustainability, and the private sector particularly large water users have a massive impact on this precise resource. By pushing large water users to be transparent a culture of responsible water use will be fostered.
- There is a need to mainstream water footprint assessments as water resource management tool to enable ease of their application. This is specifically related to the ease of accessing data that is required for water footprint sustainability assessment, which is mostly held by the biodiversity conservation sector. However due to the fact that water footprint has still not been mainstreamed effectively as a management tool, this information is not readily available for application in water footprint assessments.
- Water footprint tools are more suitable as a metaphor than a metric.
- There is a need to push for voluntary disclosure by companies on their water use to aid uptake of water footprint as a management tool.

Methodology

- The natural assimilative capacity of the environment is not accounted for in greywater footprint assessments, as result estimates of the greywater footprint are not very accurate in many cases.
- Difficulties of greywater assessment are partly attributed to the variation in water quality standards and therefore there is a need to standardize accounting framework for greywater. Furthermore, greywater footprint for extractive industry is not well developed and needs further investigation.
- It is important to note that the greywater footprint is different to that of the blue and green, both in calculation and cannot simply be equated. The blue- and greenwater footprints represent volume, whereas the greywater footprint represents impact.

Data and assessment

- Successful application of water footprint tools requires that key decision makers related to water use in the company are involved from the onset. This helps to clarify the purpose of the assessment and to get a high level buy-in from key stakeholders in the company, because outcomes of a water footprint assessment might require a fundamental change in water use by the company.
- Data usage for all stages of the water footprint assessments need to be standardized, to ensure that the same national datasets are used when carrying out water footprint assessment. However, business should not hesitate to undertake a high level assessment if the very fine scale data is not readily availability. The insights gained from such high level assessments are still quite invaluable.
- Water footprint assessments can be very complicated, it is therefore advisable for a company seeking to undertake an assessment to involve expert practitioners to help guide the process to avoid any potential pitfalls.
- Consideration of the contextual issues such as the social, environmental and political dynamics at the point of water use is critical for understanding impact. This is especially pertinent for South Africa, where issues of redress to water access need to be considered, and the fact that water resources are unevenly distributed, as a result the impact of water abstraction is dependent on when and where the water was abstracted.

Greenwater: gross versus net

- The issue here is the difference between natural evaporative demand and evaporative demand of a specific crop. For example if the natural evaporation of natural vegetation exceeds that of a crop, does it imply that the crop has a negative evaporative demand (water saver) compared to the natural vegetation? This poses a major challenge in the interpretation of water footprint assessment.

Impact analysis

- Current methodology for water footprint assessment does not consider the impact of water use in the value chain;
- The local nature of water makes it difficult to effectively understand the impact of water use on local water resources at the watershed level. The use of risk maps so far is the most effective way for assessing where the impact of water use lay in the value chain.
- To effectively understand impact requires the disaggregation of water footprint components. This implies that the interpretation of water footprint is more complex than carbon footprint.

Weighted water footprint

Weighted water footprint assessments have been proposed to reduce the complexity associated with water footprint assessment, but they have major shortfalls as outlined below:

- The use of weighted water footprint was an attempt to reduce and understand this complexity to ensure harmonization across geographic and sectoral boundaries, for effective communication.
- Even though the WF assessment approach ensures that the key elements can be disaggregated (e.g. blue, grey, green, direct & indirect), using a weighting approach that produces a single volumetric figure to assess impact on water resources can be misleading.
- Weighted indicators are difficult to predict for non-physical parameters such as socio-economic and political issues, and opportunity cost of water use. As a result weighting can only be undertaken in a qualitative manner, which is subjective.

Overall, it can be concluded that water footprinting is indeed a useful tool that companies can use as a first estimation of their water use and impact. The major pitfall is the lack of consensus on the use and reporting of the water footprint studies. Companies need to be careful on the reporting of water footprints based just on the numbers, especially for areas that are not well understood and even more critical, on misrepresenting the numbers to suit their outcomes.

Furthermore, the study showed the water footprint data and knowledge base for industries is not well developed, and more work is required to gain confidence in the tool. Going forward, a standardised guide on the use of the water footprint and its application needs to be developed. A starting point would be the updated report that will be released later this year by the Water Footprint Network.

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1. INTRODUCTION

1.1 Background to the Project

The Water Research Commission has commissioned an exploratory study to understand the applicability of water footprints to South Africa. The purpose of the study is to contribute to the understanding of water footprints and water accounting in South Africa, as well as explore the concept and relevance of water neutrality. The study is intended to inform the industrial sector and to contribute to the sustainable management of water resources.

A first Reference Group meeting for this project was held on 23 November 2011. At this meeting the scope of this project and its primary objectives were clarified and agreed upon. The case studies and direction of the project going forward will be guided by these objectives, listed below:

- Understand how to use water footprint in the corporate sector in South Africa
- Explore how to use water footprint as part of a water-energy assessment, including addressing questions of trade-offs
- Explore how to position water offsetting within the context of responses, water risk and policy, and how water footprints may contribute

1.2 Project Objectives

Several reports have been submitted as part of the study. This final deliverable summarises the work carried out to date and highlights the key learning points to be taken away. The final deliverable has been split into three focussed volumes:

- ***Volume I:*** Literature Review

  This volume explores the international experience with water footprints and linkages to carbon footprints and offsetting has been completed as the first deliverable and helped in scoping the project and highlighting key issues which should be addressed.

- ***Volume II:*** Policy and Regulation

  This volume places the water footprinting tool in context with various other water resource management strategies, policies and tools.

- ***Volume III***: Key insights from South African Case Studies

  This volume summarises the key learnings from the South African case studies and makes recommendations for the applicability of water footprinting for the corporate sector.

This report deals with Volume III of the final deliverable.

1.3 Structure of the report

Given the above scope, the purpose of this document is to frame the motivation, approach and key learnings from the water footprint case studies. The document proceeds as follows:

- ***Chapter 2*** provides a motivation for South African corporates to conduct water footprint studies.
- ***Chapter 3*** provides a brief explanation to water footprinting, looking at the key components that make up the study.
- ***Chapter 4*** provides a background on water in South Africa, including a country-level water footprint, water use and water quality information, and a summary of the economy.
- ***Chapter 5*** provides the process and important decisions which must be considered when defining case studies
- ***Chapter 6-9*** summarises the case studies that were conducted.
- ***Chapter 10*** provides key insights and lessons learnt by conducting the range of water footprint studies.

2. MOTIVATION FOR WATER FOOTPRINTING

The water risks facing private business are growing as the resource becomes increasingly stressed worldwide. Risks include changing water rights, "increasingly stringent water quality regulations, growing community interest and public scrutiny of water-related activities" (Morikawa et al. 2007). Business operations are reliant on "healthy water management systems, coherent policies that govern water use, and functioning ecosystems to access water and avoid risk". Internal measures to manage water risks alone (i.e., efforts to reduce water footprints within a company's direct operation and supply chain) cannot eliminate exposure to water risk and uncertainty about water supply. In response to these increasing risks, some businesses have begun to take more "proactive and comprehensive strategic water management actions" and in some cases, reporting these actions to stakeholders and the public (Morikawa et al. 2007).

With water insecurity increasingly being acknowledged by companies as a significant business risk (Orr et al. 2009; Ceres 2010; CDP 2012; Larson et al. 2012), a number of protocols, tools and decision-support frameworks have been developed in order to help understand the nature of the risks businesses face. In most of the initiatives and frameworks, some form of water accounting is included to enable comparison of performance or measurement of progress towards targets. Water withdrawal in volume or consumptive use is generally used (Larson et al. 2012).

The accounting tools, and in particular, water footprints are a good starting point to understand water use per unit product or economic output, and the distribution of water consumption across the value chain of a sector. The numbers alone however do not help in the quantification of risk as they are not able to reflect the local context of the watershed of interest, and thus, water accounting metrics alone are not sufficient in developing a robust water strategy for a company (Larson et al. 2012). A number of tools, including the WWF Water Risk Tool (WWF and DEG 2011) and WRI Aqueduct tool (WRI 2012) go beyond accounting, to assess physical, regulatory and/or reputational business risks (Larson et al. 2012).

The WF concept has influenced business conceptions about water dependencies and risks. By estimating the water footprint of its products a company can gain a better sense of the volume of water that is consumed in their production. Because water footprint accounting includes the water consumed in direct operations as well as in supply chains that provide product ingredients, companies have become more aware of their water dependencies outside of their own facilities and begun to consider the vulnerability of their supply chains.

2.1 Drivers for corporate water footprint accounting

The drivers to why a corporate would carry out water footprint assessment as a water accounting tool are explored. These are separated into three specific risk drivers of physical, reputational and regulatory risk.

This research explores the drivers for corporate water accounting, focusing on water footprinting (WF) as a tool in particular. UNEP (2011) research suggests that businesses consider water footprint a useful framework for understanding their water use. The tool can be used to identify production, facility and/or supply chain "hot spots" of water risk. The WF is seen to be particularly useful in "big picture" strategic planning and helping companies prioritise actions and set targets and objectives for water efficiency.

2.1.1 Marketing and enterprise risk

Due to the increasing awareness on the need to manage water resources sustainably, and consumer expectations, many companies have been motivated to develop better understanding of their dependence on water and the risks they face. Some companies have faced very direct risks related to the sustainability of water supplies, with massive implications on their operations. As a result they have taken steps to mitigate these risks. Investors are also increasingly getting concerned about the water related business risks companies are faced with and are demanding business to demonstrate that measures are being put in place to mitigate these risks.

On the other hand some companies would like to account for their water use purely from a marketing position to create a competitive advantage. Such companies are not faced with direct water related business risks, but rather for strategic positioning. Due to the fact that business operations are having major impact on water resources either through waste discharge into the system or direct competition with other users, society is demanding for accountability. Companies that are seen to be responsible are accorded the opportunity to build their brands.

2.1.2 Reporting and disclosure

Companies are required to report regularly on their activities either internally to inform their strategy or to external stakeholders, such as shareholders, investors and the regulator. Over the years water accounting has become an importing feature in sustainability reporting as water related business risks become apparent. For example many listed companies voluntarily ascribe to initiatives such as the CDP-Water Disclosure Project, which requires them to disclosure their water related business risks. Water footprint assessments become crucial in generating the information required by the companies to report on their activities and the measures that have been put in place to mitigate their risks.

2.1.3 Regulatory environment

From a regulatory perspective companies are also expected to adhere to certain conditions in their water use license such as the quantity of water abstracted and waste discharged. Water use information is required by the regulator in order to monitor water use in a specific catchment or geographic location, information which is provided by the water users including business.

The biggest regulatory risks business face is related to the potential imposition of water restrictions during periods of drought. Effective water accounting and water footprint assessment can help a company to engage with the regulator before any restrictions are imposed. For example that voluntarily implements water efficiency measures, could seek for preferential treatment from other inefficient water users, when the regulator introduces water restrictions. In this way a company can cushion itself against potential water risks, by voluntarily implementing water efficiency measures.
South Africa is in the process of introducing a Waste Discharge Charge System (WDCS) that will require all major water users to pay for their waste discharge. This is going to make water accounting even more pertinent for key water users, to ensure that they operate within the set regulations and to minimize the cost of water use.

Based on the above, it is very clear why water accounting and footprint tools are critical for any major water users that would like to take a proactive stance in understanding and managing their dependence on water. This is more so for the industrial sector in South Africa, that is highly dependent on water for their operations and has a massive impact on the resource as a result of the discharge of waste.

3. COMPONENTS OF A WATER FOOTPRINT

3.1 Blue-, Green- and Greywater

A water footprint contains three components:

- A **bluewater footprint** refers to the volume of surface and ground water required for the production of a good or service, and is the freshwater traditionally thought of when considering water resources.

- A **greenwater footprint** refers to the volume of rainwater used to produce a product which does not run off or recharge groundwater, but is stored in or temporarily on top of the soil.

- A **greywater footprint** addresses pollution, and represents the volume of freshwater that is required to dilute or assimilate the load of pollutants based on existing ambient water quality standards.

Distinguishing between the types of water is important when thinking about the implications of water use. For example, a large greenwater footprint in a water scarce area has different impacts and considerations than a large bluewater footprint in the same area. Additionally, the components are relevant to different industries. A greenwater footprint will be highly relevant to agriculture but irrelevant to industry, whereas a greywater footprint may be more relevant to industry than agriculture. Thus, the case studies will be chosen and designed so that each component of the footprint is highlighted and explored.

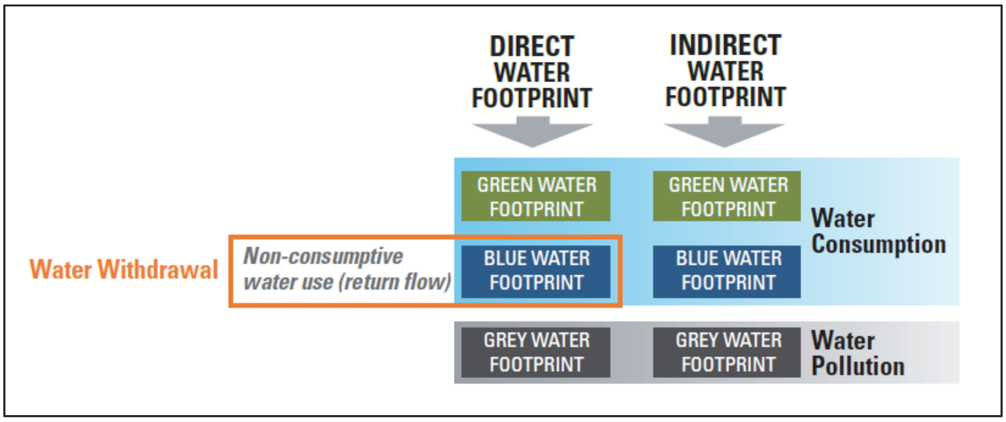

Figure 1: Components of a water footprint (Source: The Coca-Cola Company (2010), based on the Water Footprint Assessment Manual)

3.2 Upstream, Operational and Downstream Footprints

Another aspect of water footprints that will be represented through case studies is the direct component of a water footprint compared to an indirect water footprint. The direct water footprint represents operational water use or discharge, and will be most relevant to mining and manufacturing companies. The upstream water footprint will be most relevant when considering companies with agricultural raw materials such as the food and beverage industry or textiles.

Finally, the downstream water footprint will be most relevant where downstream use of a product has significant water implications, such as in the consumer goods industry.

3.3 Facility, Product and Company Footprints

A water footprint can be conducted for a facility or site, a product, or an entire company. The design of the study and potential uses of the footprint vary with each perspective. The case studies will attempt to illustrate all three of these approaches, while being cognisant that conducting a water footprint for an entire company can become very complex if many products are made. Additionally, questions arise regarding the truncation in supply chain. For example, if conducting the water footprint of a facility, it is not clear whether the footprint should focus only on the operational footprint and that of products made in the facility, or whether it should also consider the footprint of constructing the facility.

3.4 Production, Consumption and Imports, Exports

Finally, a water footprint can consider the water required to make products, or the water required to support consumption. As this project is focussed on understand the application of water footprints in industry in South Africa, it will focus on production rather than consumption.

The case studies will, however, look at both imports and exports as they relate to the water footprint in the corporate sector. Regarding exports, the water footprint of production for different products will be investigated, and the proportion of product which is consumed internally and the proportion exported will be determined. Understanding internal consumption compared to exports will help illustrate the link to internal food security as well as virtual water flows through trade.

The cases will also be chosen to highlight an example of importing of raw materials to make a product. This will enable an illustration of importing virtual water through trade, and the implications that reliance on foreign raw materials may have.

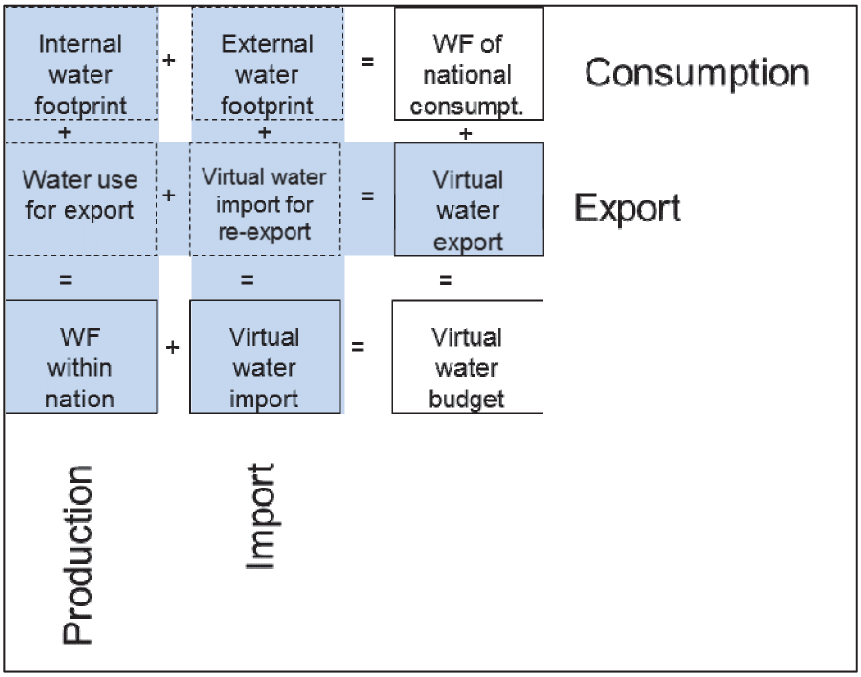

Figure 2: Production/Consumption and Import/Export Water Footprints

3.5 Use, Methodology and Context of a Water Footprint

3.5.1 Potential Uses of Water Footprint in Industry

The potential uses of water footprints in the private and public sectors are still being explored and developed. As described in the Literature Review, a water footprint has the potential for three main uses in industry. Additionally, it is important to distinguish the differing degree of complexity of each of these potential uses, and the questions which arise for each potential use:

- ***Reporting, disclosure and internal benchmarking*** is arguably the simplest potential use because only an understanding of internal operations and supply chain is required. It is not necessary to understand the impacts of the water footprint in particular areas because the focus is on arriving at a number, rather than understanding the impact of that number. Thus, the questions which must be answered relate more to the water footprint methodology itself rather than understanding impacts.

- ***Risk filter or marketing*** is more complex because impacts must be understood in order to understand risk or explain the implications of water use for marketing purposes. The local context of the water footprint throughout the supply chain must be understood for communication and strategizing.

- ***Planning and decision-making*** with water footprints is the most complex potential use because impacts must be understood to a degree of certainty required to support significant investments and long-term decisions. The environmental, economic and social context must all be thoroughly understood.

A significant barrier to using a water footprint for any of these purposes relates to the unanswered methodology or contextual questions which must be better understood in order for a water footprint to be considered an appropriate tool. For example, the representation of water quality impacts as a quantity of water required for dilution has been questioned as an overly simplistic and potentially misleading way to represent water quality. Therefore, before water footprints can be used for reporting or benchmarking water quality, they appropriateness of a greywater footprint must be addressed.

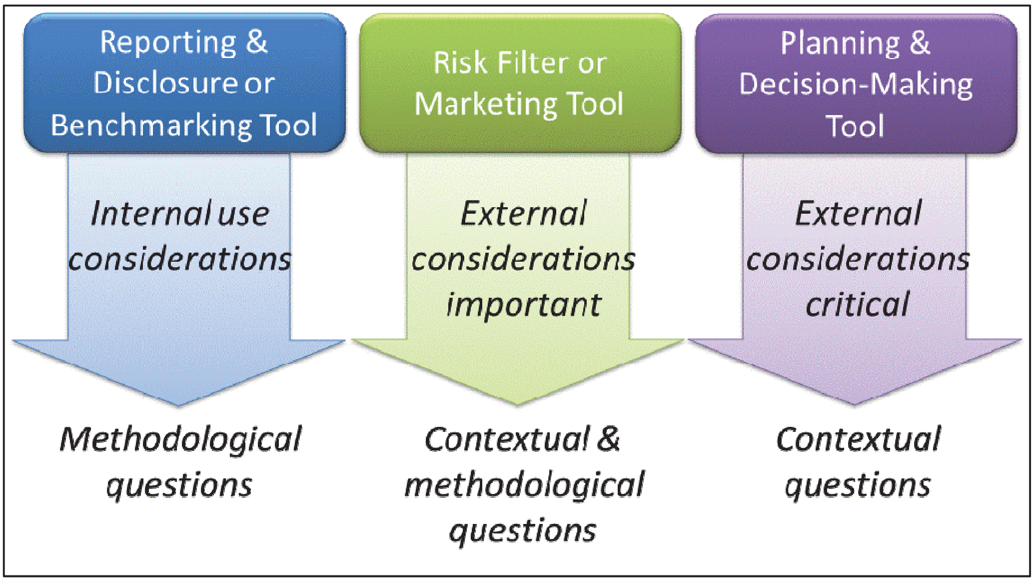

Figure 3: Water Footprint Potential Uses and Key Questions

3.5.2 Methodology Questions

In order for a water footprint to be used for reporting and disclosure or benchmarking, a common methodology must be established which fairly represents the water footprint across a diverse spectrum of sectors and water users. Without a common methodology, reporting and benchmarking is meaningless, and can ultimately be misleading. The Literature Review highlighted the key methodological or technical questions which arise. These include:

- ***Representation of Water Quality*** – Significant questions exist regarding whether representing water quality as the volume of water required to dilute a polluted stream is meaningful or appropriate. The greywater footprint does not consider the type of pollutant or its impact on the environment, so does not enable any kind of response but instead loses valuable information. For both point and non-point sources of pollution, the case studies will explore whether greywater as it currently stands is an effective representation of water quality, and what alternatives may exist.

- ***Net versus Gross Accounting*** – Water footprints currently take a gross approach, looking at the total water used, rather than a net approach which would compare the water use to a baseline condition. This is particularly important in the energy context when comparing biofuels or hydropower, which have significant gross water footprints but much smaller net water footprints, to that of coal. Additionally, it is important in the agricultural sector when considering greenwater use. Considering that water footprints are expanding to being used in a wide range of sectors, the implications of a net versus gross approach should be studied.

- ***Distribution Losses*** – Losses during the irrigation process are not accounted for by the Water Footprint Network methodology, and rather perfect irrigation is assumed. This has important implications when comparing different types and locations of agriculture, and when considering comparative advantages. Agriculturally-focused case studies will explore whether distribution losses should be taken into account, and what the options would be.

- ***Truncation in Supply Chain*** – Where to truncate the supply chain is not clear, and has potentially significant impacts. For example, the Water Footprint Network methodology indicates that the water footprint of consumption by employees working to make a product should not be included in the water footprint for that product. Whether or not this is the most appropriate approach, and the implications of alternative approaches, will be investigated through the case studies.

- ***Access to Data*** – For complex processes and products, accessing data and completing calculations is a resource-intensive process. The realistic ability of companies to conduct footprints, and how to gain the most benefit for the resources used should be further explored.

3.5.3 Impact and Context

Understanding impacts and context is critical when a footprint is to be used to represent risks or make decisions, and thus a water footprint cannot easily be used for these purposes until an approach to understanding context is developed. The key questions relating to understanding impact and context which must be explored with the case studies are:

- ***Local Impact*** – As water is a local resource, a water footprint must be rooted in a local context. However, a meaningful approach to understanding a water footprint in its local context has not yet been developed. The case studies will pay particular attention to developing a clear understanding of local context, and in the case of the Western Cape region, will seek to link the water footprint of products to the water footprint of the basin.

- ***Complexity of Environmental, Social and Economic Considerations*** – When making decisions or considering risk, a number of economic, social and environmental factors must be considered of which water footprint may be one. How a water footprint may be presented and considered alongside these other factors, rather than being presented as a stand-alone measure, will be explored.

- ***Trade-offs, Opportunity Cost and Comparative Advantages*** – A water footprint can contribute to decision-making, but only if the trade-offs and opportunity costs of alternatives are considered. How one may understand trade-offs will be explored, particularly as it relates to carbon and water as discussed below.

3.6 Water, Energy and Carbon

A final set of issues of particular interest in this project are the linkages between water, energy and carbon.

3.6.1 Energy, Carbon and Water Trade-Offs

A first issue to explore through the case studies in this category are potential trade-offs between carbon, energy and water. Water and energy are linked in that they are both required to produce the other. For example production of hydropower and extraction of coal require water. Additionally, energy is required to move and treat water. Thus, the use of either has implications for the other. Additionally, water and carbon are linked as carbon is often a direct by-product of energy production.

The trade-offs between energy and water, and between carbon footprints and water footprints, will be explored in the case studies. As energy and water are both valuable resources, the linkages between them in energy production and industrial processes will be understood. Additionally, energy and industrial processes may include a trade-off decision between water use and carbon emissions, such as is the case in wet and dry cooling. Case studies focussed on energy and industry represent a good opportunity to explore the potential to use carbon and water footprints to understand such trade-offs.

3.6.2 Offsetting and Institutions

The second issue related to water, energy and carbon is whether an offsetting mechanism can be used with water in a similar way as has been done with carbon. The main difference is that water is a local resource and use has local impacts, whereas carbon may be considered on a global level.

The key questions to address are:

- How can water offsetting be effective, given the local nature of water?
- What will be the benefit of offsetting to the entity supporting offsetting efforts?
- What institutional structure will support such an offsetting mechanism?

Two types of offsetting have been discussed. Social responsibility offsetting would include efforts to offset water impacts to support the environment and society, without having a direct benefit back to the offsetting entity. Regulatory offsetting, on the other hand, would facilitate offsetting in a way which provides a direct benefit to the offsetting entity, such as a higher guarantee of supply during a drought period. Interest in regulatory offsetting was expressed most strongly by the Reference Group. Potential frameworks for regulatory offsetting, including a company working with a local government to save water in municipal water supply, will be explored in at least one case study.

4. THE SOUTH AFRICAN CONTEXT

To further support the exploration of how water footprints can be applicable in South Africa, several case studies were carried out. These case studies were structured to reflect the sectors with the most significant water implications, as well as sectors with important economic and social impacts.

This section will introduce water use and water quality in South Africa and additional insight will be added, and comparisons made, by providing an estimate of the water footprint in South Africa. Finally, the contribution of economic sectors in South Africa will be summarised.

4.1 Water Use and Water Quality

4.1.1 Water Use

Water resources management tools quantify the water use according to water abstraction requirements. The total water requirements for South Africa in the year 2000 were 12 871 million m^3 per year (DWAF 2004). By sector, 62% of water requirements are for irrigation in agriculture, 27% is for urban use, 8% is for bulk industry and power generation and 3% for forestry.

Total available yield in 2000 was estimated to be 13 227 million m^3 per year, meaning water use requirements in the near future can be met (DWAF 2004). However, water availability is a concern in South Africa and meeting demand has historically and will continue to require significant infrastructure investments, demand management and protection of water resources.

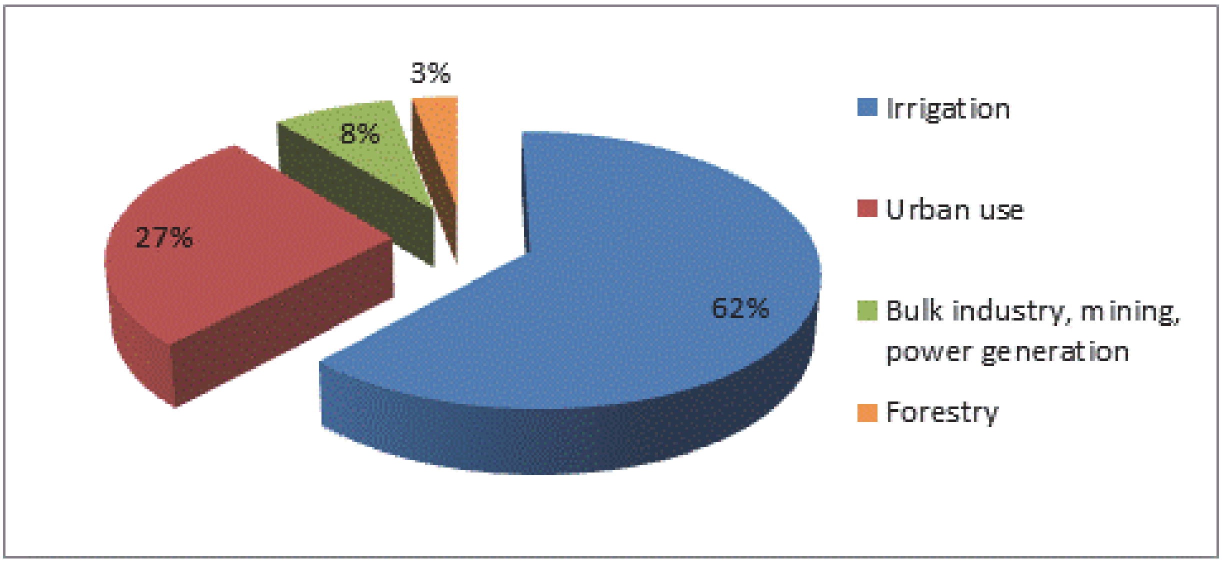

Figure 4: Water use by sector in South Africa in 2000 (Source: DWAF 2004)

4.1.2 Water Quality

Water quality issues also present a challenge for managing water resources in South Africa going forward, and are an important consideration to maintaining a sustainable water supply. Industrial discharge, urbanisation and sewage discharge, agricultural use of pesticides and herbicides, and generally more intensive use of water resources can all introduce water quality problems. The Department of Water & Sanitation (previously known as Department of Water Affairs) runs several national water resource quality programmes in South Africa to monitor water quality indicators including eutrophication, microbial levels, salinity levels, and levels of other key chemicals. Water quality becomes linked to water availability because water quality issues can often be managed through treatment or dilution, and while dilution is often less expensive, it can significantly reduce the quantity of water available for other uses.

Water quality issues vary by geographical area, and the nature of activity occurring in that area. Figure 5 highlights key water quality concerns throughout South Africa. The case studies selected impact the Vaal River System and the Breede River System, two economic significant regions in South Africa. The key water quality challenges for these areas which will inform the greywater analysis in the case studies are:

- ***Vaal River System*** – *Major water quality issues include acid mine drainage from active and defunct mines, untreated domestic and industrial effluent, discharges from urban and industrial effluents, and the contribution of inorganic and organic compounds into the Vaal River from heavy industry (CSIR 2010).*
- ***Western Cape Breede River System*** – *Major water quality issues are elevated concentrations of dissolved salts from intensive agricultural land-use, and irrigation return flows containing fertilizers and pesticides (CSIR 2010).*

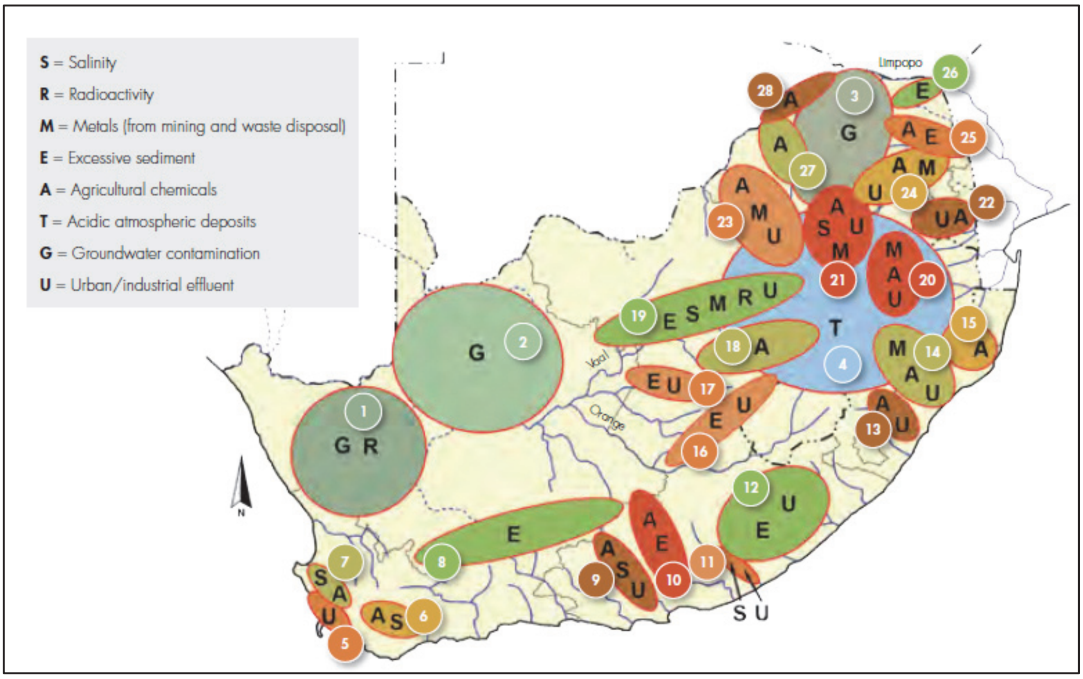

Figure 5: Summary of water quality issues by geographical area in South Africa (Source: CSIR 2010)

4.2 South Africa's Water Footprint

Understanding the water footprint of South Africa can provide a slightly different perspective on water than is given by a water resources management approach. This is because a water footprint incorporates rainwater use in addition to surface water, and presents water quality as a greywater footprint. A water footprint also considers the water necessary to support consumption as well as production and can identify the virtual water included in goods imported or exported, helping to illustrate the water implications of trade.

4.2.1 Production Water Footprint

The water footprint estimated at a global level by Mekonnen and Hoekstra (2011) for South Africa is shown in Figure 6, with the following components:

- Over 75% of the footprint is associated with greenwater. The greenwater is primarily used in crop cultivation, forestry or to produce animal feed for livestock.
- The bluewater footprint is about 7 billion m^3 per year, the vast majority of which is used in crop cultivation, with the remainder in urban, industrial and livestock watering.
- The greywater footprint is about 6 billion m^3 per year and is largely attributable to crop production and urban-industrial waste water discharge.

To be used at a national level, these numbers and the sector contributions require significant revision, because they depend upon global rather than national data sources.

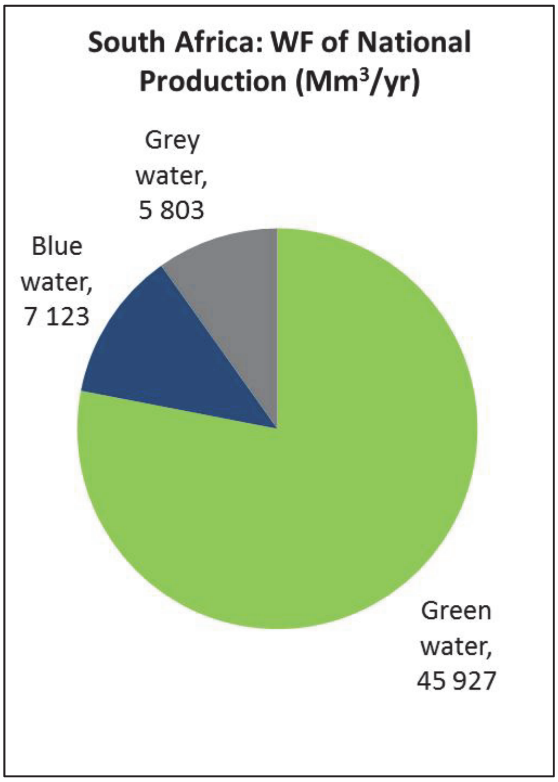

Figure 6: Production water footprint for South Africa

Distinguishing Water Footprint and Water Abstraction

The overall water footprint is significantly higher than the 13 billion m^3 of water per year of water use requirements identified by the DWA. This is because the footprint takes into account green- and greywater, in addition to the bluewater which represents surface and ground water. Water requirements identified by the DWA are most closely linked to the bluewater footprint.

However, the bluewater footprint is significantly lower than the water use requirements on the country's water resources. This is because the bluewater footprint represents the evapotranspiration associated with making a product, beyond what is available from the effective rainfall. The water footprint excludes return flows and assumes perfect irrigation, not including distribution losses and inefficiencies. The bluewater footprint and the water requirements estimated by the DWA can be checked against each other by considering typical efficiency of water use and return flows. Of the 13 billion m^3 of water per year estimated by the DWA, approximately 60% (7.8 billion m^3) of that water goes toward agriculture and 40% (5.2 billion m^3) toward industrial and urban use. It may be assumed that average agricultural efficiency is about 60%, and average urban and industrial return flows are approximately 50% of the total water abstracted. Thus, the evaporation losses (bluewater footprint) from agricultural use may be estimated as 4.7 billion m^3, and from urban and industrial water use as 2.6 billion m^3. These represent the bluewater component of water footprint, which results in an estimate of water used and not returned to the system of 7.3 billion m^3 of water per year, which is similar to the estimated bluewater footprint.

Green-, Blue- and Greywater Implications

To properly understand the meaning of the water footprint, the green, blue and grey components must be considered individually rather than added together and considered as a whole. This is because each component is different in nature and has different implications for water resources.

The greenwater footprint must consider the impact of rainwater use at a local level in order to inform water resources management. To understand the impact on water resources, the greenwater footprint of developed land in a geographical area should be compared to the greenwater footprint of the natural vegetation. This will give the net greenwater footprint, and indicate the potential water resources impact of the developed use of land. Additionally, consideration of potential alternative uses of greenwater, such as alternative crops which may be grown, can help link the greenwater footprint to economic, social and security implications. On the other hand, greenwater is directly related to climate variability and change, which may imply vulnerability.

The bluewater footprint must also be understood at a local level, and should be framed in the context of water availability and water requirements for environmental, social and economic use. Although the bluewater footprint as a number is significantly smaller than the greenwater footprint, its implications are potentially larger as the distribution of bluewater can be more easily by human actions. As decision-makers can control and manage distribution of bluewater, trade-offs between competing uses should inform bluewater discussions.

Finally, the greywater footprint must be further broken down to understand its implications. The greywater footprint is a theoretical representation of the quantity of water in the receiving water body that may be required for its dilution to an acceptable target level, regardless of the type of contaminant. It should be noted that greywater footprint is more in line with the ecological (land) footprint philosophy, in that it is the equivalent receiving water body water required to assimilate waste. For the grey footprint to have meaning and to understand the impact, the type of pollution must be identified, which will again require analysis at a local level. Although the greywater footprint is the same size as the bluewater footprint, its impacts may be more severe in a given location, depending on the type of contamination and geographical location.

4.2.2 Consumption Water Footprint

Unlike a traditional water resources management approach, a water footprint also can illustrate the water required to support consumption. The water footprint for consumption in South Africa is shown in Figure 7. It includes two components: (1) water used within South Africa to produce the goods consumed in South Africa, and (2) water used in other countries to produce goods which are imported and consumed in South Africa.

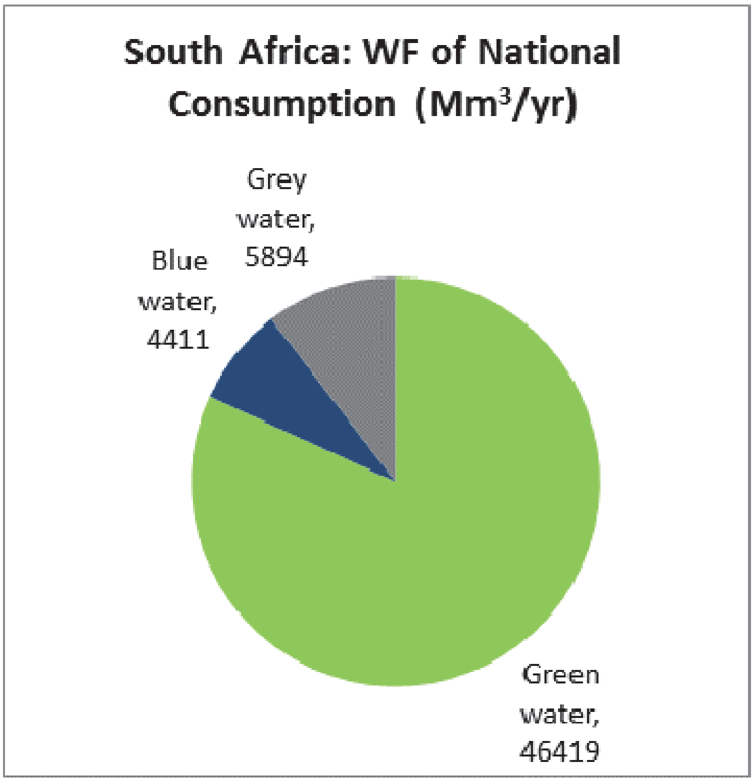

Figure 7: Water footprint of consumption in South Africa

A water footprint for consumption is helpful to understand water requirements to support the consumption patterns in a country, and to provide awareness to the population. It also provides insights on food and water security, as it can be seen whether a country relies on internal production or external production and trade to support consumption. This import and export perspective is further discussed in the next section.

The water footprint for consumption in South Africa is fairly balanced with the water footprint of production, except in the case of bluewater. South Africa's bluewater consumption requirements are approximately 4 400 million m^3 per year whereas its production bluewater footprint is over 7 000 million m^3 per year. This means that South Africa is a net exporter of bluewater.

4.2.3 Water Footprint of Imports and Exports

The data used to show the water footprints of production and consumption can be combined to directly illustrate the flow of virtual water through trade. Figure 8 shows the virtual water flows through the import and export of goods, and the net virtual water imported. South Africa is a net virtual water importer of green- and greywater, and a net virtual water exporter of bluewater.
With the significant exchange of virtual water through the trade of goods, and the importance of trade as it relates to economic and security issues, virtual water imports and exports through trade should be addressed by the case studies.

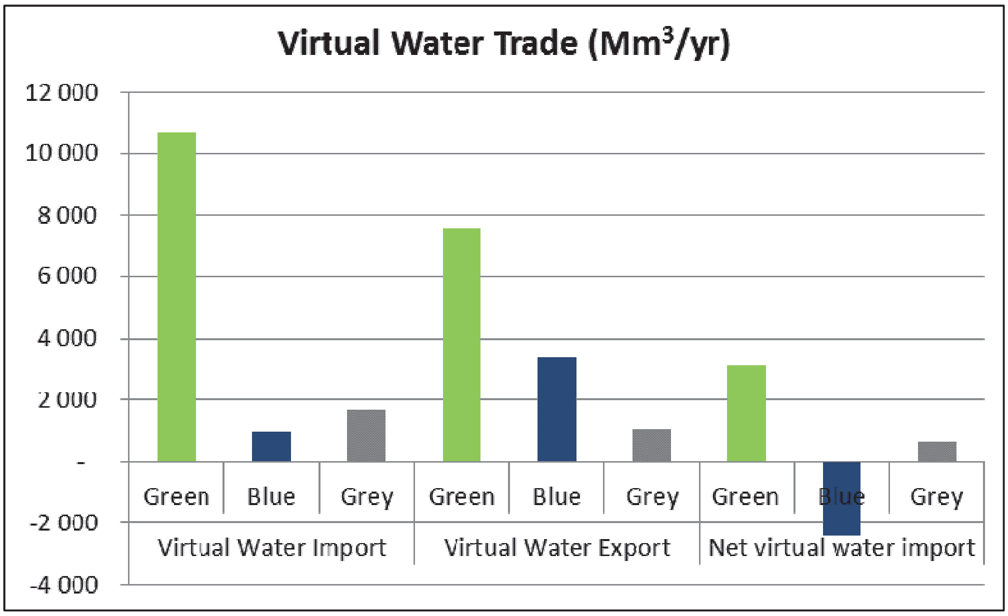

Figure 8: South Africa's virtual water trade

Focussing on exports can shed light on which products account for exported virtual water. For example, the net export of bluewater is largely attributable to the export of crops. Further work must be done to break down which types of crops contribute to the net export of bluewater, and to understand the economic value of these exports. Where appropriate, the virtual bluewater exported through crops will be discussed in the case studies.

Although South Africa is a net importer of green- and greywater, it does export both types through trade in crops, animal and industrial products. To understand the greywater implications of exported products, the nature of the greywater footprint must be unpacked. For case studies which have significant greywater footprints, the distribution between local and foreign consumption of the goods can be understood to begin building the picture of greywater impacts of exports.

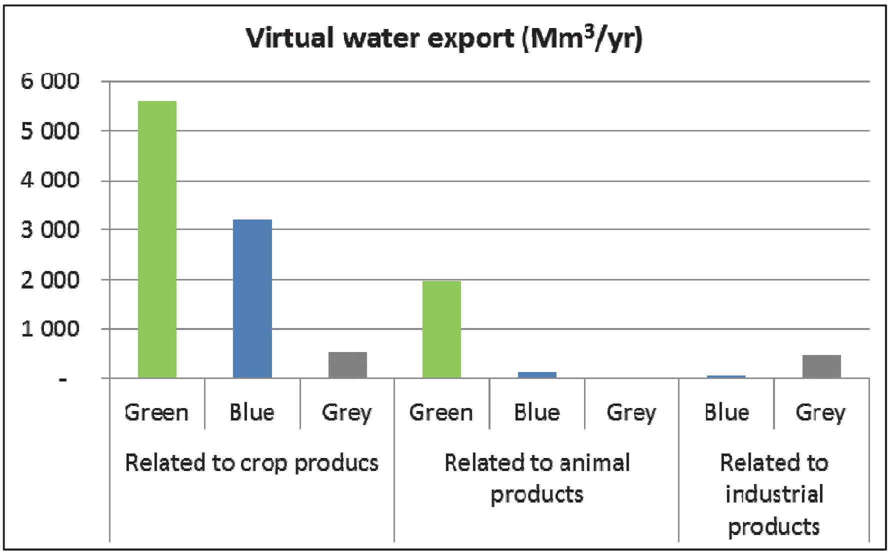

Figure 9: South Africa's virtual water exports

Focussing on imports shows that South Africa imports greenwater through crop product imports, and greywater through crop products and industrial products.

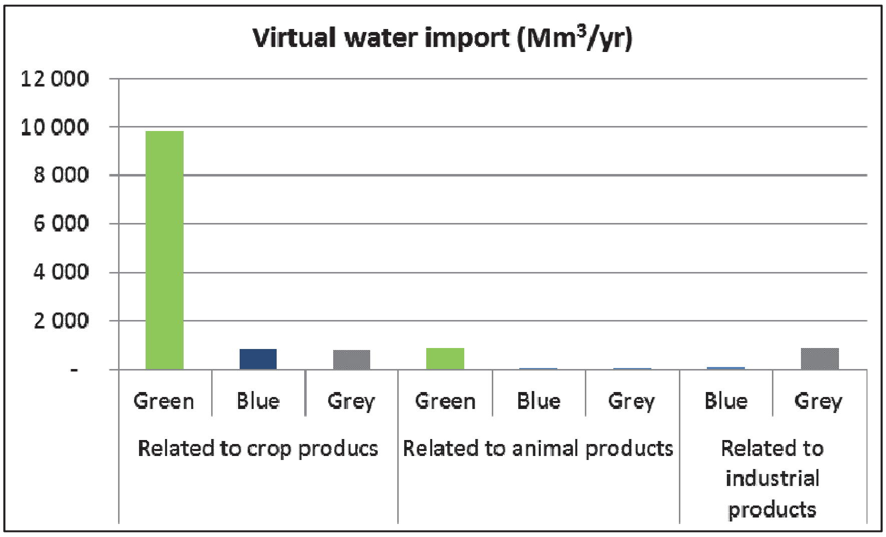

Figure 10: South Africa's virtual water imports

4.3 Economy of South Africa

Finally, the economic and related social implications of different industries should be considered when choosing case studies. Figure 11 provides the percentage GDP contribution by sector in South Africa. Financial and business services is the largest sector at 24%, followed by manufacturing at

17%, government services at 15%, and wholesale, retail, motor trade, catering and accommodation at 13%. Besides manufacturing and agricultural components of wholesale and retail, the largest economic sectors represent the tertiary economy, and are not significant direct water users. While it would be interesting to complete a study to understand the consumption water footprint of the employees of these sectors, that will not be the focus of this project as employees are currently considered outside of the boundary when considering the water footprint of a company (although this assumption may be challenged at a later time).

The larger focus will be on the primary and secondary economies both because these are the more significant water users and these sectors underpin much of the rest of the economy. For example, much of the wholesale and retail, or financial and business services, exist to facilitate the agricultural or mining sectors. Additionally, industries such as agriculture and mining are important in supporting rural communities and small towns, and are critical in providing employment. Thus, they play an important role in the South African economy and its social development. Finally, industries such as agriculture and energy are critical to national food and energy security considerations.
The primary and secondary sectors of the economy that will be focussed on are agriculture, fishing and forestry, which contributes 3% of the GDP, electricity and water at 2%, mining and quarry at 6%, wholesale and retail at 13%, and manufacturing at 17%.

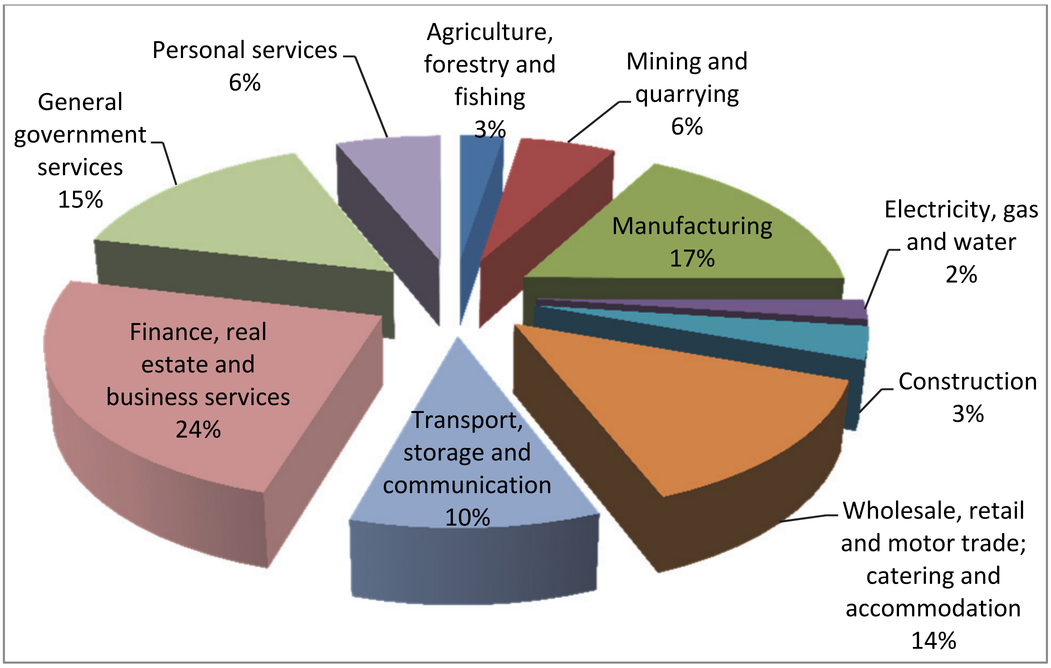

Figure 11: Contribution to GDP by sector in South Africa in 2013 (3rd quarter)

4.4 Sectors to Study

To summarise, the sectors most important to address in case studies include those which are significant water users, have significant water quality implications, and are important to the South African economy. These sectors include:

- ***Agriculture*** – The agricultural sector is the most intensive water user in South Africa in terms of water abstraction and its water footprint. The agricultural sector also plays an important role in the economy by providing rural employment and underpinning much of the economy. It is important to understand the greenwater footprint, and the economic and social implications of this sector.

- ***Manufacturing*** – The manufacturing sector is the second largest economic sector and has important blue- and greywater implications.

- ***Electricity, gas and water*** – Electricity, gas and water underpin the rest of the economy, and have important blue- and greywater implications. Additionally, the electricity sector offers an opportunity to consider trade-offs between water and energy.

- ***Mining*** – The mining sector is an important economic contributor and has significant water quality implications, for example in the Vaal River system. The greywater footprint with mining will thus be particularly important, and offers an opportunity to consider whether a greywater footprint is an appropriate representation of water quality.

- ***Wholesale and retail*** – Wholesale and retail plays an important role in the economy, including its role in imports and exports. This sector has little direct water use, but is heavily connected to its upstream water footprint for the production of goods and its downstream water footprint from the use of its products. Understanding water risks or opportunities in the supply chain can potentially offer important insights.

5. STEPS IN DESIGNING A WATER FOOTPRINT CASE STUDY

According to the Water Footprint Assessment Manual, a water footprint has the 4 steps shown in the figure below. While these steps provide good guidance for a typical water footprint study, the design of case studies here will diverge slightly from these steps to reflect the project's primary objectives and to stay within the scope of the project.

These steps are explained extensively in the Manual, and are summarised in the Literature Review. They are not explained extensively below, but certain decisions which must be made are highlighted. Detailed steps taken for each case study were captured in the case study write ups.

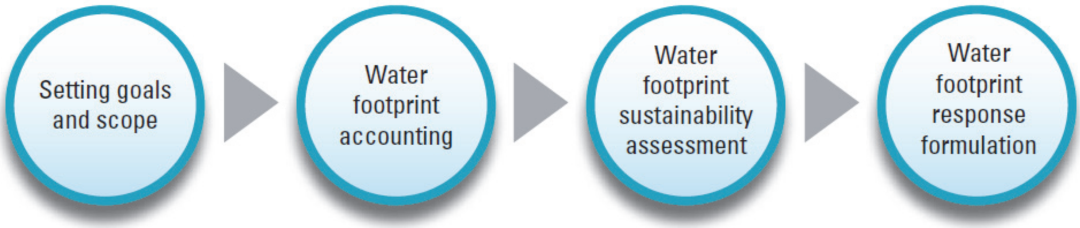

Figure 12: Steps in a Water Footprint Assessment, According to the Water Footprint Assessment Manual (Source: The Coca-Cola Company (2010), based on the Water Footprint Assessment Manual)

5.1 Purpose and Scope

The first step is to identify the purpose or the goal of the water footprint study, as the purpose will determine the scope and methodology of the footprint study.

The 3 potential uses of water footprint which have been discussed are: (1) Reporting and disclosure or internal benchmarking, (2) Understanding supply chain risks or marketing, and (3) Planning and decision-making. Most uses will fall into one of these broad categories. For example, determining the water footprint of upstream supply as versus operational processes speaks to understanding supply chain risks, and can be used to determine where to focus water-related efforts to reduce risks.

Identifying the purpose will guide how broad or narrow to make the study, whether to focus on the company or a specific product, and whether to focus on upstream, operational or the downstream footprint.

Scoping is important to determine the bounds of the study, and to create a study which leads to the intended outcome within the available timeframe and using available resources. The scoping steps should address the following:

- **Blue-, green- and/or greywater** – Whether to include blue-, green- and greywater in the study, or whether to focus on only one or two components. Bluewater is usually scarcer and has high opportunity costs than greenwater, and thus is typically the focus of analysis and of traditional water resources tools. However, greenwater may be of interest because it often plays a significant role in agricultural production and has not been included in traditional types of analysis. Greywater will be interesting when water pollution is a concern.

- ❖ **Truncation of supply chain** – Where to truncate the analysis when looking at the supply chain. The general rule expressed in the Water Footprint Assessment Manual is to include all water use in the supply chain that 'significantly' contributes to the footprint, although exact guidelines have not been developed. The water footprint of labour in the supply chain, including the food, clothing, and other consumption of workers in the process, is generally excluded in a water footprint. In relation to supply chain location, some might have inputs that are located outside their geographic area of interest such as imported goods. In such a case the water footprint might only be restricted to the same geographic location, while taking into consideration the external footprint through water accounting, but without necessarily undertaking a sustainability assessment of that external footprint.

  - o **Facility, product or company** – This will determine the type of lens used in doing the water footprint study and can help identify issues at both a macro and micro scale.

  - o **Upstream, operational or downstream** – Will the study consider the entire supply chain?

  - o **Local versus imports –** Will the study only look at goods made with ***local*** raw materials, or whether ***imports*** will also be considered. This is important when considering availability and reliability of data.

- ❖ **Period of time** – Water availability and demand varies within a year, and from year to year. The water footprint will also vary depending on the time period chosen. For example, a bluewater footprint will be higher in a dry year than a year with significant rainfall. Thus, an assessment must specify whether it is looking at a particular year, a number of years, or an average.

- ❖ **Production or consumption** – A water footprint can be conducted from a consumption perspective, a production perspective or both. Some of the above entities around which footprints are completed are clearly either consumption or production-focused. For example, a footprint for a product will focus on the freshwater required throughout the supply chain for the production of that product. A footprint for a consumer will determine the freshwater required for the products consumed according to that consumers habits. However, for a geographically delineated area such as a country, either production or consumption water footprints may be of interest and should be clarified for the assessment.

The scoping step would normally include whether the study will look at the footprint from a consumption or production perspective. However, the industry focus of this project naturally lends itself toward a production-based approach. A consumption-based approach would be more relevant when determining the footprint of a group of consumers, such as people within a nation.

5.1.1 Methodology

The starting point for methodology will in most cases be that described in detail in the Water Footprint Assessment Manual. The Manual describes an approach to calculating a blue-, green- and greywater footprint for the following:

- Crop
- Animal product
- Manufactured product
- Commodity
- Consumer or group of consumers
- Nation

For the purposes of the case studies below, the methodologies for crops, animal products, manufactured products and commodities will likely be most relevant.

Crops

The Manual describes the equations and steps required to calculate the green-, blue- and greywater footprints. The source of data, however, must be determined. A common and fairly simple technique is to use CLIMWAT 2.0, a database maintained by the Food and Agriculture Organisation (FAO), to obtain climate and rainfall data. This data can be incorporated into the CROPWAT, which is a computer program used to find crop water requirements based on a crop coefficient and climate data. Certain decisions must be made on a case-by-case basis, such as the type of soil used and whether to adjust climate data from that provided by CLIMWAT if more accurate climate data is available.

Questions will also arise regarding the method of calculation for bluewater. It can either be assumed that sufficient irrigation is provided to meet crop requirements, or actual irrigation can be researched and used. Actual irrigation requires knowledge of local irrigation practices, and is more accurate but not always possible due to information constraints.

For greywater, it must be determined whether the Manual's approach to calculating a greywater footprint will be followed. In the case studies, it is intended to calculate the greywater footprint and also to explore alternative representations of water quality.

Animal Products

The water footprint of an animal product begins with the footprint of supporting the animal itself. This includes producing the feed required to support the animal, and its required drinking and servicing water. Thus, the diet of the animal and the source of feed must be established. Crop requirements will be calculated based on the method described above for crops.

For the manufacturing and processing parts of a footprint, the operational processes must be understood. This will likely involve understanding the operations within a facility or process, described below.

Manufactured Products and Commodities

The methodology for manufactured products and commodities involves understanding the supply chain, and calculating the water footprint of each step in the supply chain which is to be included in the analysis according to the scope of the study. The SABMiller supply chain for beer production is shown in the figure below.

Although some technical questions will arise, the basic methodology as described in the Manual is fairly straightforward once the scope is set. The question becomes whether the methodology should diverge from the Manual. This includes the appropriateness of the greywater footprint to represent water quality, using net versus gross accounting, and excluding distribution losses in irrigation. These kinds of questions lead into the next step.

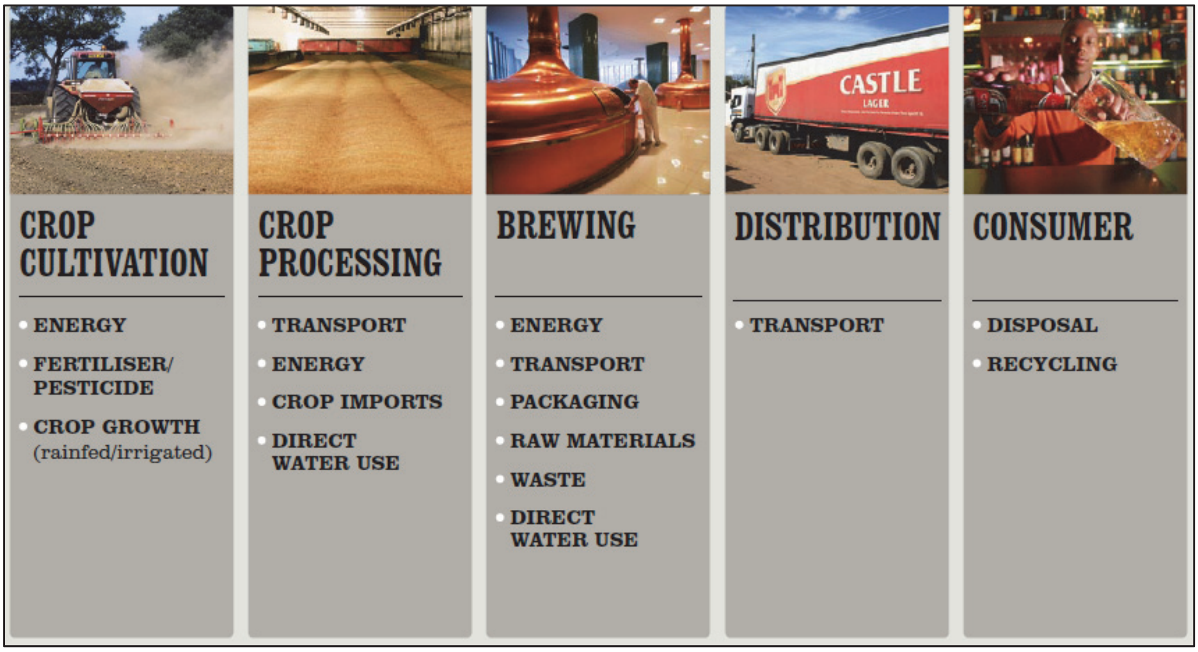

Figure 13: Value chain for beer production (Source: SABMiller and WWF-UK 2009).

5.1.2 Questions or Issues to Explore

Questions or issues to explore refers to the methodological and contextual questions which have arisen from the Literature Review and discussion above, such as whether the grey footprint is a good representation of water quality.

In a normal water footprint study, these kinds of questions do not need to be addressed and this step can be left out, unless it is the purpose of the study to do so. These kinds of questions are included in the case study descriptions below because this WRC project is intended to explore water footprint questions through the process of completing case studies.

5.1.3 Some key observations related to scoping

- ***Establishing the boundary***: It is very important to discuss the boundary issues clearly at the scoping stage, to avoid uncertainties related to truncation of the water footprint analysis. For example, large business may have different business units that are either independent or produce inputs for the product. The uncertainties related to water footprint attribution need to be clarified upfront.

- ***Seek experienced practitioner:*** For a company that is embarking on undertaking a water footprint assessment for the first time, it is important to engage and experienced water footprint practitioner in addition to building in house capacity. This is because water footprint assessment and water risk management in general is a journey that requires adequate capacity to deliver any tangible results.
- ***Obtain buy-in from management:*** High level buy-in from key water managers in the company is required to ensure commitment, because the results from water footprint assessments can be profound and may require a complete overhaul of how a company manages its water. Getting buy-in from key decision makers will make it easy to mainstream the outcomes of the water footprint assessment and make any critical decisions that will be required.
- ***Establish disclosure policy:*** At the scoping stage the company also needs to take stock in relation to how much information they are willing to share and if there are confidential issues, a clear protocol for their resolution will be required upfront to avoid pitfalls in the course of the assessment.

5.2 Water Footprint Accounting

This is the most important step in the water footprint assessment process, which involves the actual assessment of water use by the entity whose water footprint is to be determined. Before delving into more detail on how water accounting is carried out it, it is important to consider some key concepts lined to water accounting:

i. The classification of water footprint into three main categories of blue-, green- and greywater footprints
ii. The different types of water footprint assessments; process, product, business and catchment water footprint.

Even though the scope of this report is the applicability of water footprint for the industrial sector, insights will be collated from various sectors where water footprint assessments have been carried out as the beverage sector or specific crop water footprint assessments.

5.2.1 Classification of water footprint

Water footprints are categorized into three main types, which all need to be taken into consideration when the overall water footprint of any entity or product is calculated. The categories of water footprint are:

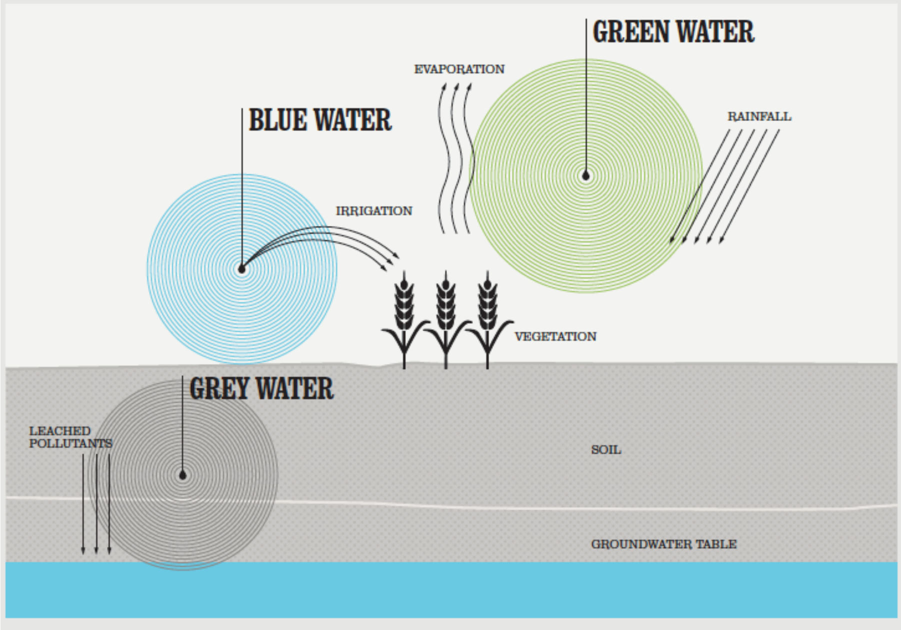

Figure 14: Classification of water footprints: green, blue and grey

The figure above shows the different water types of water that are used as typology of water footprint (SABMiller 2008)**:**

- A **bluewater footprint;** representing water that is abstracted from surface or groundwater resources
- A **greenwater footprint**; this represents water use linked to rainfall
- A **greywater footprint;** is water that is used to dilute pollutants to acceptable ambient conditions.

In addition to the color-coding of water footprint, consideration also needs to be made for i) direct or indirect water use or ii) consumptive or non-consumptive water use. These categorizations of water use are described further below: -

- **Direct and indirect water use:** Water footprint assessments also take into consideration whether the water use is direct or indirect. Direct water use is linked to operations of a company such as the amount of water used for cooling. Indirect water use refers to water that is associated with the supply chains of a company. In undertaking water footprint assessment both the direct and indirect aspects of water use need to be taken into consideration to ensure effective water use accounting.

- **Consumptive and non-consumptive water withdrawal**: Consumptive water use is water that has either been incorporated into a product or has undergone evapotranspiration linked to a specific process. Water that has been abstracted from a system and returned at a different point or time is also regarded as having been consumed. Non-consumptive water use on the other hand is water that is returned back into the system and is then available for use downstream.

In the following section each of the water footprint classes will be discussed in more detail, outlining how each of them can be determined and the potential issues that are likely to be encountered in relation to the industrial sector in South Africa.

5.2.2 Types of water footprint assessments relevant to the industrial sector

Water footprint assessments can be carried out for various entities depending on the scope and goal of the assessment. For a business, water footprint assessment could be carried out for the entire business establishment, a product or a process. Each of these dimensions of water footprint assessments provide a distinct challenge on their implementation, and the approach to carrying out the assessment might also vary, depending on what is being assessed.

Figure 15: Types of water footprint assessment

In the following sections, each of these water footprint assessments will be discussed in more detail. The water footprint assessment approach will vary for each entity, depending on their value chains. For example products that have an agricultural value chain will have a distinctly different water footprint approach linked to crop water use, compared to an entity whose supply chain is for example associated with power generation.

Water footprint of a process step

The water footprint of a process is the volume of water used per unit time and is divided by the quantity of the products from the process. It could also be expressed as water volume per product unit (Hoekstra et al. 2011). A good illustration of water footprint of a process step is the assessment of water footprint of a crop, for an industry with an agricultural supply chains.
The water footprint of a crop is the ratio of volume of water required to grow the crop to the yield:

$$WF\ (m^3/ton) = \frac{Crop\ water\ use\ (m^3/ha)}{Crop\ yield\ (ton/ha)}$$

Similar to most water footprints of entities, the water footprint of a crop is comprised of green-, blue- and greywater use. However in most cases it's the blue- and greenwater footprints that are most significant, as a result greywater footprint may not be incorporated in some assessments as illustrated below. For the industrial sector in particular greywater footprint is of most concern in the operations/factory compared to supply chains.

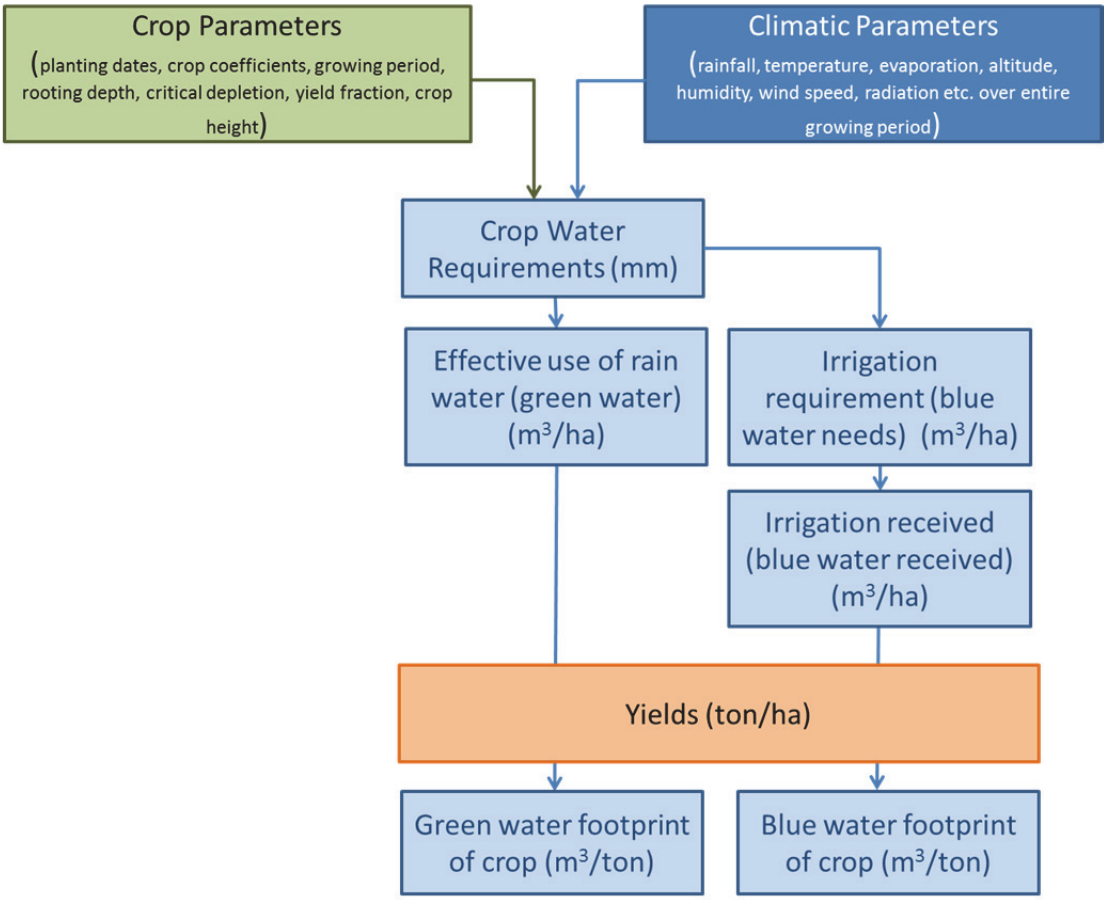

Figure 16: Steps to calculate the water footprint of a crop (NBI 2012)

Even though the above example of crop production was used as an illustration of a process water footprint in the context of industrial sector where crops are used as an input, crops can in their own right be viewed as a product.

Water footprint of a product

In order to assess the water footprint of any product, it is important to understand the process of how the product was produced. This is illustrated in Hoekstra et al. (2011) that cited the example of the process steps in the production of a cotton shirt, which comprise: cotton growth, harvesting, ginning, carding, knitting, bleaching, dying, printing and finishing. It is important to note that in some cases the process steps may not be linear, because each step might require multiple inputs e.g. to produce meat will require feed to be produced; the animals need to be raised before meat can be produced (Hoekstra et al. 2011).

The water footprint of a product is defined as the total volume of water used directly or indirectly to produce a product. For agricultural products the water footprint is expressed as m^3/ton or L/kg.

The calculation of water footprint of a product can be broadly categorized into two main types:

- **The chain summation approach:** This is the simplest form of assessing the water footprint of a product, but can only be applied to a system that produces only one output product (Hoekstra et al. 2011). In this case the water footprints of various processes involved are attributed to that one product output. The water footprint in case is therefore a summation of the entire process water footprint divided by the quantity of product. The flaw with this approach is that in real practice there are hardly any processes that have single product output.

- **The step-wise cumulative approach:** this approach comprise of a summation of the various water footprints of the input products that were used in the making of the main out product. For example beer requires wheat and hops as primary ingredients in its brewing. To determine the water footprint of beer requires therefore the summation of the water footprints of the individual crops, in addition to the water footprint of the actual brewing process, the distribution of beer and disposal of waste by the consumer. The cumulative water footprint of the various processes equates to the water footprint of beer.

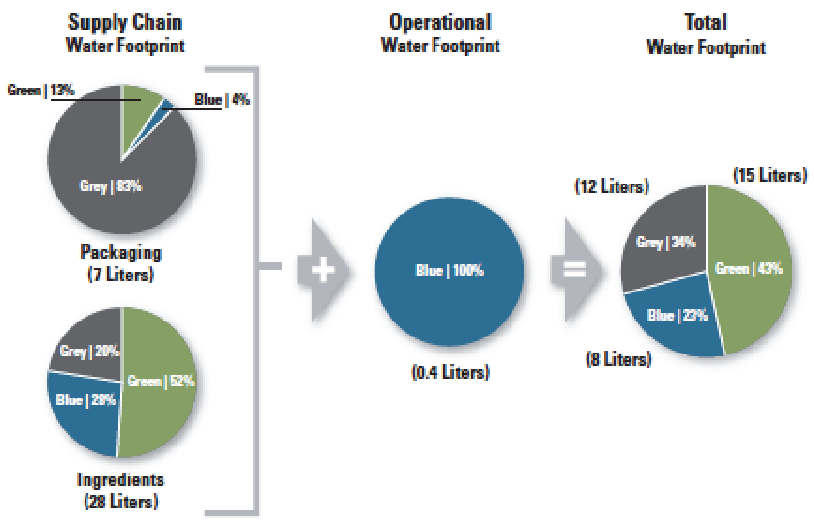

Figure 17: The water footprint of a bottle of Coca Cola (TCCC 2010)

The water footprint of a facility

The water footprint of a facility is carried out for large business that might be concerned about a specific facility in their vast operations. In this case the assessment will not focus on the entire business operations of the company, but that specific facility. This type of assessment is driven partly by the fact that due to their wide geographic spread, the water risks a company faces will depend on the location of their operations. For example a few years ago, The Coca-Cola Company (TCCC) undertook a comprehensive source vulnerability assessment of their operations in South Africa (SRK 2009), which showed that their risks varied widely. In such as case if the company undertook a water footprint assessment, they might have focused only on those facilities that are of most concern to them, as opposed to assessing their entire business.

In calculating the water footprint of a business there are two variations that need to be taken into consideration:

1. Facility plus associate supply chains. One option would be to assess the water footprint of the facility, including the supply chains that are linked to the facility only and not those associated with the entire business operations.

$$WF_{facility} = WF_{facility,oper} + WF_{facility,sup}$$

2. Operational water footprint. In Some cases a business might be concerned about the sustainability of water supply to its operations only, in which case a water footprint for the operations might be carried out without taking the associated local supply chains into consideration.

In the above cases, the first option is the only one that constitutes a genuine water footprint assessment, because it takes into consideration all aspects of the water value chain. Due to the challenges of incorporating supply chains into water footprint assessments, companies sometimes only focus on their operational water footprint and report that as the water footprint of the facility, which is misleading because operational water footprint on its own does not constitute a water footprint assessment.

Water footprint of a business

The water footprint of a business is probably one of the most strategic assessments to carryout, because it enables the business to have an overview of both its operational and strategic risks and to devise mitigation measures accordingly. The business water footprint is also likely to be very high level depending on the size of the business, location and spread of its supply chains. Due to the broad nature of this assessment, it should potentially precede a product water footprint assessment. A business wide water footprint assessment enables one to identify the weak spots in the business value chain and then dig deeper through a product water footprint assessment as an example.
The water footprint of a business is defined as the total volume of freshwater used directly or indirectly to operate a business. The key elements of a business water footprint are:

- **Operational water footprint;** defined as the volume of water consumed or polluted as a result of the operations of the business
- **Supply chain water footprint;** is the volume of freshwater consumed or polluted to produce the input goods and services required for the business to operate.

- **Overhead water footprint;** and any other water footprint not directly linked to a product, such as water used in toilets, gardening or washing of working clothes.
- **End User water footprint;** this is water footprint associated with the use of the products of a business, such as pollution from the use of detergents by consumers. This water footprint in strictest sense is that of a consumer not a business, but nonetheless it's important for business to understand their downstream linkages.

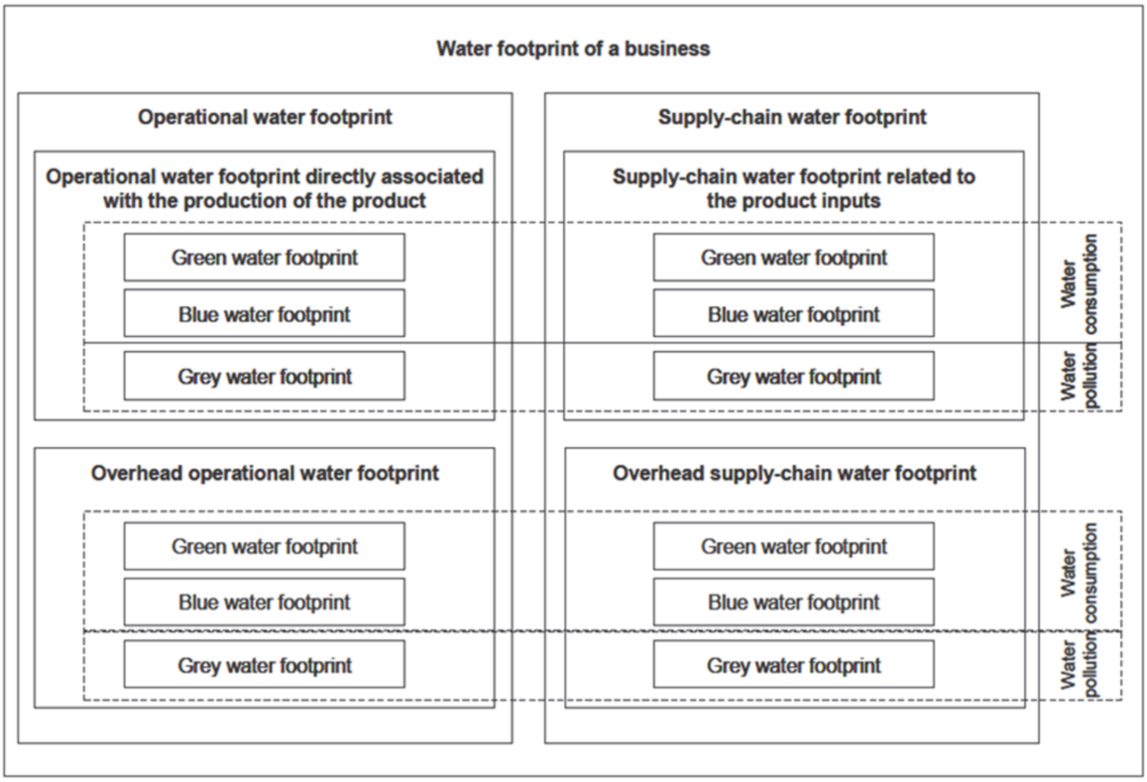

Figure 18: Illustration of the different components of water footprint assessment that a business need to carryout (Hoekstra et al. 2011)

To calculate water footprint of a business therefore, requires the summation of the water footprints of the business final **output products**, which gives rise to the operational water footprint. The supply chain water footprint is the summation of the different water footprints linked to **input products** of the business.

$$\mathrm{WF_{business}} = \mathrm{WF_{Operations}} + \mathrm{WF_{Supply\ Chains}}$$

In assessing the water footprint of a business there is strong focus on separating operations from supply chains. This is important because a business has direct control over its operations but not supply chains, hence cannot be held responsible for water use linked to its supply chains, but may face considerable business related risks. Depending on the type of business and the products of the business, the water footprint of a product may in essence be equated to the water footprint of the business, as long as the different components of the product water footprint are attributed to their the operations or supply chains of the business.

Water footprint assessment for a business takes an integrated approach that considers both operational and supply chain water use, which is a departure from the practices of most companies who tend to focus on their operations, even though their supply chains consume more water. Since supply chains present larger risks to companies, water footprint assessments offer an opportunity for companies to shift their in-house focus on water management to their supply chains.

Water footprint assessment help companies to have a holistic overview of the water value chain, instead of just focusing on the fact that they have water licenses. Developing understanding on where and when water is abstracted for use by a company, and consideration of the environmental, social and economic impacts of water use are critical for developing a robust water management strategy by companies. Greywater footprint helps companies develop a good understanding of how the assimilative capacity of water resource is impacted by effluents, and the potential risks posed to business operations.

The water footprint manual (Hoekstra et al. 2011), gives a good step-by-step breakdown of who a business water footprint can be undertaken. The steps provided are quite generic for any business, but the individual water footprint type such as the calculation of process water footprints may vary depending on the products in question. Water footprint assessment considers consumptive water use as opposed to water withdrawals in general, which offers a more robust and pragmatic approach to water management.

1) As stated earlier, the water footprint of a business is the summation of the operational and supply chain water footprints;

$$\boldsymbol{WF_{bus}} = \boldsymbol{WF_{bus,oper}} + \boldsymbol{WF_{bus,sup}} \quad \text{[Volume/time]}$$

2) The next step is to determine how the operational and supply chains of the business are linked to the production of the product, and the related overhead water footprint, as given below:

Operational water footprint

Operational water footprint measures the consumptive water use in a business operation and includes water loss through evaporation, the volume of water incorporated into a product and overhead water footprint linked to operational activities not associated with the product. Effluent from the operations should also be considered through the greywater footprint assessment.

$$\boldsymbol{WF_{bus,oper}} = \boldsymbol{WF_{bus,oper,inputs}} + \boldsymbol{WF_{bus,oper,overhead}}$$

Supply chain water footprint

Supply chain water footprint is calculated by summing the various input product water volumes, linked to the different products of a business, as illustrated below.

$$WF_{bus,sup} = WF_{bus,sup,inputs} + WF_{bus,sup,overhead}$$

If the supply chain of various input products is originating from more than one source, the water footprint of the supply is calculated by multiplying the individual water footprints of the inputs with different sources of origin.

The source of a product is therefore very important for determining the water footprint of a business. Two sources of product origins can be distinguished:

a) Product from a business unit of the same company
b) Product from a supplier outside the company

In former case, information on the water footprint can be obtained through company driven water auditing. However, when a different company supplies the product, then the water footprint value of that product has to be obtained from the supplier in order to compile the overall business water footprint. Due to the nature of the industrial sector in South Africa, it's mostly the blue- and greywater footprint that is quite pertinent compared to the greenwater footprint. This however also varies significantly depending on the type of business in question. For example entities that have a strong footprint linked to agriculture, green- and bluewater footprint might be important, whereas for petro-chemical industrial greywater footprint might be main issue of concern.

5.2.3 Key observations linked to water footprint assessment

The uptake of water footprint as a water management tool has been increasing in South Africa and globally, with several companies having assessed their footprints. Based on these experiences some key lessons are starting to emerge regarding water footprint assessment, ranging from issues such as setting a scope to more technical issues of model design and data usage. These are elaborated below:

- ***Data identification, request and collection:*** Key data inputs relating to company operations and production processes (as defined by the scope of the water footprint assessment) must be identified and requested of the relevant operations managers. Several iterations are required to ensure that the data requested and collected matches that required, and to ensure that the points at which measurements are taken are known.

- ***Analysis spreadsheets:*** Using the data obtained, models detailing the water input and output volumes and type must be developed for each step in the production process. These models will generate the individual green-, blue- and greywater footprints for each demarcated step of production. Note that it is important to identify the assumptions made and the basis for calculations in order to allow for comparisons to be made with other similar water footprints. That is, the assumptions must be consistent between similar footprints.

Where agricultural water footprint calculations are required, the relevant collected data must be input into the CROPWAT and CLIMWAT databases to generate green- and bluewater requirements for the crop in question.

- ***Collation of results:*** Once the green-, blue- and greywater footprints for each step of the production process have been calculated, the overall water footprint for the product or company can be determined.

Issues to consider in the water footprint accounting process:

- **Assumptions and data accuracy**
  - Water footprint accounting should be used as a means for facilitating discussion, rather than for determining conclusions based on the ultimate figures produced by the accounting process. Because the water footprint calculations are dependent on certain assumptions and estimates, the results are seldom highly accurate. Thus, it is important to determine, prior to initiating the accounting process, why the footprint is being calculated and how it will be used. In doing so, appropriate comparisons can be made. For instance, if a water footprint is being calculated for a consumer product like a soft drink, prior investigation should be done to determine how similar soft drinks are produced. This will be helpful in making assumptions and drawing boundaries within the accounting process such that the final water footprint will be meaningful and comparable across the industry. Furthermore, a lesser emphasis can be placed on accuracy when water footprints of comparable products are based on similar boundaries and assumptions.

- **Allocation of water footprints in process steps (attribution)**
  - The ultimate water footprint of a product consists of a series of underlying water footprints, each representing one stage in the production process. However, the allocation of water footprints between each step is not always easily determined. For instance, consider the water footprint of sugar production where bagasse, which is produced as a by-product, is used to produce electricity. In this case, the electricity produced by bagasse offsets the water footprint of electricity that would otherwise be purchased for farm or factory operations. The question thus becomes whether to

apply this offset to the water footprint of electricity used in producing the sugar (because electricity is being generated at the factory) or whether the saved water should offset the agricultural water footprint (the growing of sugarcane) given that bagasse is a by-product of sugarcane.

- Such complexities are tied into the issue of assumptions, as raised above. For instance, if the assumption is that by-products should be included in the scope of the assessment, then it would be appropriate to offset the electricity against the sugarcane cultivation step in the production process. However, if it is assumed that by-products will not form part of the water footprint of sugar production, then it would be more appropriate to offset the footprint associated with the electricity produced against the footprint of electricity that would have otherwise been purchased.

- There is no prescribed way of dealing with such issues in the accounting process. Instead, each scenario should be dealt with on a case-by-case basis, with the underlying aims of the water footprint analysis effecting how the issue should be dealt with.

Insufficient data

- Because water footprint analyses on a company level are a fairly new initiative, and often require in-depth information and data for accurate results, companies may not always have readily available information in the detail required. Furthermore, due to sensitivities around certain data, companies may not be able to provide the required data. Thus, due to a lack of access to certain data, high-level water footprints may have to suffice even when water footprint analyses over individual processes would be more useful, as this would provide more focused information on which processes carry the greater water footprint, and would facilitate discussions on how to improve the overall consumption of water.

Greywater footprint

- The greywater footprint focuses more on the quality of water impacted as opposed to the volume of water considered in the green- and bluewater footprints. Therefore, the greywater footprint impacts may be more severe in a given location, depending on the type of contamination, geographical location and deterioration of water sources in that area. For a grey footprint to have meaning and to understand its impact, the type and volume of pollution must be identified. However, linked to the issue of insufficient data described above, companies often do not have the systems required to establish an accurate reading of the pollutants that contaminate the water being used. As a result, greywater footprints are often difficult to determine.

5.3 Sustainability assessment

Once a company has undertaken a water footprint whether it's that of an entire business or of a product, the next most important step is to try and make sense of that figure. This is important because the contextual issues are critical in developing understanding of the water footprint value. For example a high water footprint figure in a catchment that has abundant bluewater resources might not be as critical as a low water footprint value in a highly stressed catchment.

Sustainability assessments are carried out as part of the water footprint assessment, to inform a business on their performance relative to the context of the catchment in which they are operating. The sustainability assessment also helps the company to answer some questions that they are worried about related to their water risks, and what they are trying to achieve with the water footprint assessment.

In addition to helping companies manage their physical water risks, sustainability assessments are useful in assessing the impact of a business on a water resource. This is achieved by asking two fundamental questions related to the location of water abstraction and timing (Ercin et al. 2010). So far most water footprint assessments that have been carried out in South Africa, have excluded sustainability assessments. This is worrying, because it's only through a sustainability assessment that the *so what* question can be answered.

To undertake a sustainable assessment, the three key dimensions of sustainable development, namely environment, economic and social indicators are used. In the following sections, each of these dimensions of sustainability assessment is discussed in more detail.

5.3.1 Environmental indicators

Environmental indicators as used in sustainability assessments are framed in the context of how the blue-, green- and greywater footprint compared to water availability in the catchment where the assessment is being carried out.

Bluewater scarcity

Bluewater scarcity is used to assess the extent to which water users in a catchment meet environmental flow requirements. Environmental flow objectives are defined as the minimal water flows required in a river system or catchment to ensure that it remains ecologically functional.

Water abstraction from a river or a catchment in general will impact on the environmental flow requirements of the system. To counter any negative impact of water abstraction on environmental flows, there is a need to balance water allocation between the different users, with the environment regarded as a water user. Ideally every major river system is supposed to have its environmental flow requirements determined to ensure that other users do not infringe on the rights of the system to function effectively.

Bluewater scarcity is the measure used to assess the sustainability of bluewater footprint, because it provides an indication of the extent to which environmental flow requirements have been met or violated but the water use.

Bluewater scarcity is calculated by dividing the bluewater footprint by the bluewater availability. While bluewater availability is calculated by subtracting environmental flow requirements from runoff. Since the bluewater scarcity gives an indication of violation of environmental flow requirements, it's a good indicator of environmental impact of water use.

The South African Situation

In South Africa the National Water Act 1998 (NWA) requires that for each major river system or catchment resources quality objectives (RQO) are established, to ensure that environmental flow requirements are achieved during water allocation. However, there are very few river systems where environmental flow requirements have been established. So what does a company do if it needs to undertake a sustainability assessment as part of the water footprint assessment?

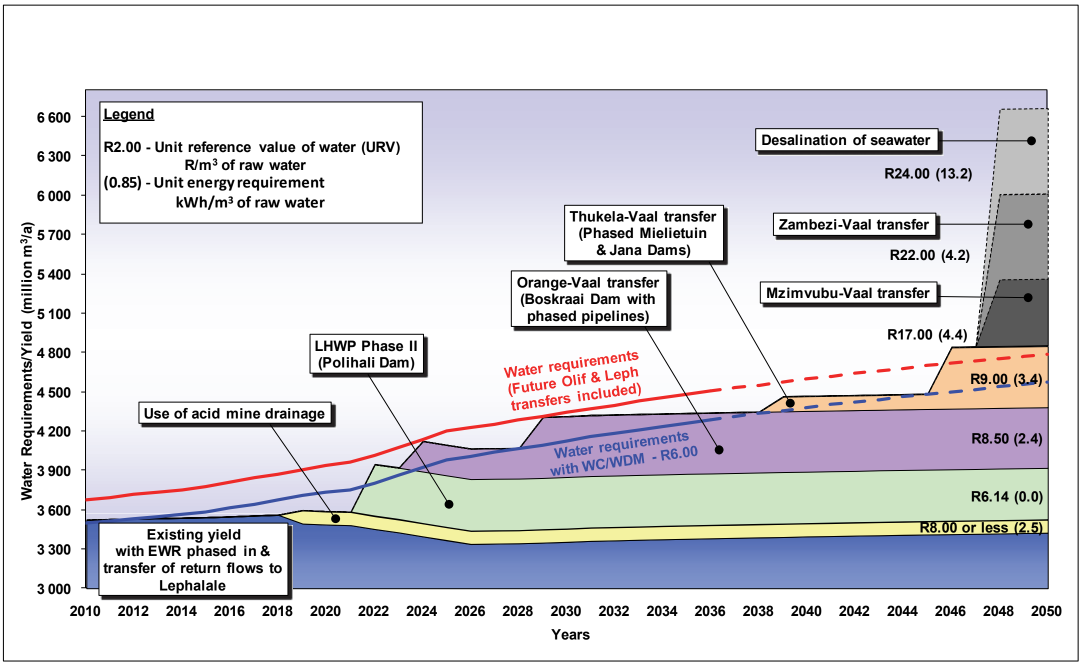

Figure 19: Water reconciliation strategies for the Upper Vaal water supply system (DWA 2010)

There are numerous sources of information that a company can use to get an indication of its bluewater sustainability, which include: -

- **Water Reconciliation Strategies (WRS).** For each of the 9 water management areas in South Africa, water reconciliation studies have been carried out as part of the water resource planning to balance long term water demand and supply. These reconciliation strategies provide a useful indicator of the state of bluewater resources in a catchment, and company could use these data sets as a proxy for understanding the water situation in the catchment.

Greenwater scarcity

Greenwater scarcity refers to the conversion of rainfall from use by natural vegetation to other productive uses such as crops for food, fuel, fibres or wood for timber, with implications for terrestrial biodiversity. It denotes the amount of water in a catchment or any geographic area that is not used by natural vegetation.

Biodiversity provide important ecosystem goods and services and impact on catchment hydrology, including stabilization of runoff, water quality, and groundwater flow. When biodiversity is degraded through land use changes, these important ecosystem services and goods are affected. The sustainability of greenwater footprint is therefore directly linked to the availability of greenwater in the catchment or geographic area of operation. When the greenwater footprint exceeds greenwater availability, there is cause for concern.

Greenwater availability is calculated by determining the total evapotranspiration of rainfall from the land surface, minus evapotranspiration from protected areas (natural vegetation), and minus the evapotranspiration from unproductive land, as shown in the formula below.

$$WA_{green}\,[X,t] = ET_{green}\,[X,t] - ET_{env}\,[X,t] - ET_{unprod}\,[X,t]$$

Where: -

WA_{green} = Greenwater availability in a catchment *x*, in a certain period *t*

ET_{green} = Total evapotranspiration of rainwater over land

$ET_{env}\,[X,t]$= Evapotranspiration from land reserved for natural vegetation

$ET_{unprod}\,[X,t]$= *Evapotranspiration from unproductive land*

Greenwater scarcity on the other is a ratio of total water footprint in a catchment to the total water availability in the catchment, at a specific location and period, as shown below:

$$WS_{green}\,[x,t] = \frac{\sum WF_{green}\,[\mathrm{x},\mathrm{t}]}{WS_{green}\;[x,t]}$$

One of the major constraints in the assessment of greenwater scarcity is the lack of comprehensive data, at an appropriate scale for its assessment. As a result most water footprint assessments do not include greenwater scarcity in their sustainability assessment. However, in the case of South Africa there are numerous datasets and research that has been done on biodiversity that should offer very useful insight, especially if the sustainability is undertaken at a catchment level.

For an entity seeking information on greenwater scarcity for inclusion in sustainability assessment, some of the key sources information includes the following: -

- Various groups in South Africa has been undertaking climate change modeling, hence a lot of data is available on climate change projections. The ACRU model has been used variously to generate individual sub-catchment runoffs for South Africa (Schulze et al. 2011), and this information is available freely for use in assessing the sustainability of greenwater footprints.
- There is a comprehensive vegetation map for South Africa that shows all the vegetation types in the country (Mucina & Rutherford 2006)[1]. For some of these vegetation types, their water requirements have been modeled. Based on this information, it is possible to estimate the total amount of water that has been used by plants other than natural vegetation and hence the greenwater scarcity can be determined.
- Protected area maps are also widely available in South Africa at the level of catchments, which is useful for estimating total greenwater availability, which is used to assess greenwater scarcity.
- The national freshwater ecosystem priority areas assessment (NFEPA).

Climate change and greenwater sustainability

Climate change impact on greenwater availability need to be taken into account when assessing greenwater footprint, this is because changes in temperature will affect both precipitation and runoff from catchments. In South Africa climate change projections (Midgley et al. 2009) show that: -

- Most of South Africa is projected to experience variable stream flows despite higher predicted flows overall, with parts of the Western Cape projected to receive lower stream flow compared to the rest of the country.
- Evapo-transpiration will increase by a range of between 5-15% throughout the region by 2050, with the lowest increases expected in the humid south and southeast coasts, and parts of Northern Cape, while most of the interior plateau is expected have very high increases in evapotranspiration.
- Greater soil erosion is predicted for most parts of the interior during wet years, which could be as a result of increased runoff and unsustainable land use practices.
- Higher irrigation water demand is projected for South Africa, with more than 90% showing increases in days at which topsoils are at a wilting point.

This projected impact of climate change will have serious consequences on the sustainability of greenwater in South Africa. Companies that are located in catchments that are projected to receive less rainfall should therefore be prepared to experience challenges related to assurance of supply.

The challenge associated with water footprint sustainability in South Africa in many cases is because of the fact that this information sits with the biodiversity conservation sector and is not readily available to water resources experts who are mostly responsible for water footprint assessment.

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[1] http://bgis.sanbi.org/vegmap/project.asp.

5.3.2 Economic indicators

Sustainability of water footprint also needs to be viewed in the context of how water allocation is carried out in the catchment and whether such decisions result in economically efficient water use. The economic sustainability of a water footprint is in essence an understanding of the various water users in the catchment and the contribution of their activity to the local economy. For a water footprint to economically sustainable, the benefits of the resultant footprint (green, blue, grey) from such activities should outweigh the costs of the footprint (Hoekstra et al. 2011).

In practice this may be difficult to quantify and interpreting what constitutes economic efficiency can be highly subjective. In addition to that water allocation decisions are not based purely on economic efficiency, but also seek to address issues of inequality and the environment.

5.3.3 Social indicators

Water has a very strong social dimension, because it is a basic human need. As a result water allocation for basic human consumption takes precedence over all other users in a catchment. The basic human water needs include access to clean drinkable water, water for washing and cooking among others. In South Africa the law requires that every citizen must have access to a minimum of 25 Litres of water per day.

If any water use activity in a catchment infringes on the human needs for water, this is regarded as unsustainable as it is likely to cause major social problems in the catchment. To ensure that water use is socially just requires the implementation of basic principles such as water user pays principle or the polluter pays principle. In South Africa for example, water users pay a charge for their bluewater use and for discharging waste into the system, which is in line with the water user and polluter pays principles.

Developing the criteria for incorporating social indicators into sustainability assessment is very difficult, because of the challenges in quantifying such indicators. However, information is available data such as access to safe drinking water. A company that is seeking to incorporate such criteria can also generate this data through better understanding of the surrounding communities where their operations or supply chains are located.

5.3.4 Understanding the water value chain and its vulnerability

The discussions in this report have so far only focused on how companies can undertake a water footprint assessment in trying to understand and mitigate their water risks. The shortfall with the water footprint assessment methodology is that it doesn't say much about the value chain of water. In essence a water footprint assessment does not give any insights into the vulnerability associated with the source of water, infrastructure and the receiving water resource, which constitute the value chain of water (figure below).

Figure 20: An illustration of the value chain of water

It's important for a company to assess the links between these paths to be more resilient. If any of these links fail, it will impact the entire value chain with major consequences for any business sustainability.

This kind of approach therefore needs to be undertaken in conjunction with the typical water footprint assessment discussed earlier. The value chain assessment is particularly vital in developing response strategies to mitigating water risk, because in addition to pinpointing the vulnerable links, it helps a company to identify specific leverage points in the system to mitigate its water risks. Many companies, especially those in the drinks and beverages sector are starting to embark on this approach to try to understand their water vulnerability and how to respond to the risks. This approach could also potentially be useful for the mainstream industrial sector such as mining and power generation that have a large greywater footprint and are highly dependent on upstream generation of input materials.

5.3.5 Identifying water footprint hotspots and impact

Sustainability assessments as defined by the environmental, economic and social indicators help to identify the hotspots in the catchment that might prove to be of concern to the company's operations. Hotspots can be defined as those geographic locations in a watershed where a company's operations or supply chains are located and pose a potential risk to its business sustainability from an environmental, social or economic perspective. The hotspot identification is therefore directly linked to water footprint sustainability assessment and the impact of the entity on the watershed.

Identifying the hotspots in the watershed will help companies to respond appropriately to their water footprint and the potential risks they face. Such water related risks include: -

- **Physical water risks**, related to assurance of water supply both in terms of quantity and quality;
- **Reputational risks**, as a result of perceived impact of the entity's operations on the local water resources;
- **Regulatory risks**, associated with government response to either the acute nature of water challenges in the watershed or the perceived poor water management practices of key water users in the watershed.

A combination of the sustainability assessment and understanding the value chain of water as described in the previous sections are key in helping a company map its potential risks and to develop appropriate response strategies.

In relation to impact assessment of a company's business operations, this is carried out at the watershed level where the company's operations or supply chains are located, and where the water risks to the company are likely to manifest themselves. The issues to consider in assessing the impact of a company's operations are i) the location of the company, ii) the upstream catchment where its supply chains are located and, iii) the downstream are of influence of the company (TCCC 2010).

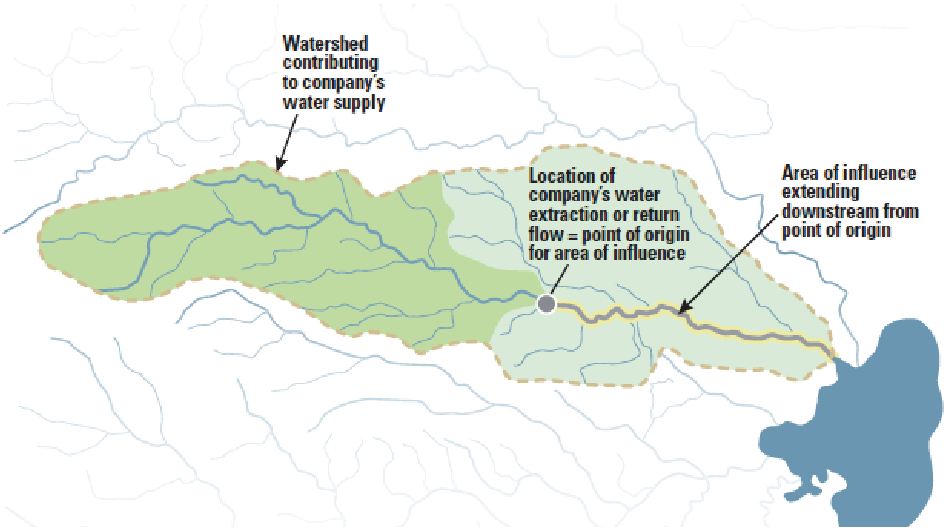

Figure 21: Conceptual diagram of impact assessment boundaries (TCCC 2010)

The impact assessment is different from water value chain assessment, in that it does not focus on the infrastructure related vulnerability that an entity might be exposed to. The assessment does not therefore constitute a water risk assessment for the company, but an additional layer of information that is used in conjunction with other sources of information to develop understanding on how the company should respond to its risks.

5.4 Formulating a response strategy

The response of an entity in relation to its water footprint is framed in such a way as to address the impact of the water footprint on the local water resources and to mitigate the potential risks such an entity might be exposed to (TCCC 2010). The options that a company can undertake in responding to a situation where its water footprint is deemed unsustainable could include the following (TCCC 2010, Hoekstra et al. 2011): -

- Minimizing water use through improved efficiency measures and reuse of water;
- Treating wastewater so that its impact on water resources can be reduced;
- Engaging with other stakeholders, such as local communities, government and other water users to address the challenges posed by water as a shared risk.

The Coca-Cola Company for example states in its water footprint report (TCCC 2010), that they have developed a water stewardship framework that starts by focusing on sustainable water use within the watersheds in which their operations are located. In relation to their facilities, the issues that they address may include specific engagement actions either in their bottling facilities located in stressed watersheds or in regions with significant social and ecological impacts. The Coca-Cola Company, also notes that in responding to water footprint, two key issues must be taken into consideration: -

- Response actions should start with a company's own operations and include collaborative efforts to help protect the local watersheds where it operates
- Companies with agricultural supply chains need to understand water use in their supply chain and support sustainable practices.

The above observations apply to the industrial sector as well even though not all of them are linked to agricultural supply chains. In this case the downstream greywater footprint might be a more critical issue compared to upstream supply chains. However in the case of power generating companies in South Africa the upstream value chain is vital because of the linkages with coal mining, which has significant impact on local water resources.

A range of case studies were conducted to understand the applicability of water footprinting to different sectors using different lenses. Presented in the next chapters are the outcomes of those case studies, which looked at the following key industries in South Africa:

- Agriculture
- Food and Beverage
- Retail
- Mining
- Chemical & Manufacturing
- Power Generation

6. CASE STUDY A: Agriculture and Retail

6.1 Motivation for case

Woolworths is one of the largest retailers in South Africa, and sells food, household, beauty and clothing products amongst others. It has good knowledge of its supply chain as part of its Good Business journey focus, which enables access to information and linking of product sales to suppliers.

Woolworths was selected as a case study in order to investigate how water footprints may be a useful tool to the retail sector. The retail sector is most dependent on water upstream in its supply chain, and has downstream water implications from consumer use of products. Therefore, although the retail sector is a low direct water user relative to other industries such as food & beverage, it is nonetheless highly dependent on water through its supply chain. A water footprint can help illustrate these upstream and downstream dependencies and implications, and illustrate linkages between the consumer and production.

The water footprint of Woolworths operations, such as transportation and store operation, have not been focused on as literature has shown that these aspects of the supply chain are minor compared to the upstream and downstream implications.

Woolworths provides the opportunity to perform a water footprint accounting on a variety of products. The selected products are intended to represent a variety of consumer products which illustrate different applications of the water footprint accounting method. The selected products include:

i. ***Irrigated carrots from the Ceres area, to represent a local irrigated crop***
ii. ***Imported beans from Kenya, to represent an imported crop***
iii. ***Cheese production in the Western Cape, to represent a livestock-based product with an operational water footprint component***
iv. ***Dishwashing detergent produced in Johannesburg, to represent a consumer good with an operational and a downstream water footprint component***

Because each product requires a discrete study, the scope, methodology, accounting and interpretation will be discussed separately for each product. The analyses will be brought together at the end in a discussion which synthesises how the water footprint concept can be useful to Woolworths across a variety of products.

For confidentiality reasons, suppliers are not identified and the quantities of the studied products sold by Woolworths are indicative rather than accurate. However, the information shared is sufficient to facilitate a discussion on the potential applicability of water footprint as a tool to the retail sector.

The following questions were intended areas of focus in this study:

- *What is the basic methodology and what considerations arise for completing a green-, blue- and greywater footprint study?* Examples of the green-, blue- and greywater footprint will be calculated in this study, and the methodology and assumptions will be fully explained.

Additionally, upstream, operational and downstream parts of the supply chain will all be considered.

- *How can the water footprint of imported products inform a company's supply chain considerations, and how can it link to a carbon footprint?* The analysis of an imported food product will illustrate the virtual water imported through trade, and insights that may be gained through a water footprint analysis will be explored.

- *How should greywater in downstream consumer use of a product be considered?* As with other greywater analyses, the downstream greywater implications of product use will raise questions regarding the interpretation of the greywater footprint.

- *Given the difficulty and resources required to do water footprint analyses, how can a company with many products most efficiently use a water footprint?* Woolworths represents a company with a wide range of products, and a good opportunity to explore whether estimations or different degrees of rigour may be used for different products, and whether an analysis of certain products could provide insights for similar products.

6.2 Carrots from Ceres

6.2.1 Scope

This study will focus on crop cultivation for carrots. Packaging, transportation, distribution, sale and consumption are excluded from this analysis. The decision to focus on crop cultivation was made because literature has shown that for agricultural products, crop cultivation constitutes the vast majority of the water footprint. Focusing on crop cultivation will thus illustrate the most substantial part of the footprint while allowing a focused analysis.

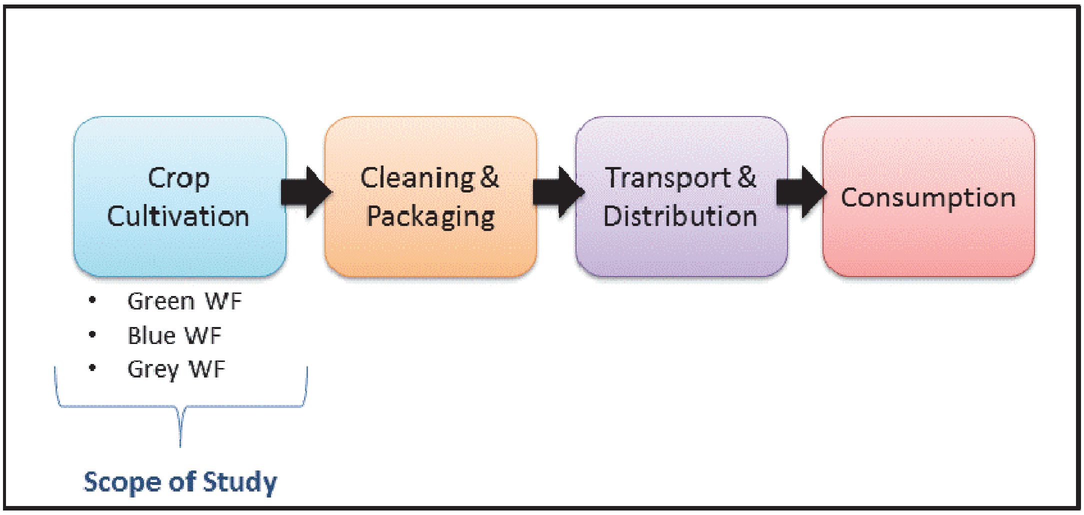

Figure 22: Scope of study for carrots from Ceres

This section explains the information requested to complete the water footprint, the methodology used, and summarises key assumptions that were made. Although each water footprint study will require a unique approach, it is intended that this can serve as a guide for performing similar water footprint studies on agricultural products.

6.2.2 Information, methodology and assumptions

Information requested

The list of questions below was asked prior to beginning the water footprint accounting. Questions 1-6 are directly relevant to the water footprint accounting, while question 7 regarding irrigation is for the purpose of comparing the bluewater footprint to actual irrigation.

1. Where specifically are the crops grown?
2. What is the crop yield in tons per hectare?
3. What is the crop growing season, meaning when are crops planted and when are they harvested?
4. What is the soil type?
5. What type of fertiliser is used, and in what quantity (kilograms per hectare)?
6. If known, what is the monthly rainfall for the location of growth?
7. Irrigation:
    a. How much irrigation is used (m^3/ha)?
    b. What type of irrigation is used?
    c. What is the efficiency of irrigation?
    d. What is the source of water used for irrigation?

Assumptions

The assumptions below were made based on the availability of information, and to bound the scope of the study:

- The water footprint of packaging, transporting, retailing and consumption of carrots is assumed to be small compared to the water footprint of crop cultivation.
- Planting and harvesting occur year round, on a continuous basis. To represent year-round planting, and to show the impact of planting and harvesting at different times in the year, it was assumed that planting occurs at the beginning of each month.
- Nitrogen is used as the indicator for greywater, and a 10% leaching factor is assumed. The maximum acceptable value for nitrogen concentration is assumed to be 10 mg/L, and the natural concentration of nitrogen if no human activity were present is assumed to be 0 mg/L. These assumptions represent the common approach taken in literature for water footprint assessments. Because alternative information was not available, it was assumed that fertiliser is applied evenly throughout the year.

Methodology

The methodology applied follows the methodology provided in the Water Footprint Assessment Manual, as described below.

1. Determine the ***most representative weather station*** which has information provided on the SAPWAT or FAO's CLIMWAT database. In this case, a weather station in the Ceres region available on SAPWAT was used.

2. Determine the ***crop water requirements*** for carrots grown in Ceres for the indicated growing cycle. This represents the average millimetres of water that would be required to support optimal growth of the crop in the given location and growing season. The crop water requirements can be found for most crops using SAPWAT or the FAO's CROPWAT and CLIMWAT databases. As the crop water requirement will change throughout the growing cycle of the crop, the crop water requirement is represented in 10-day timesteps from the time it was planted to the time of harvesting.

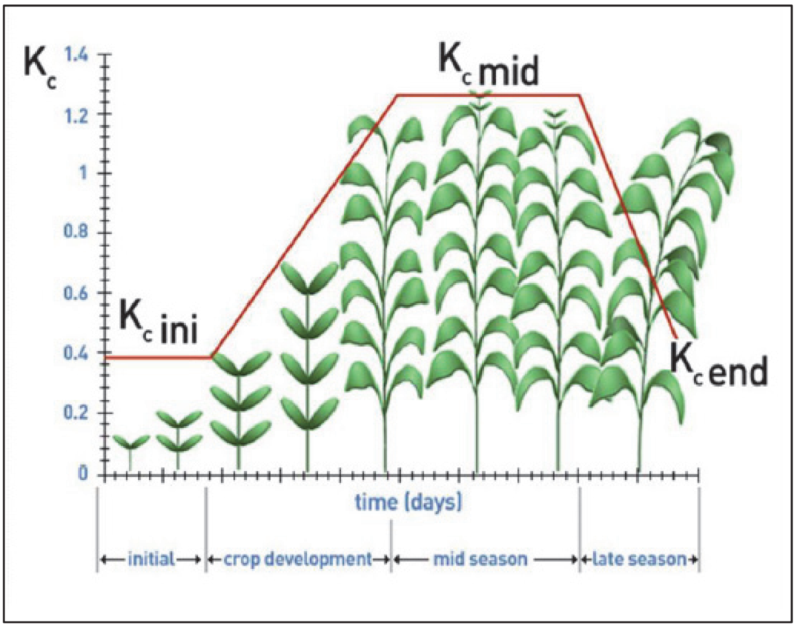

Figure 23: Variation in the crop coefficient Kc (based on Allen et al. 1998)

In this case, carrots are grown year round by the supplier, rather than having a single growing season in the year. To accommodate continuous growing, a separate water footprint was calculated for planting at the beginning of each month, making 12 water footprints in total.

The crop water requirement, ET_c [t]mm/day, is typically determined by multiplying a crop coefficient K_c [t], which is representative of the particular crop, times the evapotranspiration ET_0 [t] mm/day for a reference crop at that particular location and time.

$$ET_c[t] = K_c[t] \times ET_0[t]$$

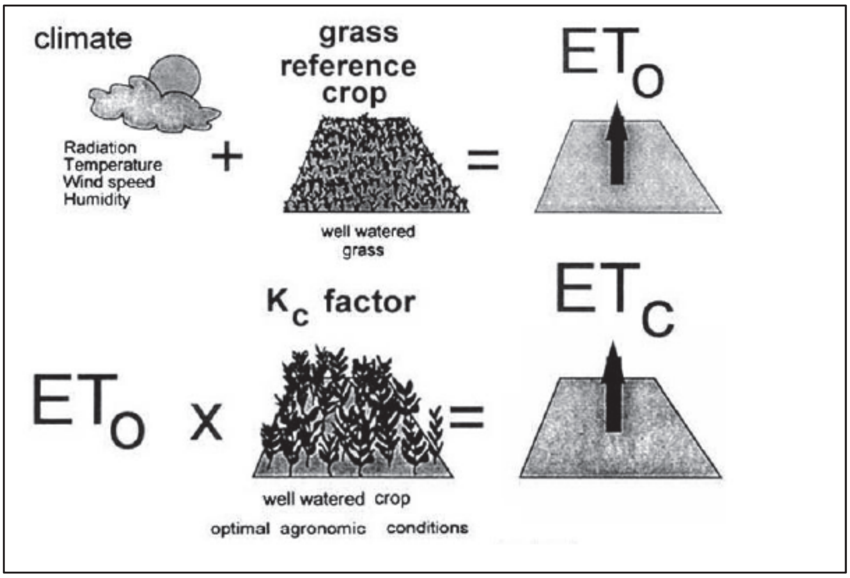

Figure 24: An illustration of the calculation ETc (Allen et al. 1998)

3. Determine the ***greenwater footprint***.
    a. Using the SAPWAT or CLIMWAT 2.0 database, determine the effective rainfall for the geographic location for each 10-day time step relevant to the growing cycle of the crop. Effective rainfall is the rainfall which enters the root zone and which the crop can use for evapotranspiration, and therefore excludes run off.
    b. For each 10-day time step, take the minimum of the effective rainfall and the crop water requirement. The greenwater use, $CWU_{green}[e,c]$, is equal to the minimum effective rainfall (precipitation), $p_{eff}[t]$, and crop water evaporation requirement at that time step (t).

$$CWU_{green}[e,c,t] = \min(ET_c[t], p_{eff}[t]$$

    c. Sum the minimums for each 10-day time step through the growing cycle to find the millimetres of greenwater used by the crop for the entire growing cycle. Multiply by 10 to convert millimetres of water to m^3 per hectare, which represents crop greenwater use.

$$CWU_{green}[e,c,t] = 10 \times \sum_{t=0}^{T} CWU_{green}[e,c,t]$$

    d. Divide by yield to find the greenwater footprint in terms of m^3 per ton of crop.

4. Determine the ***optimal bluewater footprint***.
    a. For each time step, subtract the greenwater use found above from the crop water requirement. This represents the irrigation requirement.

$$I_r[t] = ET_c[t] - CWU_{green}[e,c,t]$$

    b. As the optimal bluewater footprint assumes optimal irrigation, it is assumed that the blue crop water use for each time step is equal to the irrigation requirement. Find total blue crop water use by summing overall all time steps and multiplying by 10 to convert from mm to m^3 per hectare.

$$CWU_{blue}[e,c,t] = 10 \times \sum_{t=0}^{T} CWU_{blue}[e,c,t]$$

c. Divide by yield to find the bluewater footprint in terms of m^3 per ton of crop.

5. Determine the ***actual bluewater footprint***, which is the amount of irrigation actually delivered to and made available to the crop for evapotranspiration, as opposed to the optimal amount of irrigation. This can be found by multiplying actual irrigation by irrigation efficiency. If it is known, it is desirable to do this for each time step used above because this illustrates the use of water for a specific point in time. However, as actual irrigation for each time step is often not known, an annual total is instead used to represent the actual bluewater footprint.

6. Determine the ***greywater footprint***. In this case, the method most typically used in literature was followed. The greywater footprint is the volume of water that would be required to assimilate a pollutant load back to acceptable levels. Because the greywater footprint can be thought of as a dilution factor, the pollutant requiring the highest level of dilution should be used to calculate the greywater footprint. If the pollutant requiring the highest level of dilution is diluted, all other pollutants will be sufficiently diluted as well. Literature typically uses nitrogen as the indicator for greywater footprint, and it is assumed that 10% of the total nitrogen applied leaches into groundwater or runs off to surface water (Gerbens-Leenes 2010).
   a. Multiply the leaching factor times the nitrogen applied (kilograms per hectare) to find pollutant load (L) per hectare.
   b. Divide by the maximum acceptable concentration of nitrogen (kilograms per m^3) minus the natural concentration of nitrogen. Consistent with literature, the maximum acceptable concentration of nitrogen was assumed to be 10 mg/L or 0.01 kg/m^3, and the natural concentration of nitrogen were there no human activity is assumed to be 0.

$$WF_{grey} = \frac{L_{add}}{c_{max} - c_{nat}}$$

6.2.3 Water Footprint Accounting and Interpretation

Green-, blue- and greywater footprint

The green-, blue- and greywater footprints per ton of carrots from Ceres are shown in Table 9 for 6 different planting months throughout the year. The average greenwater footprint for carrots from Ceres is 78 m^3/ton of carrots produced, the average bluewater footprint is 96 m^3/ton, and the average greywater footprint is 25 m^3/ton.

The green- and bluewater footprints change significantly depending on the planting month, providing a clear illustration of the temporal nature of a water footprint. Carrots planted in May have the lowest water footprint with an entirely greenwater footprint of 104 m^3/ton, while carrots planted in November have highest water footprint with a combined blue- and greenwater footprint of 235 m^3/ton. The difference is due to the lower evapotranspiration requirements during the winter growing period. Carrots planted in May have only a greenwater footprint and no bluewater footprint, meaning that no irrigation is required, due to the increased effective rainfall during the winter. Conversely, the bluewater footprint of carrots planted in November accounts for 85% of the blue- plus greenwater footprint.

Because it was assumed that fertiliser applications rates are the same year-round, the estimated greywater footprint is thus constant regardless of the planting month. However, use of fertiliser may vary throughout the year and introduce variation in the greywater footprint as well.

Table 1: Water footprint for carrots from Ceres

	Planting Month						
	March	**May**	**July**	**Sept**	**Nov**	**Jan**	**Average**
Green WF (m^3/ton)	128	104	99	64	35	39	78
Blue WF (m^3/ton)	31	0	64	125	200	158	96
Grey WF (m^3/ton)	25	25	25	25	25	25	25

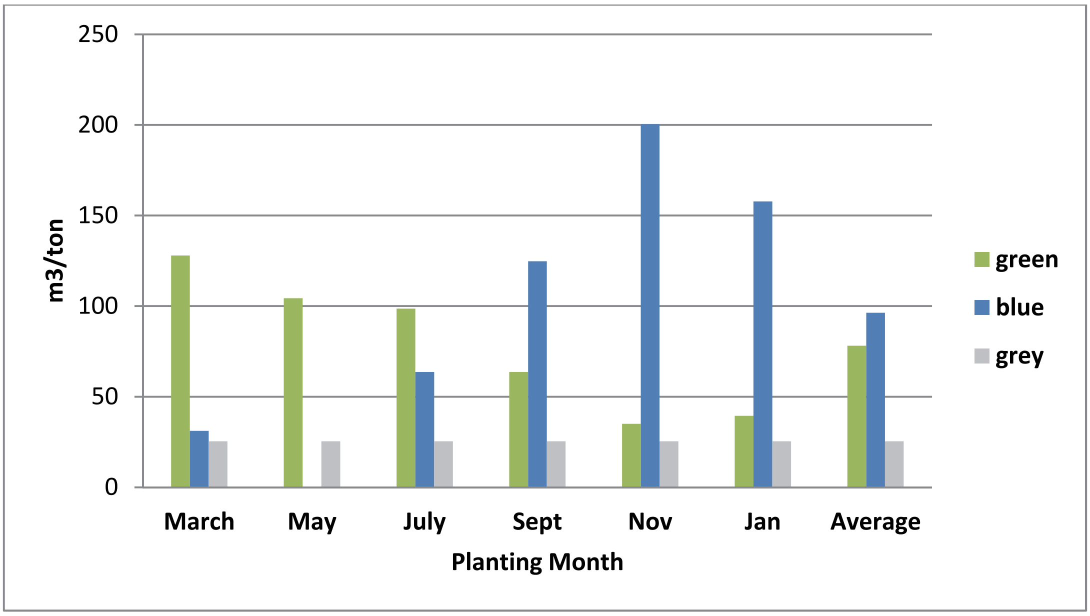

Figure 25: Water footprint for carrots in Ceres based on planning month

To further illustrate the temporal nature of the water footprint, the monthly blue- and greenwater footprint for year-round production is shown in the figure below. The bluewater footprint increases substantially in dry summer months and the water footprint is higher overall due to higher temperatures. The greenwater footprint increases in winter months due to higher rainfall, and the overall footprint is lower due to lower temperatures and lower evapotranspiration.

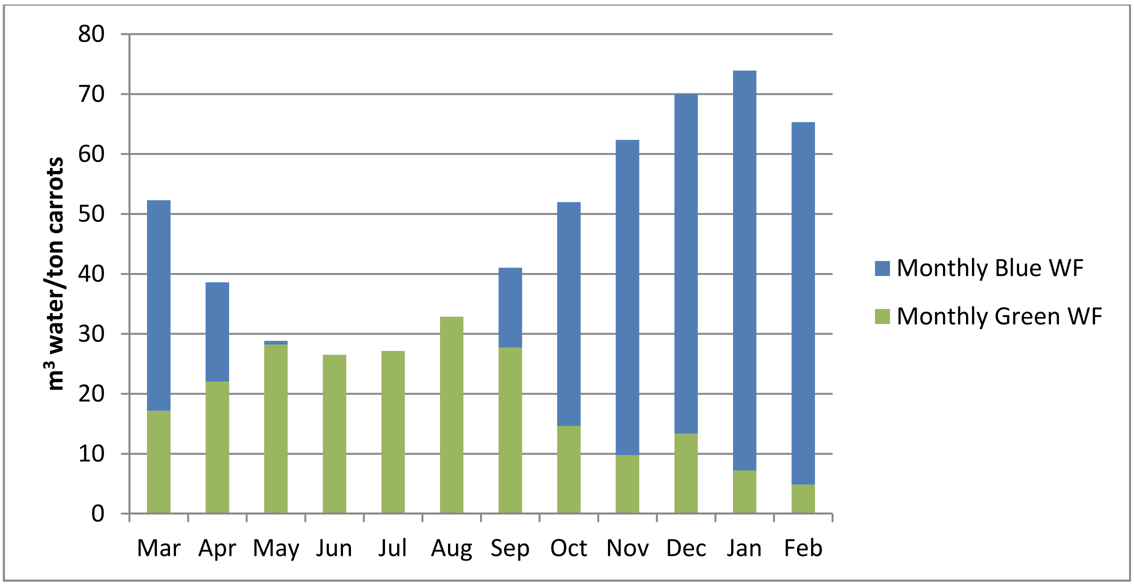

Figure 26: Monthly green- and bluewater footprint for carrots from Ceres, assuming year-round planting and harvesting

Actual irrigation

The bluewater footprint represented above shows the amount of embedded water (evapotranspiration) that would be required for optimal crop growth. While the optimal bluewater footprint can be a useful indicator for irrigation, actual irrigation will be a better representation of actual surface water use.

Figure 27 shows the optimal bluewater footprint per ton of carrots compared to actual water abstraction for irrigation. It also shows the effective irrigation, which takes distribution losses into account and represents the water which reaches the crop and may be used for evapotranspiration. Here, irrigation efficiency is assumed to be approximately 75% based on grower estimates.

The optimal bluewater footprint is 96 m^3/ton, compared to 127 m^3/ton for actual water abstraction and 95 m^3/ton. This indicates that the bluewater footprint for effective irrigation is essentially equal to the optimal bluewater footprint, and the abstracted water is slightly higher than the optimal bluewater footprint to accommodate distribution losses.

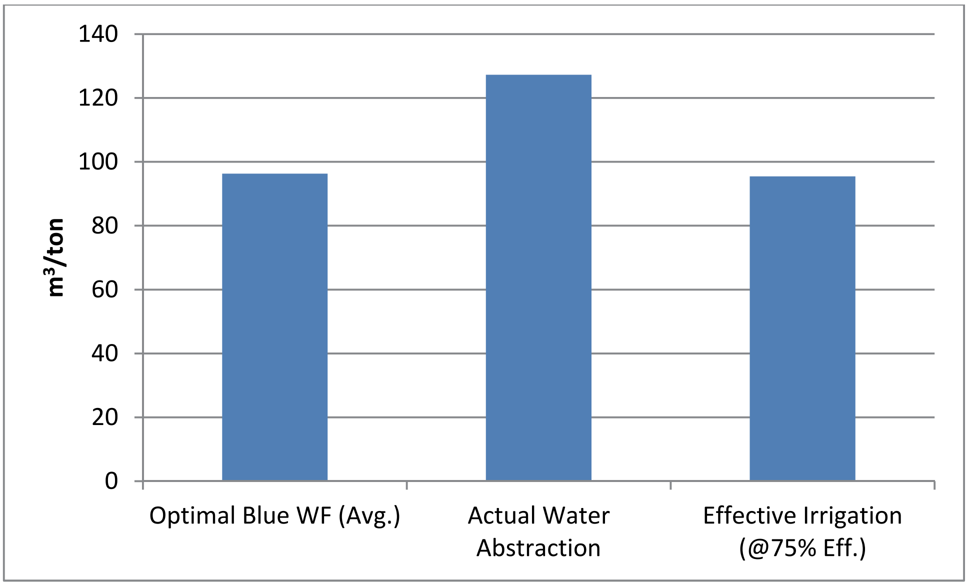

Figure 27: Comparison of the optimal bluewater footprint and actual irrigation

The case study on carrots from a company perspective, abstraction for irrigation is the most appropriate measure of the bluewater footprint, rather than effective irrigation which is delivered to the crops. This is because for the purposes of benchmarking, and understanding impacts and risks, the full amount of surface water abstracted and not returned to the source is relevant.

6.3 Beans from Kenya

6.3.1 Scope

The purpose of this study is to determine the green- and bluewater footprint of bean production in Kenya, and to illustrate water dependencies which result from importing agricultural products.

The green- and bluewater footprint of beans from Kenya will also be compared with the water footprint of beans from other countries. This provides an example of comparing the water footprint of a commodity from different supply chain alternatives, while acknowledging that the broader environmental, economic and social circumstances of supply options must be understood to give meaning to a water footprint comparison.

This study focuses on crop cultivation. Based on literature, packaging, distribution, sale and consumption are excluded and presumed to be small in comparison.

Additionally, this study calculates only the green- and bluewater footprint, and excludes the greywater footprint because fertiliser use was not known for this supplier.

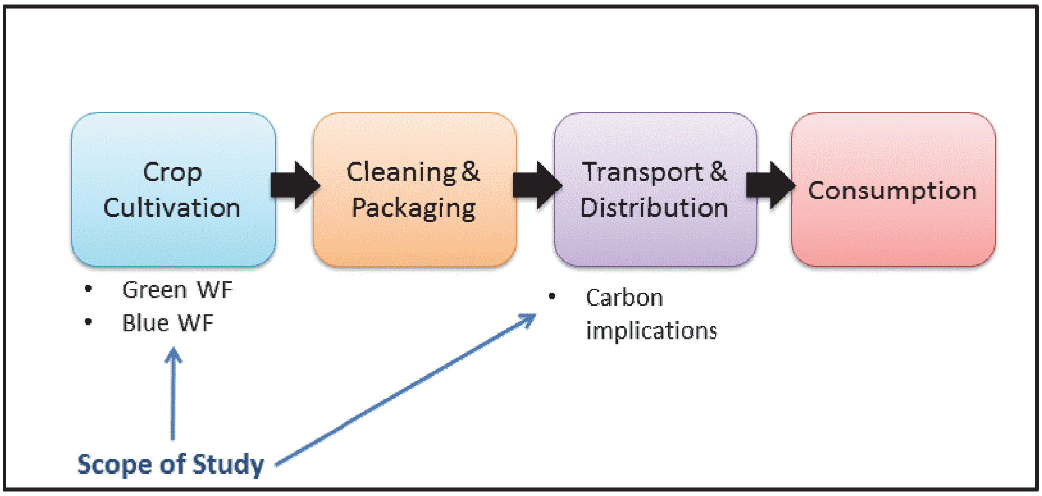

Figure 28: Scope of footprint assessment for beans from Kenya

6.3.2 Information, methodology and assumptions

The information requests, methodology and assumptions follow closely on those used in the study on carrots from Ceres in the Section 6.2.2, and thus are not repeated here. Average yields and planting seasons were assumed based on literature as limited information was available from the supplier.

6.3.3 Water footprint accounting and interpretation

High level water footprint

The blue- and greenwater footprint per ton of beans produced in the two main growing seasons is shown below. Similar to the analysis on carrots, this indicates the temporal nature of a water footprint. Beans planted in March have a slightly lower blue- plus greenwater footprint than beans planted in September, which is indicative of lower evapotranspiration requirements for the growing season for beans planted in March. Additionally, beans planted in March have a significantly higher greenwater footprint and lower bluewater footprint than beans planted in September, indicating lower irrigation requirements for beans planted in March.

Table 2: Blue- and greenwater footprint of beans grown in Kenya

	March Planting	September Planting
Green WF (m^3/ton)	484	316
Blue WF (m^3/ton)	72	276
Green + Blue WF (m^3/ton)	**556**	**592**

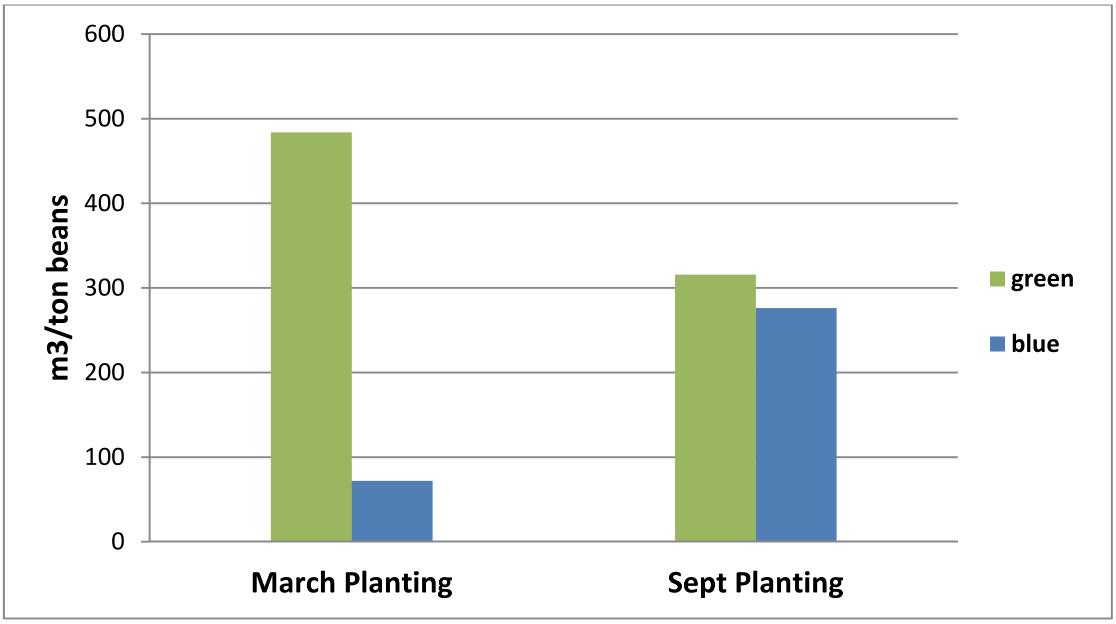

Figure 29: Water footprint of beans grown in Kenya

Comparative advantages of imports and local production

Importing of beans from Kenya represents an example of virtual water flows through trade in products, and has implications for Woolworths in terms of its supply chain dependencies on imports. For Woolworths to understand its supply chain water risks, the context of local water resources in the growing regions in Kenya must be understood.

Importing of products also introduces the idea of comparative advantages of growing crops in different locations. Understanding comparative advantages and water implications of crops from different areas can help to understand supply options for commodities.

The water footprint of local and external supply options may also be viewed alongside the carbon footprint from transportation from different suppliers. This can help to create a more comprehensive picture of environmental impacts which takes into account both water and carbon.

As an example, the water footprint for beans grown in Kenya as versus grown in the Western Cape in South Africa is shown in Figure 30. While the overall water footprint for beans grown in Kenya is higher, the majority of the footprint is greenwater. Beans grown in the Western Cape, in contrast, have a much higher bluewater footprint. To fully understand the implications of these different water footprints, the availability, social and economic consequences, and alternative uses for rainwater and irrigation in Kenya and the Western Cape would have to be fully understood. Additionally, to understand water risks, climate variation and the stability of water allocation regimes must also be considered.

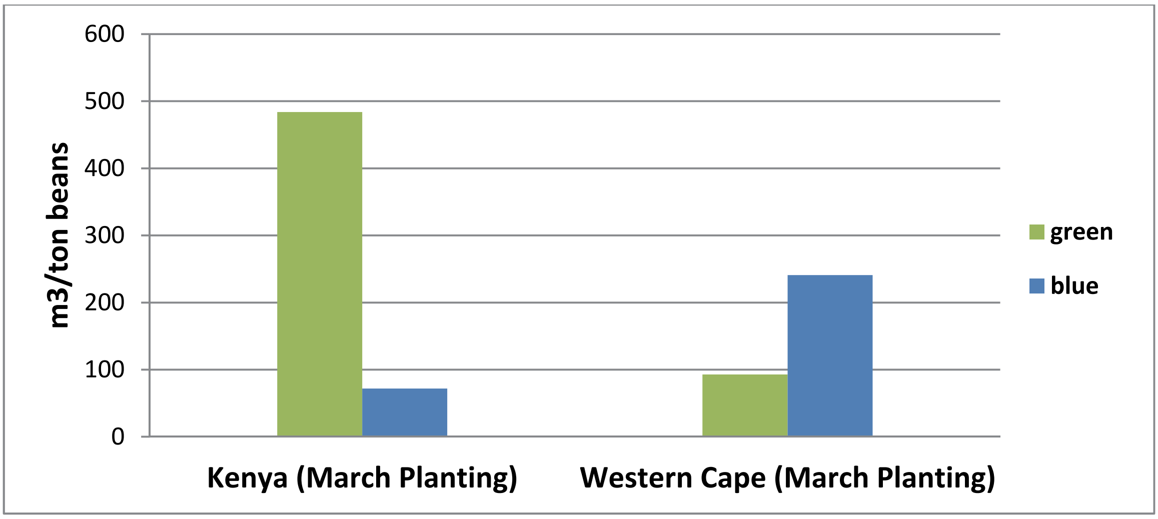

Figure 30: Water footprint of beans grown in Kenya and the Western Cape

While the water footprint indicates higher surface water requirements in the Western Cape than in Kenya, and local production of goods will result in a lower carbon footprint. Table 16 contains estimated energy and carbon emission information for the transportation of 1 ton of goods which can be used to estimate carbon emissions of transporting food products.

Table 3: Energy requirements and carbon emissions for transportation of goods (based on IPCC 1999 and Schipper 2010)

Transport Method	g CO_2 per ton-km
Maritime Shipping	5
Rail	7
Truck	60
Air	200

Table 4: Estimate of carbon footprint for importation versus local production of beans

	Kenya to Cape Town	Western Cape to Cape Town
Weight of Product (tons)	100	100
Estimated Distance Travelled by Truck (kilometres)	100	200
Estimated Distance Travelled by Air (kilometres)	4000	0
Estimated Carbon Emissions (tons CO_2 / ton beans)	8.06	0.12
Estimated Carbon Emissions (tons CO_2 / year)	**806**	**12**

Using the figures in table above, the estimated carbon footprint for transporting 1 ton of beans from Kenya to Cape Town is compared to the carbon footprint of transporting 1 ton of beans from growing regions in the Western Cape to Cape Town. With the additional air travel, the carbon footprint for beans imported from Kenya is much higher than beans grown locally. For this analysis, it is assumed that the carbon footprint for beans is the same in both locations in all respects except for transportation.

Despite having a carbon and water footprint estimate for different potential suppliers, drawing concrete conclusions from these footprints is challenging. The preference of sourcing goods locally is clear from a carbon perspective, as it is always preferable to have a lower carbon footprint and the location of the footprint does not need to be considered.

From a water perspective, however, the preference is unclear. The Western Cape has a lower overall water footprint but a higher bluewater footprint, indicating higher use of surface water. The relative value and impacts of green- and bluewater in each of the growing areas must be understood. This requires understanding the water availability in each region, economic and social implications of agricultural production. It also requires understanding the scarcity and value of water, and the opportunity cost associated with water use.

6.4 Cheese from the Western Cape

6.4.1 Scope

The purpose of this study is to determine the green-, blue- and greywater footprint of cheese production in the Western Cape, and to link this with the Woolworths supply chain to explore water dependencies and potentially water risks.

Unlike carrots and beans, the processing step of cheese-making also plays a potentially important role in terms of blue- and greywater, and thus will be considered in the analysis. It presents an opportunity to understand the implications of direct water use in production to the implications of water use in the supply chain.

This study will focus on animal grazing for milk production, the dairy, and the cheese production process. The water footprint for transportation, distribution, sale and consumption are excluded from this analysis as they are assumed to be small in comparison. While the water footprint for packaging materials may be important in terms of greywater, it will be excluded in this analysis as the primary focus will be on cheese production and an analysis of the water footprint of packaging materials would require a substantial study in itself.

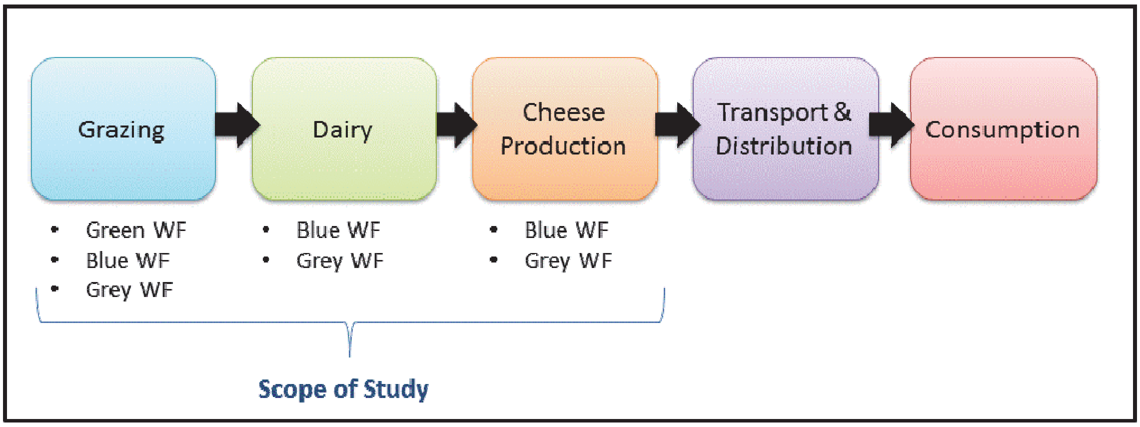

Figure 31: Scope of water footprint study for cheese production

6.4.2 Information, methodology and assumptions

The water footprint for cheese can be thought of in 3 main steps: (1) Grazing and cattle servicing, (2) Dairy, and (3) Operational processes for cheese production.

Information

The information below was gathered in order to calculate the water footprint of milk production and operations for cheese production.

Grazing and cattle servicing

1. *What is the geographical origin of the milk?*
2. *What source of feed is used for cows, and what is the average consumption?*
3. *What is the average lifespan of a cow, and how much milk does it produce?*
4. *What is the average volume of water consumed for drinking purposes?*
5. *What is the average volume of water used for servicing each cow?*
6. *What volume of water (m^3 per hectare) is used for irrigation of pastures?*

Dairy

7. *What are the abstraction and effluent volumes of water per unit of milk production?*
8. *What are the incoming and effluent chemical oxygen demand (COD) concentrations?*
9. *What is the source of abstraction, and where does the effluent flow to?*

Cheese Production Operations

10. *What is the process flow diagram for cheese production?*
11. *What volume of water is used in direct operations for cheese production, and what are the water quality parameters of incoming streams?*
12. *What is the volume of water in effluent streams, and what is the concentration of pollutants in effluent streams?*
13. *What volume of milk is required to produce each kilogram of cheese, and what quantity of cheese is produced?*

Assumptions

The following assumptions were made due to the availability of information, and to keep the study focused.

Grazing and cattle servicing

- It is assumed that 80% of pastures are rainfed and 20% are irrigated, based on an estimate from farmers.
- Approximately 30% of the diet of cows used to supply the cheese producer with milk is in the form of concentrates, which largely consist of grains. It was assumed that concentrates consist of maize, wheat, barley and cottonseed oilcake according to supplier information. It was also assumed that the concentrations are sourced from South Africa, and that the footprint represents the average footprint for production of these crops in South Africa.
- Pasture yields are assumed to 3 tons of Lucerne grass per hectare of non-irrigated land, based on research on the average pasture yields in the relevant areas. Irrigated pastures are assumed to have a yield of 4 tons per hectare.

Dairy

- Estimates for the dairy water footprint are based on literature values. It is assumed that approximately 6 litres of water are used per kilogram of milk produced, and 75% to 90% of this water becomes effluent (Strydom 1993). Further, it is assumed that COD is the main pollutant of concern and the average COD in effluent streams is 3,800 mg/L (WRC 2001).
- As the cheese production facility receives milk from a variety of dairies, the source of abstraction and destination of effluent streams is not known. It is assumed that effluent water is used for irrigation, and a 10% leaching factor for pollutants is assumed.

Cheese production operations

- The cheese production facility produces butter and powdered milk, in addition to cheese. Waste water data and water use data for receiving of milk, central cleaning and other common processes are only known for the facility as a whole, and not for specific products. Due to confidentiality, it is unknown what percentage of milk is used to make cheese as compared to butter and powered milk. For simplicity, it was assumed that 50% of the incoming milk is used to make cheese, and therefore 50% of the waste water footprint and the footprint from water use in common processes is attributable to cheese.
- Abstraction concentrations are assumed to be equal to the acceptable standard for each contaminant.

Methodology

The methodology used follows that provided in the Water Footprint Assessment Manual for animal-based products.

Grazing and cattle servicing

The water footprint for grazing and cattle servicing is determined by finding the water footprint of the feed according to the method explained in the carrots case study, and is put into terms of m^3 water per ton of milk. The servicing and drinking requirements are added to the water footprint of feed.

Dairy

The bluewater footprint for the dairy is determined by subtracting the effluent returned to the source of abstraction from the abstraction volume. In this case, it is assumed that 85% of water is returned.

The greywater footprint is determined as a point-source of discharge, and represents the volume of water which would be required to assimilate added pollutants in the effluent stream to an acceptable standard. COD is assumed to be the pollutant of importance.

$$WF_{grey} = \frac{L_{add}}{c_{max} - c_{nat}} = \frac{Effl \times c_{eff} - Abstr \times c_{act}}{c_{max} - c_{nat}}$$

Cheese production

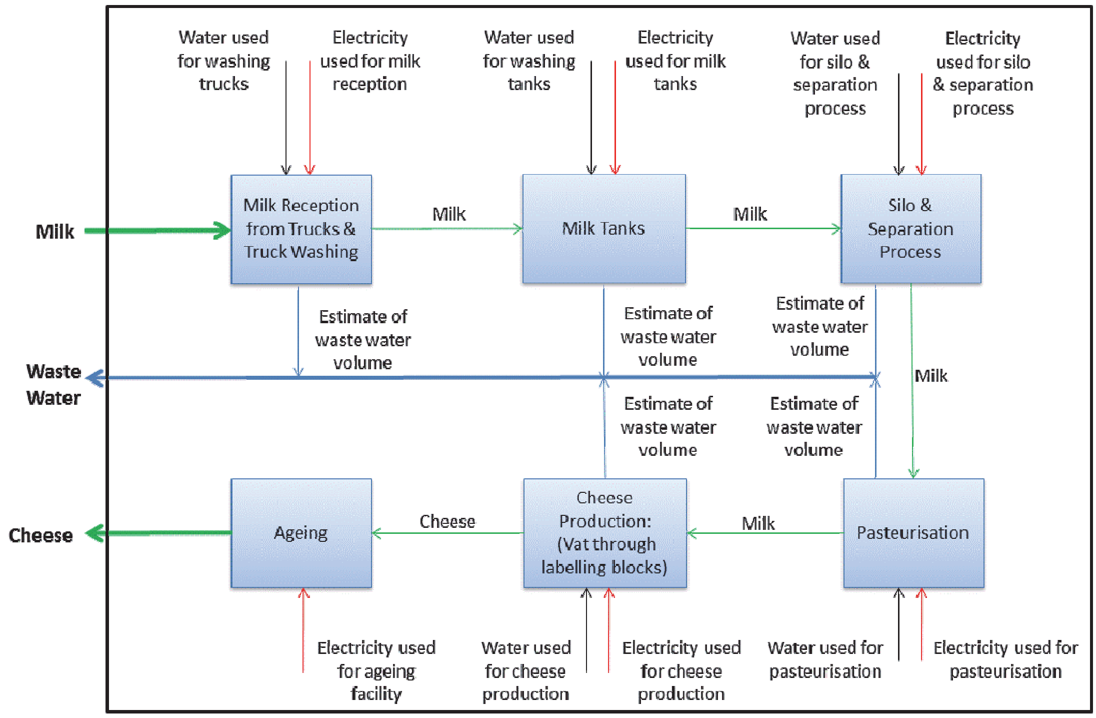

Figure 32: Diagram of cheese production process

1. Determine the bluewater footprint of cheese production by determining the water abstraction attributable to cheese production, and subtracting any effluent which is returned to the point of abstraction. At the cheese production facility, all effluent water is

used for irrigation and thus is not returned to the catchment. The bluewater footprint equals the volume of water abstracted for cheese production. The processes relevant to cheese production are shown in Figure 32. For processes which are common to making of butter and powdered milk, which are also produced in the facility, a proportional amount of the bluewater used was taken into account.

2. Determine the greywater footprint of cheese production. As the effluent stream is used for irrigation, the greywater footprint is determined first by determining the greywater footprint as a point source of pollution, and then by assuming a 10% leaching and runoff factor for the effluent streams which are used for irrigation, as consistent with literature (Gerbens-Leenes 2010).

3. Determine the bluewater footprint of electricity by determining the total electricity requirements, and using the literature value of 0.16 m^3 per gigajoule.

6.4.3 Water Footprint accounting and interpretation

High level cheese water footprint

The water footprint per ton of cheese produced is given in Table 5. The water footprint is split into the cattle and grazing, dairy and cheese production steps.

A key message which emerges is that the upstream water footprint of grazing and cattle servicing for milk production accounts for more than 99% of the blue- and greenwater footprint. The majority of this is greenwater, connected to the rain-fed pastures used for cattle grazing. This is based on the gross greenwater footprint approach which looks at total rainwater use. However, if a net approach is taken that looks at the difference in greenwater used for evapotranspiration for grazing as compared to a natural state, the greenwater footprint would be significantly lower and potentially even close to zero.

Table 5: Water footprint of cheese production

		Cattle & Grazing	Dairy	Cheese Production
Green WF	m^3/ton cheese	9604	0	0
	percentage	100%	0%	0%
Blue WF	m^3/ton cheese	2584	12	10
	percentage	99%	0%	0%
Grey WF	m^3/ton cheese	353	39 (390 if not used for irrigation)	37 (370 if not used for irrigation)
	percentage	82%	9%	9%

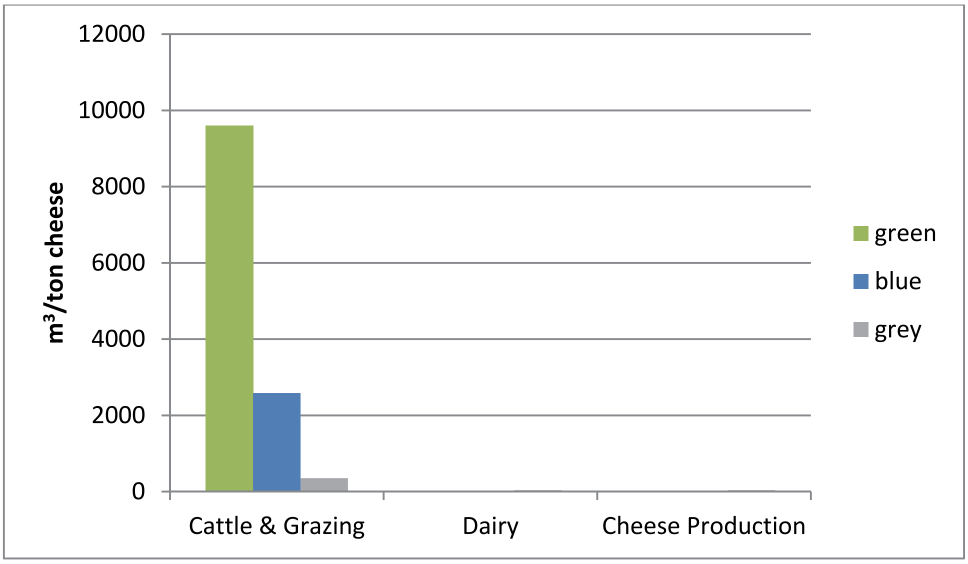

Figure 33: Upstream and operational water footprint of cheese production

The dairy and cheese production steps also have a significant greywater footprint before irrigation of effluent streams is taken into account. If effluent streams are not used for irrigation or are poorly managed, the greywater footprint of the dairy and cheese production processes will increase substantially (Figure 32).

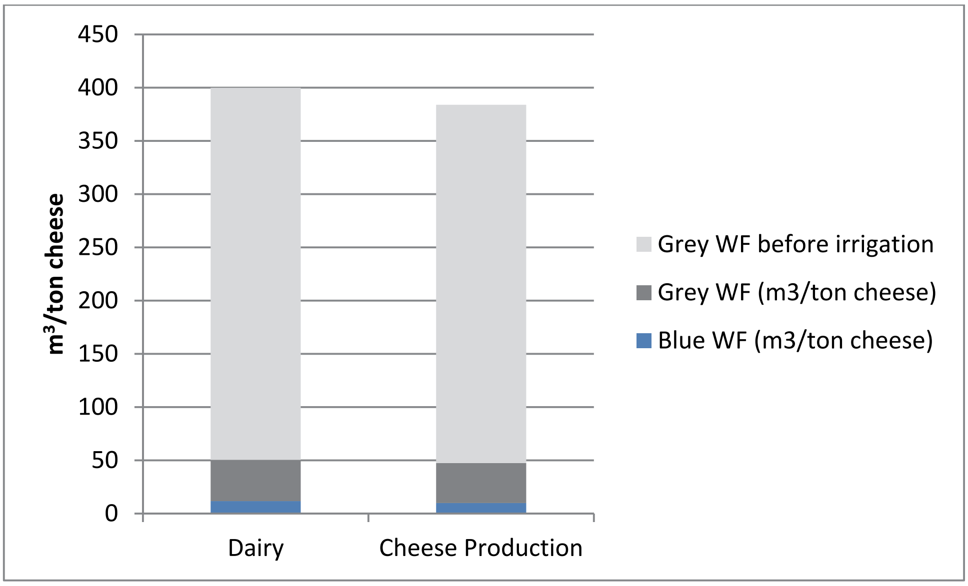

Figure 34: Dairy and cheese production process water footprint per ton of cheese

Grazing and cattle servicing water footprint

The green- and bluewater footprint for grazing and cattle servicing for the production of 1 ton of milk is shown in Figure 35. The majority of the footprint is connected to cattle feed, 70% of which comes from grazing and 30% of which comes from concentrates. Servicing and water consumption together account for 5% of the bluewater footprint, and none of the greenwater footprint.

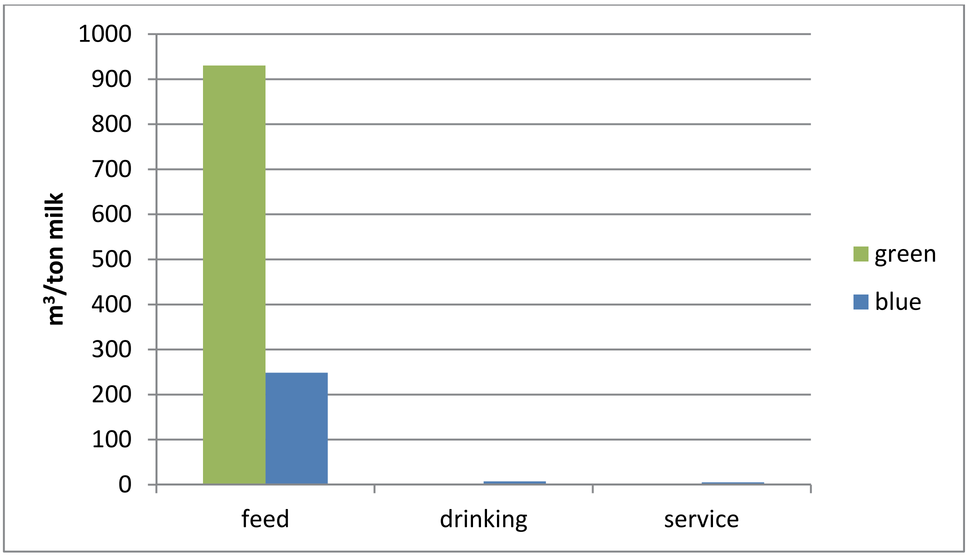

Figure 35: Water footprint for grazing and cattle servicing

As stated in the assumptions, a feed yield of 3 tons per hectare for non-irrigated pastures and 4 tons per hectare for irrigated pastures are assumed. However, the dairy cattle used to supply the facility graze in four main areas of the Western Cape, each having slightly different rainfall, yields, and therefore different water footprints. This means that differences exist in the local supply chain regarding water footprint, creating a spatial story that water footprint can help to inform if the specific rainfall and yields of each area are known.

Focusing on the feed, the importance of the concentrates in contributing to the water footprint is apparent. With concentrates, which consists largely of grains and oilseed, the combined green- and bluewater footprint is over 1200 m^3/ton of milk as compared to 700 m^3/ton of milk if the cows were pasture-fed only. This is due to the higher water footprint of concentrate, as compared to grass.

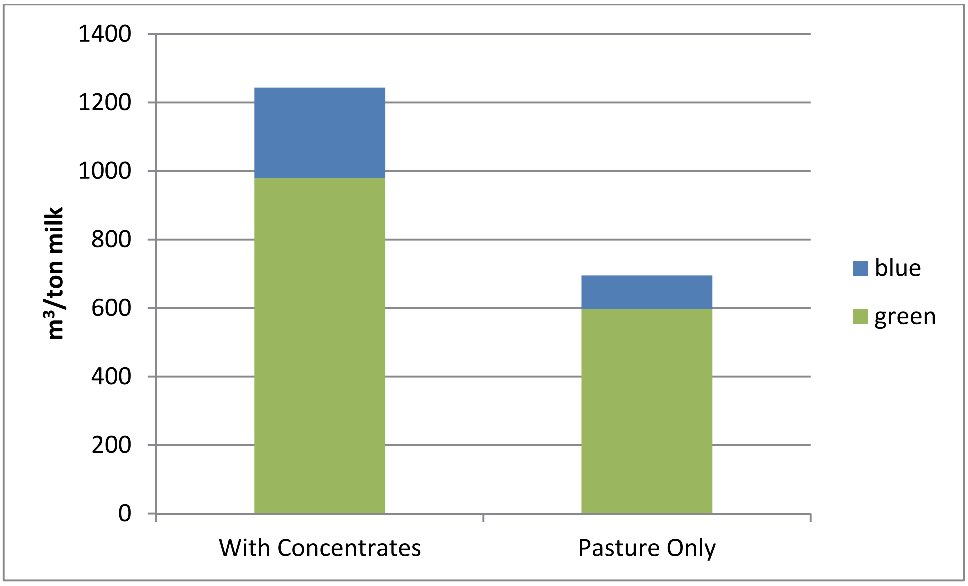

Figure 36: Water footprint of milk comparing feed with concentrates and pasture-grazing only

An alternative approach to greenwater is to consider the net greenwater footprint, which considers the difference in the greenwater footprint compared to what it would have been with natural vegetation. The net greenwater footprint is most relevant when considering impacts as the key focus is on the impact on water resources from a previous state. The gross greenwater footprint is relevant for considering risks as total water dependency, and risks to that water supply, must be identified. Additional information regarding concentrates and pastures is required to calculate the greenwater footprint in this case due to the unknown origin of concentrates and multiple locations of pastures. However, it is expected that the net greenwater footprint would be substantially lower than the gross greenwater footprint, and in turn would reduce the overall water footprint per ton of cheese.

Dairy

The water footprint for the dairy process is almost entirely greywater, due to the COD load in effluent water. This value is intended to recognise the water quality implications associated with milk production. However, as it is based on literature values, it should be viewed as indicative. The greywater footprint may change based on actual effluent volumes and COD levels, and may be impacted with the destination of effluent water. For example, if the effluent is either treated or used for irrigation, a smaller amount of COD will reach surface or groundwater sources and the greywater footprint will be lower.

Concerns regarding the greywater footprint have been discussed earlier. In summary, the greywater footprint is not representative of a physical volume of water, unlike the blue- and greenwater footprints. It is a metaphorical indicator of water quality impacts, similar to the concept of land requirements in an ecological footprint analysis. The greywater footprint loses information regarding the type of pollutant, and does not support a response.

In addition to the above, significant water quality concerns are associated with production of dairy products. The greywater footprint is, however, relatively small as compared to the blue- and greenwater footprint in the overall water footprint of cheese production. This indicates that the greywater footprint representation of water quality may under-emphasise the importance of water quality concerns.

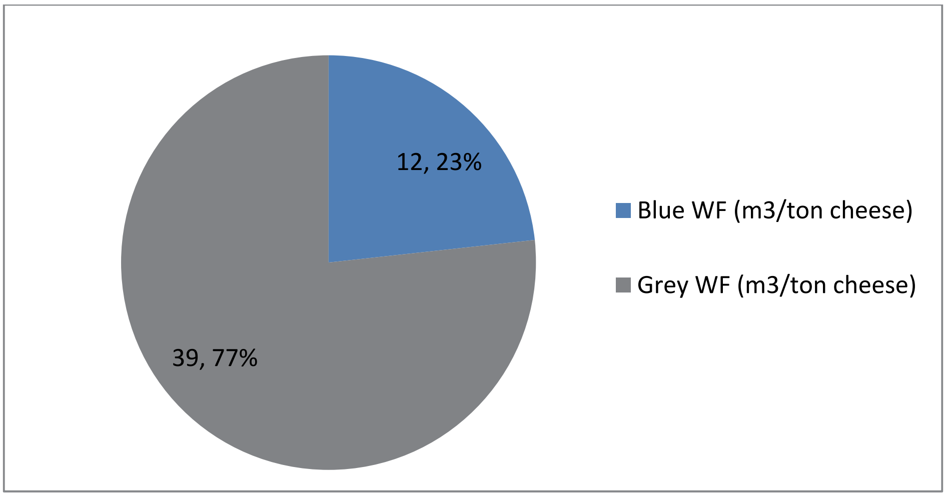

Figure 37: Dairy water footprint for cheese production

Cheese production

The operational water footprint covers direct use of water at the cheese production facility. Milk is delivered to the facility, and includes a blue component of approximately 10 m^3/ton of cheese, and a grey component of 37 m^3/ton of cheese (Figure 38). There is no greenwater footprint because rainwater is not used in the operational stage of cheese production.

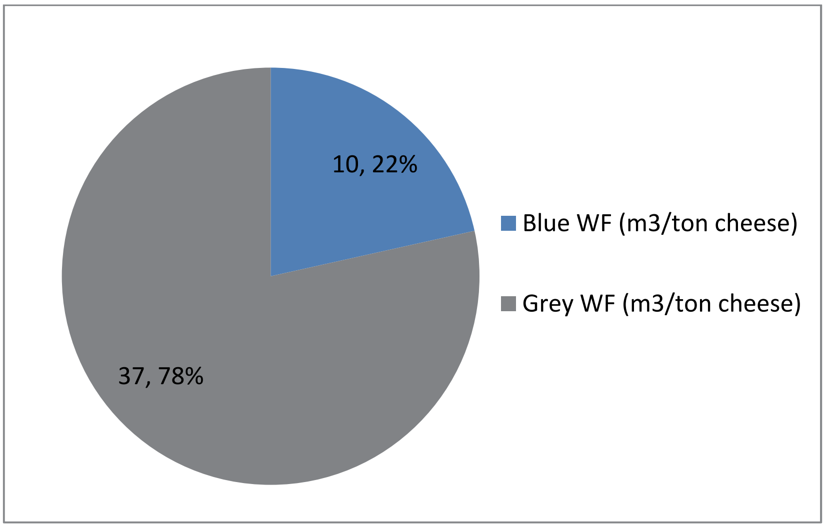

Figure 38: Operational water footprint for cheese production

Bluewater Footprint

The bluewater footprint represents the water entering the production facility which is used for the production of cheese, minus the effluent water from cheese production which is returned to the source of abstraction. The cheese production facility in question uses the effluent stream to irrigate crops on site, and therefore no water is returned to the source from which it was abstracted.

The bluewater footprint can be broken down by the various steps in the production process. This level of viewing water use on site becomes a standard operational water use study which is based on meter readings on-site.

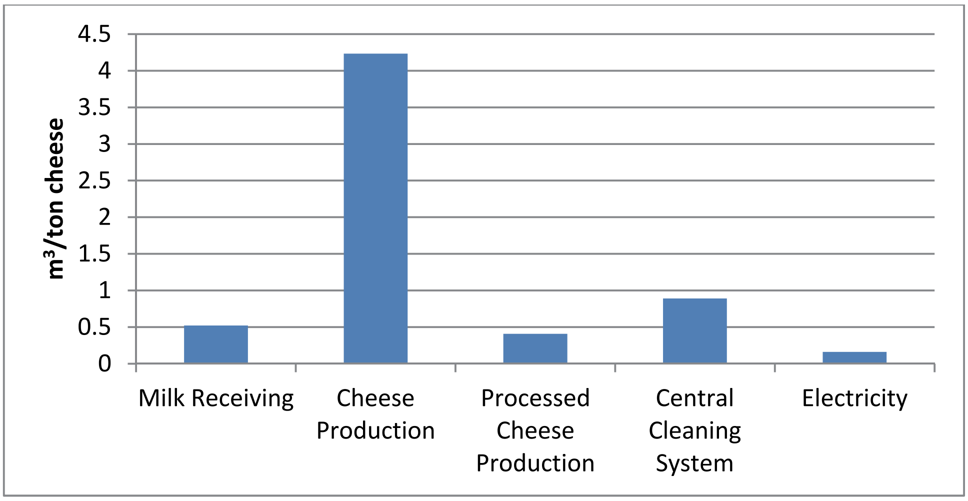

Figure 39: Operational bluewater footprint of cheese production

Greywater Footprint

The greywater footprint from operations looks at the water that would be required to assimilate the added pollutant load in effluent streams to acceptable concentrations. The calculation thus requires the abstraction and effluent water volumes, and the concentration of pollutants in these streams. The pollutant which requires the highest level of dilution determines the greywater footprint because if this pollutant is assimilated, all others requiring less dilution would have been assimilated as well.

For the cheese production facility, the greywater footprint is 37 m^3/ton cheese and is determined by nitrates, as this pollutant requires the highest quantity of water for assimilation.

Table 6: Effluent stream concentrations from cheese production process and greywater footprint

	Average Return Flow Concentration	Standard for Discharge	Assumed Abstraction Concentration	Grey WF (m^3/ton cheese)
COD	5225.9	400	0	14
Ammonia N	11.6	2	0	6
Nitrate as N (mg/L)	54.6	1.5	0.5	37
Orthophosphate as P	108.5	10	0	11
Faecal Coli	22759.8	1000	0	24

6.5 Manufacture of dishwashing detergent

6.5.1 Scope

The dishwashing detergent manufacturing facility produces cosmetics, detergents and toiletries. The company supplies Woolworths in South Africa with a range of dishwashing liquids ranging from Lemongrass, Anti-Bacterial, Pink Grapefruit and Sensitive. The dishwashing liquid is manufactured and packaged on-site. The packaging options vary between 1.5 L and 0.75 L bottles. The main type of dishwashing liquid manufactured on-site is the Lemongrass 0.75 L range and is consequently, the focus of the water footprint study.

The purpose of this study is to determine the green-, blue- and greywater footprint of dishwashing liquid detergent manufactured in South Africa. Unlike the agricultural products, the raw materials used for the manufacture of dishwashing liquid is chemically based, as such, there is a small greenwater footprint as compared to the blue- and greywater footprint.

Of particular interest is the greywater footprint associated with using the dishwashing liquid. Therefore, this study presents an opportunity to understand the direct implications of using this dishwashing liquid and its contribution to the overall water footprint of the consumer product.

As a water footprint looks at the water use through the entire supply chain of a product, the following broad steps are relevant for calculating a water footprint: (1) Raw material production, (2) Dishwashing soap production, (3) Transportation and distribution, and (4) Consumer use of the dishwashing soap.

The two steps of focus for this study are the production of dishwashing soap and the consumer use of the soap. Step 2 of dishwashing soap production will include the water used during the making of dishwashing soap and the wastewater produced during this process. This is the water used in direct operations. Step 4 of consumer use will look at the water used during the dishwashing process, and the waste water produced during this process.

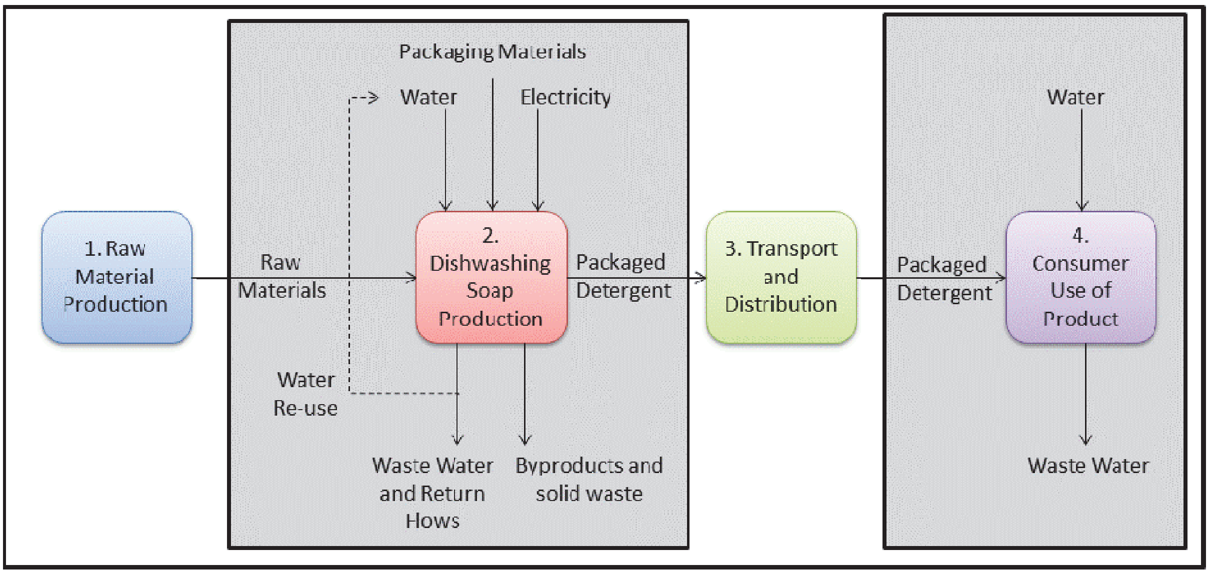

Figure 40: Steps and areas of focus for water footprint in supply chain for dishwashing soap

Raw material production was included in the study, but due to the limited information available, estimates of the water footprint were made. Transport and distribution was excluded from this study as its contribution to the overall water footprint was assumed to be negligible.

It is anticipated that bluewater and greywater will be the main components of the footprint, as rainwater will not likely play a large role in the supply chain steps.

6.5.2 Information, methodology and assumptions

The areas that are covered in this report are the raw materials production, Dishwashing soap production (including packaging) and the consumer use of the product.

Information Requested

The following information was requested from the manufacturer.

Step 1: Raw Material Production

- What are the raw materials used?
- Are the raw materials imported or local products?

Step 2: Dishwashing Soap Production

- What is the quantity and origin of all raw material inputs?
- What is the quantity and origin of water abstracted?
- What is the power consumption required?
- What are the quantity, origin and material used for packaging?
- What is the volume of waste water produced the concentration of pollutants in the stream and location to which flows return?
- What are the treatment options for the waste water?
- What is the operational time of facility?
- What is the average daily production of dishwashing soap and any by-products or solid waste when facility is operational?

Step 3: Transport and Distribution

A review of other studies has shown that the water footprint of this step is negligible compared to other steps. Thus, the water footprint of this step was assumed to be negligible.

Step 4: Consumer Use of Product

- What is the average volume of water used with a given quantity of dishwashing soap?
- What are the concentration of main pollutants from dishwashing soap in waste water stream, and concentration of these pollutants in the original clean water?

It should be noted that not all information requested from Manufacture M was made available for the study, therefore, estimates were made where information was lacking.

Methodology

The methodology used for calculating the water footprint primarily followed the guidelines set out in the Water Footprint Manual. In the absence of data, estimates from the closest process were used.

Step 1: Raw Material Production

The raw materials, which are sourced from external suppliers, are chemically based. In-depth knowledge of the exact processes involved in the production was excluded from this study, however, it was important to understand the source of these raw materials, if it is were produced locally or imported and this has implications on the study.

It should be noted that due to the limited data available in literature regarding chemical processes, much of the water footprint calculations were based on calculations using estimates of similar processes.

- Water: This contributes 45.05% of the dishwashing liquid and contributed to the bluewater footprint.
- Sodium Laureth Ether Sulphate (SLES 25%): This contributes 28.8% of the dishwashing liquid. This raw material constitutes 75% water which contributed to the bluewater footprint. No information was available to calculate the greywater footprint.
- Sulphonic acid: This contributes 15.3% of the dishwashing liquid. Since the base materials for this product can be made from sulphuric acid it was assumed that ten percent of this raw material was water which contributed to the bluewater footprint.
- Triethanolamine (TEA): This contributes 7.24% of the dishwashing liquid. No water forms part of this product and therefore the bluewater footprint was estimated to be zero.
- Marlipal: This contributes 2.00% of the dishwashing liquid. The raw material is sourced from Germany and is a derivative of palm oil. The global average for the blue-, grey- and greenwater footprints were used as an estimate for this raw material.

Step 2: Dishwashing Soap Production

The production of dishwashing liquid by the manufacturer was dependant on the demand from Woolworths. As such, the operational time for the production of dishwashing liquid varied. On average, nine hundred 750 ml bottles of dishwashing liquid was produced each month. It was assumed that this required one percent of the total energy consumed per month by the facility. The bluewater footprint was therefore calculated using the literature value of 0.16 m^3/GJ. Although there is an associated greywater footprint associated with the generation of electricity, there is no information available for this at the moment.

No additional water was used in the process. Water used for general cleaning and domestic use was excluded from this study.

The waste water generated from the production of dishwashing liquid was accumulated with the total wastewater from the facility. The waste water is collected by an external waste water treatment company and disposed of at a landfill. No information regarding the composition of waste water was released and therefore, the greywater footprint could not be estimated.

The products are packaged on-site using 750 ml bottles from 20% recycled PET, labelled and stored in cardboard boxes. Water footprint values for the packaging were estimated from a case study on Coca-Cola for the bottling and labelling and from the case study of Stora Enso's Skoghall Mill for the cardboard.

Step 3: Transport and Distribution

Not applicable.

Step 4: Consumer Use of Product

Only a greywater footprint was attributed to the consumer use of the dishwashing liquid. This followed the method outlined by the Water Footprint Manual where:

$$WF_{grey} = \frac{L_{add}}{c_{max} - c_{nat}}$$

All waste water produced was assumed to return to municipal flow. The two main components that contribute to the greywater footprint are TEA and the organics (SLES and sulphonic acid) present in the dishwashing liquid.

The water used for the washing of dishes is assumed to return to the municipal sewers and therefore the bluewater footprint was assumed to be zero.

Total Water Footprint

According to the Water Footprint Manual, the water footprint of product p (volume/mass) is equal to the sum of the relevant process water footprints divided by the production quantity of product p:

$$WF_{Prod}[p] = \frac{\sum_{s=1}^{k} WF_{proc}[s]}{P[p]}$$

in which $WF_{proc}[s]$ is the process water footprint of process step s (volume/time), and $P[p]$ the production quantity of product p (mass/time).

Therefore, the total green-, blue- and greywater footprint associated with the production and use of the dishwashing liquid was summed over the four steps outlines in the scope: (1) Raw material production, (2) Dishwashing soap production, (3) Transportation and distribution, and (4) Consumer use of the dishwashing soap.

It must be noted that due to the lack of available data, the total green-, blue- and greywater footprints are a conservative estimate and should be seen as the minimum water footprint values.

Assumptions

The following is a summary of the assumptions made for the study, light of the limited data available:

- The water footprint of only the main components in the dishwashing liquid were taken into account as these account for approximately ninety eight percent of the raw materials used.

- One percent of the total water usage, electricity consumption and waste water discharge were used for the calculations.
- Many of the raw materials used in the process are synthesized chemicals of which little or no information is available. In these instances, the water footprint was estimated from the closest available chemical process.
- Marlipal is a palm oil derivative that is processed in Germany. Due to the lack of available data, the global average water footprint was used as an estimate for its WF.
- The main pollutant in normal dishwashing liquid was phosphate. This is hazardous to the receiving water environment as it leads to eutrophication. No phosphate was present in the production of dishwashing liquid from the manufacturer.
- TEA: Some all-purpose cleaners contain the sudsing agents diethanolamine (DEA) and triethanolamine (TEA). When these substances come into contact with nitrites, often present as undisclosed preservatives or contaminants, they react to form nitrosaminescarcinogens that readily penetrate the skin. Therefore, TEA should not be discharged to sewers.
- Dilution factor: 5 ml dishwashing liquid per 10 L of water.
- The bluewater footprint for the consumer use was assumed to be zero
- All dishwashing liquid produced by the manufacturer in one year was assumed to be used within that same year.
- The bluewater footprint for power consumption was based on electricity generated through coal which is estimated to be 0.16 m^3/GJ.

6.5.3 Water footprint accounting and interpretation

Step 1: Raw Material Production

The calculations for the water footprint of the raw materials were limited to the dominant species as shown in the table below which constituted 98% of the dishwashing liquid product.

Table 7: Water footprint for raw materials per ton of dishwashing liquid product

Species	%	Source of Raw Material Supplier	Location	Transport	Type	WF_{GREEN} m^3/ton	WF_{BLUE} m^3/ton	WF_{GREY} m^3/ton
Water	45	Municipality	SA	Pipeline		0	0.451	0
Sodium Laureth Ether Sulphate (SLES 25%)	28.8	Akulu Marchon	SA	Tanker	oil	0	0.216	*
Sulphonic Acid	15.3	Akulu Marchon	SA	Tanker	oil	0	0.0153	*
Marlipal (palm oil derivative)	2	Crest Chemicals	Germany	Ship/Drums	Plant	96	0.02	*
Triethanolamine (TEA)	7.2	Protea Chemicals	China	Ship Drums	Chemical	0	0	*
TOTAL	**98**					**96**	**0.703**	

*no data available

Greenwater footprint

The greenwater footprint consists of only the water footprint from the palm oil derivative, estimated at 96 m^3/ton dishwashing liquid. This value was estimated using the global average water footprint for palm oil.

Bluewater footprint

The bluewater footprint comprised of the water that is incorporated into the products which was calculated to be 0.703 m^3/ton dishwashing liquid.

Greywater footprint

The total greywater footprint for the raw material could not be surmised due to the lack of data on the chemical used. For instance:

Sulphonic acid & SLES: Estimates for this was based on the production of sulphuric acid. Once again, there is a large greywater footprint associated with this; however, due to lack of data, no estimate was made.

TEA: The waste water produced here is rich in ammonia which has large greywater implications. No data available to estimate this footprint.

It is believed that the greywater footprint for these chemical is important and further investigation into these processes need to be conducted in order to understand the implications.

Step 2: Dishwashing Soap Production

The process flow diagram for the dishwashing liquid process is illustrated in the figure below. The operational water footprint for the process can be broken into two parts:

- Production of dishwashing liquid
- Packaging of the product

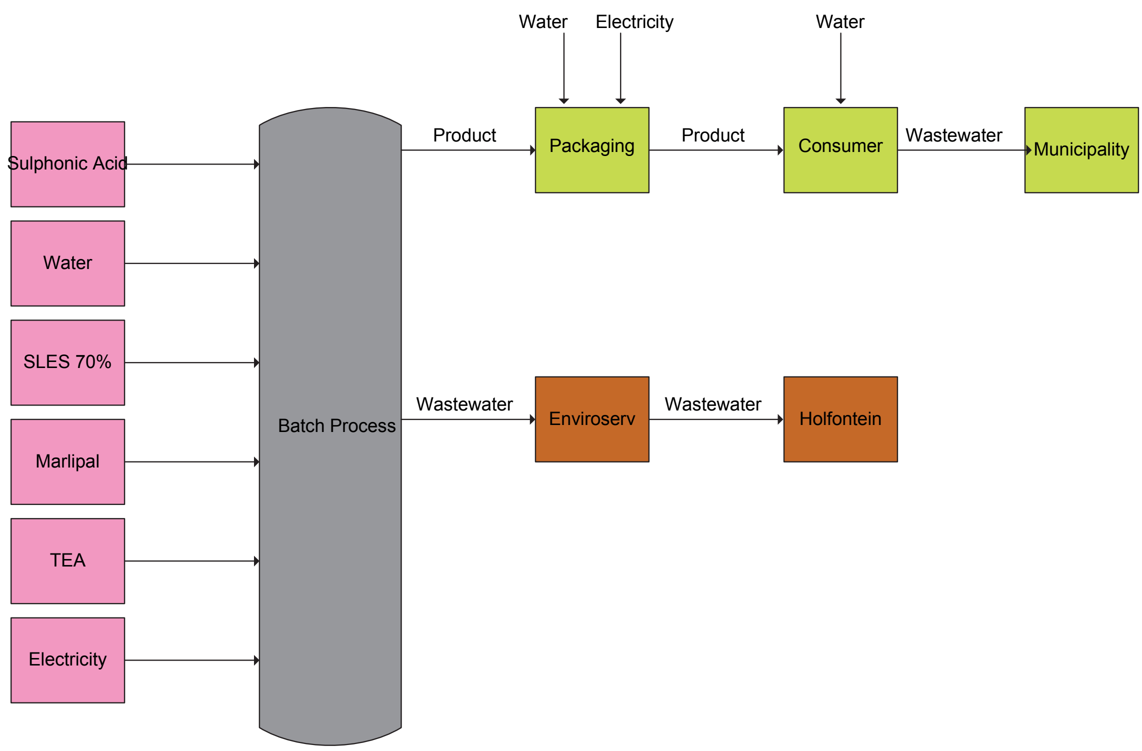

Figure 41: Process flow diagram

Production

Green- and bluewater footprint

There is no greenwater footprint associated with the production of the dishwashing liquid.

The bluewater footprint for the production of dishwashing liquid comprised of the electricity used to run the process and is estimated to be 2 m^3/ton of dishwashing liquid.

Greywater footprint

The total waste water produced from the facility is collected by a wastewater company and disposed of at a landfill. No information was released regarding the composition of this waste water. It can be deduced that since this wastewater isn't released back to normal municipal sewers, a large greywater footprint is associated with the process. Until further information is gathered, it is difficult to estimate the impact of the operational greywater footprint.

Packaging Materials

The packaging materials used in this process for the 750 ml bottle of dishwashing liquid are

i. Cardboard boxes
ii. PET bottles (20% recycled PET)
iii. Labelling

Table 8: Water footprint for the packaging materials used in the production of dishwashing liquid

	Cardboard boxes				PET Bottles	Labelling
	Forestry	Processing	Chemicals	TOTAL		
	m^3/ton board	m^3/ton board	m^3/ton board	m^3/ton board	m^3/ton	m^3/ton
WF_{GREEN}	1669	1.9	0.01	1670.91	0	0
WF_{BLUE}	0	0	0.05	0.05	10	10
WF_{GREY}	0	125	0.04	125.04	225	225
Per ton dishwashing liquid product						
	m^3/ton					
WF_{GREEN}	2.00	0.0023	0.00001	2.00	0	0
WF_{BLUE}	0	0	0.00006	0.00	0.26	0.004
WF_{GREY}	0	0.15	0.00005	0.15	48.6	0.087

Green- and bluewater footprint

The table 8 gives the breakdown of the water footprint associated with the various packaging materials used for the dishwashing liquid. The green- and bluewater footprint for the cardboard used in the packaging process is 2 m^3/ton of dishwashing liquid and 0 m^3/ton of dishwashing liquid respectively. There is a contribution to the bluewater footprint from the PET bottles as well as the labels, but these are minor and are < 0.3 m^3/ton of dishwashing liquid

Greywater footprint

The manufacture of PET bottles contributes the largest greywater footprint for the packaging process as compared to the cardboard and labelling and is 48.6 m^3/ton of dishwashing liquid.

Step 3: Transport and Distribution

Not applicable.

Step 4: Consumer Use of Product

In order to estimate the greywater footprint for the consumer use, it was assumed that all dishwashing liquid produced in a year was used by the consumers.

Table 9: Downstream water footprint for dishwashing liquid used in a year

Pollutant	TEA (m^3/ton)	COD (m^3/ton)
WF_{GREEN}	0	0
WF_{BLUE}	0	0
WF_{GREY}	Infinite	9800

Green- and bluewater footprint

There is no greenwater footprint associated with the use of dishwashing liquid. The bluewater footprint was also assumed to be zero as the water is treated by the municipality and returned within a specified time frame.

Greywater footprint

The main contribution is the greywater that is produced by the dilution of the dishwashing liquid in potable water at a ratio of 2000:1. The main pollutants in this stream are the TEA and the organics (SLES and sulphonic acid).

TEA is not a compound that is naturally present in a water body and should not be allowed to be discharged, therefore $c_{max} = c_{nat} = 0$. This creates an infinitely large greywater footprint for the dishwashing liquid.

The greywater footprint for the organics was calculated based on the Chemical Oxygen Demand (COD), which is a widely accepted estimate of organics present in water. The natural concentration was estimated to be 20 mg/l and the discharge limit sits at 65 mg/l. This gives the combined greywater footprint for SLES and sulphonic acid of 9800 m^3/ton of dishwashing liquid.

The above value is the greywater footprint that the manufacturer discharges. This is not the greywater that reaches the water body as there are various steps for treatment of wastewater by the municipalities in South Africa. The calculation of this exact value lies outside the scope of this study, but it is something to be further investigated once more data is available.

Total Water Footprint

Presented in Table 10 and Figure 42 are the total green-, blue- and greywater footprints associated with the manufacture of dishwashing liquid.

Table 10: Water footprint for the various stages in the supply chain per ton of dishwashing liquid

	Raw materials	Production	Packaging	Consumer use	Total WF
WF_{GREEN}	95.74	0	2.00	0	**97.75**
WF_{BLUE}	0.70	2	0.00	0	**2.71**
WF_{GREY}	5.96	0	0.09	9800	**9806.05**

The largest greenwater footprint for the dishwashing liquid process is associated with the raw materials and the packaging steps. This is to be expected as both these processes involved an agricultural source as an input.

The largest bluewater footprint is seen the production step of the dishwashing liquid process and the consumer use of the products contribute the largest greywater footprint.

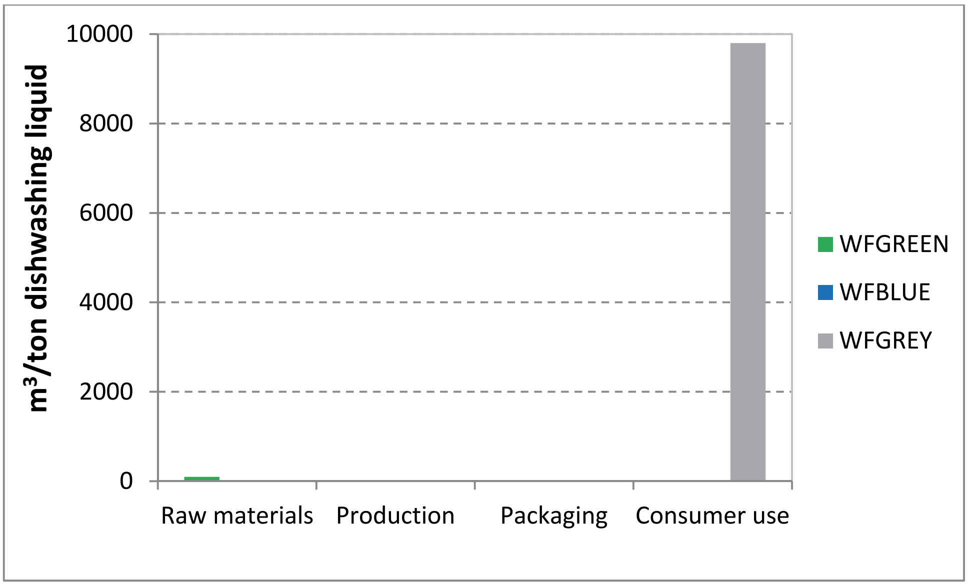

Figure 42: Green-, blue- and greywater footprints for the dishwashing liquid product

The figure below shows the percentage breakdown of the green-, blue- and greywater footprint for the dishwashing liquid product. The product is dominated by the greywater footprint which contributes to 98.99% of the total water footprint.

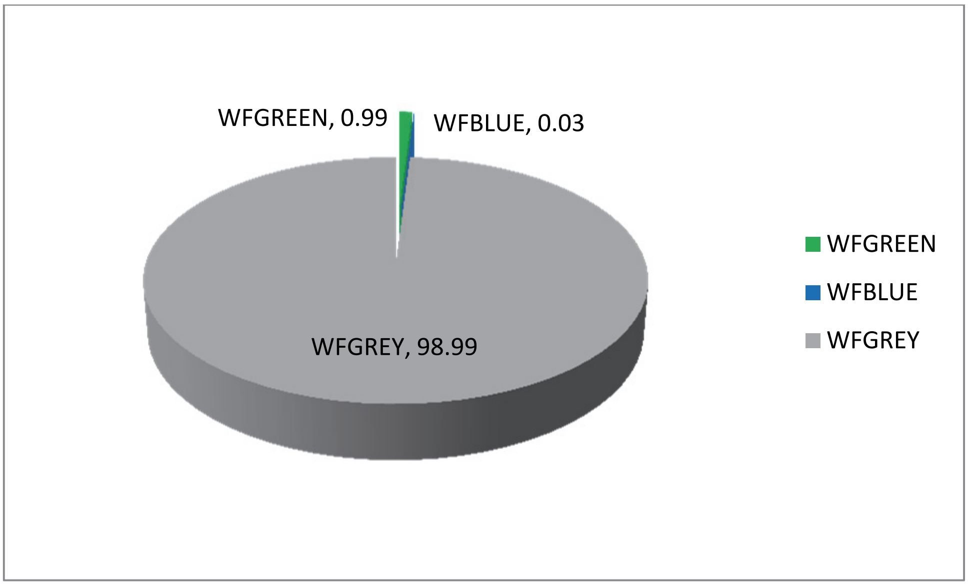

Figure 43: % Total Water Footprint for dishwashing liquid

The greywater footprint associated with the use of the product is 99% of the total greywater footprint. This number will change when more data is available and the contributions for the greywater footprint for the raw materials production and production of the dishwashing liquid is known.

6.6 Conclusions

The key insights and recommendations for Woolworths from this water footprint case study on selected products are as follows.

Water footprint of selected Woolworth's products

- The water footprint of vegetables and cheese highlight the importance of upstream water implications in the Woolworths supply chain with food products, and the water footprint of dishwashing soap emphasizes the downstream water implications of consumer use of products. The water footprint associated with agricultural products is largely green- and bluewater, while the water footprint of downstream consumer use is largely greywater. The temporal nature of water dependencies for agricultural products is also made clear by the water footprint.

- Of the products studied, cheese has the largest water footprint both on a per ton of product, and on an annual basis for supply to Woolworths. This exemplifies the increased resource requirements for animal-based food products compared to vegetables. It also highlights an important water dependency in the Woolworths supply chain. Climate change and water allocation regime changes for dairies could pose potential risks which should be considered.

6.7 Recommendations

- ***Comparing supply chain alternatives:*** Water footprint can help to compare supply alternatives by illustrating the water implications of different supply options. At a regional or international level, water and carbon footprints can be viewed alongside each other to understand both carbon and water implications and carbon-water trade-offs. At a local level, a water footprint may help to inform supply options provided local information is available.

- ***High-level understanding of water in the supply chain:*** Woolworths could gain a high-level understanding of its water dependencies in the supply chain by doing a basic water footprint of several representative products with significant water implications, including food and clothing products. A high-level water footprint could indicate the geographic location of water dependencies, the type of water, and the temporal nature of the water footprint. To deal with complex supply chains and processes, the products and processes with significant water implications should be the focus of the study. This will allow for the understanding of important water implications while completing the footprint using reasonable resources.

- ***Targeted risk assessments:*** Water footprint can also be used as a starting point for targeted risk assessments. Due to the complex nature of Woolworths supply chain, it is likely that Woolworths would have to start with a particular geographic area or product of concern. A water footprint can illustrate the extent and nature of water dependency, which can help to identify potential risks.

6.8 Key learnings

Each of the product water footprints above feeds into Woolworths supply chain, either upstream or downstream, and tells a part of the story of Woolworths water dependencies and implications.

6.8.1 Water footprint in the supply chain

A representative quantity of each products sold is given in the table below, along with the approximate proportion of the product which originates from the supplier studied in the above analyses. Exact numbers are not given for confidentiality reasons, but the quantities below are representative of scale.

Table 11: Representative quantities of products sold by Woolworths

	Representative Quantity of Product Sold in Stores (kg)	Proportion Originating from Supplier Studied
Carrots	1 500 000	20%
Beans	175 000	80%
Cheese	1 500 000	100%
Dishwashing Liquid	150 000	100%

The annual water footprint for the quantity of each product sold by Woolworths indicates the water dependencies and implications associated with the sale of each product. Cheese has a significantly larger green-, blue- and greywater footprint than either beans or carrots, highlighting the increased water demands of animal-based products as compared to plant products.

Table 12: Water footprint of products sold by Woolworths from selected suppliers

<table>
<tr><th colspan="2"></th><th>Carrots</th><th>Beans</th><th>Cheese</th><th>Dishwashing Liquid</th></tr>
<tr><td rowspan="3">Litres per Kilogram</td><td>Green</td><td>22</td><td>400</td><td>9 604</td><td>-</td></tr>
<tr><td>Blue</td><td>100</td><td>174</td><td>2 606</td><td>1</td></tr>
<tr><td>Grey</td><td>25</td><td>n/a</td><td>429</td><td>9 800</td></tr>
<tr><td rowspan="3">m^3 per Year</td><td>Green</td><td>6 600</td><td>56 000</td><td>14 405 520</td><td>-</td></tr>
<tr><td>Blue</td><td>30 000</td><td>24 360</td><td>3 908 644</td><td>1 500</td></tr>
<tr><td>Grey</td><td>7 500</td><td>n/a</td><td>643 702</td><td>1 470 000</td></tr>
</table>

6.8.2 Using the water footprint

The three main uses of water footprint which have been discussed thus far are benchmarking and tracking, risk assessment and planning. However, while these concepts apply in theory with Woolworths, individual tracking, risk assessments and planning is not practical for Woolworths given the wide variety of products it sells. Thus, the discussion of how Woolworths can use water footprint as a tool given its position as a retailer as opposed to a producer has a slightly different focus.

6.8.3 High-level awareness of nature, location and timing of water in supply chain

Although it would be difficult for Woolworths to complete an analysis on all of its products, a water footprint of representative products could help to illustrate the nature, location and timing of water dependencies in the supply chain. A limited number of specific products representing basic or high volume product categories could be studied to begin to create this picture. The products chosen in this study provide a start to that, representing plant-based and animal-based products, as well as a consumer product. Additional food items, such as grains and meats can be added, and cotton-based clothing items would likely also have important water implications. Imported and local products should also be represented.

Water footprint is a useful tool to identify water implications in the supply chain, and to create a perspective of water which looks outside the direct operations of the company. Woolworths, for example, can see that the majority of its water footprint is in its upstream supply chain and is largely associated with the production of agricultural products. Additionally, however, the water footprint illustrates that downstream implications exist, particularly in terms of water quality. Even if Woolworths is aware of the upstream and downstream water dependencies, the water footprint aids with communication by creating a clear picture and indications of the quantity of water dependency.

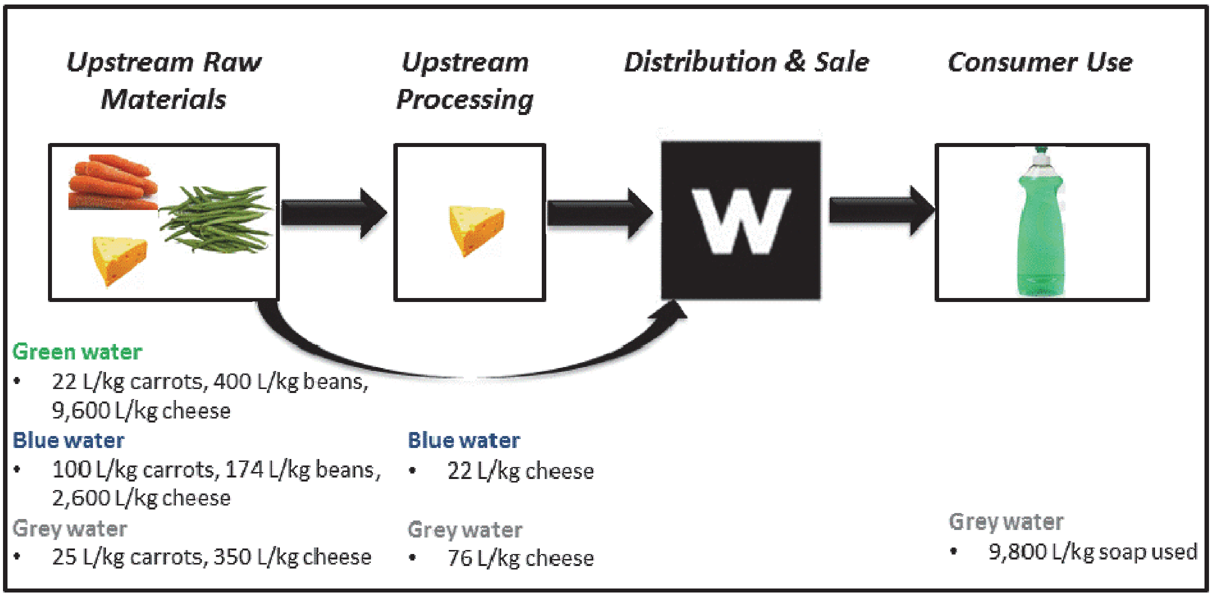

Figure 44: Water footprint of selected products in Woolworths supply chain

As water is a local resource, understanding the geographic origin of water is a necessary step in understanding water risks and impacts. Because the water footprint traces the origin for the production of goods in the supply chain, the geographic location of the water footprint is retained. The water footprint also identifies green-, blue- and greywater use so dependencies on rainwater as well as surface or groundwater are identified. As discussed, the greywater footprint as an indicator of water quality impacts is less helpful because it does not represent a physical quantity of water and it loses information regarding the type and impact of pollutants.

The water footprint for the selected products, for example, indicates a high green- and bluewater footprint associated with cheese production in the Western Cape, flagging this as a significant water dependency in the Woolworths supply chain. As this supply accounts for 100% of the basic cheese sold by Woolworths, it is a particularly important consideration.

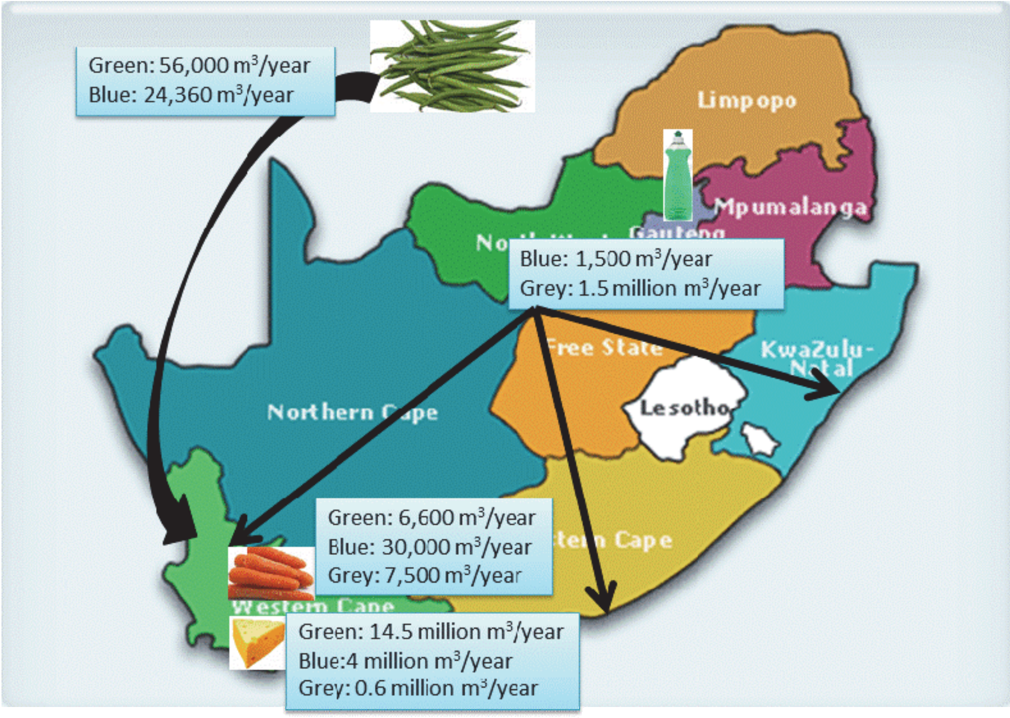

Figure 45: Geographical local of water footprints in Woolworths supply chain

Finally, as observed with the water footprint of beans and carrots, the temporal dimension of water in the Woolworths supply chain can be illustrated using the water footprint. This can inform an understanding of when water risks associated with certain products, and therefore product supply risks, may be highest.

Despite being able to gain a high-level understanding of water in the supply chain, challenges will remain with regard to gathering information and analysing complex processes in the supply chain. It would be important to identify the water footprint scope so it focuses on the most significant water implications such as water use in agriculture, rather than completing a water footprint for every step in the supply chain, including those which are likely very small in comparison.

6.8.4 Targeted risk assessments and planning

Tracking and benchmarking water implications, assessing water risks and using water footprint in planning decisions is relevant to Woolworths, but likely on a targeted or representative basis. With the large number of products, one approach is to focus water footprint analyses on products originating in areas of known high water risk or where water is central to an environmental, social or economic debate. A water footprint can identify the water dependencies of that supplier at the local level, and can indicate water dependencies further in the supply chain.

A risk assessment would then be required to understand the water risks and security of those suppliers. For example, in relation to cheese, changes in the water allocation regime may impact the availability of bluewater. Climate changes may decrease rainfall and increase temperatures, thereby decreasing greenwater availability and increasing evapotranspiration and bluewater requirements. The Water footprint may also be used to compare the water-related implications of different supply alternatives, and to view water implications alongside other environmental factors such as carbon emissions. For example, Woolworths may use a water footprint in conjunction with a carbon footprint to understand the carbon-water trade-offs of sourcing locally versus importing products. Additionally, water footprint can highlight differences in water implications between local suppliers, provided accurate data is available. As a retailer, Woolworths can also use the water footprint to identify opportunities to improve water management, and can work with its upstream suppliers.

As a final point, water footprint has been used as an external communication and awareness tool for communicating water implications to the public for specific products or commodities. As a retailer, Woolworths is well-positioned to facilitate this type of consumer awareness. However, using water footprint as an external communication tool requires a cautious approach as a water footprint may be misinterpreted if not understood within the local context. Unlike a carbon footprint where it is always better to minimise carbon emissions, water use is not necessarily bad and the impact of a water footprint depends on the local environmental, social and economic context. Using a water footprint for external communication would require a thorough understanding and description of these nuances.

7. CASE STUDY B: Food and Beverage

Due to sensitivities around the information, no details regarding the methodology and data have been included.

7.1 Motivation for case

The food and beverage companies in South Africa play a significant role in the economy and it is important to understand the water footprinting associated with such processes. A food processing company, Company FP was thus selected as a case study to represent the food and beverage industry, and to explore the applicability of water footprint as a tool for this sector.

In addition to representing the food and beverage industry, the Company FP case study will be used as an opportunity to explore the following questions which were raised in the Framework Report, and which are relevant to understanding the applicability of water footprint as a tool for the corporate sector.

- *What is the basic methodology and what considerations arise for completing a green-, blue- and greywater footprint study?* Examples of the green-, blue- and greywater footprint will be calculated in this study, and the assumptions will be fully explained. Upstream and operational parts of the supply chain will be considered. Subsequent case studies will build on the water footprint accounting methods illustrated here.

- *How can the green-, blue- and greywater footprint best be framed in the local context, and what are the risks associated with the water footprint?* This will be explored by discussing the implications of Company FP's water footprint in the context of the local water resources.

- *What are the implications of using a net versus a gross approach in rain-fed agriculture?* The standard water footprint approach uses a gross approach, and the alternative of a net approach will be considered.

- *Is greywater an appropriate representation of water quality in agriculture and food processing?* The greywater footprint from fertilizer use and processing wastewater discharge will be calculated and the approach discussed.

- *Should distribution losses in irrigated agriculture be included in a water footprint?* Currently, distribution losses are not accounted for. The impact of this approach and of the alternative will be explored.

- *How can a water footprint contribute to understanding comparative advantages in agricultural production?* This will be explored by comparing the water footprint of imported grapes compared to what would be the case if the grapes were produced locally.

Scope

The Company FP water footprint was calculated for upstream and operational water implications, including the cultivation of fruit and the making and packaging of the fruit concentrate. It excluded the downstream water footprint, which includes distribution, sale and consumption.

The water footprint focussed on the blue- and greenwater footprint, and included the greywater footprint to the extent possible. The water footprint was calculated for the company and facility, as well as for Company FP's main products which is fruit concentrate.

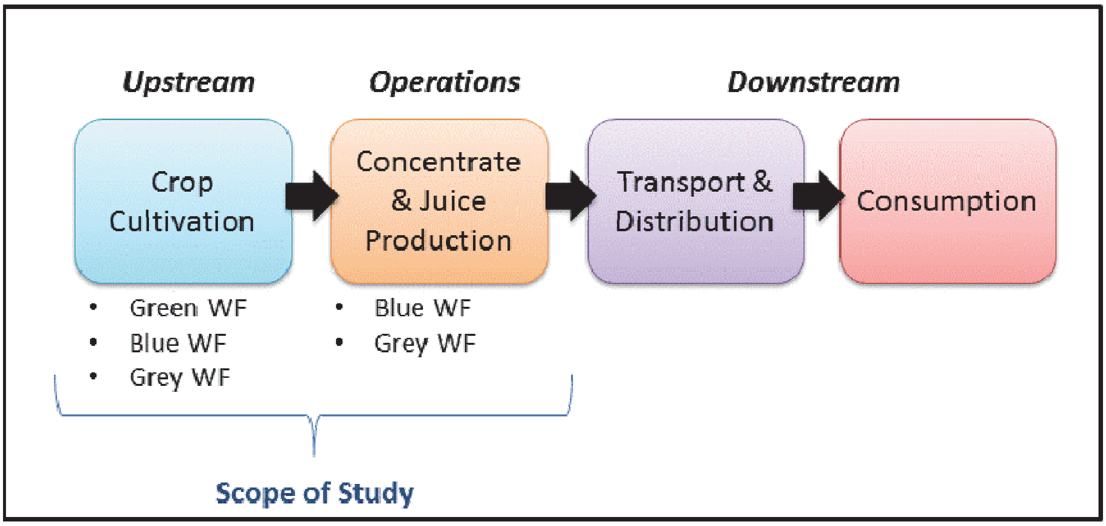

Figure 46: Scope of Company FP water footprint study

The Company FP water footprint was linked to the local context where possible. This included linking Company FP's water footprint to local water resources, and explaining the Company FP water footprint in terms of social and economic implications.

Finally, the current water footprint for grape concentrate with grapes imported from Argentina will be compared a theoretical water footprint of grapes sourced locally. This was used for the purpose of understanding comparative advantages of importing versus sourcing locally, and used to frame an analysis of carbon-water trade-offs when transportation of grapes from Argentina was taken into account.

7.2 Water Footprint Accounting and Interpretation

7.2.1 Facility and product water footprint

The water footprint for all Company FP production is shown in Table 1. The greenwater footprint is estimated to be approximately 5.1 million m^3 water per year, which is entirely attributable to growing of crops used in beverage production. The bluewater footprint for the facility is estimated to be 12.7 million m^3 water per year, which is again almost entirely attributable to crop growth. The greywater footprint is estimated to be 2.8 million m^3 water per year, and is largely driven by crop growth with a small operations component.

Approximately 99% of Company FP's water footprint is attributable to crop growth, highlighting the importance of water in Company FP's upstream supply chain. This includes apples and pears from the Elgin region, and grape concentrate imported from Argentina. It is important to note here that the options to source locally grown grapes is always investigated; however, due to limited availability and wine production, this option has not been able to be taken up for the past few years.

The bluewater footprint of direct operations is estimated to be slightly negative, meaning that Company FP returns more to the resource than is abstracted for use. This is because water is produced in the process of making fruit concentrate, and the water is then treated and returned to the river. The greywater footprint of operations is approximately 60,000 m^3 water per year, and contributes approximately 2% of the greywater footprint.

Table 13: Overall water footprint of Company FP

		Crop Growth	Electricity	Operations	TOTAL
Green WF	(m^3/year)	5121364	0	0	5121364
	Percentage	100%	0%	0%	
Blue WF	(m^3/year)	12687771	76448	-63260	12700959
	Percentage	99.9%	0.6%	-0.5%	
Grey WF	(m^3/year)	2 778 223	not calculated	67 410	2845634
	Percentage	97.6%	not calculated	2.4%	

The water footprint of electricity used during fruit concentrate production is estimated based on literature values, and is a relatively small contributor to the bluewater footprint compared to fruit production. The greywater footprint of electricity was not calculated due to the unavailability of information.

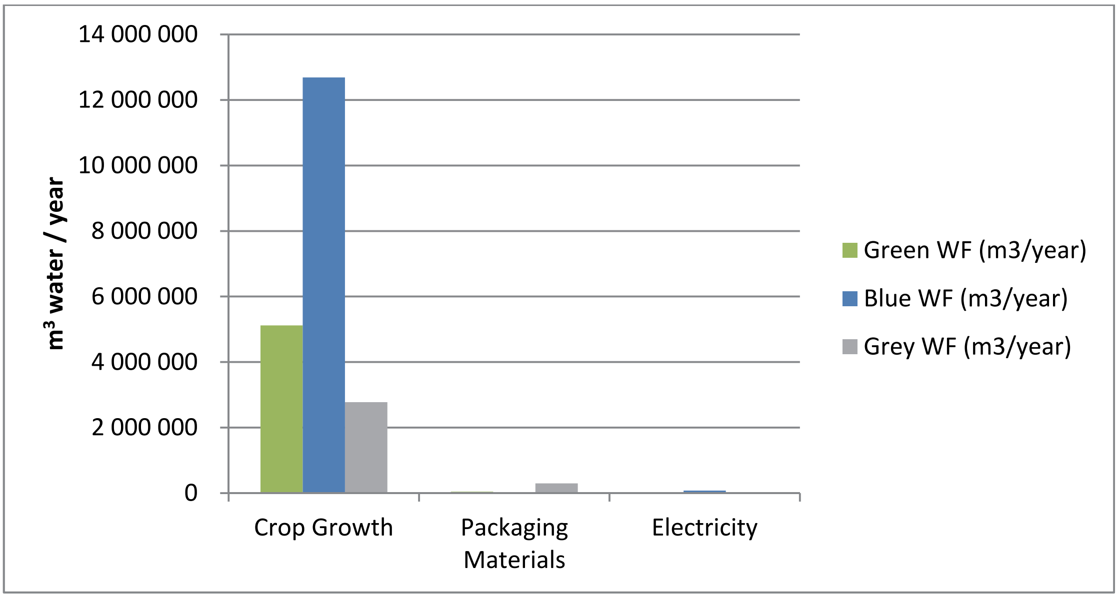

Figure 47: Company FP water footprint for facility and company

Table 14: Water footprint per unit of product made

	Crop Growth	Electricity	Operations	TOTAL
Green WF (m^3 water / m^3 product)	141	0	0	141
Blue WF (m^3 water / m^3 product)	219	2.1	-1.7	220
Grey WF (m^3 water / m^3 product)	43	not calculated	1.9	45

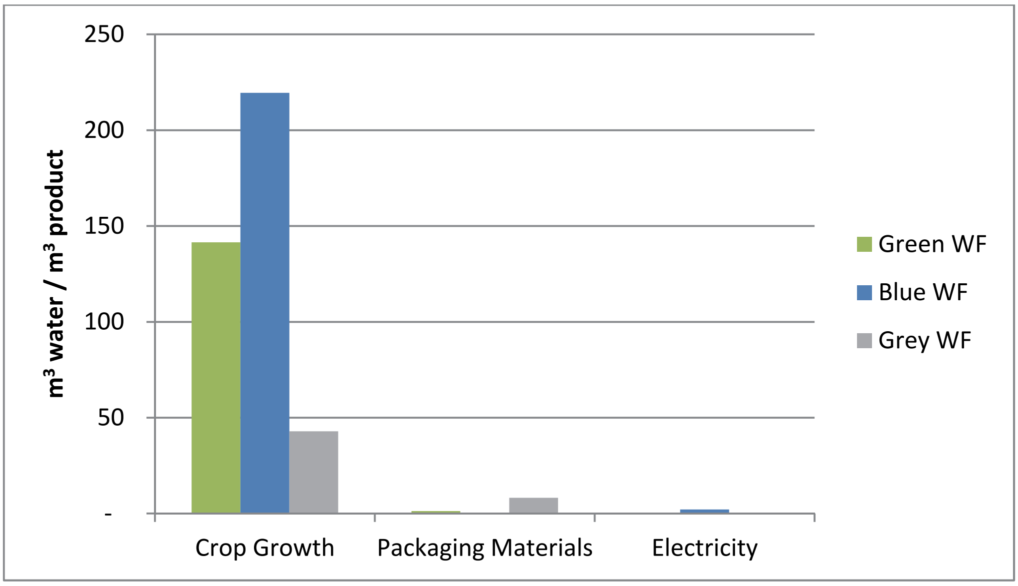

Figure 48: Company FP water footprint per unit of product made

The water footprint per unit of product made is shown in Figure 48. The numbers reflect the water footprint for the facility in terms of the ratio of green, blue and grey and the contribution from crop growth, electricity and direct water use in operations.

This representation of a water footprint is relevant for benchmarking and tracking because it calculates the water footprint for a set volume or product, whereas the overall water footprint for the facility may increase or decrease depending on production.

7.2.2 Crop production

As the contributor to 99% of Company FP's water footprint, it will be helpful to better understand the components of the water footprint for crop production and the origin of the footprint.

Water footprint per beverage type

The water footprint from crop production for Company FP products is attributable to the growth of apples and pears in the Elgin area, and to grapes grown in the Mendoza region of Argentina. The green- and bluewater footprint for fruit concentrates are shown in Figure 49, and the green- and bluewater footprint per ton of fruit for apples, pears and grapes are shown in Figure 50. The grape concentrate has the largest per unit of product water footprint, followed by the pear concentrate and apple concentrate. This is driven by the larger per ton of fruit water footprint of grapes, as compared to apples and pears, shown in the figure below.

All of the crops require irrigation, and the bluewater footprint for each product is the largest component of the footprint for each product.

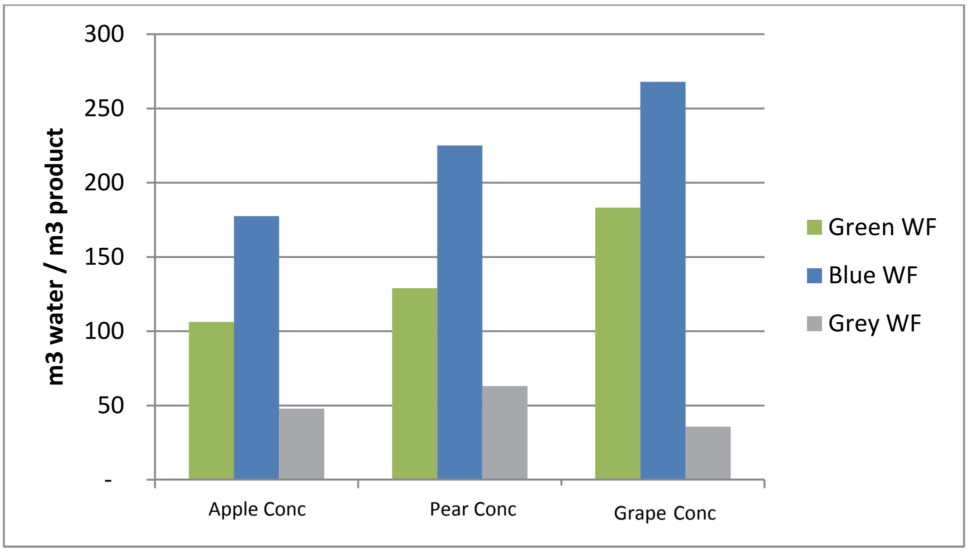

Figure 49: Water footprint for crop cultivation for fruit concentrates

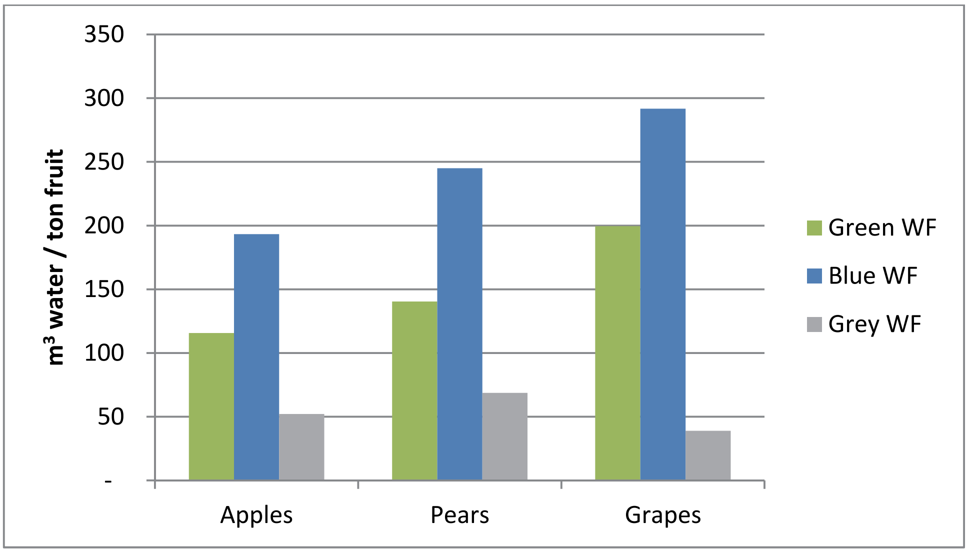

Figure 50: Water footprint per ton of apples, pears and grapes

Net versus gross evaporation

The water footprint above depicts the gross water footprint for crop cultivation, consistent with the methodology of the Water Footprint Assessment Manual. However, an alternative view is to depict the net water footprint, which represents the difference in the water footprint from a natural reference condition. The net water footprint is a possible alternative to the gross water footprint which may be appropriate when considering impacts because it represents the impact of the human activity on the water resources system, as opposed to the gross water footprint which does not consider the water footprint that would have existed even if there had been no human activity.

In the case of agriculture, the net versus gross question is most relevant to the greenwater footprint. The gross greenwater footprint represents the total greenwater evapotranspiration, whereas the net water footprint depicts the increase in greenwater evapotranspiration from the natural vegetation that would have existed without human activity.

To illustrate this difference, an estimate of the net water footprint for apples in the Elgin area was calculated and compared to the gross water footprints for the apples and pears grown in the area. Data for the evapotranspiration of natural vegetation is not readily available using the same methods used to calculate the water footprint of crops, and thus this analysis was based on literature values and should be considered indicative of the net greenwater footprint. The natural vegetation is assumed to be renosterveld, with its crop water requirements and evapotranspiration estimated based on literature. Using estimated crop coefficients in literature, the evapotranspiration of renosterveld is approximately 560 mm per year for the Elgin area. As a point of comparison, the evapotranspiration of renosterveld in the Voëlvlei Nature Reserve was estimated to be 680 mm per year.

The evapotranspiration of renosterveld is estimated to be higher than that of apples in the Elgin region. This implies that the greenwater footprint of apples is actually less than the greenwater footprint of renosterveld. The reason for this is that renosterveld has relatively higher evapotranspiration requirements in the winter than do apples, coinciding with higher rainfall and thus allowing renosterveld to utilise more rainfall.

Table 15: Evapotranspiration of natural vegetation and apples

	Evapotranspiration of Natural Vegetation	Evapotranspiration of Apples
Greenwater (mm/year)	561	382
Bluewater (mm/year)	0	638

The net greenwater footprint of apples is reduced to reflect the difference in use of rainwater for evapotranspiration from the natural state. Because theoretically less rainwater is used for evapotranspiration by apples than with natural vegetation, the net greenwater footprint may be thought of as being negative.

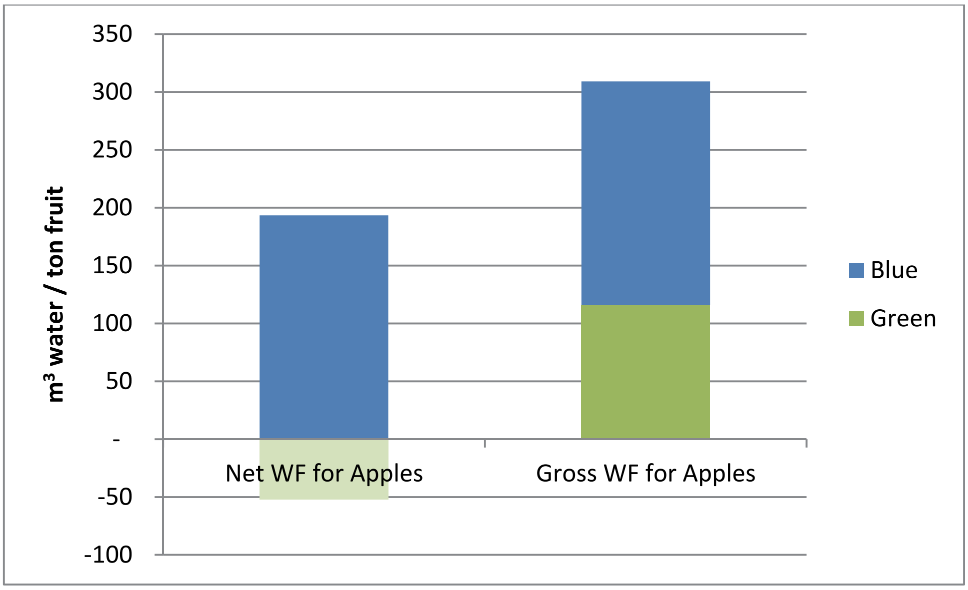

Figure 51: Net and gross water footprint for apples

The question arises of whether it is more appropriate or informative to use the gross water footprint or the net water footprint. The answer likely depends on the intended use of the water footprint.

The use of the gross water footprint in the Water Footprint Assessment Manual likely links back to the origins of water footprint in virtual water, where the virtual water concept was intended to represent the virtual flow of water between countries through trade. Virtual water was not originally used to indicate environmental impacts.

However, corporates using water footprint as a tool to understand or measure impacts for reporting purposes may lean more towards the net greenwater footprint approach. This is because an understanding of impacts must be based on some natural or reference state, which the net approach incorporates but the gross approach, does not.

Alternatively, if a corporate is looking to understand risks, the gross greenwater footprint approach is likely more useful. Understanding risk requires understanding actual water requirements to support an activity throughout the supply chain, and identifying risks which may impact water availability or quality. Excluding a part of the greenwater footprint when considering risks will yield an incomplete picture of water dependency, and incomplete understanding of risk.

Actual Irrigation

The bluewater footprint represented above shows the amount of embedded water (evapotranspiration) that would be required for optimal crop growth. While the optimal bluewater footprint can be a useful indicator for irrigation, actual irrigation will be a better representation of actual surface water use.

The optimal bluewater footprint of apples, compared to the estimate of water abstracted for irrigation and water which reaches the roots for evapotranspiration (effective irrigation after distribution). The effective irrigation assumes 90% efficiency, based on it being drip and sprinkler irrigation.

The optimal bluewater footprint is slightly lower than the estimated water abstracted for irrigation, and is very close to the estimated irrigation volume delivered to crops. This means that the crops are receiving approximately the optimal amount of irrigation for growth and that the optimal bluewater footprint is a reasonable representation of actual irrigation.

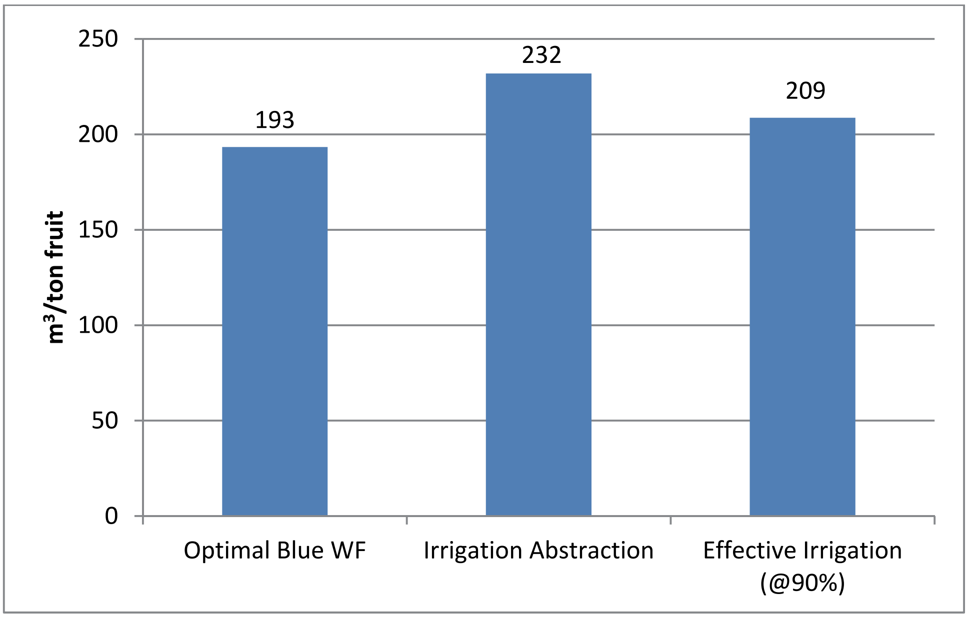

Figure 52: Comparison of the optimal bluewater footprint and irrigation

One of the questions raised in the Framework Report is how to consider distribution losses in water footprint accounting when looking at actual irrigation. The two main options are: (1) Calculate the water footprint based on actual water abstraction, or (2) Calculate the water footprint based on the irrigation which is taken up for evapotranspiration. The first option focuses on physical water use, while the second focuses on the embedded or virtual water required for crop growth.

The methodology in the Water Footprint Assessment Manual follows the second option, where the water footprint represents only the water taken up by the crop for evapotranspiration. It does not account for distribution losses. This approach ties back to the origin of water footprint in virtual water, where the virtual water concept was developed to represent the virtual trade of water through agricultural products at a national or regional level in order to explain how nations compensate for water scarcity.

However, when approaching water footprint from a company perspective, the focus is on benchmarking, understanding risks and planning. With this perspective, it is important to understand actual water use, including distribution losses, in order to provide a complete picture. Leaving out distribution losses would ignore an important contributor of water use and an opportunity to make improvements. Thus, from the company perspective, including distribution losses in irrigation is likely a more useful measure of a water footprint.

In Company FP's case, the irrigation efficiency of sampled farmers is already at around 90%, meaning that very little opportunity to improve irrigation efficiency exists at present.

7.2.3 Greywater footprint in agriculture

The greywater footprint resulting from fertiliser use in crop production is 48 m^3 water/ m^3 apple concentrate, 63 m^3 water/ m^3 pear concentrate and 36 m^3 water/ m^3 grape concentrate. These numbers are based on estimates of nitrogen fertiliser application and assumed leaching and runoff factor of 10%. There is a question of accuracy, as the appropriate factor for leaching and runoff requires a thorough understanding of fertiliser application rates over time, rainfall and runoff patterns and soil parameters.

However, an even more fundamental question arises of how informative or appropriate the concept of greywater footprint is for representing water quality implications, as was raised in the Framework Report. The greywater footprint concept is analogous to the ecological footprint approach. In ecological footprint, the impacts of human activity are quantified into an area of land which is required to support that activity. Similarly, the greywater footprint represents the volume of water required to assimilate water pollution. Neither of these is intended to represent a physical or identifiable volume of water, but is more intended to serve as a metaphor for environmental impacts.

The greywater footprint is thus very different from the green- and bluewater footprint. Blue- and greenwater footprints represent physical quantities of water used and have a real-world manifestation. Conversely, the greywater footprint cannot be thought of as having a real-world physical interpretation.

In terms of usefulness, the greywater footprint can serve as a metaphorical indicator of water quality impacts. However, it cannot be viewed the same way as a blue- or greenwater footprint, or thought about in a physical sense. In terms of thinking about real-world impacts and risks associated with activity, the greywater footprint concept is not as directly relevant as the blue- and greenwater footprints.

Alternate approaches to water quality will be explored in subsequent case studies, including Company P and Eskom, which focus on industrial processes.

7.2.4 Imports and comparative advantages

Importation of grape concentrate from Argentina means that a portion of Company FP's production water footprint is external to South Africa. As mentioned previously, it is important to note that the options to source locally grown grapes are always investigated; however, due to limited availability and wine production, this option has not been able to be taken up for the past few years. In terms of understanding its supply chain water risks, then, Company FP must consider both its water footprint in South African and in Argentina. The scale of the water footprint from imports is shown in the figure below. The imported bluewater footprint is approximately 5 million m^3 per year, while the imported greenwater footprint is approximately 3 million m^3 per year. This is somewhat lower than the local bluewater footprint of 7.7 million m^3 per year and greenwater footprint of 2.1 million m^3 per year (Figure 53).

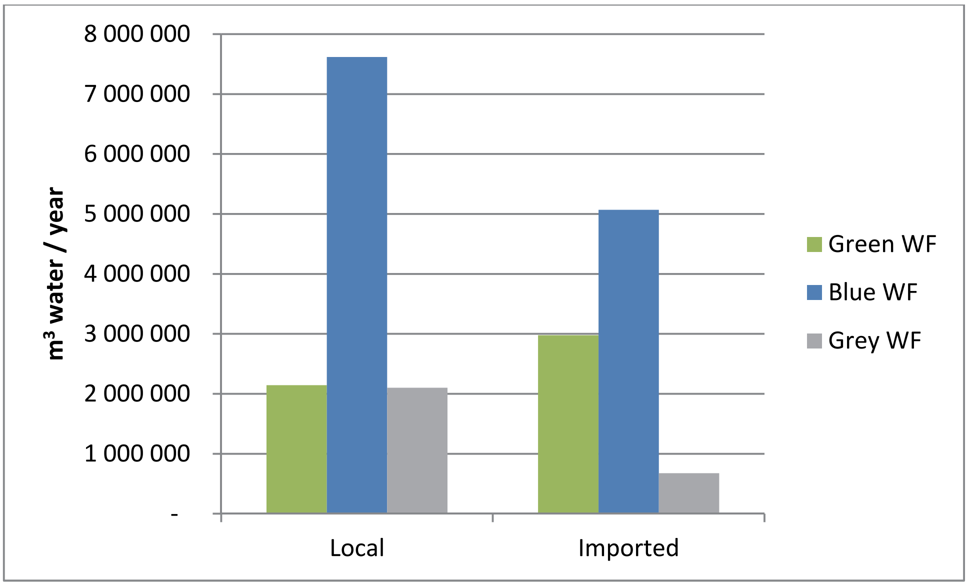

Figure 53: Local and imported water footprint for Company FP

Importing grape concentrate from Argentina raises the consideration of comparative advantages of crop production from a water perspective, which a water footprint can help to shed light on. As an example, Figure 54 illustrates the water footprint per ton of grapes grown in the Mendoza region of Argentina, as compared to South Africa. As can be seen, the Mendoza region has a higher greenwater footprint, a lower bluewater footprint and a slightly lower footprint overall than grapes grown in South Africa.

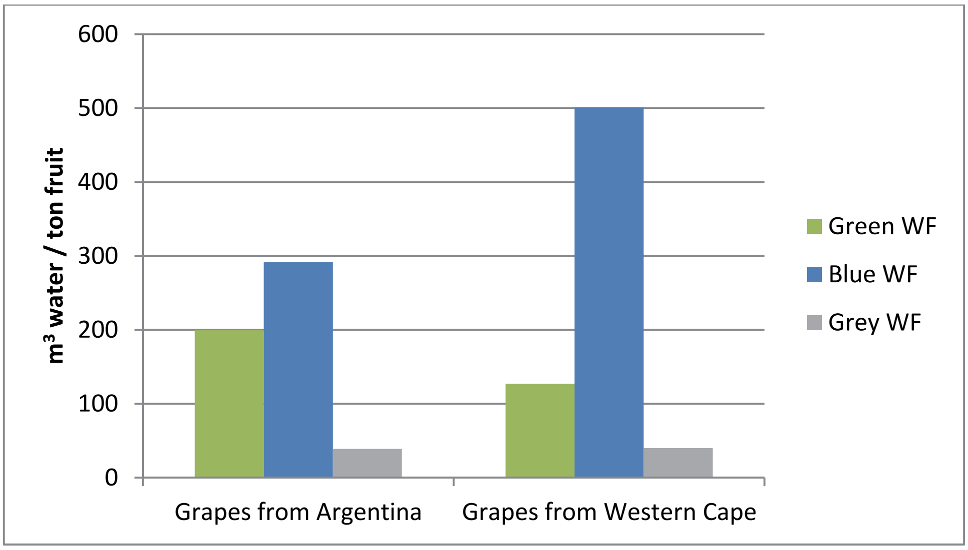

Figure 54: Water footprint of grapes from Argentina and the South Africa

While the comparison does indicate a difference in the water footprint, it is difficult to conclusively state whether one water footprint is preferable in terms of impacts and risks than another. To determine this, a full assessment must be undertaken to understand the water and environmental context in each region, as well as the social and economic implications of water use and the associated opportunity costs.

A water footprint and a carbon footprint viewed together could help to understand broader environmental implications of importing products as versus sourcing them locally. The water footprint understood in its local context can highlight water impacts, while the carbon footprint of transporting goods demonstrates carbon impacts. Table 16 contains estimated energy and carbon emission information for the transportation of 1 ton of goods which can be used to estimate carbon emissions of transporting food products.

Table 16: Energy requirements and carbon emissions for transportation of goods (based on IPCC (1999) and Schipper (2010))

Transport Method	g CO_2 per ton-km
Maritime Shipping	5
Rail	7
Truck	60
Air	200

Grapes are imported from Argentina in the form of grape concentrate, rather than grapes themselves. Assuming that the concentrate is transported by maritime shipping from Argentina to South Africa and estimating travel distances, the carbon footprint of transportation is shown in Table 17.

Table 17: Comparison of estimated carbon emissions from importing grape concentrate and buying local grapes

	Mendoza to Elgin	Western Cape to Elgin
Weight of Product (tons)	13230 (concentrate)	64522 (fresh grapes)
Estimated Distance Travelled by Truck (kilometres)	1500	50
Estimated Distance Travelled by Maritime Shipping (kilometres)	3720	0
Estimated Carbon Emissions (tons CO_2 / year)	**14 368**	**1 936**

Despite having a carbon and water footprint estimate for different potential suppliers, drawing concrete conclusions from these footprints is challenging. The preference of sourcing goods locally is clear from a carbon perspective, as it is always preferable to have a lower carbon footprint and the location of the footprint does not need to be considered. From a water perspective, however, the preference is unclear as the water footprint of each alternative must be understood in terms of local context and opportunity costs.

Thus, although a carbon and water footprint for alternatives may be a useful illustration and communication tool, the implications of the water footprint requires a contextual understanding prior to the ability to weigh carbon and water implications.

7.2.5 Direct water use in operations

Direct water use includes a water quantity and a water quality aspect, and thus the blue- and greywater footprints are important components. Water supply and water quality play a critical role in operations for production, risks and planning, and thus represent important components of the water footprint analysis.

Water use and quality are often already measured by corporates, and in the case of Company FP are areas of focus for improving the sustainability of operations. A water footprint represents a slightly different approach to operational water use than do traditional measures in order to view blue- and greywater in the context of the supply chain and alongside each other.

Company FP's operational process abstracts water from the Eikehoff dam, and then treats the water in-house to required quality for different operational uses. Water is then treated and returned to a different resource.

The blue- and greywater footprints from operations are shown in Table 18. This includes the production of fruit concentrate which is ultimately used in Company FP products, and the production of beverages from the concentrate.

Table 18: Water footprint from Company FP operations

	m^3/year from Operations	m^3 water / m^3 product from Operations
Green WF	0	0
Blue WF	-63260	-1.75
Grey WF	67410	1.86

7.2.6 Bluewater footprint

The bluewater footprint is equal to the amount of water abstracted for production minus the effluent water returned to the catchment from which it is abstracted. Company FP returns its treated effluent to the river, and therefore its bluewater footprint equals the volume abstracted minus the volume returned.

The bluewater use is split into the two production processes to manufacture the fruit concentrates. Each of these components has a slightly negative bluewater footprint, meaning that more water is returned in effluent streams than is abstracted for production purposes. This is driven by the water resulting from making of concentrate from fresh fruit. The total effluent returned exceeds the amount abstracted by about 63 000 m^3/year.

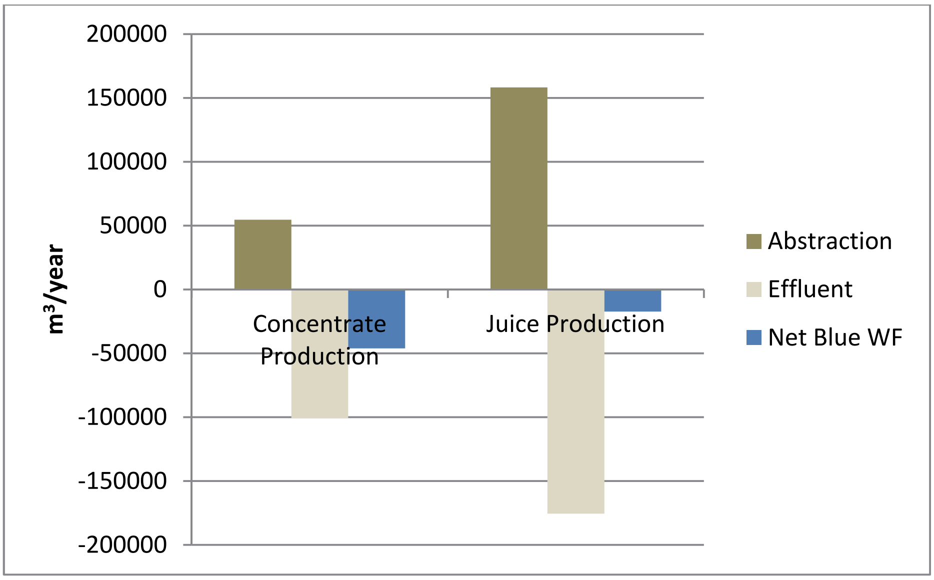

Figure 55: Abstraction, effluent and net bluewater footprint of operations

As a next step to this analysis, the bluewater footprint of specific parts of the operations process could be determined, including concentrate preparation, packaging, concentrate production and electricity. This analysis would require calculating the water abstracted for the specific operational process minus the water returned to the river from that specific process. Using this method, the processes which are net water users as opposed to those which are net water contributors would be identified.

This process-specific focus somewhat moves away from the intent of the water footprint, where the strength is to represent blue-, green- and greywater use through the supply chain and to understand water impacts and risks at a high level. The water footprint methodology converges with standard approaches to understanding operational water use when process-specific analyses are undertaken, as it is a matter of associating bluewater use with operations and measuring waste water discharge.

Company FP already collects data, monitors and improves its operational water use at a process-specific level. The main value of the water footprint for operations context is to place the operational water footprint in the context of the supply chain, and to identify green-, blue- and greywater when relevant. However, the water footprint's representation of water quality through the greywater footprint is still unclear and requires further discussion.

7.2.7 Greywater footprint

The greywater footprint from operations looks at the water that would be required to assimilate the added pollutant load in effluent streams to acceptable concentrations. The calculation thus requires the abstraction and effluent water volumes, and the concentration of pollutants in these streams.

The pollutant which requires the highest level of dilution determines the greywater footprint because if this pollutant is assimilated, all others requiring less dilution would have been assimilated as well. The greywater footprint does not add together or average the greywater footprint from different contaminants.

In the case of Company FP, the greywater footprint calculation is somewhat limited because not all incoming concentrations are available to be compared with outgoing measurements for contaminants of interest. Based on available information, the greywater footprint from operations is that which is attributable to total dissolved solids, and is 51,000 m^3 per year or 1.86 m^3 per m^3 of beverage.

Table 19: Greywater footprint of operations associated with different pollutants

	m^3 water / year	m^3 water / m^3 product
Nitrogen	-2 872	-0.08
Ammonia	67 410	1.42
Total dissolved solids	51 437	1.86

As explained before, the main benefit of the greywater footprint is to represent water quality in a metaphorical way similar to the idea of an ecological footprint. The greywater footprint is not intended to represent a physical of water, but rather a conceptual indication of water quality.

The greywater footprint is not intended to provide a detailed description or sufficient information to inform a response to water quality issues. For corporates, the greywater representation of water quality thus loses critical information. Alternative approaches to water quality will be explored in later studies. Initial concerns which arise from this study regarding the greywater footprint are:

- It does not distinguish between different types of pollutants, or identify the nature of the pollutant in the greywater representation. In this case, for example, the greywater footprint is determined by total dissolved solids even though they may be less of a concern in practice than other contaminants such as phosphates, and in some regions salinity. Therefore, the greywater footprint loses valuable information.

- It does not recognise where water quality may be improved for certain contaminants through treatment. For example, Company FP treats its water so the nitrogen content is actually improved. Nitrogen is a water quality concern in the area due to agricultural runoff, so improvement of nitrogen levels is an important consideration. The greywater footprint loses any improvements to water quality by looking only at the contaminant requiring the largest volume of water for assimilation.

7.3 Water footprint uses

Three main categories of uses were discussed in the Framework Report for water footprints: (1) Benchmarking and tracking, (2) Risk assessment, and (3) Planning. Each of these categories has a significant communication element which water footprint can help to inform, and thus use of water footprint as a communication tool for these purposes will be a common theme. Due to sensitivities around the project, the risk assessment was excluded from this report.

7.3.1 Benchmarking and tracking

A first potential use of the water footprint for Company FP is in terms of internal and external benchmarking and tracking. Note that different degrees of sophistication with benchmarking and tracking are possible. This discussion focuses on a straight-forward quantitative representation which does not explore impacts and sustainability. Benchmarking and tracking may become more nuanced and comprehensive by bringing in the sustainability and risk assessment discussed in the next section.

Internal tracking

Company FP can use the water footprint per unit of production internally to measure its water footprint for each major step in its supply chain, and to track changes in the footprint over time. Currently, Company FP tracks its direct water use in operations closely and has made progress in recent years in decreasing its direct water use. However, water use throughout the supply chain, including crop production, is not tracked. The water footprint has potential to serve as a tool which comprehensively measures water use throughout the supply chain over time. No similar tool is available to understand water use throughout the supply chain, meaning that a water footprint fills an important gap.

For tracking purposes, it will likely be most informative to view the water footprint in terms of cubic metres of water per cubic metre of product in order to account for fluctuations in production volumes. Note that the greenwater footprint is presented in both gross and net terms as the use of the footprint will determine whether the net or gross footprint will be more informative. As previously discussed, for understanding impacts the net water footprint will likely be more relevant, whereas for understanding risks the gross footprint is likely more helpful.

Additionally, it would likely be desirable to break down crop growth into separate categories of fruit production, and operations into separate production processes. The water footprint may also be expanded in scope to include potentially important components such as the water footprint of packaging materials.

Table 20: Example of water footprint for internal tracking purposes

	Crop Growth	Electricity	Operations	TOTAL
Gross Green WF (m^3 water / m^3 product)	141	-	-	141
Net Green WF (m^3 water / m^3 product)	-	-	-	-
Blue WF (m^3 water / m^3 product)	219	2.1	-1.7	220
Grey WF (m^3 water / m^3 product)	43	not calculated	1.9	45

External benchmarking and reporting

In addition to internal benchmarking and tracking, a water footprint can be used for external reporting and potentially external benchmarking. Regarding external reporting, there is not currently a standard for reporting corporate water implications. The Carbon Disclosure Project, for example, has focused on awareness of water use, risks and opportunities rather than quantification of water implications. Water footprint does, therefore, represent a potential tool for external reporting which considers water implications throughout the production supply chain.

If used for external reporting, standard approaches would have to be developed, such as reporting on both net and gross greenwater footprints. It would also be important to explain the concept of the water footprint, and indicate the important of considering the local context. Given the importance of the local context, external reporting using a water footprint becomes a much more complex message which has significant risk of misinterpretation. While a water footprint can be used to communicate awareness of water implications in the supply chain, it should not be a metric viewed in isolation of context.

Regarding external benchmarking, a water footprint may be a useful tool for benchmarking if water footprints for substantially similar products exist. For the food and beverage industry, benchmarking of the overall water footprint would only be possible if the products used for comparison were very similar to the product in question. This is because the type of crop and the amount of crop used for production is the primary driver of the overall footprint, so small variations in product type will make a comparison less relevant. For example, in Company FP's case comparable studies would have to focus on apple, pear and grape concentrate production. Detailed studies on these products have not been completed. Coca-Cola has completed a water footprint for orange juice, as shown in Figure 56(a). The water footprint of orange juice has a lower bluewater component but higher greenwater component than the water footprint for Company FP. However, the type of crop is the main driver of the differences in the water footprint of the beverages as shown in Figure 31b, so comparing two different types of beverages is not necessarily informative – the same type of beverage would have to be used to make a comparison relevant.

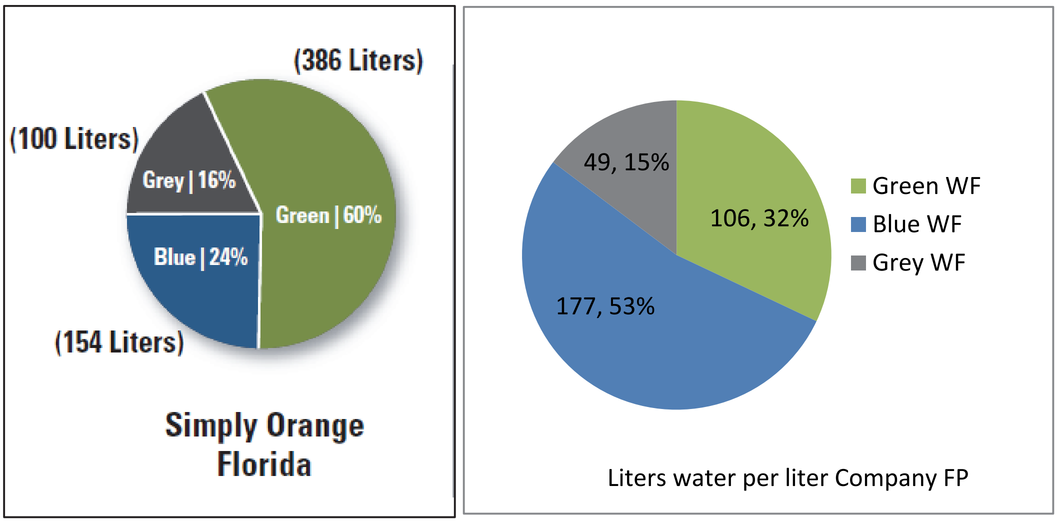

Figure 56: (a) Water footprint for Minute Maid orange juice and (b) Company FP

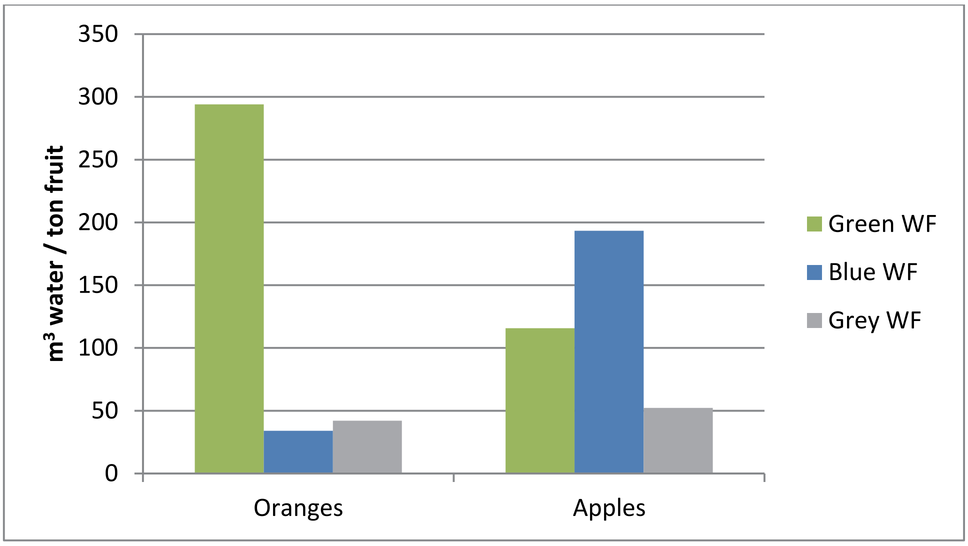

Figure 57: Water footprint of apples and oranges

7.3.2 Planning

The final purpose which a water footprint may be useful to a corporate is in planning and decision-making. For example, a water footprint could be helpful to understand the water-related aspects of different supply options for commodities, or different location options for the development of new operational facilities. To use a water footprint for planning and decision-making requires a comprehensive sustainability assessment around the decision in question.

In Company FP's case, the water footprint may be useful for comparing fruit supply options in that it can illustrate the water implications in the supply chain, and can help to understand the water-related aspects of crop production in different locations. The water footprint of different supply options would have to be informed by an analysis of the local water supply and risks.

7.4 Conclusions

The water footprint for Company FP highlights key points regarding Company FP's water footprint, and addresses some of the questions raised in the Framework Report regarding the water footprint methodology and application.

- Company FP's total greenwater footprint is approximately 5.1 million m^3/year, its bluewater footprint is 12.7 million m^3/year, and its greywater footprint is 2.8 million m^3/year. If a net perspective is taken for the greenwater footprint, the South African portion of the greenwater footprint is zero.

- 99% of Company FP's water footprint is attributable to its upstream supply of apples, pears and grapes. This highlights the importance of understanding water risks and implications outside of the production facility, and focusing attention on suppliers.

- Due to the import of grape concentrate from Argentina, a part of Company FP's water footprint is outside of South Africa. The imported component of Company FP's water footprint is 3 million m^3/year of greenwater, 5 million m^3/year of bluewater, and 0.7 million m^3/year of greywater.

- The water footprint of direct operations accounts has a blue and a green component. The bluewater footprint is slightly negative, as Company FP returns more water in effluent than it abstracts for operations. The greywater footprint of operations accounts for approximately 2% of the overall greywater footprint.

- The risk assessment for Company FP focuses on blue- and greenwater, and primarily on the water associated with crop cultivation due to the relative importance of crop cultivation in the footprint. The risks associated with the allocation regime are relatively low, compared with other areas in South Africa, as the river is well-managed and development planning supports agricultural business.

7.5 Recommendations for using water footprint

- ***Water in the supply chain:*** In the food and beverage industry, water footprint is useful for highlighting water implications in the supply chain, and expanding the focus from direct water use in operations. It is also useful to understand blue- and greenwater in the supply chain, as opposed to traditionally looking at just bluewater. Understanding the supply chain and blue- and greenwater is a useful starting point for a risk analysis because it clarifies water dependencies, and considers rainwater in addition to surface or groundwater.

- ***Tracking:*** The water footprint presents a potentially useful tool to track water implications through the supply chain. No other tool currently exists for this purpose, so it may fill an important gap.

- ***Net and gross greenwater footprint:*** The greenwater footprint can be represented as a gross volume to indicate total water use or a net volume to indicate the difference from a natural state. The preferred approach will depend on the purpose of the footprint. If the footprint is being used to understand impacts, then the net greenwater footprint is more relevant because it indicates the change in greenwater use from a natural state. If the footprint is being used to understand risks, the gross greenwater footprint is more relevant because risks are associated with overall water dependency, and not just the change from the natural state.

- ***Irrigation abstraction as bluewater:*** When a bluewater footprint is based on actual irrigation, the total abstraction is more relevant from a corporate perspective than the irrigation after distribution losses (the embedded water used by crops for evapotranspiration). This is because whether considering risks or impacts, total water use is relevant and not just the embedded water in the crop.

- ***Comparing supply alternatives and carbon trade-offs:*** Water footprint can be helpful to illustrate the water aspects of different supply options, and to present water-related information alongside a carbon footprint. However, understanding alternative supply options from a water perspective requires a thorough understanding of local water resources and opportunity costs.

- ***Further investigation of water quality representation:*** The greywater footprint is analogous to an ecological footprint as an indicator, and is not intended to represent a physical quantity of water and does not inform quality risks and responses. This is different from the green- and bluewater footprints which do represent physical quantities. Thus, the greywater footprint should not be added with blue- and greenwater, and the usefulness of the greywater footprint to corporates is a question which will be explored in subsequent case studies.

8. CASE STUDY C: Mining and Power Generation

8.1 Motivation for case

Eskom is a public utility company providing 95% of electricity supplied to South Africa and 45% of electricity supplied to the rest of Africa. Eskom has various power stations situated all across South Africa and is a major contributor to the country's economy. Electricity generation at Eskom takes place predominantly through coal power; which has an important extractive component (coal mining). Eskom uses a total of 70% of the countries coal supplies. The Matla Power station, which was commissioned in 1979, was selected as the case study facility for the project. It was initially meant to be in existence for 30 years, but its lifespan has been extended by a further 30 years.

Presented in Figure 58 is the block flow diagram for the Matla Facility which shows the processes involved in the supply chain and operations of the facility.

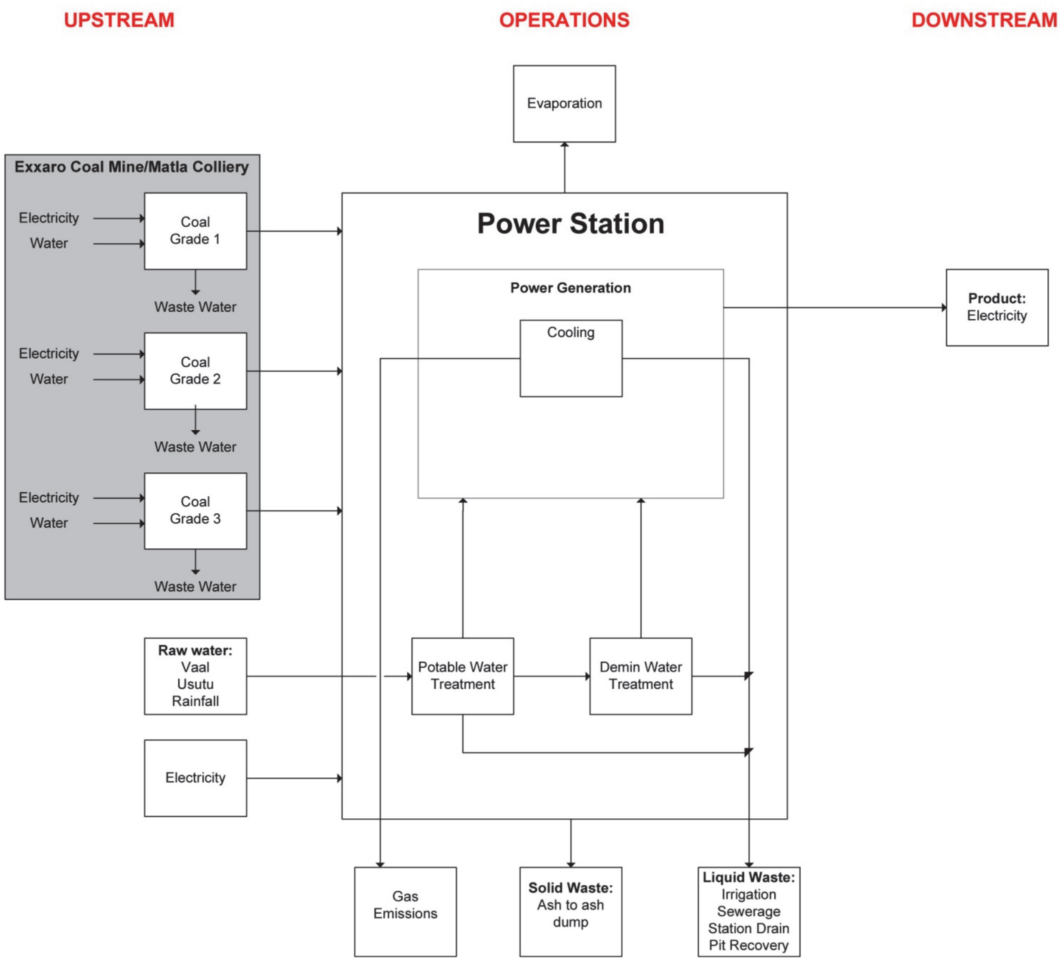

Figure 58: Block flow diagram for Matla Power Station

Upstream

Exxaro Resources is the supplier of coal to the Matla power station from the Matla Colliery. The preparation of coal at the Matla Colliery (underground mining) undergoes the following preparation:

- Crushing
- Screening
- Washing
- Separation

The washing and separation processes are the most water intensive. The mining process is estimated to use 160 L of water per ton of coal mined, and subsequently produces 1.2 L of liquid effluent[2]. Coal mining breaks up rock mass – allowing water and other substances to mix, leading to sulphuric acid which leaches other heavy metals from the rocks and exacerbating the problem of Acid Mine Drainage (AMD), which sees high levels of ferric sulphide and sulphuric acid, which drastically lowers the pH of any water source. This contributes a very large greywater footprint, due to the contamination of the water.

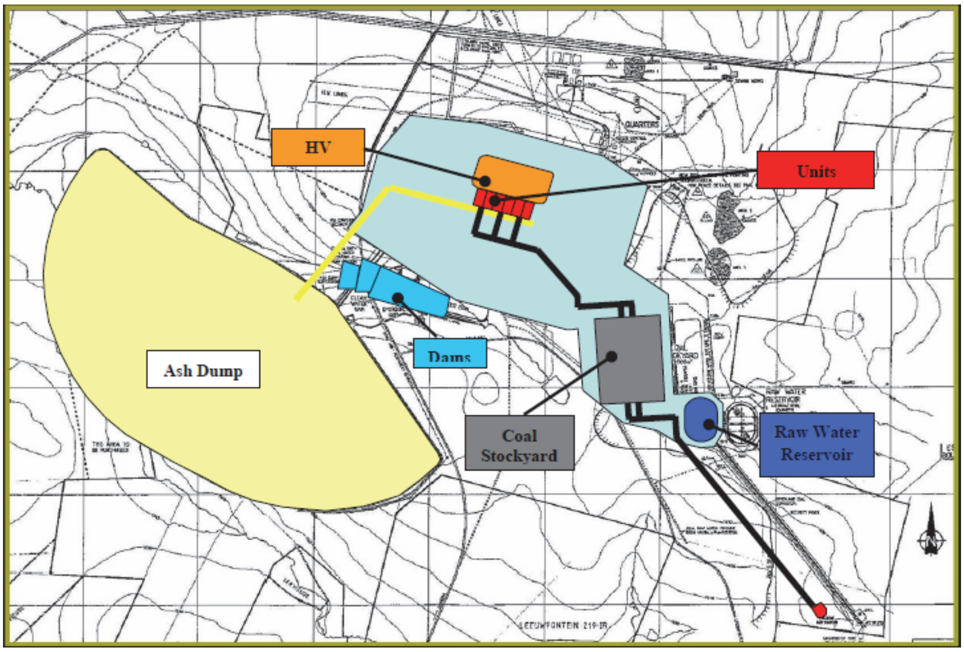

Figure 59: Site layout for a typical power station

The specific water consumption at Matla power station sits at approximately 2000 L/MWh[3]. A wet cooling system uses approximately 1.8 L water per kWH sent out, i.e. some 7.7 million m^3 per annum for a 5 400 MW power station[4]. Exxaro provides 14 Mt/yr (1.16 million tons of coal per month) of coal, of varying grades, from open cast mining to Matla power station. Eskom's coal-fired power stations use conventional pulverised coal technology, with average thermal efficiencies of 33%. Coal

[2] Wassung, N. (2012) Water Scarcity and Electricity Generation in South Africa: Part 1, Master's Thesis, University of Stellenbosch)

[3] Advances in Dry Cooling Deployed at South African Power Stations, S. Lennon, 2011 Summer Seminar

[4] Vaal South EIA\R30 Scoping phase\Reports\DSR\Draft Scoping Report 140806~final.doc

quality is poor with average calorific values of 4500 kcal/kg (19 MJ/kg), ash 29.5%, and sulphur 0.8% [5]. With the current deterioration of coal quality, Matla has experienced up to 40% in losses.

Operations

Coal from the Matla Colliery is combusted to produce electricity. The facility uses a wet-cooling system. Raw water is obtained from the Upper Vaal and Usutu. Potable water is also used in the processes. Industrial and domestic sewage is sent to Matla for treatment. The treated effluents is combined with the ash and sent to ash dumps or the ash dam. Any seepage from here is collected and sent back to the plant for treatment.

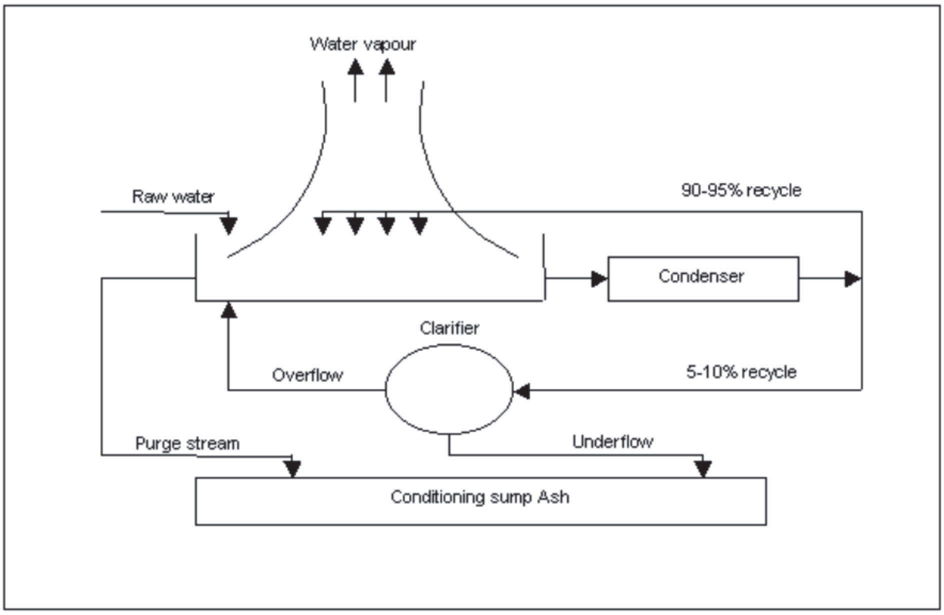

Figure 60: Schematic representation of wet-cooling system

Downstream

The electricity generated at the Matla facility is used by the facility itself and surrounding municipal and business operations.

8.2 Scope

The Eskom case study was conducted on the basis of a coal-fired power station that is located in a water-stressed area. The Matla Power Station was selected to focus on a water footprint of a facility.

Since the utility company does not rely on any agricultural products, the greenwater footprint was adapted to represent the interception of rain water. The blue- and greywater footprints were considered for the upstream and operations, with particular focus on the greywater footprint and water quality. The key questions for the water footprint case study with Eskom's Matla Facility are as follows:

[5] Eskom Annual Report, 2010

i. Understand the green-, blue- and greywater footprints for coal-based power generation, and the distribution of the water footprint between upstream and operational processes.
ii. Understand the magnitude of the environmental impact of power generation through coal, and opportunities for a water footprint to improve environmental performance, by highlighting the upstream and operational water footprints of a power station.
iii. Understand the water risk for a power station located in a water-stressed catchment, and how a water footprint can help to understand this risk.
iv. Understand the relationship that exists between water and energy, and how a water footprint can help to illustrate this relationship.

8.3 Information, methodology and assumptions

Presented below in Figure 61 is a simplified block flow diagram indicating the input and output streams for the facility that will used as a basis for the water footprint study.

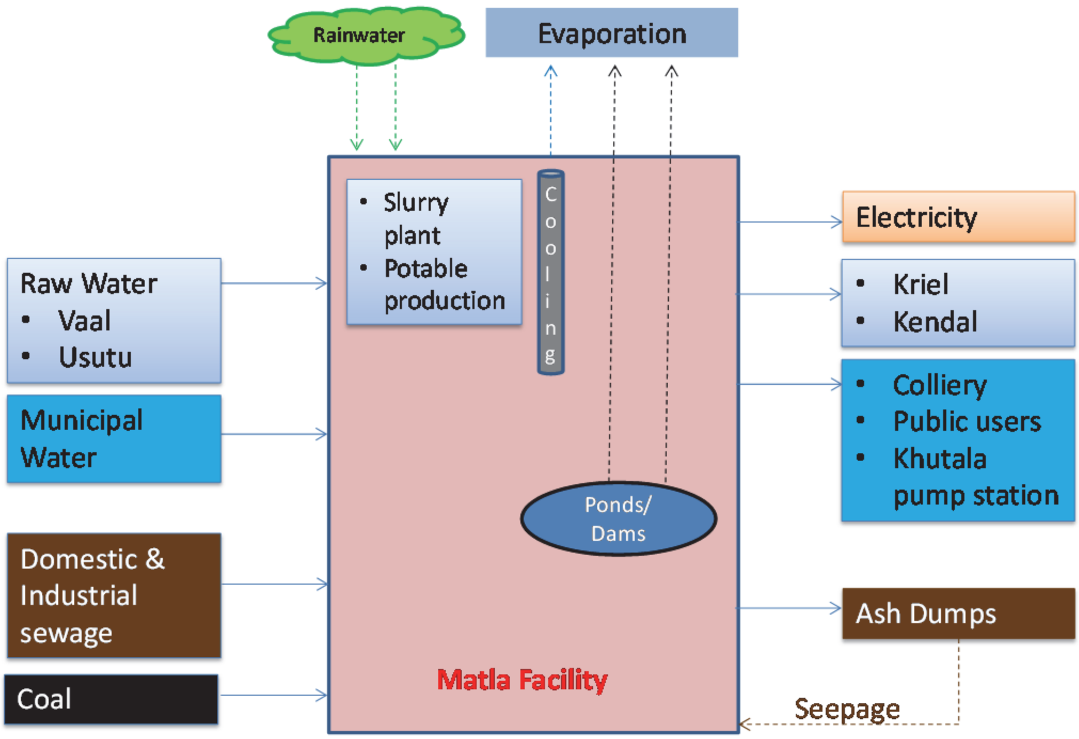

Figure 61: Simplified process diagram

8.3.1 Information Requested

The two main resource requirements from Eskom was the availability of staff to explain the production processes and the provision of data. In addition to direct operations, it was also necessary to understand the process and gather data for the coal extraction process.

Knowledge of the following items was required in order to conduct the water footprint study:

- Plant layout of the Matla Power Station

- ❖ High level process flow diagram with stream compositions and utilities
- ❖ Source of all raw materials
- ❖ Distribution network for products, i.e. local or international?
- ❖ Form, source and consumption of surface water
- ❖ Waste water treatment/disposal strategies
- ❖ Power consumption for the facility

The water footprint was calculated over the period 2009 to 2011. The following information was requested from Eskom Matla Power Station. No data was received for the upstream supply chain due to sensitivities around Exxaros' planning process. In the absence of this data, estimations were made using a report documenting the salt balance around the Matla Colliery.

Upstream

The main raw materials required by the facility are coal and raw water, which is processed on site.

- What are the different processes involved in the mining of the coal?
- What is the ash content of the different grades of coal?
- What is the feed rate of the coal to the Matla station?
- What are the quantity (TDS & composition of main species) and quality and source of raw water used in the mining processes?
- What is the quality (TDS & composition of main species) and quantity of waste water produced?
- What is the treatment and disposal method of this waste water?
- What is the electricity consumption for the mining process?

Operations

- What is the operational time for the station?
- What is the quantity (TDS & composition of main species), quality and source of raw water used in the mining processes?
- What is the quantity (TDS & composition of main species), quality and source of raw water used in the mining processes?
- What is the treatment and disposal method of this waste water?
- How much electricity is consumed by the process?
- What was the total raw water used by the Matla Power station over the past 10years?
- What is the volume of waste water treated and re-used?
- What was the production rate over the past 10years?
- What is the change in the quality of waste water versus the grade of coal?
- What is the production rate of electricity versus the grade of coal?
- What are the gas emissions from the power station?
- What is the volume and area of the ash dam?
- What is feed rate and water content in the ash slurry to the ash dump?
- What is the percolation rate of the waste water in the slurry?
- What is the rate of evaporation from the ash dump?

Downstream

The downstream use of the product will not be included in the study. However, it should be noted that the water footprint associated with the use of electricity can be considered negligible when compared to the upstream and operational footprints.

8.3.2 Methodology

The water footprints for the Power Generation Industry comprise of the green-, blue- and greywater footprints.

The study will commence by breaking down the case study into distinct steps or processes over which the water footprint analysis will be applied. The truncation of the water footprint analysis will occur after the upstream and operations phase, i.e. the downstream water footprint will not be included in the studies.

Unlike agricultural products, very little information exists for the consumptive use of water for industrial applications. Instead, there is much reported about the water abstraction for various processes. The success of the studies relies heavily on the information supplied by the company. In the case where no data is available, a considered estimation will be made based on the relevant information available in literature.

A standard method for calculating the green-, blue- and greywater footprint has been outlined in the Water Footprint Manual[6].

There is a slight deviation in the standard method for calculating the greenwater footprint, as reported by Hoekstra. Until now, no greenwater footprint calculations have been made for industries as it has been assumed that there is none. This report looks at defining the greenwater footprint as the rain water that is intercepted and stored in the detention ponds, therefore not reaching the ground water table, and is therefore “lost” or “consumed” in the process. Therefore,

$$WF_{Green} = quanity\ of\ rainfall\ (m)\ x\ surface\ area\ (m^2) x\ \%\ intercepted$$

It is important to understand the source, form and quantity of water used from surface waters in order to carry out the bluewater footprint calculations. The standard method for calculating the bluewater footprint is as follows:

$$WF_{blue} = BlueWaterEvaporation + BlueWaterIncorporated + LostReturnFlow$$

The standard method for determining the greywater footprint, as outlined in the Water Footprint Manual, is estimated on the basis of the major pollutant present in the water and is largely a dilution measure and is calculated as follows:

$$WF_{grey} = \frac{V_{eff}\ x\ (c_{eff} - c_{nat})}{c_{max} - c_{nat}}$$

[6] http://www.waterfootprint.org/downloads/TheWaterFootprintAssessmentManual.pdf

Where V_{eff} is the volume of effluent, c_{eff} is the concentration of the pollutant in the effluent discharged, c_{nat} is the natural concentration of the pollutant in the receiving body of water and c_{max} is the maximum allowable concentration of the pollutant that can be discharged to that receiving body of water.

Alternative methods will be explored for the purpose of understanding the appropriateness of the current greywater method and to understand if a different definition and approach for greywater would be more appropriate and helpful in representing water quality. For example, one issue to consider is that they greywater footprint produced by different industries can vary dramatically in terms of composition and concentration. A greywater footprint may contain medium concentrations of a poisonous substance, such as arsenic, and high concentrations of a natural occurring element such as sodium. In this case, it would be injudicious to estimate the greywater composition based solely on the concentration of the sodium present. Therefore, all greywater footprint analyses will use the methodology outlined in the Water Footprint Manual as an initial estimate.

Upstream

The upstream water footprint for this study comprised mainly of the extraction of coal from the Matla Colliery. In the absence of data, the water footprint components were estimated using data from the salt balance over the colliery. The green-, blue- and greywater footprints were calculated on the basis of a ton of coal. Based on the quantity of coal used to generate power over the years 2009 to 2011, a water footprint relating to the power production was calculated.

Operations

The operations greenwater footprint looked at the interception of rain water as defined above. Water from storm drains, both clean and dirty water, had been captured. Therefore, 100% interception of the rain water was assumed for the facility.

The operational bluewater footprint looked at the consumption raw water coming into the facility from the Vaal and Usutu sources and the potable water coming in from Municipal sources. The evaporation component for the bluewater footprint was comprised of the water evaporation from ponds and dams as well as the water lost through evaporation from the cooling towers. The lost return flow component of the bluewater footprint was estimated from the raw water and municipal water coming in less the water allocated to the various processes, i.e. the water that was not accounted for in the process.

The Matla facility does not discharge any waste, and as such, the operational grey footprint was zero.

8.3.3 Assumptions

The following assumptions were made when calculating the water footprint components for Matla Colliery:

- Potable water was used for domestic use and was excluded from the calculations.
- The greywater footprint was calculated on the basis of the sulphate concentrations.

- The bluewater footprint was calculated as the sum of the evaporation and Run Off Mine (ROM) less 10% which was allocated to the greenwater component.
- The greenwater footprint was estimated by multiplying the annual rainfall in the area (700 mm) with the total area of the Matla Colliery (1.04 km^2) and assuming that 10% of that rainfall is intercepted by the mine.

The following assumptions will be made when conducting the water footprint study for the Matla facility:

- The greenwater footprint was calculated on the assumption that all rainfall was intercepted and stored in the dirty and clean storm pans.
- A total surface area of 0.1 km^2 was used to calculate the evaporation from the dams and ponds at the Matla facility.
- It was assumed that all make-up water was lost to evaporation from the cooling towers.
- The lost return flow was estimated from the raw and municipal water coming into the facility that was not accounted for.

8.4 Water footprint accounting and interpretation

8.4.1 Upstream Water Footprint

Presented here are the calculations made for estimating the Water Footprint of Matla Colliery. Matla Colliery produces 14 Mega tons per annum (Mtpa) of coal[7] from three different mines and is 1.04 km^2 in size[8]. The area experiences a Mean Annual Rainfall (MAR) of approximately 700 mm.

Presented below is the water usage for the process of coal mining to electricity generation. It is evident that water is crucial to the process. It is important to understand the quantity of water used in these steps and the extent of degradation of the water quality. Presented in Table 21 -22 is the water used per ton of coal in the process of coal mining.

[7] http://www.exxaro.com/content/ops/coal_matla.asp
[8] http://en.wikipedia.org/wiki/Emalahleni_Local_Municipality,_Mpumalanga

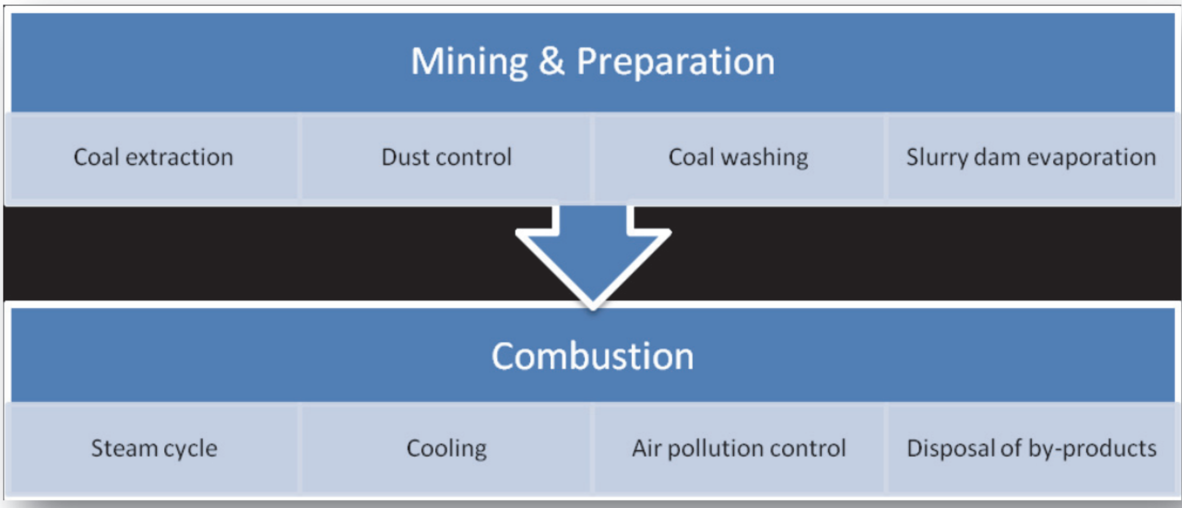

Figure 62: Water usage for the generation of electricity

The following data is quoted from Wassung (2012) regarding the water use for coal mining:

Table 21: Water used in the coal mining process

Process	Water Usage	Units
Mining	0.16	m^3/ton coal
Crushing		m^3/ton coal
Screening		m^3/ton coal
Washing	0.038 to 0.150	m^3/ton coal
Separation		m^3/ton coal
Dust Suppression	0.042	m^3/ton coal
Evaporation	0.229	m^3/ton coal
TOTAL	**0.431**	**m^3/ton coal**
Effluent produced	0.0012	m^3/ton coal

It should be noted that the above information does not take into account recycling measures and assumes that the wastewater goes directly to the ash dumps.

Water footprint components

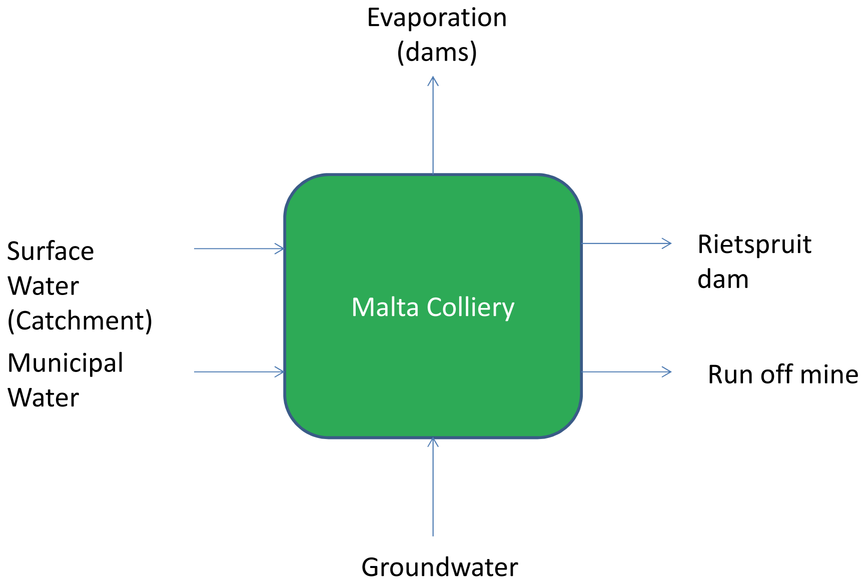

Figure 63: Simplified process diagram for Matla Colliery

The data presented in Table 22 has been estimated using a report on the salt balance of the Matla Colliery

Table 22: Data for Matla Colliery

	Units	mine 1	mine 2	mine 3	Total
Evaporation	m^3/yr	27950	84500	2500	**114950**
Groundwater	m^3/yr	693000	1299000	610000	**2602000**
Surface Water	m^3/yr	14450	512340	405051	**931841**
Run Off Mine	m^3/yr	274000	650000	274000	**1198000**
c_{eff}	SO_4 (mg/L)	430	788	210	
C_{max}	SO_4 (mg/L)	155	155	155	
C_{nat}	SO_4 (mg/L)	30	30	30	
Grey WF	m^3/yr	46240	3106829	583273	**3736343**
Grey WF	m^3/ton coal				**0.27**
Blue WF	m^3/yr	299155	726050	276250	1301455
Blue WF	m^3/ton coal				**0.09**
Green WF	m^3/yr				72800
Green WF	m^3/ton coal	10%MAR			**0.0052**

Figure 64 gives the water footprint components for the individual mines at the Matla Colliery. The greenwater footprint for all three mines is minute in comparison to the blue and grey components. However, it should be noted that the greenwater footprint has been estimated and should be further investigated.

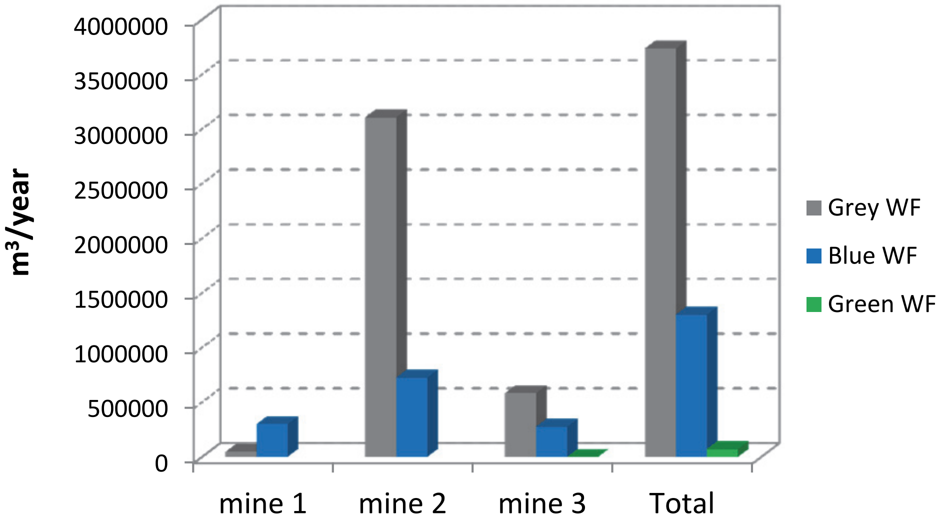

Figure 64: Water footprint components for the individual mines at Matla

Interestingly, the water footprint trends differ quite drastically between the three mines. For mine 1, the largest water footprint can be allocated to the blue component whereas with mine 2 and mine 3, the greywater component dominates the water footprint. A large greywater footprint is expected for the mining industry due to the quantity and poor quality of wastewater produced. The greywater component in mine two is significantly higher than that of the bluewater component, indicating extra washing stages to produce a high grade coal with fewer impurities on its surface or coal of very high concentration of impurities on its surface. The total grey-, blue- and greenwater footprints for the Matla Colliery is 3 736 343 m^3/year, 1 301 455 m^3/year and 11 495 m^3/year, respectively.

The annual coal production for the Matla Colliery is 14 million tons. Figure 65 gives the water footprint components for Matla Colliery as a function of its annual production. This gives the total grey-, blue- and greenwater footprints for the Matla Colliery is 0.27 m^3/ton coal, 0.09 m^3/ton coal and 0.0008 495 m^3/ton coal respectively.

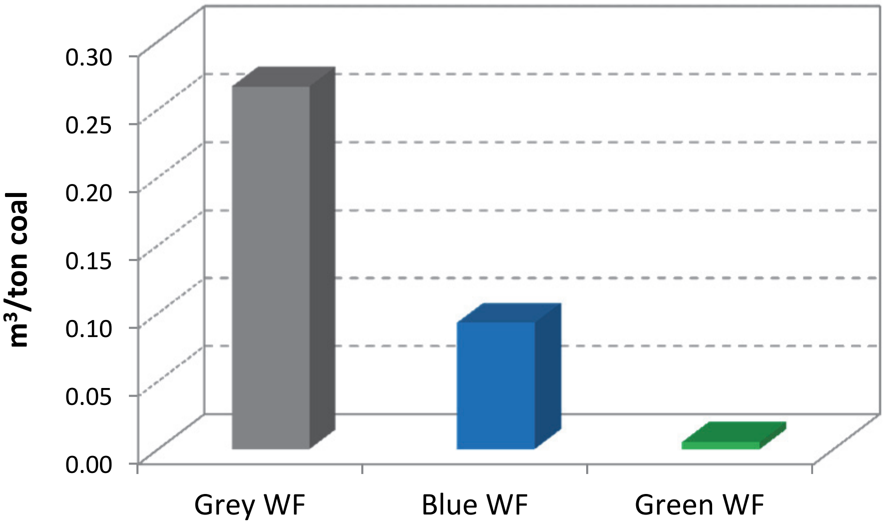

Figure 65: Water footprint components for the mining of coal at Matla

Presented in Figure 66 is the water footprint components calculated per unit of energy for the years 2009 to 2011. There is little difference in the footprint values as the production rates did not change significantly over the three years.

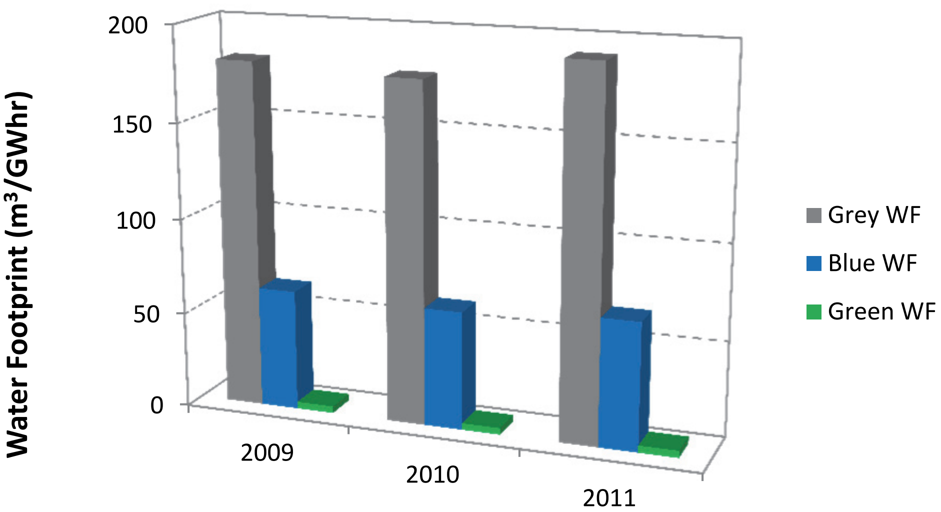

Figure 66: Water footprint components for the period 2009 to 2011

8.4.2 Operational Water Footprint

Greenwater footprint

The operational greenwater footprint is comprised of the rainwater that has been intercepted and stored in ponds. In the case of Eskom, there are two storage ponds that collect the rain water. One being the water from storm drains, which is considered clean and sent to the clean storm water pond, and the second pond, the dirty storm water dam, sees the collection of the runoff from the plant. It is important to collect this water seeing that the burning of coal leads to many particulates settling on the ground that could potentially combine with the rain water and reach the water resources.

The greenwater footprint ranges from 5.7 million m^3/yr to 7.0 million m^3/yr for the period 2009 to 2011. When looking at the greenwater footprint based on quantity of power generated for that year, it can be seen that the values range from 209 m^3/GWhr to 333 m^3/GWhr (Figure 67).

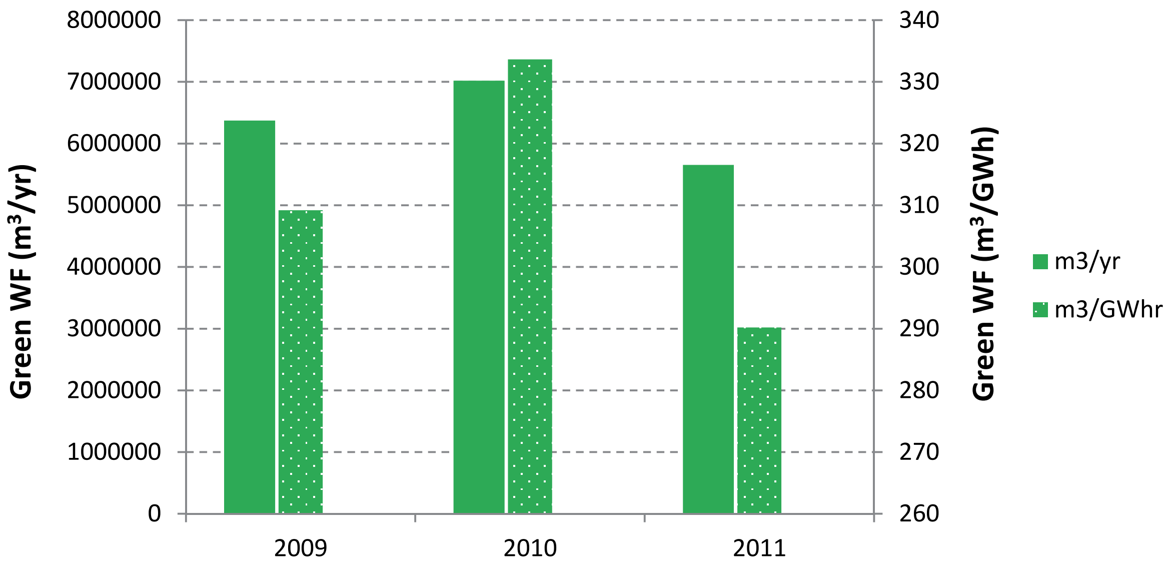

Figure 67: Operational Greenwater Footprint for Matla Facility

Bluewater footprint

The bluewater footprint looked at three components:

- Evaporation from dams/pond
- Evaporation through cooling towers
- Lost return flow
- Water incorporated into products, which was zero.

Presented below is the list of the various water retention pods/dams at the Matla facility.

Table 23: Waste Water Storage facilities at Matla Facility

	Storage Facility	Capacity
1	Dirty Storm Water Dam (Unit 7 Dam)	109883 m^3
2	New Ash Dam – Final Cut	154300 m^3
3	Old Ash Dam – AWR Dams (North)	73221 m^3
4	Old Ash Dam – AWR Dams (South)	73221 m^3
5	Old Ash Dam – SWR Dams	146442 m^3
6	Clean Storm Water Pan (Raw Water Pan)	3000 m^3
7	New Ash Dam – Seepage Dam1	5150 m^3
	Seepage Dam2	29400 m^3
8	Sewage Plant – Emergency Pond	1500 m^3
9	Sewage Plant Maturation Pond	7000 m^3
10	Grit Separation Plant	9400 m^3
11	Old Ash Dam – Ash Deposit Rehabilitated	Rehabilitated Solid Ash Deposit – 37.2 m Tons of ash
12	New Ash Dam System – Ash Deposit	Current Solid Ash Deposit – 61 m Tons of Ash

Figure 68 and Figure 69 gives the breakdown for the operational bluewater footprint on an annual basis and per unit power basis. The largest contributor is the evaporation from the cooling towers. This is expected as the Matla facility uses a wet cooling system. The lost return flow and the evaporation from ponds/dams are minimal as compared to the waster consumed through the cooling towers.

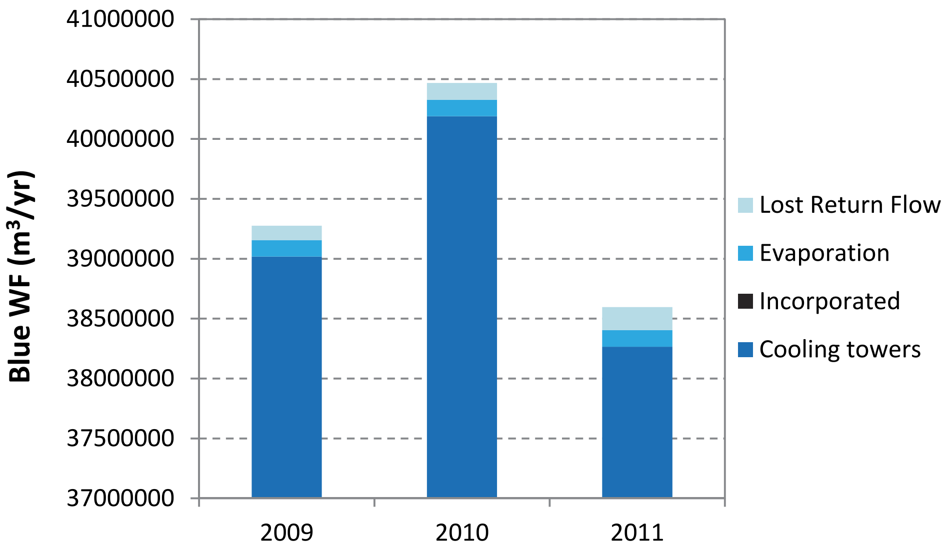

Figure 68: Operational bluewater footprint for Matla facility

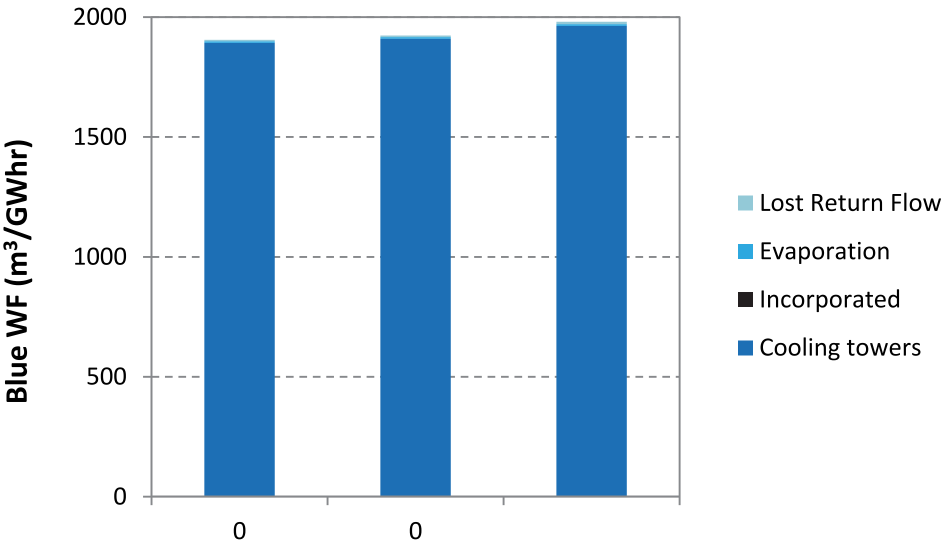

Figure 69: Operational bluewater footprint for Matla facility based on power generated

Figure 70 gives the percentage contribution to the operational bluewater footprint. The evaporation from the cooling towers accounts for 99% of the blue footprint. The evaporation from dams and ponds sits at 1% and the contribution from the lost return flow is 0.3%, which is negligible.

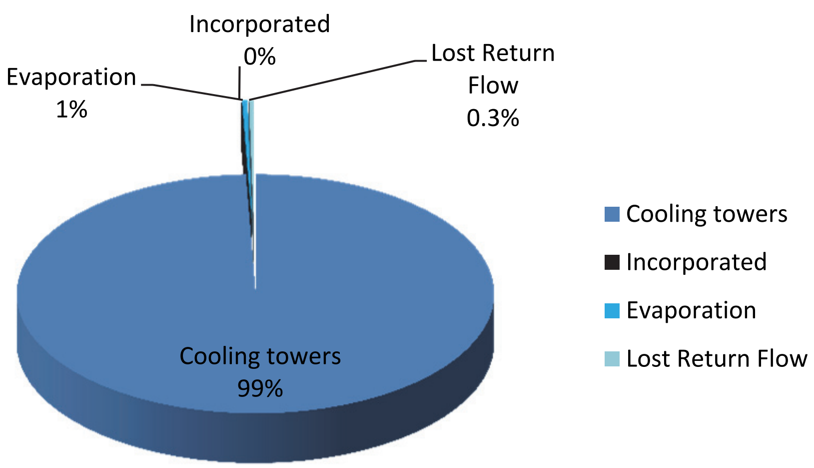

Figure 70: Components of the operational bluewater footprint for 2009

Greywater footprint

The total effluent generated by the facility is co-disposed with the ash to the ashing system and re-used. The final effluent generated from sewage is returned to the cooling water system and re-used. From the information gathered, the Matla facility has no greywater footprint as no water is discharged back to surface water. However, the likelihood of an industrial facility having a zero greywater footprint is extremely low. It should be noted, if one has to consider any accidents that may occur, the seepage from ash dumps and other solid waste dumps, failing storm water drains and failure dirty water collection systems, polluted water would reach either surface or ground water sources. This cannot be quantified at this time, but should be taken into consideration.

Table 24: Gaseous emissions from Matla facility calculated from coal analysis and emission factors[9]

	MAR 2011	APR 2011	MAY 2011	JUN 2011	JUL 2011	AUG 2011	SEP 2011	OCT 2011	NOV 2011	DEC 2011	JAN 2012	FEB 2012
CO_2	1665.34	1383.55	1623.65	1347.12	1533.48	1693.13	1611.73	1893.13	2060.37	1738.69	2057.17	1549.18
SO_2	16.91	15.86	15.75	14.93	16.31	17.27	15.82	18.91	19.95	17.13	19.89	14.94
NO_x	5.30	4.97	4.93	4.68	5.11	5.41	4.96	5.92	6.25	5.37	6.23	4.68

***kilotons per month**

The direct greywater footprint for the operational water footprint is not expected to be large. However, due to the combustion of coal, the production of electricity sees a large quantity of fly ash being produced, the main component being silicon dioxide. The fly ash is usually dumped in ash piles and discharged as slurry. Eskom currently emits approximately 225 mega tons of CO_2 per annum amongst other gasses, which can accumulate and lead to acid rain, contributing to an even larger greywater footprint. Even up to now, government has no clear policy on coal, especially considering the current state of climate change. Table 24 gives the gaseous emissions from the Matla facility, which contributes approximately 10% of the Eskom's total CO_2 emissions.

8.4.3 Total Water Footprint

Presented in Figure 71 is the combination of the footprint components for the upstream and operations. The largest contributor to the water footprint is the blue component. This is due to the large quantity of water lost by evaporation through the cooling towers and the evaporation ponds/dams at the facility.

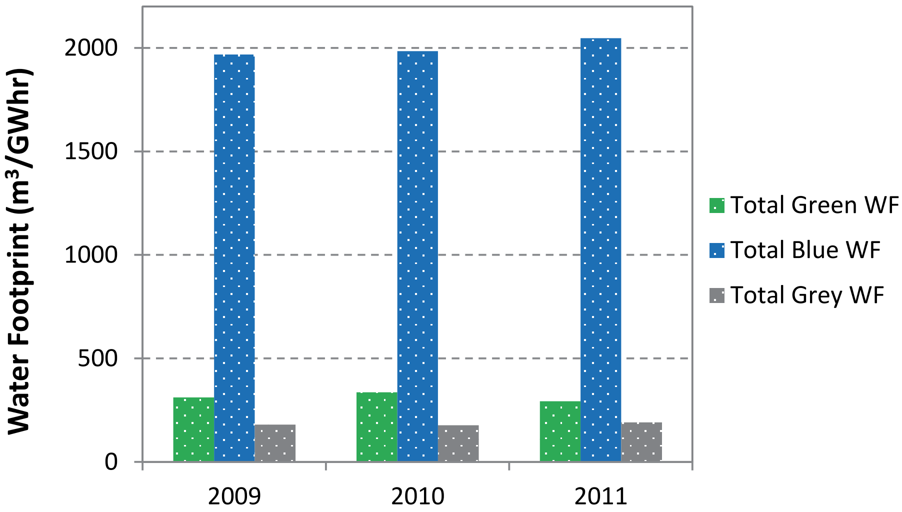

Figure 71: Total Water Footprint for the upstream and operations

[9] Matla Air Quality Report

It is interesting to see that the greenwater footprint is the second largest contributor as compared to the greywater footprint. This is attributed to the operational greenwater footprint, which assumed that all rain water to the facility was intercepted and stored in ponds. It should be noted here that the greywater footprint seen here is attributed to the upstream only, where the greywater footprint dominated.

8.4.4 Sustainability and Risk Assessment

The sustainability and risk assessment takes into account different dimensions such as environmental, social and economic. This assessment will focus on the water risks associated with the facility by taking into account the local water resources, water allocations and local environmental, socio-economic considerations. The effect of climate change and rainfall patterns will also be discussed.

Figure 72 shows the locations of the various power stations of Eskom. Although the Matla facility is located in the Olifants catchment, it draws water from the Vaal catchment and faces similar concerns to Company P.

Water risk in the supply Chain

The Vaal River catchment contains South Africa's economic heartland with the highest concentration of urban, industrial, mining and power generation development in South Africa. Activities such as agriculture, forestry, mining, urbanization and power generation coupled to adverse natural climatic conditions such as a highly variable rainfall and excessive evaporation have created a highly regulated and in some areas a highly polluted river system. Concerns include AMD, salinity, eutrophication, metals, endocrine disruptors and pathogens. The Vaal River therefore poses a considerable challenge to the many water resource managers who are committed to ensuring the future supply of appropriate quality water to the various sectors of the economy. This challenge is further exacerbated by illegal water use in the area.

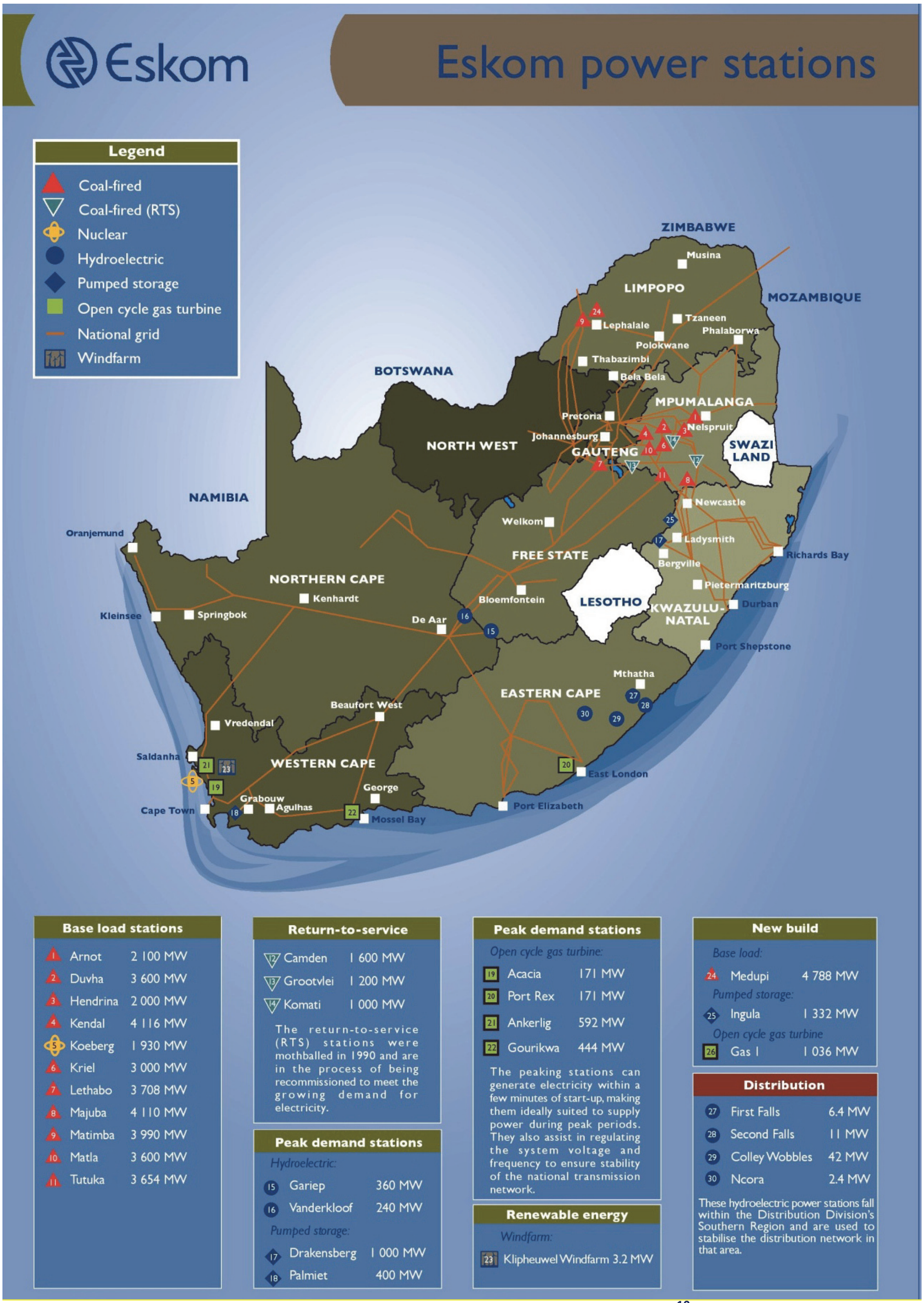

Figure 72: Locations of Eskom's power stations[10]

Eskom currently operates 12 coal fired-power stations (Figure 72) which received water from the Integrated Vaal River System. In the coming years, increases in the population and higher standards of living will result in an increase in the requirement for energy. This is further exacerbated by

[10] http://www.eskom.co.za/c/article/730/map-of-eskom-power-stations/

urbanisation. Consequently, demands on water resources will increase due to the interdependent relation between energy and water. In many countries, electricity accounts for more than 60% of water processing and distribution operating costs. This is particularly the case in South Africa where there are extensive transfer schemes and water treatment facilities[11].

Table 25: Water requirements for Eskom[12]

Power Station	Primary Water Source	Water Requirements (million m^3/annum)					
		2006	2010	2015	2020	2025	2030
Hendrina	Komati Sub-system	31.0	32.4	33.0	32.7	32.7	32.7
Arnot		29.4	33.4	36.1	36.5	36.6	36.6
Duvha		50.8	50.4	51.6	52.2	52.2	52.2
Komati		2.6	5.6	9.9	8.3	8.4	8.4
Kriel	Usutu Sub-system	38.8	40.7	43.5	43.2	43.5	43.5
Matla		51.5	51.6	53.6	54.3	54.3	54.3
Kendal		3.2	3.3	3.4	3.4	3.4	3.4
Camden		5.5	19.2	23.2	23.2	23.2	23.2
New coal-fired 1		0.0	0.6	2.9	3.7	3.7	3.7
Majuba	Zaaihoek Sub-system	19.2	25.6	25.6	24.1	24.1	24.1
Tutuka	Grootdraai Sub-system	34.5	46.2	44.3	48.8	48.8	48.8
Grootvlei	Vaal Dam	0.8	6.1	10.4	10.1	10.1	10.1
Lethabo		45.5	46.6	49.4	50.1	50.1	50.1
New coal-fired 2		0.0	0.0	0.6	3.0	3.0	3.0
New coal-fired 3		0.0	0.0	0.0	2.6	3.0	3.0
Total		**312.9**	**361.7**	**387.5**	**396.3**	**397.2**	**397.2**

It should be noted that all of Eskom's power stations are located in the Vaal catchment, which places the company at serious risk, especially due to the poor water quality in the Vaal. Power stations require water of good water quality in order to be

The reconciliation study looks at the availability of water in the resource versus the requirements for water use and the potential of the resource to meet these requirements. Owing to the result of the emerging gap between water supply and demand indicated in the reconciliation options analysis for the Vaal system presented in figure below, there is a mismatch between the water available and the water requirements in the different catchment which poses a water supply risk.

Poor water quality also poses a potential risk. The water is required for the cooling tower should have a low dissolved ion content, therefore allowing for more cycles of concentration. As the cycles of concentration increase, the water circulating becomes more concentrated with dissolved salts due to the evaporation of water. This can be dangerous as it can cause fouling and heat exchange problems in the cooling tower. The water saturated with dissolved salts is then removed from the system, and desalinated before being introduced back to the system. In instances where the water is too saturated, the solution is discharged, therefore requiring fresh intake of water and consequently increasing the demand for water.

[11] Eberhard, The Future of South African Coal: Market, Investment and Policy Challenges, Program on Energy and Sustainable Development, Working Paper #100, January 2011
[12] http://www.dwaf.gov.za/Projects/Vaal/documents/VaalBulkReconStratDec06.pdf

For Eskom, an understanding of its water footprint (blue and grey) will help in the understanding of the physical impact the Matla facility has on the downstream users as well as the downstream of the Vaal. Furthermore, with stricter environmental legislature coming into practice, Eskom can mitigate the reputational risks associated with the contamination of water and through the mining of coal. It will also be in a position to interrogate further regulatory or other tools (Waste Discharge Charge System) that the government will put into place by understanding its own limitations and the risk and boundaries in which it can operate.

It is recommended that a comparison between a dry, wet and a combination of cooling be looked at in conjunction with the positioning of the facilities within South Africa to further understand the risks that may be associated with a particular

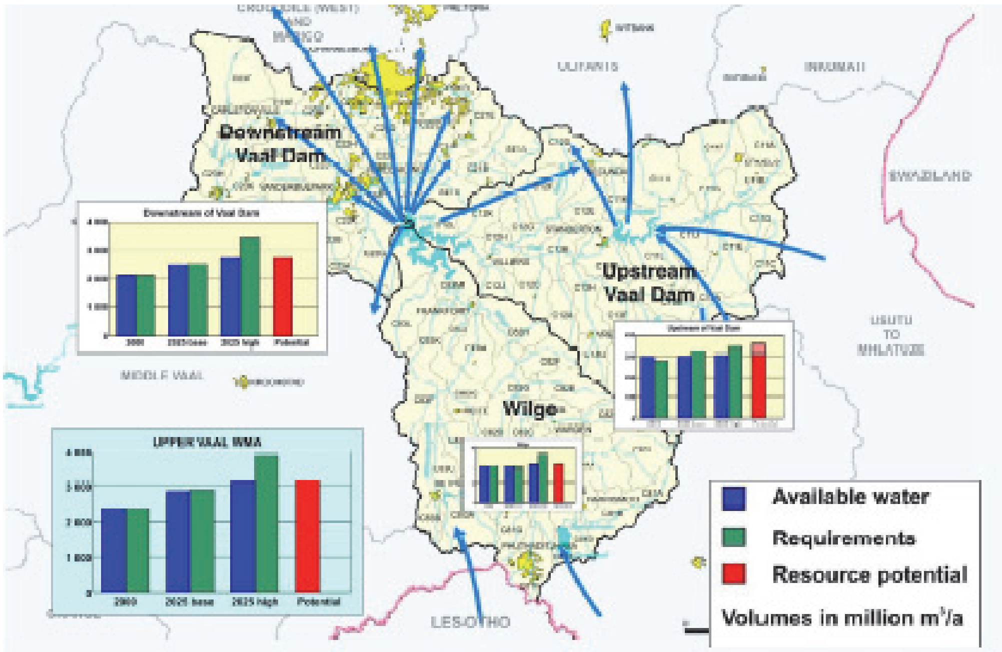

Figure 73: Upper Vaal WMA Future Water Reconciliation

8.4.5 Impacts of climate change

The Vaal region has not experienced significant drought in the last few years, however future rainfall is difficult to predict future rainfall patterns in the area owing to impacts of climate change and therefore the supply of water through rainfall is uncertain. Should there be a severe drought in the region, there is a real risk of water restrictions. To close the short-term gap requires effective water conservation and demand management, the control of illegal irrigation in the Upper Vaal and the effective treatment of AMD. However, these measures may not be enough unless there is constant communication between corporates, industries, governments and communities, especially when there will be an increase in the competition between industrial and domestic users should a drought occur[13].

[13] http://www.theneweconomy.com/energy/south-africas-water-management-faces-tough-future

8.4.6 Future plans for the Vaal

There is little risk associated with bulk water service provision. Rand Water is well managed, and institutionally and operationally sound. Water disruptions are unlikely as the Vaal system is supported by a comprehensive reconciliation plan and there is institutional capacity in the institutions responsible for water resources management and water services provision. The water reconciliation plan for the Vaal system, shown in Figure 74, indicates the different options available for meeting the water demands of the region. The critical augmentation schemes required to meet the water demand for this region include the Lesotho Highlands Water Project (LHWP) Phase 2, the Orange-Vaal water transfer and the Thukela-Vaal water transfer scheme. Although long term plans to ease the situation are already in place, Phase II of the Lesotho Highlands Water Project (LHWP) is not scheduled to start delivering water to the Vaal until 2020.

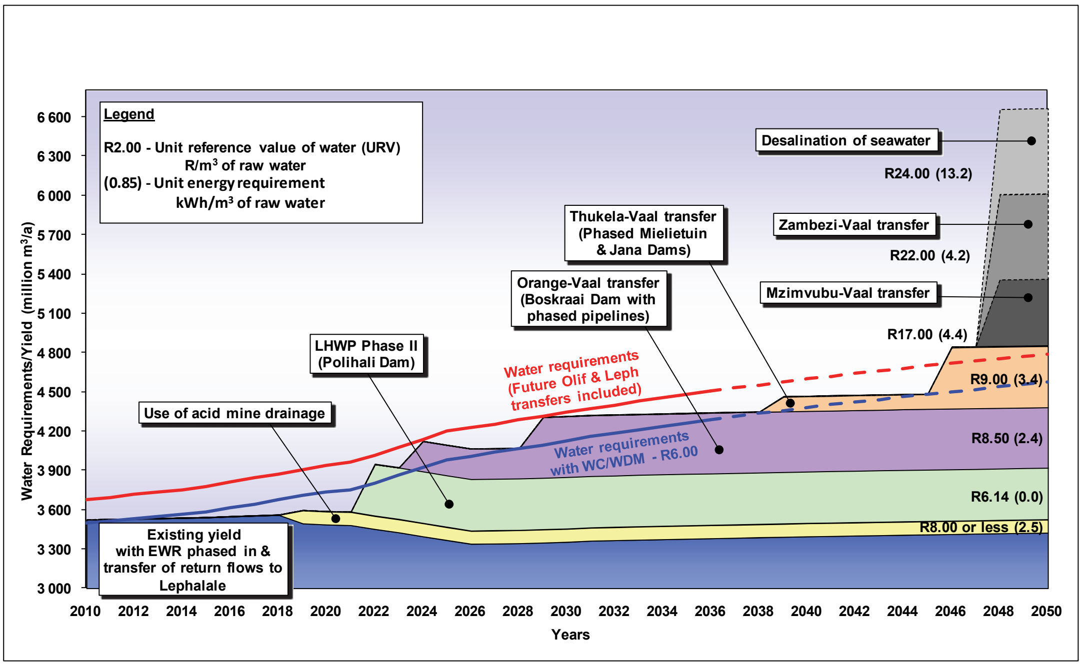

Figure 74: Vaal System augmentation options

8.5 Water Footprint Uses

The water footprint accounting is a useful metric to understand the facility's appropriation of surface water as well as its contribution to water quality issues. However, the real impact of the facility's water footprint is best understood when discussed in a local context. Two categories are discussed here: Benchmarking and Planning as it relates to water-risk. Each of these categories has a significant communication element which water footprint can help to inform, and thus use of water footprint as a communication tool for these purposes will be a common theme.

8.5.1 Benchmarking

Internal benchmarking

A potential use for the water footprint for the Eskom facility is to track its water usage internally. Eskom has numerous coal-fired power stations spread across South Africa. It would be useful to compare these facilities whilst considering their locations to water-stressed catchment. Furthermore, Eskom uses three cooling methods:

1. Wet-cooling
2. Dry-cooling
3. Wet-dry-cooling

It would also be useful to track the water footprint associated with these cooling methods.

Once the above has been considered Eskom should look at its entire supply chain and understand its water usage at each point of the chain and its impact on water quality. Currently, no tool exists to understand the water use throughout the supply chain, showing that water footprinting addresses a crucial need.

External benchmarking

In addition to internal benchmarking and tracking, a water footprint can be used for external reporting and potentially external benchmarking. Regarding external reporting, no standard for reporting corporate water implications currently exists. The Carbon Disclosure Project, for example, has focused on awareness of water use, risks and opportunities rather than quantification of water implications. Water footprint does, therefore, represent a potential tool for external reporting which considers water implications throughout the production supply chain.

If used for external reporting, standard approaches would have to be developed, such as reporting on both net and gross greenwater footprints. It would also be important to explain the concept of the water footprint, and indicate the important of considering the local context. Given the importance of the local context, external reporting using a water footprint becomes a much more complex message which has significant risk of misinterpretation. While a water footprint can be used to communicate awareness of water implications in the supply chain, it should not be a metric viewed in isolation of context.

Regarding external benchmarking, a water footprint may be a useful tool for benchmarking if water footprints for substantially similar products exist. For the chemical industry, benchmarking of the overall water footprint would only be possible if the products used for comparison were very similar to the product in question. For the Power Generation Industry, comparable studies between the different forms of energy generation such as hydro, solar, wind, nuclear and coal-fired power would be interesting, especially when related to water consumption and impact on water quality.

8.5.2 Planning

An important use of the water footprint is to assist corporates in their planning and decision-making. In the case of the Matla facility, it may be useful to compare the supplies of coal from different areas in South Africa and understand the impacts of different grades of coal on the electricity production as well as water consumption and degradation. Furthermore, Eskom's power stations require large volumes of water therefore the availability of water and competition for that water needs to be considered.

8.6 Conclusions

Distribution of the Water Footprint between the Upstream and Operations

This study showed a large greywater footprint associated with the extraction of coal and a large operational bluewater footprint associated with the generation of electricity from coal. The operational footprint exceeds the upstream water footprint due to the large blue component.

Environmental Impact of a Power Generation through Coal Mining

The effect of coal mining on water quality is well documented. The water footprint study showed a significant impact on the water resources from the greywater footprint in the upstream process and a large volume of water lost through evaporation from the cooling towers. Not only is the water quality severely contaminated, but there is a large loss of water through evaporation.

Water Risk for Matla facility

The Matla facility is at significant risk due to the availability of freshwater and the quality of the water (AMD) in the Vaal region. Eskom's coal-fired power stations are all based in this region, creating even higher risk for the company.

Increases in population, urbanisation and higher standards of living will increase the demand for electricity and consequently, demand on water resources will be increased. The competition for water resources will be exacerbated if there is a period of drought in the area.

The risk associated with the quality of water in the Vaal is directly related to the use of the water in the cooling towers and the cycles of concentration. If the water quality coming into the system is very poor, the number of cycles needs to be decreased and discharged more often, further increasing the intake water to the tower.

Using Water Footprints to Illustrate the Relationship between Water and Energy

Power station has inherently large bluewater footprints due to the loss of water through evaporation from the cooling towers. Even though the potential greywater footprint from the actual generation of electricity is minimal in comparison to the blue component for the operations, the overall generation of electricity has a significant impact on water quality from the extraction of coal.

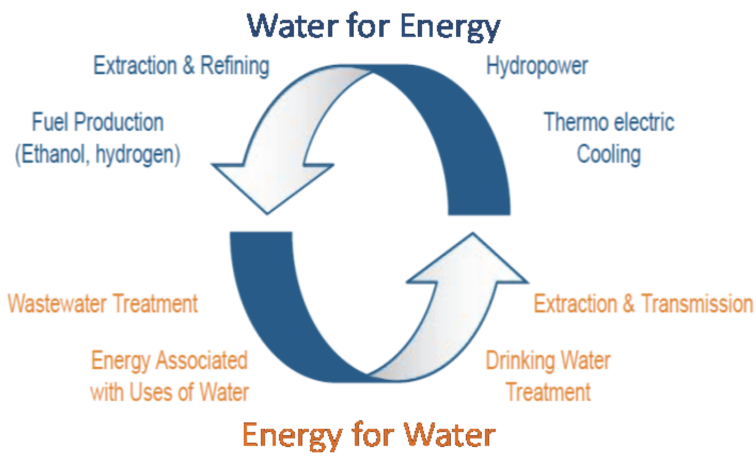

Figure 75: Water-Energy Nexus

In the energy sector there is a link between the energy-water trade-offs. Saving water requires energy, so an inverse effect is seen. It is crucial to find the best operating practice that is both economically and environmentally sound. The lesson here for Eskom is that in its drive to be more water efficient, more energy is required to do so and a compromise between the two needs to be established.

9. CASE STUDY D: Chemical and Manufacturing

Due to sensitivities around the information, no details regarding the company, methodology and data have been included.

9.1 Motivation for case

Company P is an integrated energy and chemicals company. The plant is situated in the Vaal area, a water-stressed region, and this is of interest as many of the processes require large volumes of water, either in the process or as a utility.

9.2 Scope

The purpose of this study is to determine the green-, blue- and greywater footprint for a chemical plant and gain an understanding of how water footprints can inform environmental impact and water risk and thereby identify opportunities to improve performance.

An important aspect of the chemical plant facility is the extractive component in its upstream supply chain. It would be useful to understand the distribution of the water footprint components, in particular the blue- and greywater footprint, seeing that the Upper Vaal is a stressed catchment with severe water quality issues and in a region prone to drought.

In addition, due the large scale of this study, it will be used to explore the issues surrounding scale and boundaries for the water footprint study.

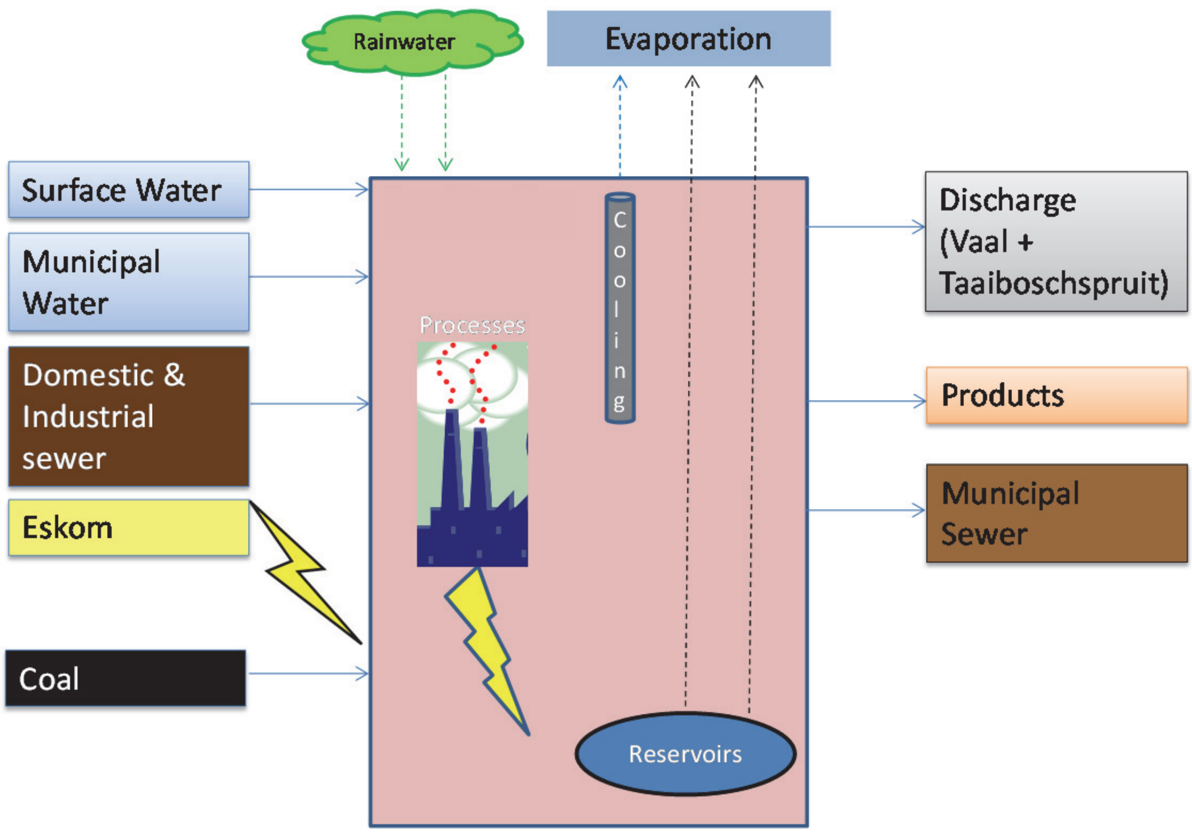

Figure 76: Simplified process diagram

The study has been conducted on the basis of the facility located in the Vaal. The site is inclusive of majority of the operations at Company P and can therefore be used as a proxy for the company water footprint in this region.

The water footprint will be a high level water footprint of the upstream processes of coal extraction and the operational water footprint concerned with the generation of utilities, manufacture of chemicals and the disposal of waste was conducted. The distribution of the products is of interest; however, this study will not look at the water footprint of the downstream use of the products. Presented above is a simplified depiction of the operations at the Vaal facility that was

9.2.1 Key Questions

The following key questions will be addressed in this study:

i. *How to define and apply the greenwater footprint to industry with specific regard to the interception of rain water?*

ii. *How can water quality be used to inform the greywater footprint?*

iii. *What are the green-, grey- and bluewater footprints of the Company P site and how is the footprint allocated between the upstream and operations?*

iv. *What are the local impacts of the chemical and manufacturing industry as it relates to water risk?*

v. *How do we tackle the issue of water as a by-product versus water that is embedded? Furthermore, how does the attribution of by-products affect the company's water footprint?*

vi. *When approaching a water footprint for a complex process, how should the boundaries be drawn and what assumptions can be made to ensure an informative but manageable analysis?*

vii. *How does seasonality affect the water footprint?*

9.3 Information, methodology and assumptions

9.3.1 Information

The following information will be used to conduct the study:

- **Basis for study:** A comparative study will be conducted over an average day in the following periods of the processes:
  - a) Summer
  - b) Winter
  - c) Shutdown

9.3.2 Methodology

The water footprints for the Chemical & Manufacturing Industry comprise of the green-, blue- and greywater footprints.

The study commenced by breaking down the case study into distinct steps or processes over which the water footprint analysis was applied. The truncation of the water footprint analysis occurred after the upstream and operations phase, i.e. the downstream water footprint was not be included in the studies.

Unlike agricultural products, very little information exists for the consumptive use of water for industrial applications. Instead, there is much reported about the water abstraction for various processes. The success of the studies relies heavily on the information supplied by the company. In the case where no data is available, a considered estimation was made based on the relevant information available in literature.

A standard method for calculating the green-, blue- and greywater footprint has been outlined in the Water Footprint Manual.

There is a slight deviation in the standard method for calculating the greenwater footprint, as reported by Hoekstra. Until now, no greenwater footprint calculations have been made for industries as it has been assumed that there is none. This report looks at defining the greenwater footprint as the rain water that is intercepted and stored in the detention ponds, therefore not reaching the ground water table, and is therefore “lost” or “consumed” in the process. Therefore,

$$WF_{Green} = quantity\ of\ rainfall\ (m)\ x\ surface\ area\ (m^2) x\ \%\ intercepted$$

It is important to understand the source, form and quantity of water used from surface waters in order to carry out the bluewater footprint calculations. The standard method for calculating the bluewater footprint is as follows:

$$WF_{blue} = BlueWaterEvaporation + BlueWaterIncorporated + LostReturnFlow$$

The standard method for determining the greywater footprint, as outlined in the Water Footprint Manual, is estimated on the basis of the major pollutant present in the water and is largely a dilution measure and is calculated as follows:

$$WF_{grey} = \frac{V_{eff}\ x\ (c_{eff} - c_{nat})}{c_{max} - c_{nat}}$$

Where V_{eff} is the volume of effluent, c_{eff} is the concentration of the pollutant in the effluent discharged, c_{nat} is the natural concentration of the pollutant in the receiving body of water and c_{max} is the maximum allowable concentration of the pollutant that can be discharged to that receiving body of water.

Alternative methods will be explored for the purpose of understanding the appropriateness of the current greywater method and to understand if a different definition and approach for greywater would be more appropriate and helpful in representing water quality. For example, one issue to consider is that the greywater footprint produced by different industries can vary dramatically in terms of composition and concentration. A greywater footprint may contain medium concentrations of a substance containing toxic amounts of elements such as arsenic, and high concentrations of a natural occurring element such as sodium. In this case, it would be injudicious to estimate the greywater composition based solely on the concentration of the sodium present. Therefore, all greywater footprint analyses will use the methodology outlined in the Water Footprint Manual as an initial estimate.

Upstream

The upstream water footprint for this study comprised mainly of the extraction of coal. In the absence of data, the water footprint components were estimated using data from the Matla Colliery. The green-, blue- and greywater footprints were calculated on the basis of a ton of coal mined. This made it easy to calculate the green-, blue- and greywater footprints for the Company P Colliery based on the intake of coal for the summer, winter and shutdown periods.

Operations

The operational greenwater footprint was calculated using the equation outlined above. It was assumed that 10% of the rainfall was intercepted and thus "consumed"

The operational bluewater footprint for the facility was a little more complicated. The components of the operational bluewater footprint were:

i. Water incorporated into products
ii. Water lost through evaporation from the cooling towers inside the facility
iii. Water lost through evaporation form the reservoirs situated inside the facility
iv. Water abstracted and not returned in the same period of time (Lost return flow)
v. Water used in the generation of electricity from Eskom

i. Water incorporated into products

The operational bluewater footprint for incorporation of water into the products was assumed to be 20% (as per discussion with Company P) of the water used.

ii. Water lost through evaporation from the cooling towers inside the facility

The operation bluewater footprint for water lost through evaporation from the cooling towers within the facility was estimated using a mass balance for a wet cooling tower:

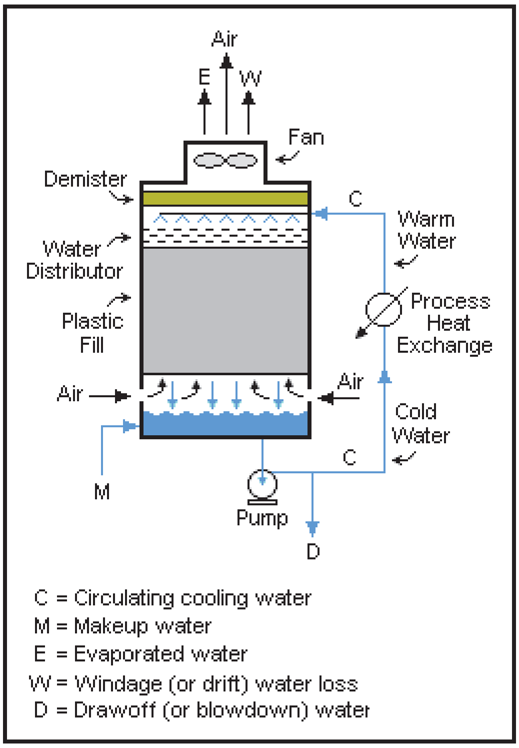

Figure 77: Schematic for wet-cooling tower

$$Makeup\ water\ = Evaporation + Drawoff + Windage$$

The cycle of concentrations ranged between 2.7 to 4.5 for the various periods. As the cycles of concentration increase, the water circulating becomes more concentrated with dissolved salts. This can be dangerous as it can cause fouling and heat exchange problems in the cooling tower. The water saturated with dissolved salts is then removed from the system, and desalinated before being introduced back to the system. In instances where the water is too saturated, the solution is discharged.

Windage (or drift) losses (W) is the amount of total tower water flow that is evaporated into the atmosphere and therefore lost. This is generally assumed to be 1%. In order to simplify the calculations, the water lost through evaporation from the facility was assumed to be equal to the makeup water.

iii. *Water lost through evaporation form the reservoirs situated inside the facility*

There are two reservoirs that are situation inside the facility. Both these reservoirs have a surface area of 5000 m^2 each. An average rate of evaporation for the different periods was estimated from data from the average monthly evaporation data for the different periods[14].

$$Evaporation = surface\ area\ x\ evaporation\ rate$$

[14] http://www.waterandclimatechange.eu/evaporation/average-monthly-1985-1999

iv. *Water abstracted and not returned in the same period of time (Lost return flow)*

The contribution of the lost return flow to the operation bluewater footprint was estimated as the potable water used for reservoir 2 and firewater as it does not return to the catchment from which it has been abstracted within the same time period.

v. *Water used in the generation of electricity from Eskom*

Electricity is another input into the production process which will have water footprint implications. Literature values are used to estimate the water footprints of electricity, as directly calculating the water footprint will require a detailed analysis of coal-based electricity generation. It is expected that a more informed water footprint for electricity will be developed as another case study, and the values used in this study will be updated accordingly.

To determine the bluewater footprint of electricity, it was assumed that all electricity is coal-based and a literature value for the water footprint of coal was used. Although coal likely has a significant greywater footprint, only a bluewater footprint value of 0.16 m^3 per gigajoule was available in literature. The greywater footprint value should be included once it is known, and the bluewater footprint revised if more accurate data becomes available.

The operational greywater footprint considers the volume of effluent discharged to the Vaal. The calculations were made on the basis of sulphate and Total Dissolved Solids (TDS), both constituents are cause for concern in the Vaal catchment.

9.3.3 Assumptions

The following assumptions were made when calculating the water footprint components for Matla Colliery:

- Potable water was used for domestic use and was excluded from the calculations.
- The greywater footprint was calculated on the basis of the sulphate concentrations.
- The bluewater footprint was calculated as the sum of the evaporation and Run Off Mine (ROM) less 10% which was allocated to the greenwater component.
- The greenwater footprint was estimated as 10% of the evaporation value. An alternative way of estimating the greenwater footprint could also have been estimated by multiplying the annual rainfall in the area (700 mm) with the total area of the Matla Colliery (1.04 km^2) and assuming that 10% of that rainfall is intercepted by the mine. This value has also been presented in Table 22.

The following assumptions will be made when conducting the water footprint study for the facility:

- The water footprint study can be assumed as a proxy for the water footprint for Company P.
- The data received for the summer, winter and shut down months represented the water footprint for those periods.
- In the absence of data for the mining activities, the water consumption was estimated using values from Wassung, 2012 and the water footprints calculated using data from Matla Colliery.

- The greenwater footprint was calculated using the mean daily rainfall multiplied by the total area of the facility. This value was then multiplied by 10%, which was assumed to be the intercepted rain water.
- The greywater footprint was calculated on the basis of the sulphate and TDS concentrations.
- The greywater footprint associated with acid rain in the area has been excluded from this study due to lack of information.
- A standard percentage in the loss of water through evaporations from the cooling towers in each business unit has estimated from the data given.
- The potable water used for reservoir 2 and firewater was assumed to be the lost return flow as it does not return to the catchment from which it has been abstracted within the same time period.
- For the bluewater footprint, 20% the water were assumed to be "incorporated" into the product.
- Water consumed from the cooling towers is water that is evaporated, water that has been drawn off and water that is lost through windage. These values were calculated using the standard mass balance for a wet cooling tower together with the available data.
- An average rate of evaporation for the different periods was estimated from online data.

9.4 Water Footprint accounting and interpretation

9.4.1 Upstream

Coal is used at the facility, however, only for the purposes of steam and electricity generation. The extraction and processing of coal has a direct green-, blue- and greywater footprints associated with it. In the absence of data, the water footprint of a typical coal mine was used to estimate the green-, blue- and greywater footprint for the coal mining at Company P based on actual coal consumption. The mine selected as the Matla Colliery as it forms part of the overall project that looks at the water footprint of a power generation facility.

Water Footprint of a typical coal mine

Presented here are the calculations made for estimating the Water Footprint of a typical coal mine. Due to the limited data available, data for the Matla Colliery has been used. It should be noted that Matla Colliery feeds into the Olifants Catchment and not the Vaal catchment, where Company P is located.

Company P utilised 4350 tons/day, 5300 tons/day and 5600 tons/day of coal during the summer, winter and shut down period respectively. Presented in Figure 78 is the daily total water footprint component for Company P. The grey footprint dominants the upstream coal mining process. This is expected as many of South Africa water quality problems stem from the mining industry.

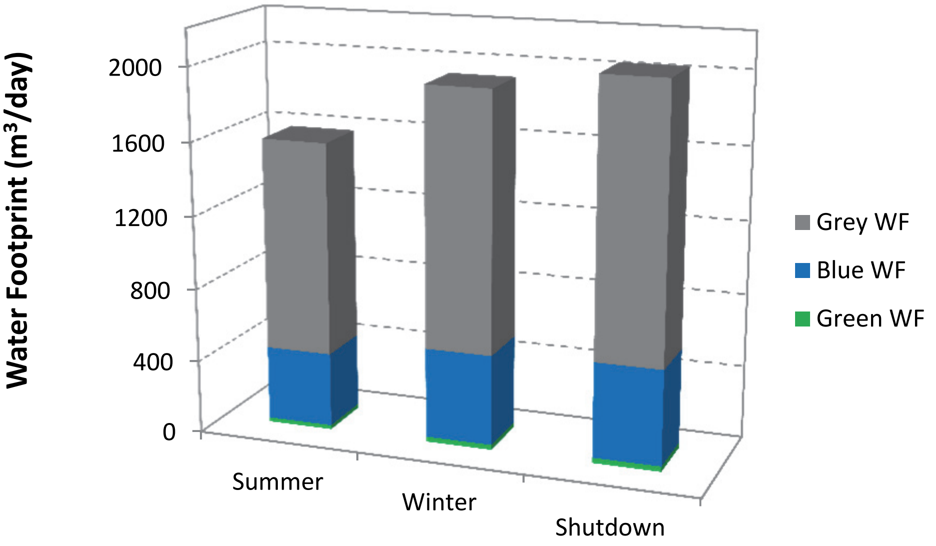

Figure 78: Daily water footprint data for Company P

Figure 79 shows that the greywater footprint accounts for 73% of the total water footprint of the coal mine. The blue- and greenwater footprints accounts for 26% and 1% respectively.

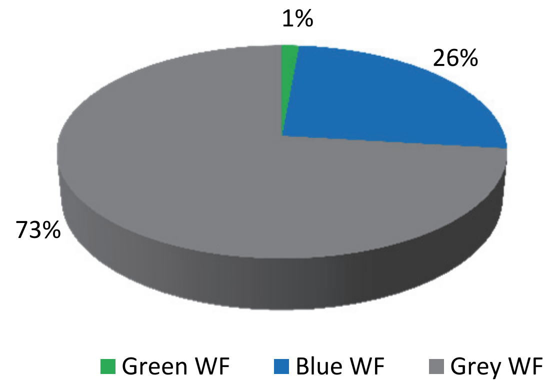

Figure 79: Breakdown of water footprint components for the coal mining at Company P

9.4.2 Operational Water Footprint

Water Footprint: Green

The greenwater footprint is linked to rainfall patterns in the Vaal facility area. During the summer and shutdown periods (January and March), the rainfall is higher than that of the winter period (July), therefore the resulting footprint is expected as the green footprint has been estimated from the total rainfall in the area. In summer and shutdown periods, the greenwater footprint sits at 9217 m^3/day and 13339 m^3/day whereas the greenwater footprint in winter sits at 1125 m^3/day. It should also be noted that during the winter period, there was only one day of rain, unlike the summer and shutdown periods where rainfall occurred on 7 and 6 days in that period, respectively.

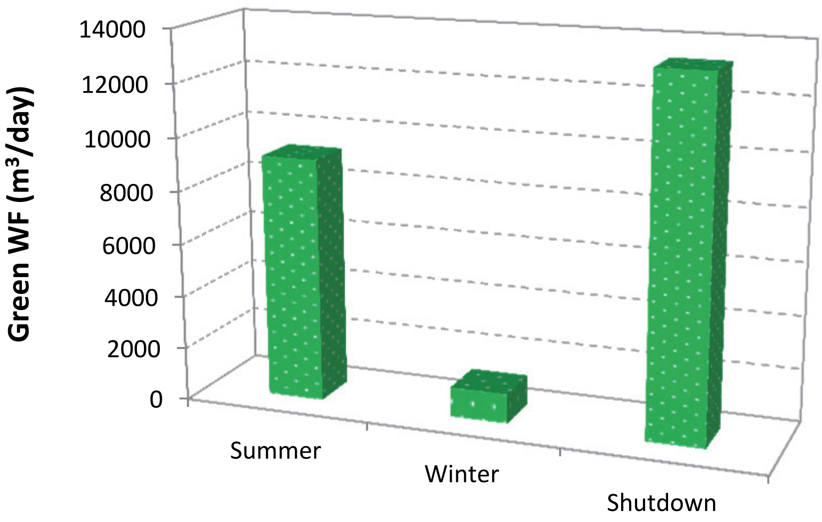

Figure 80: Greenwater footprint for different periods at Company P

Water Footprint: Blue

Aforementioned, the bluewater component is linked to the quantity of surface water that is consumed during the process and is comprised of five components as illustrated in Figure 82. The bluewater footprint for the different periods ranges between 20 909 m^3/day and 26 391 m^3/day. There is not much deviation in the bluewater component across the different periods, which is surprising. One would expect a higher bluewater footprint for the summer period, where temperatures are higher and the rate of evaporation is higher as well, however seasonal effects are more pronounced when it comes to water balances of zero liquid effluent systems. The evaporative rates for the summer, winter and shutdown period were 30 mm/month, 20 mm/month and 40 mm/month respectively.

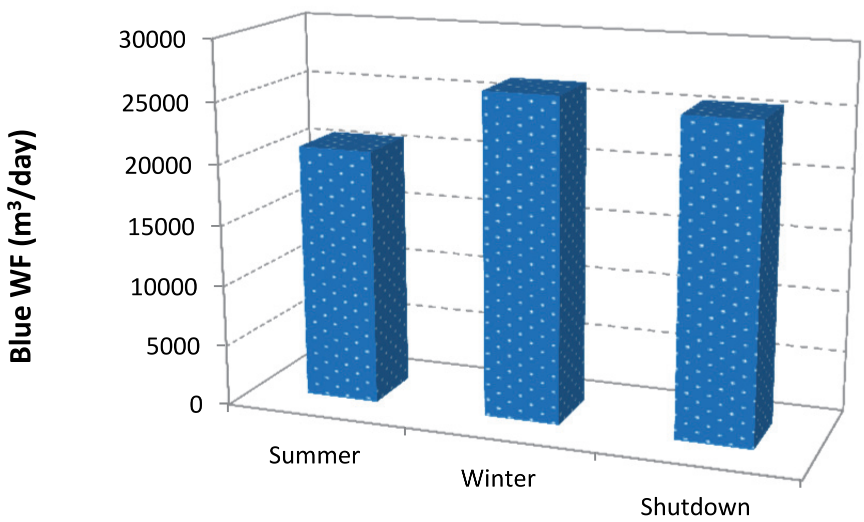

Figure 81: Bluewater footprint for different periods at Company P

Aforementioned, Figure 82 gives the components that were used to calculate the overall operational bluewater footprint for the facility. The major contributor to the bluewater footprint is the water lost through the evaporation from the cooling towers which ranges from 40% to 53%. The next major contributor is water that is incorporated into the products which range from 23% to 27%. It should be noted that the second major contributor for the winter period is the contribution of the lost return flow. An understanding of the facility's production and the products manufacturing these periods will assist in understanding the difference in contributions of these five components. The smallest contributors are the water used in the generation of electricity and the water lost through evaporation from the reservoirs.

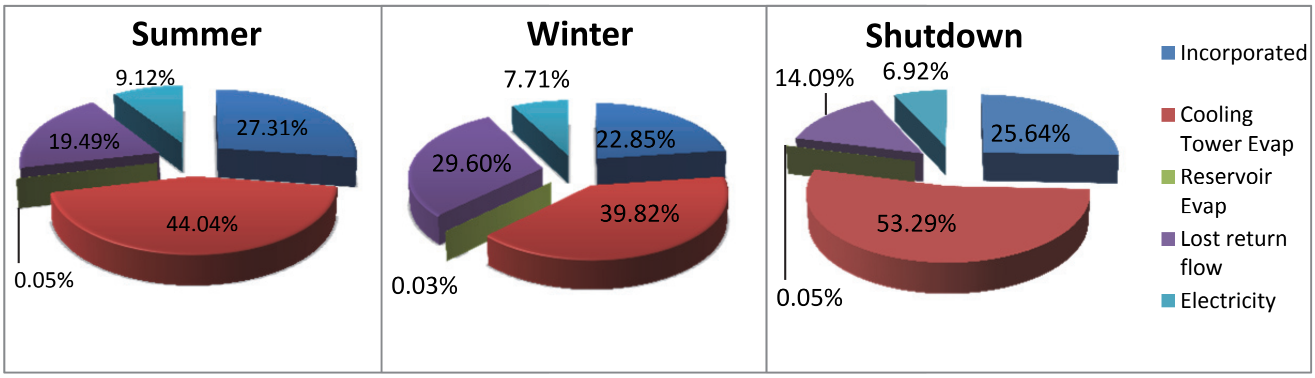

Figure 82: Typical components for the bluewater footprint

Water Footprint: Grey

The operational greywater footprint for Company P's final effluent discharge was calculated using both sulphate and Total Dissolved Solids (TDS) as the constituent, both pose major quality concerns in the Vaal catchment. The maximum concentrations for sulphate and TDS used in the calculations were 155 mg/L and 450 mg/L respectively. The water footprint based on sulphate ranges from 51 200 m^3/day to 95 940 m^3/day whereas the TDS grey footprint ranges from 85 290 m^3/day to 99 180 m^3/day. Both these constituents are significant.

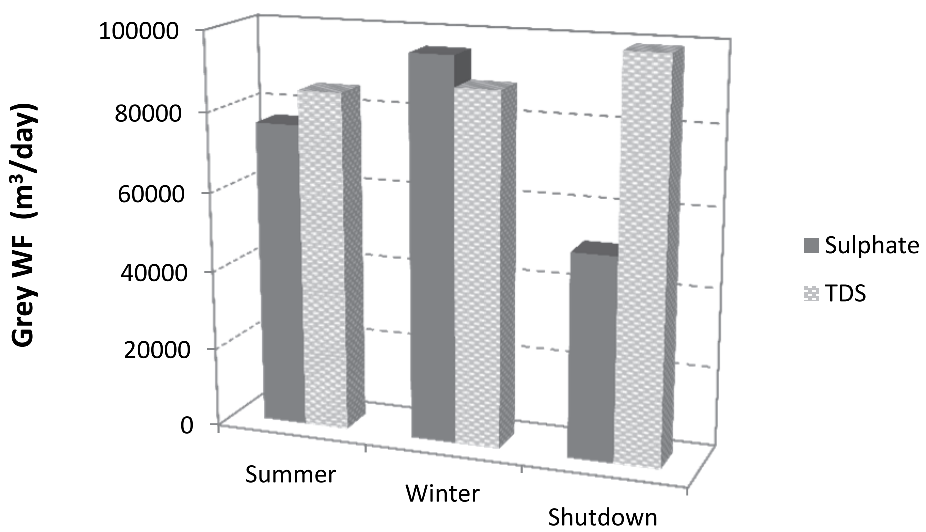

Figure 83: Greywater footprint for different periods at Company P

9.4.3 Comparison of upstream and operational water footprints

A comparison of the operational water footprint components reveals that the greywater is the dominant contributor to Company P's water footprint for both the upstream and operations accounting for approximately 70% of the overall water footprint.

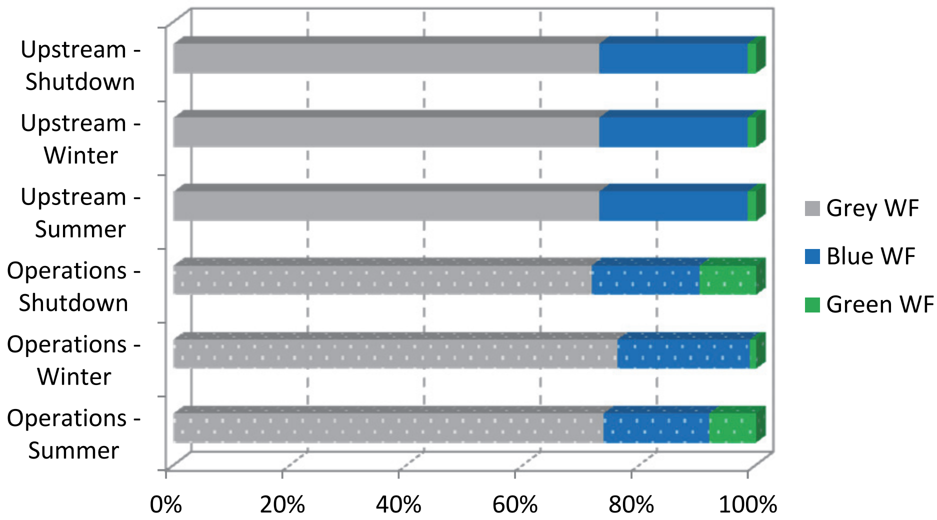

Figure 84: Summary of blue- and greywater footprints for the summer, winter and shutdown periods

There is a higher contribution of the bluewater footprint for the upstream water footprint than the operations, whereas the greenwater footprint is larger for the operations. This is due to the surface area used in the greenwater footprint calculations. For the operations greenwater footprint, the area of the town of Company P was used due to the facility treating not only the plants effluent streams but the surrounding communities as well, whereas for the upstream greenwater footprint, only the surface area of the mining area was used, therefore, the greenwater footprint is directly related to the surface area used in the calculations and must therefore be considered as an indicative value.

9.4.4 Downstream Water Footprint

The water footprints associated with the delivery, transport and use of the products, generated by Company P, fall outside the scope of this work. It should be noted that steam and water are also products sold by Company P to outside businesses. This would account for the high bluewater footprints calculated in the operational phase. It can be argued that the water or steam sold off to outside companies should be removed from the facility water footprint; however, the facility is still responsible for water usage in its production. It should be noted that the water footprint uses are similar to those of the previous chapter.

9.5 Key Summary Points

9.5.1 Greenwater footprint: Interception of rain

Traditionally, the greenwater footprint has largely been the focus of the agricultural sector in assessing its water risk, in that this assessment methodology has not been applied by the industrial sector. However, this report re-examines the definition of the greenwater footprint and looks to apply it to the industrial sector.

In this study, the greenwater footprint was defined as the rainwater that does not run off or reach the ground water, but is instead intercepted, collected and stored in reservoirs, evaporation ponds, dams, etc. that may be present at an industrial site. This natural path of the rain water has been altered and evaporated and is thus "consumed".

In comparison to the blue- and greywater footprints, the greenwater footprints values that were calculated account for less than 10% for the operational footprint and 1% for the upstream footprint. The large difference in these values is attributed to the surface areas used in the calculations. The assumptions made here are a first estimate and these values should be interrogated further. It would be useful for Company P to understand its full water footprint, not just water entering and exiting the facility in the traditional routes. Furthermore, the greenwater footprint is closely linked to rainfall patterns. Climate change will have an impact on these rainfall patterns and this should be monitored carefully.

9.5.2 Greywater footprint: Water quality

The greywater footprint looks at the water that would be required to assimilate the added pollutant load in effluent streams to acceptable concentrations. The calculation thus requires the abstraction and effluent water volumes, and the concentration of pollutants in these streams. The pollutant which requires the highest level of dilution determines the greywater footprint because if this pollutant is assimilated, all others requiring less dilution would have been assimilated as well. In the case for Company P's facility, TDS was the major constituent. The greywater footprint does not add together or average the greywater footprint from different contaminants.

Unlike the blue- and greenwater footprints, the greywater footprint does not look at volume of water consumed. It looks at the quality of water being impacted on by a process. In the case of the mining and chemical industries, the production of large volumes of concentrated waste gives rise to large greywater footprints.

The greywater footprint is not intended to provide a detailed description or sufficient information to inform a response to water quality issues. For corporates, the greywater representation of water quality thus loses critical information. Initial concerns which arise from this study regarding the greywater footprint are:

- It does not distinguish between different types of pollutants, or identify the nature of the pollutant in the greywater representation. For example, most greywater footprinting is determined by total dissolved solids even though they may be less of a concern in practice than other contaminants such as phosphates, and in some regions salinity. Therefore, the greywater footprint loses valuable information if the water footprint is not linked to the resource to which the effluent is being discharged to.

- It does not recognise where water quality may be improved for certain contaminants through treatment. The greywater footprint loses any improvements to water quality by looking only at the contaminant requiring the largest volume of water for assimilation.

In the case of Company P, the two components looked at were sulphate and TDS, both have significant impact on an already deteriorated water resource. It should be noted that even though the contribution of acid rain was excluded in this study, the impacts of acid rain on local water resources should also be understood and monitored.

Here one also needs to perhaps consider the historical context of this facility, which was designed early 1950s as a once through system with effluent discharge. Such a design will clearly have a large grey footprint but that grey footprint also needs to be compared to the Vaal in some way.

9.5.3 Allocation of the green-, grey- and bluewater footprints between the upstream and operations

The allocation of the water footprint components show that there is a significant greywater footprint (73%) upstream, due to the effluent generated from coal mining whereas the operational greywater footprint contributes 78% to the total operation footprint.

The bluewater footprint is much less ranging between 15% in the operation to 26% in the upstream. The greenwater footprint ranges from 0.8% in the operations to 1% in the upstream and from 1 to 10% in the operations.

Knowing the allocation of the water footprint between the upstream and operations is useful to determine where potential water risks lie, i.e. within the factory boundaries or outside. This is particularly useful for larger companies with diverse activities and varied supply chains.

9.5.4 Water risk

The quality of South Africa's water sources have deteriorated drastically over the past decades. Many chemical and manufacturing industries that include an extractive process in their supply chain contribute significantly to the overall greywater footprint of South Africa. It therefore becomes important for industries to understand the impacts their processes have on the water quality and the risk this poses to themselves and their surroundings. If a company has a large water footprint in an area that has an abundance of water and little threat to the catchment, the risk is low compared to the same company in a threatened catchment.

The water footprint assessment manual talks to industries achieving a "zero blue WF" and a "zero grey WF" and challenges industries to stop discharging chemical loads to surface waters. There are numerous measure and regulations in place to try to remedy the destruction caused by pollution. The Department of Water and Sanitation is also taking a strong stance with the introduction of the Waste Discharge Charge System which is aimed at cleaning up those catchments which are severely threatened. The Vaal catchment, where Company P abstracts and discharges water, is one of those severely threatened catchments.

9.5.5 By-products: attribution and issue of water as the by-product

There were some interesting questions that were raised during this study, mainly surrounding the issue of attribution and whether the producing company should bear the water footprint of the by-products that are sold to other companies. Another interesting issue is that Company P provides surrounding industries with utilities such as electricity and steam. The question again rises as to whether the water footprints associated with these items be considered as part of Company P's water footprint or the purchasing companies. Company P also treats effluent from the surrounding communities and industries. Should this affect the overall water footprint? The best way to answer this question is by defining the scope and boundary for the water footprint upfront. This is further explained below.

9.5.6 Drawing up boundaries for a complex process

The water footprint is entirely dependent on where the boundary is drawn, the level of detail included and the availability of information. Ring-fenced data does provide a good estimate, as with the results shown above, and as mentioned before, it would be more interesting and definitely more useful to Company P to understand the individual water footprints of the business units and the products produced.

The boundary of the water footprint also clarifies some of the issues raised above regarding the attribution, water as a product and the sale of by-products.

9.5.7 Effect of change of season on the water footprint

With changing seasons comes change in rainfall patterns. South Africa is a semi-arid country with seasonal rainfall patterns that is becoming increasingly difficult to predict due to the impact of climate change. This poses a great risk to any industry that relies on a constant supply of water from the countries water resources. This could have great implications on the blue- and greywater footprints.

Companies with large bluewater footprints run the risk of being shamed or fined, should water restrictions be put into place in order to protect the resource. The greywater footprint will be impacted from the point of view that if there is less water in the resource then there will be little dilution of the pollutants due to little or no rainfall and stricter discharge limits may be implemented to compensate for the lack of rainfall. This implies that companies will either have to step up their water management practices or be charged through the Waste Discharge Charge System.

9.5.8 Carbon-water trade-offs

One of the tools that had been established from the climate change debate was carbon footprinting. Until now, carbon footprints have been well established and well accepted. Even though water footprint was established around the same time, the concept of water footprints is still in its infancy. The carbon and water footprints should be used. In the energy sector there is a link between the carbon-water trade-off – saving water, requires energy, so an inverse effect is seen. It is crucial to find the best operating practice that is both economically and environmentally sound. The lesson here for Company P is that in its drive to be more water efficient, more energy is required to do so and a compromise between the two needs to be established.

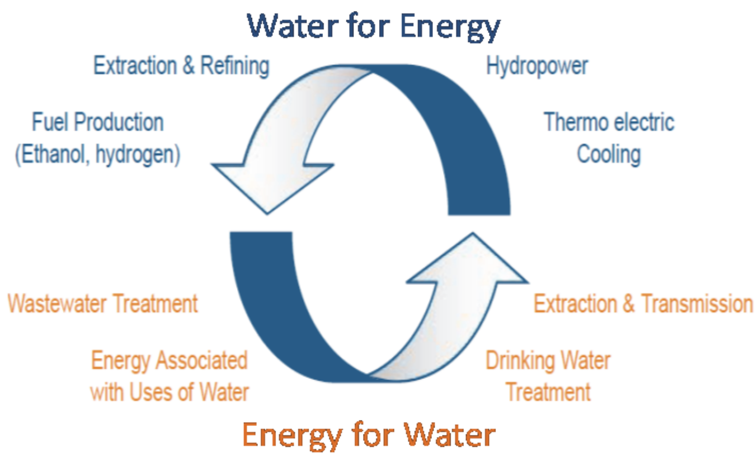

Figure 85: Water-Energy Nexus

9.5.9 Water Footprinting for Company P

The uptake of water footprint in the industrial sector in South Africa is still very limited, partly because of the nature of water use in this sector, which differs from other sectors that have a strong link to agricultural supply chains, where water footprint tools have been pioneered. It was for this reason that the Water Research Commission (WRC) initiated this project to explore the potential of adapting water footprint assessment for the industrial sector in South Africa.

A water footprint is useful due to its distinction between green- and bluewater use. To mitigate bluewater impacts and associated risks, companies might improve their water use efficiency or engage with affected parties to improve their access to water services. Therefore internal efficiencies will become the primary focus. For companies, like Company P, that have large diversified supply chains, understanding the water footprint in the companies supply chain will also aid with supply chain efficiencies.

The potential reputational risk being faced by a company may also be informed through the use of water footprinting. Depending on the nature of the business, the relative water consumption of the company at a specific site may help understand the relative water importance of the enterprise, and therefore the resultant importance in the catchment. This may be important in terms of the company reputation as a high water user/polluter. WF studies have helped companies be accountable to (and receive feedback from) key stakeholders, as well as help build a good reputation relating to water transparency and responsible water practices. By Company P reporting on its high level water footprint, it encourages other corporates to start doing the same and could empower the sector to move towards self-regulation.

10. CRITIQUE AND KEY LEARNINGS OF WATER FOOTPRINTING

Water footprint assessments have been carried out in South Africa for several years and this project has also presented some case studies. As a result there is a lot of experience and knowledge that has been gained from this assessment. This report will try to capture some of these key learnings and insight to enrich this guide. Some of the issues that will be highlighted include:

- Generic challenges shortfalls in approach that are likely to hinder effective water footprint assessment;
    - Specific contextual issues that need to be taken into consideration when assessing water footprint in South Africa (e.g. interbasin transfers in relation to sustainability assessment etc.)

Water footprint assessments have rapidly evolved, with several companies and countries having undertaken water footprint assessment. In South Africa, it's mostly large companies with global links that have undertaken water footprint assessment. This could be attributed to the fact that there are still many issues that act as a barrier to the effective uptake of water footprint in South Africa. Some the challenges are related to the following issues broadly:

10.1 Institutional, regulatory and policy implications

- The South African water policy does not include the water footprint assessment and its potential for use by large water users. This lack of clarity in the policy framework has created uncertainties in how business should interpret the results of water footprint assessments and its implications on their water use.
- Water footprint assessment methodology places a lot of emphasis on the hydrological aspect, which is a hindrance to effective integration into policy. This is because water footprint assessments are very complex and they are more effective in being used as a metaphor than a metric. There is a need to incorporate economic and ecological aspects of water footprint, to move into a more holistic goal of sustainable development.
- There are different players in the water footprint field, which complicates the issues because of differences in methodological approach (ISO vs WFN). There is need to develop closer alignment of the different initiatives being implemented and align with global processes.
- In many cases there are no clear regulatory framework for disclosure and the reporting of water footprint assessment outcomes, In addition there is no clarity on the application of water footprint tools, for example a company that has undertaken an operational water footprint might report this as their sole water footprint, even though it does not include their supply chains. Due to the disparity in the application of the water footprint concept, there is a need to agree on an industry wide approach on the application of water footprint approaches. This is partly linked to the fact that some elements of the water footprint such as greenwater are not applicable to some sectors, especially those with no links to

agricultural supply chains. For example, for the industrial sector, grey- and bluewater footprints are more pertinent than bluewater footprints

- Water footprint is a very attractive concept, but it needs to be understood within a specific context. For example labeling of goods and services based on their water footprint can be misleading, because it does not give the full picture.
- Related to water use, companies need to specifically relate their water use efficiency in their annual report. The argument here is that water is at the core of the economy and sustainability, and the private sector particularly large water users have a massive impact on this precise resource. By pushing large water users to be transparent a culture of responsible water use will be fostered.
- There is a need to mainstream water footprint assessments as water resource management tool to enable ease of their application. This is specifically related to the ease of accessing data that is required for water footprint sustainability assessment, which is mostly held by the biodiversity conservation sector. However due to the fact that water footprint has still not been mainstreamed effectively as a management tool, this information is not readily available for application in water footprint assessments.
- Water footprint tools are more suitable as a metaphor than a metric
- There is a need to push for voluntary disclosure by companies on their water use to aid uptake of water footprint as a management tool

10.2 Methodology

- The natural assimilative capacity of the environment is not accounted for in greywater footprint assessments, as result estimates of the greywater footprint are not very accurate in many cases.
- Difficult of greywater assessment is partly attributed to the variation in water quality standards and therefore there is a need to standardize accounting framework for greywater. Furthermore, greywater footprint for extractives is not well developed and needs further investigation.
- It is important to note that the greywater footprint is different to that of the blue and green, both in calculation and cannot simply be equated. The blue- and greenwater footprints represent volume, whereas the greywater footprint represents impact.

10.3 Data and assessment

- Successful application of water footprint tools requires that key decision makers related to water use in the company are involved from the onset. This helps to clarify the purpose of the assessment and to get a high level buy-in from key stakeholders in the company, because outcomes of a water footprint assessment might require a fundamental change in water use by the company.

- Data usage for all stages of the water footprint assessments need to be standardized, to ensure that the same national datasets are used when carrying out water footprint assessment. However, business should not hesitate to undertake a high level assessment if the very fine scale data is not readily availability. The insights gained from such high level assessments are still quite invaluable.
- Water footprint assessments can be very complicated, it is therefore advisable for a company seeking to undertake an assessment to involve expert practitioners to help guide the process to avoid any potential pitfalls.
- Consideration of the contextual issues such as the social, environmental and political dynamics at the point of water use is critical for understanding impact. This is especially pertinent for South Africa, where issues of readdress to water access need to be considered, and the fact that water resources are unevenly distributed, as a result the impact of water abstraction is dependent on when and where the water was abstracted.

10.4 Greenwater: gross versus net

- The issue here is the difference between natural evaporative demand and evaporative demand of a specific crop. For example if the natural evaporation of natural vegetation exceeds that of a crop, does it imply that the crop has a negative evaporative demand (water saver) compared to the natural vegetation? This poses a major challenge in the interpretation of water footprint assessment.

10.5 Impact analysis

- Current methodology for water footprint assessment does not consider the impact of water use in the value chain;
- The local nature of water makes it difficult to effectively understand the impact of water use on local water resources at the watershed level. The use of risk maps so far is the most effective way for assessing where the impact of water use lay in the value chain.
- To effectively understand impact requires the disaggregation of water footprint components. This implies that the interpretation of water footprint is more complex than carbon footprint.

10.6 Weighted water footprint

Weighted water footprint assessments have been proposed to reduce the complexity associated with water footprint assessment, but they have major shortfalls as outline below:

- The use of weighted water footprint was an attempt to reduce and understand this complexity to ensure harmonization across geographic and sectoral boundaries, for effective communication.

- Even though WF assessment approach ensures that the key elements can be disaggregated (e.g. blue, grey, green, direct & indirect), using a weighting approach that produces a single volumetric figure to assess impact on water resources can be misleading;
- Weighted indicators are difficult to predict for non-physical parameters such as socio-economic and political issues, and opportunity cost of water use. As a result weighting can only be undertaken in a qualitative manner, which is subjective.

Overall, it can be concluded that water footprinting is indeed a useful tool that companies can use as a first estimation of their water use and impact. The major pitfall is the lack of consensus on the use and reporting of the water footprint studies. Companies need to be careful on the reporting of water footprints based just on the numbers, especially for areas that are not well understood and even more critical, on misrepresenting the numbers to suit their outcomes.

Furthermore, the study showed the water footprint data and knowledge base for industries is not well developed, and more work is required to gain confidence in the tool. Going forward, a standardised guide on the use of the water footprint and its application needs to be developed. A starting point would be the updated report that will be released later this year by the Water Footprint Network.

11. REFERENCES

Advances in Dry Cooling Deployed at South African Power Stations, S. Lennon, 2011 Summer Seminar

CDP South Africa, 2011. CDP Water Disclosure South Africa Report

CERES 2011. Murky Waters, Corporate Reporting on water risk: A benchmarking study of 100 companies. CERES, Boston, USA.

CSIR (2010) A CSIR perspective on water in South Africa – 2010, (http://www.csir.co.za/nre/docs/CSIR%20Perspective%20on%20Water_2010.PDF, accessed online 25 February 2011).

Daniel, M.A. and Sojamo, S. 2012. From risks to shared value? Corporate strategies in building a global water accounting and disclosure regime. Water Alternatives 5(3): 636-657

DEG and WWF, 2011. Assessing water risk: A practical approach for Financial Institutions. WWF Germany, BerlinUNEP

DWAF (Department of Water Affairs and Forestry) 2004. *National water resource strategy, First edition* (September 2004).

Eberhard, The Future of South African Coal: Market, Investment, and Policy Challenges, Program on Energy and Sustainable Development, Working Paper #100, January 2011

Eskom Annual Report, 2010

Gerbens-Leenes, W. and A.Y. Hoekstra (2011). The water footprint of sweeteners and bio-ethanol, Environmental International.

Hepworth N, Agol D, Von-Lehr S and O'Grady K, 2011. AWS Kenya case study summary report: Exploring the value of water stewardship standards in Africa. Alliance for Water Stewardship/Marks & Spencer/ GIZ.

Hoekstra, A.Y. and A. Chapagain, M. Aldaya and M. Mekonnen (2011a). The Water Footprint Assessment Manual.

IPCC (1999). Penner, J., D. Lister, D. Griggs, D. Dokken and M. McFarland (Eds.). Aviation and the Global Atmosphere. Cambridge University Press, UK.

Jovanovic, N., C. Jarmain, W. de Clercq, T. Vermeulen and M. Fey (2011). Total evaporation estimates from a Renosterveld and dryland whear/fallow surface at the Voelvlei Nature Reserve (South Africa). Water SA 37(4).

Larson, W.M.; Freedman, P.L.; Passinsky, V.; Grubb, E. and Adriaens, P. 2012. Mitigating corporate water risk: Financial market tools and supply management strategies. Water Alternatives 5(3): 582-602

Mekonnen, M.M. and Hoekstra, A.Y. (2011) National water footprint accounts: The green, blue and grey water footprint of production and consumption, Value of Water Research Report Series No. 50, UNESCO-IHE, Delft, the Netherlands. *Available at* http://www.waterfootprint.org/Reports/Report50-NationalWaterFootprints-Vol1.pdf.

Morikawa M, J Morrision, P Gleick, 2007. Corporate reporting on water: A review of eleven global industries. Pacific Institute, Oakland, California.

Morrison J., Schulte P., and Schenk R., 2009. Corporate Water Accounting: An analysis of methods and tools for measuring water use and its impacts. Pacific Institute, ISBN: 978-1-893790-23-0

Matla Air Quality Report

Mucina L, MC Rutherford 2006. The vegetation of South Africa, Lesotho and Swaziland. SANBI, Pretoria.

Nel, D.C., Marais, C. & J.N. Blignaut. 2008. 'Water Neutrality: A first quantitative framework for investing in water in South Africa'. Conservation Letters.

Orr S, Cartwright A, Tickner D (2009). Understanding water risk: A primer on the consequence of water scarcity for government and business. WWF, Gland.
Carbon Disclosure Project (2011). Collective responses to raising water challenges. Carbon Disclosure Project, London, UK.

Porter, M.E. (1985) *Competitive Advantage*, Free Press, New York, 1985.

SABMiller and WWF-UK (2009). Water Footprinting, Identifying & Addressing Water Risks in the Value Chain, *available at http://www.sabmiller.com/files/reports/water_footprinting_report.pdf*.

Schipper, L., C. Saenger and A. Sudardshan (2010). Transport and carbon emissions in the United States: The long term view. Energies 2010(3).

Spedding, L and Rose, A. 2008. Business Risk Management: A sustainable approach. Elsevier, Oxford, UK 9780750681742

The Coca-Cola Company and The Nature Conservancy (2010). Product Water Footprint Assessments, Practical Application in Corporate Water Stewardship.

Vaal South EIA\R30 Scoping phase\Reports\DSR\Draft Scoping Report 140806~final.doc

Wassung, N. (2012) Water Scarcity and Electricity Generation in South Africa: Part 1, Master's Thesis, University of Stellenbosch)

Wixley, T, and Everingham, G. 2010. Corporate Governance, Siber Ink, Tokai, South Africa. 9781920025328Hoekstra & Chapagain, 2008

WRI, 2012. http://www.wri.org/our-work/topics/water/top-supply-chain-facilities-report-water-risk-exposive-using-wri

Coca Cola, 2010. http://assets.coca-colacompany.com/6f/61/43df76c8466d97c073675d1c5f65 /TCCC_TNC_WaterFootprintAssessments.pdf

http://www.theneweconomy.com/energy/south-africas-water-management-faces-tough-future

http://www.dwaf.gov.za/Projects/Vaal/documents/VaalBulkReconStratDec06.pdf

http://www.waterandclimatechange.eu/evaporation/average-monthly-1985-1999

http://www.exxaro.com/content/ops/coal_matla.asp

http://en.wikipedia.org/wiki/Emalahleni_Local_Municipality,_Mpumalanga

http://www.dwaf.gov.za/Projects/Vaal/documents/VaalBulkReconStratDec06.pdf

http://www.eskom.co.za/c/article/730/map-of-eskom-power-stations/

http://www.exxaro.com/content/ops/coal_matla.asp

http://www.theneweconomy.com/energy/south-africas-water-management-faces-tough-future

http://www.waterfootprint.org/downloads/TheWaterFootprintAssessmentManual.pdf