Chapter 4: Case study – Lethabo power station

The case study presented in this chapter serves to determine what water management procedures and structures are in place in practice at Eskom Business Unit level, what is the result of such implementation and to identify areas of improvement. From this case study it can be determined where the most critical water management issues lie and what possible solutions to water management problems can be found on business unit level in the context of the water management structure developed in Chapter 3.3. Lethabo serves as an appropriate representative case study since it was observed by the author of this dissertation that Eskom power stations utilise similar business processes and the older power stations face similar implementation problems.

4.1 Background information

Lethabo power station is a fossil fuel power station next to the Vaal River in Northern Free State with an installed capacity of six 618 MW units resulting in a maximum capacity of 3708 MW. The construction of Lethabo started in 1980 after intensive environmental studies were conducted at the site. 350 Hectares of Bluegum trees were removed at the site, which resulted in a significant rise in the underground water table. The soil was levelled and layered with an ash and sand mixture, therefore a sophisticated piling design was required to build all major structures on (Hariram, 2011).

4.1.1 Lethabo power station water usage

Lethabo power station makes use of a wet cooling system where water used to cool turbine exhaust steam is exposed to ambient air at the cooling towers to reduce the temperature before it is circulated back to the condenser. It is estimated that 95 % of water consumed at wet cooled power stations are lost to the atmosphere by means of evaporation. Due to the fact that so much water is evaporated, other water losses in the system may easily be regarded as being trivial to the bigger picture. Lethabo operates on an otherwise closed cycle where all water that is not evaporated is recycled to minimise unnecessary water loss. Lethabo power station consumes around 100 Mℓ of water per day. Therefore the potential socio-economic impact an over-consumption of 5 % presents, in other words 5 Mℓ of water per day, is the equivalent of 5000 households if it is assumed that one household consumes 1 kℓ/day. This amounts to an annual water cost of R2,5 million being wasted. The opposite also holds true, a 5 % reduction in water consumption will result in significant amount of water and money being saved (Lethabo, 2011).

The evaporative cooling water usage at Lethabo power station varies, depending on the ambient air temperature and relative humidity, between 1.7 - 1.9 ℓ/kWh. The target for water consumption is determined annually based on historical data and Eskom water management requirements. For the year 2012 the water target of Lethabo is an average of 1.774 ℓ/kWh. The monthly target varies based on seasonal trends. As illustrated in Figure 4.1, the target for summer 2012 is 1.82 ℓ/kWh. This target was not achieved every day as a result of a lot of water going to the ash dams, low load factor and low rainfall (Wentzel, 2012).

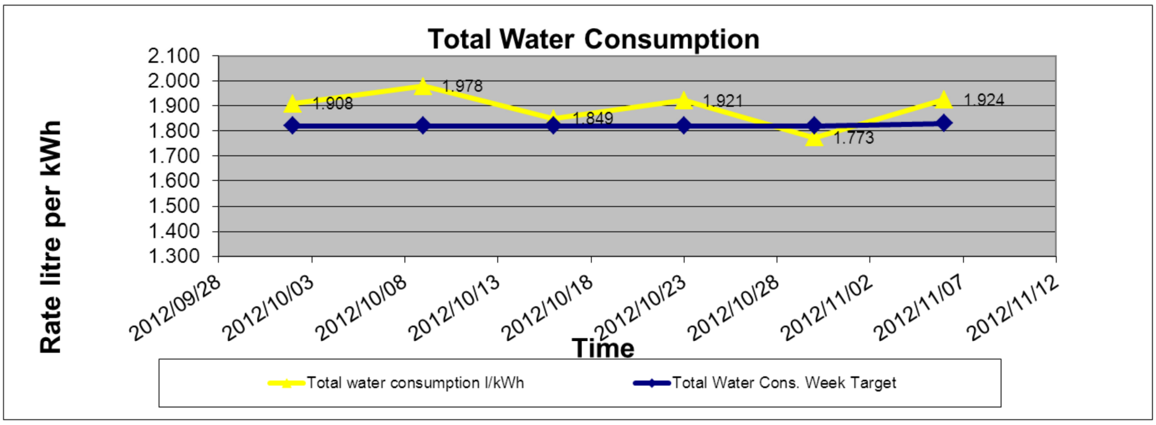

Figure 4.1: Total water consumption between 28 October and 12 November 2012.

In comparison with other wet cooling Eskom power stations, Lethabo's water consumption rate is relatively low as illustrated in Figure 4.2. It can also be observed that older power stations (like Camden, Hendrina and Komati) consume more water due to the systems being more maintenance intensive and less efficient.

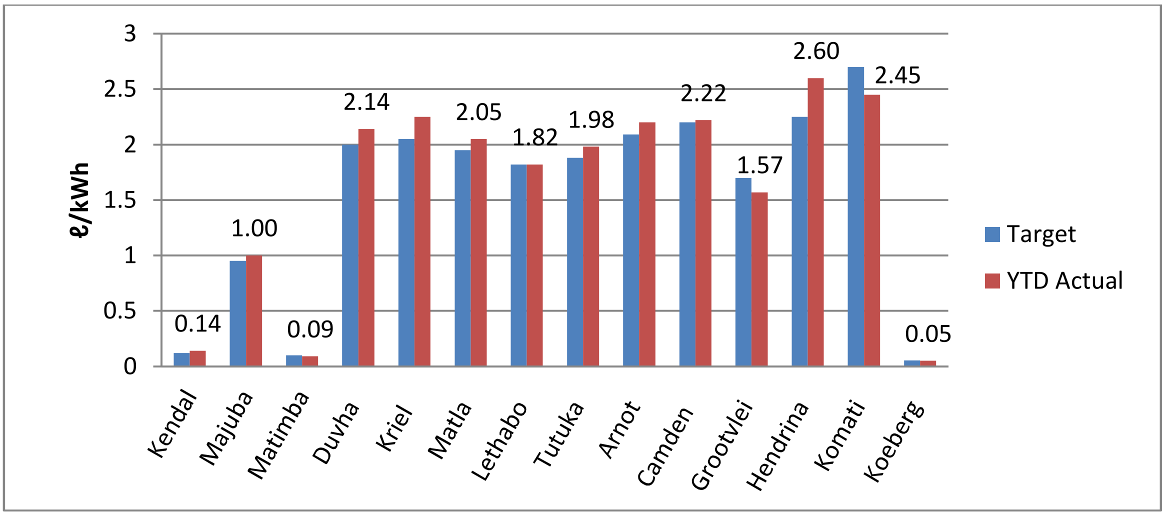

Figure 4.2: Eskom power station water usage for 2011/2012 compared to water usage targets (Eskom[1], 2012).

4.1.2 Environmental management

The raw materials utilised for power generation activities constantly interact with the environment and therefore have certain impacts on water, land and air. All power stations have the responsibility to sustainably manage raw materials. In order to minimise the negative environmental impacts on water at Lethabo, the managers, staff and contractors are committed to (Cloete, 2010):

- Comply with the South African Environmental legislation and regulations in terms of water aspects as well as complying with Eskom environmental policies, guidelines and other requirements.
- Manage water pollution where possible.
- Minimising water effluents by continuously improving the processes and systems on the plant to prevent negative impacts on the environment.
- Utilising natural resources efficiently and continuously investigate ways to optimise.
- Ensuring that all employees and contractors are aware of what impact their activities have on the environment.
- The implementation of effective training and assessment of environmental legislative compliance.
- The implementation of an Environmental Management System that adheres to the requirements of ISO14001.
- Providing a framework for the setting and reviewing of appropriate environmental targets and objectives, e.g. monthly water usage targets.

Environmental management, more specific water management, forms part of Lethabo's overall business strategy. Personnel are all collectively responsible for the performance of the business unit and therefore, each person is required to do their part in the water conservation drive.

4.2 Lethabo water management

Water management at Lethabo power station is done according to the standards, specifications and strategies set by Eskom as illustrated in Chapter 3.3. The key strategic water management strategies at business unit level include the following:

- Compliance to Eskom Environmental Management Policy
- Compliance with water licences
- Continuous water audits & monitoring of water usage
- Power station water balances

Lethabo specific strategies are discussed in the sections that follow.

4.2.1 Lethabo water management structure

The water management structure in place at Lethabo power station is illustrated in Figure 4.3. Here it can be seen that the Power Station Manager (PSM) is overall responsible for water management. The Operating Head of Department (HOD) reports to the PSM, the Water Treatment Plant (WTP) Operating Manager reports to the Operating HOD, and the Senior Technologist reports to the WTP Operating Manager. The Senior Technologist is responsible for identifying potential savings and more efficient practices. He is therefore in charge of the water management sub-committee which does investigations, reporting and giving feedback on why targets are not reached and what can be done to solve problems.

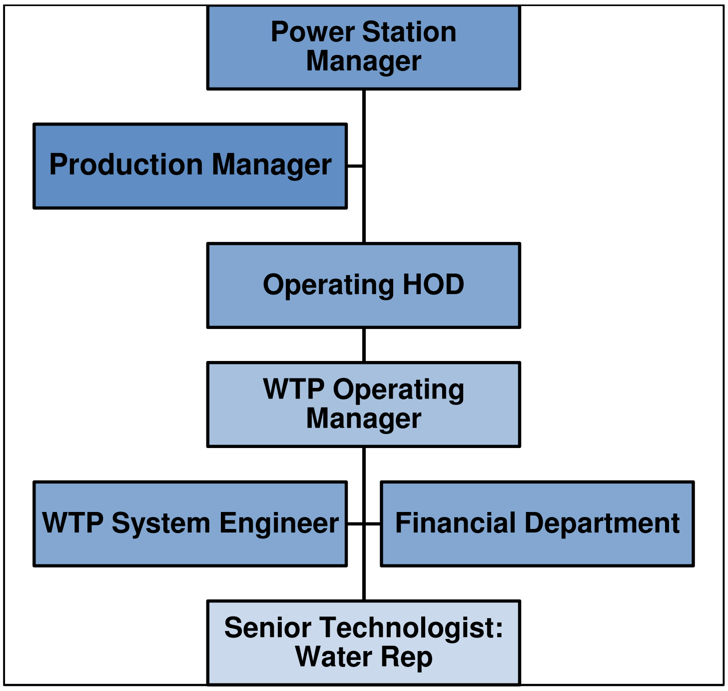

Figure 4.3: Water management structure at Lethabo power station.

4.2.2 Lethabo water management policies and procedures

Water management at Lethabo is guided by different policies and procedures. These include the Zero Liquid Effluent Discharge (ZLED) policy, the Water Accountability Directive and procedures like how to report on water consumption to Eskom's Generation Primary Energy department (GPE). These policies and procedures are implemented by setting certain goals in terms of water consumption and rewarding the power station by adding to the Key Performance Indicator (KPI) if water targets are reached.

Water management is seen as part of environmental management at Lethabo and therefore all of the procedures on environmental management are relevant to water management. The procedures at Lethabo in terms of environmental management are as follow (Cloete, 2010):

- LBE11001 Environmental Management System Manual
- LBE21001 Procedure for Identifying and Updating Environmental Aspects
- LBE21004 Internal Environmental Impact Assessment
- LBE21005 Environmental Policy Procedure
- LBE22001 Environmental Training, Awareness & Competence
- LBE22002 Environmental Communication and Reporting (Internal & External)
- LBE22002 Environmental Legal & Other Requirements
- LBE22004 Waste Management Procedure
- LBE22005 Environmental Spill Pollution Management Procedure
- LBE23001 Environmental Audits
- LBE23002 Environmental Records and Information Management
- LBE23004 Environmental Monitoring & Measurement Procedure

4.2.3 ZLED policy

Lethabo is one of Eskom's power stations where the ZLED (Zero Liquid Effluent Discharge) policy has been adopted. This means that all water, except water evaporating at cooling towers, are recycled within the power generation process. If the ZLED policy is implemented effectively it results in a significant reduction in the use of raw water. This is not always possible due to steam leaks and water draining into the ground. According to ZLED all pollutants must be captured by the cascading process and sent to ash dams, or ash heaps where water evaporates and leaves pollutants behind. This is not always the case since polluted water also drains into the ground. Between the pilings, underneath the power station, there are various sand filled openings, or voids (Hariram, 2011). From here the water is directed into the station draining system, but since several of the drains are blocked it is not clear if some of the water is distributed back to the river basin or enters another underground water resource. Until it is determined exactly where this water is going, and what the impact is thereof, it will be difficult to control and effectively maintain the power station's boundary limits in terms of ZLED.

4.2.4 Roles and responsibilities

The persons responsible and accountable for Water Management according to LBE110011 (Environmental Management System Manual) are as follow:

- ***Power Station Manager***
  - Authorisation and insurance of implementation of water management systems
  - Ensuring that adequate resources are allocated
  - Visible demonstration of management's commitment towards water conservation
  - External communication regarding water management

- ***Head of Departments***
  - Implementation of water management systems in specific area of responsibility
  - Reporting of water related issues to the Water Representative
  - Ensuring awareness of employees and contractors on his plant in terms of water management systems
  - Ensuring compliance to the water management systems and that al procedures are up to date
  - Reporting of water management system problems at HOD meetings

- ***WTP Operating Manager***
  - Implementation and maintenance of water management systems
  - Ensuring compliance to ISO 14001
  - Continuous integration of water management systems with plant operations

- ***System Engineer***
  - Implementation and maintenance of water management systems
  - Ensuring new issues are communicated to the water management representative
  - Investigation of solutions to water related problems
  - Communication of information and suggestions of plant improvements
  - Responsible for preventative maintenance
  - Modification control for new or altered plant systems
  - Reporting of non-conformance to the water management system

- Prepared to respond to emergencies
- Incident coordination and follow-up
- Hazardous substance control

- ***Senior Technologist / Water Rep***
  - Implementation of water management systems
  - Compiling of performance reports
  - Ensure compliance with ISO14001
  - Monitoring water performance data
  - Coordination of management reviews and internal audits

Sub-committee meetings are held at least once a month, chaired by the appointed water management representative. At these meetings it is discussed for example whether there are new leaks in the system and areas of water management improvement are identified. Business review meetings are also held once a week with the operating manager to discuss if the weekly water usage target has been met and if not, why not. Minutes of these meetings are kept as record for future reference. The reporting channel for water management issues was given in Figure 4.3.

4.2.5 Reporting on water consumption

Lethabo has implemented a procedure on the reporting of water consumption to Eskom's Generation Primary Energy department (GPE) which states that all water consumption data must be collected, calculated and verified before being distributed. The responsibility of collecting data lies with the operators at the water treatment plant. The chemist responsible for Water Management at the water treatment plant (WTP) will capture data onto a spread sheet and verify that the information is correct. Once the data is verified, it is signed by the chemist responsible for Water Management and the Chemical Services manager.

4.2.6 Enforcing policies and procedures

All personnel working at the power station is responsible for water conservation. Signage related to the water conservation drive is displayed on information panels as one enters the power station. Ultimately, the PSM is responsible to ensure that all personnel comply with the water conservation policies. Non-conformance is punishable by means of KPI point reductions. However, it is not a simple process to determine who is responsible for a certain water spillage; therefore the KPI of operating personnel working at the WTP is influenced to a greater extent if water targets are not reached.

The station's overall KPI is negatively influenced when the monthly water consumption target is not reached. It therefore has an impact on all employees' bonuses if water is not managed according to standards.

4.2.7 Compliance with water licence

The latest Lethabo water licence was issued on 25 May 2011 in terms of the National Water Act, 1998 (Act. No. 36 of 1998). The licence is valid for 20 years and will be reviewed every five years. Water utilisation for practises of taking water from the Vaal River, storing water on site and disposing of waste in a manner that may detrimentally impact on a water resource are allowed according to this licence. Lethabo is however not licenced to discharge waste or water containing waste in a water resource or disposing of water that has been heated in the power generation process.

According to the licence Lethabo is authorised to utilise a maximum quantity of 53 071 000 m^3 water per year from the Vaal River (DWA, 2011). Lethabo utilised an amount of 41 270 400 m^3 water in 2010, and is currently also operating well below the authorised quantity. According to the licence Lethabo is also responsible to continually investigate new technologies which support the re-use of water containing waste and to conserve water at all times. Continual processes of raising awareness on the need for water conservation also forms part of the licence requirements and Lethabo is achieving this by having quarterly Water Management sessions with all employees on the power station and displaying water saving messages on information boards at the entrance of the power station.

One of the clauses to the contract that is not necessarily being met is *"All necessary supply-side and demand-side management strategies must be implemented to conserve energy and to reduce the amount of water abstracted per megawatt produced".* These management strategies exist, but they are not implemented completely, since the amount of water utilised per megawatt produced at Lethabo have not been yet been optimised.

4.3 Lethabo water balance

A schematic layout of the Lethabo water reticulation system, showing all the gate keepers are illustrated in Figure 4.4. Where possible, water is lost only by means of evaporation, whilst all dissolved and suspended solids are retained. The net result is no deliberate discharge of pollutants and optimal use of available water resources.

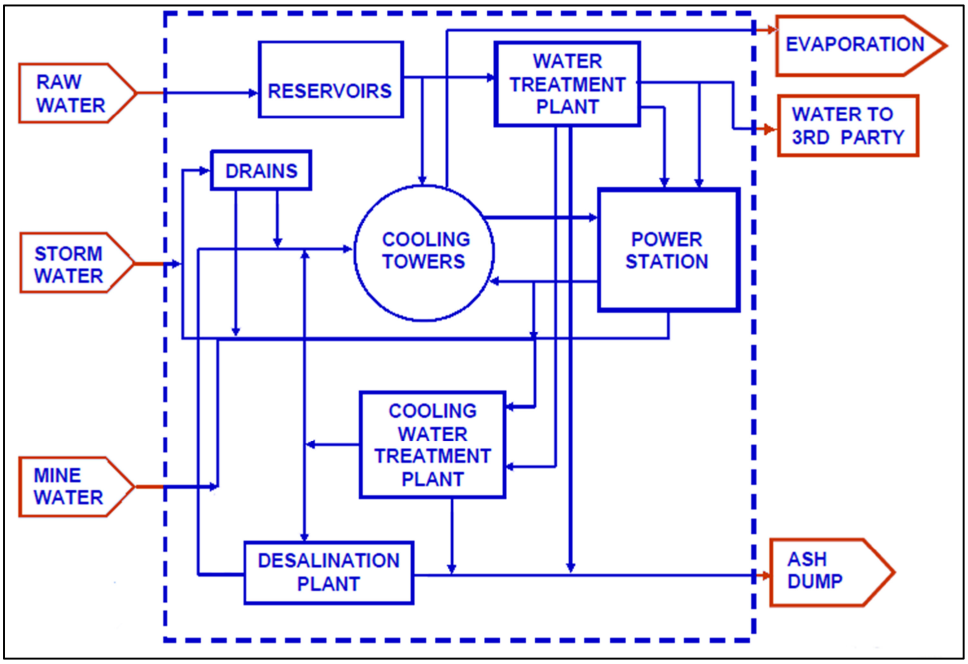

Figure 4.4: Lethabo power station water balance illustration.

From Figure 4.4 it can be seen that water enters the system as raw water from the Vaal River, storm water from rainfall and mine water from the New Vaal Colliery. Ideally water exits the battery limits of the station only by means of evaporation at the cooling towers and the ash dump as well as drinking water to third parties like the mine.

Cascading of the water inside the system from higher to lower quality uses enables high levels of re-use and the preventing of pollutants entering natural water resources. Effluent streams inside the power station's battery limits are directed towards the station drains and dams, and water from the draining system is recovered into the cooling water system. This reduces the raw water consumption. The cascading of water in this manner results in increased concentration salts in the cooling water, which must be kept within specified limits to protect materials of construction. Water that is of higher salt concentration than specified for the cooling water system is redirected towards the ash conditioning and removal system.

A water balance, conducted by Lethabo power station personnel, for the window period between 1 January 2010 and 31 December 2010 was derived from the data given in Table 4.1.

Table 4.1: Lethabo data for period between 1 January 2010 and 31 December 2010 (Cramer, 2011).

Input Data	Unit	Value
Station Load Factor	%	81%
Units Sent Out	MWh	23574920
Thermal Efficiency	%	34.77
Coal Burnt	Tons	16715509
% Ash in Coal (as received)	%	38.7%
Vaal Water Received	Mℓ	41270.40
Mine Water Received	Mℓ	824.78
Rainfall (actual)	Mm	760.50
Potable to Third Parties	Mℓ	518.68
Sewage Water Recovered to CCW	Mℓ	45.00
Water to Ash Dump	Mℓ	841.60
Water to Fly Ash Conditioners	Mℓ	430.47
Water to Bottom Ash Quenching	Mℓ	1096.48
Fly Ash to Ash Resources	Tons	1193841
Water To Ash Dump Dust Suppression	Mℓ	600

The amount of water consumed by the power station during this period was calculated to be 44,186 Mℓ (Cramer, 2011). Thus, during 2010 Lethabo consumed on average 1.873 ℓ/kWh which is higher than the annual goal of 1.82 ℓ/kWh for Lethabo power station. Lethabo therefore contributed to Eskom not reaching its annual consumption target of 1.32 ℓ/kWh.

There are several water recovery possibilities that may potentially result in overall water consumption reduction at Lethabo power station. The calculations in the paragraphs that follow are based on the data given in Table 4.1.

4.3.1 Reduction in water to ash dump

Supposing that it is technically and economically possible to recover 60 % of the water sent to the ash dump, it is calculated that a total of 1,421 Mℓ of water can be saved per year. This results in a potential cost saving of R4,263,390 per year. At the current price of water it is not economically feasible to install such technologies, but with the potential increase in the future water price and looming water scarcity, recovery of water sent to the ash dams may prove to become economically viable.

It is estimated that water costs Lethabo power station R3000/Mℓ (Lethabo, 2011). The total water received include raw water, storm water as well as mine water.

Table 4.2: Calculation of consumption rate and cost saving for reduced water usage at ash plant based on 2010 water usage data.

Input data:	**Value**	**Unit**
Units sent out during 2010:	23,574,920	MWh
Total water received:	44,186	Mℓ
Water to ash systems:	2,369	Mℓ
Total consumption rate for 2010:	1.874	ℓ/kWh
Cost of water:	3,000	R/Mℓ
Total water usage if 60% of water to ash is retained:	42,765	Mℓ
Water recovered from ash dump:	4	Mℓ/day
New water consumption rate:	1.814	ℓ/kWh
Cost saving:	4,263,390	R/year

From calculation results given in Table 4.2 it can be observed that if Lethabo power station reduce the amount of water to the ash dump, fly ash conditioners and bottom ash quenching by 60 % it may result in a R4,263,390 saving per year. It also results in the water consumption rate being 1.814 ℓ/kWh which is lower than the target of 1.82 ℓ/kWh and therefore influences the station KPI positively.

The capital cost of a desalination plant capable of handling 4 Mℓ water per day is estimated to be R5 million. The membranes would have to be replaced every five years, at a cost of R3 million. Since it will result in more than R4 million savings in water cost annually, the power station will save up to R32 million over a ten year period. It is thus feasible from a financial as well environmental point of view to install such technologies at power stations to be able to reduce the salt concentration of water and reduce the amount of water sent to the ash dams due to their high salt concentration.

4.3.2 Increasing the amount of mine water utilised

Eskom has invested capital cost into the construction of water systems at the New Vaal Colliery during its initial building phases. In return a contract was set up that states Lethabo can receive a specified amount of treated as well as untreated water from the mine at no additional cost. To manage the untreated water quality in terms of its salt concentration, a Reverse Osmosis (RO) plant was constructed on Lethabo power station site, but it is not currently being utilised to its full capacity. Lethabo has therefore already paid for water from the mine in the form of capital investment, but during 2010 only 825 Mℓ of mine water was utilised, which is 2460 Mℓ less than contract requirement (Cramer, 2011). Untreated mine water will typically add to the overall salt loading on the power station and therefore have a potential negative impact on LTPH (Long term plant health) and long term environmental impacts for Eskom. The treatment of this mine water must therefore be optimised.

Recovering too little mine water could result in the eventual loss of coal due to potential flooding of the active mining area and it is therefore in both New Vaal Colliery and Lethabo's interest to re-use as much as possible mine water.

The calculations given in Table 4.3 show the impact on Lethabo water consumption and the cost saving if mine water is recovered according to contractual requirement. The calculations are illustrative of the potential contribution that the saving could make toward offsetting the cost of treatment, even if full cost recovery is not possible at the moment.

Table 4.3: Calculation of cost saving for increased mine water recovery based on 2010 water usage.

Input data:	**Value**	**Unit**
Units Sent Out	23,574,920	MWh
Total water received:	44,186	Mℓ
Water from mine:	825	Mℓ
Water from mine requirement:	2,460	Mℓ
Reduction in raw water usage:	1,635	Mℓ
Cost of water	3,000	R/Mℓ
Cost saving:	4,906,320	R/year

From Table 4.3 it can be seen that a total annual saving of R4.9 million is possible. This amount can be utilised to invest in mine water treatment technologies and it will contribute to annual water saving of 0.069 ℓ/kWh.

4.3.3 Potential reduction in specific water consumption

The potential reduction in specific water consumption if 60 % of water sent to the ash dump is recovered and the maximum amount of water from the mine is utilised is 0.13 ℓ/kWh. A summary of calculation results is given in Table 4.4.

Table 4.4: Summary of calculations.

Units Sent Out	23,574,920	MWh
Total water received:	42,765	Mℓ
Potential reduction in specific consumption rate:	0.130	ℓ/kWh
Cost saving if 60 % ash water is recovered:	R 4,263,390	/year
Cost saving if maximum amount of water is utilised:	R 4,906,320	/year
Cost of desalination plant over 10 years:	R 10,000,000	/10 years
Total cost saving over period of 10 years:	R 81,697,100	/10 years