Chapter 2: Literature Study

A summary of the water situation in South Africa is given in paragraph 2.1, followed by a description of the pressing need for effective water management in the power generation sector in paragraph 2.2. Effective management of water in terms of quality is discussed in paragraph 2.3. Water management strategies of South Africa are specified in paragraph 2.4 and examples of comparable international water management frameworks are given in paragraph 2.5. Finally, the similarities and differences between the water management framework of a country with similar water management issues and what a South African framework would entail are discussed in paragraph 2.6.

2.1 Water availability in South Africa

Water is an important and limited natural resource in South Africa. This is evident from the fact that the average rainfall of the country is 492 mm/yr, which is merely half of the world average rainfall of 985 mm/yr, making South Africa a water scarce country (RandWater, 2012). The rainfall is mostly seasonal and unevenly distributed as illustrated in Figure 2.1. This means that water usage targets on power stations are subject to their location.

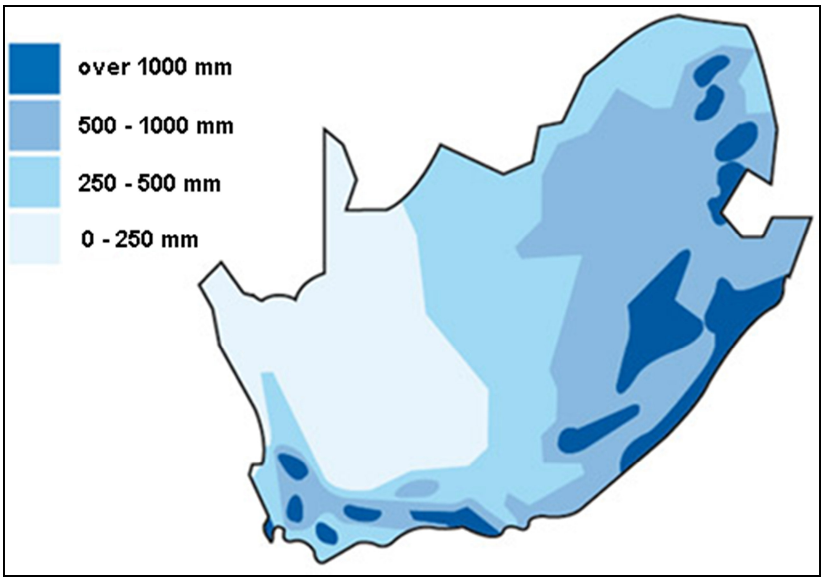

Figure 2.1: Mean Annual Rainfall distribution in South Africa (RandWater, 2012).

It is estimated by the 2030 Water Resource Group (WRG) that the demand for water in South Africa will reach 17,700 million m^3/yr by 2030, with only 15,000 million m^3/yr available if the current trend is followed (WRG, 2009). This poses a serious dilemma since it means that the demand for water will exceed the supply by 18 % in less than 20 years from now. The WRG (2009) stated that the demand for water may increase even beyond these estimations due to the rising development of industries in South Africa and uneven resource distribution. The projected differences between the water supply and demand for 2030 in each of South Africa's nineteen catchment management agencies (CMA) are illustrated in Figure 2.2. These CMAs have been identified to deal with the management of water resources as well as the handling of its stakeholders (Stats SA, 2005). Most of the older Eskom power stations, with wet cooling and ash removal systems, are situated in stressed CMAs like Upper Vaal and Inkomati. This has serious implications on the water availability as well as water quality of the associated CMA.

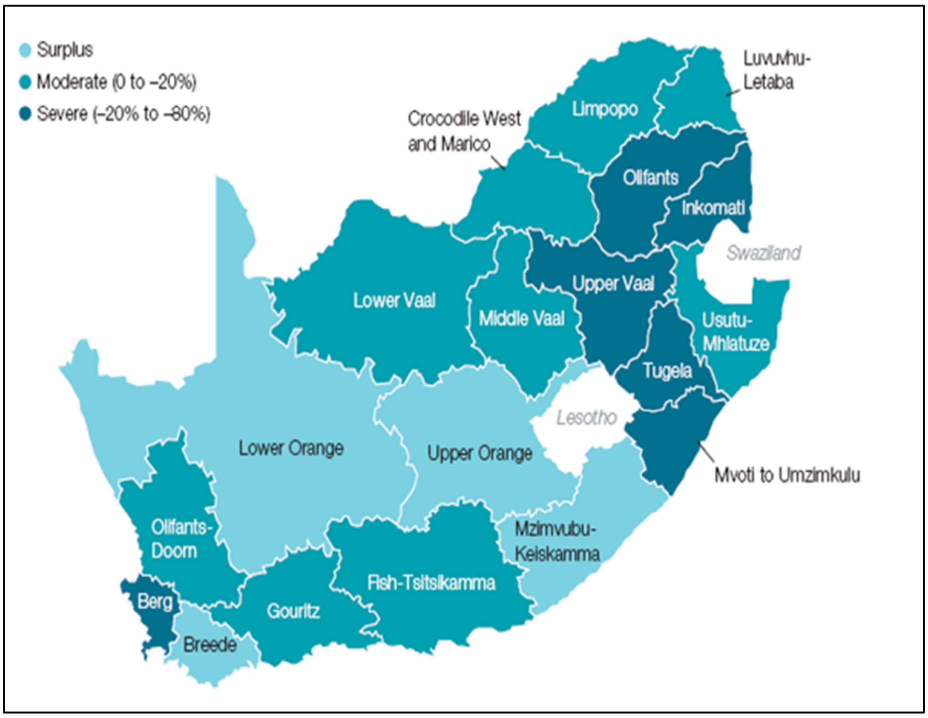

Figure 2.2: The gap between existing supply and projected demand for water in 2030 (Eskom[2], 2012).

Climate change may decrease the amount of water available with a further 1,000 million m^3/yr, significantly increasing the shortage and adding to the already eminent problem of water scarcity. In this context, the Minister of Water Affairs, Edna Molewa, has warned South Africa that serious repercussions would follow in the next ten years if something is not done now. Therefore, an amount of R70 000 million has been assigned towards the improvement of South Africa's water infrastructure, quality management and resource planning for the next three years (DWA, 2012).

The infrastructure of South Africa is developed in such a way that it can support its commercial, mining and electricity generation sectors as well as supply water to most of its urban domestic users (Mwendra *et al*., 2003). All of these sectors, including the power generation sector, must take into account that water supplies are limited. They must always strive towards reducing the amount of water utilised as well as not contributing to the deterioration of water quality.

2.2 Power generation water usage

Water resources are utilised for many different purposes at a power station. These include cooling, production of demineralised and potable water, ash disposal, dust suppression, wet cleaning and regeneration. For functions that are dependent on high quality water, for example demineralised water, the quality of incoming water is critical for efficient system operation. Efficient water usage at a power station is dependent on how well water resources are managed and the methods used to keep water chemistry within the required limits (Eskom, 2004).

As illustrated in Figure 2.3, it is estimated that the power generation sector currently utilises 2 % of South Africa's natural water resources, not taking into account the water consumed as part of the mining process of coal which is mined for power generation purposes. Even though this may seem inconsequential, it amounts to a total of about 320 million m^3/yr making Eskom one of South Africa's single biggest consumers of water (Govender, 2009).

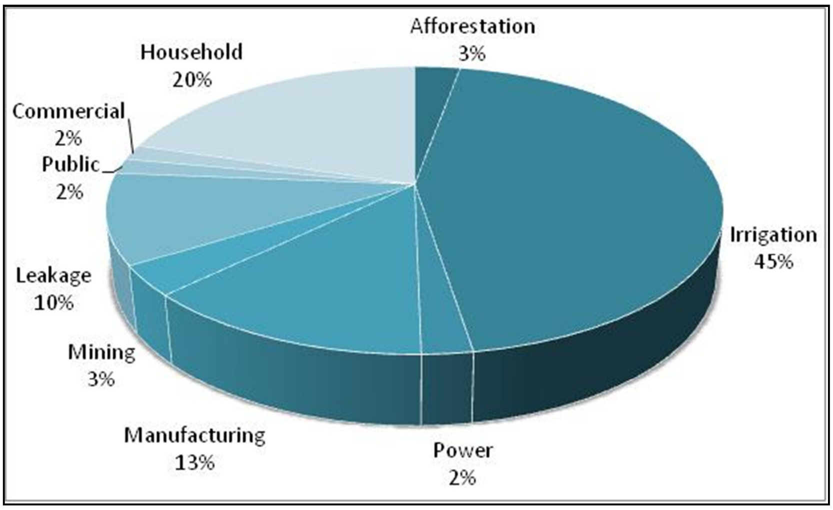

Figure 2.3: Water usage in South Africa (Eskom[2], 2012).

The amount of water consumed by Eskom overall is expressed in terms of litres of water consumed per unit of electricity sent out (ℓ/kWh). This is called its gross water consumption or specific water use indicator. Eskom's specific water use indicator is projected to be 1.35 ℓ/kWh and previous indicators are illustrated in Figure 2.4.

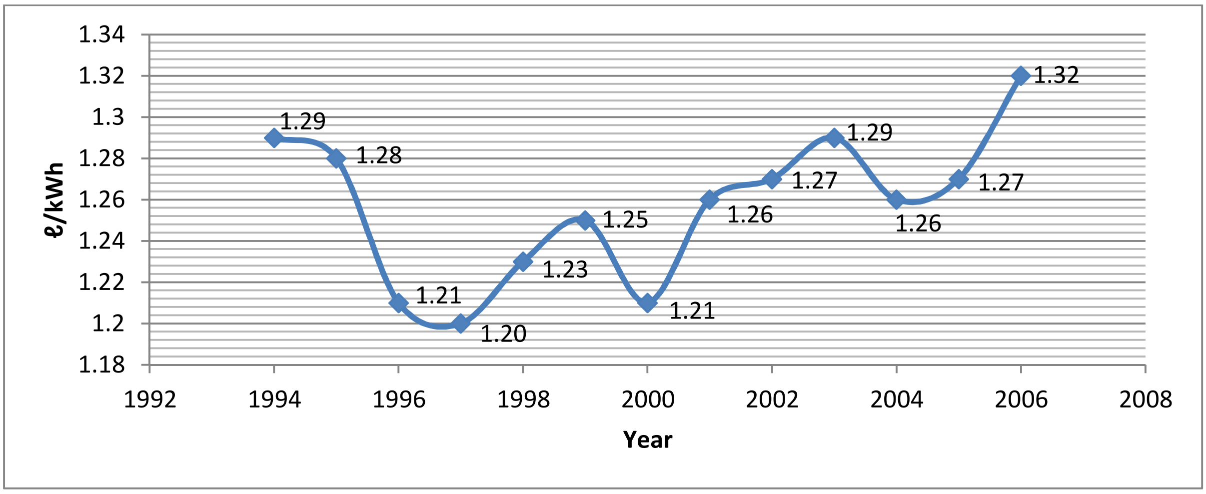

Figure 2.4: Eskom's specific water use indicators for 1994 to 2006 (Eskom[1], 2011).

The Sustainability Index (SI) is used as a benchmark for how much water Eskom is allowed to consume. The SI value is 1.35 ℓ/kWh and the maximum allowed value is 1.40 ℓ/kWh. Currently Eskom is utilising more than 1.35 ℓ/kWh due to the dependency on wet cooled power stations to deliver more power until the new build dry cooled power stations are commissioned (Eskom[1], 2011). Eskom power station water usage is estimated to go down significantly once the older wet cooled power stations are decommissioned as illustrated in Figure 2.5.

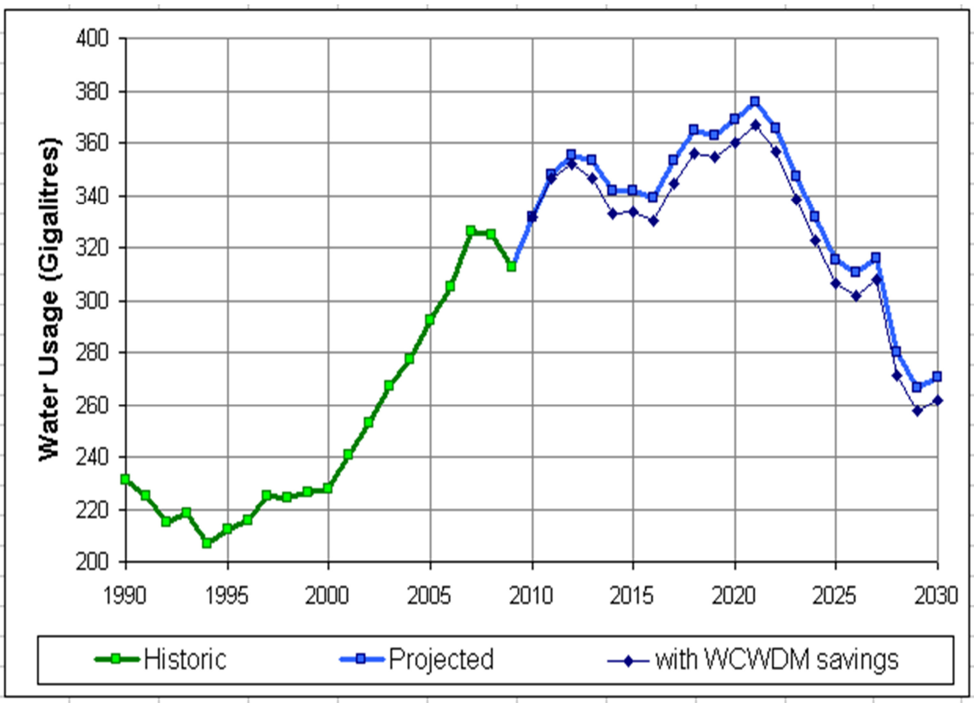

Figure 2.5: Eskom historic and projected future water usage (Eskom[1], 2011).

2.2.1 Fossil fuel power generation

For power generation from conventional pulverised fuel (PF), the present water consumption is projected to be 1.54 ℓ/kWh (Fischer, 2012). According to Choeu (2011), South Africa currently has 37,698 MW of coal fired power installed and another 9,600 MW of coal fired power planned for the near future at Medupi and Kusile power stations. The newer dry cooled power stations have a water consumption of 0.161 ℓ/kWh, which is dramatically better since this means that dry cooled power stations consume only 10.5 % of the amount of water wet cooled power stations consume. This reduction in water usage only causes a small loss in efficiency, but it has other implications like higher capital and maintenance costs that must also be taken into consideration. Eskom has chosen to pay a higher price in terms of capital cost and maintenance to be able to add power to the grid without putting strain on South Africa's natural water resources.

The total estimated water usage for power generated from coal in South Africa from 1989 to 2003 is illustrated in Figure 2.6.

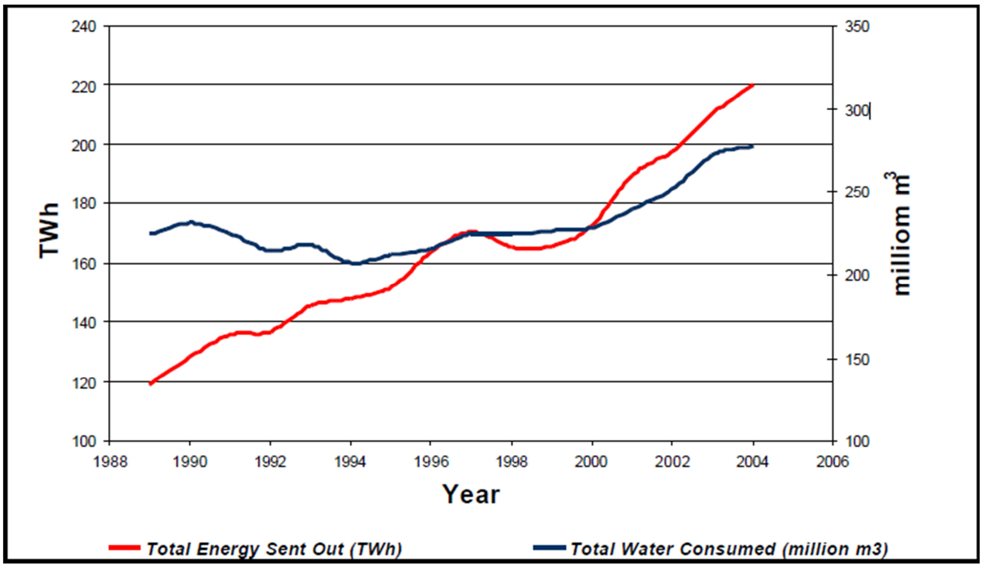

Figure 2.6: Eskom water use compared to energy produced (WBCSD, 2007).

From Figure 2.6 it can be seen that water consumption relative to power generated decreased from 1990 when awareness of water scarcity was first raised within Eskom. This is good, since the increase in power demand with time is inevitable. Nevertheless, the demand has increased significantly since 2000 and more efforts are necessary to prevent future water unavailability. The further deployment of low water consumption power generation technologies is of critical importance if the power generation sector chooses to be a leader in water conservation.

Recent statistics on the consumption of water for coal fired power stations are illustrated in Figure 2.7.

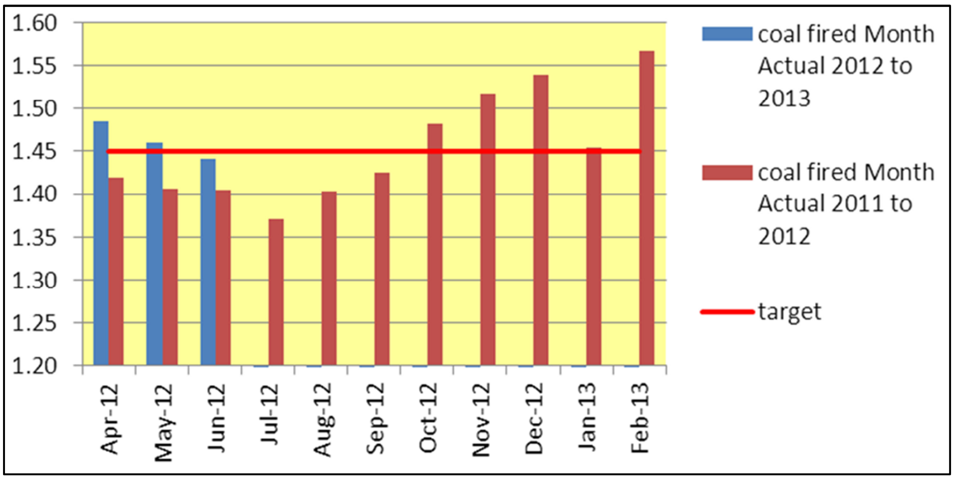

Figure 2.7: Coal fired power stations water performance 2012/13 (Eskom[2], 2012).

From Figure 2.7 it can be seen that the water usage of Eskom for the 2012/2013 financial year is significantly higher than the water usage of the 2011/2012 financial year. This may be ascribed to the focus on increased power generation due to the pressure on the grid with the electricity supply being just enough to satisfy the demand. This focus on increased power generation has conflicting priorities as a result. Wet cooled power stations still in operation are forced to generate more power, which in turn results in more water being consumed, and therefore difficulty to reduce water consumption. Also, power station scheduled outages have been postponed often over the past few years, resulting in more failures and higher water consumption as the power stations age.

Eskom has three fully operational power stations that make use of dry cooling methods. These power stations are Kendal, Matimba and Majuba which in total deliver 10,000 MW dry cooled power to the national grid. The new build power stations Medupi and Kusile will also make use of dry cooling technologies and together they will add 9,500 MW to the grid. Even though dry cooling technologies are more expensive in terms of operation and maintenance through the lifetime of the plant, it utilises 90 % less water which rationalises the higher operating and maintenance cost when compared to wet cooling technologies. For this reason the long term strategy implemented by Eskom is for all future fossil fuel power stations to be designed as dry cooled. Eskom fossil fuel fired power stations operate in closed cycles to prevent contaminated water from entering natural resources and thereby also reusing water to lower the total consumption (Eskom, 2008).

2.3 Water quality

South Africa is currently facing the predicament of its water quality continuously deteriorating. The quality of water in rivers and dams are drastically deteriorating due to mine and domestic waste as well as ineffective control measures (Ringwood, 2006).

DWA (2002) relates the quality of water to the amount of mineral salts dissolved therein. This can be ascribed to natural processes of soil erosion, but also to human activities like households, agricultural or mining activities. Specifically, mine water drainage is currently in the spotlight due to its acidic nature that causes increased release of minerals into the water (Stats SA, 2005).

2.3.1 Water quality accounting

The bookkeeping of water quality can help with the set-up and development of sustainable water quality control strategies. "If you can't measure it you can't manage it", meaning that regular observation and measuring of water quality is an inseparable part of effective management thereof. The National Water Act No. 36 of 1998 supports this by clearly stating that all water resources in South Africa must be monitored, recorded, evaluated and the results distributed to all stakeholders involved (Stats SA, 2005).

The accounting of water quality entails a thorough description of quality related attributes of a specific water catchment area on regular time intervals. From this data, variations in water quality can be determined and the water quality of different catchment areas can be compared. Quality accounting is an effective means of tracking progress on projects and measures taken to improve water quality (Stats SA, 2005).

2.3.2 Power generation impact on water quality

The power generation sector strives towards not affecting the quality of water negatively by making use of closed water cycles where waste water is reused. The amount of water used at power stations are dependent on how resources are managed and how the water quality is chemically controlled (Eskom, 2004).

Activities that take place on power stations that can impact water quality negatively include the following (Power Scorecard, 2011):

i. ***Water run-off from coal stockpiles:*** When rain water runs down coal on stockyards, metals and other minerals are sent to groundwater.

ii. ***Boiler blowdown:*** Water that contains impurities (metals and chemicals) is purged from boiler systems on regular intervals.
iii. ***Cooling water wastes:*** Cooling water is treated with chemicals to control the pH of cooling water.
iv. ***Thermal pollution:*** Nuclear power stations send water back to its natural source (the oceans) after it has been used by turbine components. This discharge of water at a different temperature can impact the aquatic ecosystem. Higher temperatures may be favoured by some water species, but if the power station is then decommissioned or on outage, the ecosystem may be impacted negatively.
v. ***Leaching from ash repositories:*** Coal ash, a product from coal combustion, is suspended in process water and sent by means of a pipeline to an ash dump. If water levels are not maintained it can result in ponding and thereby compromise the ash porcelinic properties and result in leaching (mobilising) of salts in the long term.

Some initiatives have been launched to utilise mine waste water for cooling water at power stations like Lethabo situated near the New Vaal colliery mine. Here reverse osmosis is used to remove the dissolved salts from the mine water.

2.4 Water management in South Africa

As have been indicated in the previous paragraphs, water management is currently playing a major role in society because of the predicted future water scarcity. The paragraphs that follow focus on the water management strategies in place for Eskom as well as for the Water Institute of South Africa to prevent or reduce the impact of water scarcity.

2.4.1 Eskom and water

As a significant user of water, Eskom has a responsibility towards the protection of South Africa's natural water resources in such a way that all other users' current and future water needs are not negatively affected by their activities. Since Eskom is a strategic water user, the Department of Water Affairs (DWA) guarantees them 99.5 % supply. Therefore, water needs to be viewed as a vital resource that requires efficient planning and accountability from Eskom. A stewardship approach will contribute to high quality water management and dedication to continuous improvement of strategies (Ringwood, 2006).

2.4.1.1 Conflicting priorities

Eskom implements yearly water usage targets and policies for every power station to reduce the amount of water consumed per kWh of electricity sent out. The problem is that only 40 % of power stations are able to reach these targets (Eskom[2], 2012). From personal observations, the author of this dissertation found that the difficulty of reaching water consumption targets may be a result of conflicting priorities.

Due to Eskom's responsibility to South Africa to consistently produce power, and the fact that no new power stations have been commissioned in the last twenty years, the current electricity demand is almost equal to the supply and there is a lot of pressure on power stations to run loads of above normal capacity. This means that power generating units are operated at capacities they are not necessarily designed for and scheduled maintenance on units are often postponed. Postponed maintenance often result in units breaking down unexpectedly, which in turn requires more water to start up again (the closed loop cycle is broken and a lot of water is lost). Also, during a scheduled outage for maintenance on a power generating unit it must be put back on line again as soon as possible, no matter how much water is used for blow-through, start-up and restart-up (when required). This results in efficient water usage on ground floor taking a backseat. In contrast with this, Eskom is making major global commitments to reduce water consumption and make water security a top priority. This commitment was demonstrated by the signing of the UN Global Compact's CEO Water Mandate on 10 February 2011 where Eskom committed to improve water resource management sustainability (Eskom1, 2011).

2.4.1.2 Water management strategies

An Eskom Water Management Task Team (WMTT) has been assigned to develop a plan that could assist power stations to reach the target of 1.32 ℓ/kWh water consumption as well as manage other water related problems. The WMTT will assist power stations to implement this plan on every plant as well as keep track of what level of success is achieved (Eskom[2], 2012).

DWA Vision 2030 has set several goals for Eskom in order to achieve the shared vision that water must be conserved and utilised in such a way that it is available to all users in terms of quantity and quality by 2030. These goals include the following (DWA, 2009):

- A Zero liquid Effluent Discharge (ZLED) philosophy which have already been adopted by most Eskom power stations

- Licencing, in terms of the National Water Act (No. 36 of 1998), of all Eskom facilities for taking water from a water resource, storing water and disposing of waste in such a way that it does not impact water resources negatively.
- ISO 14001 Environmental reporting
- The establishment of mine water recovery initiatives
- Reducing the water demand by means of energy efficiency measures
- Blue drop certification of all Eskom water supply resources and infrastructure
- Recycling and re-use of water
- Improved water management strategies at power stations

2.4.2 Water Institute of Southern Africa

On 27 August 2012, Mrs. Edna Molewa, minister of Water and Environmental Affairs announced the release of the draft of the new National Water Resource Strategy (NWRS-2) to be implemented which *"sets out the strategic direction for water resources management with a particular focus on priorities and objectives for the period 2013 – 2017. It provides the framework for the protection, use, development, conservation, management and control of water resources".* The draft was released for comment to give members of the public a chance to add their voices to the management of water in South Africa. There is immense pressure on the water resources of South Africa and the need exist to manage these resources effectively. With appropriate management, these water resources could be utilised in such a way that it supports a healthy power generation industry as well as a growing population (DWA, 2012).

2.4.2.1 Catchment Management Strategies

Catchment Management Strategies (CMS) are being developed for each of the Catchment Management Agencies (CMA) identified in South Africa. CMSs are documents that entail the statutory vision and actions that need to be taken to rectify the problems identified in terms of water management within each CMA. Development on these issues is dependent on the involvement of stakeholders, consistent updating and fixed strategies for water distribution in terms of the conservation, development, protection, control and management thereof (AWARD, 2011). DWA developed a collection of documents that provide the guidelines on Integrated Water Resource Management (IWRM). According to the National Water Act of 1998, guidelines for the development of CMSs were also required, which was completed by February 2007. These guidelines contain the outline of strategies to be implemented with the purpose of achieving sustainable, equitable and efficient management of the natural water resources in each respective area. Strategies are a means of achieving the goal of adhering to both the policies and requirements related to a project. To enable a strategic and integrated approach towards IWRM, a framework was developed that illustrates the main strategies of water resource management in South Africa. This framework is illustrated in Figure 2.8. The framework for guidance of CMS consists of the following components (Pollard et al., 2007):

A. Foundational information for the Catchment Management Strategy

1. Catchment description
2. Assessment using STEEP criteria (STEEP Forces: Social, Technical, Economic, Ecological and Political Forces)
3. Reconciliation
4. *Vision*

B. Water Resource Management Strategies

5. Resource Directed Measures (RDM)
6. System development charges (SDCs) – tap fees charged to new customers of the water system

C. Facilitating strategies

7. Public Engagement and capacity development
8. Information management and monitoring
9. Finance

D. Integration strategy

10. Institutions and co-operative governance

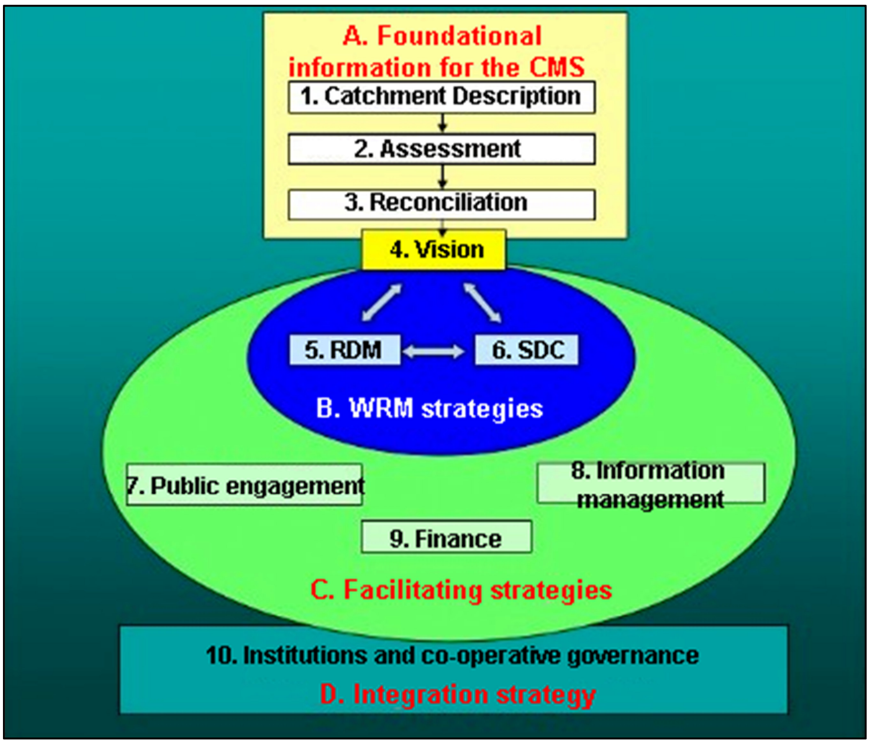

Figure 2.8: A framework for the guidance of CMS (Pollard et al., 2007).

2.4.2.2 Water permits and licensing

Any water utilisation is to be registered according to the National Water Act (No. 36 of 1998). Once registration is finalised, the licensing process can commence. Permits will only be valid until licenses are received. Water licences are valid for 30 years, but they are to be reassessed every five years. Water utilisation for the following practises needs registration (DWA, 2008):

i. Taking water from a water resource;
ii. Storing water;
iii. Hindering or diverting the flow of water from its course;
iv. Actions that may cause a reduction in stream flow;
v. Controlled activities that may have a damaging impact on a water resource;
vi. Discharging waste or water containing waste into a water resource;
vii. Disposing of waste or water containing waste that could potentially have a damaging impact on a water resource;
viii. Disposing of water that has been heated in an industrial or power generation process;
ix. Making changes to the bed, banks, direction or characteristics of a water course;
x. Removing, discharging or disposing of underground water that is necessary for efficient activities or the safety of people;
xi. Using water for recreational purposes.

2.5 Other water management frameworks

The South African water management strategies in place on national level as well as on power generation level can now be compared to the water management framework of a country with similar water scarcity issues, namely Australia, to determine the similarities and differences between their water management frameworks.

2.5.1 An Australian water management framework

Australia has concerns similar to South Africa with regard to their limited water resources, resulting in environmental water management becoming a very important focus area for their country. In response to this concern, the Minerals Council of Australia has developed a water management framework with the objective to *"Manage water as a key business asset with social, cultural, environmental and economic value"* (Ringwood, 2006).

Opportunities for continuous improvement were identified to offer assistance in developing a water strategy for mineral businesses (Ringwood, 2006). The framework given in Figure 2.9 was designed to give a systematic approach for water consumption reporting and sharing of information (AGNWC, 2012).

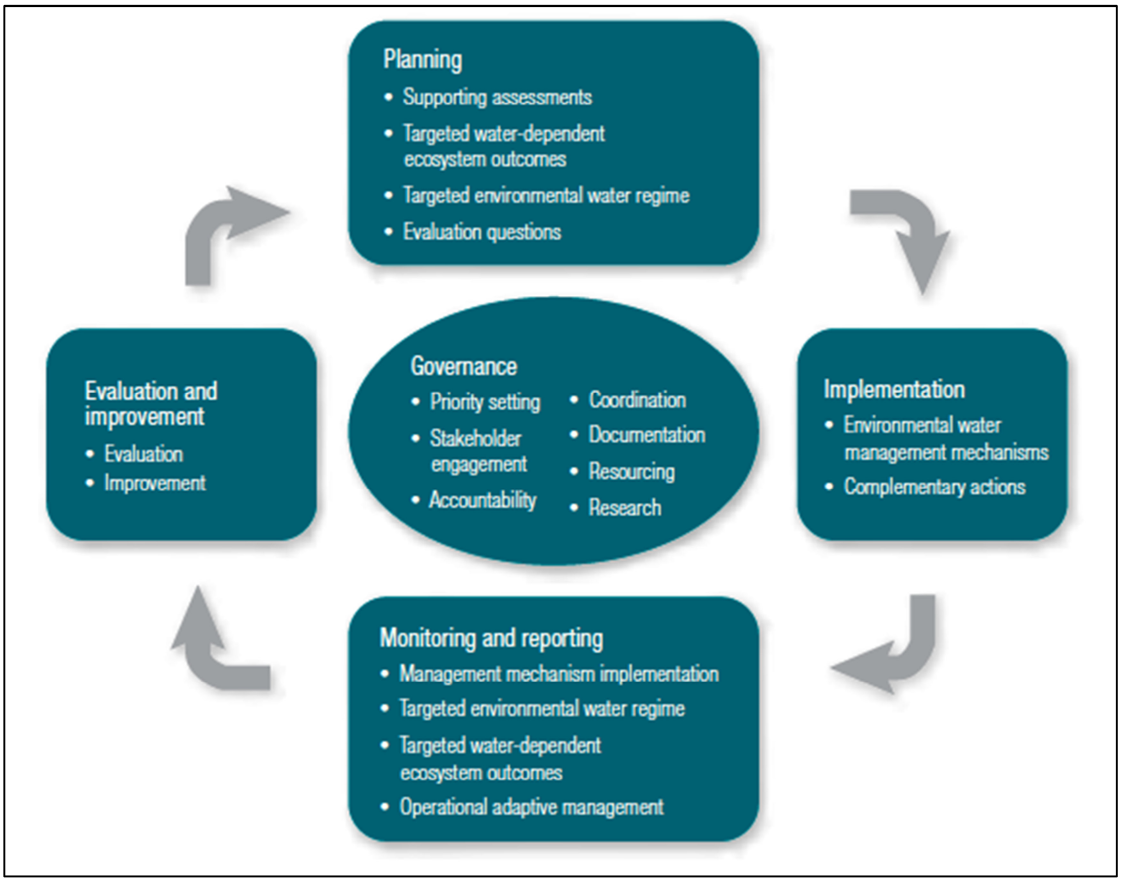

Figure 2.9: A framework that integrates all the main elements of water management (AGNWC, 2012).

Past experiences in Australia have identified the need for a water management framework as the one illustrated in Figure 2.9. This is done to better understand the requirements of water usage and the implementation of legislations and policies to form part of the overall water management objectives. This framework allows for consistent evaluation of water management practices and supplies a foundation for information gathereing and good practice reporting (AGNWC, 2012).

This approach takes into account the following factors (AGNWC, 2012):

- The history of water management in Australia
- Improved transparency and better understanding of water management
- Growing competition for limited water resources
- Water quality protection

- National policy developments
- Effects of climate change
- Social, economic and indigenous water objectives

An agreement has been reached in Australia to have a consistent approach to water management for all rural and urban water usage. Such a plan entails specific water consumption targets and water distribution planning (AGNWC, 2011).

2.5.2 Urban water management

The framework designed as suggestion for better urban water management in Western Australia is illustrated in Figure 2.10.

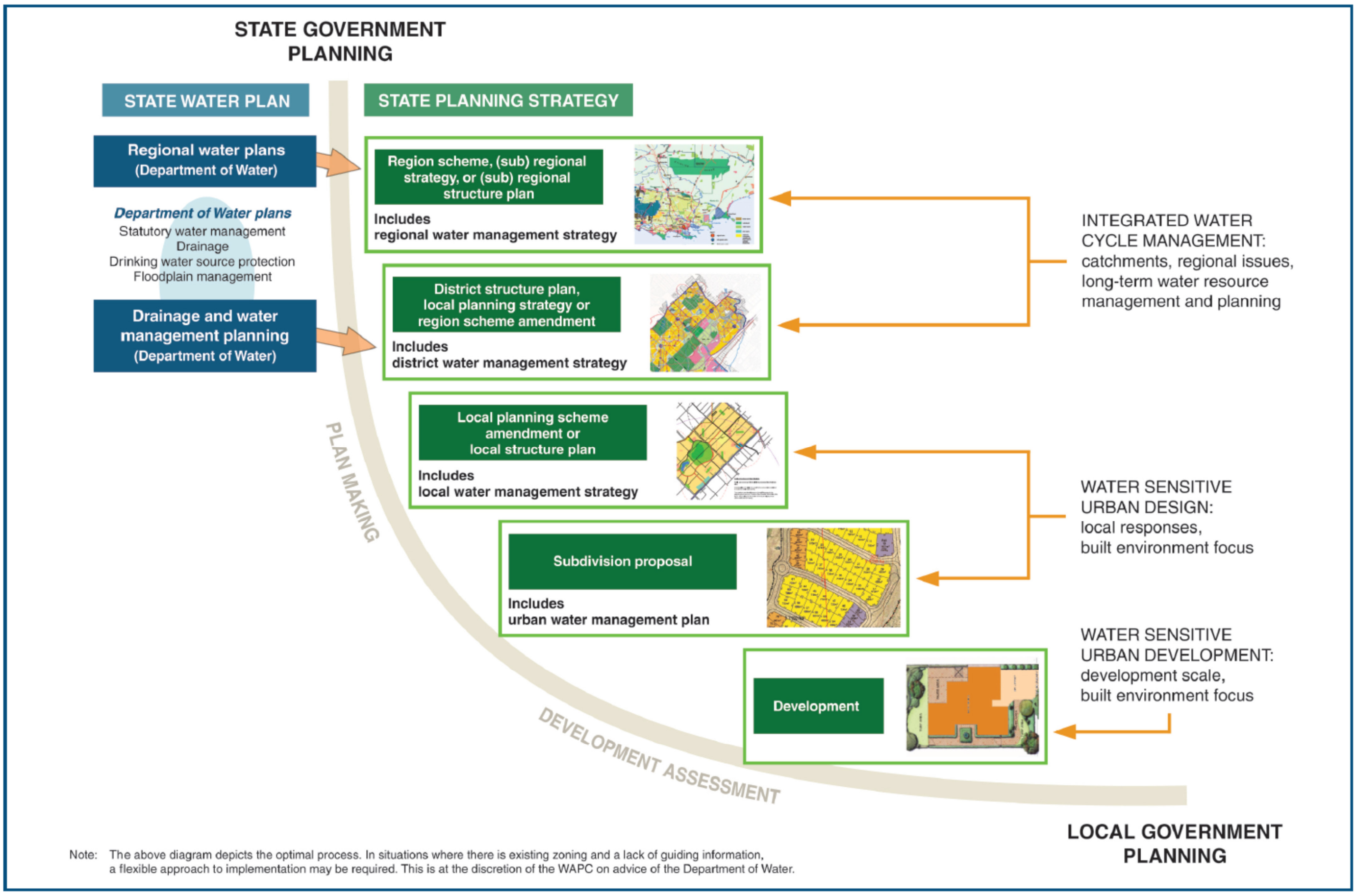

Figure 2.10: Water management framework for urban areas in Australia (WAPC, 2008).

The main planning tools that form part of the framework illustrated in Figure 2.10 are policies, strategies and plans. Policies provide the direction on how the plans should commence by taking into account values, main concerns and anticipated outcomes. Strategies offer a way of implementing the policies and give attention to goals, concepts and values (WAPC, 2008).

2.6 Comparison to the South African water management framework

Important aspects of the Australian water management framework given in paragraph 2.5.1:

- The framework is transparent and takes a comprehensive approach to water management (AGNWC, 2012).
- The framework provides a better understanding towards the requirements for water management (AGNWC, 2012).
- The framework adopts legislation and policy measures for the correct implementation of water management objectives (AGNWC, 2012).
- The framework manages water as a key business asset in terms of social, environmental and economic value (Ringwood, 2006).
- The framework addresses the overall problems of various power stations in a similar approach as to how the urban water management framework addressed state government planning (Alberta, 2008).
- The framework identifies and addresses long term risks and opportunities of improvement (Alberta, 2011).
- The framework formalises and builds upon existing processes as part of the Government's commitment to protect and effectively manage the water resources of South Africa (Alberta, 2011).

These aspects should also form part of the South African water management framework for power generation which is explored in Chapter 3.