CLEAN STREAM ENVIRONMENTAL CONSULTANTS

SPECIALIST SURFACE WATER REPORT AS INPUT TO THE EIA FOR THE TWEEFONTIEN OPTIMISATION PROJECT AMENDMENT

Report No.: JW090/13/D367 – Rev 1

September 2013

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Executive Summary

The Tweefontein Complex is an existing Xstrata Coal South Africa mining complex. Xstrata Coal South Africa is a subsidiary of Xstrata South Africa (XSA) and is a member of the Glencore group of companies.

In 2010, XSA applied for authorisation for new activities as part of the then proposed Tweefontein Optimisation Project. The activities applied for were authorised and have commenced. XSA has since re-assessed and altered their planning in terms of the mining and related activities at the existing Tweefontein Complex. As a result, the Tweefontein Optimisation Amendment Project will entail the mining of additional areas and the construction of additional infrastructure. The proposed additional activities will result in changes to the approved operations within the Tweefontein Complex. Therefore, XSA has embarked on the mandatory environmental regulating processes necessary to obtain approval for the additional mining areas and infrastructure which have been identified.

Clean Stream Environmental Consultants (Clean Stream) have appointed Jones & Wagener (Pty) Ltd (J&W) to update the specialist surface water inputs to the amendment to the EMP to address these changes in the mine and infrastructure planning.

This document is the surface water specialist report for the proposed TOPA. The purpose of the document is to assess the current surface water conditions on the site, to quantify the possible impacts of the proposed mining, and to develop mitigation measures for the site.

Study Approach

The surface water study entails an assessment of the baseline surface water environment in the vicinity of the proposed activities. This is to characterise the surface water regime at the proposed development site and the catchment in which it resides, in terms of surface water quality and quantity.

A mine water balance model was developed to determine the quantity of water that will need to be managed at the TOPA operation over the life of mine.

Thereafter an assessment of the potential impacts and mitigation of the impacts of the proposed development on the receiving water environment can be defined and addressed. The method by which the impacts are quantified is to first assess the impact assuming no mitigatory measures are applied in order to provide a "worst case" scenario. Thereafter the mitigation measures are evaluated and the residual impact indicated.

A preliminary surface water management plan, as well as a surface water monitoring programme, is provided.

Project Description

The Tweefontein Complex is situated near the towns of Ogies and Witbank in the Mpumalanga Province, within the Olifants River catchment. The proposed mining right area is approximately 11 880 hectares in extent. The mining methods employed include both opencast and underground mining.

TOPA is situated within the Olifants river catchment with the northern portion of the site draining to the Tweefonteinspruit and the southern portion draining to the Saaiwaterspruit.

The project comprises the construction of borrow pits, expansion of several opencast and underground workings, as well as other changes in mine and infrastructure planning.

TOPA has been divided into three phases for the purpose of this study, these are described below:

- **Phase 1: 2012 to 2015**

  The first phase will start when mining of additional opencast and underground sections begin and will continue up until Witcons plant has been rehabilitated.

- **Phase 2: 2015 to 2031**

  The second phase will commence once Wtcons plant has been rehabilitated and the Zaaiwater Tailings facility comes on line. The Zaaiwater Tailings facility will only come on line when mining of the Zaaiwater opencast area is complete.

- **Phase 3: 2031 onwards**

  The third and last phase will commence after Zaaiwater Tailings facility has been decommissioned and Boschmans North Tailings facility comes on line.

Infrastructure

The TOPA project will involve the construction of the following facilities:

- Material handling system, mine stockpiles, conveyors
- Product screen and mineral sizing system
- Additional diesel storage tanks
- Additional fencing
- Additional explosive magazines
- Several discard dumps
- Several Borrow pits
- ROM tip area
- Xstrata Alloy's Independent Power Plant (IPP)
- Product Conveyor PCD West
- Product Conveyor PCD East
- Product Conveyor evaporation dam
- Mine Infrastructure Area PCD (MIA PCD)
- Waterpan 2 Seam PCD and reservoir
- Vlaklaagte shaft access PCD and reservoir
- Zaaiwater PCD
- Eskom Low Grade Stockpile PCD
- Boschmans North return water dam
- Zaaiwater Tailings Dam
- Boschmans North Tailings Dam
- Several Silt traps
- Several Haul roads
- Process Water Reticulation

- Several pipelines
- Sewage treatment plant
- Water Treatment Plant
- Several Silt traps
- Golf Course
- Additional opencast areas
- Additional underground areas

Water Supply

Two types of water will be required on the site, namely potable water and process water.

Potable water requirements are relatively small at the Tweefontein plant area, of the order of 60 m³/day. This water will be obtained by treating mine water make to potable standards using a small Reverse Osmosis Plant. This will be a package plant and the necessary licences will be applied for.

Make up water for the coal processing plant will be supplied from the water make on the mine, including existing water within previously mined areas.

Waste Management

Both general and hazardous waste will be produced on site.

General and hazardous waste disposal will tie in with the current practices and facilities at Tweefontein Complex. Domestic waste is collected in skips and removed by a licensed contractor and scrap metal/metal waste is collected in skips and recycled by a licensed contractor.

Stormwater Management

Being an existing mine there are various dirty areas that already exist on site. Projects are in the process of being implemented as part of the IWWMP Action Plan, including clean and dirty water separation. These include:

- Upgrading of the water management at the Boschmans Coal Processing Plant (CPP), including installation of an upgraded dirty water collection system with a new pollution control dam located in the north eastern corner of the site, from where the water will be returned to the Plant Holding Dam at the plant area. The Plant Holding Dam will be the main feed dam to the coal washing plant.
- Various clean water canals around the plant area.
- Clean water canals on the opencast areas directing clean water away from the opencast workings.
- Several pollution control dams at key areas where dirty water will be generated, including the following:
    - At the ROM tip feeding into the crusher and washing plant (Mine infrastructure area)
    - Rail load out area where processed coal will be placed on the conveyor
    - Conveyor area where the conveyor will feed the railway loop and loading facility
    - Product surge bin area
    - Eskom Low Grade Stockpile area
    - Sized Coal Stockpile area.

- Two new tailings facilities to come on line to facilitate the expansion of the mine (the Zaaiwater tailings facility and the Boshmans North tailings facility).
- Construction of a new golf course on rehabilitated opencast areas (old Hamster and Boschmans South East Pit), to replace existing Tweefontein golf course which will be mined through.
- Water supply for the Xstrata Alloys' Independent Power Plant (IPP) will be from the Plant Holding dam. The IPP has its own IWULA and IWWMP in which stormwater management measures and impacts are included, and is not addressed here. (Reference: Xstrata Alloys Lesedi Power Plant IWULA and IWWMP, April 2011 by Digby Wells).

In line with best practice, as well as the requirements of the National Water Act (NWA) and its associated regulations (GN704), contaminated storm water volumes will be minimised by preventing runoff from clean areas from flowing into the dirty areas. This will be achieved by means of clean water diversion canals that will collect clean runoff, diverting it around dirty areas.

Dirty water and storm water runoff from the dirty areas will be contained by means of dirty water containment canals which will collect all dirty water and convey it to the PCDs.

All clean and dirty water separation canals and berms will be designed and sized to accommodate the peak flow expected for at least a 1:50 year event.

The PCDs will be equipped with HDPE geomembrane liners to minimise seepage of contaminated water to the groundwater system. The dams will be sized to prevent spillage for events up to at least the 1:50 year event (a 2% or lower risk of spill in any one year). In line with best practice, the PCDs will be operated as empty as possible at all times to ensure that sufficient storm water retention capacity is available at all times.

Mine water Management

There will be a surplus of water at Tweefontein complex over the life of mine. Water will be pumped to available storage areas in the mined out workings for temporary storage prior to treatment.

The water balance will need to be regularly updated as the mine develops and the LOM changes.

The main plant and discard dump area will be able to be contained by the coal processing plant PCD with a capacity of 150 Ml, this dam being kept empty through pumping back to the Plant Holding Dam from where water will be reused in the plant.

Additional smaller dams will be provided at the ROM tip, MIA, Railway loop and Conveyor transfer house. All of the dams will be lined as detailed in this document, but typically with a geosynthetic liner underlain by a clay layer and a leakage detection system. Numerous clean and dirty canals are required to separate clean and dirty water, and all of these have been sized to have a 2% risk of spilling.

Impact assessment

The major concerns with regards to TOPA's surface water impacts revolve around the effective separation of clean and dirty water, effectively isolating the pits and plant area, adequate sizing of the dirty water facilities and effective use of dirty water so that the impact on the clean catchment remains minimal. The impact assessment is detailed in Section 8 and is indicated in **Table 8.4** of this document.

With the majority of the operation being conducted using opencast mining the potential impact on the surface water quality and quantity is significant. TOPA also has the potential to contribute significantly to the cumulative impacts in the catchment as it is situated amongst a number of other mining activities, including other XSA operations (the Goedgevonden, iMpunzi, Tweefontein South complexes), as well as other mines belonging to Anglo American, BECSA and others.

The surrounding surface water resources, namely the Saaiwaterspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River are already heavily impacted by mining activities in the catchment, with little or no capacity to assimilate further impacts. Sound water management, in line with the legislation and best practice will therefore be essential to ensure that both the existing impacts from Tweefontein Complex, are reduced and future impacts are mitigated as far as is practicable.

Further with the mitigation and management measures detailed in this document and having a Water Treatment Plant to treat the mine impacted water before releasing to the environment, these impacts on surface water quality and quantity will be minimised.

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CLEANSTREAM 2010 SURFACE WATER USERS REPORT

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Abbreviations used

Al	Aluminium
BEE	Black Economic Empowerment
BEEH	Bio-resources Engineering and Environmental Hydrology
BPG	Best Practise Guidelines
Ca	Calcium
Cl	Chloride
DNWRP	Directorate National Water Resource Planning
DM	District Municipality
DMR	Department of Mineral Resources
DRH	Direct Run-off Hydrograph
DTM	Digital Terrain Model
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWF	Dry Weather Flow
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EMP	Environmental Management Program
EMPR	Environmental Management Program Report
ERA	Environmental Risk Assessment
Fe	Iron
GA	General Authorisation
GN	Government Notice
GNR	Government Notice Regulation
HCV	High Calorific Value
HDPE	High Density Polyethylene
ICFR	Institute for Commercial Forestry Research
IPP	Independent Power Plant
IWULA	Integrated Water Use Licence Application
IWWMP	Integrated Water and Waste Management Plan

J&W	Jones & Wagener
K	Potassium
LCV	Low Calorific Value
LM	Local Municipality
mamsl	metres above mean sea level
mg/ℓ	milligram per litre
mS/m	millisiemens per meter
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MDEDET	Mpumalanga Department of Economic Development, Environment and Tourism
Mg	Magnesium
Mn	Manganese
MU	Management Unit
Na	Sodium
NDA	National Department of Agriculture
NEMA	National Environmental Management Act
NEM:WA	National Environmental Management: Waste Act
NWA	National Water Act, 1998 (Act 36 of 1998)
PCD	Pollution Control Dam
PP	Public Participation
RDF	Recommended Design Flood
RMF	Regional Maximum Flood
ROM	Run Of Mine
RWQO	Receiving Water Quality Objectives
SANCOLD	South African National Commission on Large Dams
SAWS	South African Weather Service
SDF	Standard Design Flood
SEF	Safety Evaluation Flood
SO_4	Sulphate
SS	Suspended Solids
TDS	Total Dissolved Solids
XSA	Xstrata South Africa

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1. INTRODUCTION

1.1 Background

The Tweefontein Complex is an existing Xstrata Coal South Africa mining complex. Xstrata Coal South Africa is a subsidiary of Xstrata South Africa (XSA) and is a member of the Glencore group of companies.

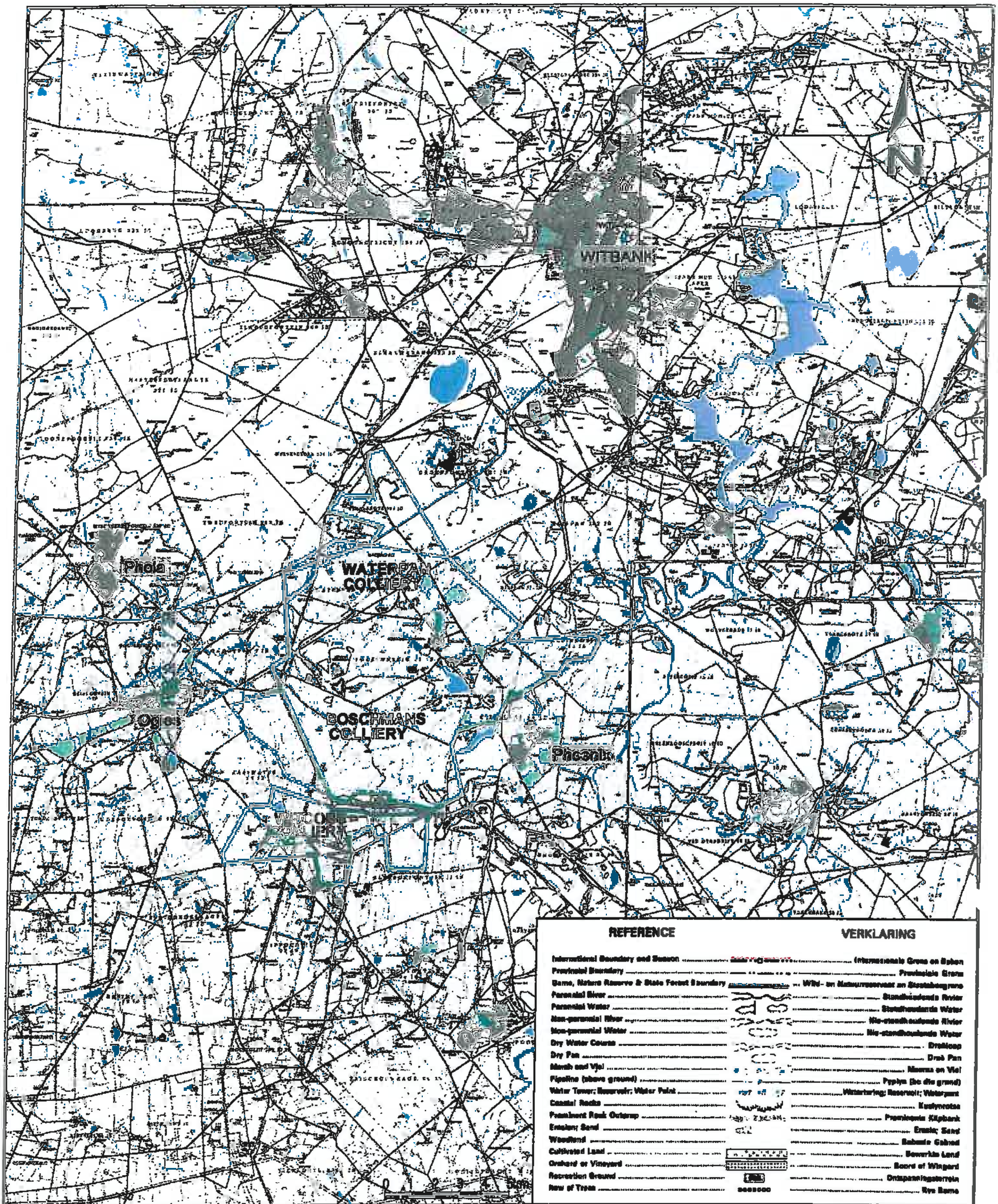
In 2010, XSA applied for authorisation for new activities as part of the then proposed Tweefontein Optimisation Project. The activities applied for were authorised and have commenced. XSA has since re-assessed and altered their planning in terms of the mining and related activities at the existing Tweefontein Complex. As a result, the Tweefontein Optimisation Amendment Project will entail the mining of additional areas and the construction of additional infrastructure. The proposed additional activities will result in changes to the approved operations within the Tweefontein Complex. Therefore, XSA has embarked on the mandatory environmental regulating processes necessary to obtain approval for the additional mining areas and infrastructure which have been identified.

Clean Stream Environmental Consultants (Clean Stream) have appointed Jones & Wagener (Pty) Ltd (J&W) to update the specialist surface water inputs to the amendment to the EMP to address these changes in the mine and infrastructure planning.

This document is the surface water specialist report for the proposed TOPA. The purpose of the document is to assess the current surface water conditions on the site, to quantify the possible impacts of the proposed mining, and to develop mitigation measures for the site.

1.2 Terms of reference

This project involves the compilation of a specialist surface water report for the TOPA. This includes the following aspects:



Chief Directorate, Surveys and Mapping
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Jones & Wagener
Engineering & Environmental Consultants

Xstrata South Africa (Pty) Ltd
Tweefontein Optimisation Project Amendment

LOCALITY PLAN

Job No: D367-00

Figure 1.1(a)

- Baseline assessment
- Site water management
- Water balance
- Impact assessment.

These specific components for the specialist surface water study are described in more detail below:

1.2.1 *Baseline assessment*

The objective of the baseline study is to characterise the surface water regime at the site and the catchments in which it resides in terms of surface water quality and quantity.

Please note that the surface water study does not include the delineation of sensitive areas such as pans and wetlands, or the assessment of aquatic ecology.

1.2.2 *Site water management*

A review of surface water management aspects in terms of the environmental legislation, with surface water input to the environmental applications for the TOPA, as well as the formulation of a preliminary surface water management plan for the site.

1.2.3 *Water Balance*

Revision of the site water balance and water balance flow diagram for Tweefontein complex, to incorporate proposed infrastructure and mine planning changes.

1.2.4 *Impact assessment*

Assessment of the impact of the project and its components on surface water in the area, in terms of both water quality and water quantity.

Formulation of proposed mitigation measures for significant impacts, as well as monitoring required to measure the success of the mitigation measures.

1.3 Study area

The study area is indicated on **Drawing Number D367-00-001** in **Appendix A**. The study area covers the entire Tweefontein complex. Contaminated water will first report to the proposed plant pollution control dams, and any water make from here will be reused or pumped back to the plant or to underground storage.

The TOPA has been divided into three phases for the purpose of this study and the water balance modelling. These are described below:

- **Phase 1: 2012 to 2015**

  The first phase will start when mining of additional opencast and underground sections begins and will continue up until Witcons and Waterpan coal processing plants have been rehabilitated.

- **Phase 2: 2015 to 2031**

  The second phase will commence once Witcons plant has been rehabilitated and Zaaiwater Tailings facility comes on line. The Zaaiwater Tailings facility will only come on line when mining of the Zaaiwater opencast area is complete.

- **Phase 3: 2031 onwards**

  The third and last phase will commence after Zaaiwater Tailings facility has been decommissioned and Boschmans North Tailings facility comes on line.

A full description of the hydrological setting for the site is given in **Sections 5** and **6**.

1.4 Approach and methodology

The following actions were undertaken as part of the surface water specialist study for this project:

- Information received from the client, the design engineering consultants and the lead environmental consultant was reviewed and relevant issues noted.
- Rainfall data was obtained from the Institute for Commercial Forestry Research (ICFR) database and the South African Weather Service (SAWS) and processed for use in the hydrological calculations and water balance modelling.
- Topographical maps and satellite imagery (Google Earth) were reviewed to assess catchment conditions and to delineate the catchments within the study area.
- Peak flood flows at relevant locations within the study area were estimated for various recurrence intervals using a number of methodologies applicable to South African conditions. At the time of writing this component of the work was in the process of being updated to include revised floodline delineations. This section to be updated once this floodline determination study for TOPA has been completed.
- Mean annual runoff and dry weather flows were determined using the WRSM2000 (Pitman) synthetic streamflow generation model. The output was used to determine the impact of the project on catchment yield.
- A site-specific water balance model was developed to estimate the site water surplus/ deficit, to assess the storage capacity of the proposed pollution control dams and quantify make up or reuse water required to prevent spillage of dirty water from the site.
- The site water management was assessed in terms of the current legislation and a preliminary storm water management plan was compiled.
- The potential impacts associated with the proposed project were assessed according to the methodology stipulated by the lead environmental consultant. Impacts were assessed for the construction, operational, decommissioning and post closure phases. Potential impacts were detailed, then mitigation measures described, with residual impacts then being assessed.
- A water quality monitoring programme for the site was compiled.

2. LEGISLATIVE ASPECTS

2.1 Regulatory Requirements

A detailed legal assessment is discussed in the main Environmental Impact Report (EIR) compiled by Clean Stream. The Acts and Regulations that pertain to the surface water for mining projects include:

- The Constitution of the Republic of South Africa (Act 108 of 1996).
- The National Water Act, Act 36 of 1998 (hereafter referred to as NWA).
- The National Environmental Management Act, Act 107 of 1998 (hereafter referred to as NEMA).
- National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEM:WA).
- The Environmental Conservation Act, Act 73 of 1989 (hereafter referred to as ECA).
- Government Notice (GN) 704 of 4 June 1999: Regulation on use of water for mining and related activities aimed at the protection of water resources (hereafter referred to as GN704).
- Government Notice (GN) R139 of 24 February 2012: Regulations regarding the safety of dams in terms of Section 123(1) of the NWA.
- Government Notice (GN) R991 of 18 May 1984: Requirements for the purification of waste water or effluent.
- Government Notice (GN) R398 and 399 of March 2004: General Authorisations in terms of the NWA.
- Government Notice (GN) R543 to 546 of June 2010: Listed activities in terms of NEMA.
- Government Notice (GN) R636 of August 2013: National norms and standards for disposal of waste to landfill, in terms of NEM:WA.

2.2 Applicable policies and/or guidelines

The following DWA Best Practice Guideline documents are relevant to this project:

- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series A: Best Practice Guideline A2: Water Management for Mine Residue Deposits, July 2008
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series A: Best Practice Guideline A4: Pollution Control Dams, August 2007
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series A: Best Practice Guideline A6: Water Management for Underground Mines, July 2008
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G1: Storm Water Management, August 2006
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G2: Water and Salt Balances, August 2006

- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G3: Water Monitoring Systems, July 2007
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G4: Impact Prediction, December 2008
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series G: Best Practice Guideline G5: Water Management Aspects for Mine Closure, December 2008
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series H: Best Practice Guideline H1: Integrated Mine Water Management, December 2008
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series H: Best Practice Guideline H2: Pollution Prevention and Minimization of Impacts, July 2008
- Best Practice Guidelines for Water Resource Protection in the SA Mining Industry, Series H: Best Practice Guideline H3: Water Reuse and Reclamation, June 2006

3. DETAILS OF THE APPLICANT AND ENVIRONMENTAL ASSESSMENT PRACTITIONER

3.1 Name and address of the Applicant

These are given in the main EMP document.

3.2 Details of the surface water specialists

Clean Stream was appointed by XSA Tweefontein Complex, a member of the Glencore group of companies, as the Environmental Assessment Practitioner to conduct the EIA for TOPA.

J&W were appointed as sub-consultants to address the surface water components of the EIA. Details of the J&W project team members and their experience are provided in **Table 3.2(a)**.

Table 3.2(a) J&W team members and relevant experience

Jones & Wagener (Pty) Ltd			
Postal address:	P.O. Box 1434, Rivonia, 2128		
Tel:	(011) 519 0200		
Fax	(011) 519 0201		
Project team members			
Name	**email address**	**Experience**	**Responsibility**
Michael Palmer	palmer@jaws.co.za	Pr Eng, MSc Eng Civil (Water, Environmental) 14 years experience	Review of the surface water specialist report.
Malini Moodley	moodley@jaws.co.za	BSc Eng Civil (Water, Environmental) 6 years experience	Surface water quantity baseline assessment, impact assessment and water balance.
Tolmay Hopkins	tolmay@jaws.co.za	MSc (Agric) Microbiology; 14 years experience in water and waste management	Surface water quality baseline assessment

4. DESCRIPTION OF THE PROJECT

The overall project is described in the main EIA document, compiled by the lead environmental consultant. Aspects relevant to the surface water component are detailed in the sections that follow.

4.1 General description

The Tweefontein Complex is situated near the towns of Ogies and Witbank in the Mpumalanga Province, within the Olifants River catchment. The proposed mining right area is approximately 11 880 hectares in extent. The mining methods employed include both opencast and underground mining.

The project comprises the construction of borrow pits, expansion of several opencast and underground workings, as well as other changes in mine and infrastructure planning

TOPA has been divided into three phases for the purpose of this study, these are described below:

- **Phase 1: 2012 to 2015**

  The first phase will start when mining of additional opencast and underground sections begin and will continue up until Witcons plant has been rehabilitated.

- **Phase 2: 2015 to 2031**

  The second phase will commence once Wtcons plant has been rehabilitated and the Zaaiwater Tailings facility comes on line. The Zaaiwater Tailings facility will only come on line when mining of the Zaaiwater opencast area is complete.

- **Phase 3: 2031 onwards**

  The third and last phase will commence after Zaaiwater Tailings facility has been decommissioned and Boschmans North Tailings facility comes on line.

Aspects of the TOPA that are relevant to the surface water component of the EIA are detailed in the sections that follow.

4.2 Surface infrastructure

4.2.1 Site layout

The proposed site layout is shown in **Drawing Number D367-00-002** in **Appendix A** with various underground and opencast mining areas associated with TOPA indicated in **Drawing Number D367-00-001** in **Appendix A**. The TOPA project will involve the construction of the following facilities:

- Material handling system, mine stockpiles, conveyors
- Product screen and mineral sizing system
- Additional diesel storage tanks
- Additional fencing
- Additional explosive magazines
- Several discard dumps
- Several Borrow pits
- ROM tip area

- Xstrata Alloy's Independent Power Plant (IPP)
- Product Conveyor PCD West
- Product Conveyor PCD East
- Product Conveyor evaporation dam
- Mine Infrastructure Area PCD (MIA PCD)
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- Vlaklaagte shaft access PCD and reservoir
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- Eskom Low Grade Stockpile PCD
- Boschmans North return water dam
- Zaaiwater Tailings Dam
- Boschmans North Tailings Dam
- Several Silt traps
- Several Haul roads
- Process Water Reticulation
- Several pipelines
- Sewage treatment plant
- Water Treatment Plant
- Several Silt traps
- Golf Course
- Additional opencast areas
- Additional underground areas.

4.2.2 Sources of Water

Two types of water will be required on the site, namely potable water and process water. The source and use of each is described below.

4.2.2.1. Potable water

Potable water requirements are relatively small at the Tweefontein plant area, of the order of 60 m^3/day. This water will be obtained by treating mine water make to potable standards using a small Reverse Osmosis Plant. This will be a package plant and the necessary licences will be applied for.

4.2.2.2. Process water

Coal processing will include the following:

- Loading of coal and discard onto trucks
- Hauling coal to- and discard from- the ROM tip
- Crushing and washing of coal at the plant
- Conveying coal to the railway loop and loading facility.

Make up water for the coal processing plant will be supplied from the water make on the mine, including existing water within previously mined areas.

4.3 Solid waste – water management

Solid waste has the potential to impact on surface water through contaminated runoff. The waste management proposed for the site is discussed below. The following sources will generate waste on the site:

- Site offices
- Workshops
- Plant areas.

It is anticipated that both hazardous and general waste will be produced.

General and hazardous waste disposal will tie in with the current practices and facilities at Tweefontein Complex. Domestic waste is collected in skips and removed by a licensed contractor and scrap metal/metal waste is collected in skips and recycled by a licensed contractor.

4.3.1 Disposal of general waste

All domestic, commercial, industrial waste, builder's rubble and other waste classified as General Waste (G) under the South African Minimum Requirements (MR) for the Handling, Classification and Disposal of Hazardous Waste (*Department of Water Affairs and Forestry, 1998*), will be removed from the site by an appropriately licensed waste removal contractor and disposed of at a licensed general waste facility.

4.3.2 Disposal of hazardous waste

All waste classified under the MR as hazardous (H or h), including grease, oils, acids, fluorescent tubes, etc. will be removed by a licensed waste removal contractor and disposed of at an appropriately licensed landfill.

All hazardous waste is currently removed by a contracted waste company, Waste Group, which disposes of the waste at Holfontein, a licensed H:H hazardous waste landfill.

4.3.3 Disposal of mine residue

Coal processing on site includes crushing, screening and washing. The discard is then placed on the existing discard dump at the Tweefontein plant area. Once the new Tweefontein plant (at Boschmans) is operational, discard will be managed as follows:

- Once the existing dump no longer has capacity, the discard and slurry will be placed in a co-disposal facility. Initially this will be located on the rehabilitated Zaaiwater Pit, which will be mined out by 2015, prior to the commissioning of the plant.
- The Zaaiwater facility is expected to be adequate until around 2031 (depending on the final layout of the area) when a new facility will be constructed on the rehabilitated Boschmans North pit.

It is important to note that the necessary designs and planning are in progress to ensure that the footprint for the co-disposal facilities are suitably prepared and properly engineered to ensure both stability of the dump, as well as to contain affected runoff and seepage.

The residue placed on surface will remain on surface post closure and be rehabilitated.

The possibility of mining the discard dumps also exists, but this will be undertaken from a portion of the existing dump if this proves to be viable.

4.4 Liquid waste – water management

4.4.1 Disposal of process effluent

It is not expected that the plant will produce any process effluent, with process water being recycled within the plant as far as is practicable. Any spills of process water during upset conditions will report via the contaminated storm water system, via a silt trap to the CPP Pollution Control Dam (PCD). From here, it will be pumped to the Plant Holding Dam for reuse in the plant, or to the old underground workings on the mine.

Water collected in the discard facility return water dams will be pumped to the Plant Holding Dam for reuse, or underground storage.

4.5 Water pollution management facilities

4.5.1 Domestic waste water management

Provision has been made for a sewage plant on site. This will most likely be a package plant such as a Prentec Plant, Biodisc, or similar. These types of plants have operated successfully over several decades in similar applications, provided the operational and maintenance components are correctly managed.

There are existing sewage plants on the Witcons, Waterpan and Boschmans sites which will be utilised up to their full capacities.

Details of the sewage treatment plant will be supplied in the Water Use Licence and are given briefly in Section 4.5.1.

The treated sewage plant effluent will be discharged to the natural system.

4.5.2 Storm water management

4.5.2.1. <u>Background</u>

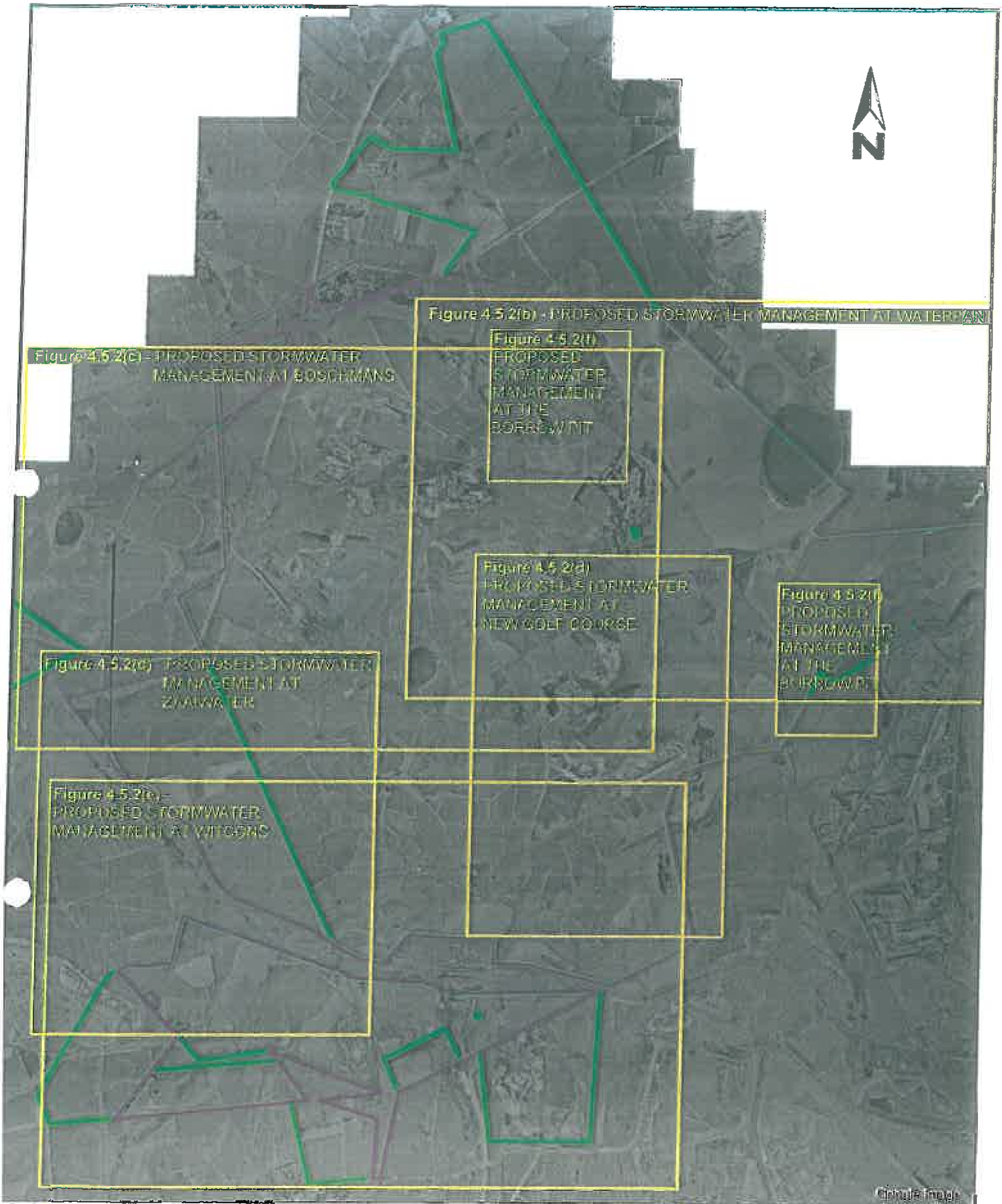
An effective surface water management system is essential to ensure efficient operation of the site and to protect the natural water resource during the construction, operational and post closure phases of the project. This entails the management of dirty water generated on site (including process plant effluent, as well as dirty storm water runoff from the plant infrastructure areas), as well as handling of clean water flowing towards the site.

Being an existing mine there are various dirty areas that already exist on site. Projects are in the process of being implemented as part of the IWWMP Action Plan, including clean and dirty water separation. These include:

- Upgrading of the water management at the Boschmans Coal Processing Plant (CPP), including installation of an upgraded dirty water collection system with a new pollution control dam located in the north eastern corner of the site, from where the water will be returned to the Plant Holding Dam at the plant area. The Plant Holding Dam will be the main feed dam to the coal washing plant.
- Various clean water canals around the plant area.
- Clean water canals on the opencast areas directing clean water away from the opencast workings.

- Several pollution control dams at key areas where dirty water will be generated, including the following:
  - At the ROM tip feeding into the crusher and washing plant (Mine infrastructure area)
  - Rail load out area where processed coal will be placed on the conveyor
  - Conveyor area where the conveyor will feed the railway loop and loading facility
  - Product surge bin area
  - Eskom Low Grade Stockpile area
  - Sized Coal Stockpile area.
- Two new tailings facilities to come on line to facilitate the expansion of the mine (the Zaaiwater tailings facility and the Boshmans North tailings facility).
- Construction of a new golf course on rehabilitated opencast areas (old Hamster and Boschmans South East Pit), to replace existing Tweefontein golf course which will be mined through.
- Water supply for the Xstrata Alloys' Independent Power Plant (IPP) will be from the Plant Holding dam. The IPP has its own IWULA and IWWMP in which stormwater management measures and impacts are included, and is not addressed here. (Reference: Xstrata Alloys Lesedi Power Plant IWULA and IWWMP, April 2011 by Digby Wells).

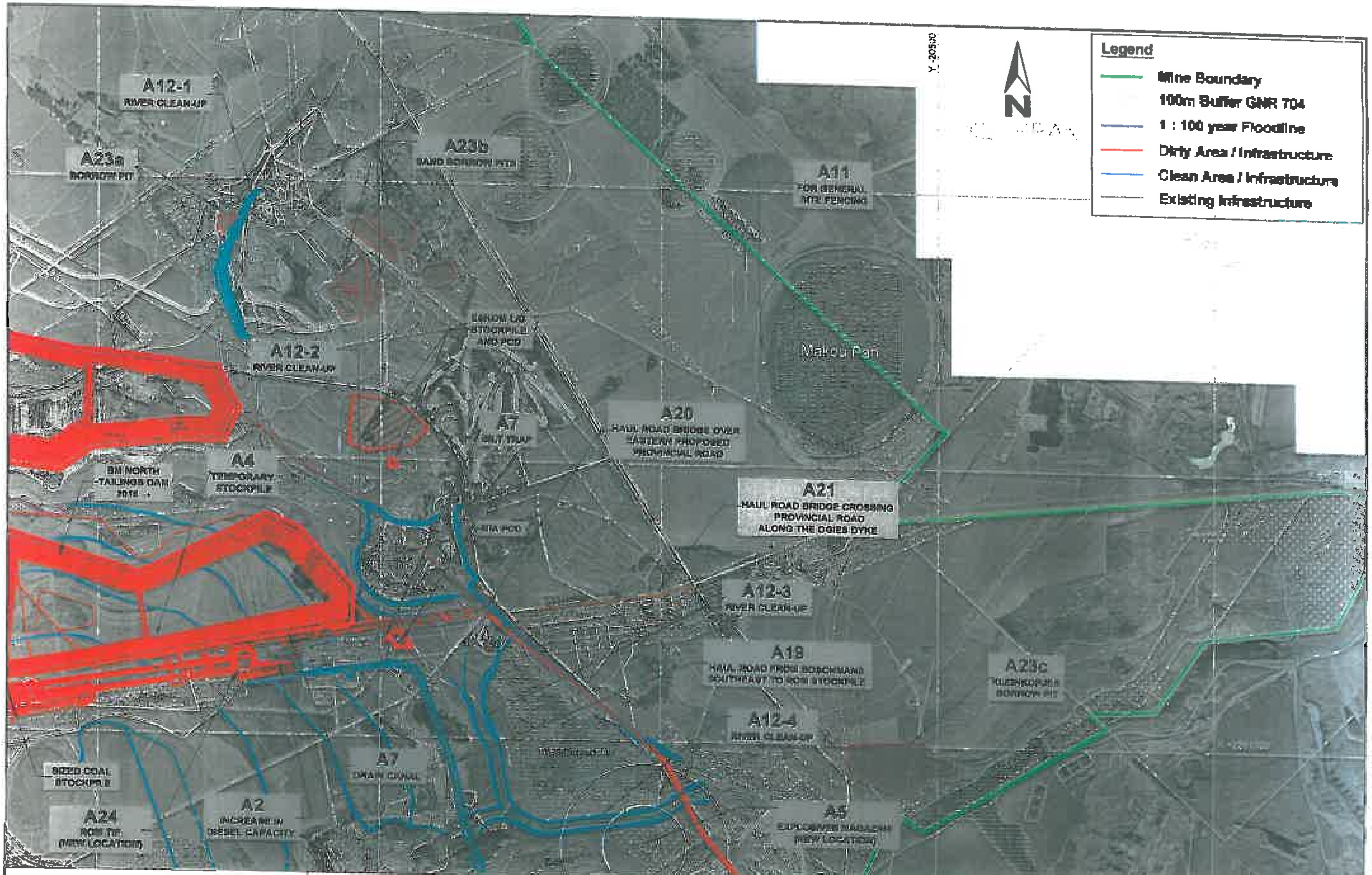
TOPA is situated within the Olifants river catchment with the northern portion of the site draining to the Tweefonteinspruit and the southern portion draining to the Saaiwaterspruit. A layout of the proposed surface water management infrastructure is shown in **Figures 4.5.2(a)** to **(f)**



Scale 1 : 75 000(A4)

Cape Lo29

Jones & Wagener Consulting Civil Engineers	Xstrata South Africa (Pty) Ltd Tweefontein Optimisation Project Amendment **KEY PLAN FOR SURFACE WATER MANAGEMENT INFRASTUCTURE FIGURES**	Job No: D367-00 **Figure 4.5.2(a)**



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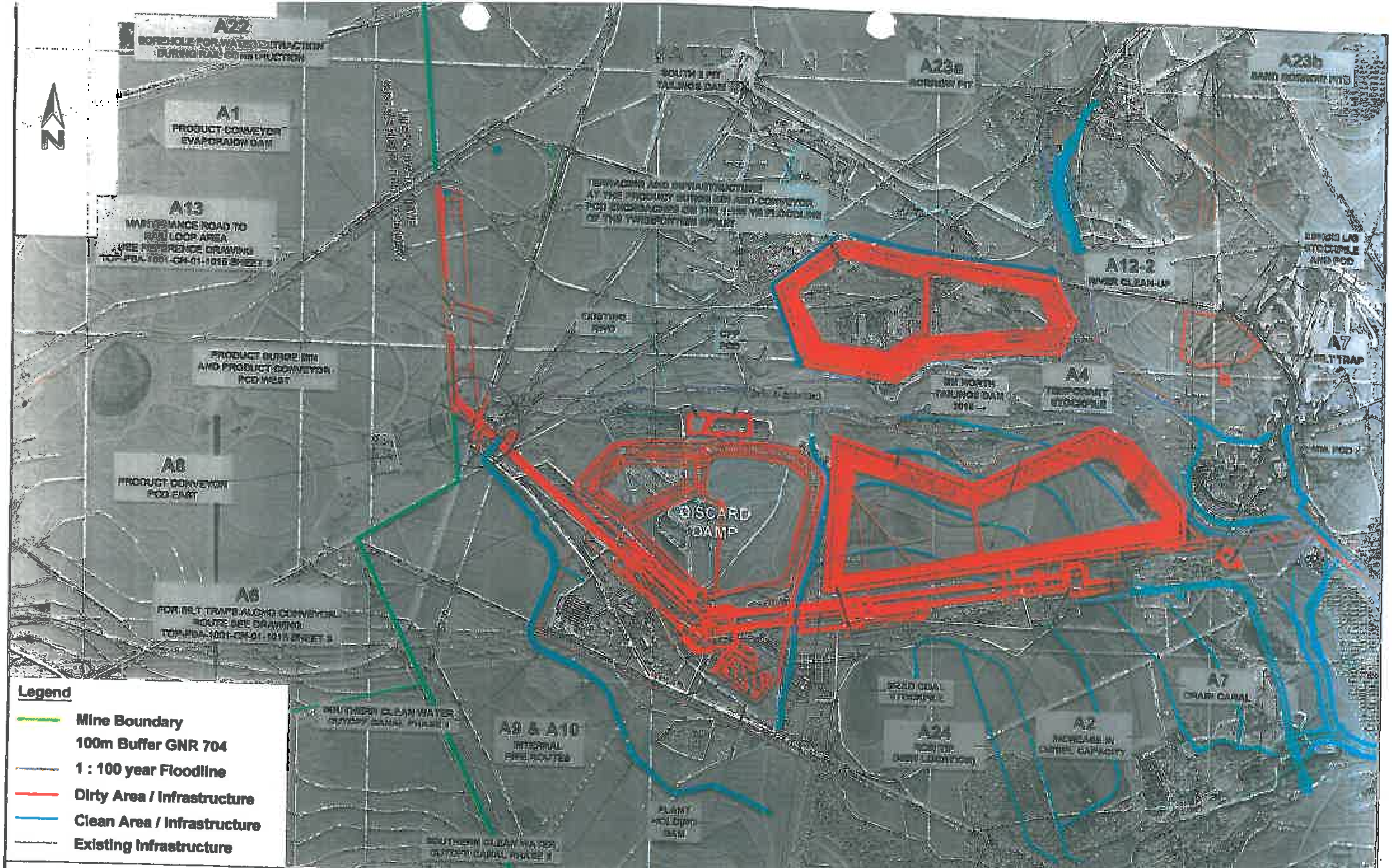
Tweefontein Optimisation Project Amendment

PROPOSED STORMWATER MANAGEMENT AT WATERPAN

Scale 1 : 25 000 (A3)
Cape Lo29

Job No: D367-00

Figure 4.5.2(b)



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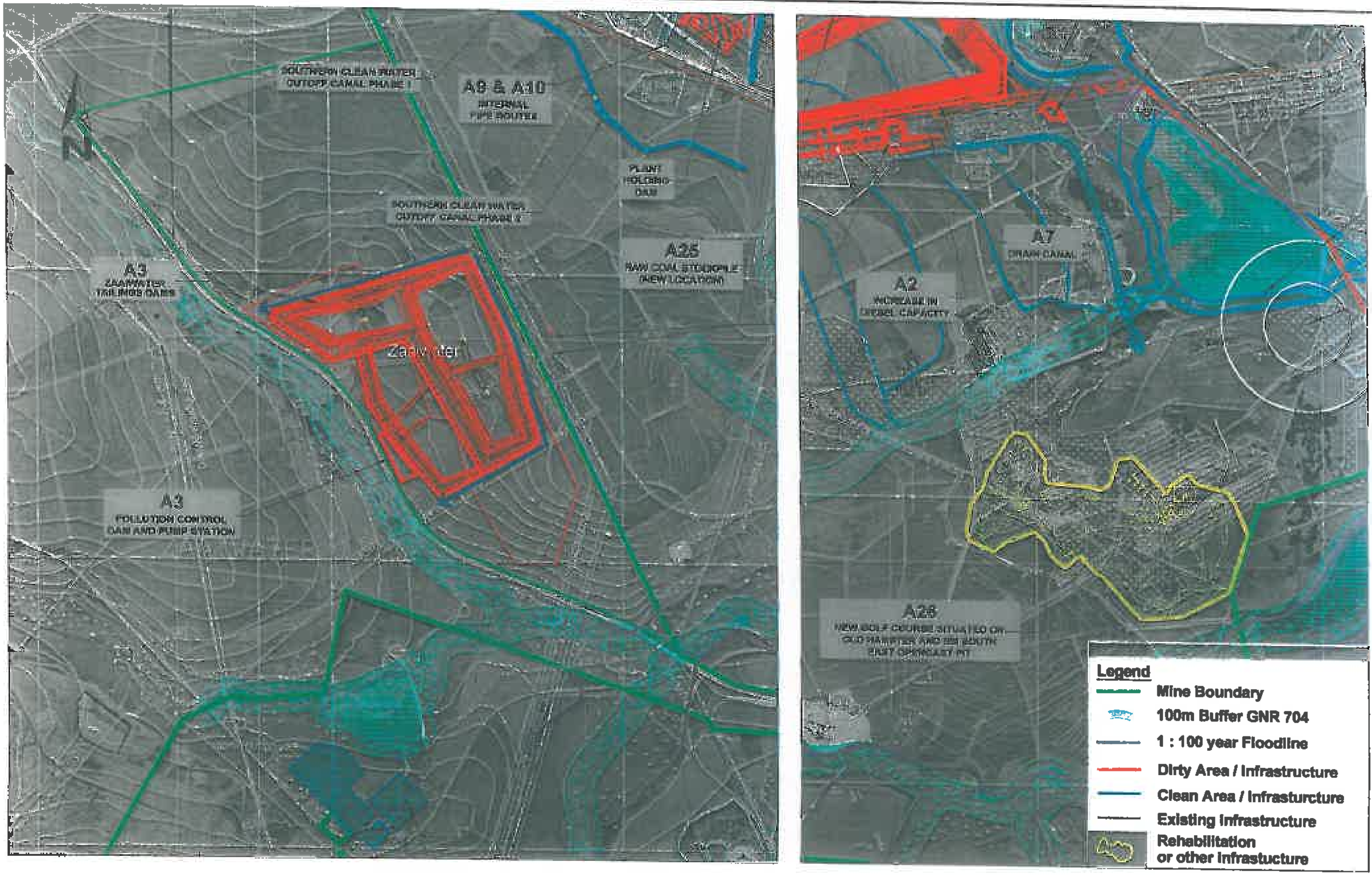
Tweefontein Optimisation Project Amendment

PROPOSED STORMWATER MANAGEMENT AT BOSCHMANS

Scale 1 : 25 000 (A3)
Cape Lo29

Job No: D367-00

Figure 4.5.2(c)



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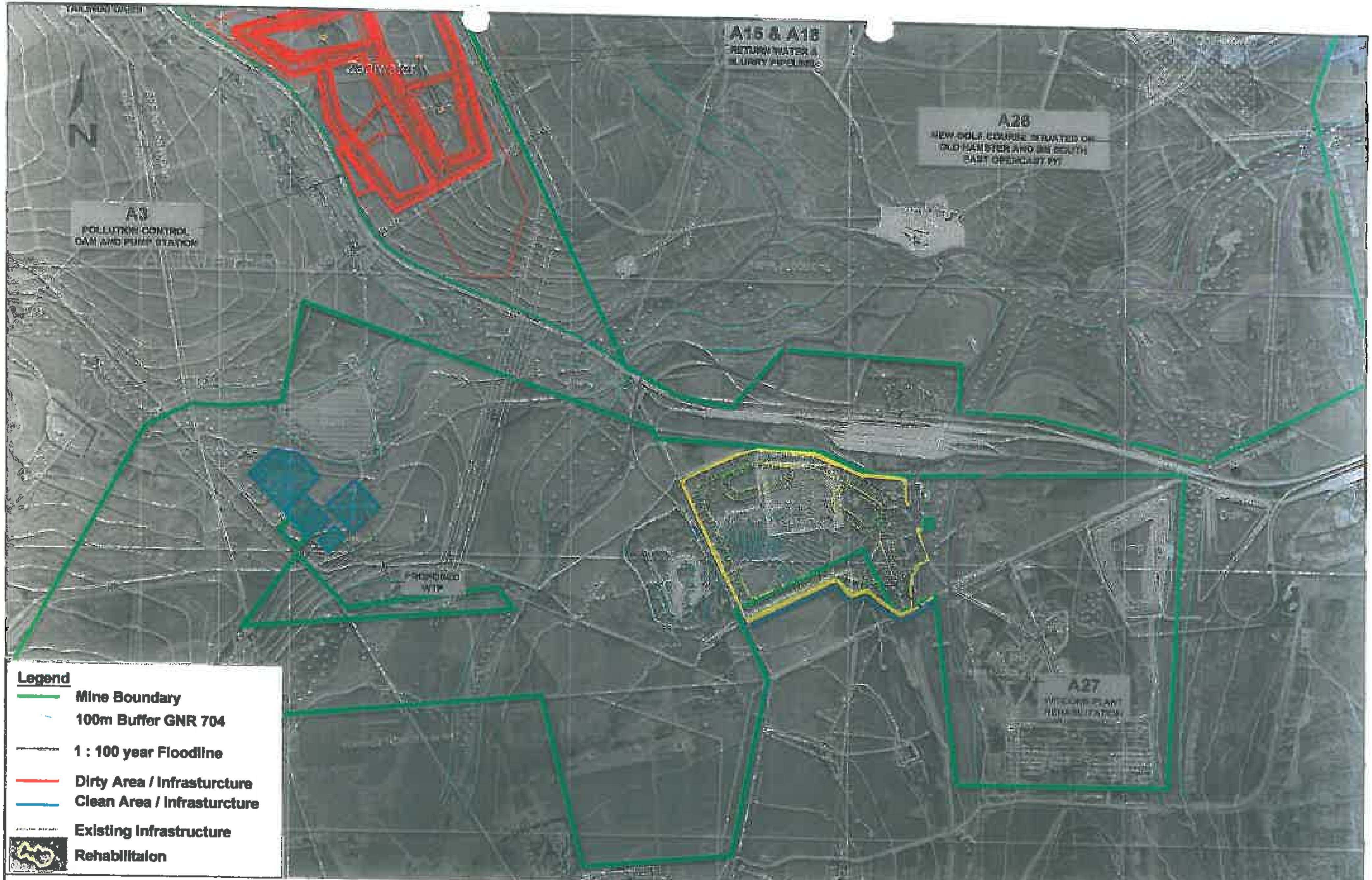
Tweefontein Optimisation Project Amendment

PROPOSED STORMWATER MANAGEMENT AT ZAAIWATER AND NEW GOLF COURSE

Scale 1 : 25 000 (A3)
Cape Lo29

Job No: D367-00

Figure 4.5.2(d)



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PROPOSED STORMWATER MANAGEMENT AT WITCONS

Scale 1 : 25 000 (A3)
Cape Lo29

Job No: D367-00

Figure 4.5.2(e)

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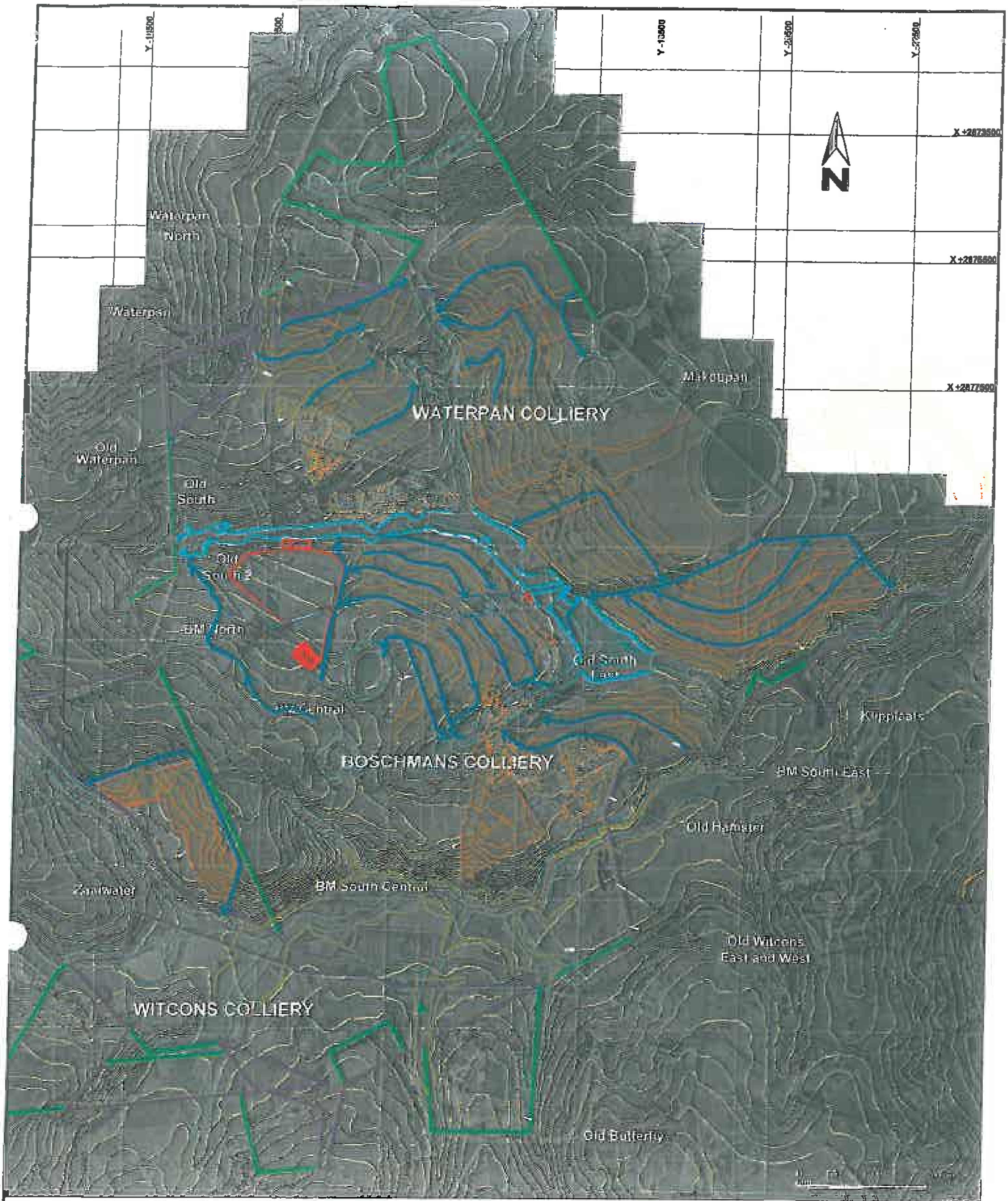
Tweefontein Optimisation Project Amendment

PROPOSED STORMWATER MANAGEMENT AT THE BORROW PITS

Scale 1 : 10 000 (A3)
Cape Lo29

Job No: D367-00

Figure 4.5.2(f)



LEGEND:

Surface Boundary	1 : 100 Year Floodlines (J&W)
Mineral Boundary	1 : 100 Year Floodlines (Others)
100m Buffer GNR 704	Clean water canals
	Dirty water canals

Cape Lo29

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Tweefontein Optimisation Project Amendment

PROPOSED STORMWATER MANAGEMENT AT THE OPENCAST PIT

Job No: D367/00

Figure 4.5.2(g)

4.5.2.2. Storm water management in clean areas

In line with best practice and the requirements of the National Water Act (Act 36 of 1998) (NWA), contaminated storm water runoff volumes will be minimised by preventing runoff from clean areas from entering the dirty areas. This will be achieved by means of clean water diversion canals that will collect clean runoff and divert it around the dirty areas.

All clean water diversions will be designed to accommodate the peak flow expected for at least a 1:50 year event.

Plant and stockpile areas

Although the plant area is close to the water shed, there are still clean water catchments draining to the coal processing area. The clean catchment runoff from the areas upslope of the Plant and stockpile areas will be collected and diverted around the dirty areas by means of a cut-off channel and berms. Clean water will be directed away from dirty area and back to the clean water catchment.

Coal discard facilities

Clean catchment runoff from the areas upslope of the coal discard facilities will be collected and diverted around by means of a cut-off canal and berm. The diverted water will be released from the canals once it has passed the discard facilities.

Opencast pits

Clean runoff from areas upslope of the opencast pits will be collected and diverted by means of cut-off canals and berms. These will comprise a perimeter drain on the upslope side of each pit boundary. Where mining will be in an upslope direction, a series of sacrificial contour drains will be constructed ahead of the advancing active pit to ensure that clean runoff to the workings is minimised. These will be mined through as mining progresses. This can be seen in **Figure 4.5.2 (g)**.

Borrow pits

Each borrow pit will be provided with a clean water cut-off canal and berm on its upslope perimeter to divert clean runoff around the borrow pit operation. This can be seen in **Figure 4.5.2 (f)**.

4.5.2.3. Storm water management in dirty areas

No contaminated water will be discharged from the site for events up to at least the 1:50 year recurrence interval. Infrastructure that will be provided to ensure the containment of contaminated water is described in the sections that follow, and illustrated in **Figures 4.5.2(a) to (h).**

Boschmans/Tweefontein Plant Area

Plant area will be upgraded. Current planning is for the following to be present at the plant area, and is illustrated in **Figure 4.5.2(c)**:

- A ROM tip feeding into the crusher and washing plant, known as the Mine Infrastructure Area (MIA) with PCD to collect contaminated runoff from this area.

Contaminated water from the MIA PCD will be pumped to the Plant Holding Dam for re-use or storage underground for eventual treatment.

- A plant area where the coal will be washed, runoff will be collected in the Coal Processing Plant PCD (CPP PCD) and pumped either to the Plant Holding Dam for reuse or to underground storage for eventual treatment.
- The product stockpile area, where processed coal will be stockpiled and placed on the conveyor in a stacker/reclaimer system. Runoff from this area will drain to the CPP PCD.
- Dirty water from the conveyor will be collected on the southern banks of the Tweefonteinspruit in the Product Conveyor PCD East, before the conveyor crosses the Tweefonteinspruit. Water collected in this PCD will be pumped to the CPP PCD.
- Product surge bin area and Product Conveyor PCD west. The product surge bin will be located on the northern bank of the Tweefonteinspruit, on the western boundary of the TOPA project area. This area will be paved with concrete and bunded. All contaminated runoff from the product surge bin area will be collected in the Product Conveyor PCD west, and pumped from there to the CPP PCD for re-use.
- Dirty runoff from the rail load out area and rail loop will be collected in the Product Conveyor evaporation dam. Contaminated water from this PCD will be pumped to the CPP PCD for re-use. Workshops, offices, wash bays, waste storage areas etc.

All of the above will be contained within the designated dirty water areas by means of canals, silt traps, and pollution control dams. The canals and PCDs have been designed to contain at least the 1:50 year flood event.

Provision has been made for coal sediment in the runoff from both the processing area and the main dump by the use of two large settling facilities around the Tweefontein plant area, one located close to the plant to collect drainage from the thickeners and terrace, and the second upstream of the CPP PCD.

Subsoil seepage collection has also been allowed for, which will consist of drainage systems located some 2 to 3m below surface (the depth to be finalised depending on the geotechnical investigation results), which will drain back to the CPP PCD or to a sump located close to the dam from where water will be pumped back to the Plant Holding Dam.

Waterpan and Witcons Plant Area

These plant areas will be rehabilitated within the next three years. The Waterpan and Witcons proposed surface water management is illustrated in **Figures 4.5.2 (b)** and **(e)** respectively.

Rehabilitation will involve demolition and removal of all surface infrastructure, removal of all contaminated material from the plant areas, with shaping, capping and re-vegetating of the areas to make them free draining and clean. Similarly, the discard dumps will be shaped and capped to ensure that runoff from them is clean. Seepage collection will be implemented where required to mitigate surface and groundwater impacts.

Coal stockpiles

Current planning is for the following new coal stockpiles to be constructed:

- **CPP product stockpile:** This will be located within the designated dirty water area at the plant, and will drain to the CPP PCD.
- **ROM stockpiles at the ROM tip:** The ROM stockpiles will be located adjacent to the ROM tip, between the ROM tip and the MIA. The entire ROM tip and stockpile area will drain to the MIA PCD
- **Sized Coal Stockpile**: Runoff and seepage from the sized coal stockpile area will be directed to the CPP PCD. Contaminated water from this PCD will be pumped to the Plant Holding Dam for re-use.
- **Eskom Low Grade Stockpile**: Runoff and seepage from Eskom low grade stockpile will be directed to the Eskom low grade stockpile PCD. Contaminated water from this PCD will be pumped to the Plant Holding Dam for re-use.

The sized coal stockpile will be located adjacent to the Boschmans/Tweefontein plant and the Eskom low grade stockpile will be located to the north of the Waterpan Dump 1a. As for the plant, all stockpile areas will be terraced, enabling clear delineation of clean and dirty areas.

Storm water runoff from the product stockpile will be collected in a series of concrete lined perimeter drains which will convey the water to the CPP PCD, via silt traps.

The stockpile areas will be equipped with a clay liner and herringbone sub-surface drainage system to collect seepage water from the stockpile areas, minimising the ingress of dirty water to the groundwater system. The sub-surface drainage system will discharge into the perimeter storm water channel.

The storm water canals and pipes will be sized to prevent spillage of dirty water to clean areas (i.e. beyond the Stockpile boundaries) for events up to at least the 1:50 year recurrence interval (a 2% or lower risk of spill in any one year).

Coal discard facilities

Three discard facilities will be provided in a phased manner and are illustrated in **Figures 4.5.2 (c)** and **(d)**. These include:

- Existing Discard Facility
- Zaaiwater Discard facility from 2015 -2031
- Boschmans North Discard facility from 2031 onwards

A PCD will be provided at each discard facility to collect both storm water runoff and seepage from the discard sites. Storm water runoff will be collected by means of a concrete lined canal which will discharge via a silt trap into the PCD.

As for the stockpile areas, the discard facilities will be equipped with clay liners and herringbone sub-surface drainage systems. Seepage water collected in the sub-surface drainage system will discharge into the dirty water canal for collection in the PCD.

The storm water canals will be sized to prevent spillage of dirty water to clean areas (i.e. beyond the discard facility boundaries) for events up to at least the 1:50 year recurrence interval (a 2% or lower risk of spill in any one year).

Pollution control dams

All dirty water generated at the plant areas, stockpile and discard facility sites will be collected in the PCDs.

These dams will be equipped with geo-membrane (2.0 mm thick HDPE) liners to minimise seepage of contaminated water to the groundwater system and will be sized to prevent spillage for events up to at least the 1:50 year event (a 2% or lower risk of spill in any one year). Silt traps will be provided at the inlets to the PCDs to collect suspended solids and minimise the risk of capacity loss in the dams due to siltation.

In line with best practice, the PCDs will be operated as empty as possible at all times to ensure that sufficient storm water retention capacity is available at all times.

Water collected in the PCDs will be pumped to the Plant Holding Dam for reuse in the process. In the event that there is insufficient available capacity in the Plant Holding Dam during extreme rainfall conditions, surplus water will overflow via the storm water drainage system to the CPP PCD, from where it will be pumped to underground storage compartments at Boschmans.

4.5.2.4. Storm water management at the proposed Golf Course

The existing golf course at Tweefontein is to be mined through and it is therefore proposed to develop a new golf course on old rehabilitated opencast pits, namely old Hamster and Boschmans South East pits.

Water required for irrigation of the golf course will be supplied from Tweefontein Dam. The golf course designers have provided an average daily irrigation demand for the golf course which amounts to approximately 893 m^3/day. They also indicated that this number would vary during the different seasons, depending on evaporation, rainfall, growing conditions etc. Therefore irrigation demand can rise to around 1300 m^3/day during warm summers, and drop to around 500 m^3/day during cooler winter months, with less growth.

A layout of the proposed golf course can be seen in **Figure 4.5.2(d).**

Basic principles and recommendations for the storm water management at the proposed golf course are as follows:

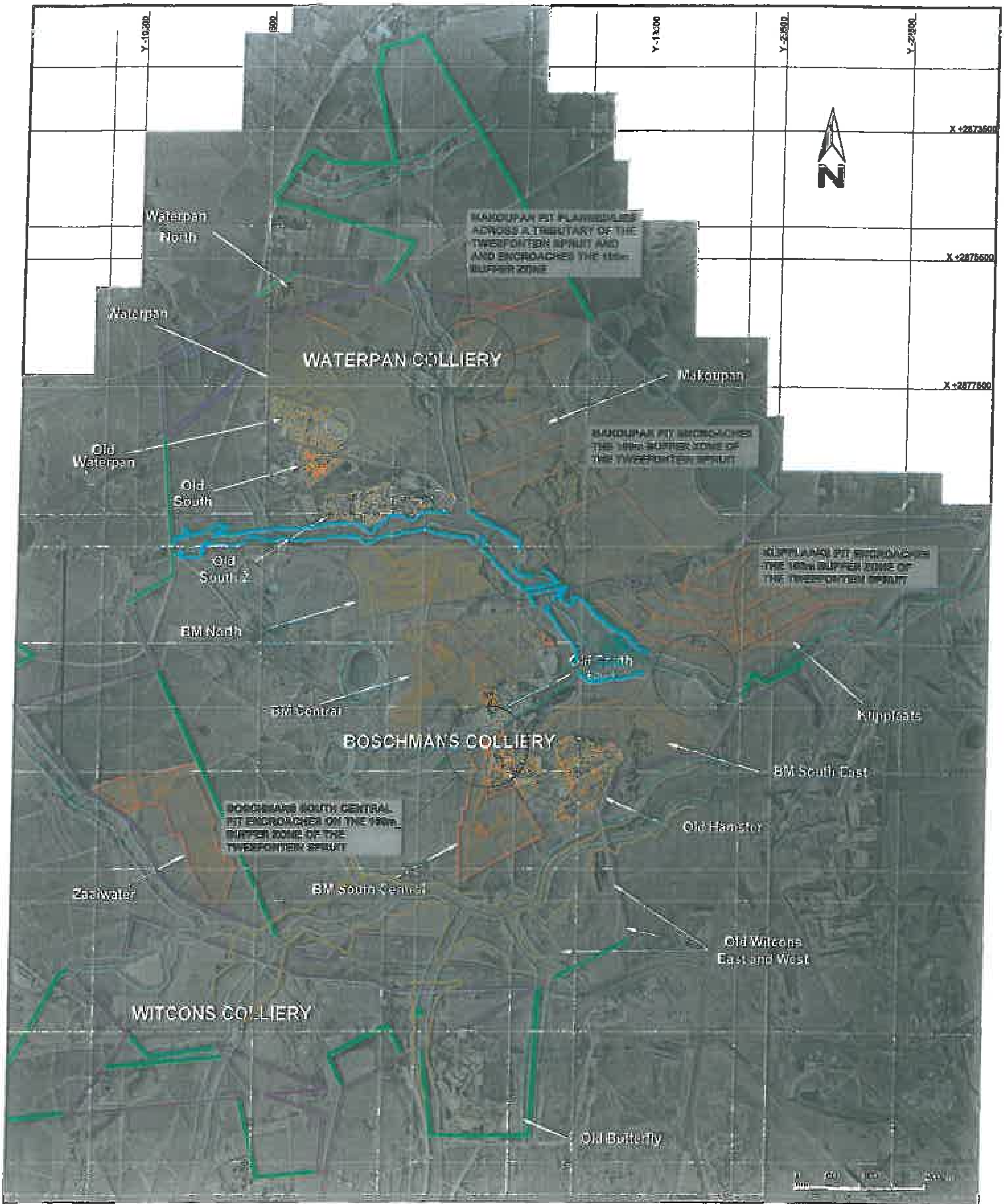
- Minimise mine water make by maximising free drainage areas i.e. avoid surface drainage into the final voids.
- However, if the expected water quality of runoff from the golf course is poor enough (due to fertilizers or irrigation using mine water) to preclude drainage to the natural rivers, then drainage must be to the voids.
- Drainage to voids is not desirable as it would increase the overall mine water make, adding to the overall water volumes that will ultimately require treatment. This would also not represent best practice.

4.5.2.5. Flooding of mine or mine infrastructure during extreme flood events

GN 704 stipulates that no mine workings may be placed within the 1:50 year floodline and no mine residue deposits or stockpiles may be placed within the 1:100 year floodline, or a distance of 100 m from any watercourse, whichever is the greater.

On the block plan, the following opencast mining pits are currently indicated to fall within the 1:50 year floodline or the 100 m buffer zone (refer to **Figure 4.5.2(h)**).

- Makoupan
- Klipplaat
- Boschmans South Central



LEGEND:

Surface Boundary	1 : 100 Year Floodlines (J&W)
Mineral Boundary	1 : 100 Year Floodlines (Others)
100m Buffer GNR 704	

Cape Lo29

Jones & Wagener Engineering & Environmental Consultants	Xstrata South Africa (Pty) Ltd Tweefontein Optimisation Project Amendment **OPENCAST PITS IN RELATION TO THE FLOODLINE AND GN 204 100m BUFFER ZONE**	Job No: D367/00 **Figure 4.5.2(h)**

The Makoupan pit also encroaches on buffer zone of the Pan to the North east as indicated in **Figure 4.5.2(h).**

With the exception of the above areas, the majority of the mine infrastructure, including the opencast pits, workshops, offices and related infrastructure is located well outside the 1:100 year floodlines.

Under extreme flooding conditions in the Tweefonteinspruit the workings at Makoupan, Klipplaat and Boschmans South Central could be flooded, with consequent contamination of the flood waters, as well as loss of life if this occurs during operations.

The extent of at Makoupan, Klipplaat and Boschmans South Central will need to be altered to prevent encroachment on the floodline of the Tweefonteinspruit. Alternatively, adequately sized and engineered flood protection berms will be provided at these pits.

No mining within these areas should take place without adequate flood protection measures in place, or the relevant authorisations, in terms of GN704 exemptions and Section 21(c) and (i) water use licenses (in terms of the NWA).

Please refer to the impact assessment in Section 8 for detailed mitigation measures.

4.5.3 Water storage facilities

4.5.3.1. General description of dams

Water containment dams at TOPA are given in **Table 4.5.3(a)**.

4.5.3.2. Safety Aspects

With the possible exception of the CPP PCD, Plant Holding Dam, MIA PCD and the Boschmans RWD, all of the other dams will have a wall height of less than 5 m and storage capacity less than 50 000 m^3 and will therefore not be classified in terms of Dam Safety Legislation (under Section 117(c) of the NWA).

Each dam will be surrounded by a security fence and lockable gate to prevent unauthorised access. In addition to this, warning signs at each dam as to dangers of drowning, warnings against drinking of the water and provision of emergency flotation devices will be provided. Access in and out of all water retaining structures will be ensured by means of ramps or ladders, as well as safety ropes (where ramps or slopes cannot be provided).

4.5.3.3. Sizing of dams

Legislation

South African legislation, in the form of Government Notice 704 (GNR704) of 1999, in terms of the NWA, stipulates that all dirty water must be contained, with a 2% or lower risk of spilling to the clean system in any one year (spill events are to be limited to once in 50 years or longer). Similarly, clean water diversion systems must also be designed to accommodate the 1:50 year event.

Sizing of the Dams

The Dams were designed by DRA consulting engineers and the sizing of the dams is detailed in their design report. The dams have been sized in accordance with GNR704 to have a risk of spill of 2% or less in any one year. This will be achieved by providing sufficient pumping capacity at each dam to enable the water to be pumped to the Plant Holding Dam before spilling to the environment. The CPP PCD will similarly be provided with sufficient pumping capacity to pump the expected peak flows to underground storage quickly enough to prevent spillage.

It should be noted that dams are only part of the overall water management strategy and as such the risk of spilling is dependent on several other components of the water management system, including operational practices, the rate of reuse of water from the dams and effective water level control in the dams.

Table 4.5.3(a) Pollution Control Dams and Capacities at TOP

PCD Dam name	Capacity	Status of Authorisation	Source
Coal Processing Plant PCD	150 000	Authorised under TOP	
Product Conveyor PCD West	2 300	Authorised under TOP	
Product Conveyor evaporation dam	7 500	Authorised under TOP	
MIA PCD	98 560	Authorised under TOP	
WaterPan 2 Seam Reservoir	1 500	Authorised under TOP	
Plant Holding Dam	80 000	Authorised under TOP	
Witcons PCD	12 000	Authorised under TOP	
Zaaiwater PCD	46 000	Authorised under TOP	Golder Associates Water use Table
Boschmans North Tailings RWD	250 000	New	
Vlaklaagte shaft Access PCD	7 200	Authorised under TOP	
Vlaklaagte shaft area reservoir	1 500	Authorised under TOP	
Eskom Low Grade Stockpile PCD	16 284	Authorised under TOP	
Product Conveyor PCD East	2 300	New	
WaterPan 2 Seam PCD	7 200	Authorised under TOP	

Please note that some of the water uses authorised in terms of the existing water use licences at Tweefontein Complex require amendment. The details of the required amendments were not available at the time of writing this report and an application for amendment will be submitted to the DWA once this had been confirmed by XSA.

A commitment is made in the impact assessment to calibrate the water balance once actual measured data is available from the site.

Assumptions

The assumptions used in the overall water balance model are set out in Section 5. These include aspects such as the following:

- The water use and water losses are based on values from the 2010 water balance
- The surface water inflows are estimated based on surface runoff models
- The surface areas used are based on layouts provided by XSA
- The rainfall and evaporation inputs are discussed in Section 5
- By their nature, models are theoretical estimates of natural phenomena that are too complex to be derived exactly. It is inevitable that there will be variations in the actual flows compared to predicted flows. These can only be addressed by recalibration of modelled data with measured data, from which more reliable estimates of extreme and average water flows can be developed.

4.5.3.4. Technical design of the proposed dams

The design of the dams will be based on the principles set out below.

Design parameters

As stated above, the dams will be sized, in conjunction with an abstraction pumping capacity, to ensure a risk of spill of 2% or less in any one year, as required by GN704. The planned capacities of each dam are provided in **Table 4.5.3(a)**.

Dam construction

It is proposed to construct the dams as follows:

- A homogeneous earth embankment will be constructed.
- A leak detection system will be installed in the dam basin.
- A clay liner will then be installed, on to which a 2mm HDPE liner will be placed.
- A stabilising layer will then be added, most likely cement stabilised soil to form a protective layer for the liner system, as well as to act as a ballast to prevent the liner from floating.

The above details will be confirmed in the IWULA.

Minimisation of siltation and seepage

- Siltation

  Sediment traps will be provided at the inlets to each PCD to collect fines in the storm water, minimise the risks related to reduced water holding capacity as a result of siltation and reduce the need to de-silt the dams in the future.

- Seepage

With the conceptual liner as given above, any leakage through the liner will be collected in the sub-soil drainage system and pumped back into the dam. Seepage is therefore not expected from the pollution control dams.

However, the existing plant and discard facility at Boschmans will be upgraded by means of a clean seepage collector system upstream of the plant (to address the perched water table that results in seepage entering the plant area) and a dirty seepage water collection system downstream of the site.

Inlets

Controlled storm water inlets will be provided at the pollution control dams for the discharge of storm and effluent water from the Plant and discard facilities. Silt traps will be provided at the inlets to minimise the risk of silt deposition in the dams.

Emergency overflow

The dams will be equipped with spillways to cater for emergency overflows.

The spillways will be sized to accommodate the required recommended design flood (RDF) and safety evaluation flood (SEF), as per the relevant South African National Commission on Large Dams (SANCOLD) guidelines.

Monitoring

- Stability

  The dams walls will be inspected regularly to ensure their stability and safety.

- Water quality

  The water quality in the dams will be sampled in accordance with the water quality monitoring programme detailed in Section 11.

- Water quantity

  Water levels in the dams, as well as pumping volumes, will be monitored on a regular basis to ensure that the site water balance is efficiently managed and to provide data that will allow calibration of the water balance model.

  These activities will be undertaken in accordance with the monitoring programme detailed in Section 11.

4.5.4 Polluted water treatment facilities

4.5.4.1. Process water treatment

XSA's current strategy for the management of dirty water generated by the mining activities is storage in mined out underground compartments and ultimately treatment for reuse or discharge to the river system. A water treatment plant is currently being planned and is expected to be in operation by October 2015. This plant will initially treat 15 Ml/day to a standard that can be discharged to the natural river system.

All dirty water generated at Tweefontein complex will ultimately be pumped to either the Boschmans South 4 Seam or the ATC 2 Seam underground workings (at iMpunzi Complex), where it will be stored prior to treatment. The treatment plant will pump directly from the ATC 2 Seam, as well as the Boschmans South 4 Seam workings.

A separate environmental authorisation process has been followed for the proposed water treatment plant.

4.5.4.2. Sewage water treatment

Staff housing will be provided in the hostel, therefore sewage treatment will be required for the staff during working hours as well as the staff living onsite. The number of staff expected to be on site on a daily basis has still to be confirmed, but the peak treatment capacities for the existing sewage facilities at Tweefontein Complex is 1160 m³/day. Details are given in **Table 4.5.4(a)** below.

Table 4.5.4(a) Sewage treatment plants at the various shafts and pits around Tweefontein Complex

Location	Hydraulic design capacity (DWAF, m³/d)	Type	Disposal of treated effluent
Waterpan (Coalville)	700	(Activated sludge) sewage plant	
Boschmansfontein	400	(Activated sludge) sewage plant	Return to beneficiation plant
Waterpan	60	Septic tank Sewage plant	Return to beneficiation plant after liming

As discussed previously, if the capacity of the above systems is not adequate, a new plant will be constructed with the necessary approvals being applied for.

All sewage water will be treated to the DWA general limits and the effluent will be released into the natural system.

4.6 Mine plan

The mine layout used for the surface water assessment and the overall water balance is shown in **Drawing Number D367-00-001** in **Appendix A**. Mining at Tweefontien Complex will continue until 2050. Certain of the TOPA areas are currently being mined in terms of the currently approved EMP.

4.6.1 Settlement and subsidence

Subsidence in the underground sections is generally prevented by ensuring htat the pillars are correctly sized to support the mine's roof. The required factors of safety to ensure this have been implemented in all of the recent underground areas at the Tweefontein Complex. However, in some of the older sections the safety factors are marginal, limiting the possible development (for example) of discard facilities on these undermined areas. There areas also some areas where stooping was undertaken, but where collapse has not occurred over the full area stooped. These areas have been identified and fenced off until such time as they have stabilised through collapse into the workings.

For opencast areas, settlement in the mining spoils is expected post mining.

4.6.2 Drainage paths that may be affected by mining

The mine area is extensive and many surface water resources are located within the TOPA boundaries. The main water resources that may be affected include the Tweefonteinspruit and its tributaries, the Saaiwaterspruit and 5 pans.

The current mine plan involves mining through the north eastern tributary of the Twefonteinspruit (which runs around the northern boundary of the old Waterpan plant area), as well as mining through, or adjacent to 2 of the pans.

In addition, some streams will be affected by haul roads, pipelines and conveyors, which need to cross them. The necessary licenses for these activities will be applied for in the TOPA Integrated Water Use License Application (IWULA).

4.7 Legacy rehabilitation project (Tweefonteinspruit river clean-up)

XSA Tweefontein complex have initiated a river clean up strategy at TOPA, (as indicated in **Figure 4.7(a)**), which will consist of various clean up phases around the Waterpan Dump area as well as at Tweefontein dam.

The project will entail isolation of the discard dumps to prevent ground water pollution, as well as clean water management in the form of clean water diversions around the dirty footprint area.

At the time of writing the above project had been put on hold by XSA Tweefontein Complex management.

Figure 4.7(a) Tweefonteinspruit River clean-up project

4.8 Watercourse alterations

Existing watercourse alterations within the Tweefontein Complex are listed below.

Waterpan Colliery:

- The flood protection berm at the plant area encroaches on the 1:100 year floodline of the unnamed tributary to the Tweefonteinspruit.
- Haul road crossing on the tributary at the plant.
- Rail crossing on the tributary at the plant.

- Secondary road crossing on the tributary, downstream of the plant.
- Waterpan discard dumps 1a, 1b and 2 are located within the watercourse.
- Mine access road across the Tweefonteinspruit, upstream of Tweefontein Dam.
- Tweefontein Dam, on the Tweefonteinspruit.

Boschmans Colliery:

- The plant pollution control dams are located on the 1:100 year floodline.
- Rail crossing on the Tweefonteinspruit at the plant area.
- The Moolmans defunct opencast pit is located within the 1:100 year floodline of an unnamed tributary to the Tweefonteinspruit. A stream diversion canal has been constructed to divert the flow around between the opencast pits.
- The R555 provincial road crosses the Tweefonteinspruit.
- The Waterpan South Pit opencast workings encroach on the 1:100 year floodline of the Tweefonteinspruit.

Witcons Colliery

- The flood protection berm at the plant area encroaches on the 1:100 year floodline of the unnamed tributary to the Tweefonteinspruit.
- Haul road crossing on the unnamed tributary.
- The Transnet Richards Bay railway line crosses both the Saaiwaterspruit and the unnamed tributary.
- The Goedgevonden Colliery rail loop crosses both the Saaiwaterspruit and the Klippoortjiespruit.
- Provincial Road R545 crosses both the Saaiwaterspruit and the Klippoortjiespruit.
- The access road to the Transnet Saaiwater rail siding, as well as the Witcons plant, crosses the Klippoortjiespruit.
- Witcons Dam is located on the Saaiwaterspruit.
- The Witcons old opencast pits are located on the floodplain of the Saaiwaterspruit, within the 1:100 year floodline.

Proposed watercourse alterations under the TOPA include the following:

- The terracing and infrastructure at the product surge bin encroaches on the 1:100 year floodline of the Tweefonteinspruit.
- The CPP Pollution Control Dam will be located within the 1:100 year floodline.
- The Product Conveyor PCD East will be located within the 1:100 year floodline.
- The Tweefonteinspruit river cleanup project will involve work within the watercourse of the Tweefonteinspruit, as well as the northern tributary which flows past the old Waterpan plant area and discard dump.
- Explosives magazines- new location will be within or close to a watercourse.
- Pipeline transferring water from Klipplaat East and West to ATC borehole crossing of Saaiwaterspruit.
- Pipeline transferring water from Klipplaat East and West to ATC borehole crossing of unnamed tributary to the Saaiwaterspruit.
- Additional opencast mining areas within or close to watercourses.

- Borrow pits within or close to watercourses.
- New Golf course
- Boschmans weir

Proposed watercourse alterations under the TOP that will require amendment, will include alterations to additional opencast areas within or close to watercourses.

Proposed watercourse alterations already applied for under the TOP will include:

- Pipeline to transfer water from the MIA PCD to the Plant Holding Dam.
- Pipeline to transfer water back from the Plant Holding Dam to the MIA area.
- New load out conveyor maintenance road to rail loop area.
- New haul road at Tweefonteinspruit
- New MIA access road culvert on Tweefonteinspruit
- Crossing of conveyor belt over Tweefonteinspruit to load out facility
- Northern river crossing of conveyor belt on Tweefonteinspruit to load out facility
- River crossing on Tweefonteinspruit for slurry pipeline and return water to plant
- Moolmans river diversion and haul road crossing on Tweefonteinspruit
- Boschmans North Pit ROM discard conveyor belt wetland crossing and river diversion on Tweefontienspruit
- Waterpan discard dump rehabilitation
- Old Witcons rehabilitation
- Various opencast mining areas through wetlands

5. WATER BALANCE

The objective of the water balance modelling is to estimate the volumes of water that will be generated by the proposed activities, including effluent water and surface runoff from the dirty areas. This is assessed, together with the water demands on the site, to determine whether the site will operate with a water surplus or deficit and to determine the storage capacity required to ensure legal compliance in terms of prevention of spills from the site. The water balance modelling is therefore a key input to the overall water management strategy for the site.

5.1 Mine Plan

The 2013 LOM plan was used for the water balance modelling of the future mining areas. Plans of historical opencast and underground 1, 2, 4 and 5 seam mining, provided by XSA, were used to determine the current water make.

5.2 Computational methodology

Daily rainfall data from the South African Weather Service (SAWS) rainfall stations 0478292 Langsloot and 0478330 Secunda, together with monthly evaporation data estimated from the "Surface Water Resources of South Africa 1990" (WRC, 1995), also known as WR90, were input to a hydrological model based on the Soil Conservation Services (SCS) method to determine runoff on a daily basis using antecedent conditions. The method (as adapted to South African conditions by Schmidt & Schulze) is believed to be highly suitable for the site, having been developed in catchments with areas of approximately 8 km^2, and smaller.

The groundwater inflows to the future and historical opencast areas were derived by Groundwater Complete. Recharge rates to the underground workings were also derived by Groundwater Complete. These rates of inflow were then brought into the J&W model, where extreme rainfall impacts and surface water make can be assessed. The water use and storage / treatment requirements can subsequently be computed.

The surface runoff areas were measured from layout drawings and aerial photographs provided by XSA, DRA and Clean Stream. Water consumption information related to the mining operation was provided by XSA and DRA. This data was entered into the water balance model.

The overall water balance for the mine was subsequently calculated.

5.3 Assumptions, information used and limitations

5.3.1 Assumptions and information used

The overall schematic water balance for Tweefontein is presented in the figures in Section 5.5. These figures indicate the average underground, opencast and surface water make over the life of the mine. Please note that, as can be seen in the figures, the life of mine has been divided into three phases (i.e. 2015 when Witcons plant Waterpan plant is rehabilitated is rehabilitated, 2015-2031 when Zaaiwater slurry dam comes on line and 2031 onwards when Boschmans North slurry dam comes on line) and a schematic water balance flow diagram is presented for each.

The following activities are included:

- Water used for dust suppression on surface, at the ROM tip, MIA workshop as well as at the main plant has been accounted for.

- Surplus dirty water from the pollution control dams (PCDs) (that cannot be treated) will be stored in various underground workings.
- The Xstrata Alloys Independent Power Plant (IPP) is to be supplied from the Plant Holding Dam.
- Potable water use at the workshops, offices and change house will be supplied from the potable water treatment plant. Information regarding potable use is still required.
- Sewage flows from the change house, workshops and offices will be directed to the sewage treatment plants at the Tweefontein and Vlaklaagte areas. The treated sewage wastewater will be released into the environment (i.e. Tweefonteinspruit).
- Dirty runoff from each of the dirty areas will be directed to the designated PCD for that area.
- The proposed golf course is to be located on the rehabilitated old opencast South East Pit (Moolmans) and Hamster Pit.
- 30 ha of the golf course will be irrigated at an average rate of 893 m³/day, as indicated by the golf course designers. This irrigation rate was taken into account in the water balance.

The following key assumptions and information have been used:

- Runoff from the external catchment draining towards mine surface infrastructure area will be diverted, minimising the volume of water reporting to the PCDs.
- The underground and opencast mining areas used for the modelling are based on the LOM plans as indicated in **Table 5.3(a)** below.
- The surface water inflows to the dams are estimated, based on the surface runoff model.
- The layout drawings used to delineate the various sub-catchments on the mine surface infrastructure site were provided by CSEC, as well as XSA. These are indicated in **Table 5.3(a)** below.
- Infrastructure drawings indicating the positions and sizes of the proposed borrow pits on the mine were provided by CSEC, as well as XSA. These were used to model the water balance for each borrow pit. These are indicated in **Table 5.3(a)** below.
- It was assumed that the borrow pits will be opened at the start of mining (i.e. 2012 and will remain until they are mined through).
- Information received from the Golf Course specialist is given in **Table 5.3(b)** below.
- The capacity of the PCDs was provided by XSA, as well as DRA Mining, and summarised in a table by Golder Associates. This is reproduced in **Table 5.3(c)** below.
- Irrigation water required for the Golf course will be supplied in a ratio of 40% and 60% from the final voids and Tweefontein dam respectively.
- In terms of water losses, the following assumptions, based on the 2010 Water balance model for Tweefontein were considered reasonable for the purpose of the water balance modelling:
  - Dust suppression on surface of 1 000 m³/day was assumed.
  - Dust suppression at MIA workshop area of 80 m³/day was assumed.
  - Dust suppression at New ROM tip of 80 m³/day was assumed.
  - Dust suppression at the Plant area of 704 m³/day was assumed.

- IPP water supply of 1 200 m³/day was assumed.

- It was assumed that 60% of the water from the CPP will be returned to the Plant Holding Dam and the remainder will be stored underground.
- Groundwater inflows to the opencast areas were provided by Groundwater Complete on 19 August 2013 (file name "OpencastinflowsforJ&W-08-2013.xls").
- Recharge rates to the underground workings were provided by Groundwater Complete on 3 September 2013 (file name "EstimatedGWinflowoverLOM-09-2013.xls").

Table 5.3(a) List of Drawings received from XSA and CSEC

Drawing Description	Date received	Date indicated on the drawing	Details
2012 TOP Opencast Amendment – JH - 20130726	29 July 2013	5 June 2013	LOM
TFN North 1 Seam UG EMP .dwg	29 July 2013	4 June 2013	LOM
TFN North 2 Seam UG EMP Rev 4.dwg	29 July 2013	4 June 2013	LOM
TFN 4 Seam mined out and future mining	17 Oct 2012	15 Oct 2012	LOM
TFN North 5 Seam G EMP.dwg	29 July 2013	24 June 2013	LOM
TOP-PBA-1001-CN01-1015Rev CS.dwg	29 July 2013	26 July 2013	Infrastructure

Table 5.3(b) List of information received from the Golf course specialist

Drawing Description	Date received	Details
Golf Course Tabulated. pdf	19 Feb 2013	Conceptual details
Golf Course Irrigation Estimates.pdf	19 Feb 2013	Irrigation demands
Golf Course Planning concept.pdf	19 Feb 2013	Preliminary concept

Table 5.3(c) List of PCD names and capacities

PCD Dam name	Capacity	Source
Coal Processing Plant PCD	150 000	Golder Associates Water use Table
Product Conveyor PCD West	2 300	
Product Conveyor evaporation dam	7 500	
MIA PCD	98 560	
WaterPan 2 Seam Reservoir	1 500	
Plant Holding Dam	80 000	
Witcons PCD	12 000	
Zaaiwater PCD	46 000	
Boschmans North Tailings RWD	250 000	
Vlaklaagte shaft Access PCD	7 200	
Vlaklaagte shaft area reservoir	1 500	
Eskom Low Grade Stockpile PCD	16 284	
Product Conveyor PCD East	2 300	
WaterPan 2 Seam PCD	7 200	

Information regarding potable water intake and use, as well as sewage treatment volumes and effluent discharge volumes has not been included in the modelling at this stage.

5.3.2 *Limitations*

Important limitations to the modelling include the following:

- By their nature, models are theoretical estimates of natural phenomena that are too complex to be derived exactly. It is inevitable that there will be variations in the actual flows when compared to the predicted flows. This can only be addressed by the recalibration of modeled data with measured data, from which more reliable estimates of extreme and average water make and runoff volumes can be developed.

- The overall mining plan is likely to change as the mine develops and more information becomes available on the actual geology, as opposed to that predicted at the planning stage.
- The water use and water losses are assumed based on information obtained from the client, as well as typical values for similar operations.
- It is important to note that the timing of rehabilitation can have a significant impact on the overall water balance. It is therefore important that the water balance be revisited during the mining operation.
- Volumetric modelling of the underground water storages and pumping / dewatering is not included in the Tweefontein Complex water balance model. This modelling will form part of the XSA overall water balance model.

5.4 Rainfall data

5.4.1 Selection of rainfall station

The water balance modelling approach used historical daily rainfall data from rainfall stations close to the site. Stations within a 50 km radius were considered. The water balance modelling requires historical daily rainfall data from a gauge in close proximity to the site. The rainfall data from the Langsloot and Secunda rainfall stations was evaluated and found to have reliable data, with observed extreme events within the record. The records were found to have similar characteristics and were combined to create a rainfall record spanning from 1914 to 2008, a record length of 95 years. The statistical extremes for the combined rainfall record are presented in **Table 5.4(a)**.

Selection of rainfall station

The issue of which rainfall station should be used for the water balance modelling is often raised. At this site, the baseline hydrology (peak flood flows, etc.) has been computed using the Ogies rainfall station. However, Langsloot is preferred for the water balance modelling. The motivation for this is as follows:

- Ogies rainfall data has events of 1 day, 2 day, 3 day and 7 day duration that are equivalent to the 1:20 year statistical events for the area, as computed by Adamson (TR102). This is problematic for daily simulations in that the modelling undertaken is intended to provide at least a 1:50 year risk of spilling. By contrast, the baseline hydrology and flood peaks use methods that are more robust in terms of the rainfall characteristics of the general area.
- For the same short duration rainfall events, the Langsloot rainfall record contains several extreme events, ranging from 1:200 years for the 1 day event to 1:50 years for the 7 day event. Langsloot is still relatively close to the site (although not the closest gauge), being just under 40 km away. The rainfall record has a slightly lower MAP than Ogies, but (as indicated) higher extreme events. In terms of the overall mapping of rainfall in the area, there are no significant climatic differences within this general area and the use of the Langsloot station offers a more conservative water balance modelling approach.

Table 5.4(a) Statistical rainfall extremes for the combined Langsloot/Secunda rainfall station

Event	Rainfall depth (mm)					
	1 day	2 day	3 day	7 day	1 month	Annual
1:2 yr	63	86	101	146	188	727
1:10 yr	93	121	137	182	248	897
1:20 yr	109	140	154	195	275	932
1:50 yr	136	168	178	212	313	965
1:100 yr	160	194	199	225	344	983
1:200 yr	188	223	221	238	378	998
Max Recorded	175	196	196	212	368	1087

5.4.2 *Rainfall extremes*

The Langsloot rainfall record was analysed to look at the wet cycles. Extreme rainfall for the hydrological years seldom exceeds 2 to 3 years in duration, with the longest "wet cycle" approximately 5 years to peak.

Wet or extreme periods used in the modelling include the rainfall experienced in:

- 1992 and following years (wettest five years on record)
- 1951 and following years (second wettest five years on record)
- 2004 and following years (short term peak – wettest two years on record)
- 1961 and following years (driest five years on record).

5.5 Water balance modelling

5.5.1 *Water Make*

The total mining water make is expected to increase from a current value of approximately 7 Ml/day to a maximum of approximately 27.6 Ml/day at around 2049/50, for average rainfall. The average water make over the remaining life of mine will be approximately 19 Ml/day.

The contributions from the individual opencast and underground sections are expected to be as shown in **Table 5.5(a)**, for average rainfall.

The combined underground and opencast water make is shown in **Figure 5.5(a)**. This figure presents the water make over the life of the mine, for average rainfall, showing the predicted seasonal variation in water make. The individual contributions from the opencast and underground sections are shown in **Figures 5.5(b)** to **(h)**.

The post closure water make is estimated for underground to be approximately 2 083 m^3/day and opencast to be 24 778 m^3/day, with the total post closure water make for Tweefontein complex estimated at 26.9 Ml/day for average rainfall.

Table 5.5(a) Estimated water make at the individual sections, for average rainfall

Mining section	Average water make over LOM (2012 to 2050) (m^3/day)	Maximum annual water make (m^3/day)	Peak summer water make (m^3/day)	Post closure water make (m^3/day)
Opencast:				
Waterpan North	338	1505	1937	1465
Waterpan	1686	4202	6690	3896
Makoupan	3705	8116	15275	7239
Boschmans North	1436	1786	3121	1524
Boschmans Central	1841	2428	4026	2224
Boschmans South East	741	1130	2345	876
Boschmans South Central	920	1581	2529	1480
Klipplaat	2215	2883	6003	2424
Zaaiwater	1019	1162	2096	1008
Waterpan Old opencast	396	-	745	396
Witcons Old opencast	291	-	536	291
South 2 old Pit opencast	431	-	798	431
South old Pit opencast	131	-	242	131
South East pit opencast	790	-	1563	790
Old Hamster pit	603	-	1204	603
Underground:				
Witcons 2 and 4 Seam	345	356	772	338
Old No. 1 2 Seam	3	21	46	1
Boschmans South East 2 Seam	102	140	304	85
Vlaklaagte (1, 2, 4 &5 Seam)	149	166	361	166
Waterpan (1, 2, 4 & 5 Seam)	687	965	2097	361
Boschmans North (1, 2 & 4 Seam)	436	496	1078	445
Klipplaats 2 and 4 Seam	83	234	507	58
Boschmans South 2 and 4 Seam	634	651	1417	629

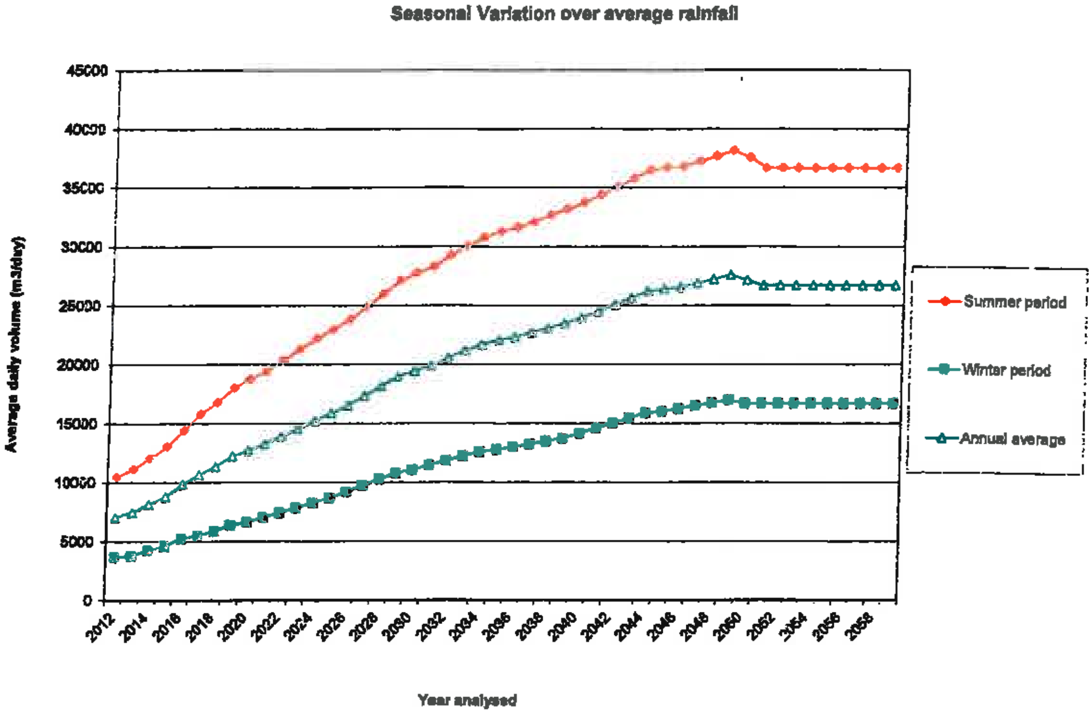


Figure 5.5(a) **Graphical water balance for average rainfall during the operational and post closure phases, showing seasonal variations**

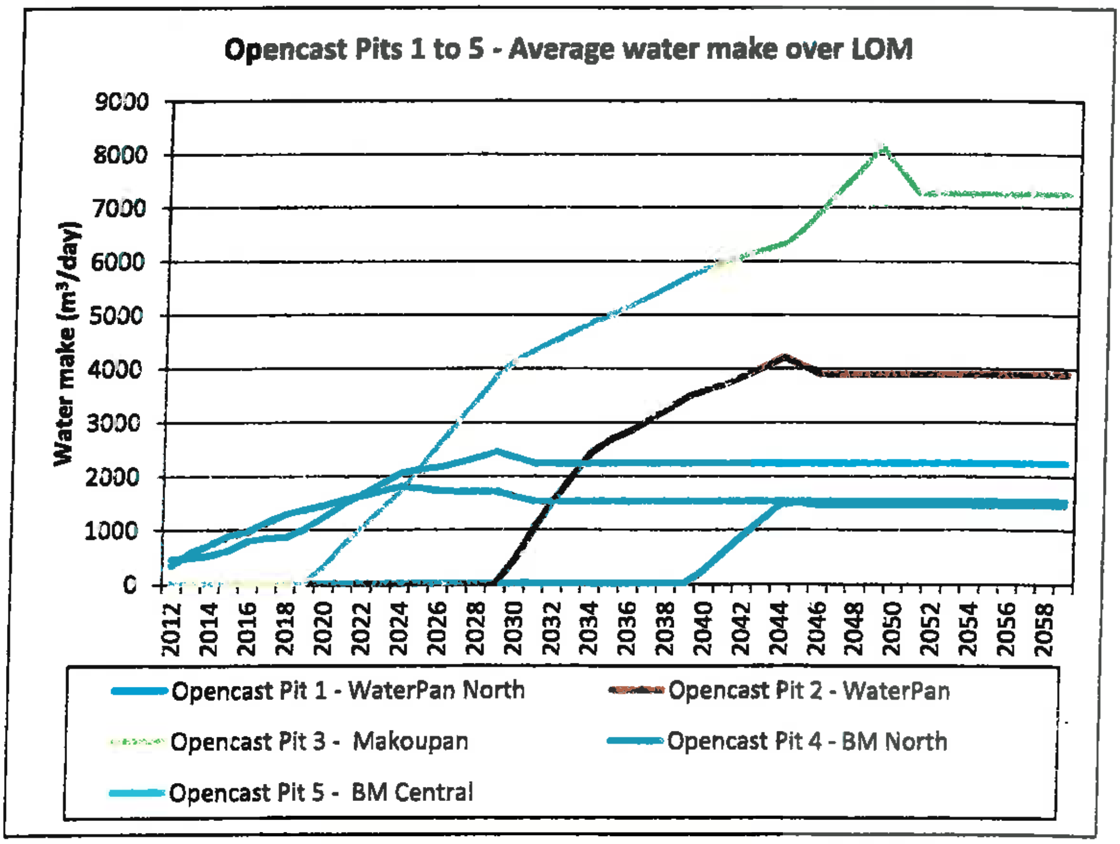


Figure 5.5(b) **Graphical water balance for average rainfall during the operational and post closure phases: Opencast pits 1 to 5**

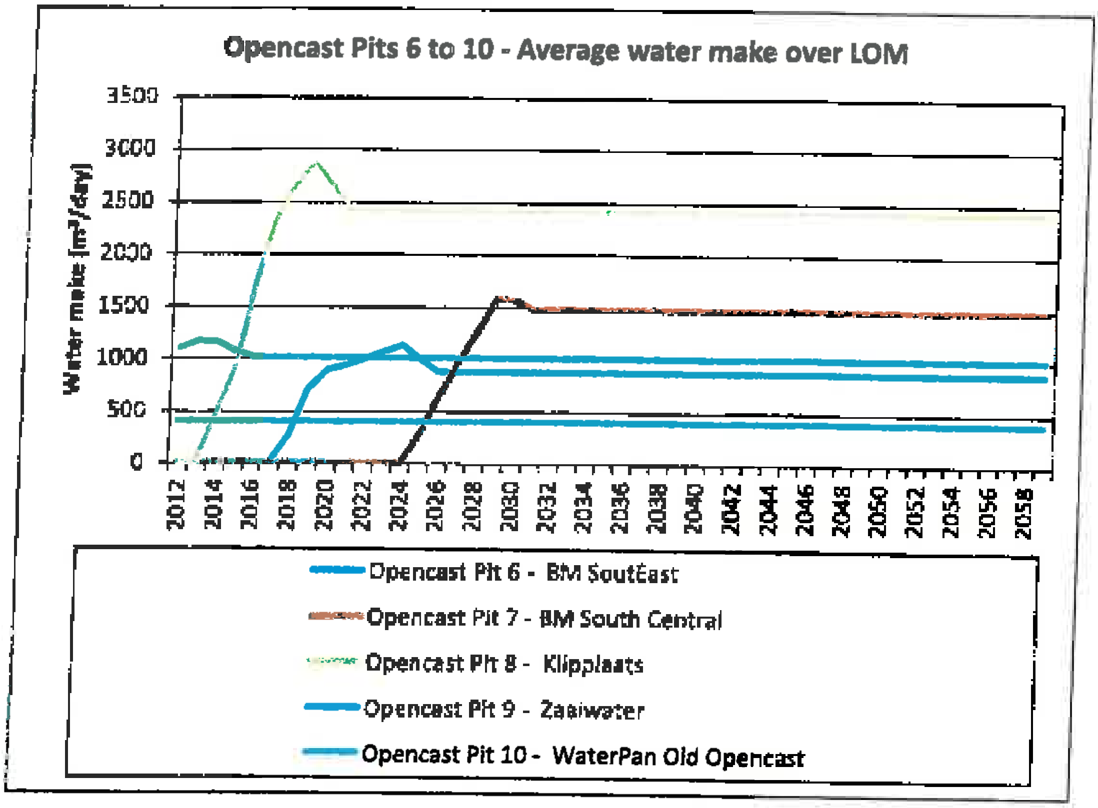


Figure 5.5(c) **Graphical water balance for average rainfall during the operational and post closure phases: Opencast pits 6 to 10**

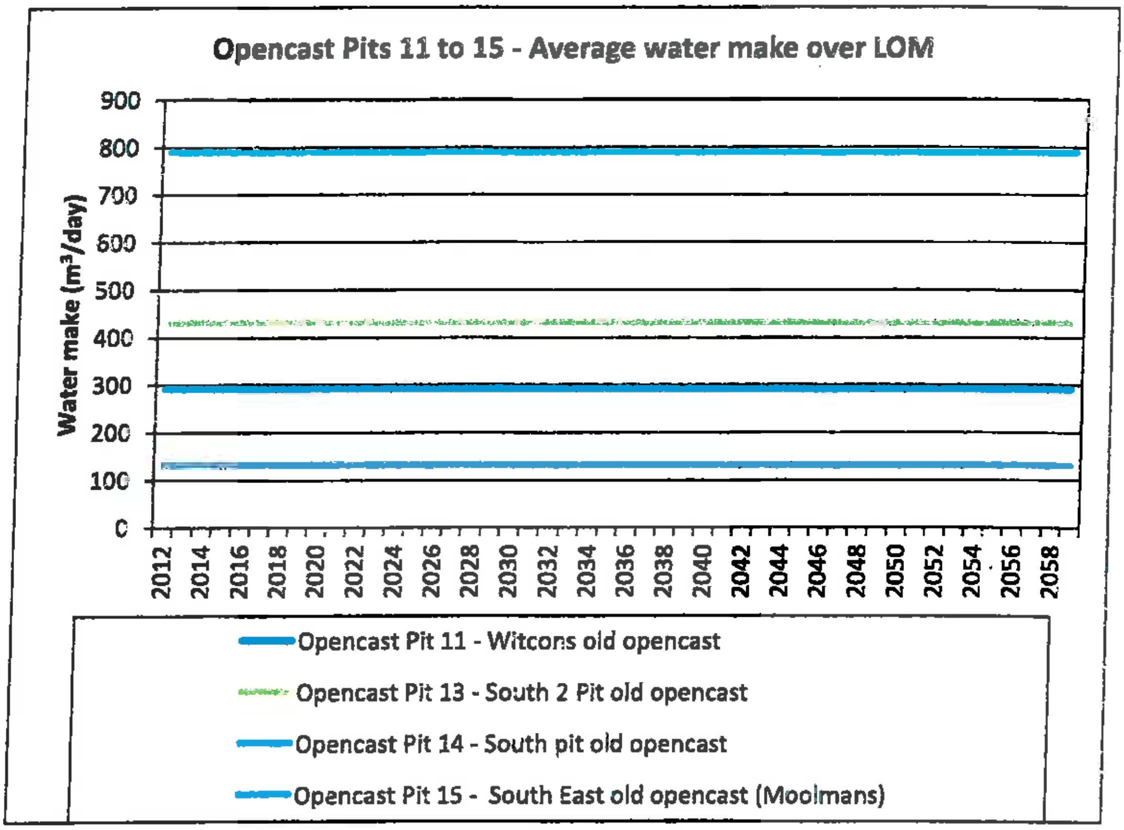


Figure 5.5(d) **Graphical water balance for average rainfall during the operational and post closure phases: Opencast pits 11 to 15**

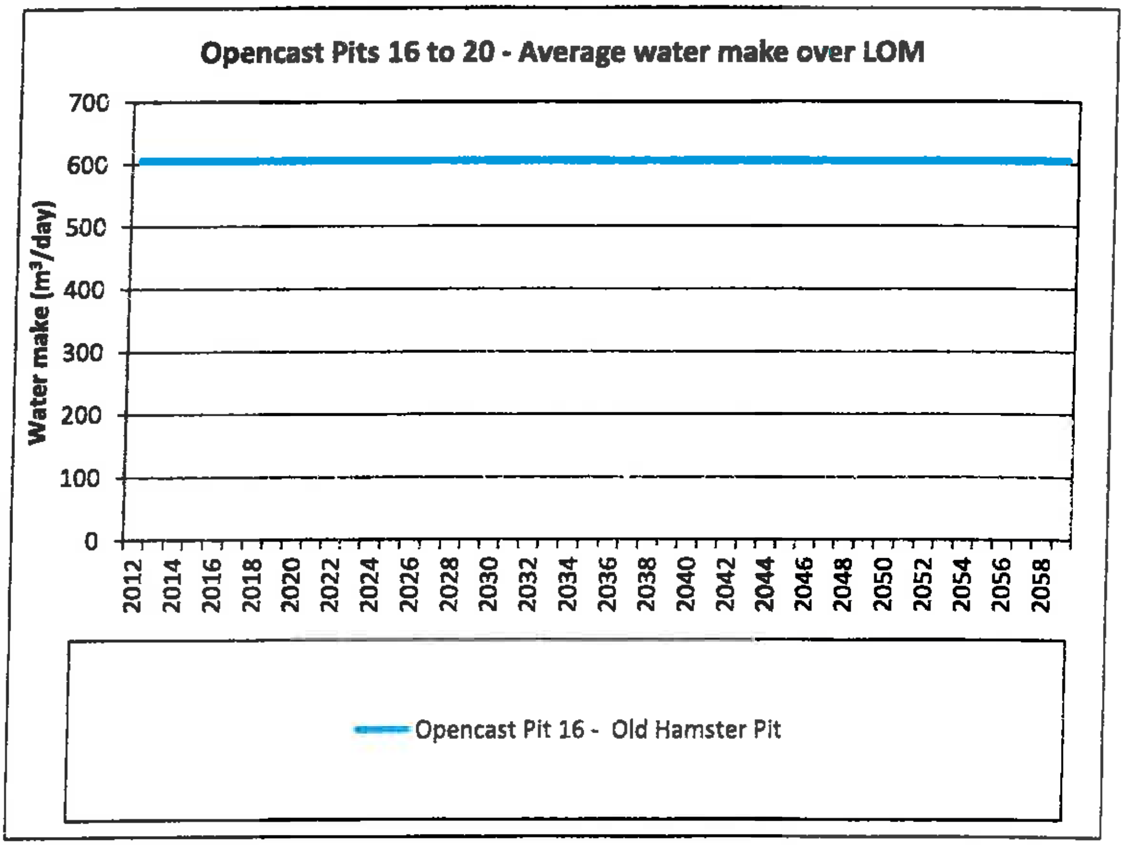


Figure 5.5(e) **Graphical water balance for average rainfall during the operational and post closure phases: Opencast pits 16 to 20**

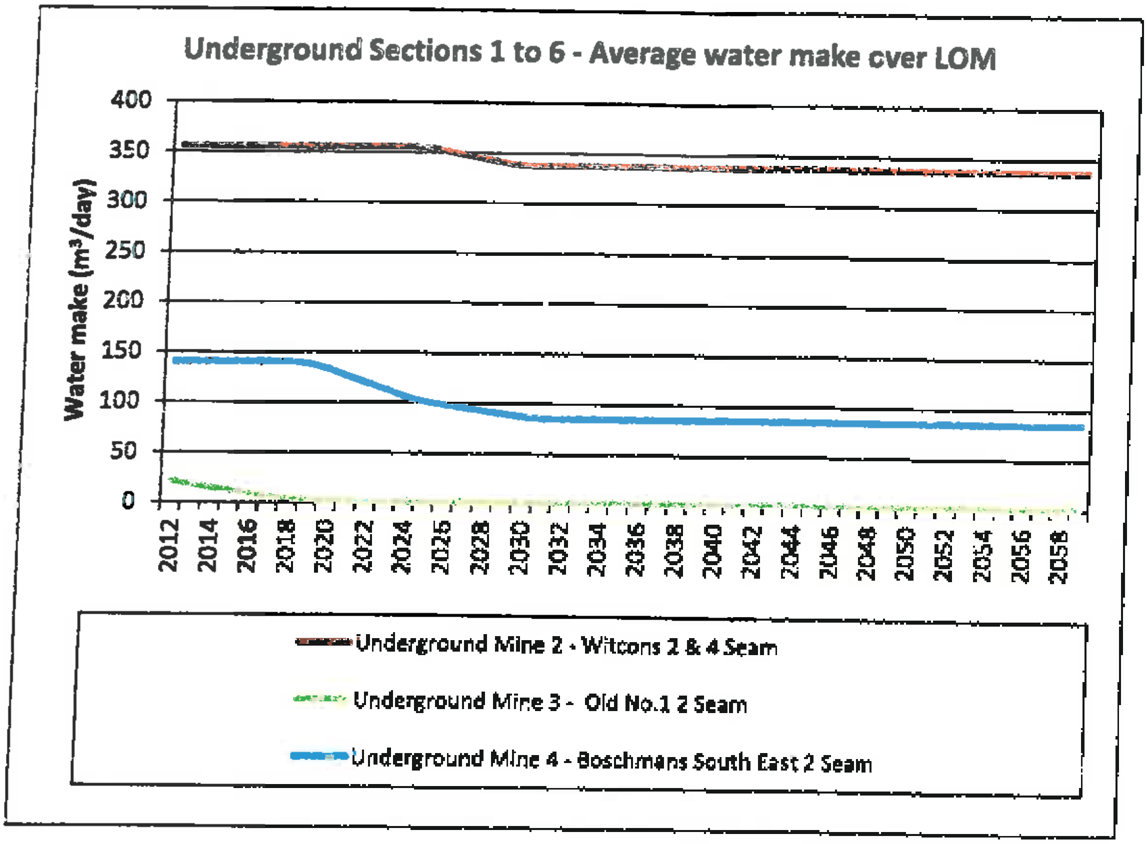


Figure 5.5(f) **Graphical water balance for average rainfall during the operational and post closure phases: Underground sections 1 to 6**

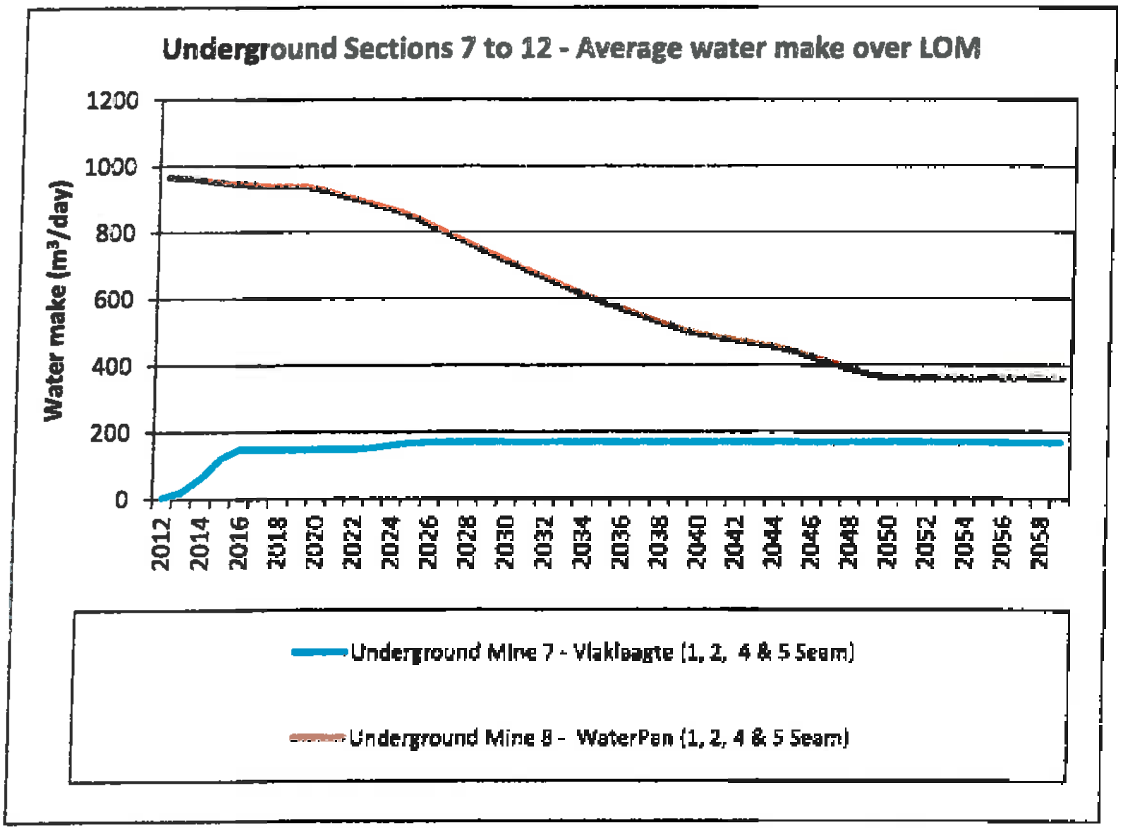


Figure 5.5(g) **Graphical water balance for average rainfall during the operational and post closure phases: Underground sections 7 to 12**

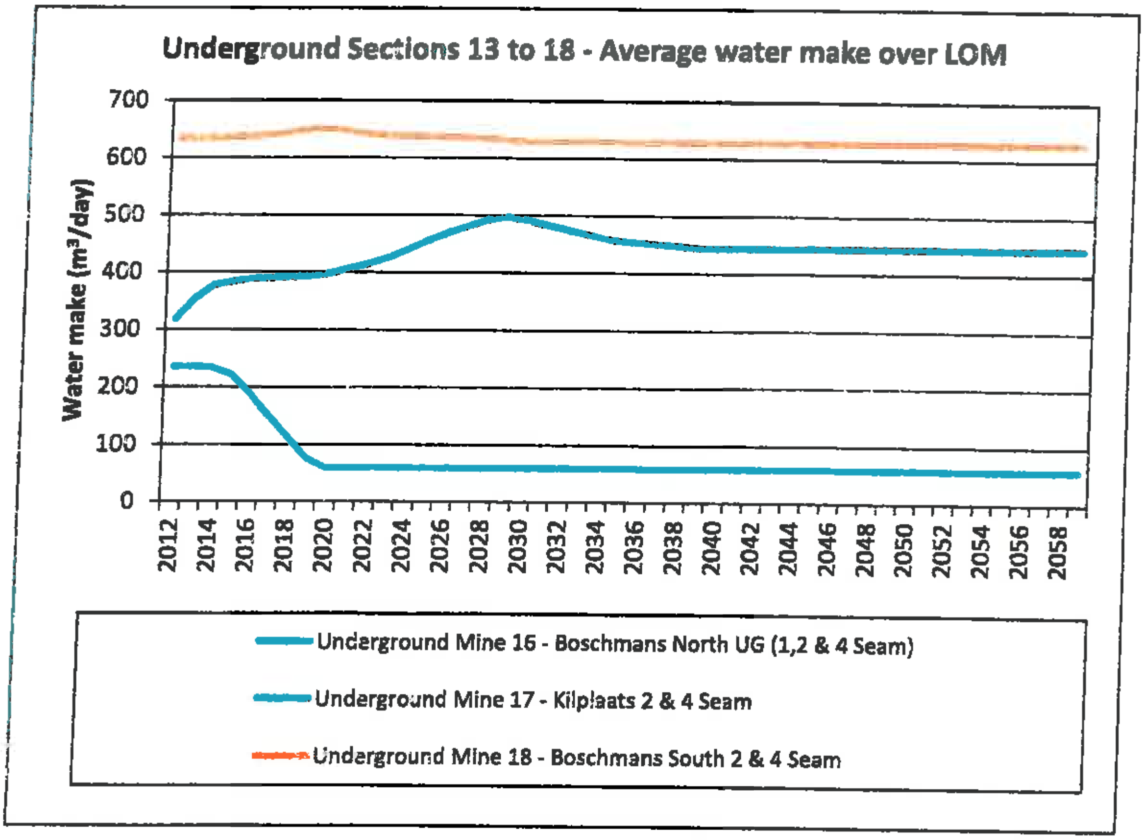


Figure 5.5(h) **Graphical water balance for average rainfall during the operational and post closure phases: Underground sections 13 to 18**

5.6 Water Use

Water is used at Tweefontein complex for coal processing, dust suppression and domestic use.

The water use at the coal processing plants has been quantified as shown in **Tables 5.6(a)** and **(b)** for the TOP and Witcons plants respectively. Based on discussions with XSA, it has been assumed that the Witcons plant ceases operations in 2016.

Dust suppression and domestic use are shown in **Table 5.6(c)**.

5.7 Dewatering

In order to mine many of the reserves at Tweefontein complex, it will be necessary to dewater underground sections that have been allowed to accumulate water since mining ceased. The dewatering at Tweefontein complex involves pumping of water between underground sections and the water will not be deposited in surface dams. The volumetric balances of the underground storage areas is modelled in the overall XSA water balance. The planned dewatering schedule is, however, summarised in **Table 5.7(a)**.

Table 5.6(a) Water use at TOP Plant

Description	Water (m^3/day)
Based on 15.0 Mtpa ROM	
Plant water demand	16 633
Water in ROM feed coal	3 738
Water in product	2 056
Water in discard	6 280
Water in slurry	12 035
Slurry return (at 62.5%)	7 522
Make-up requirement	9 111

Table 5.6(b) Water use at Witcons Plant

Description	Water (m^3/day)
Plant water demand	2 737
Water in ROM feed coal	350
Water in product	630
Water in discard	357
Water in slurry	2 100
Slurry slurry water to UG (at 60%)	1 253
Make-up requirement	2 737

Table 5.6(c) Dust suppression and domestic use at Tweefontein complex

Description	Water use (m^3/day)	Source
Dust suppression on surface	1000	2010 Water Balance
Dust suppression at MIA workshop area	80	
Dust suppression at New ROM tip	80	
Dust suppression at the Plant area	704	
IPP water supply	1200	
Abstraction to Plant Reservoir	16 633	

Table 5.7(a) Planned dewatering schedule at Tweefontein complex (taken from Golder Associates planning model)

Mining area	Pump to	Dewatering Start-end	Volume to be dewatered (m^3)	Maximum Dewatering Rate (m^3/month)
Old Ogies UG (at Goedgevonden)	Waterpan 2 Seam	Jan 13 – Jul 14	4 800 000	300 000
Goedgevonden OC (at Goedgevonden)	Waterpan 2 Seam	Jan 13 – Dec 14	2 000 000	350 000
Waterpan 2 Seam	Boschmans South	Jan 24 – Dec 33	15 000 000	167 000
Waterpan 4 Seam	Waterpan 2 Seam	Jan 24 – Dec 27	3 000 000	62 500
Old No. 1	Boschmans South	Aug 12 – Dec 12	1 400 000	300 000
Boschmans North	Boschmans South	Jan 13 – Dec 23	8 700 000	230 000
Boschmans South/East	Boschmans South	Jul 13 – Dec 14	6 520 000	365 000
Klipplaat East	ATC 2 Seam (at iMpunzi)	Jul 13 – Aug 15	7 515 000	300 000
Klipplaat West	ATC 2 Seam (at iMpunzi)	Jan 14 – Dec 15	2 145 000	92 000
Makoupan	Boschmans South	Jul 17 – Dec 18	3 300 000	205 470
Boschmans South	Water Treatment Plant	Oct 15 onwards	56 000 000	225 000

5.8 Schematic water balance diagram

The schematic water balance diagram is presented in **Figures 5.8(a)** to **(f)**, and indicates the expected average flows over the life of mine. The potable water balance has still to be compiled.

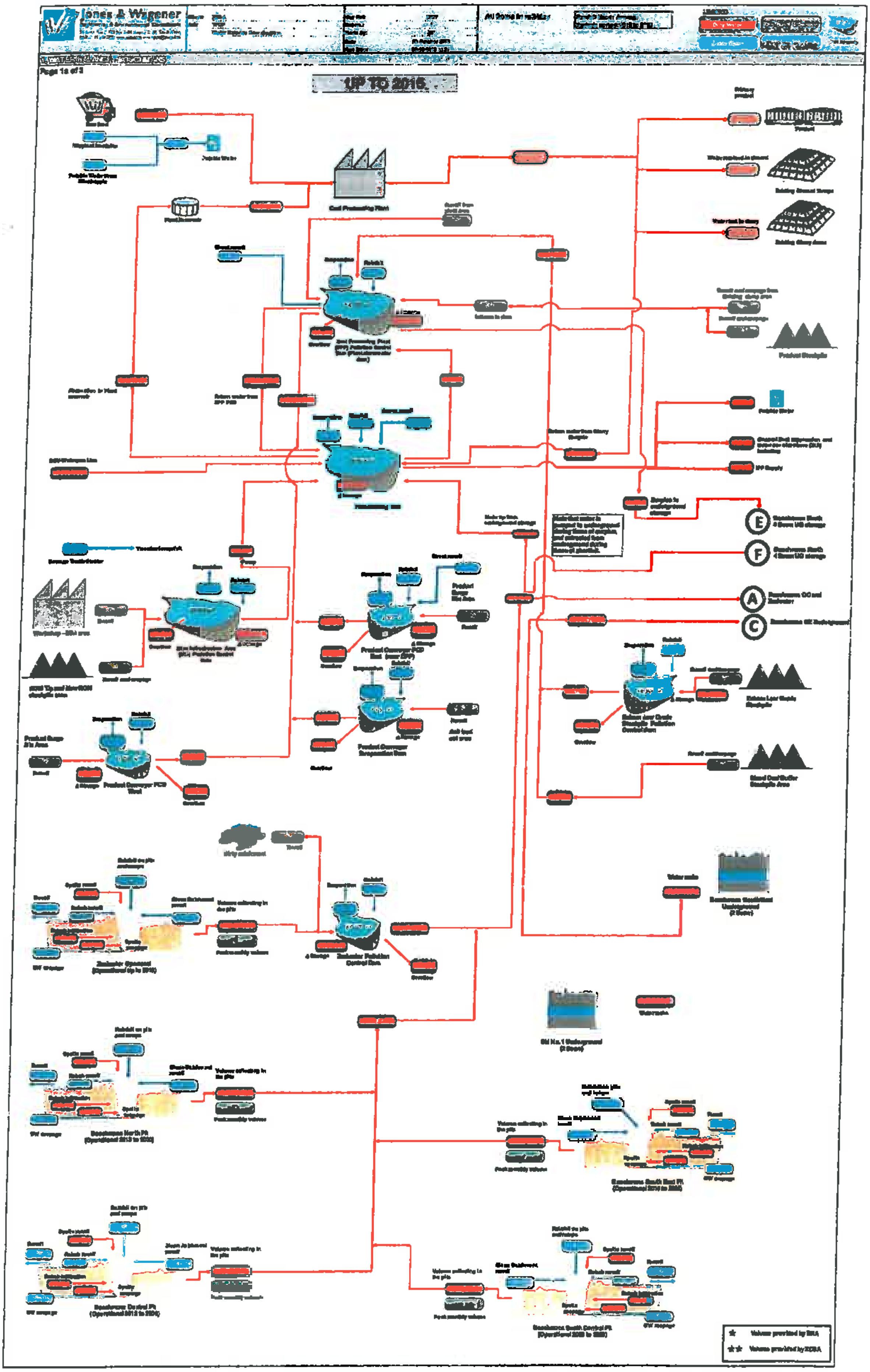


Figure 5.8(a)(i) Schematic water balance diagram (2012 to 2015) – page 1 of 3

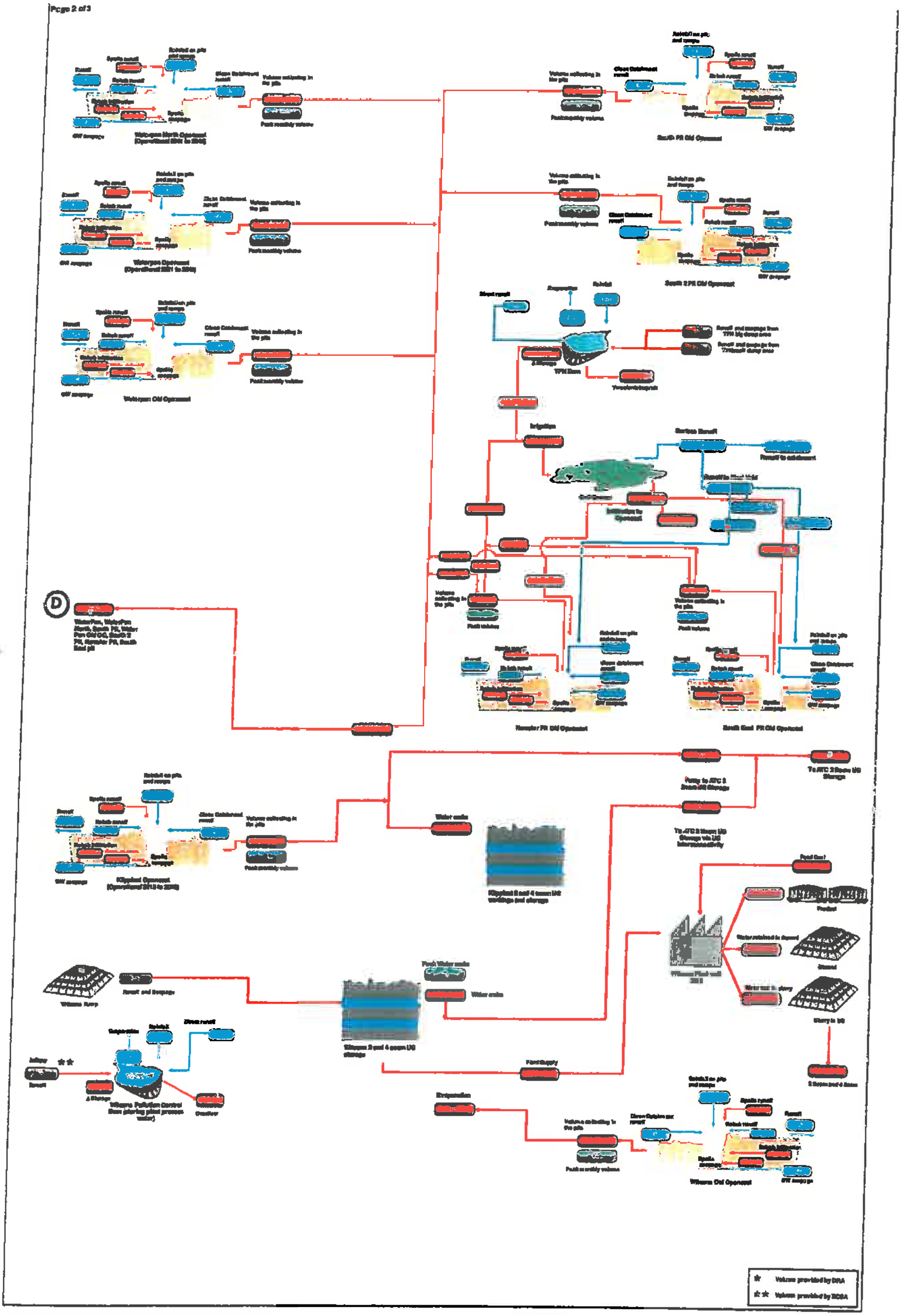


Figure 5.8(a)(II) Schematic water balance diagram (2012 to 2015) – page 2 of 3

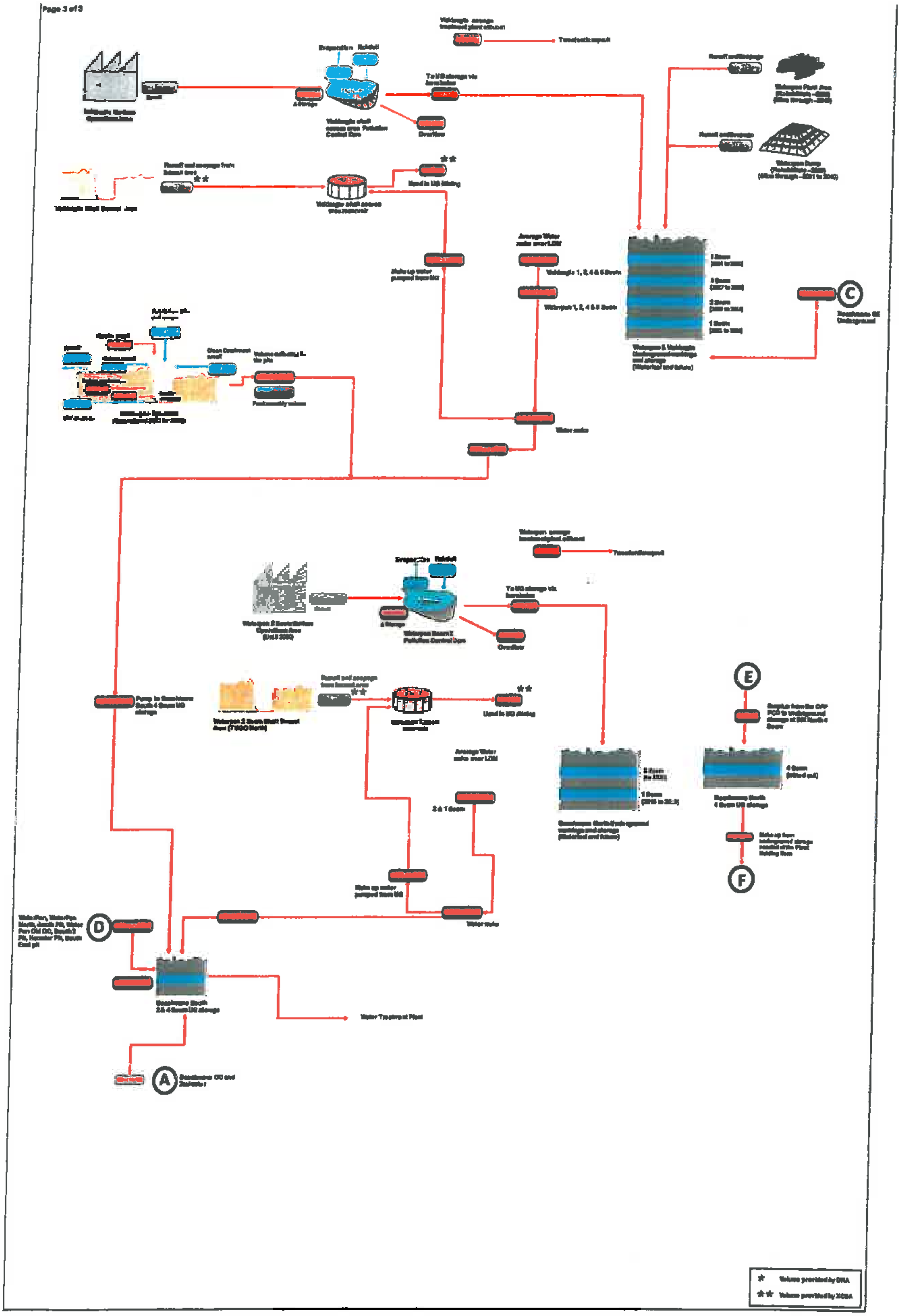


Figure 5.8(a)(iii) Schematic water balance diagram (2012 to 2015) – page 3 of 3

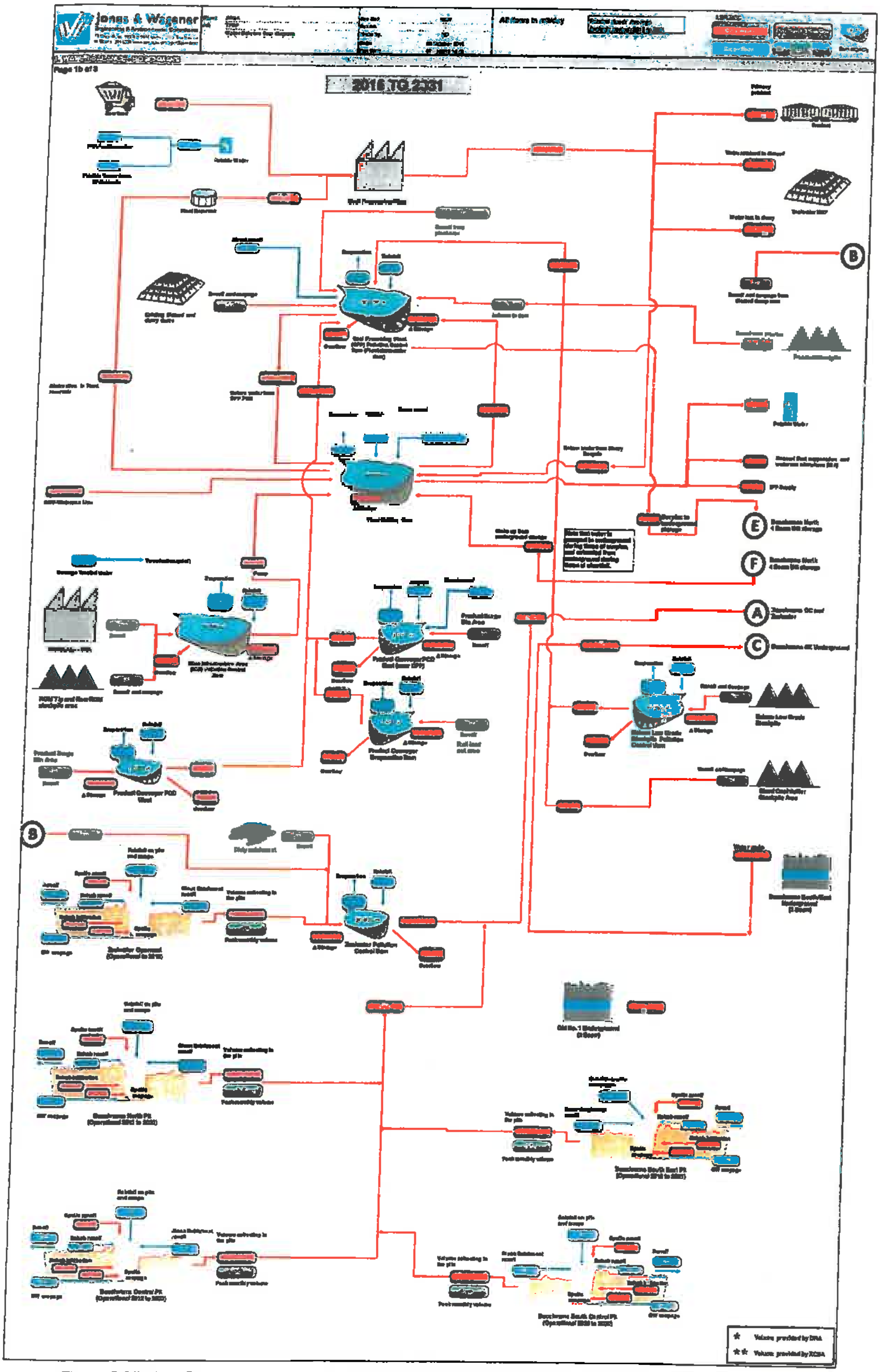


Figure 5.8(b)(i) Schematic water balance diagram (2015 to 2031) – page 1 of 3

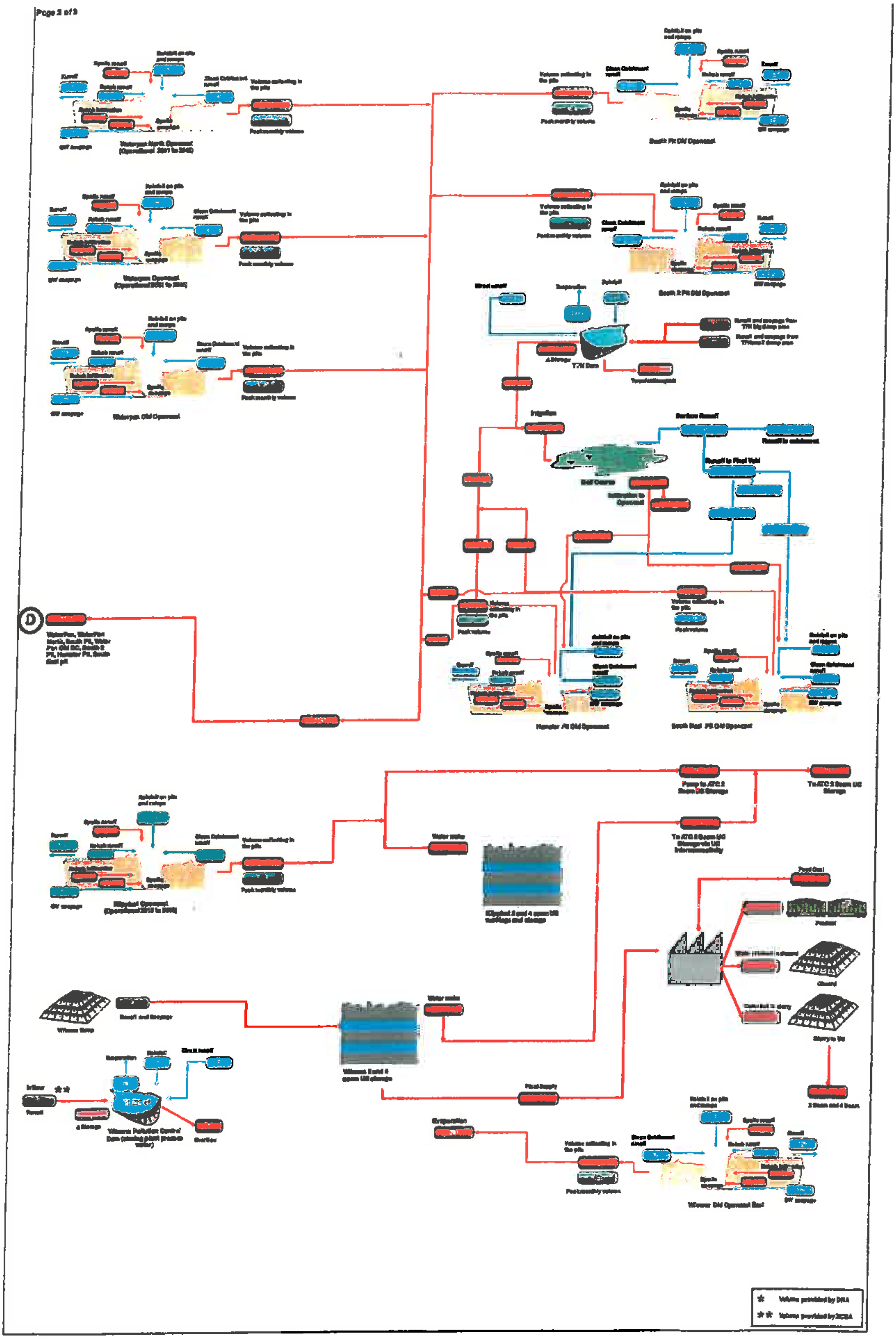


Figure 5.8(b)(ii) Schematic water balance diagram (2015 to 2031) – page 2 of 3

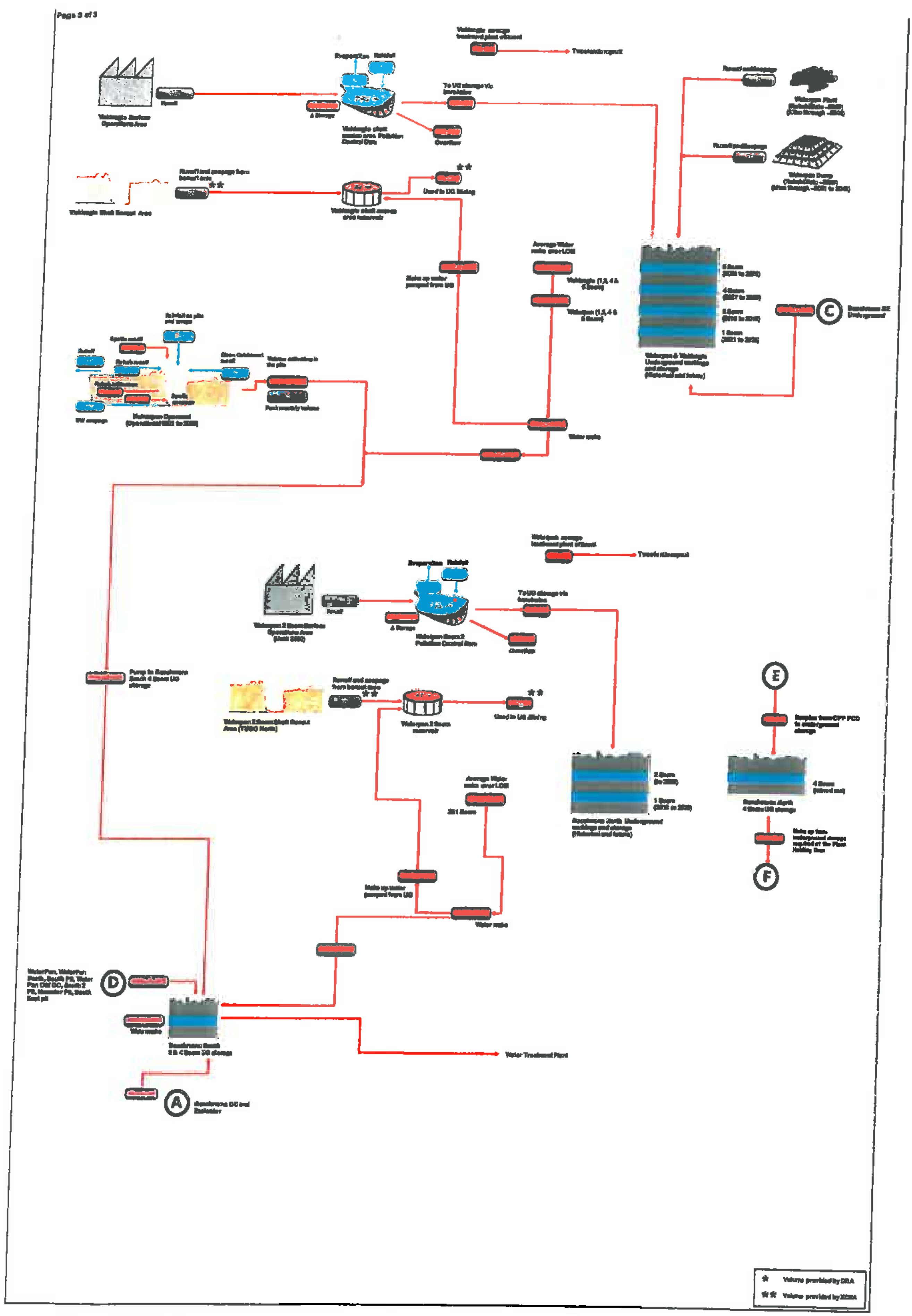


Figure 5.8(b)(iii) Schematic water balance diagram (2015 to 2031) – page 3 of 3

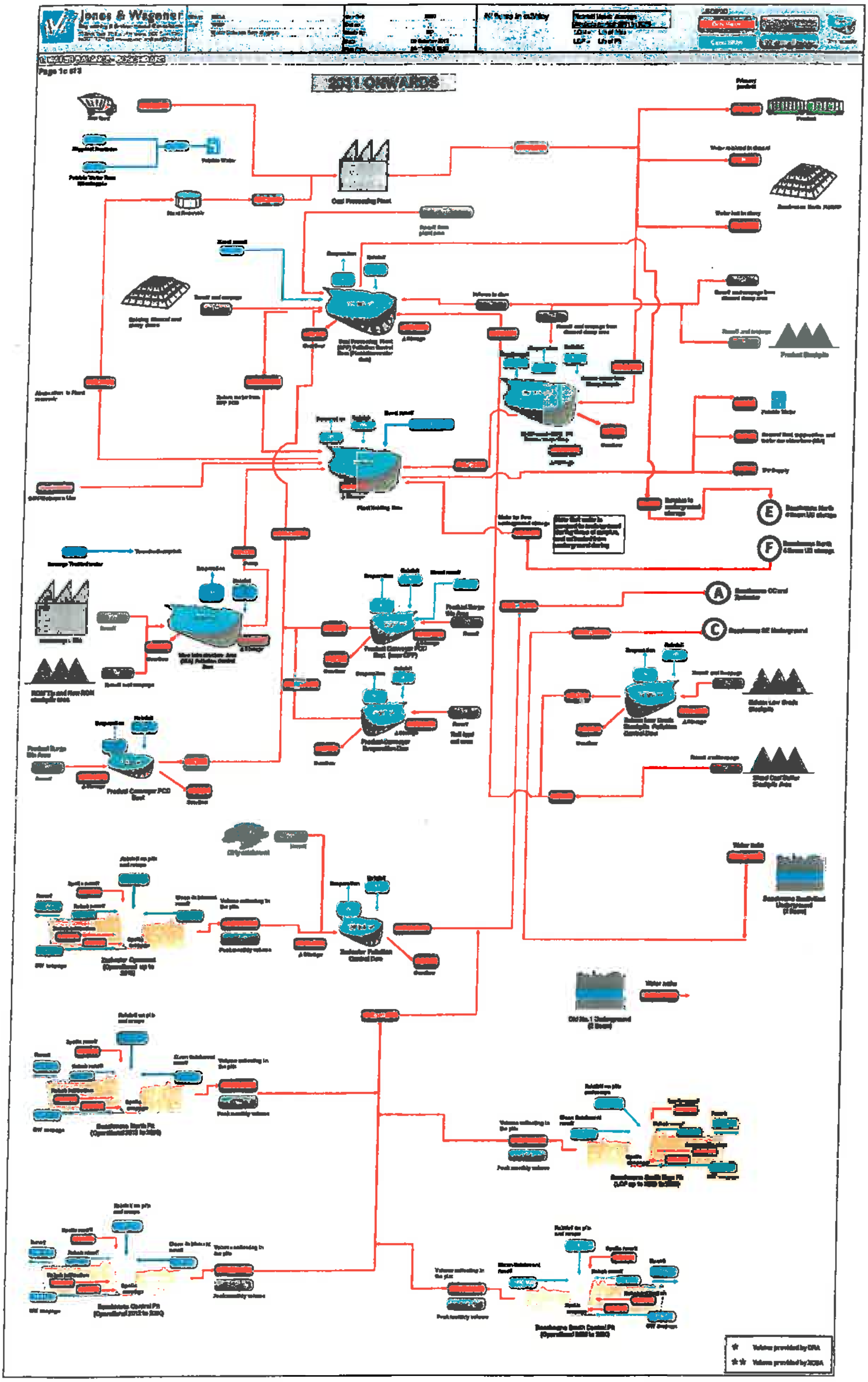


Figure 5.8(c)(i) Schematic water balance diagram (2031 onwards) – page 1 of 3

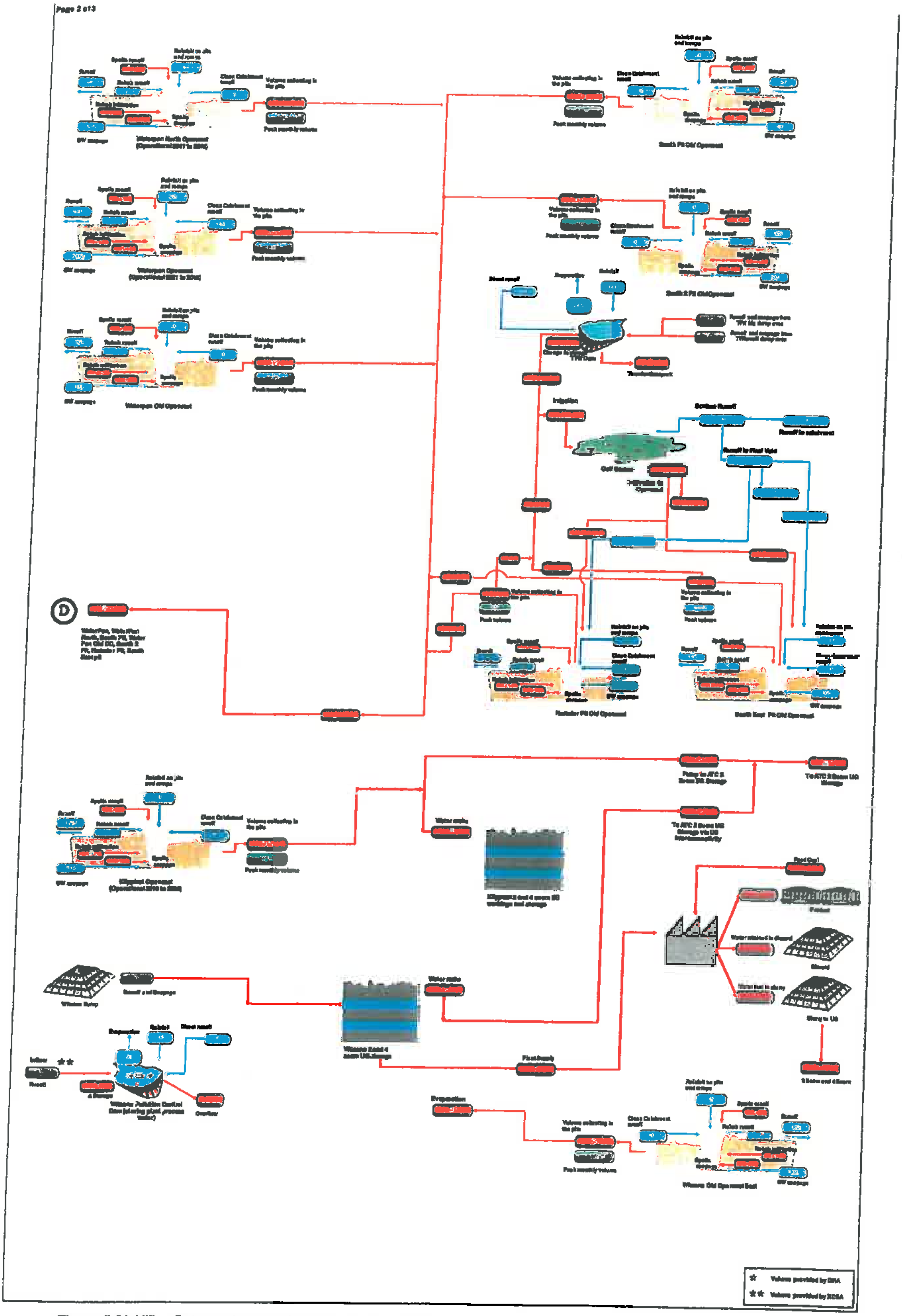


Figure 5.8(c)(ii) Schematic water balance diagram (2031 onwards) – page 2 of 3

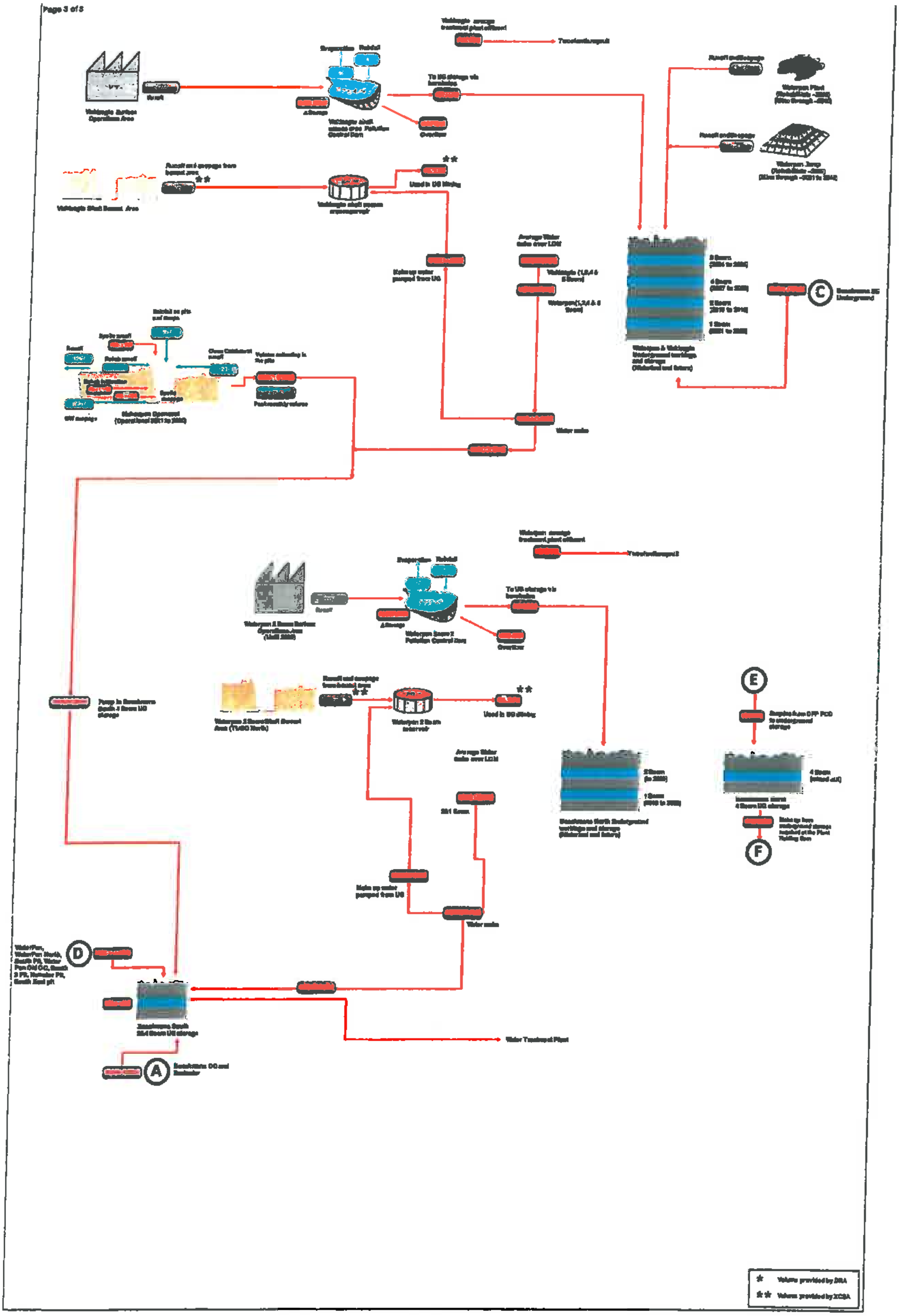


Figure 5.8(c)(iii) Schematic water balance diagram (2031 onwards) – page 3 of 3

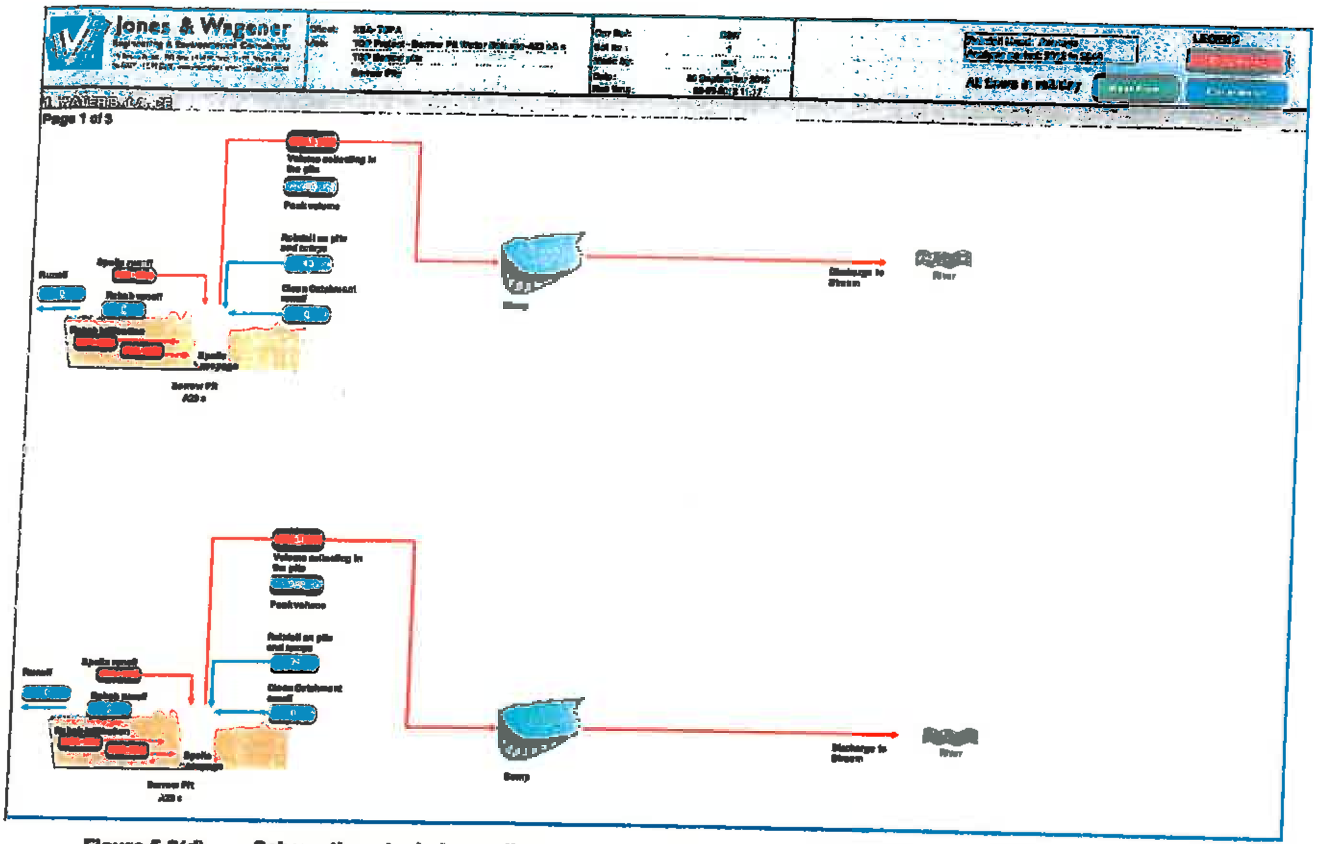


Figure 5.8(d) Schematic water balance diagram over the LOM for Borrow pits A23a and A23c

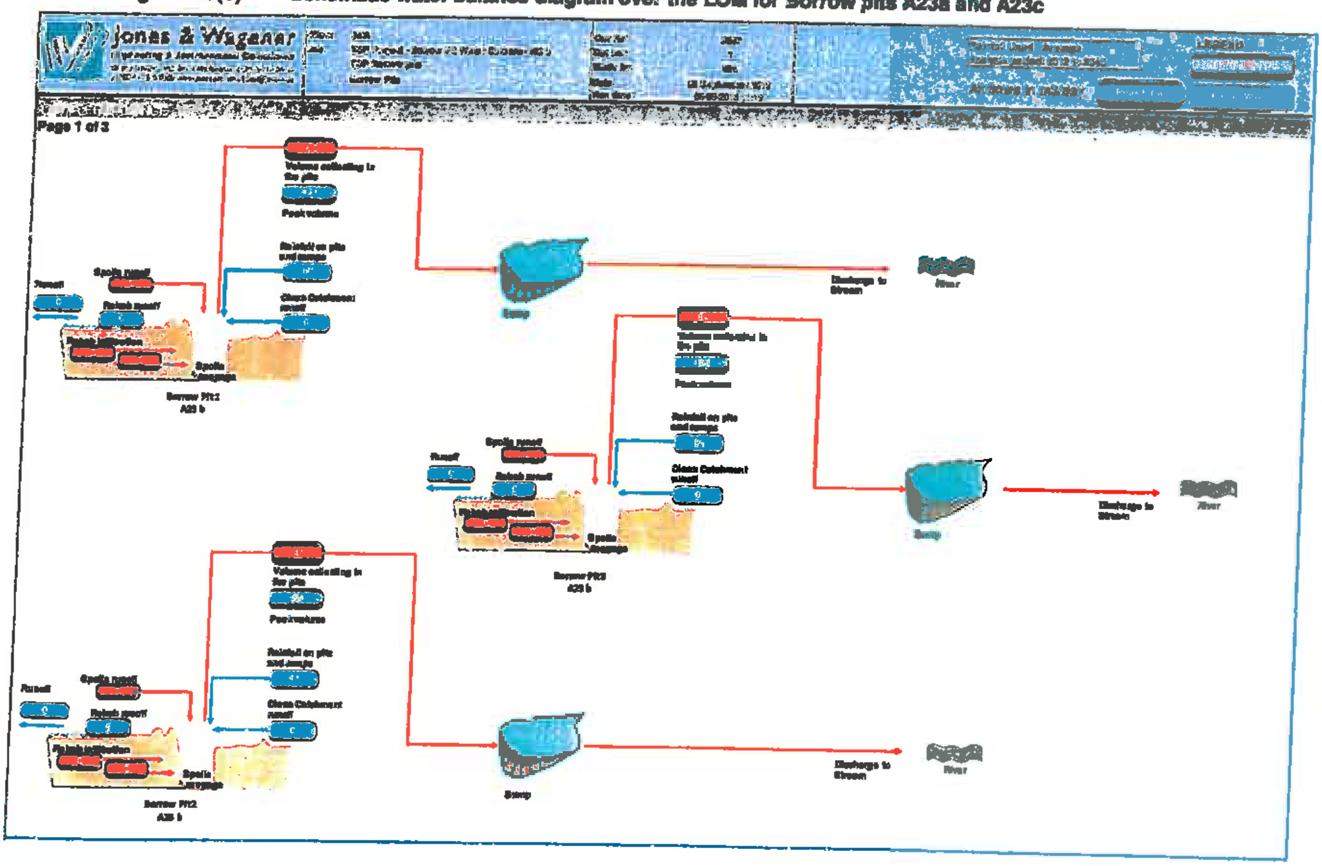


Figure 5.8(e) Schematic water balance diagram over the LOM for Borrow pit A23b

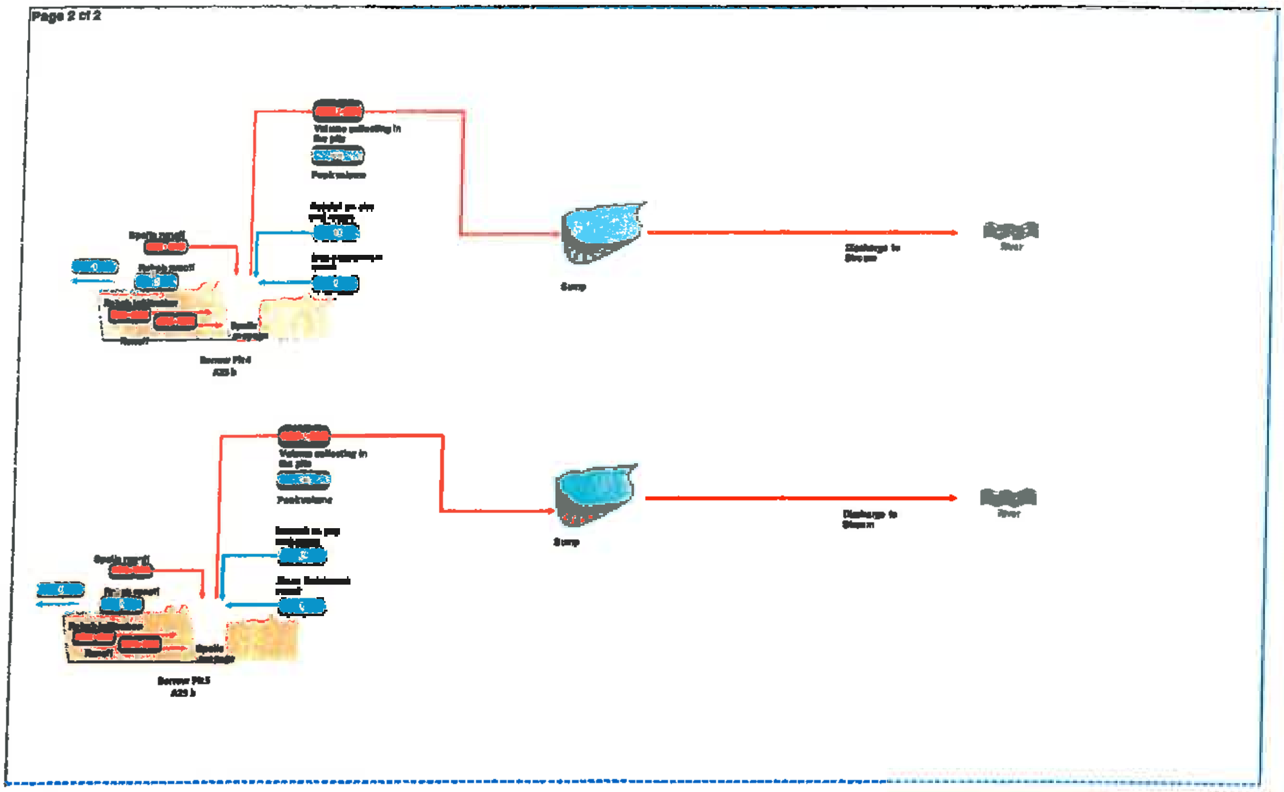


Figure 5.8(f) Schematic water balance diagram over the LOM for Borrow pit A23b continued

5.9 Water management and storage requirement

5.9.1 *Water management for average rainfall*

XSA's current strategy for the management of dirty water generated by the mining activities is storage in mined out underground compartments and ultimately treatment for reuse or discharge to the river system. A water treatment plant is currently being planned and is expected to be in operation by October 2015. This plant will initially treat 15 Ml/day.

All dirty water generated at Tweefontein complex will ultimately be pumped to either the Boschmans South 4 Seam or the ATC 2 Seam underground workings (at iMpunzi Complex), where it will be stored prior to treatment. The treatment plant will pump directly from the ATC 2 Seam, as well as the Boschmans South 4 Seam workings.

The total volume of dirty water placed into underground storage, generated due to the mining activities (but excluding dewatering of other mining areas) over the remaining life of mine at Tweefontein complex is estimated at approximately 20 793 m^3/day, amounting to a total of some 288 million m^3 by 2050.

5.9.2 *Storage required for extreme rainfall*

5.9.2.1. Explanatory note on provision for extreme events

GNR 704 in terms of the NWA, stipulates that dirty water on mining sites needs to be contained for events up to the 1:50 year recurrence interval. The Department of Water Affairs' (DWA) Best Practice Guideline for water management defines a spill "event" as a series of spills occurring during a given 30 day period.

When determining storage requirements, it is important to understand that a particular recurrence interval does not refer to a single discrete event. For each recurrence interval there is an infinite number of events, depending on the storm duration considered. It is important to determine the appropriate storm duration to use, based on the assessment being carried out. Typically, for peak flow events, shorter duration events (< 24 hours) are considered, as these are of higher intensity and generate greater flow rates. However, for volumetric assessments (sizing of dirty water containment facilities), the duration used could be months, an entire season, or longer, as two or three months of high rainfall, for example, could raise a dam's water level to such an extent that a subsequent low recurrence interval storm could cause a spill event.

For extreme rainfall there are two considerations:

- Surface water management: The sizing of the PCD will be driven by the storm water volumes generated on the surface infrastructure during short duration (in the order of one day to a few days) events.
- Mine water balance management: During longer term extreme events (in the order of years), the management of the large volumes of water generated needs to be considered, in terms of available storage and reuse / treatment options.

The risk of spill from a PCD is a function of both dam capacity (for temporary storage of storm water runoff) and the rate at which water can be abstracted from the dam for reuse or storage elsewhere.

5.9.2.2. Surface water management during extreme events

The PCDs need to be sized to ensure a risk of spill of 2% or less in any one year. At Tweefontein complex, dirty water collected in the PCDs is pumped either to the Plant Holding Dam or to the CPP PCD, from which water is pumped to underground storage at Boschmans. The emergency overflows from most of the PCDs drain via borehole to the underground workings, further limiting the risk of spilling dirty water to the environment during extreme events.

5.9.2.3. Mine water balance management during extreme events

During long term high rainfall the excess water will be stored in the underground storage areas at Tweefontein complex and iMpunzi.

The net volume of water that will need to be stored will vary depending on the nature of the extreme rainfall. Long term extreme rainfall (5 year) extremes were modelled for the period of mining with the greatest water make (2034 to 2038). The wet or extreme periods used in the modelling include the rainfall experienced in:

(a) 1992 and following years (wettest five years on record)

(b) 1951 and following years (second wettest five years on record)

(c) 2004 and following years (short term peak – wettest two years on record)

(d) 1961 and following years (driest five years on record)

For average rainfall during the period 2044 to 2050, the modelling indicates that some 52 million m^3 will need to be stored underground. During the wettest period (i.e. 1992 and the following five years), the total surplus is modelled at approximately 61 million m^3, meaning that an additional 9 million m^3 will need to be stored during such an event.

The current treatment strategy is to always leave a buffer storage volume in the workings of at least 20% of the total. This amounts to some 50 million m^3 as a minimum (at iMpunzi, Tweefontein complex and Tweefontein South), to allow for uncertainties in the storage volume, as well as space for extreme events. It can be seen that this buffer storage will be sufficient to accommodate the additional water expected during a long term extreme rainfall event.

5.10 Management during dry periods

The latest water storage modelling indicates that there will be a minimum volume of water stored in UG workings at XSA of around 180 million m^3. This is sufficient to supply the mine's water needs during extended dry periods.

5.11 Post closure water balance

Post closure the surface infrastructure at Tweefontein complex will be demolished and removed from the site. The site will be rehabilitated and made free draining, including the pollution control dams and opencast areas. The shafts will be plugged with a concrete plug for safety reasons and backfilled using the material in the overburden stockpile.

Post rehabilitation, all surface runoff will be clean, and will be allowed to drain to the receiving environment.

The post closure water make is estimated for underground to be approximately 2 083 m^3/day and opencast to be 24 778 m^3/day, with the total post closure water make for Tweefontein complex estimated at 26.9 Ml/day for average rainfall.

The water levels in the workings will be actively maintained below decant level by pumping to the Boschmans South and ATC 2 Seam UG workings. From here, the water will be pumped to the water treatment plant and treated for reuse, sale or discharge to the natural river system.

In order to maintain the water levels below decant, it will be necessary to expand the water treatment plant with time.

5.12 Conclusion

There will be a surplus of water at Tweefontein complex over the life of mine. Water will be pumped to available storage areas in the mined out workings for temporary storage prior to treatment.

The water balance will need to be regularly updated as the mine develops and the LOM changes.

6. BASELINE ENVIRONMENTAL DESCRIPTION

The baseline information is important for several reasons. These include assessment of possible impacts and setting of objectives for closure. However, for surface water it is also important that the mine is able to identify other point sources that may be impacting on surface water so that the origin of any future impacts can be identified.

Coal mining operations at Tweefontein Complex have been ongoing for many years. There is therefore no true pre-mining environmental information. The information presented here represents the current environmental status and will set a baseline against which any further impacts or improvements to the surface water regime will be measured.

The following terminology has been used throughout this document to describe the relevant surface areas that apply to this EMP.

Area	Definition
Tweefontein mine boundary area	This area includes the existing Tweefontein mining area, which is approximately 11 880 ha in extent.
Study area	In terms of surface water, the study area is the extent of the mining area.
Tweefontein land use area	The Tweefontein land use area includes the existing and proposed opencast and underground mining areas and associated infrastructure.
Area of surface disturbance	This refers to the area where the soil and vegetation has been or will be physically disturbed due to historical, existing and proposed activities, i.e. the infrastructure associated with the workshops and office complex, Crushing and Screening Plants, etc.
Dirty water management area	The surface area where surface water will probably be impacted upon by mining activities will be retained in order to prevent spillage to the catchment.

6.1 Regional climate

The regional climate is discussed in detail in the main EIA document.

6.2 Catchment description

6.2.1 General description

Tweefontein Complex is situated within the Olifants River catchment and falls within quaternary sub-catchments B11F and B11G, with a small portion in quaternary sub-catchment B20G of the Limpopo-Olifants primary Drainage Region, (refer to **Figure 6.2.1(a)** taken from "Surface Water Resources of South Africa – 1990" Vol 1 (Midgley, Pitman & Middleton, 1995) (WR90)).

The Tweefontein Complex also falls within Catchment Management Units (CMU) 5 and CMU 6, with a small portion in CMU 19, as shown in **Figure 6.2.1(b)**.

The Tweefontein mining area includes portions of the farms Waterpan 8IS, Tweefontein 13IS, Vlaklaagte 330IS, Klienkopie 15IS, Klipplaat 14IS, Zaaiwater 11IS, Blesbokfontein 31IS and Klippoortje 32IS.

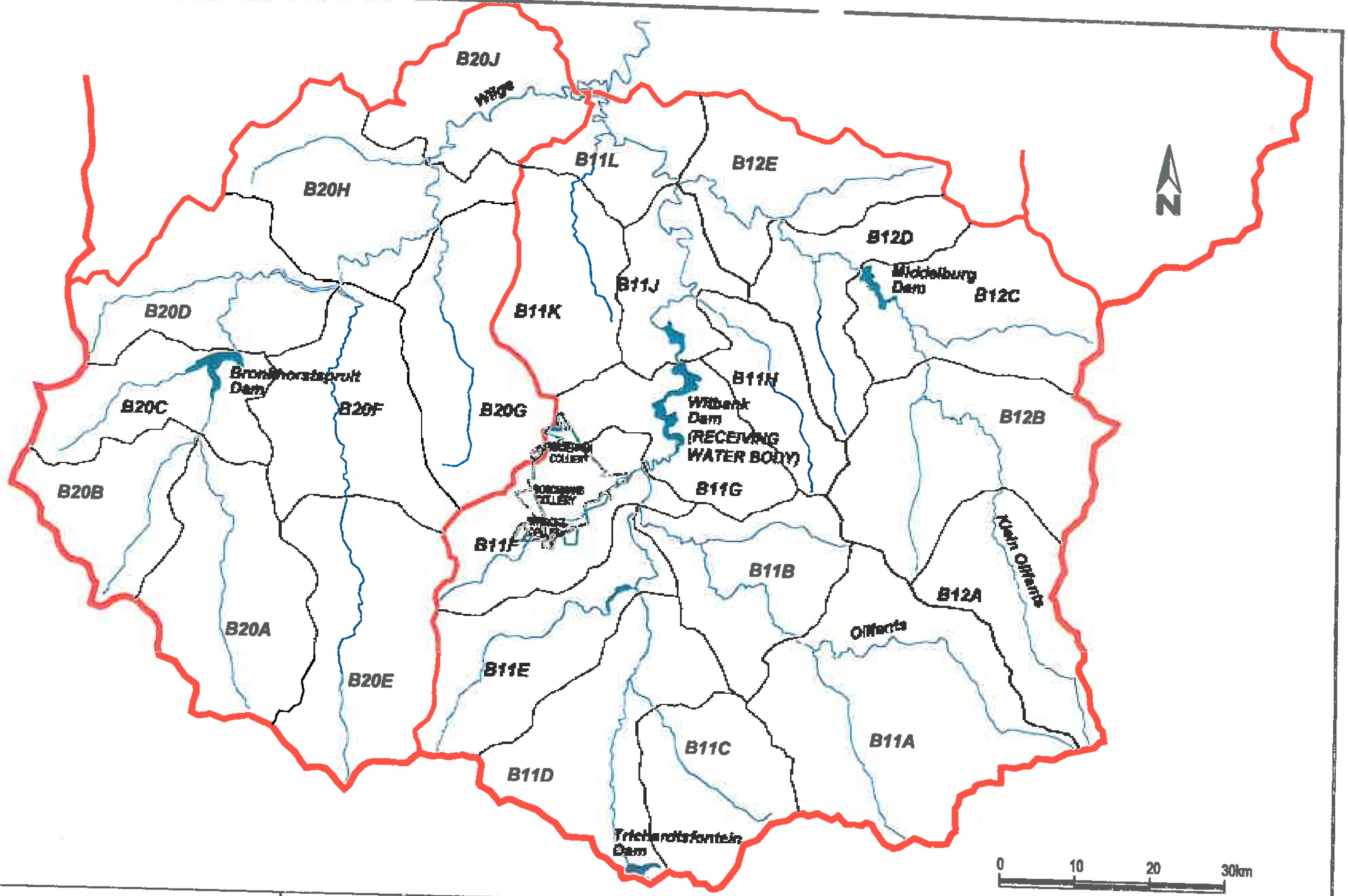
The Saaiwaterspruit and Klippoortjiespruit converge to the south west of the mining area. They drain the southern portion of the mining area, namely Witcons, while the Tweefonteinspruit drains the northern portion, namely Waterpan and Boschmans. The Tweefonteinspruit and Saaiwaterspruit converge to the east of the mining area and flow into the Olifants River. The Olifants River flows through the Witbank dam and on to the

Loskop Dam. Further downstream it flows through the central part of the Kruger National Park and into Mozambique. It eventually joins the Limpopo River and discharges to the Indian Ocean on the east African coastline.

6.2.2 *Receiving water body*

The receiving water body for the assessment of the potential surface water impacts related to the Tweefontein Complex is taken as the Witbank Dam, some 20 km downstream of the mining area. The use of this dam is motivated on the basis that:

- Beyond Witbank Dam, the potential impact of the Tweefontein Complex becomes extremely small due to the water volumes in the catchment and dilution effects.
- Further, by the time the water reaches Witbank Dam (and even before then), it is required to be suitable for use for all of the expected uses (drinking water, agricultural, industrial and aquatic ecosystems). Thus, by achieving compliance in terms of these, no additional impacts are expected downstream of Witbank Dam. The receiving water body is relevant only in so far as it defines the aerial extent of the catchment to be considered in the impact assessment, and described in the baseline study.
- The use of Witbank Dam is based on the relatively small size of the Tweefontein Complex area compared to the catchment for Witbank Dam. The next large dam is Loskop Dam.
- The catchment area to the Witbank Dam is reported as 3 579 km^2 while that for Loskop Dam totals some 12 285 km^2. The proposed area to be mined is approximately 119 km^2. The mine area thus totals approximately 3% of the Witbank Dam catchment, and only some 1% of the Loskop Dam catchment.
- The mean annual runoff (MAR) for Loskop Dam is 384 x 10^6 m^3 and Witbank Dam is some 125 x 10^6 m^3, while the MAR for the proposed mining area is estimated at 4.06 x 10^6 m^3.



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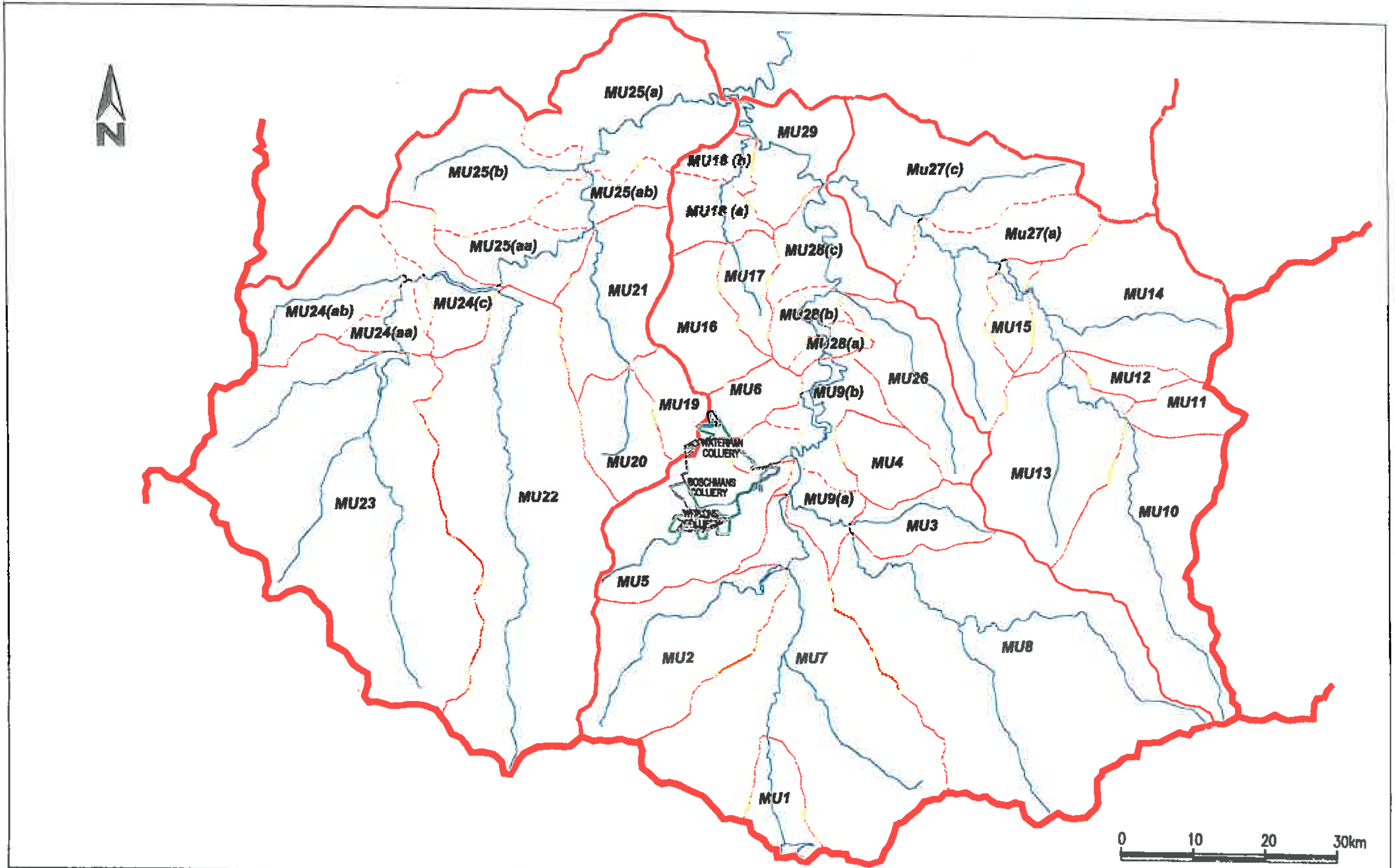
QUATERNARY SUB-CATCHMENTS AND RECEIVING WATER BODY

Job No: D367/00

Figure 6.2.1(a)



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COLLIERIES IN RELATION TO THE DWA MANAGEMENT UNITS

Job No: D367/00

Figure 6.2.1(b)

6.3 Rainfall and evaporation

6.3.1 Rainfall data

The Daily Rainfall Extraction Utility, developed by the Institute for Commercial Forestry Research (ICFR) in conjunction with the School of Bio-resources Engineering and Environmental Hydrology (BEEH) at the University of KwaZulu-Natal, Pietermaritzburg, was used to obtain summary data for all rainfall stations within the vicinity of the site. This data was assessed in terms of length of record, completeness of the data set, mean annual precipitation (MAP) and location of the rainfall station with respect to the site and the catchment. Key data extracted from the database for the four most reliable stations is shown in **Table 6.3.1(a)**. The ICFR database contains daily patched rainfall data for all official South African Weather Service (SAWS) stations, and includes data up to August 2000.

The Langsloot (0478292W) and Secunda (04783303W) stations have similar MAP, but cover different time spans. The record from Secunda was therefore appended to the Langsloot record to create a combined record with a length of 95 years. Since the two stations have a similar MAP and reliable data, combining the records was considered a reasonable approach to obtaining a longer rainfall record for use in the water balance modelling. .

A mass plot was produced for the combined record, and is shown in **Figure 6.3.1(a)**. A mass plot is a graph showing the cumulative rainfall depth with time for the full rainfall record. It is good indication of the reliability of the data set. A good mass plot will produce a straight line, with slight oscillations for seasonality. Any changes in the slope indicate a potential problem in the data set.

Table 6.3.1(a) Key data for selected rainfall stations (ICFR database)

Station number	Station name	MAP (mm)	Length of record
0478292W	Langsloot	719	1914 to 1992 (78 years)
04783303W	Secunda	719	1984 to 2008 (24 years)
0478406W	Kriel	614	1907 to 1978 (71 years)
0478093W	Ogies	734	1907 to 2000 (93 years)

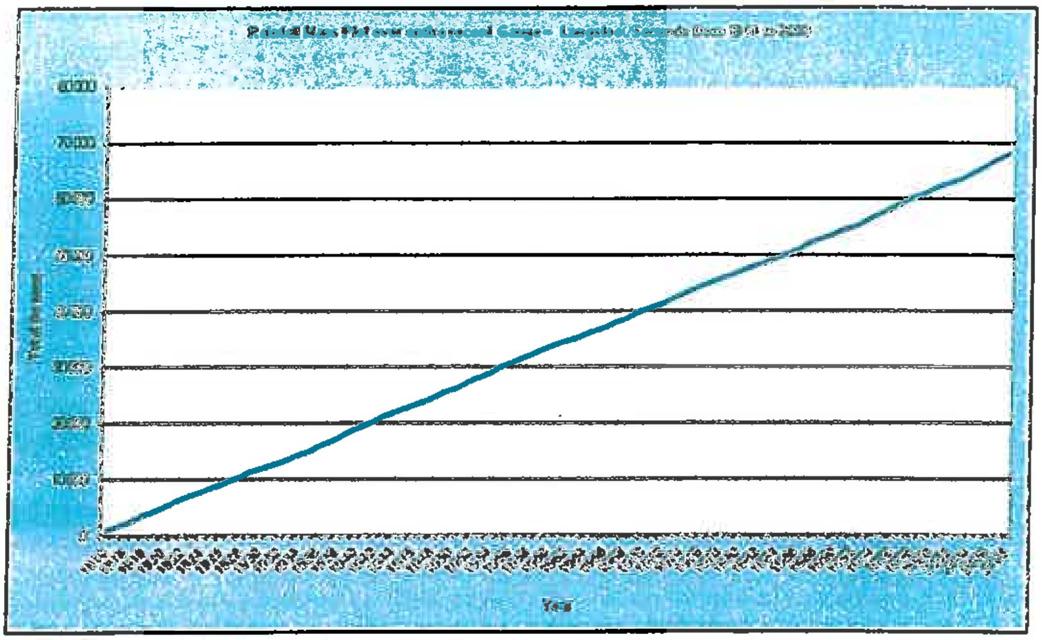


Figure 6.3.1(a) Rainfall mass plot for the combined rainfall record

The mass plot for the combined rainfall record was considered reasonable. The combined record was selected as the representative rainfall data set for the site and this was used in the water balance modelling.

The average monthly rainfall depths are presented in **Table 6.3.1(b)**. The rainfall record is shown graphically in **Figure 6.3.2(a)**. Mean monthly rainfall is shown graphically, together with mean monthly evaporation in **Figure 6.3.2(b)**.

6.3.2 Evaporation data

Evaporation data for Tweefontien was taken directly from *WR90*. The average monthly evaporation depths are presented in **Table 6.3.1(b)** and **Figure 6.3.2(b)**.

6.3.3 Maximum rainfall intensities

6.3.3.1. <u>Rainfall extremes</u>

Apart from the normal criteria of being statistically consistent, normally measured by considering the mass plot and ensuring that it is linear, it is also important that the rain gauge has a long record, and within that record that it contains rainfall events that correspond to at least the 1:50 year event, since the legal requirement is that a mine should not spill for events up to the 1:50 year recurrence interval (a 2% risk of spilling in any one year). The duration of the event can vary, and in most of the larger mines, the critical event is not the 24 hour event, but rather above average rainfall over a period of several months, typically with several extreme rainfall events occurring during a wetter than average period.

The rainfall record was analysed using the RegFlood statistical analysis software programme. The data was assessed against a number of statistical distributions and the Log Pearson Type III distribution was found to produce the best fit. The statistically determined events, using the Log Pearson Type III distribution, for various recurrence intervals are presented in **Table 6.3.3(a)**.

Table 6.3.1(b) Average monthly rainfall depths for SAWS station 0478292W Langsloot and 0478303 Secunda (based on period 1914 to 2006) and evaporation depths, from *WR90*

Month	Average rainfall (mm)	Average evaporation (mm)
October	77.2	139.7
November	112.1	133.4
December	121.9	148.7
January	129.9	147.8
February	90.5	129.1
March	82.0	127.4
April	38.0	98.0
May	19.9	81.6
June	9.6	64.7
July	6.8	69.2
August	8.9	89.4
September	21.8	115.9
Annual Total	**718.6**	**1344.9**

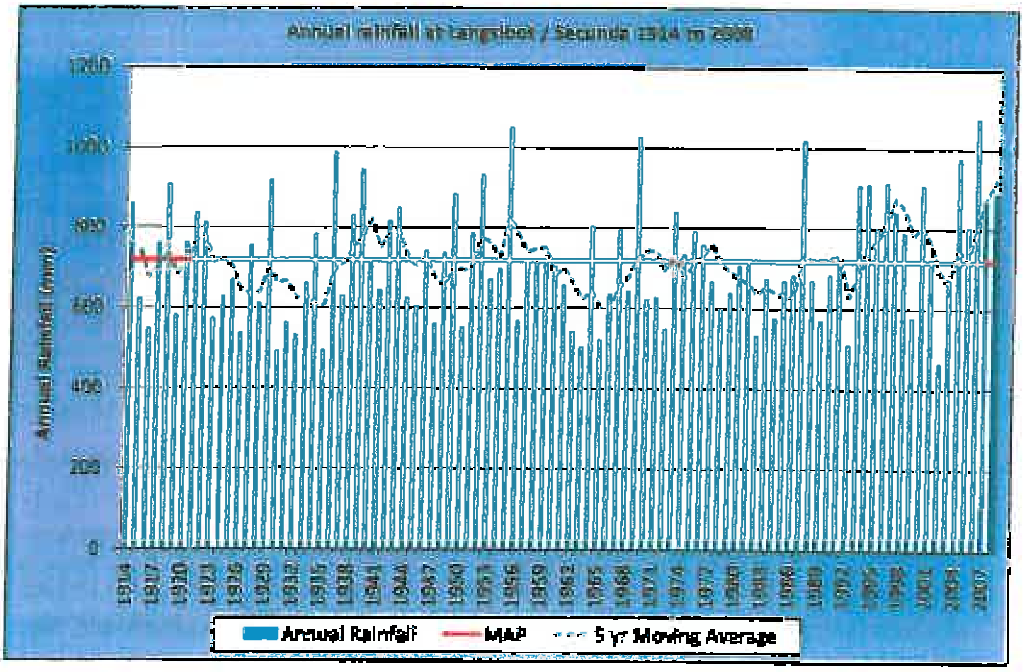


Figure 6.3.2(a) Rainfall record for Langsloot/Secunda

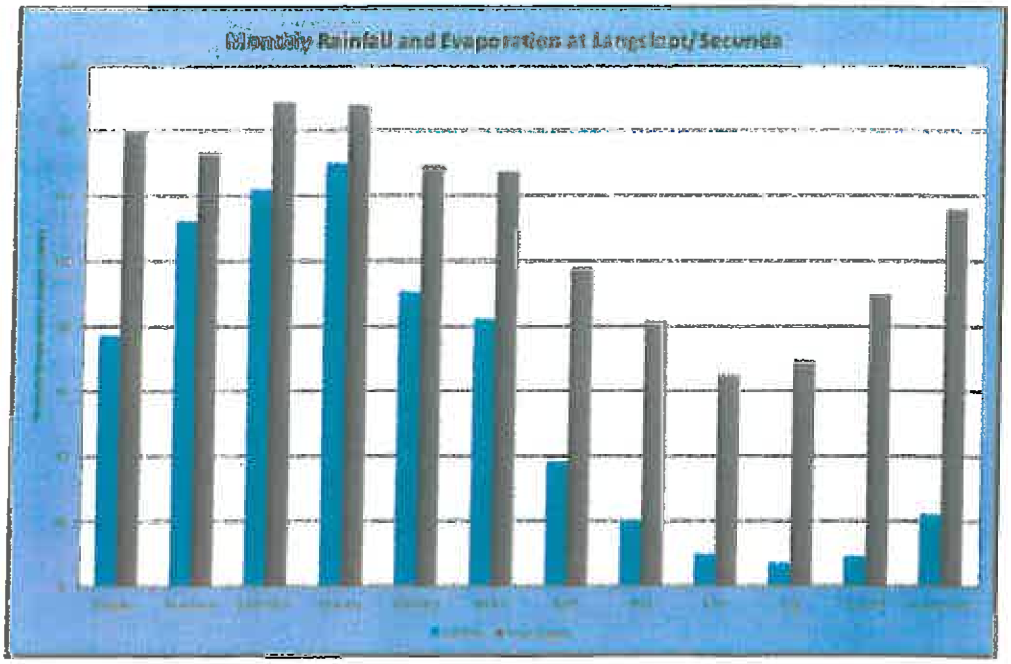


Figure 6.3.2(b) **Mean monthly rainfall and evaporation for Langsloot/Secunda**

Table 6.3.3(a) **Statistical rainfall extremes for Langsloot/Secunda rainfall station (based on Log Pearson Type III statistical distribution)**

Event	Rainfall depth (mm)					
	1 day	2 day	3 day	7 day	1 month	Annual
1:2 yr	63	86	101	146	188	727
1:10 yr	93	121	137	182	248	897
1:20 yr	109	140	154	195	275	932
1:50 yr	136	168	178	212	313	965
1:100 yr	160	194	199	225	344	983
1:200 yr	188	223	221	238	378	998
Max Recorded	175	196	196	212	368	1087

It is evident that statistical extremes of 1:50 and 1:100 years have been recorded at the stations, making this record suitable for the water balance assessment.

The Langsloot/Secunda rainfall record was also analysed to look at the wet cycles. Extreme rainfall within the hydrological record seldom exceeds two to three years in duration, with the longest "wet cycle" approximately five years to peak. The data is given in terms of a 5 year moving average relative to the mean in **Figure 6.3.2(a)**.

Wet or extreme periods used in the modelling include the rainfall experienced in:

- 1992 and the following four years (wettest five years on record)
- 1951 and the following four years (second wettest five years on record)
- 2004 (short term peak)

- 1961 and the following four years (driest five years on record)

6.4 Surface water quantity

6.4.1 Mean Annual Runoff (MAR)

The MAR for the various sub-catchments of the Tweefonteinspruit and Saaiwaterspruit were computed using the WRSM2000 (Pitman) synthetic streamflow generation model. Catchment parameters for the relevant quaternary sub-catchments are published in WR90.

The MAR for at key points of interest are shown in **Table 6.4.1(a)**. The catchments and nodes are shown in **Figure 6.4.3(a)**.

Table 6.4.1(a) Mean Annual Runoff (MAR) for Tweefonteinspruit and Saaiwaterspruit sub-catchments

Node	Catchment Area (km^2)	MAR ($x10^6m^3$)	% of MAR at Witbank Dam	% of MAR at Loskop Dam
T1	*7.21	0.25	0.2	0.07
T2	*14.50	0.49	0.4	0.13
T3	*25.84	0.88	0.7	0.23
T4	*36.92	1.26	1.0	0.33
T5	*58.99	2.01	1.6	0.52
W1	*11.08	0.38	0.3	0.10
S1	*258	8.80	7.0	2.29
S2	78	2.66	2.1	0.69
S3	186	6.34	5.1	1.65
K1	108	3.68	2.9	0.96
TOP Mine boundary	119	4.06	3.2	1.06
Witbank Dam	3 579	125	100	-
Loskop Dam	12 285	384	-	100

* Taken from Inprocon Consulting Reports No.:IPC/TW/PI/2006/1, September 2006 and IPC/SW/PI/2008/1, December 2008

6.4.2 Dry weather flow (DWF)

In the absence of any streamflow monitoring, the conventional approach to compute the dry weather flow (also often termed "normal flow") is to analyse the long term synthetic monthly streamflow time series in order to develop a flow-duration relationship. An accepted definition of the dry weather flow in a stream is that flow in the stream that is equalled or exceeded for 70% of the time, a value which can readily be ascertained from an analysis of the flow-duration relationship.

The dry weather flows (DWF) for the proposed mining area were determined using the WRSM2000 synthetic streamflow generation model and pro-rating the values for each catchment. The computed dry weather flows (DWF) for the various sub-catchments are shown in **Table 6.4.2(a)**. The catchments and nodes are shown in **Figure 6.4.3(a)**.

Table 6.4.2(a) Computed dry weather flows in the affected streams at Tweefontein

Node	Catchment Area (km^2)	Computed DWF ($x10^6 m^3$ per month average)	Computed DWF (l/s average over month)
T1	*7.21	0.00	0.00
T2	*14.50	0.01	2.86
T3	*25.84	0.01	5.10
T4	*36.92	0.02	7.29
T5	*58.99	0.03	11.65
W1	*11.08	0.01	2.19
S1	78	0.04	15.41
S2	186	0.10	36.74
S3	*258	0.13	50.96
K1	108	0.06	21.33

Note: A flow of less than 0,01 x 106 m3 per month probably implies that the river in question dries out completely during the winter months. This correlates to a flow of less than 10l/s

* Taken from Inprocon Consulting Reports No.:IPC/TW/PI/2006/1, September 2006 and IPC/SW/PI/2008/1, December 2008

6.4.3 Flood peaks and volumes

The flood peak estimations and floodline determinations for Tweefontein Complex were carried out by Inprocon Consultants (Reports IPC/TW/PI/2006/1, September 2006 and IPC/SW/PI/2008/1, December 2008).

The upstream points on the Saaiwaterspruit and Klippoortjiespruit (nodes S1, S2 and K1) were not included in the Inprocon reports as they did not fall within the scope of those studies. These were therefore determined by Jones & Wagener.

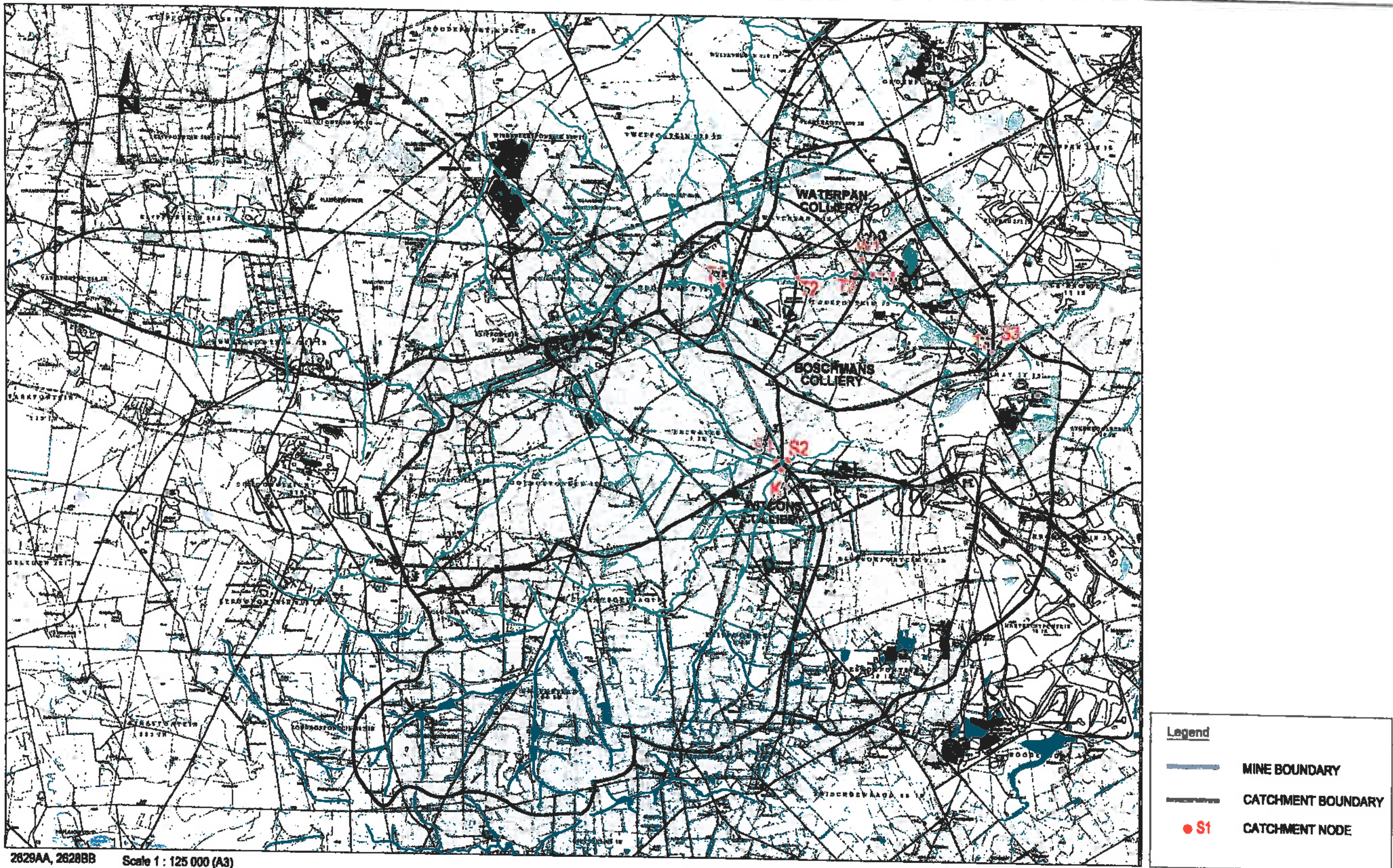
The catchment boundaries and nodes at which flood peaks have been determined are shown on in **Figure 6.4.3(a)**. Peak flows were determined using a combination of the Rational Method, Standard Design Flood, Regional Maximum Flood, Midgley & Pitman method and the Synthetic Unit Hydrograph method.

The computed peak flows and volumes are given in **Table 6.4.3(a)**.

Table 6.4.3(a) Flood peaks and flood volumes

Node	Catchment area (km^2)	Recurrence Interval	Flood Peak (m^3/s)	Flood Volume (m^3x10^6)
T1	*7.21	1:20 year	42	0.25
		1:50 year	88	0.31
		1:100 year	*115	0.41
		RMF	212	0.75
T2	*14.50	1:20 year	55	0.29
		1:50 year	112	0.60
		1:100 year	*128	0.68
		RMF	276	1.47
T3	*25.84	1:20 year	69	0.53
		1:50 year	134	1.03
		1:100 year	*202	1.55
		RMF	344	2.64
T4	*36.92	1:20 year	79	0.76
		1:50 year	149	1.43
		1:100 year	*224	2.15
		RMF	394	3.78
T5	*58.99	1:20 year	94	1.20
		1:50 year	172	2.20
		1:100 year	*243	3.11
		RMF	471	6.03
W1	*11.08	1:20 year	50	0.23
		1:50 year	103	0.47
		1:100 year	130	0.60
		RMF	249	1.14
S1	78	1:20 year	122	1.86
		1:50 year	178	2.72
		1:100 year	229	3.49
		RMF	523	7.98
S2	186	1:20 year	206	4.87
		1:50 year	301	7.12
		1:100 year	385	9.11
		RMF	804	19.02
S3	*258	1:20 year	165	5.28
		1:50 year	*290	9.28
		1:100 year	*400	12.80
		RMF	825	26.40
K1	108	1:20 year	131	2.41
		1:50 year	191	3.51
		1:100 year	245	4.51
		RMF	600	11.04

* Taken from Inprocon Consulting Reports No.:IPC/TW/PI/2006/1, September 2006 and IPC/SW/PI/2008/1, December 2008



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CATCHMENT AND NODES

Job No: D367-00

Figure 6.4.3(a)

6.4.4 *Floodlines*

The 1:100 year floodlines for the mining area along the Saaiwaterspruit were determined by Inprocon Consultants and 1:100 year floodlines along the Tweefonteinspruit were determined by J&W in 2010. These floodlines are both shown on **Figure 6.4.4(a)**.

The floodlines presented in **Figure 6.4.4(a)** are in the process of being updated and extended by J&W.

Details of the methodologies used by Inprocon are given in reports IPC/TW/PI/2006/1, September 2006 and IPC/SW/PI/2008/1, December 2008.

Floodlines along the Tweefonteinspruit were determined based on the calculated flood peaks at each node. A steady flow, backwater analysis was performed for each stream using the RiverCAD Pro analysis software. RiverCAD Pro is a software package developed by Boss International that provides a CAD interface to the HEC-RAS river modelling system. HEC-RAS was developed by the United States Army Corps of Engineers, and is considered industry standard software for floodline determination in many countries, including the United States, the United Kingdom, Europe, Australia and South Africa.

Lidar and field survey provided by the client were used which consisted of an electronic digital terrain model (DTM), in the form of a three dimensional drawing file with contours at 500 mm intervals. Floodlines were determined along the Tweefontienspruit for which peak flows were computed, within the study area.

When determining floodlines, each stream is defined by inputting a number of cross sections along the length of the stream. The cross sections are determined from the contour data. Cross sections were measured at approximately 20 m intervals on average, as well as at significant features which may act as controls.

The 1:100 year floodlines for the Tweefontienspruit are indicated in **Figure 6.4.4(a)**.

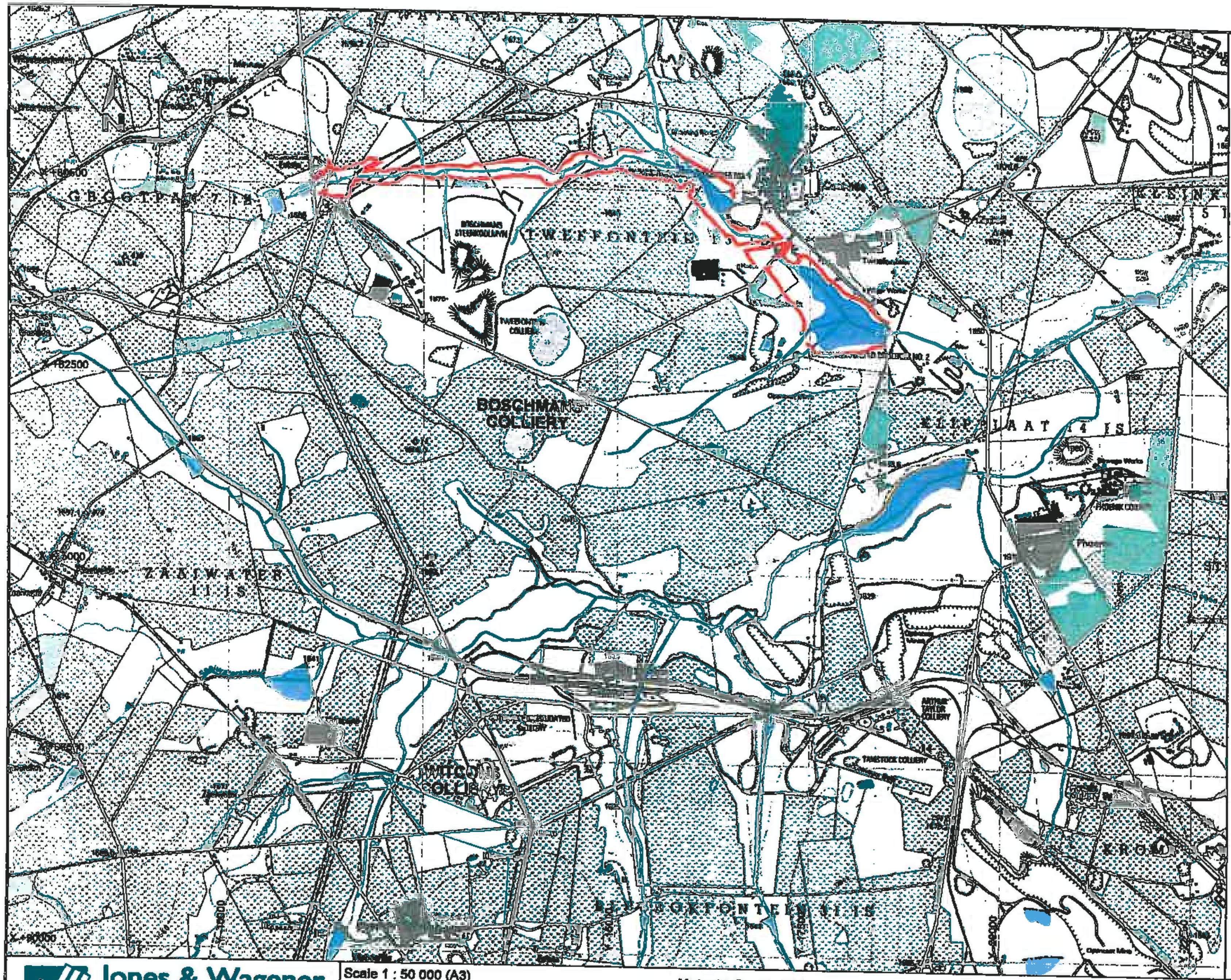
It should be noted that the accuracy of the floodlines produced in this study is commensurate with the accuracy of the digital terrain model (DTM) data provided. With a contour interval of 0.5 m, the accuracy of the floodlines can be considered to be within 0.5 m vertically. The floodlines given here are considered suitable for planning purposes only. Where infrastructure is to be located adjacent to streams, the floodlines should be determined more accurately using a DTM developed from a field survey at the area of concern. These floodlines will then be termed certified floodlines, where the current floodlines are classified as preliminary floodlines (for planning purposes only).

6.4.5 *Watercourse Alterations*

Watercourse alterations have been described in **Section 4.6**.

6.5 Surface water quality

The baseline surface water quality is described in this section. The Tweefontein Complex has an active surface water monitoring programme and annual monitoring reports are compiled by Jaco – K Consulting (JKC), summarising the surface and ground water chemistry, groundwater levels and air quality.



NOTE

J&W IN THE PROCESS OF UPDATING AND EXTENDING THE FLOODLINES.

LEGEND

- 1 : 100 Year Floodlines (J&W)
- 1 : 100 Year Floodlines (Others)
- RIVER
- BOUNDARY LINE

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1:100 YEAR FLOODLINE

Job No: D367-00

Figure 6.4.4(a)

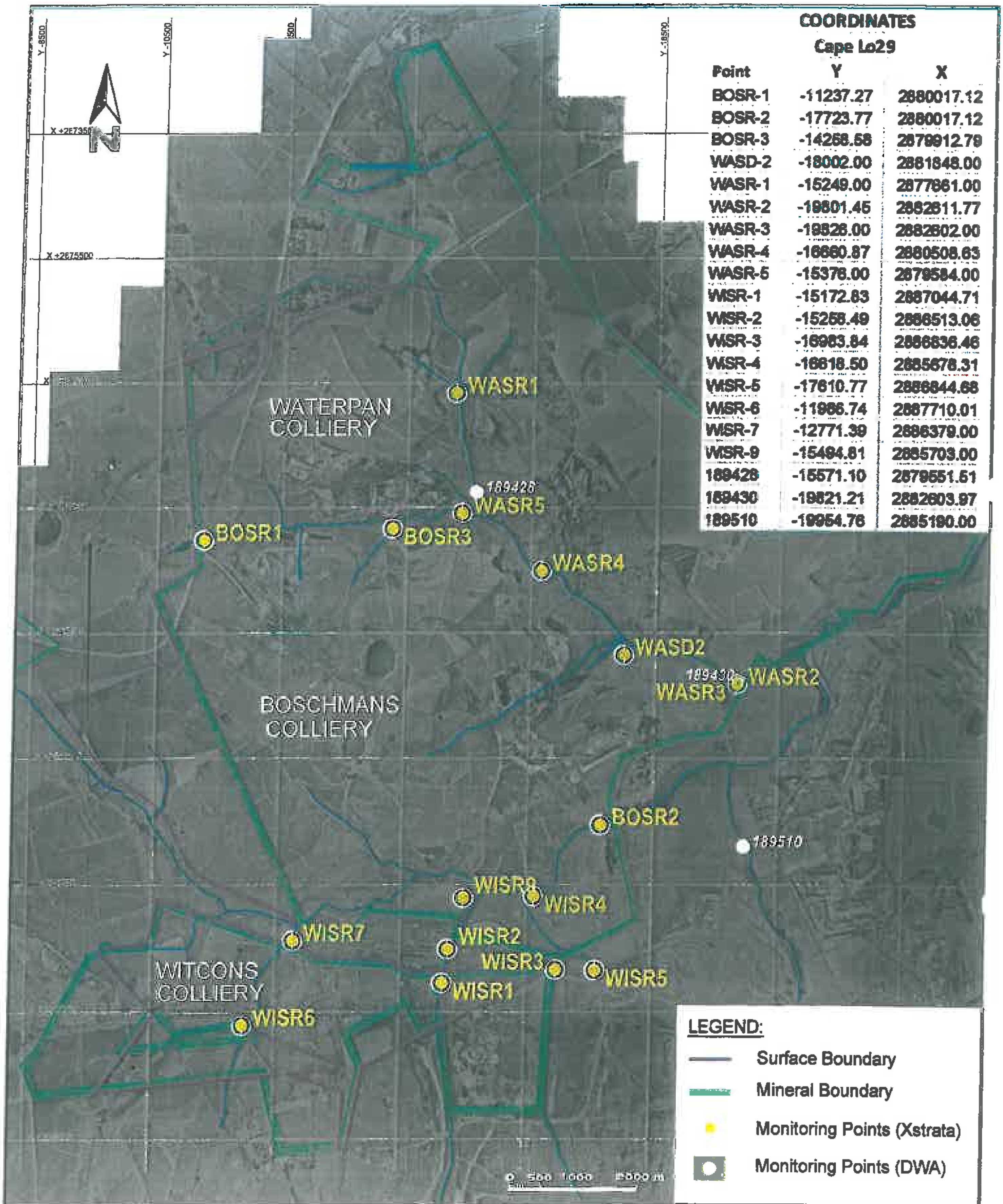
6.5.1 Surface water quality monitoring locations

The surface water quality monitoring locations used in the baseline assessment are shown on **Figure 6.5.1(a)** and a description of the surface water monitoring points is given in **Table 6.5.1(a)**.

Table 6.5.1(a) Description and co-ordinates of surface water monitoring locations used in the baseline assessment

Monitoring point	Description	Co-ordinates[1]	
		Latitude	Longitude
BOSCHMANS COLLIERY			
BOSR-1	On the Tweefonteinspruit upstream of the Boschmans plant area. No surface mining activities upstream of this sampling location. It is, however, possible that runoff from dirty areas south and west of the railway line is directed along the railway line and into the Tweefonteinspruit at this location.	-26.03075816	29.11241636
BOSR-2	On the Zaaiwaterspruit upstream of the Phoenix Dam	-26.07248434	29.17711151
BOSR-3	On a tributary, joining the Zaaiwaterspruit	-26.0302809	29.14191662
WATERPAN COLLIERY			
WASR-1	Upstream monitoring point for Waterpan Complex on the Waterpanspruit. Located adjacent to the Waterpan plant area. There is potential for seepage and spills from the Waterpan plant area to enter the watercourse upstream of the sampling location.	-26.00987093	29.1525274
WASR-2	On the Waterpanspruit	-26.02115109	29.15494456
WASR-3	On the Tweefonteinspruit	-26.05196766	29.19819399
WASR-4	Upstream of Tweefontein Dam	-26.03819308	29.17044466
WASR-5	Upstream of Tweefontein Dam	-26.02773637	29.15847188
WASD-2	Tweefontein dam	-26.04620876	29.18474994
WITCONS COLLIERY			
WISR-1	Witcons stream	-26.09426636	29.1515281
WISR-3	Tavistock stream	-26.09207984	29.16972199
WISR-4	Zaaiwaterspruit	-26.08161426	29.16569486
WISR-5	Tavistock Colliery Stream	-26.09243353	29.17586105
WISR-6	Klippoortjiespruit	-26.10061318	29.12133317
WISR-7	Upstream of discard dump	-26.08589545	29.12736125
WISR-9	Downstream of discard dump	-26.07937397	29.15088923

[1] JKC, 2013



COORDINATES

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Point	Y	X
BOSR-1	-11237.27	2880017.12
BOSR-2	-17723.77	2880017.12
BOSR-3	-14268.58	2879912.79
WASD-2	-18002.00	2881848.00
WASR-1	-15249.00	2877661.00
WASR-2	-19801.45	2882611.77
WASR-3	-19826.00	2882602.00
WASR-4	-16660.87	2880508.63
WASR-5	-15376.00	2879584.00
WISR-1	-15172.83	2887044.71
WISR-2	-15268.49	2886513.06
WISR-3	-16983.84	2886836.46
WISR-4	-16618.50	2885678.31
WISR-5	-17610.77	2886844.68
WISR-6	-11986.74	2887710.01
WISR-7	-12771.39	2886379.00
WISR-9	-15494.81	2885703.00
189428	-15571.10	2879551.61
189430	-19821.21	2882603.97
189510	-19954.76	2885190.00

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SURFACE WATER MONITORING POINTS

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Figure 6.5.1(a)

6.5.2 *Monitoring data used in baseline assessment*

Surface water quality data was received from the Tweefontein Complex in MS Excel format. Data was available for the period August 2000 to July 2012 for the Boschmans and Waterpan Collieries and for the period January 2009 to July 2012 for the Witcons Colliery.

For the purpose of this baseline surface water assessment, data for the period January 2006 to July 2012 was used for the Boschmans and Waterpan Collieries. All available data for the Witcons Colliery was used. The data reflected in this baseline description is limited to the monitoring data for the rivers and streams, and excludes an assessment of the dirty water systems, such as pollution control dams.

The detailed water quality data used in the assessment is provided in tabular format in **Appendix B.**

The last two annual monitoring reports (2011 and 2012) compiled by Jaco-K Consulting were also reviewed in compiling the baseline description.

6.5.3 *Additional data*

Water quality data was also obtained from the Department of Water Affairs' (DWA) website for the DWA monitoring points indicated in **Table 6.5.3(a)**. The data available for these points is also reflected in the table below. The location of these points is shown on **Figure 6.5.1(a)**.

Table 6.5.3(a) Water quality monitoring data from DWA's Resource Quality Services

Monitoring point name	Description	Co-ordinates		Constituents	Monitoring period
		Latitude	Longitude		
189428	Tweefontein upstream of Tweefontein Colliery. This point is located close to XSA monitoring points WASR-2 and WASR-3.	-26.02444	29.15556	pH EC SO_4	April 2009 – March 2012 (27 samples)
189430	Klipplaat at road bridge on Tweefonteinspruit	-26.05194	29.19806		April 2009 – February 2012 (22 samples)

6.5.4 *Standard used for the assessment of water quality*

The Directorate National Water Resource Planning (DNWRP) of the (then) Department of Water Affairs and Forestry (DWAF) developed a water quality management strategy for the Upper and Middle Olifants River catchment, which was published in 2009 (DNWRP, 2009). One of the key elements of this strategy is Receiving Water Quality Objectives (RWQO).

Interim RWQO were determined based on the current set of objectives in the catchments, which was modified to account for the water quality component of the Ecological Reserve. Where previous objectives were not available, the South African Water Quality Guidelines, together with the present water quality status, were used to determine the interim RWQO. The set of RWQO determined for the Upper Olifants catchment are regarded as interim objectives that will be reviewed once the water quality component of the Ecological Reserve has been updated (DNWRP, 2009).

The results of the water quality monitoring undertaken at the Tweefontein Complex were compared to the interim RWQO for the Upper Olifants River Catchment developed by the DNWRP. The Tweefontein Complex is largely located within Management Units (MU) 5 and 6 of the Witbank Dam Catchment as indicated in **Figure 6.2.1(b)**. A small portion is located within MU 19 of the Wilge River catchment. The Interim RWQO developed by the DNWRP for these management units are indicated in **Table 6.5.4(a).**

For the purpose of the assessment, monitoring data was assessed against the interim RWQO for MU5, since this is the most stringent.

6.5.5 Baseline water quality analysis

Time-series graphs were compiled for pH, EC, SO_4, Ca, Mg, K, Cl, Na, Fe, Al and Mn to illustrate the baseline water quality at each of the collieries, indicating the change in concentration of various constituents over time. The graphs are attached in **Appendix B**. It should be noted that where the concentration for a constituent was measured at the detection level, 50% of the detection level was assumed as the concentration at which the constituent occurs for the purposes of compiling the graphs.

The graph titles and a description of each are provided in **Table 6.5.5(a)**.

An overview of the water quality data for the Tweefontein Complex using pH, EC and SO_4 as indicator constituents, is provided in **Tables 6.5.5(b)** to **(d)**, and the results for the average and maximum concentration is graphically depicted in **Figures 6.5.5(a)** to **(c)**. A detailed discussion of the water quality at each of the collieries based on the time-series graphs is provided below.

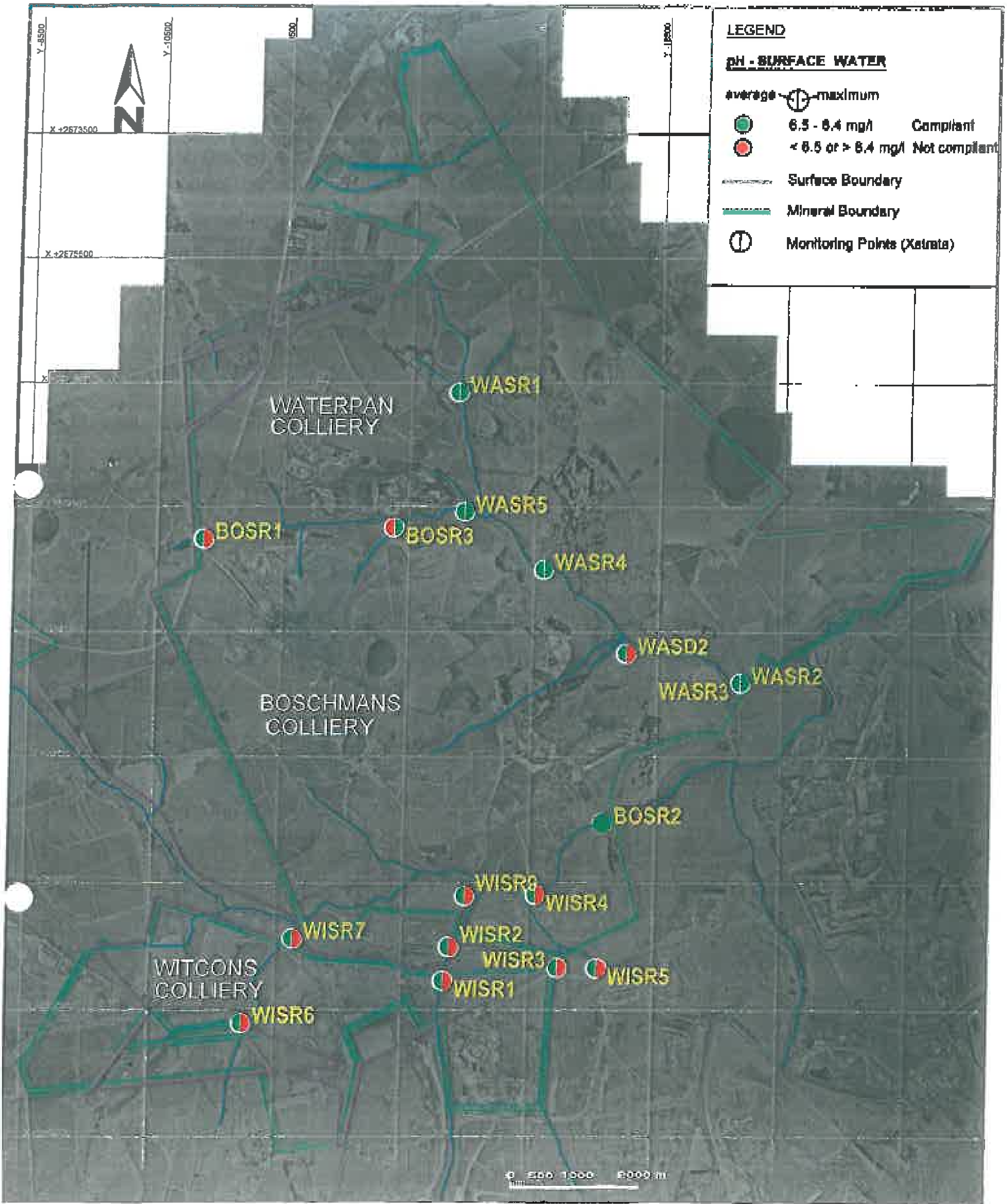
Table 6.5.4(a) Interim RWQO for Management Units 5, 6 and 19 of the Olifants River Catchment (DNWRP, 2009)

Constituent	Unit	MU 5	MU 6	MU 19
PHYSICAL				
Electrical conductivity (EC)	mS/m	70	90	70
Dissolved oxygen (DO)	% Sat	70	70	70
pH		6.5 – 8.4	6.5 – 8.4	6.5 – 8.4
Suspended solids	mg/ℓ	25	--	--
Turbidity	NTU	50	--	--
CHEMICAL, INORGANIC				
Alkalinity	mg $CaCO_3$/ℓ	--	--	85
Boron (B)	mg/ℓ	0.5	0.5	0.5
Calcium (Ca)	mg/ℓ	150	150	80
Chloride (Cl)	mg/ℓ	25	50	20
Fluoride (F)	mg/ℓ	1	1	0.5
Magnesium (Mg)	mg/ℓ	70	80	20
Potassium (K)	mg/ℓ	50	50	10
Sodium (Na)	mg/ℓ	70	115	20
Sodium Absorption Ration (SAR)	$Meql^{0.5}$	1.5	1.5	1
Sulphate (SO_4)	mg/ℓ	380	380	120
Total Dissolved Solids (TDS)	mg/ℓ	650	650	450
CHEMICAL, ORGANIC				
Dissolved Organic Carbon (DOC)	mg/ℓ	10	10	10
METALS, DISSOLVED				
Iron (Fe)	mg/ℓ	1	1	1
Manganese (Mn)	mg/ℓ	0.4	0.4	0.18
Aluminium (Al)	mg/ℓ	0.02	0.02	0.02
Chromium VI (Cr VI)	mg/ℓ	0.05	0.05	0.05
PLANT NUTRIENTS				
Ammonia (NH_3)*	mg/ℓ as N	0.007	0.007	0.007
Nitrate (NO_3)	mg/ℓ as N	6	6	6
Phosphate (PO_4)**	mg/ℓ as P	0.05	0.05	0.05
Total phosphorus**	mg/ℓ as P	0.25	0.25	0.25
Total Inorganic Nitrogen**	mg/ℓ as N	1.25	1.25	2.5
MICROBIOLOGICAL				
E. coli	# per 100 mℓ	130	130	130
Chlorophyll a	mg/ℓ	0.02	0.02	0.02

* Free ammonia as NH_3
** Median Concentration Values (50 percentiles)

Table 6.5.5(a) Description of time series graphs

Graph title	Description
Boschmans Colliery	Change of water quality at monitoring points BOSR-1, BOSR-2, BOSR-3 and BOSD-1 at the Boschmans Colliery from January 2006 to July 2012
Waterpan Colliery 1	Change of water quality at monitoring points WASR-1, WASR-4 and WASR-5 at the Waterpan Colliery from January 2006 to July 2012, as well as DWA monitoring number 189428 from April 2009 to March 2012
Waterpan Colliery 2	Change of water quality at monitoring points WASD-2, WASR-2 and WASR-3 at the Waterpan Colliery from January 2006 to July 2012, as well as DWA monitoring number 189430 from April 2009 to February 2012
Witcons Colliery 1	Change of water quality at monitoring points WISD-1, WISR-6 and WISR-7 at the Witcons Colliery January 2006 to July 2012
Witcons Colliery 2	Change of water quality at monitoring points WISR-1, WISR-2 and WISR-9 at the Witcons Colliery January 2006 to July 2012
Witcons Colliery 3	Change of water quality at monitoring points WISR-3, WISR-4 and WISR-5 at the Witcons Colliery January 2006 to July 2012



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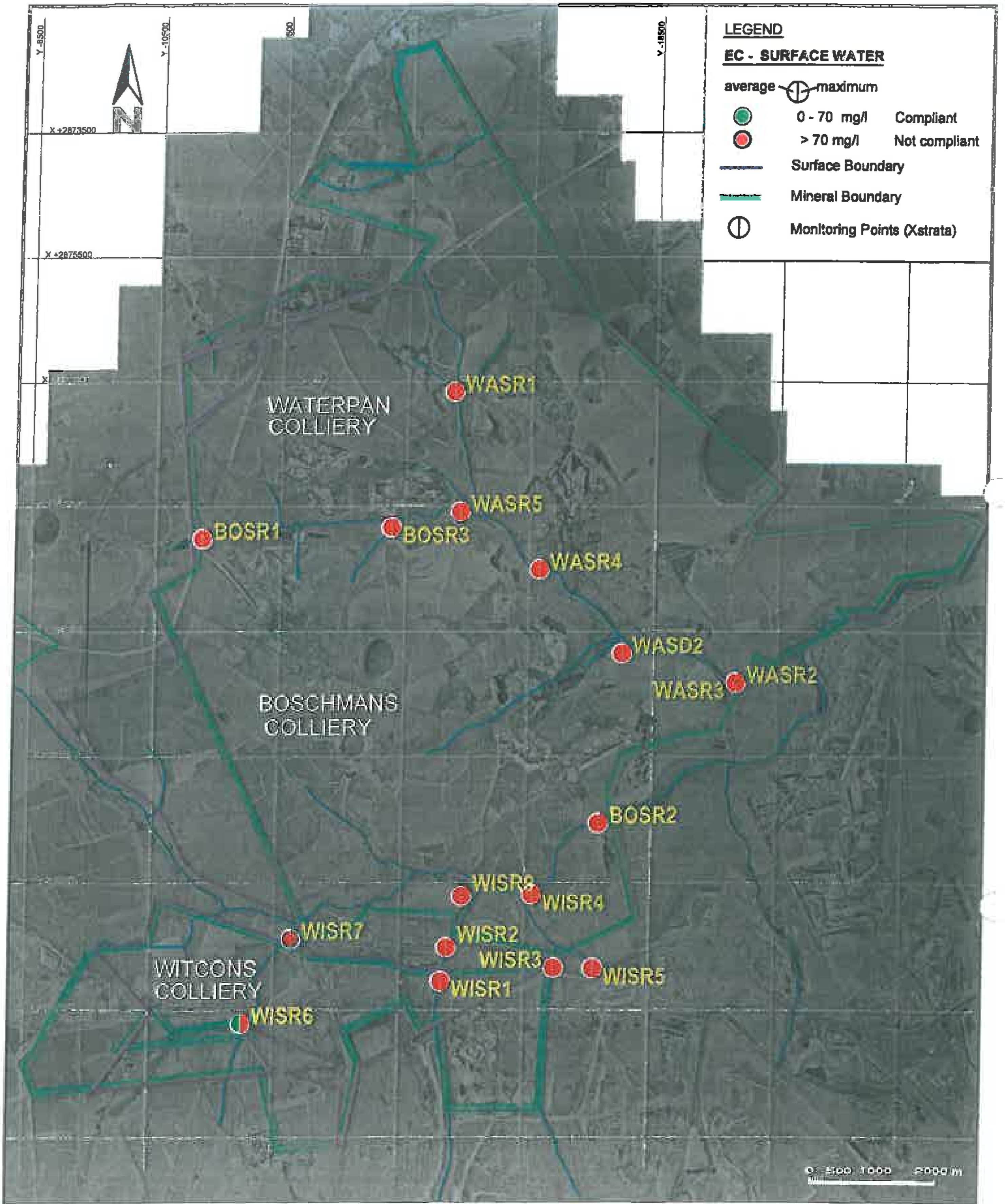
SUMMARISED
SURFACE WATER QUALITY : pH

Figure 6.5.5(a)



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Jones & Wagener Engineering & Environmental Consultants	Xstrata South Africa (Pty) Ltd Tweefontein Optimisation Project Amendment **SUMMARISED SURFACE WATER QUALITY : EC**	Job No: D367/00 **Figure 6.5.5(b)**

WASR-1

Tested	Unit	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH							
EC	mS/m						
Turb	NTU						
SS	mg/l						
TDS	mg/l						
Ca	mg/l						
Mg	mg/l						
Na	mg/l						
K	mg/l						
Tot-Alk	mg/l CaCO3						
Cl	mg/l						
SO4	mg/l						
NO3	mg/l						
F	mg/l						
Al	mg/l						
As	mg/l						
B	mg/l						
Cd	mg/l						
Cr	mg/l						
Cu	mg/l						
Fe	mg/l						
Mn	mg/l						
P	mg/l						
Pb	mg/l						
Se	mg/l						
Zn	mg/l						
Sr	mg/l						

WASR-1

Tested	Unit	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12
pH				7.6	7.2	7.3	6.8	7.4	7.5	7.2	4.9	8	6.9	6.8		
EC	mS/m			136	277	196	35	108	100	73	88	79	86	92		
Turb	NTU								1			59				
SS	mg/l								23			1383				
TDS	mg/l			1267	2706	1858	226	856	884	556	608	653	665	647		
Ca	mg/l			143	263	193	22	115	110	73	62	90	92	74		
Mg	mg/l			132	256	180	13	75	68	46	33	42	44	42		
Na	mg/l			20	29	27	17	21	20	24	30	29	37	24		
K	mg/l			4	3	9	9	7	5	7	27	9	10	7		
Tot-Alk	mg/l CaCO3			112	216	82	62	96	94	78	80	130	116	98		
Cl	mg/l			11	14	23	20	18	21	26	54	38	33	20		
SO4	mg/l			677	1461	1190	81	618	440	258	181	255	256	348		
NO3	mg/l			1	2	1	1	0.5		1	1	0.5	0.5	0.5		
F	mg/l															
Al	mg/l											0.05	0.05			
As	mg/l											0.05	0.05			
B	mg/l											0.05	0.05			
Cd	mg/l											0.05	0.05			
Cr	mg/l											0.05	0.05			
Cu	mg/l											0.05	0.05			
Fe	mg/l											0.1	0.05			
Mn	mg/l											0.4	0.1			
P	mg/l											0.05	0.05			
Pb	mg/l											0.05	0.05			
Se	mg/l											0.05	0.05			
Zn	mg/l											0.05	0.05			
Sr	mg/l											0.4	0.6			

WASR-1

Tested	Unit	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10
pH					7	7.8		7.6	8.3	7.2	8	7.7	8.1			
EC	mS/m				61	210		227	257	172	225	226	322			
Turb	NTU											2				
SS	mg/l								20			72				
TDS	mg/l				569	2057		1984	2446	1709	1931	2186	2838			
Ca	mg/l				84	310		369	377	320	320	275	413			
Mg	mg/l				30	129		137	158	118	112	99	204			
Na	mg/l				10	20		25	29	24	20	120	34			
K	mg/l				7	13		18	21	21	13	12	21			
Tot-Alk	mg/l CaCO3				46	166		210	186	102	178	182	242			
Cl	mg/l				9	11		18	24	21	14	17	21			
SO4	mg/l				310	1280		1405	1485	1055	1055	1141	1643			
NO3	mg/l				1	2		5	7	6	4	1	5			
F	mg/l				0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5			
Al	mg/l				0.5	0.5		0.5	0.24	0.5	0.5	0.35	0.5			
As	mg/l				0.5	0.5		0.5	0.022	0.5	0.5	0.011	0.5			
B	mg/l				0.5	0.5		0.5	0.26	0.5	0.5	0.16	0.5			
Cd	mg/l				0.5	0.5		0.5	0.01	0.5	0.5	0.01	0.5			
Cr	mg/l				0.5	0.5		0.5	0.01	0.5	0.5	0.01	0.5			
Cu	mg/l				0.5	0.5		0.5	0.006	0.5	0.5	0.012	0.5			
Fe	mg/l				0.5	0.5		0.5	0.03	0.5	0.5	0.05	0.5			
Mn	mg/l				0.5	0.5		0.5	0.5	0.5	0.5	0.01	0.5			
P	mg/l				0.5	0.5		0.5	0.865	0.5	0.5	1.112	0.5			
Pb	mg/l				0.5	0.5		0.5	0.003	0.5	0.5	0.018	0.5			
Se	mg/l				0.5	0.5		0.5	0.012	0.5	0.5	0.009	0.5			
Zn	mg/l				0.5	0.5		0.5	0.61	0.5	0.5	0.648	0.5			
Sr	mg/l				0.5	0.5		0.5	2.003	0.5	0.5	0.89	0.5			

WASR-1

Tested	Unit	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09
pH		7.5	8.2	7.4							8.3	7.9	7.7	7.4		
EC	mS/m	169	306	322							90	132	262	364		
Turb	NTU		2									1				
SS	mg/l		4									4				
TDS	mg/l	251	2711	2853							731	1086	2190	2729		
Ca	mg/l	81	429	566							108	184	272	459		
Mg	mg/l	13	249	155							49	68	116	159		
Na	mg/l	17	34	23							17	21	24	30		
K	mg/l	138	29	14							12	17	20	24		
Tot-Alk	mg/l CaCO3		392	590							70	122	142	198		
Cl	mg/l	16	21	20							11	17	23	43		
SO4	mg/l	941	1484	1580							406	634	1151	1590		
NO3	mg/l	1	1	4							1	1	1	4		
F	mg/l	0.5	0.62	0.5							0.5	0.5	0.5	0.5		
Al	mg/l	0.5	0.03	0.5							0.5	0.1	0.5	0.5		
As	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
B	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
Cd	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
Cr	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
Cu	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
Fe	mg/l	0.5	0.5	0.5							0.5	0.1	0.5	0.5		
Mn	mg/l	0.5	0.5	0.5							0.5	0.1	0.5	0.5		
P	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
Pb	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
Se	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
Zn	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		
Sr	mg/l	0.5	0.5	0.5							0.5	0.5	0.5	0.5		

WASR-1

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08
pH			7.9	7.2	7.5	7.2	7.8	7.7	7.5		6.8	7	7.2	7.5	7.6	7.1
EC	mS/m		417	436	462	409	366	425	206		78	88	157	226	222	104
Turb	NTU														16	
SS	mg/l														102	
TDS	mg/l		3708	4344	4733	3781	3735	4287	1929		648	718	1459	2150	2154	1009
Ca	mg/l		476	570	536	720	574	530	335		104	128	200	300	359	149
Mg	mg/l		363	313	417	295	272	364	98		44	60	71	111	141	33
Na	mg/l		75	104	126	71	69	91	21		7	12	15	20	44	8
K	mg/l		22	87	72	50	43	48	15		7	12	18	13	23	11
Tot-Alk	mg/l CaCO3		12	298	326	464	378	220	70		42	72	132	210	182	52
Cl	mg/l		34	136	123	67	52	72	17		9	94	18	17	17	6
SO4	mg/l		2009	2390	2526	2153	2183	2391	1134		366	368	785	1184	1240	430
NO3	mg/l		5	7	10	1	6	9	3		1	1	1	1	3	1
F	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.46	0.5	0.5	0.5	0.5
Al	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.03	0.5	0.5	0.5	0.5
As	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
B	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.05	0.5	0.5	0.5	0.5
Cd	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.003	0.5	0.5	0.5	0.5
Cr	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
Cu	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
Fe	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5
Mn	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5
P	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.1	0.5	0.5	0.5	0.5
Pb	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
Se	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
Zn	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.03	0.5	0.5	0.5	0.5
Sr	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.77	0.5	0.5	0.5	0.5

WASR-1

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH		7.7	7.6	7.3	7.5	7.6	7.6	7.7		8.3		7.5	8.1	
EC	mS/m	73.69	228.7695	94	113	166	194	204		254		253	286	
Turb	NTU													
SS	mg/l						39			30			33	
TDS	mg/l	478	2227	771	1094	1505	1850	1927		2523		2473	2838	
Ca	mg/l	72	364	84	182	246	300	333		441		424	447	
Mg	mg/l	34	178	43	34	82	135	120		154		198	206	
Na	mg/l	13	52	14	17	19	28	26		31		52	48	
K	mg/l	8	14	10	11	11	14	14		14		22	11	
Tot-Alk	mg/l CaCO3	54	238	114	192	196	188	218		238		188	368	
Cl	mg/l	2.84	29.778	13	20	14	26	33		27		28	21	
SO4	mg/l	294	1308	320	442	824	1073	1045		1372		1558	1427	
NO3	mg/l	1	2.645	1	1	1	1	5		7		3	7	
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Al	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.2	
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Fe	mg/l	0.6	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.1	
Mn	mg/l	0.1	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.1	
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	

WASD-2

Tested	Unit	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		3.4	3.8				
EC	mS/m	382	523				
Turb	NTU		12				
SS	mg/l		25				
TDS	mg/l	3760	4847				
Ca	mg/l	494	507				
Mg	mg/l	350	582				
Na	mg/l	9	15				
K	mg/l	9	9				
Tot-Alk	mg/l CaCO3	0	0				
Cl	mg/l	4	13				
SO4	mg/l	2632	3323				
NO3	mg/l	4	5				
F	mg/l						
Al	mg/l		14.5				
As	mg/l		0.2				
B	mg/l		0.05				
Cd	mg/l		0.05				
Cr	mg/l		0.05				
Cu	mg/l		0.05				
Fe	mg/l		0.3				
Mn	mg/l		14.4				
P	mg/l		0.2				
Pb	mg/l		0.1				
Se	mg/l		0.3				
Zn	mg/l		0.05				
Sr	mg/l		3.7				

WASD-2

Tested	Unit	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12
pH		8.1	8.1				7.7	7.2	7.5	7.2	6.9	7.9	7.2	6.5		6
EC	mS/m	242	259				117	193	953	998	1122	1083	1065	968		841
Turb	NTU		3						7			8				
SS	mg/l		18						59			45				
TDS	mg/l	1909	1938				1010	1830	11248	11574	12099	12690	12735	8966		8662
Ca	mg/l	212	238				104	198	539	488	463	485	471	362		547
Mg	mg/l	243	219				83	159	454	523	1508	1597	1736	1124		1133
Na	mg/l	50	62				34	38	41	42	43	45	47	34		45
K	mg/l	9	8				5	6	32	33	40	37	38	26		22
Tot-Alk	mg/l CaCO3	130	128				78	62	46	58	42	54	48	34		14
Cl	mg/l	61	72				17	35	23	23	23	27	21	16		6
SO4	mg/l	1338	1412				606	1167	2893	4130	7740	4048	4342	5008		4778
NO3	mg/l	1	2				1	1		10	11	5	10	11		8
F	mg/l	0.5	0.5													
Al	mg/l	0.5	1.04									0.05	0.05			
As	mg/l	0.5	0.014									0.05	0.05			
B	mg/l	0.5	0.12									0.6	0.8			
Cd	mg/l	0.5	0.01									0.05	0.05			
Cr	mg/l	0.5	0.02									0.05	0.05			
Cu	mg/l	0.5	0.011									0.05	0.05			
Fe	mg/l	0.5	0.07									0.05	0.05			
Mn	mg/l	0.5	0.01									0.05	0.05			
P	mg/l	0.5	0.01									0.9	3			
Pb	mg/l	0.5	0.018									0.05	0.05			
Se	mg/l	0.5	0.02									0.05	0.05			
Zn	mg/l	0.5	0.137									0.05	0.05			
Sr	mg/l	0.5	1.618									5.7	7.1			

WASD-2

Tested	Unit	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10
pH		7	7.9	7.8	7.6	7.7		7.9	7.7	6.6	6.8	7.9	8.3	8.1	7.8	8
EC	mS/m	487	309	272	292	213		203	227	291	55	203	236	245	232	235
Turb	NTU		1						1			21			3	
SS	mg/l		9						5			18			6	
TDS	mg/l	4383	2884	2690	2661	2088		1778	2094	2072	365	1993	1906	2033	2085	1712
Ca	mg/l	630	151	282	262	193		195	213	219	45	149	220	212	213	194
Mg	mg/l	462	259	292	246	197		172	201	193	27	127	108	173	238	214
Na	mg/l	135	68	64	56	41		41	47	47	14	105	52	47	49	45
K	mg/l	37	13	11	7	6		6	7	8	3	6	8	9	10	8
Tot-Alk	mg/l CaCO3	58	98	106	108	82		112	124	114	42	156	120	120	120	132
Cl	mg/l	37	69	64	50	33		37	44	43	11	41	41	45	48	48
SO4	mg/l	3029	1306	1827	1587	1325		1205	1202	1195	177	1067	916	1148	1327	1301
NO3	mg/l	10	1	6	3	3		2	6	2	2	1	1	1	2	3
F	mg/l	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.72	0.5	0.5	0.5		0.5	0.23	0.5	0.5	0.34	0.5	0.5	0.2	0.5
As	mg/l	0.5	0.024	0.5	0.5	0.5		0.5	0.022	0.5	0.5	0.011	0.5	0.5	0.002	0.5
B	mg/l	0.5	0.13	0.5	0.5	0.5		0.5	0.11	0.5	0.5	0.2	0.5	0.5	0.02	0.5
Cd	mg/l	0.5	0.01	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01	0.5
Cr	mg/l	0.5	0.02	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.05	0.5
Cu	mg/l	0.5	0.011	0.5	0.5	0.5		0.5	0.007	0.5	0.5	0.013	0.5	0.5	0.012	0.5
Fe	mg/l	0.5	0.04	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.04	0.5	0.5	0.07	0.5
Mn	mg/l	0.5	0.01	0.5	0.5	0.02		0.5	0.02	0.5	0.5	0.01	0.5	0.5	0.1	0.5
P	mg/l	0.5	1.656	0.5	0.5	0.5		0.5	0.882	0.5	0.5	1.118	0.5	0.5	0.031	0.5
Pb	mg/l	0.5	0.013	0.5	0.5	0.5		0.5	0.008	0.5	0.5	0.018	0.5	0.5	0.04	0.5
Se	mg/l	0.5	0.016	0.5	0.5	0.5		0.5	0.021	0.5	0.5	0.005	0.5	0.5	0.018	0.5
Zn	mg/l	0.5	0.01	0.5	0.5	0.5		0.5	0.602	0.5	0.5	0.647	0.5	0.5	0.096	0.5
Sr	mg/l	0.5	2.422	0.5	0.5	0.5		0.5	1.696	0.5	0.5	0.822	0.5	0.5	1.837	0.5

WASD-2

Tested	Unit	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09
pH		7.5	7.9	7.8	8	7.8	8.2	7.9	7.5	8.2	8.1	8.2	7.5	7.7	8.1	7.4
EC	mS/m	189	274	281	278	296	371	335	379	328	169	227	344	304	327	378
Turb	NTU		2			223			1			1			1	
SS	mg/l		4			21			21			44			103	
TDS	mg/l	177	2361	2445	2740	2871	2998	3214	3602	2968	1522	2039	2968	2177	2236	3752
Ca	mg/l	171	143	234	266	279	292	340	298	318	158	225	247	226	263	301
Mg	mg/l	27	235	231	275	287	323	322	498	318	138	209	255	211	220	371
Na	mg/l	7	44	47	45	45	48	54	58	61	41	48	56	48	49	67
K	mg/l	34	8	9	8	9	9	9	10	9	7	9	8	9	8	15
Tot-Alk	mg/l CaCO3		94	96	52	50	52	58	58	66	50	78	102	112	116	118
Cl	mg/l	26	44	45	48	50	58	61	61	64	38	47	37	44	52	40
SO4	mg/l	1172	1246	1544	1663	1862	1674	1949	2300	1985	953	1302	1590	1343	1333	2202
NO3	mg/l	2	1	4	5	4	3	4	1	1	1	1	1	4	3	6
F	mg/l	0.5	0.66	0.5	0.5	0.39	0.5	0.5	0.54	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.03	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.06	0.5	0.5	0.16	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	2.1	0.5	0.5	2.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5

WASD-2

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08
pH		8.6	8.4		7.9	7.2	7.3	6.7		7.5	6.8	6.5	6.9	6.7	7.4	
EC	mS/m	105	99		119	135	140	182		543	319	326	233	135	205	
Turb	NTU														2	
SS	mg/l		12												1	
TDS	mg/l	683	689		923	924	1065	1558		5435	3301	3385	2321	1183	2014	
Ca	mg/l	63	70		89	97	109	158		488	327	409	199	126	209	
Mg	mg/l	57	59		58	62	70	86		227	272	393	263	83	200	
Na	mg/l	49	63		79	79	89	110		128	61	84	45	20	47	
K	mg/l	6	6		8	11	13	45		19	6	13	6	0.5	9	
Tot-Alk	mg/l CaCO3	64	92		98	116	136	384		128	20	14	24	24	32	
Cl	mg/l	40	44		50	54	111	62		122	60	71	43	27	40	
SO4	mg/l	332	348		426	545	522	467		3229	1949	2071	1381	718	1120	
NO3	mg/l	1	1		0.5	1	1	1		9	3	3	2	1	3	
F	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	
Al	mg/l	0.5	0.2		0.5	0.5	0.5	0.5		0.5	0.5	0.03	0.5	0.5	0.5	
As	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	
B	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.13	0.5	0.5	0.5	
Cd	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.003	0.5	0.5	0.5	
Cr	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	
Cu	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	
Fe	mg/l	0.5	0.1		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	
Mn	mg/l	0.5	1		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	
P	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.1	0.5	0.5	0.5	
Pb	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	
Se	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	
Zn	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	
Sr	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	2.84	0.5	0.5	0.5	

WASD-2

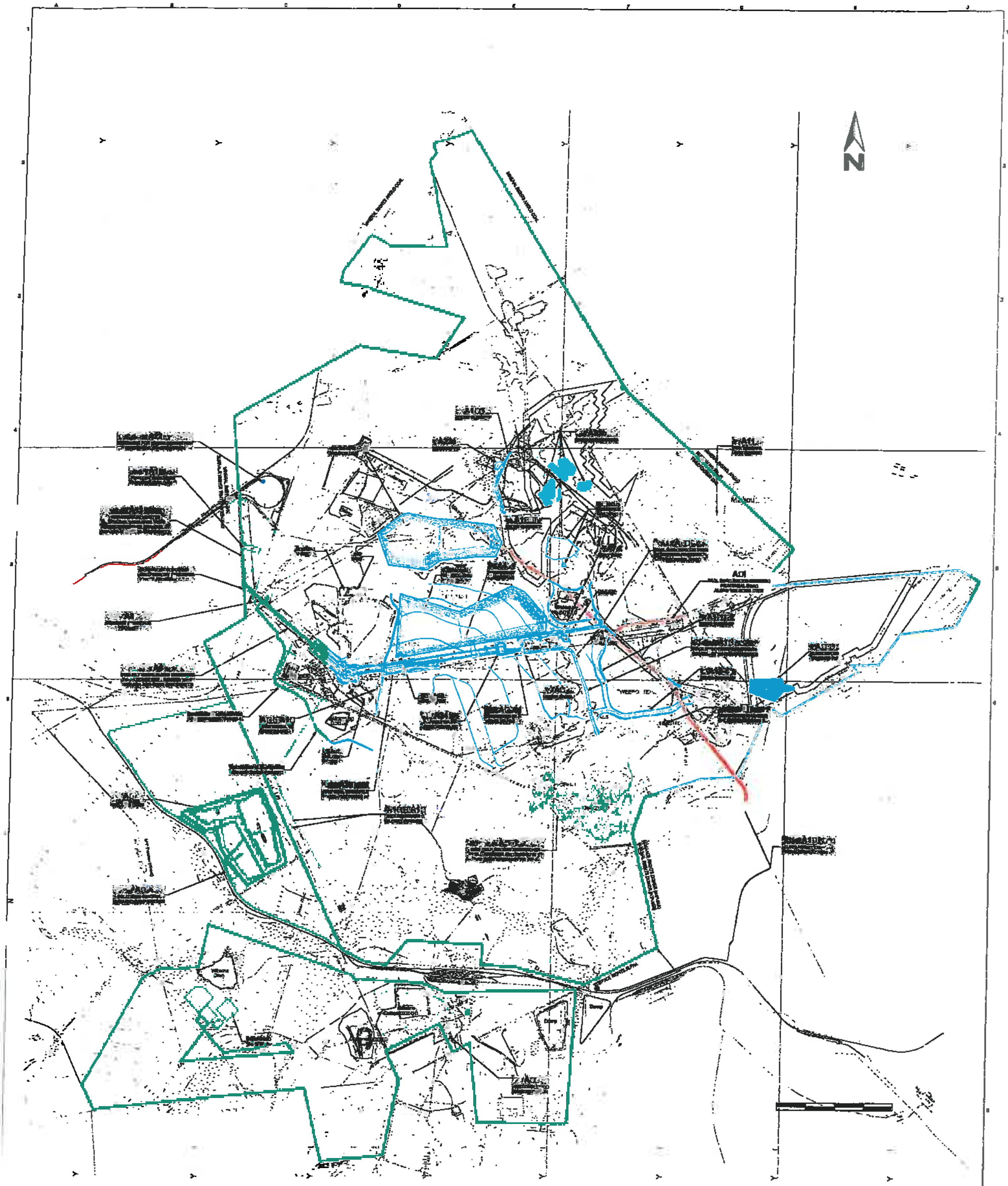
Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH						7.9	7.3	7.2	7.5	8.1	7.5	7.2		8.6
EC	mS/m					97	103	110	172	172	142	134		105
Turb	NTU													
SS	mg/l						58			2		14		
TDS	mg/l					792	827	868	1037	1054	1097	1110		683
Ca	mg/l					78	111	99	106	108	119	118		63
Mg	mg/l					36	72	67	78	80	81	89		57
Na	mg/l					54	33	34	40	43	61	67		49
K	mg/l					8	10	11	12	10	11	10		6
Tot-Alk	mg/l CaCO3					74	90	104	96	116	68	106		64
Cl	mg/l					38	34	40	41	48	50	52		40
SO4	mg/l					352	446	482	578	550	661	573		332
NO3	mg/l					1	1	1	1	1	1	1		1
F	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Al	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
As	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
B	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Cd	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Cr	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Cu	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Fe	mg/l					0.5	0.5	0.5	0.5	0.1	0.5	0.5		0.5
Mn	mg/l					0.5	0.5	0.5	0.5	0.1	0.5	0.5		0.5
P	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Pb	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Se	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Zn	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5
Sr	mg/l					0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5

APPENDIX B1a

MONITORING DATA: WATERPAN COLLIERY

Appendix B

WATER QUALITY DATA AND GRAPHS



LEGEND

- Mine Boundary
- Existing Infrastructure
- Proposed Infrastructure

Co-ordinate System: CLARKE 1880 Spheroid
Projection: Lo29

Engineering & Environmental Consultants

J & W DRAWING NUMBER D367-00-002

TWEEFONTEIN OPTIMISATION PROJECT AMENDMENT

PROPOSED INFRASTRUCTURE LAYOUT

PROJ	SCALE	ORIG. SIZE	SHEET	DRAWING NUMBER	REV
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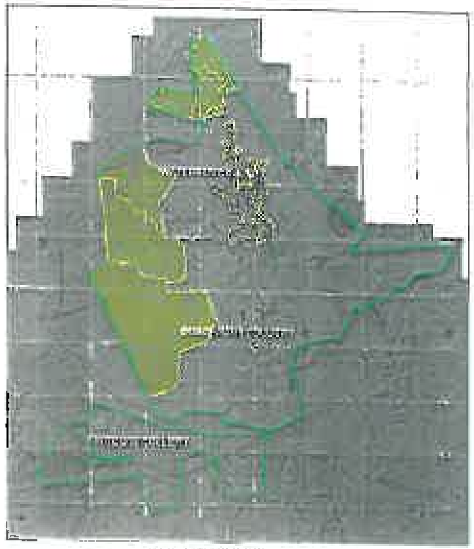
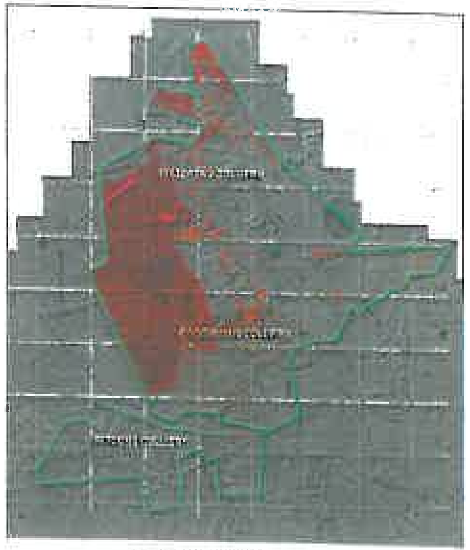
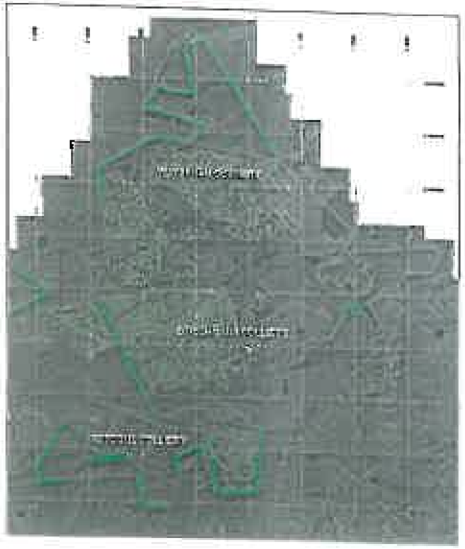


1 SEAM UNDERGROUND PLAN

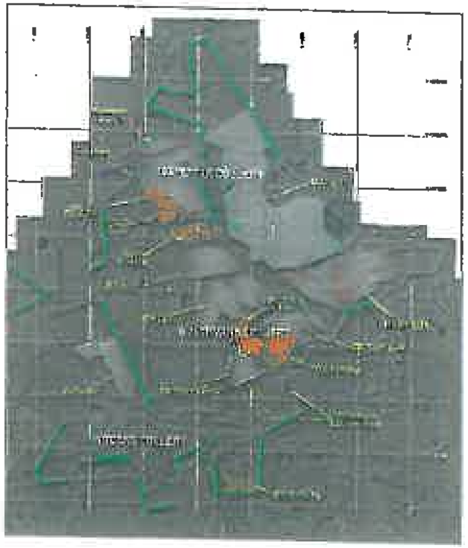


2 SEAM UNDERGROUND PLAN



4 SEAM UNDERGROUND PLAN

5 SEAM UNDERGROUND PLAN



OPENCAST WORKINGS

LEGEND:

- Surface Boundary
- Mineral Boundary
- New 1 Seam Underground
- Existing 1 Seam Underground
- New 2 Seam Underground
- Existing 2 Seam Underground
- Existing 4 Seam Underground

Co-ordinate System: CLARKE 1880 Spheroid
Projection: Lo29

Jones & Wagener
Engineering & Environmental Consultants

xstrata coal
XSTRATA COAL S.A. (PTY) LTD

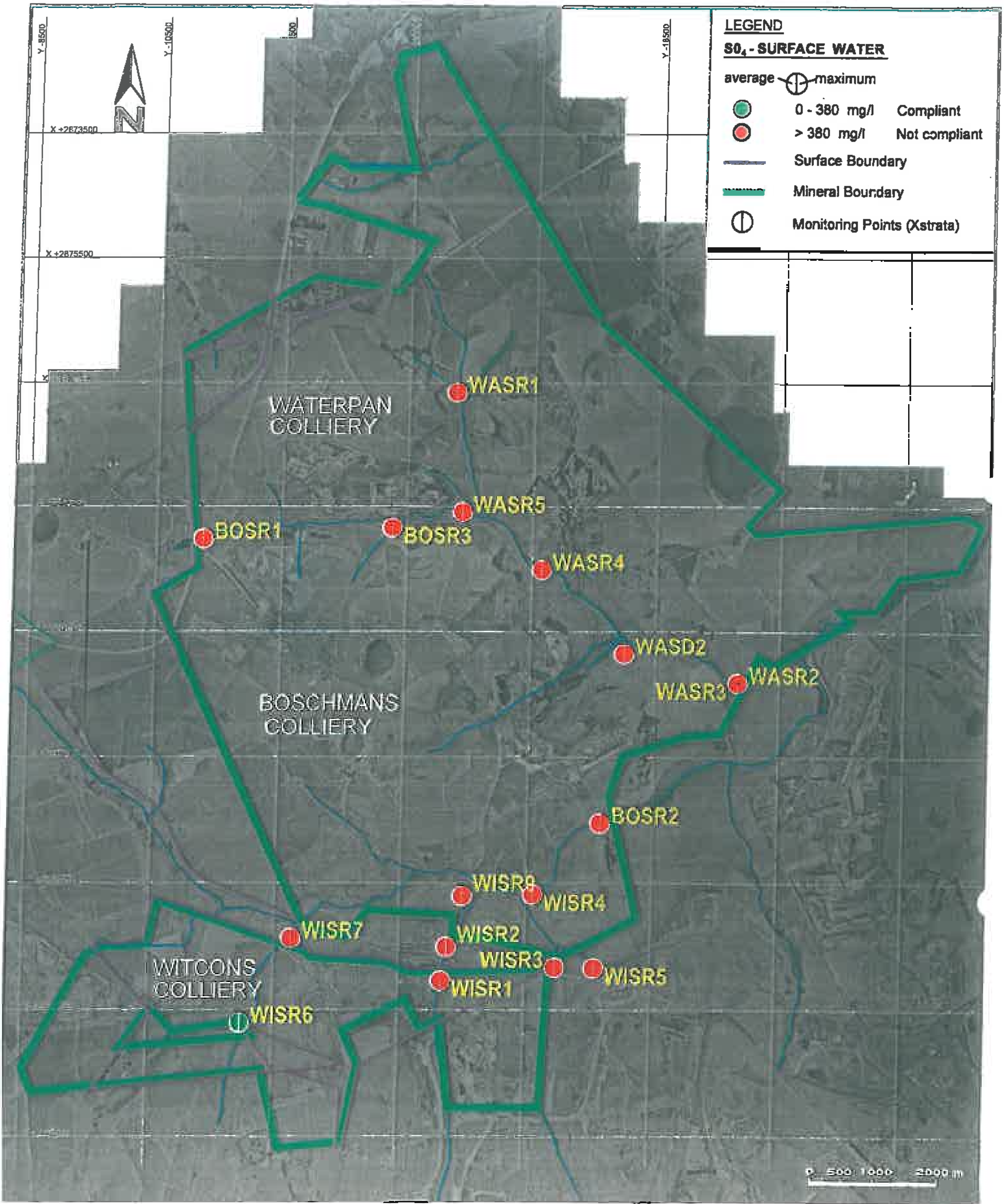
TWEEFONTEIN OPTIMISATION PROJECT AMENDMENT

STUDY AREA

SCALE	SHT. SIZE	DRAWING NUMBER	REV
1:75000	A1	AEP-JAW-XXXX-GL-XX-XXXX-A	A

J & W DRAWING NUMBER: D367-00-001

NUMBER	REFERENCE DRAWING	NUMBER	REFERENCE DRAWING	REV	DATE	REVISION	BY	CHK	APPROVED



Cape Lo29

Jones & Wagener
Engineering & Environmental Consultants

Xstrata South Africa (Pty) Ltd
Tweefontein Optimisation Project Amendment

SUMMARISED
SURFACE WATER QUALITY : SO_4

Job No: D367/00

Figure 6.5.5(c)

Waterpan Colliery

A summary of the water quality status for the period January 2006 to July 2012 is provided in **Table 6.5.5(b)**. The results are graphically depicted in **Figures 6.5.5(a)** to **(c)**.

Table 6.5.5(b) Summary of surface water quality at Waterpan Colliery (January 2006 – July 2012)

Parameter	Interim RWQO		WASR-1	WASR-2	WASR-3	WASR-4	WASR-5	WASD-2
pH	6.5 - 8.4	Average	7.5	7.5	7.5	6.8	6.7	7.4
		Maximum	8.3	8.3	8.2	7.7	7.8	8.6
		Minimum	4.9	6.3	6.4	6.2	5.8	3.4
EC (mS/m)	70	Average	205.66	343.82	273.68	347.52	319.38	327.45
		Maximum	462	795	617	528	518	1122
		Minimum	35	86.02	74	58	132	55
Ca (mg/ℓ)	150	Average	279.14	331.04	266.77	407.30	279.35	245.05
		Maximum	720	742	546	648	756	630
		Minimum	22	70	84	40	0.5	45
Mg (mg/ℓ)	70	Average	132.51	322	215.55	292.74	323.77	305.32
		Maximum	417	874	469	488	944	1736
		Minimum	13	27	28	29	114	27
K (mg/ℓ)	50	Average	20.96	8.64	10.57	14.20	9.50	12.81
		Maximum	138	34	144	35	32	45
		Minimum	3	0.5	0.5	0.5	0.5	0.5
Cl (mg/ℓ)	150	Average	29.40	32.88	70.19	44.39	19.23	44.10
		Maximum	136	92	1 362	86	30	122
		Minimum	2.84	1	14	6	7	4
SO_4 (mg/ℓ)	380	Average	1 056	2 015	1 486	2 198	1 970	1 664
		Maximum	2 526	4 638	3 152	3 800	3 879	7 740
		Minimum	81	316	3	133	741	177
Al (mg/ℓ)	0.02	Average	0.43	0.43	0.45	0.22	0.41	0.70
		Maximum	0.5	1.05	1.08	0.5	0.5	14.5
		Minimum	0.03	0.01	0.01	0.03	0.04	0.01
Fe (mg/ℓ)	1	Average	0.44	0.40	0.42	0.41	0.50	0.40
		Maximum	0.6	0.5	0.5	2	0.5	0.5
		Minimum	0.03	0.01	0.03	0.05	0.5	0.01
Mn (mg/ℓ)	0.4	Average	0.45	2.00	0.49	2.62	0.50	0.74
		Maximum	0.5	24.9	2.2	12.5	0.5	14.4
		Minimum	0.01	0.09	0.01	0.5	0.5	0.01

Text in red indicates exceedance of the Interim RWQO

The pH levels at the XSA monitoring points for the Waterpan Colliery are largely within the interim RWQO of 6.5 to 8.4. pH levels below the lower interim RWQO of 6.5 were recorded on a number of occasions at WASR-1, WASR-4, WASR-5 and WASD-2. The pH levels at DWA monitoring point 189428 were below the lower interim RWQO from April 2009 to May 2010, but have improved since June 2010 to comply with the interim RWQO.

Electrical conductivity (EC) is an indicator of the salinity of water as a result of the presence of charged ions such as carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium. The interim RWQO has been set at 70 mS/m. The EC levels at the surface water monitoring points for the Waterpan Colliery exceed this objective at all of the monitoring points for most of the time. The average EC levels measures at the Waterpan Colliery monitoring points exceed 200 mS/m, indicating an impact as a result of mining and related activities. EC levels measured at DWA monitoring points 189428 and 189430 correspond with this observation, with an average of 366 mS/m and 239 mS/m respectively measured over the period for which data is available.

This impact is further evident when sulphate (SO_4) levels are considered. Average sulphate concentrations at the Waterpan Colliery monitoring points range from 1 056 mg/ℓ to 2 198 mg/ℓ. Levels as high as 7 740 mg/ℓ has been measured in the Tweefontein Dam (WASD-2). At DWA monitoring points 189428 and 189430, an average concentration of 867 mg/ℓ and 772 mg/ℓ respectively was measured over the period for which data is available. The interim RWQO of 380 mg/ℓ is therefore significantly exceeded.

Calcium (Ca) and magnesium (Mg) concentrations at all the Waterpan Colliery monitoring points are also significantly elevated above the interim RWQO.

Average aluminium (Al) concentrations range from 0.22 mg/ℓ to 0.70 mg/ℓ. This is more than tenfold higher than the interim RWQO of 0.02 mg/ℓ. This objective is very stringent since it is based on the Aquatic Ecological Reserve determined in 2001 (DNWRP, 2009). When the levels are compared to the SA Water Quality Guidelines for irrigation and stock watering, the measured quality is below the target guideline of 5 mg/ℓ.

The average manganese (Mn) concentrations at monitoring points WASR-2 and WASR-4 (2.0 mg/ℓ and 2.62 mg/ℓ respectively) exceeded the interim RWQO of 0.4 mg/ℓ.

There has been a noticeable deterioration in the water quality measured at the Tweefontein Dam (WASD-2) in the Tweefonteinspruit for the period March 2011 to July 2012. A portion of the Boschmans Colliery also drains towards the Tweefontein Dam and therefore monitoring point WASD-2 provides an indication of the impact resulting from activities from both Waterpan and Boschmans Collieries.

Surface water resources at the Waterpan Colliery have therefore been impacted as a result of mining and mining related activities. When considering the water quality results for the period 2006 to 2012, an increasing trend[2] in the levels of EC, SO_4 and Mg has been observed at monitoring points WASR-2, WASR-4 and WASD-2, indicating an increasing impact at these points over time. Monitoring point WASR-3 has shown a decreasing trend in levels of EC, SO_4 and Mg over this period.

According to the annual report by JKC for 2012, two points showed a deteriorating trend in 2012, namely WASR-2 and WASR-5. The latter indicated a deteriorating trend during 2011 as well (JKC, 2013).

[2] Trend lines not shown on graphs

The upstream monitoring point for the Waterpan Colliery (WASR-1) also exhibits an impact (average EC and sulphate of 205.6 mS/m and 1 056 mg/ℓ respectively), although an improving trend is observed for the period 2006 to 2012 for EC, SO_4, Ca, Mg, K, Cl and Na. This monitoring point is located adjacent to the plant area and the potential for seepage and spills from the Waterpan Plant area to enter the watercourse upstream of the sampling location has been identified in the surface water report done by J&W in 2010 (J&W, 2010). The Waterpan Plant has, however, been closed, which could explain the improving water quality trend observed.

The piper diagram compiled by JKC for the 2012 monitoring data is shown in **Figure 6.5.5(d)**. It should be noted that the results for the pollution control dams are also shown. All of the monitoring points show a distinct Ca-SO_4 signature, typical of mine related impacts.

Water quality results obtained at the XSA monitoring points and the DWA monitoring points included in this assessment correlates well.

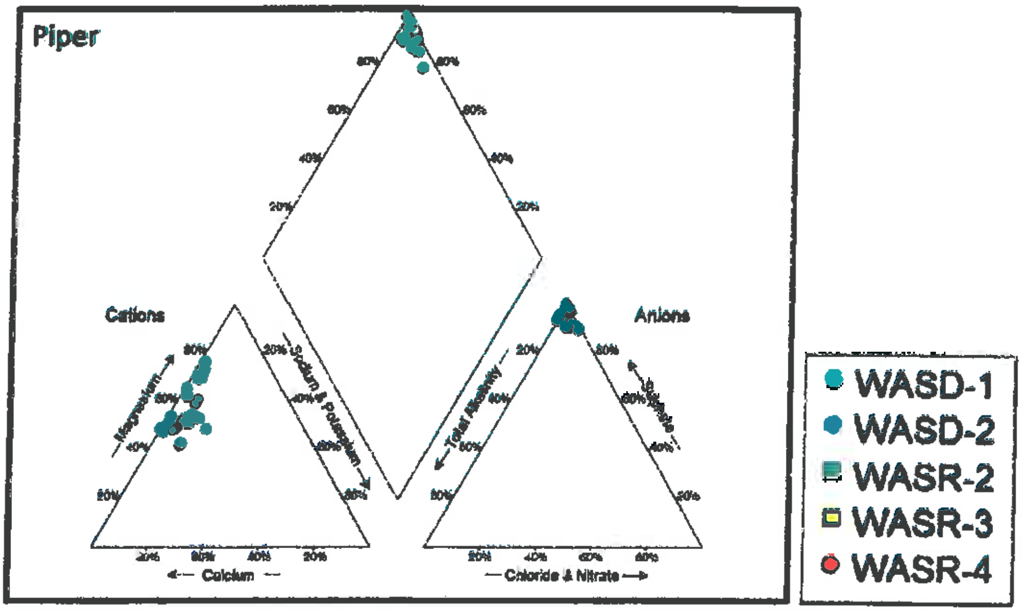


Figure 6.5.5(d): Piper diagram for Waterpan Colliery (JKC, 2013)

Boschmans Colliery

A summary of the water quality status for the period January 2006 to July 2012 at the Boschmans Colliery is provided in **Table 6.5.5(c)**. The results are graphically depicted in **Figures 6.5.5(a)** to **(c)**.

Since January 2008, the pH levels at monitoring points BOSR-1 and BOSR-2 at the Boschmans Colliery were largely within the interim RWQO of 6.5 – 8.4. Monitoring point BOSR-3 showed pH levels below the lower interim objective of 6.5 between May 2009 and November 2011. The pH level at the pan to the south-east of the Boschmans Plant (BOSD-1) exceeded the upper interim objective of 8.4 on a number of occasions since February 2010.

Table 6.5.5(c): Summary of surface water quality at Boschmans Colliery (January 2006 – July 2012)

Parameter	Interim RWQO		BOSR-1	BOSR-2	BOSR-3	BOSD-1
pH	6.5 - 8.4	Average	7.5	6.9	6.2	8.3
		Maximum	8.5	8.4	8.3	9.7
		Minimum	3.7	3.4	3.9	7.0
EC (mS/m)	70	Average	114.60	157.06	72.42	286.52
		Maximum	334	1 134	627	371
		Minimum	19	18	8	3.5
Ca (mg/ℓ)	150	Average	98.07	117.26	57.75	215.69
		Maximum	283	598	482	321
		Minimum	16	7	0.5	96
Mg (mg/ℓ)	70	Average	56.51	80.12	63.98	151.3
		Maximum	221	377	730	201
		Minimum	5	9	0.4	65
K (mg/ℓ)	50	Average	11.25	10.89	4.02	12.81
		Maximum	98	110	38	16
		Minimum	0.5	0.5	0.4	5
Cl (mg/ℓ)	150	Average	61.22	59.45	16.59	97.95
		Maximum	183	318	121	155
		Minimum	1	0	2.84	7
SO_4 (mg/ℓ)	380	Average	441.73	857	391.76	1 392
		Maximum	1 515	4 379	3 849	1 843
		Minimum	27	19	1	438
Al (mg/ℓ)	0.02	Average	0.46	1.62	0.45	0.38
		Maximum	2.41	57.3	1.08	1.09
		Minimum	0.01	0.01	0.01	0.01
Fe (mg/ℓ)	1	Average	0.41	0.83	0.78	0.32
		Maximum	1.36	21.7	18.6	0.5
		Minimum	0.01	0.03	0.02	0.03
Mn (mg/ℓ)	0.4	Average	0.64	0.53	0.60	0.41
		Maximum	10.6	6.4	6	3
		Minimum	0.01	0.01	0.01	0.01

Text in red indicate exceedance of the interim RWQO

The interim RWQO for EC has been set at 70 mS/m. The EC levels at BOSR-1 and BOSR-2 exceed the interim objective most of the time (with an average of 114.6 mS/m and 157.06 mS/m respectively). The EC level at BOSD-1 (pan to the south-east of the Boschmans Plant) exceeds the objective for most of the monitoring period with an average of 286.5 mS/m and a maximum of 371 mS/m. This pan acts as a pollution control dam for the Boschmans Plant area. The EC at BOSR-3 was below the interim objective for most of the time.

A similar scenario exists for sulphate (SO_4) concentrations. The interim objective of 380 mg/ℓ is exceeded at BOSR-1 and BOSR-2 at a number of occasions with an average of 441.73 mg/ℓ and 657 mg/ℓ measured respectively. The SO_4 concentration at BOSD-1 significantly exceeds the interim RWQO since monitoring started, with an average of 1 392 mg/ℓ, maximum of 1 843 mg/ℓ and minimum of 438 mg/ℓ measured over this period. The sulphate concentration at BOSR-3 is below the interim objective most of the time and the high average (391.76 mg/ℓ) is attributed to a number of monitoring occasions where significantly elevated sulphate concentrations (as high as 3 849 mg/ℓ) were measured. However, in the 2012 annual monitoring report by JKC, the deteriorating quality at BOSR-3 is raised as a concern as a result of a sulphate increased from 558 mg/ℓ in November 2011 to 3 391 mg/ℓ in 2012 (JKC, 2013).

The interim RWQO for calcium is exceeded on a number of occasions at BOSR-2 and BOSR-3, although the average concentration is below the objective of 150 mg/ℓ. Although the calcium concentration at the upstream monitoring point BOSR-1 is generally below the interim RWQO, concentrations above the objective were measured on a number of occasions.

The magnesium (Mg) concentrations measured at the Boschmans Colliery are close to the interim RWQO of 70 mg/ℓ, with an average concentration of 56.5 mg/ℓ, 80.12 mg/ℓ and 63.98 mg/ℓ measured at BOSR-1, BOSR-2 and BOSR-3 respectively The objective was exceeded on a number of occasions at all of these points.

Average aluminium (Al) concentrations range from 0.41 mg/ℓ to 1.62 mg/ℓ. This is significantly higher than the interim RWQO of 0.02 mg/ℓ. The objective is very stringent since it is based on the Al concentration to ensure that the Ecological Reserve is met. When the levels are compared to the SA Water Quality Guidelines for irrigation and stock watering, the measured quality is below the target guideline of 5 mg/ℓ.

The average manganese (Mn) concentration at monitoring points BOSR-1, BOSR-2 and BOSR-3 was 0.64 mg/ℓ, 0.53 mg/ℓ and 0.60 mg/ℓ respectively. This is slightly above the interim RWQO of 0.4 mg/ℓ.

Surface water resources at the Boschmans Colliery have therefore been impacted as a result of mining and mining related activities. The upstream monitoring point BOSR1 also shows signs of pollution as a result of mining and related activities, with EC and SO_4 levels elevated above the interim RWQO. There are no surface mining activities upstream of this sampling location, but it is possible that runoff from dirty areas south and west of the railway line is directed along the railway line and into the Tweefonteinspruit at this location.

When considering the water quality results for the period 2006 to 2012, an increasing trend in the levels of EC, SO_4, Ca and Mg has been observed at monitoring point BOSR-1, indicating an increasing impact at these points over time. The deterioration in water quality at BOSR-3 in 2012 was raised as a concern in the annual monitoring report by JKC (JKC, 2013). Monitoring point BOSR-2 has shown no specific trend, or a reduction in the concentration of constituents over this time.

The piper diagram compiled by JKC for the 2012 monitoring data is shown in **Figure 6.5.5(e)**. It should be noted that the results for the pollution control dams are also shown, which shows a distinct Ca-SO_4 signature, typical of mine related impacts. BOSR-1 (Tweefonteinspruit) and BOSR-2 (Zaaiwaterspruit) has a slightly different signature. BOSR-2 has a less pronounced sulphate character.

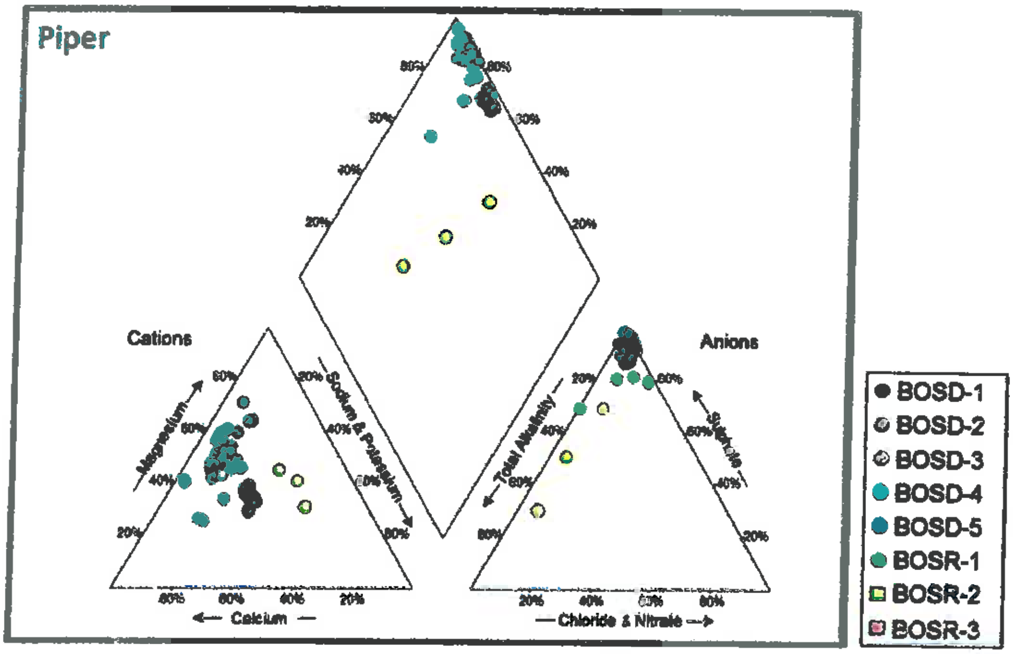


Figure 6.5.5(e): Piper diagram for Boschmans Colliery (JKC, 2013)

Witcons Colliery

A summary of the water quality status for the period January 2006 to July 2012 at the Boschmans Colliery is provided in **Table 6.5.5(d)**. The results are graphically depicted in **Figures 6.5.5(a)** to **(c)**.

pH levels at the monitoring points at Witcons Colliery were largely within the interim RWQO of 6.5 – 8.4, with the exception of WISR-4 and WISR-7 which had pH levels below the lower limit of 6.5 on a number of occasions. The pH level at WISR-6, WISR-2 and WISD-1 exceeded the upper interim objective of 8.4 on a number of occasions.

The EC levels at most of the monitoring points exceed the interim objective of 70 mS/m most of the time, with the exception of WISR-6 which had EC levels below this objective most of the time. The EC level at WISR-9 was also below the objective from January 2009 to January 2011. Thereafter the EC level increased significantly.

The interim objective of 380 mg/ℓ for sulphate is exceeded at WISR-1, WISR-3, WISR-4, WISR-7 and WISD-1. The SO_4 concentration at WISR-5 and WISR-6 was below the interim RWQO for most of the time.

The interim RWQO for calcium is exceeded on a number of occasions at most of the monitoring points, with the exception of WISR-5 and WISR-6. The calcium concentration at WISR-4, WISR-9 and WISD-1 was below the interim RWQO until January 2011, where after an increase is observed at all of these points.

The magnesium concentrations at the Witcons Colliery exceed the interim RWQO of 70 mg/ℓ at most of the monitoring points for most of the time, with the exception of WISR-5 and WISR-6.

Table 6.5.5(d) Summary of surface water quality at Witcons Colliery (January 2009 – July 2012)

Parameter	Interim RWQO		WISR-1	WISR-2	WISR-3	WISR-4	WISR-5	WISR-6	WISR-7	WISR-9
pH	6.5 - 8.4	Average	7.7	7.9	7.8	7.3	7.8	7.7	6.8	7.7
		Maximum	8.5	8.8	8.5	8.5	8.6	9.0	8.5	8.6
		Minimum	3.2	3.8	7.1	3.1	7.2	6.4	3.2	6.5
EC (mS/m)	70	Average	225.21	89.21	309.64	251.34	98.85	51.84	212.65	139.16
		Maximum	449	307	497	740	129	120	513	364
		Minimum	81	3.8	136	43	77	24	98	30
Ca (mg/ℓ)	150	Average	212.93	270.50	306.07	238.76	73.31	30.65	215.17	138.59
		Maximum	493	948	436	702	136	68	465	420
		Minimum	65	101	137	32	57	14	96	20
Mg (mg/ℓ)	70	Average	87.88	161.25	247.88	182.71	43.00	19.98	119.26	90.68
		Maximum	211	351	480	729	54	41	521	345
		Minimum	26	41	92	22	24	7	43	11
K (mg/ℓ)	50	Average	7.07	113.28	11.79	14.37	21.00	13.40	9.39	8.76
		Maximum	14	456	22	72	36	33	20	18
		Minimum	3	5	4	1	5	2	1	2
Cl (mg/ℓ)	150	Average	84.77	79.56	38.17	53.41	27.92	51.14	59.61	40.54
		Maximum	240	115	216	340	37	164	231	85
		Minimum	28	34	17	0	17	17	6	13
SO_4 (mg/ℓ)	380	Average	1 027	469.15	1 775	1 367	402.31	67.44	1 080	680.57
		Maximum	2 190	1 601	2 945	4 530	566	352	2 964	2 295
		Minimum	264	27	740	1	300	2	482	18
Al (mg/ℓ)	0.02	Average	0.34	0.40	0.36	0.41	0.43	0.34	1.52	0.38
		Maximum	0.73	0.5	0.96	1	0.5	1.08	12.6	1.01
		Minimum	0.05	0.05	0.05	0.03	0.1	0.02	0.05	0.01
Fe (mg/ℓ)	1	Average	0.28	0.37	0.29	1.95	0.39	0.37	0.39	0.34
		Maximum	0.5	0.98	0.5	23.2	0.5	0.6	1.3	0.5
		Minimum	0.01	0.05	0.03	0.03	0.03	0.02	0.04	0.04
Mn (mg/ℓ)	0.4	Average	0.62	0.32	1.13	1.94	0.47	0.53	2.55	0.38
		Maximum	3.4	0.5	4.48	18.4	0.5	2.4	14	1.2
		Minimum	0.03	0.01	0.01	0.01	0.1	0.01	0.01	0.01

Text in red indicates exceedance f the interim RWQO

Average aluminium concentrations range from 0.34 mg/ℓ to 1.52 mg/ℓ. This is significantly higher than the interim RWQO of 0.02 mg/ℓ.

The average manganese concentration at most of the Witcons monitoring points exceeds the interim RWQO of 0.4 mg/ℓ, with the exception of WISR-2 and WISR-9.

Surface water resources at the Witcon Colliery have been impacted as a result of mining and mining related activities. The impact at monitoring points WISR-5 and WISR-6, which represents upstream monitoring points, is less pronounced.

When considering the water quality results for the period 2009 – 2012, an increasing trend[3] in the levels of EC andSO_4 and Mg has been observed at monitoring points WISD-1, WISR-3, WISR-4 and WISR-9, indicating a deterioration in the water quality. Monitoring point WISR-7 has shown a decreasing trend in the levels of EC and SO_4 over this period.

The piper diagram compiled by JKC for the 2012 monitoring data is shown in **Figure 6.5.5(f)**. It should be noted that the results for the pollution control dams are also shown. All of the points, except WISR-6, show a distinct Ca-SO_4 signature, typical of mine related impacts. WISR-6 (Klippoortjiespruit) has a Ca-HCO_3 signature, reflecting the better water quality measured at this point.

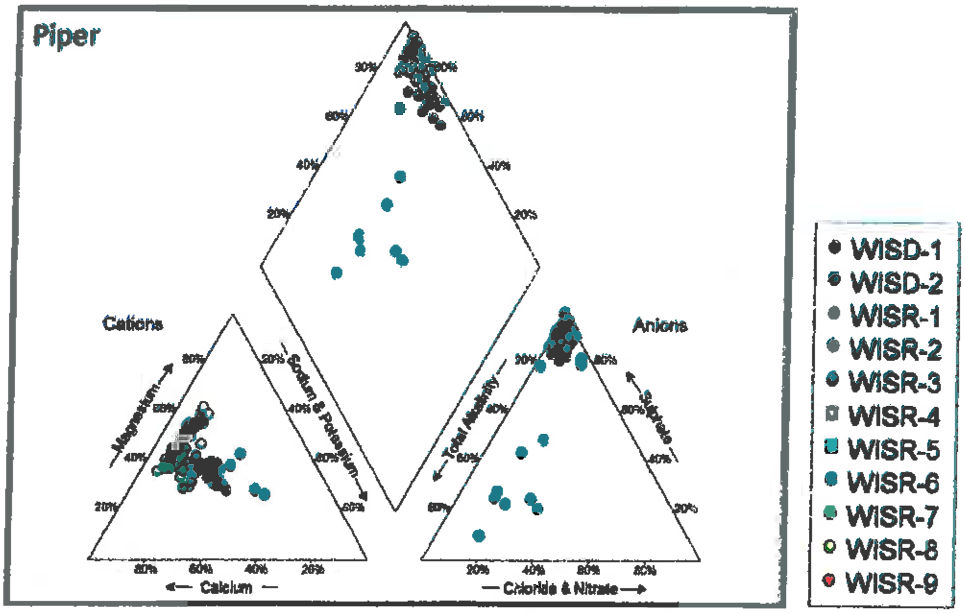


Figure 6.5.5(f): Piper diagram for Witcons Colliery (JKC, 2013)

6.5.6 Biomonitoring

Biomonitoring will be addressed by the relevant specialists.

6.5.7 Water authority

The water authority is the Department of Water Affairs, Mpumalanga Region.

[3] Trend lines not shown on graphs

6.5.8 Wetlands

The surface water study does not include the delineation of sensitive areas such as wetlands. These are addressed in the wetlands specialist reports.

6.6 Surface water users

Surface water users within the TOP site boundary were investigated as part of the hydrocensus undertaken by Clean Stream Scientific Services. This report is attached as **Appendix D**.

7. CONSIDERATION OF ALTERNATIVES

In accordance with Section 50(d) of the Mineral and Petroleum Resources Development Regulations, GN R527, under the Mineral and Petroleum Resources Development Act (2002) (MPRDA), as well as Section 32(2)(f) of the Environmental Impact Assessment (EIA) Regulations R385, dated April 2006 under the National Environmental Management (1998) (NEMA), the alternatives considered in terms of minimising the impacts on surface water and the overall water balance are discussed in this section.

Various alternatives were evaluated in terms of the overall water management while maximising extraction from the reserve. With the area being brownfields with extensive infrastructure already in place, the main concern was avoiding further contamination of surface water resources. The following options have been considered: -

7.1 Clean water management

The environmental team has made inputs to the mining alternatives in order to minimise the impacts on surface water. The following has been considered:

- Mining direction has unfortunately been fixed due to the relatively small pit lengths available and other mining considerations. Due to the topography at Boschmans North and Boschmans Central, clean water canals are required upstream of the workings directing water around the pit area.
- For all future mining, clean water canal are required around the various pits. Where practical the mining orientation located on the fall (i.e. perpendicular to the contours) has been favoured to allow clean water and runoff from rehabilitated areas to be more easily directed back to the clean water catchment (e.g. Makoupan area). However, mining constraints have largely dominated the overall layouts.
- At the Tweefontein plant area, permanent clean water canals will be constructed around the plant area.

7.2 Minimising the generation of dirty water make

With a large portion of the mine being opencast there will always be a significant dirty water make. There are no alternatives to opencast that have been considered, again due to mining considerations. However, concurrent rehabilitation of the opencast pits will be implemented to ensure the dirty foot print of TOP is minimised.

As discussed previously, the combination of historically mined areas and awkward pit shapes has meant that it is often not practical to mine uphill on the coal seam in order to minimise the dirty water make. Options that have been considered and are being implemented include: -

- Rehabilitation of the Waterpan Plant area;
- Remaining of old dumps where practical (Waterpan Dumps 1a and 1b);
- Rehabilitation of the Tweefonteinspruit including Tweefontein Dam;
- Implementing various clean and dirty water separation measures, as defined in the old and new Tweefontein IWWMP. Clean and dirty water separation will also be implemented at TOPA via the use of berms and canals.

While these are not alternatives per se, it is important to understand the current application in the context of a general clean up of the Tweefontein area. Note that similar activities are being undertaken for the other XSA operations.

7.3 Minimising the dirty water footprint

Given the significant footprint required for the waste disposal facilities, a range of alternatives were considered including: -

- Placing of slurry / discard on to an area to the south of the TOP plant, being a previously undermined area.
- Disposal underground (slurry).
- Various new waste disposal sites were considered including areas to the north of the Tweefonteinspruit, as well as to the east.
- Utilizing opencast areas (once mined) as an already disturbed footprint.

A workshop was held in 2010 with Golder, C Pod, Jones & Wagener and Groundwater Complete together with the client team to develop the options further.

It was considered that problematic areas and issues such as the pillar stability of previously undermined areas should be avoided where possible, and after much consideration, the option of using South Pit and Boschmans North after mining for a co-disposal facility was favoured and has been detailed in the EMPR documentation.

From a water management perspective, the sites do have a significant river frontage and surface water will need to be well managed. However, because there is anyway a need to manage the water make from the opencast areas, this is not expected to be a significant problem.

7.4 Maximising the reuse of dirty water

Dirty water will be collected and stored mainly in the Plant Holding Dam for reuse. Water will be used for washing the coal as well as for dust suppression on the haul roads and at the coal crushing areas.

During both the operational phase and post closure it is intended to pump water to a facility for treatment as required.

7.5 Implementing treatment where required

The treatment of water generated by mining activities during both the operational and post mining phases is determined by the water balance. While TOP will have a negative water balance if the possibility of storage underground is considered, there are periods where a positive water balance will develop due to dewatering considerations. Further, if the entire XSA reserve in the Witbank area is considered, there is the need to treat water to address a net water surplus.

7.6 Alternatives in terms of technology

The current planning is to utilise Reverse Osmosis technology for water treatment, this being proven in the Witbank Coal Field for large volumes of water. Passive treatment options have also been considered, but at this stage the volume of water appears to be too large for passive treatment.

7.7 Alternatives in terms of mine plan

Mining direction has unfortunately been fixed due to the relatively small pit lengths available and other mining considerations. These were discussed above.

7.8 Wetland offset alternatives

The wetland management strategy is being compiled by Golder, Report number 10612707-11280-3, "Rehabilitation and Wetland Management Plan for Duiker Mining (Pty) Ltd" which is a draft report still to be finalised.

7.9 Coal transportation alternatives

The primary product will be transported to the railway loop by conveyor and then offsite by train. The conveyor to the rail loop will have to cross the Tweefonteinspruit. The use of conveyors and rail is considered the more environmentally desirable option for the tonnages of coal to be produced (compared for example to road transport).

Note that haul roads will be used to move the ROM from the various opencast and underground areas to the ROM tip.

7.10 Other infrastructure alternatives

No other alternatives have been considered in terms of water management.

8. ENVIRONMENTAL IMPACT ASSESSMENT AND MITIGATION MEASURES

8.1 Introduction

In order to quantify the potential impacts, the general format of the assessment is to first assess the impact assuming no mitigation measures are applied. In some instances, these impacts could not result without extreme or unlawful practices, such as discharging all of the affected water from the plant areas and discard facilities into the river system. However, this provides a basis for the "worst case" scenario, from which mitigation measures can be evaluated (such as containment or treatment for example). The residual impact after implementation of the mitigation measures is then assessed and indicated.

As required by the MPRDA, cumulative impacts are also assessed as and where this is practical.

The format of the impact assessment is as follows:

- Section 8.2: The impact assessment methodology and rating system is described.
- Section 8.3: The nature of the various activities is described in terms of the phases of the project, from construction through to post closure.
- Section 8.4: The activities are assessed, detailing the potential impacts, proposed mitigation and residual impact over the full life cycle of the project.
- Section 8.5: cumulative impacts are discussed.

8.2 Impact assessment methodology and rating system

The rating of impacts was done according to an impact rating and assessment process provided by the lead environmental consultant. The methodology is outlined in **Appendix C**.

8.3 Activities to be undertaken as part of the proposed Tweefontein Optimisation Project Amendment (TOPA)

The following activities will be undertaken during the various phases of the proposed TOPA project.

8.3.1 Construction phase

This phase will commence when the construction contractors establish on site and will end on commissioning of any structures or infrastructure associated with the proposed TOPA and when the first load of coal is removed from the ground.

Activities to be undertaken that will potentially impact on surface water include the following:

- Opening of initial boxcuts for coal mining
- Preparation for underground mining of coal
- Opening of initial boxcuts for sand and gravel mining (borrow pits) for construction purposes
- Construction of :
  - Water management infrastructure
  - Diesel storage tanks
  - Waste management infrastructure

- Temporary coal stockpiles
- Explosives magazines
- General fencing on site
- Roads
- ROM tip
- Raw coal stockpile
- Golf course

8.3.2 Operational Phase

This phase commences at the end of the construction period, when the first load of coal is removed from the ground and will end when any structures or infrastructure associated with the proposed TOPA project reach the end of their life, the last load of coal is removed from the ground and production ceases.

- Activities that will potentially impact on surface water include the following:Opencast mining of coal
- Concurrent rehabilitation of opencast voids
- Underground mining of coal
- Opencast mining of sand and gravel borrow pits for construction phase
- Use and maintenance of:
  - Water and waste management infrastructure
    - Disposal and handling of coal discard
    - Stockpiling and handling of coal
    - Pollution Control Dams
    - Dust and fire suppression
    - Handling, disposal and treatment of sewage
  - Linear infrastructure
    - Haul roads
    - Transport of coal by conveyor
  - Other infrastructure
    - Diesel storage tanks
    - ROM tip
    - Explosive magazines
    - Crusher and screening plant
    - Coal wash plant
    - Workshops, offices and stores
  - Golfcourse (described in more detail below)
  - Xstrata Alloys IPP(described in more detail below)

8.3.2.1. Golf course

The existing golf course will be mined through, therefore it is proposed to develop a new golf course on old rehabilitated opencast Hamster and Boschmans south east pits.

Activities that can impact on surface water include the following:

- Earthworks associated with shaping of the golf course and ensuring the final landform topography is made free draining.
- Irrigation of the golf course with water obtained from the Tweefontein dam, decreasing the yield in the dam.
- Water quality of runoff from the golf course maybe poor (due to fertilizers or irrigation using mine water) thereby impacting the Tweefonteinspruit.
- Drainage of surface runoff to voids would increase the overall mine water make, therefore water treatment volumes would also increase and is not best practice.

8.3.2.2. Xstrata Alloys IPP

The Xstrata Alloys IPP has its own IWULA and IWWMP in which stormwater management measures and impacts are included and not addressed here. (Reference: Xstrata Alloys Lesedi Power Plant IWULA and IWWMP by Digby Wells, April 2011).

However, in terms of water supply to the Xstrata Alloys (IPP), this water will be supplied by the Plant Holding Dam and is included under Section 5, which is the water balance.

8.3.3 Decommissioning Phase

This phase starts at the end of the operational phase, and involves the closing down of any structures or infrastructure associated with the proposed TOPA. In theory, this phase ends when the site obtains Closure from the authorities, but may include a period where there is no activity on the site other than monitoring prior to Closure being obtained. Note that Closure refers to the point at which the State assumes responsibility for the liabilities associated with the site. This acceptance is in turn based on the proponent providing an acceptable financial provision to meet any future costs, and the attainment of various closure objectives set for the site.

Activities expected for this period include:

- Rehabilitation of areas impacted by mining and related activities within Tweefontien Complex.
- Legacy rehabilitation project.
- Decommissioning of borrow pits.

8.3.4 Post closure

This phase will commence when the site has obtained Closure. It has no defined end, with the State managing the post closure impacts related to the site. However, should the authorities deem that the proponent has not correctly defined the residual impacts, the proponent could also be required to address future impacts even after a closure certificate has been issued.

Activities expected for this period include:

- Control of runoff/seepage/decant from contaminated areas by:

- o Monitoring of aspects such as surface and ground water quality.
- o Monitoring the state of rehabilitation.

8.4 Surface water impact assessment and mitigation measures

The activities are discussed below in terms of the nature of the activity that could potentially impact on surface water, the nature of the impact if not mitigated, possible mitigations and post mitigation impact.

Note that cumulative impacts are not addressed in the tables in Sections 8.4.1 to 8.4.3, but are noted in Section 8.5.

8.4.1 Construction Phase

8.4.1.1. Impact on surface water quality

The construction phase impacts on surface water quality are detailed in **Impact Table 8.4.**

8.4.1.2. Impact on surface water quantity – catchment yield and flow rates

The construction phase impacts on surface water quantity are detailed in **Impact Table 8.4**

8.4.2 Operational Phase

8.4.2.1. Impact on surface water quality

The operational phase impacts on surface water quality are detailed in **Impact Tables 8.4**

8.4.2.2. Impact on surface water quantity – catchment yield

The operational phase impacts on surface water quantity are detailed in **Impact Table 8.4**

8.4.3 Decommissioning and Closure Phases

8.4.3.1. Impact on surface water quality

The decommissioning and closure phase impacts on surface water quality are detailed in **Impact Table 8.4**

8.4.3.2. Impact on surface water quantity – catchment yield

During decommissioning and closure the affected areas will be rehabilitated to generate clean runoff and will be restored to free draining conditions. Until the water management infrastructure is decommissioned the impact on catchment yield will remain as per the Operational Phase.

8.4.4 Post Closure Residual Impacts

8.4.4.1. Impact on surface water quality

Post closure the site will be rehabilitated, grassed and free draining. All contaminated materials will have been removed from the site.

If not reclaimed, the discard dumps will remain post closure. The impact on water quality is detailed in **Impact Table 8.4**

8.4.4.2. Impact on surface water quantity – catchment yield

Post closure all areas, including the discard facilities, will be rehabilitated and made free draining. There will therefore be no impact on catchment yield.

8.5 Cumulative impacts

The Tweefontein Complex is a large mining operation and has the potential to significantly impact on both the quality and quantity of surface water in the catchment. It is situated amongst a number of other mining activities, including other XSA operations (the Goedgevonden, iMpunzi, Tweefontein South complexes), as well as other mines belonging to Anglo American, BECSA and others. The surrounding surface water resources, namely the Saaiwaterspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River are already heavily impacted by mining activities in the catchment, with little or no capacity to assimilate further impacts. Sound water management, in line with the legislation and best practice will therefore be essential to ensure that both the existing impacts from Tweefontein Complex, are reduced and future impacts are mitigated as far as is practicable.

The TOPA has the potential to contribute significantly to the cumulative impacts in the catchment. However, with the mitigation and management measures detailed in this document and having a Water Treatment Plant to treat the mine impacted water before releasing to the environment, these impacts on surface water quality and quantity will be minimised.

Table 8.4 Impact Assessment

(Please insert the Excel Table here)

TABLE [illegible]: ACTIVITY / GROUP OF ACTIVITIES

No.	Environmental Component	Potential Impact	Yes / No	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Proposed mitigation measures	[illegible]	[illegible]	[illegible]	[illegible]
1. CONSTRUCTION PHASE (approx. 6 months - 1 year)																			
[illegible]																			
1.1.1	Surface Water Quality	Removal of material from boxcut The construction phase is considered to end once carbonaceous material, in the form of the coal seam, is exposed within the boxcut. However, much of the overburden removed prior to the exposing of coal has the potential to contain some carbonaceous material. The hard rock removed from the initial boxcut will be placed in the overburden stockpile area. This material will remain in the stockpile for the duration of mining. Thereafter it will be placed back into the final void. Impacts may arise from: Erosion during rainfall events, resulting in increased turbidity and suspended solids in the runoff water, reporting to the local watercourses. Deposition of sediments in the local watercourses, impacting on the aquatic ecology. Overburden stockpiles will potentially contain carbonaceous material, with the potential to affect downstream watercourses by increasing sulphate and TDS concentrations.	Yes	-	5	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Any clean catchment draining towards the overburden stockpiles will be diverted around by means of clean water diversion canals. These canals will be sized to accommodate at least the 1:50 year peak flow event. The overburden stockpiles will be located within the designated dirty water area. Where practically possible, runoff and seepage from the overburden stockpiles will be directed to the opencast workings. Where an overburden stockpile cannot drain to the dirty water system, a series of continuous paddocks will be provided at the toe to collect any runoff and seepage and contain / evaporate the water. Water quality monitoring will be undertaken downstream of the construction areas before and during construction, where practical, in order to detect any increase in suspended solids or turbidity. Groundwater monitoring, via boreholes, will also be undertaken on the down-gradient of the overburden stockpile. Water that is pumped out of the boxcut to be contained in the dirty water system to prevent it from contaminating the clean catchment.	To be confirmed in the final EIR	Construction Phase		
1.1.2	Surface Water Quality	Dewatering of water ingress to boxcut Water that enters the boxcut excavations, both from groundwater seepage and direct rainfall, is expected to be largely clean. However, there is a possibility that exists that this water makes contact with carbonaceous and pyritic materials. The water quality from the boxcut is therefore likely to be slightly to moderately impacted in terms of sulphate, TDS and suspended solids. Impacts may arise from: The groundwater quality from the box-cut is likely to be slightly to moderately impacted in terms of sulphate and TDS. Discharge of this potentially impacted water to the catchment will result in an increase in	Yes	-	5	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management	No surface or groundwater from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	The water will be contained at the site, in Plant Holding Dams, for use for dust suppression for haul roads and to assist with construction, and will not be discharged. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. A Water Use Licence for the dewatering of groundwater encountered during mining will be applied for, including the reuse of this water for dust suppression. Surplus water will be pumped to underground storage.	To be confirmed in the final EIR	Construction Phase		
1.1.3	Surface Water Quantity	Initial boxcut development All runoff and rainfall in the pit to be contained in the dirty water system and is therefore lost to the catchment. Loss in yield.	Yes	-	5	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	Direct clean catchment around the area via canals and berms.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		
[illegible]																			
1.2.1	Surface Water Quality and Quantity	It is noted that all new underground mining areas associated with this project will be accessed via existing shafts, and therefore no construction activities will be applicable.	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
[illegible]																			

1.2.1	Surface Water Quality	During the construction phase of the mine, [illegible] areas will be [illegible]. The [illegible] to potential [illegible] suspended solids [illegible].	Yes	-	4	5	5	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Minimising the footprint of borrow area required. Appropriate storm water management measures will be implemented, including diversion of runoff around the borrow pit area and provision of silt control facilities. Monitoring will be implemented in the downstream watercourses to enable any impacts to be detected and addressed.	To be confirmed in the final EIR	Construction Phase		
1.2.2	Surface Water Quantity	Loss in yield.	Yes	-	1	1	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	The footprint of borrow pits should be kept as small as possible. In addition, runoff from the borrow pits will, once having passed through adequate silt control facilities, be considered suitable for discharge to the system. The loss in yield is considered insignificant and no further mitigation is proposed.	To be confirmed in the final EIR	Construction Phase		
1.4.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. The surrounding surface water resources, namely the [illegible], [illegible], Steenkoolspruit and Olifants River, is considered a stressed water resource in terms of both the quantity of water in the system and the quality of the water. It also forms part of the water supply for the Witbank area (from Witbank Dam), as well as for irrigation water further downstream (from the Loskop Dam). Any impact on the quantity or quality of water in the system has the potential to affect the quality and assurance of supply to the community and agriculture.	Yes	[illegible]	1	1	2	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Construction activities will be timed to take place in the dry season, as far as is practicable. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel. Appropriate storm water management measures will be implemented, including the temporary diversion of upstream run-off from the construction and laydown areas. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar product will be kept on site, and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase. An appropriate sewage management strategy will be implemented during the construction phase. Water quality monitoring will be undertaken downstream of the construction areas, before and during construction where practical, in order to detect any increase in suspended solids or turbidity. If erosion is evident, or the water quality monitoring indicates an increase in suspended solids, water management around the construction areas will be reviewed.	To be confirmed in the final EIR	Construction Phase		
1.4.2	Surface Water Quantity	During construction, prior to the commissioning of the pollution control dam, surface runoff will be released to the catchment once sediment has settled out. The water management infrastructure will be constructed first to enable the containment of dirty water generated during the remainder of the construction period. Impacts may arise from: Containment of contaminated runoff water emanating from the site, with no release to the catchment.	Yes	[illegible]	1	1	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		

1.5.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. The surrounding surface water resources, namely the Saaiwaterspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River, is considered a stressed water resource in terms of both the quantity of water in the system and the quality of the water. It also forms part of the water supply for the Witbank area (from Witbank Dam), as well as for irrigation water further downstream (from the Loskop Dam). Any impact on the quantity or quality of water in the system has the potential to affect the quality and assurance of supply to the community and agriculture.	Yes	[illegible]	4	1	[illegible]	4	28	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	Construction activities will be timed to take place in the dry season, as far as is practicable. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel. Appropriate storm water management measures will be implemented, including the temporary diversion of upstream run-off from the construction and laydown areas. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar product will be kept on site, and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase. An appropriate sewage management strategy will be implemented during the construction phase. Water quality monitoring will be undertaken downstream of the construction areas, before and during construction where practical, in order to detect any increase in suspended solids or turbidity. If erosion is evident, or the water quality monitoring indicates an increase in suspended solids, water management around the construction areas will be reviewed.	To be confirmed in the final EIR	Construction Phase		
1.5.2	Surface Water Quantity	During construction, prior to the commissioning of the pollution control dam, surface runoff will be released to the catchment once sediment has settled out. Impacts may arise from: Containment of contaminated runoff water emanating from the site, with no release to the catchment. Although runoff from dirty areas will be contained (see management measures) and the probability of impact is definite, its significance has still been assessed as very low on the basis of the very small area that will be contained.	Yes	[illegible]	[illegible]	[illegible]	4	8	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		
1.6.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. The surrounding surface water resources, namely the Saaiwaterspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River, is considered a stressed water resource in terms of both the quantity of water in the system and the quality of the water. It also forms part of the water supply for the Witbank area (from Witbank Dam), as well as for irrigation water further downstream (from the Loskop Dam). Any impact on the quantity or quality of water in the system has the potential to affect the quality and assurance of supply to the community and agriculture.	Yes	-	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	Construction activities will be timed to take place in the dry season, as far as is practicable. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel. Appropriate storm water management measures will be implemented, including the temporary diversion of upstream run-off from the construction and laydown areas. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar product will be kept on site, and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase. An appropriate sewage management strategy will be implemented during the construction phase. Water quality monitoring will be undertaken downstream of the construction areas, before and during construction where practical, in order to detect any increase in suspended solids or turbidity. If erosion is evident, or the water quality monitoring indicates an increase in suspended solids, water [illegible]	To be confirmed in the final EIR	Construction Phase		
1.6.2	Surface Water Quantity	During construction, prior to the commissioning of the pollution control dam, surface runoff will be released to the catchment once sediment has settled out. Impacts may arise from: Containment of contaminated runoff water emanating from the site, with no release to the catchment.	Yes	-	1	1	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		

1.7.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. The surrounding surface water resources, namely the Saalboomspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River, is considered a stressed water resource in terms of both the quantity of water in the system and the quality of the water. It also forms part of the water supply for the Witbank area (from Witbank Dam), as well as for irrigation water further downstream (from the Loskop Dam). Any impact on the quantity or quality of water in the system has the potential to affect the quality and assurance of supply to the community and agriculture.	Yes	[illegible]	4	1	3	4	15	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	Construction activities will be timed to take place in the dry season, as far as is practicable. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel. Appropriate storm water management measures will be implemented, including the temporary diversion of upstream run-off from the construction and laydown areas. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar product will be kept on site, and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase. An appropriate sewage management strategy will be implemented during the construction phase. Water quality monitoring will be undertaken downstream of the construction areas, before and during construction where practical, in order to detect any increase in suspended solids or turbidity. If erosion is evident, or the water quality monitoring indicates an increase in suspended solids, water [illegible]	To be confirmed in the final EIR	Construction Phase		
1.7.2	Surface Water Quality	During construction, prior to the commissioning of the pollution control dam, surface runoff will be released to the catchment once sediment has settled out. Impacts may arise from: Containment of contaminated runoff water emanating from the site, with no release to the catchment.	Yes	[illegible]	1	1	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		
[illegible]																		
1.8.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. The surrounding surface water resources, namely the Saalboomspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River, is considered a stressed water resource in terms of both the quantity of water in the system and the quality of the water. It also forms part of the water supply for the Witbank area (from Witbank Dam), as well as for irrigation water further downstream (from the Loskop Dam). Any impact on the quantity or quality of water in the system has the potential to affect the quality and assurance of supply to the community and agriculture.	Yes	[illegible]	4	1	2	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	Construction activities will be timed to take place in the dry season, as far as is practicable. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel. Appropriate storm water management measures will be implemented, including the temporary diversion of upstream run-off from the construction and laydown areas. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar product will be kept on site, and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase. An appropriate sewage management strategy will be implemented during the construction phase. Water quality monitoring will be undertaken downstream of the construction areas, before and during [illegible]	To be confirmed in the final EIR	Construction Phase		

1.8.2	Surface Water Quantity	During construction, prior to the commissioning of the pollution control dam, surface runoff will be released to the catchment once sediment has settled out. Impacts may arise from: Containment of contaminated runoff water emanating from the site, with no release to the catchment. Although runoff from dirty areas will be contained (see management measures) and the probability of impact is definite, its significance has still been assessed as very low on the basis of the very small area that will be contained.	Yes	-	1	1	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		
1.9.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. The surrounding surface water resources, namely the Saaiwaterspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River, is considered a stressed water resource in terms of both the quantity of water in the system and the quality of the water. It also forms part of the water supply for the Witbank area (from Witbank Dam), as well as for irrigation water further downstream (from the Loskop Dam). Any impact on the quantity or quality of water in the system has the potential to affect the quality and assurance of supply to the community and agriculture.	Yes	-	2	1	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	Construction activities will be timed to take place in the dry season, as far as is practicable. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel. Appropriate storm water management measures will be implemented, including the temporary diversion of upstream run-off from the construction and laydown areas. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar product will be kept on site, and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase.	To be confirmed in the final EIR	Construction Phase		
1.9.2	Surface Water Quantity	Neutral Impact	Yes	Neutral	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	N/A	N/A	Neutral Impact	To be confirmed in the final EIR	Construction Phase		
1.10.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. The surrounding surface water resources, namely the Saaiwaterspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River, is considered a stressed water resource in terms of both the quantity of water in the system and the quality of the water. It also forms part of the water supply for the Witbank area (from Witbank Dam), as well as for irrigation water further downstream (from the Loskop Dam). Any impact on the quantity or quality of water in the system has the potential to affect the quality and assurance of supply to the community and agriculture.	Yes	-	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	Construction activities will be timed to take place in the dry season, as far as is practicable. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel. Appropriate storm water management measures will be implemented, including the temporary diversion of upstream run-off from the construction and laydown areas. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar product will be kept on site, and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase. An appropriate sewage management strategy will be implemented during the construction phase. [illegible]	To be confirmed in the final EIR	Construction Phase		

1.10.2	Surface Water Quantity	During construction, prior to the commissioning of the pollution control dam, surface runoff will be released to the catchment once sediment has settled out. Impacts may arise from: Containment of contaminated runoff water emanating from the site, with no release to the catchment. Although runoff from dirty areas will be contained (see management measures) and the probability of impact is definite, its significance has still been assessed as very low on the basis of the very small area that will be contained.	Yes	[illegible]	1	1	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		
1.11.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion during rainfall events, resulting in increased turbidity and suspended solids in the runoff water, reporting to the local watercourses. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. Deposition of sediments in the local watercourses, impacting on the aquatic ecology. The ROM tip will potentially contain carbonaceous material, with the potential to affect downstream watercourses by increasing sulphate and TDS concentrations.	Yes	-	5	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. The ROM tip will be located within the designated dirty water area. Water quality monitoring will be undertaken downstream of the construction areas before and during construction, where practical, in order to detect any increase in suspended solids or turbidity.	To be confirmed in the final EIR	Construction Phase		
1.11.2	Surface Water Quantity	All runoff and rainfall to be contained in the dirty water system and is therefore lost to the catchment. Loss in yield.	Yes	-	5	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		
1.12.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion during rainfall events, resulting in increased turbidity and suspended solids in the runoff water, reporting to the local watercourses. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. Deposition of sediments in the local watercourses, impacting on the aquatic ecology. The Coal Stockpile contains carbonaceous material, with the potential to affect downstream watercourses by increasing sulphate and TDS concentrations.	Yes	[illegible]	5	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Any clean catchment draining towards the coal stockpiles will be diverted around by means of clean water diversion canals. These canals will be sized to accommodate at least the 1:50 year peak flow event. The coal stockpiles will be located within the designated dirty water area. Where practically possible, runoff and seepage from the coal stockpiles will be directed to the opencast workings. Where a coal stockpile cannot drain to the dirty water system, a series of continuous paddocks will be provided at the toe to collect any runoff and seepage and contain / evaporate the water. Water quality monitoring will be undertaken downstream of the construction areas before and during construction, where practical, in order to detect any increase in suspended solids or turbidity. Groundwater monitoring, via boreholes, will also be undertaken on the down-gradient of the coal stockpile.	To be confirmed in the final EIR	Construction Phase		
1.12.2	Surface Water Quantity	All runoff and rainfall to be contained in the dirty water system and is therefore lost to the catchment. Loss in yield.	Yes	-	5	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		

1.20.1	Surface Water Quality	During the construction phase topsoil will be stripped and civil works, in the form of earthworks and terracing will be undertaken as part of preparation of the area for the construction of various water management infrastructure. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. The surrounding surface water resources, namely the Saaiwaterspruit, Tweefonteinspruit, Steenkoolspruit and Olifants River, is considered a stressed water resource in terms of both the quantity of water in the system and the quality of the water. It also forms part of the water supply for the Witbank area (from Witbank Dam), as well as for irrigation water further downstream (from the Loskop Dam). Any impact on the quantity or quality of water in the system has the potential to affect the quality and assurance of supply to the community and agriculture.	Yes	[illegible]	5	[illegible]	2	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Construction activities will be timed to take place in the dry season, as far as is practicable. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel. Appropriate storm water management measures will be implemented, including the temporary diversion of upstream run-off from the construction and laydown areas. Surface water management measures, such as storm water canals, sediment traps and PCDs are to be constructed first to ensure that runoff and dirty water spills are contained. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar product will be kept on site, and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase. An appropriate sewage management strategy will be implemented during the construction phase. Water quality monitoring will be undertaken downstream of the construction areas, before and during	To be confirmed in the final EIR	Construction Phase		
1.20.2	Surface Water Quantity	During construction, prior to the commissioning of the pollution control dam, surface runoff will be released to the catchment once sediment has settled out. Impacts may arise from: Containment of contaminated runoff water emanating from the site, with no release to the catchment. Although runoff from dirty areas will be contained (see management measures) and the probability of impact is definite, its significance has still been assessed as very low on the basis of the very small area that will be contained.	Yes	-	[illegible]	[illegible]	4	5	20	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	The aerial extent of the disturbed and potentially contaminated areas will be kept to a minimum. Areas where dirty construction activities are carried out (e.g. servicing areas and workshops, fuel storage areas, waste storage areas) will be minimised and surrounded by bunds. Upslope runoff will be diverted around construction activities.	To be confirmed in the final EIR	Construction Phase		
8. Operational Phase (approx. 30 years)																			
[illegible]																			
2.13.1	Surface Water Quality	Mine water discharge : Discharge of contaminated water It is important to note that the mine water balance assessment undertaken in Section 5 of the surface water specialist report, is aimed at ensuring that the mine does not spill water during the operational phase, except for very extreme events related to floods in excess of at least the 1:50 year event. The water management measures detailed in Sections 4 and 5 of the surface water specialist report, are mitigation measures, focusing primarily on the treatment and reuse of water. However, to merely indicate that the mine will not spill dirty water does not allow an assessment of the potential impact of non-compliance with the mitigation measures proposed. In order to assess the impact without mitigation, this impact assessment assumes that all dirty water is discharged to the catchment, where after detail is provided on how this will be prevented, and the impact after management is then assessed. Impacts are as a result of runoff entering the pits and coming into contact with carbonaceous material. The potential impact on aquatic life or downstream users of water within the rivers is highly dependent on the pH of the water discharged. This is because acidic conditions will result in mobilisation of metals, and this would be a major contributing factor to the potential toxicity of the water.	Yes	-	5	[illegible]	5	5	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management and water quality monitoring.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	The mine water balance will be managed as detailed in Sections 4 and 5 of the Surface water specialist report. These measures will include the following: Containment of all dirty water generated on the mine in lined PCDs sized to have a risk of spill of 2% or less in any one year. Treatment of excess dirty water for reuse at the Tweefontein operations. Pumping of excess water that cannot be treated or reused to storage in old underground compartments at Boschmans Provision of water management facilities with a risk of spill that is lower than 2% in any one year. A surface water quality monitoring programme will be implemented, as detailed in Section 11 of the surface water report, to detect any impacts. A water balance monitoring programme will be implemented, as detailed in Section 11 of the surface water specialist report, to enable calibration of the water balance.	To be confirmed in the final EIR	Operational Phase		
2.13.2	Surface Water Quantity	Isolation of Dirty Catchment The loss in yield associated with mining at the TOPA operation will be primarily due to the pit area and catchment area of dirty footprints which will be isolated from the catchment. The percentage reduction of yield in the Witbank Dam and Loskop Dam catchment due to the TOPA operation (opencast pits) amounts to approximately 1 % and 0.32% respectively. The impact on catchment yield to the watercourses in the immediate vicinity of the mining operations is expected to be high.	Yes	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Minimise the dirty footprint through concurrent rehabilitation with rehabilitated areas draining back to the catchment. Construct clean water cut-off canals upstream of the pit to direct clean water back to the catchment.	To be confirmed in the final EIR	Operational Phase		

2.14.1	Surface Water Quality	From a surface water impacts perspective, the concurrent rehabilitation of opencast areas is a mitigation measure required to minimise the impact on catchment yield. This activity is therefore covered in the assessment for items 2.13.1 and 2.13.2 above.																	
2.14.2	Surface Water Quantity	From a surface water impacts perspective, the concurrent rehabilitation of opencast areas is a mitigation measure required to minimise the impact on catchment yield. This activity is therefore covered in the assessment for items 2.13.1 and 2.13.2 above.																	
2.15.1	Surface Water Quality	**Mine water discharge : Discharge of contaminated water.** Impacts due to runoff coming into contact with carbonaceous material in and around the access shaft. The potential impact on aquatic life or downstream users of water within the stream is highly dependent on the pH of the water discharged. This is because acidic conditions will result in mobilisation of metals, and this would be a major contributing factor to the potential toxicity of the water.	Yes	-	9	3	4	8	[illegible]	[illegible]	[illegible]	[illegible]	effective dirty water management and water Quality Monitoring.	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	The ... will be managed as detailed in Sections 4 and 5 of the surface water specialist report. These measures will include the following: Containment of all dirty water generated underground by pumping to lined PCDs sized to have a risk of spill of 2% or less in any one year. Treatment of excess dirty water for reuse at the Tweefontein operations. Pumping of excess water that cannot be treated or reused to storage in old underground compartments at Boschmans Provision of water management facilities with a risk of spill that is lower than 2% in any one year. A surface water quality monitoring programme will be implemented, as detailed in Section 11 of the surface water report, to detect any impacts. ... as detailed in Section 11 of the surface ...	To be confirmed in the final EIR	Operational Phase		
2.16.1	Surface Water Quality	Impacts are as a result of runoff entering the open borrow pits and causing an increase in turbidity, Suspended solids and erosion potential.	Yes	-	5	2	4	8	16	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead	Dirty water to be contained within the dirty system. Suitable water management measures such as berms and canals to be put in place. In particular areas where borrow pits are located near wetlands, monitoring the water quality of the downstream environment, as well as the receiving water resources.	To be confirmed in the final EIR	Operational Phase		
2.16.2	Surface Water Quantity	Loss in yield	Yes	-	1	1	4	8	M	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals.	Minimise the borrow area footprint through concurrent rehabilitation with rehabilitated areas draining back to the catchment once the borrow area has served its purpose. Construct clean water cut-off canals upstream of the pits to direct clean water back to the catchment.	To be confirmed in the final EIR	Operational Phase		
2.17.1	Surface Water Quality	**Disposal and handling of coal discard** The discard facilities will be exposed to rainfall and wind. Runoff and seepage water from the discard facilities will be contaminated, with elevated salinity, particularly sulphate. The movement and handling of coal discard at the dumps will potentially generate dust, which could migrate by wind onto the adjacent areas. Sediment washed by storm water runoff into the pollution control facilities can significantly reduce the storage capacity of these facilities. The discard facilities falls within the Tweefonteinspruit and Saaiwaterspruit catchment. Impacts may arise from: Wind-blown dust settling in adjacent watercourses, with resultant deterioration in water quality within the watercourses. Contaminated storm water runoff and seepage discharging from the discard dumps into the watercourses with resultant increase in suspended solids, siltation of carbonaceous materials, increase in salinity, particularly sulphate, and potential decrease in pH in the pan or downstream watercourses. Infiltration of contaminated seepage from the stockpiles area into the groundwater, with consequent groundwater contamination and potential seepage into the watercourses.	Yes	-	10	5	5	8	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment. Instead impacted mine water will be directed to the appropriate pollution control dam.	Runoff from the upslope catchment will be diverted around the discard facilities. The clean water diversion systems will be designed to accommodate the peak flow expected for at least a 1:100 year event. The footprint of the discard dumps will be minimised as far as is practical. Runoff from discard dumps will be collected in dedicated storm water channels and directed via a silt trap to a PCD. The dirty storm water channels will be lined with impermeable material (concrete, HDPE or similar) to prevent seepage of contaminated water from the channels. All dirty water containment facilities will be designed to have a risk of spill of 2% or less (1:50 year recurrence interval) in any one year. The discard will be compacted to limit infiltration of rain water and reduce the potential for spontaneous combustion. Fine discard will be passed through a thickener and filter press system to produce a filter cake, which will be disposed with the coarse discard. This will eliminate the need for a slurry dam and pipeline, as well as the associated risks to surface water quality. The footprint of the discard facilities will be lined with compacted clay to minimise infiltration to the groundwater system. The discard dumps will be equipped with a herringbone drainage system to collect all seepage and direct it via the storm water system to the PCD. Water collected in the PCDs will be pumped to the Plant Holding Dam for reuse in the TOP Plant. An inspection and maintenance plan will be implemented on the storm water, seepage collection systems, pumps and pipelines to ensure that all components, including the sediment handling ...	To be confirmed in the final EIR	Operational Phase		

2.17.2	Surface Water Quality	**Stockpiling and handling of coal** The coal stockpiles will be exposed to rainfall and wind. Runoff and seepage water from the stockpiles will be considered contaminated, with elevated salinity, particularly sulphate. The movement of coal will potentially generate dust, which could migrate by wind onto the adjacent areas. Sediment washed by storm water runoff into the pollution control facilities can significantly reduce the storage capacity of these facilities. Impacts may arise from: Wind-blown dust settling in adjacent watercourses, with resultant deterioration in water quality within the watercourse. Contaminated storm water runoff and seepage discharging from stockpiles area into the Tweefonteinspruit and Saaiwaterspruit, with resultant increase in suspended solids, siltation of carbonaceous materials, increase in salinity, particularly sulphate, and potential decrease in pH in the pan or downstream watercourses. Infiltration of contaminated seepage from the stockpiles area into the groundwater, with consequent groundwater contamination and potential seepage into the watercourses.	Yes	-	8	3	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	The water management at the stockpiles will be integrated with the TOP Plant, utilising the same CPP PCD and clean water diversion measures. Runoff from the upslope catchment will be diverted around the stockpiles and associated infrastructure. The clean water diversion systems will be designed to accommodate the peak flow expected for at least a 1:100 year event. The footprint of the stockpiles will be minimised as far as is practical. All dirty water containment facilities will be designed to have a risk of spill of 2% or less (1:50 year recurrence interval) in any one year. The stockpile terrace will be graded to ensure that drainage is away from the watercourses. The stockpile area will be lined with compacted clay to minimise infiltration to the groundwater system. The stockpiles will be equipped with a herringbone drainage system to collect all seepage and direct it via the storm water system to the CPP PCD. All storm water and seepage water from the stockpiles area will be collected in the CPP PCD. An inspection and maintenance plan will be implemented on the storm water and seepage collection systems to ensure that all components, including the sediment handling facilities are maintained and that storm water canals and pipelines remain unblocked and free flowing – monthly inspections will be carried out. A surface water quality monitoring programme will be implemented to detect any impacts.	To be confirmed in the final EIR	Operational phase		
2.17.3	Surface Water Quality	**Pollution control dams : storage of polluted water** The water in the pollution control dams will be of poor quality, with potential to impact on the downstream water resources, primarily in terms of increased salinity (particularly sulphate) and potentially reduced pH if there are spillages or leaks from the dams. Impacts may arise from: Inadequate sizing or lining system on the dams. Poor maintenance resulting in loss of storage capacity due to sediment build-up in the dams	Yes	-	10	3	8	5	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	The pollution control dams will be engineered to have sufficient capacity to limit the risk of spill to less than 2% in any one year. In line with best practice, the PCDs will be operated as empty as possible at all times to ensure that sufficient storm water retention capacity is available at all times. In the event that there is insufficient available capacity in the Plant Holding Dam during extreme rainfall conditions, excess storm water will be pumped in the Boschmans underground storage compartments. The pollution control dams will be equipped with a geomembrane liner to minimise leakage of contaminated water to the surface or ground water systems. An inspection and maintenance plan will be implemented to ensure that the dams are kept in good working order and to monitor sediment build-up. When sediment levels reach a pre-determined level, sediment will be removed to ensure that sufficient storm water storage capacity is maintained at all times. A surface water quality monitoring programme will be implemented to detect any impacts.	To be confirmed in the final EIR	Operational phase		
2.17.4	Surface Water Quality	**Dust and fire suppression with contaminated water** Dust and fire suppression systems will be provided on surface along haul roads, at the plant , stockpile areas, MIA workshop area, new ROM tip area and along the conveyor. These will involve spraying of water onto coal handling areas, as well as a deluge system in case of fire. This water will become contaminated once it comes into contact with the coal. Impacts may arise from: Spillage of dust suppression or fire water to the watercourses or adjacent pans, with resultant deterioration in water quality, in terms of elevated salinity, particularly sulphate.	Yes	-	4	1	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	All dust and fire suppression will take place within the designated dirty water areas of the plant, stockpile, conveyor and discard facility areas. Excess water will therefore drain via the dirty storm water system to the PCDs and will be pumped back to the Plant Holding Dam or reuse in the TOP Plant.	To be confirmed in the final EIR	Operational phase		
2.17.5	Surface Water Quality	**Handling, disposal and treatment of sewage** Water from the ablution facilities will contain organic matter, which is high in nitrogen and could therefore cause eutrophication if enters the water resource. The sewage treatment plants will be located at three points namely at the TOP MIA area, Vlaklaagte Area and WaterPan area. During operations the effluent from the sewage treatment plants will be discharged into the Tweefonteinspruit. Impacts may arise from: Discharge of untreated sewage into the watercourse. Discharge of treated water not meeting the specified discharge standards into the watercourse.	Yes	-	8	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management and water Quality Monitoring.	Water quality monitoring to be implemented to ensure that the treatment standards are met. Erosion protection will be required at discharge points.	All domestic waste water will be treated in the sewage treatment plant. The sewage water will be treated in the plant to acceptable effluent standards. Sludge will be deposited in dry beds within the designated dirty water area and removed by a licensed waste contractor. An inspection and maintenance plan will be implemented to ensure that the sewage treatment plant always operates within specification. A surface water quality monitoring programme will be implemented to detect any impacts.	To be confirmed in the final EIR	Operational phase		
2.17.6	Surface Water Quantity	Please refer to 2.19.4 below for impacts of infrastructure on Surface water Quantity																	

2.18.1	Surface Water Quality	**Haul roads** The operation and maintenance of haul roads have the potential to generate poor quality runoff due to contact of the water with coal, hydrocarbons and waste material. Impacts may arise from: Contaminated storm water runoff, as well as washdown water and hydrocarbon spills that discharges from the site, with resultant deterioration in water quality within the Trichardtspruit, with resultant increase in suspended solids, hydrocarbons (oils and greases), siltation of carbonaceous materials, increase in salinity and potential decrease in pH in the watercourses.	Yes	-	6	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	All spills will be contained within dedicated bunded areas. Spill sorb or a similar type of product must be kept on site and used to clean up hydrocarbon spills in the event that they should occur. Water quality monitoring will be undertaken downstream of the areas, where practical, in order to detect any increase in suspended solids or turbidity. If erosion is evident or the water quality monitoring indicates an increase in suspended solids, water management around the construction areas will be reviewed.	To be confirmed in the final EIR	Operational phase		
2.18.2	Surface Water Quality	**Transport of coal by conveyor** Transport of coal by conveyor has the potential to impact on watercourses and general runoff quality, primarily due to spillage of coal, as well as contaminated water from the belt itself and at transfer stations. Impacts may arise from: Dripping of water from the conveyor belt at low points, as well as spillage at transfer stations. Spillage of coal at transfer stations. Wind blown dust at transfer stations settling on the adjacent surface and in watercourses. Storm water runoff coming into contact with these emissions would suffer a deterioration in water quality, with increased salinity, particularly sulphate.	Yes	-	5	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Transfer stations will be paved with concrete, bunded to prevent run-on of clean water and to contain dirty runoff. A lined PCD will be provided at each transfer station. PCDs will either be sized as evaporation ponds, or the water collected in them will be pumped along the conveyor to the conveyor PCD. Conveyors will be rotated at the transfer stations to ensure that the dirty side faces upwards at all times. Transfer stations will also be provided with belt scrubbers to clean the belt to prevent carbonaceous material from being dropped along the route. The conveyor will be completely enclosed at watercourse crossings to prevent any spillage of water or coal into the watercourses. Watercourse crossings will be designed to accommodate at least the 1:100 year event without overtopping. Dust suppression will be employed at the transfer stations to minimise dust emissions. A shroud will be provided along the entire conveyor length to prevent rain from falling directly onto the conveyor and to protect it from wind.	To be confirmed in the final EIR	Operational phase		
2.18.3	Surface Water Quantity	**Please refer to 2.19.4 below for impacts of infrastructure on Surface water Quantity**																
[illegible]																			
2.19.1	Surface Water Quality	**Diesel storage tanks, ROM tip, Explosive magazines** The operation and maintenance of diesel storage tanks, ROM tip, Explosive magazines etc. have the potential to generate poor quality runoff due to contact of the water with coal, hydrocarbons and waste material. Impacts may arise from: Contaminated storm water runoff, as well as washdown water and hydrocarbon spills that discharges from the site, with resultant deterioration in water quality within the Trichardtspruit, with resultant increase in suspended solids, hydrocarbons (oils and greases), siltation of carbonaceous materials, increase in salinity and potential decrease in pH in the watercourses.	Yes	-	8	4	4	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	All spills will be contained within dedicated bunded areas. Spill sorb or a similar type of product must be kept on site and used to clean up hydrocarbon spills in the event that they should occur. A surface water quality monitoring programme will be implemented to detect any impacts.	To be confirmed in the final EIR	Operational phase		
2.19.2	Surface Water Quality	**Activities and operations of the plant itself:** **Mine surface infrastructure including the Crusher and screening plant as well as the coal wash plant** The handling and movement of coal at the Plant will potentially generate significant amounts of dust, loose coal and sediment on the ground. This will be exposed to rainfall and wind within the plant area and any surface water that comes into contact with it will be considered contaminated. Sediment washed by storm water runoff into the pollution control facilities can significantly reduce the storage capacity of these facilities. In addition, water used for washing the coal in the Plant will be contaminated and will have potential to impact should the water seep or spill to the catchment. Impacts may arise from: Wind-blown dust settling in adjacent watercourses, pans or surface areas, with resultant deterioration in water quality within the pan or watercourse and runoff water. Contaminated storm water runoff discharging from the Trichardtsfontein, Waterpan and Witcons Plant area into the Trichardtspruit and Saaiwaterspruit, with resultant increase in suspended solids, siltation of carbonaceous materials, increase in salinity, particularly sulphate, and potential decrease in pH in the watercourses. Discharge of contaminated water in the form of uncontained process water spillages or plant wash down water into the Trichardtspruit and Saaiwaterspruit, with resultant increase in suspended solids, [illegible]	Yes	[illegible]	[illegible]	3	6	4	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Runoff from the upslope catchment will be diverted around the Plant and associated infrastructure. The clean water diversion systems will be designed to accommodate the peak flow expected for at least a 1:100 year event. The footprint of the Plant areas will be minimised as far as is practical. Witcons and WaterPan Plant areas are to be rehabilitated by 2018. Witcons Plant area is located in a dedicated dirty water area and drains to the Witcons PCD with the Witcons Dups draining to Witcons 2 and 4 seam underground workings. Water pan Plant and dump are located in a dedicated dirty water area and drains to WaterPan and Vlakfontein underground workings. The TCP plant, including thickeners, will be located within the dedicated dirty water area, which will drain to the Coal Processing Plant PCD (CPP). Other areas which include the surge bin, rail load out, conveyor, Eskom low grade stockpile and sized coal stockpile areas which will form part of the expansion, will also be located in dedicated dirty areas that will all drain to the CPP PCD with the Mine Infrastructure Area (MIA) draining to the Plant Holding Dam. No carbonaceous material will be kept outside of the dirty water area. All dirty water containment facilities will be designed to have a risk of spill of 2% or less (1:50 year recurrence interval) in any one year. All pipeline routes will be inspected regularly to enable early detection of leaks. All storm water from the plant area and coal handling facilities will be collected in the CPP PCD. An inspection and maintenance plan will be implemented on the storm water system to ensure that	To be confirmed in the final EIR	Operational Phase		

2.19.3	Surface Water Quality	**Workshops offices and stores** The workshops, offices, stores and waste handling areas have the potential to generate poor quality runoff due to contact of the water with coal, hydrocarbons and waste material. Impacts may arise from: Contaminated storm water runoff, as well as washdown water and hydrocarbon spills that discharges from the site, with resultant deterioration in water quality within the Trossfonteinspruit, with resultant increase in suspended solids, hydrocarbons (oils and greases), siltation of carbonaceous materials, increase in salinity and potential decrease in pH in the watercourses. Leakage of contaminated water from pipelines, poorly maintained storm water channels, sumps, sediment traps and oil skimmers, etc.	Yes	-	5	3	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	The workshops, offices, waste handling areas, stores, etc. will be located within the Mine Infrastructure area (MIA) designated dirty water area. All spills will be contained within dedicated bunded areas (at workshops, waste handling and storage areas, etc.). Both general and hazardous wastes will be stored in skips until removal from the site. The skips in turn will be located under cover to prevent ingress of direct rainfall. Waste oil will be stored in drums in a bunded storage area. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. All contaminated runoff and spills that escape bunded areas will be collected and contained in the MIA PCD.	To be confirmed in the final EIR	Operational Phase		
2.19.4	Surface Water Quantity	**TOPA All surface Infrastructure** The loss in yield associated with mining at the TOPA operation will be primarily due to the catchment area of dirty footprints which will be isolated from the catchment. The percentage reduction of yield in the Witbank Dam and Loskop Dam catchment due to the TOPA operation (all surface infrastructure) amounts to approximately 1.04 % and 0.24% respectively. Therefore the impact on surface water yield in the watercourses is low.	Yes	-	8	2	4	5	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	All active and "dirty" areas to form part of the dirty water management area. This area to be separated from the clean water management area by berms and canals. No surface water from the dirty footprint area is to be discharged into the environment, instead impacted mine water will be directed to the appropriate pollution control dam.	Minimise the dirty footprint through concurrent rehabilitation with rehabilitated areas draining back to the catchment. Construct clean water cut-off canals upstream of the pit to direct clean water back to the catchment.	To be confirmed in the final EIR	Operational Phase		
2.19.5	Surface Water Quality and Quantity	**Flooding of mine or mine infrastructure during extreme flood events** GN 704 stipulates that no mine workings may be placed within the 1:50 year floodline and no mine residue deposits or stockpiles may be placed within the 1:100 year floodline, or a distance of 100 m from any watercourse, whichever is the greater. On the block plan, the following opencast mining pits are currently indicated to fall within the 1:50 year floodline or the 100 m buffer zone (refer to Figure 4.5.2(f) in the surface water specialist report): • Malsopen • Klippiest • Boschmans South Central With the exception of the above areas, the majority of the mine infrastructure, including the opencast pits, workshops, offices and related infrastructure is located well outside the 1:100 year floodlines. With no mitigation measures, under extreme flooding conditions in the Olifants River the workings at Malsopen, Klippiest and Boschmans South Central could be flooded, with consequent contamination of the flood waters, as well as loss of life if this occurs during operations.	Yes	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Ensure compliance with regards to GN 704.	Ensure compliance with regards to GN 704.	No mining within these areas will take place without the relevant authorisations, in terms of GN704 exemptions and Section 21(c) and (i) water use licences (in terms of the NWA). The extent of at Malsopen, Klippiest and Boschmans Central will be altered to prevent encroachment on the floodline of the Trossfonteinspruit. Alternatively, adequately sized and engineered flood protection berms will be provided at these pits. The conveyor will be elevated above the 1:100 year level at all watercourse crossings.	To be confirmed in the final EIR	Operational phase		
[illegible]																			
2.22.1	Surface Water Quality	The water generated from the golf course will contain fertilizers that will have the potential to impact on the downstream water resources, primarily in terms of increased nutrients.	Yes	-	6	2	4	8	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	Water quality monitoring to be implemented.	Minimise mine water make by maximising free drainage areas i.e. avoid surface drainage into voids. If the expected water quality of runoff from the golf course is poor (due to fertilizers or irrigation using mine water) enough to preclude drainage to the natural rivers, then drainage must be to the voids. A surface water quality monitoring programme will be implemented to detect any impacts. Drainage to voids is not desirable as it would increase the overall mine water make, therefore water treatment volumes would also increase and is not best practice. Avoid over-irrigation of the golf course.	To be confirmed in the final EIR	Operational phase		
2.22.1	Surface Water Quantity	Water will be abstracted from the Trossfontein Dam as well as the voids for irrigation of the watercourse. Portions of the golf course will drain to the final voids of the old Hamelar and Boschmans South East pits.	Yes	-	4	2	4	8	[illegible]	[illegible]	[illegible]	[illegible]	Control irrigation volumes to prevent over-irrigation. Minimise extent of golf course that drains into the final voids.	Water quality monitoring to be implemented.	Minimise mine water make by maximising free drainage areas i.e. avoid surface drainage into voids. Minimise irrigation quantities by adjusting volumes according to seasons and recent rainfall.	To be confirmed in the final EIR	Operational phase		
[illegible]																			
[illegible]																			

3.20.1	Surface Water Quality	**General decommissioning and rehabilitation** Impacts resulting from general rehabilitation and decommissioning works will be similar to those during the construction phase, with rehabilitation earthworks and movement of construction equipment on the site. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. Contaminated soils below the plant and stockpiles area may have a long term impact in terms of leaching contaminants to the ground and surface water systems. These impacts are expected to be relatively small, with the resultant impact post decommissioning being positive in comparison with the operational phase.	Yes	-	3	3	3	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	The water management berms and canals isolate active areas from the catchment by diverting upslope clean runoff around the active areas and containing runoff generated on the active areas. These can only be removed once the area has been rehabilitated, but may result in increased erosion if not properly planned. The PCDs will be used to contain affected runoff and seepage (from the discard facilities) until such time as the area becomes clean.	Decommissioning and rehabilitation activities will be timed to take place in the dry season, as far as is practical. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel – particularly in close proximity and within the catchment areas of the pans. The storm water management measures, including PCDs will be decommissioned last, to ensure adequate storm water management during the rehabilitation phase. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar type product will be kept on site and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase, which will include the handling of contaminated materials / soils found on site. All traces of hydrocarbons and residual waste will be removed before infrastructure is demolished. All coal will be removed from the stockpiles prior to rehabilitation. Contaminated soils will be excavated and placed on the discard facilities prior to their rehabilitation, or removed from site by an appropriately licensed waste contractor.	To be confirmed in the final EIR	Decommissioning and closure phase		
3.20.2	Surface Water Quality	**Decommissioning and rehabilitation of water management infrastructure and PCDs** The water management berms and canals isolate active areas from the catchment by diverting upslope clean runoff around the active areas and containing runoff generated on the active areas. These can only be removed once the area has been rehabilitated, but may result in increased erosion if not properly planned. The PCDs will be used to contain affected runoff and seepage (from the discard facilities) until such time as the area becomes clean. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. These impacts are expected to be relatively small, with the resultant impact post decommissioning being positive in comparison with the operational phase.	Yes	-	3	3	2	4	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	The water management berms and canals isolate active areas from the catchment by diverting upslope clean runoff around the active areas and containing runoff generated on the active areas. These can only be removed once the area has been rehabilitated, but may result in increased erosion if not properly planned. The PCDs will be used to contain affected runoff and seepage (from the discard facilities) until such time as the area becomes clean.	This infrastructure will be decommissioned and rehabilitated last. Refer to impacts under 3.20.1 above for general management measures.	To be confirmed in the final EIR	Decommissioning and closure phase		
3.20.3	Surface Water Quality	**Recovery of water levels and possible decant** At the opencast areas, water quality will be affected through oxidation of pyrites and contact with infiltration. Pits will be rehabilitated by backfilling, shaping and ensuring they are free draining. Once the pits have been backfilled and re-shaped dewatering will cease and water levels will begin to recover in the workings. Surface area around the shafts are generally affected, with overburden from the shaft excavation remaining on surface until rehabilitation. Shafts would need to be plugged and backfilled with overburden material ensuring that carbonaceous material is removed or isolated. Decant control measures will therefore need to be implemented to prevent decant during the decommissioning phase.	Yes	-	3	2	3	4	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management	Opencast pits that are backfilled and re-shaped in order for dewatering to cease and water levels to begin to recover in the workings. Shafts would need to be plugged and backfilled with overburden material ensuring that carbonaceous material is removed or isolated.	All pits will be backfilled without a final void, rehabilitated and made free-draining. All shafts will be plugged and backfilled. All carbonaceous material will be removed and isolated. Monitoring of water levels in the mine and the associated water quality is committed to. This will allow both calibration of the post mining water quality and water volumes. The water level in the workings will be actively managed to ensure it remains below the decant elevation. The post closure mine water make will be pumped from the mine workings and treated in a water treatment plant, which will remain operational post closure. Discharge of clean water to the river system.	To be confirmed in the final EIR	Decommissioning and closure phase		

3.21.1	Surface Water Quality and Quantity	Impacts resulting from the legacy rehabilitation works will be similar to those during the construction phase, with rehabilitation earthworks and movement of construction equipment on the site. Impacts may arise from: Erosion of soils during rainfall events, with elevated suspended solids in the runoff water. Resultant elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and the adjacent pans. Exposure of carbonaceous sediments in the watercourses to oxygen, with resultant oxidation effects will have the potential to generate highly contaminated runoff and seepage, which may become acidic. Hydrocarbon spillages from fuel storage, servicing areas or construction equipment itself, with resultant elevated hydrocarbon concentrations in runoff water, watercourses and the adjacent pans. Contaminated soils below the discard dumps and stockpile area may have a long term impact in terms of leaching contaminants to the ground and surface water systems. These impacts are expected to be relatively small, with the resultant impact post decommissioning being positive in comparison with the operational phase.	Yes	-	10	3	5	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Minimise the extent of disturbance and effective dirty water management	The water management berms and canals isolate active areas from the catchment by diverting upslope clean runoff around the active areas and containing runoff generated on the active areas. These can only be removed once the area has been rehabilitated, but may result in increased erosion if not properly planned. The PCDs will be used to contain affected runoff and seepage (from the discard facilities) until such time as the area becomes clean.	Rehabilitation activities will be timed to take place in the dry season, as far as is practical. The footprint of disturbed areas will be minimised. "No-go" zones will be delineated for construction plant and personnel – particularly in close proximity and within the catchment areas of the pans. The storm water management measures/plan to be put in place to ensure effective dirty water management and containment. Servicing of construction vehicles will take place only in dedicated areas that are equipped with drip trays. Bunded containment and settlement facilities will be provided for hazardous materials, such as fuel and oil. Spill-sorb or a similar type product will be kept on site and used to clean up hydrocarbon spills in the event that they should occur. Erosion protection measures will be implemented at steep areas. A waste management plan will be developed for the construction phase, which will include the handling of contaminated materials / soils found on site. All traces of hydrocarbons and residual waste will be removed before infrastructure is demolished. All coal will be removed from the stockpiles and discard dumps prior to rehabilitation. Contaminated soils will be excavated and placed on the discard facilities prior to their rehabilitation, or removed from site by an appropriately licensed waste contractor. [illegible]	To be confirmed in the final EIR	Decommissioning and closure phase		
[illegible]																				
3.22.1	Surface Water Quality and Quantity	Golf Course to remain post closure. Therefore impacts same as per operational phase.																		
[illegible]																				
3.16.1 3.3.1	Surface Water Quality	Borrow pits that are not mined through by opencast pits will be rehabilitated and made free draining. This will involve general construction activities, as detailed under item 3.20.1.	Yes	-	4	2	4	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management	Borrow pits to be backfilled and rehabilitated and made free draining.	Rehabilitate the borrow pits by backfilling, shaping and ensuring they are freedraining. All affected water to be collected and treated where required. Water quality monitoring and rehabilitation monitoring will be implemented during the decommissioning phase to evaluate the success of the final rehabilitation and to determine any shortcomings.	To be confirmed in the final EIR	Decommissioning and closure phase		
3.16.2 3.3.2	Surface Water Quantity	Containment of contaminated storm water in the borrow pits.	Yes	-	4	2	4	6	36	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management	Borrow pits to be backfilled and rehabilitated and made free draining.	Maximise the volume of clean runoff during the decommissioning phase by ensuring rehabilitated areas are free draining. Storm water from the borrow pits will be temporarily contained in a sump during the rehabilitation process, so as to allow suspended solids to settle out. Ultimately all storm water from the borrow pits will be returned to the catchment.	To be confirmed in the final EIR	Decommissioning and closure phase		
6. Post-Closure Phase																				
[illegible]																				
4.23.1	Surface Water Quality	Post closure all areas associated with the TOPA Plant and Discard facilities will be rehabilitated and made free draining, with the clean runoff discharging to the natural river system. The discard facilities, unless reclaimed, will remain a permanent risk to the environment post closure. Impacts may arise from: Erosion of capping soils on the side slopes of the discard facilities, with elevated suspended solids in the runoff water, resulting in elevated suspended solids in the watercourses, as well as sedimentation in the watercourses and potentially the adjacent pans. Erosion of discard material, should the full thickness of capping material erode, potentially resulting in elevated salinity, particularly sulphate, in the watercourses. Seepage of contaminated water from the discard facilities into the groundwater system, resulting in a deterioration in groundwater quality, with potential daylighting of this water into the watercourses or pans. Discharge of leachate / seepage from the discard facilities (either uncontrolled or through the herringbone drainage system) into the natural watercourses or pan, with resultant elevated salinity, particularly sulphate, and potentially low pH.	Yes	[illegible]	10	3	4	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Effective dirty water management		Water levels in the workings will be maintained and monitored at a pre-determined environmental safe level to prevent decant. Water level control will be by active pumping to either the Seam 4 Seam or the ATC 2 Seam underground storage compartment, for treatment in the WTP. The treatment capacity of the WTP will be upgraded timeously to ensure that all surplus water at Transfontein can be treated without decant. The upstream clean water diversion channels will remain in place post closure. The herringbone drainage system, PCDs and pumping system will remain in place post closure to ensure that seepage water is not released to the natural river system. Seepage water will be collected in the PCDs and pumped to underground storage. Decommissioning and rehabilitation activities will be timed to take place in the dry season, as far as is practicable. The discard dumps will be shaped, capped and rehabilitated with slopes gentle enough to be stable in the long term. The opencast pits will be shaped, rehabilitated and made free draining. Erosion protection measures will be implemented at steep areas where required. Water quality monitoring will be undertaken downstream of the mining areas in order to detect any water quality impacts. The discard dumps, PCDs and pump stations and pipelines will be inspected regularly for damage and leaks to ensure early detection and repair.	To be confirmed in the final EIR	Post Closure Phase		
[illegible]																				
4.22.1	Surface Water Quality and Quantity	Golf Course to remain post closure. Therefore impacts same as per operational phase.																		

9. FINANCIAL PROVISION

For the operational phase, the water management costs are included in the infrastructure costs in most respects, including pollution control dams and the associated storm water canals, pumps and pipes.

At closure these facilities will be demolished and removed and the area will be rehabilitated. The cost related to this will be included in the overall closure costing.

Post closure the area will be rehabilitated and will not generate dirty runoff. The underground mine workings will be allowed to fill. Once a pre-defined safe water level has been reached, this water level will be maintained by pumping the water make from the workings to a water treatment plant. This will be some years after mining ceases. The treatment plant employed may be a local, stand-alone plant, or a regional plant servicing a number of operations.

10. SUMMARISED WATER MANAGEMENT PLAN

In Section 8, mitigation measures have been indicated to manage the impacts assessed. These measures need to be incorporated into an Integrated Water and Waste Management Plan (IWWMP) that can be used to implement, audit and measure the performance of the water management measures detailed in the EMP.

This section is intended to only provide inputs on key aspects of the water management plan.

10.1 Construction Phase

10.1.1 Key issues and objectives

- To prevent contamination of surface water runoff from the cleared construction site areas.
- To minimise erosion in the construction site areas and to minimise siltation in the adjacent water courses and pans.
- To ensure that the required water management infrastructure is constructed in time.

10.1.2 Key strategies

Areas where impacts in terms of construction activities could occur are listed below:

- Timing of construction activities. As far as is practically possible, construction should take place during the dry winter months.
- Construction of water management measures.
    - The upstream diversion should be constructed first to minimise the flow of water across the construction site
    - The construction of the dirty water management measures should be completed prior to commissioning and operating the plant.
- Construction of the materials handling areas.
    - The run of mine and product stockpiles will be located within the dirty water area.
- Control of suspended solids. Should wet conditions occur during construction, suspended solids in the watercourses and pans must be monitored and silt traps must be provided on construction areas, should suspended solids be detected.

10.1.3 Monitoring

Monitoring of water quality is on-going and will continue through the construction and operational phases. A monitoring programme for the Tweefontein Complex is detailed in Section 11.

10.1.4 Knowledge gaps

Final design of the infrastructure and water management measures has still to be completed. The adequacy of the measures detailed in this document will be reviewed in the final designs and updated in the Water Use License application.

10.2 Operational Phase

10.2.1 Key issues and objectives

- To minimise the impact on catchment yield
- To identify and control surface runoff that may be affected by the planned activities, as well as the water balance associated with the various plant and Discard Facilities, and to ensure that the risk of spilling this water into the clean catchment is:
  - In line with licensing requirements
  - In line with legislative requirements
  - Commensurate with the risks to downstream users associated with any spillage. This is taken currently at a 2% or lower risk in any one year, or the 1:50 year flood occurrence.
- To prevent clean runoff from upstream / upslope areas from spilling into the dirty water systems for flood events up to at least the 1:50 year recurrence interval.
- To ensure adequate monitoring so that the objectives of the water management system can be met.

10.2.2 Key strategies

The key management strategy is to keep clean water clean and to minimise the generation of dirty water. This is to be achieved by diverting runoff from clean catchments around the dirty areas and minimising the extent of dirty areas as far as is practical. Clean and dirty water systems will be designed and managed to have a risk of spill of 1% or less (for clean systems) and 2% or less (for dirty systems) in any one year (1:100 year and 1:50 year recurrence interval events, respectively).

- Minimising loss of catchment yield:

  The various Plant and Discard Facilities site is very small in relation to the Tweefontein mine area and the Tweefonteinspruit and Saaiwaterspruit catchments.

  The loss of this yield is dependent on the on-site management and planning activities, including the following:
  - Placement of upstream diversion berms/ canals so that the maximum volume of upstream runoff can be diverted around the plant, back to the TOPA water management system.
  - Minimising the dirty water footprint on the Plant and Discard Facilities.
  - Investigating and implementing water conservation and demand management, together with maximising recycling and reuse strategies on the site.
  - Implementation of a water flow, pumping and dam water level monitoring programme to enable calibration of the water balance model and efficient management of the site water balance.
- Managing the generation of dirty water

  Provision has been made to collect, store and reuse dirty water generated by the plant activities. The proponent has committed to having a 2% or lower risk of spilling in any one year and the water balance modelling has been shown that the planned PCDs have adequate capacity to ensure that this level of risk can be achieved.

The risk of spilling is a function of adequate storage capacity, balanced against the reuse of water in the coal processing. Subject to calibration of the water balance model it is expected that the site will operate with a water surplus and will need to store water in various underground compartments.

In line with best practice, the PCDs will be operated as empty as possible at all times to ensure that sufficient storm water retention capacity is available at all times.

In the event that there is insufficient available capacity in the Plant Holding Dam and CPP PCD during extreme rainfall conditions, excess storm water will be pumped to the Boschmans underground storage compartments.

Ongoing calibration of the water balance is required to ensure that the estimations in terms of water make-up, water shortages and storage requirements are evaluated during the life of the plant. Key strategies to address these issues involve:

- Monitoring of water volumes pumped and stored
- Documentation of any problems in reusing dirty water, such as operational difficulties
- Ongoing rainfall monitoring
- Management of water pumped/ draining into the pollution control dams and the CPP PCD and Plant Holding Dam, including documentation of water volumes abstracted for use in the process
- Adjustment for any changes in process or infrastructure layout, where these could affect the water balance
- Ongoing monitoring of water levels within the pollution control dams, as well as any spillages
- Ongoing monitoring of water volumes imported from TOP Mine, including process, raw and potable water.

All of the above highlight the fact that the water management will be a dynamic and ongoing process, aimed at ensuring compliance with legal requirements and good environmental practice over the life of mine.

10.2.3 Monitoring

The objective of the surface water monitoring system is to ensure that the water management systems perform according to specifications, to act as a pollution early warning system, to check compliance with license requirements and for reporting purposes. The objective of these systems will be achieved if there is no impact (attributable to the various Plant and Discard Facilities) on the downstream environment.

Monitoring requirements are detailed in Section 11.

10.2.4 Knowledge gaps

The water balance is at this stage based largely on theoretical modelling of the hydrological aspects and theoretical production values/ parameters obtained from the mine. Monitoring of inflows, water use volumes and dam water levels will therefore be an important input to calibration of the water balance model and to ensuring that the risks associated with the water management system are adequately defined. Key variables to be monitored are detailed in Section 10.2.2 above.

10.3 Decommissioning

10.3.1 Key issues and objectives

- To rehabilitate the plant, stockpile and discard facility areas to ensure that they are free-draining and that runoff from these areas is clean
- To limit the risk of increased erosion on site and downstream, relating to areas being rehabilitated and consequently impacting on water quality
- To ensure that the area is decommissioned and rehabilitated "from the inside out", thereby preventing spillage of any dirty water or waste in the process.

10.3.2 Key strategies

- Dismantling and removal of the entire plant
- Removal of all carbonaceous material and other contaminants / waste materials from the site
- Shaping and grassing of the plant area
- Shaping, capping and grassing of the discard facilities
- Erosion protection
  - The general area is vulnerable to erosion. During rehabilitation, the areas where grass has not yet been established will be monitored to ensure that there is not excessive erosion prior to the grass establishing, and where necessary additional erosion protection such as the use of dump rock or repair of gullies will be undertaken until such time that the rehabilitated surfaces can be shown to be sustainable.

10.3.3 Monitoring

Monitoring during decommissioning will be based on the operational phase monitoring, adapted to suit the final works to be implemented during this phase. However, in terms of surface water this will be primarily downstream of the area, as for the operational phase.

10.3.4 Knowledge gaps

The final land use for the site is not certain at this stage. This may influence the rehabilitation strategy.

10.4 Post Closure

10.4.1 Key issues and objectives

- To manage the rehabilitated area post closure.

10.4.2 Key strategies

The key strategy is to ensure that the rehabilitation in terms of shaped land form and vegetation cover is maintained in the long term to ensure long term sustainability of the rehabilitated area. Management of seepage from the discard dumps will also be required. This water will discharge to the Discard Facility PCDs and be pumped to underground storage.

10.4.3 Monitoring

Monitoring post closure will be undertaken only where required to prove the sustainability of the site. In terms of surface water, this relates primarily to managing the surface topography (monitoring for erosion), and water quality downstream of the site.

10.4.4 Knowledge gaps

The final land use for the site is not certain at this stage. The required post closure water management measures and monitoring may be influenced by the final land use.

11. MONITORING AND AUDITING

The objective of the surface water monitoring system is to ensure that the water management systems perform according to specifications, to act as a pollution early warning system, to check compliance with license requirements and for reporting purposes. The objectives of these systems will be achieved if there is no impact (attributable to the TOP project) on the in-stream and downstream fitness for use criteria.

11.1 Water quality monitoring

11.1.1 Monitoring locations

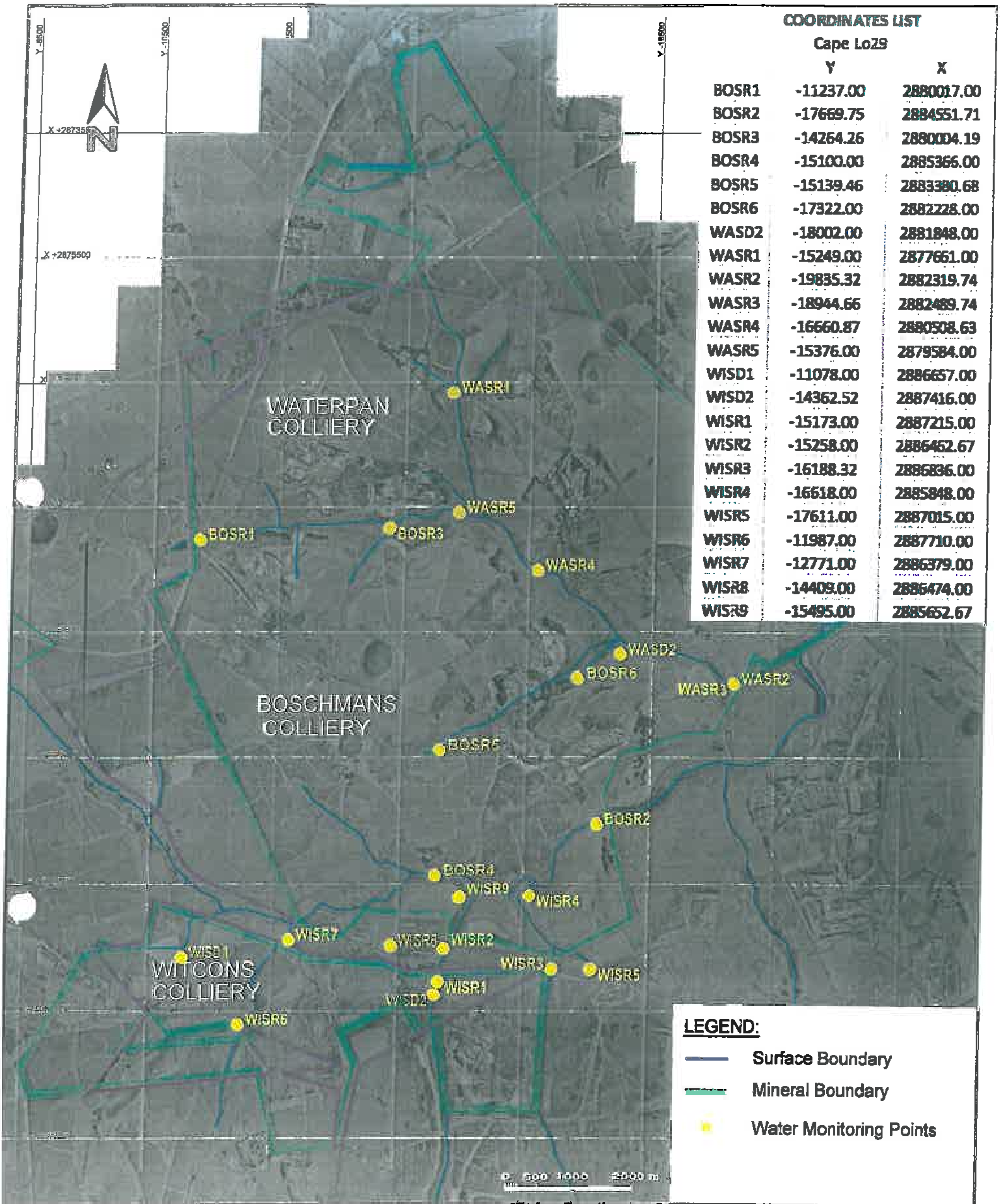
The proposed monitoring locations are shown in **Figure 11.1.1(a)**. The locations are described in **Table 11.1.1(a)**. The frequency of sampling and the constituents to be analysed are indicated in **Table 11.1.2(a)**.

Table 11.1.1(a) Details of surface water quality monitoring locations

Monitoring point	Description	Co-ordinates[1]	
		Latitude	Longitude
BOSCHMANS COLLIERY			
BOSR-1	On the Tweefonteinspruit upstream of the Boschmans plant area. No surface mining activities upstream of this sampling location. It is, however, possible that runoff from dirty areas south and west of the railway line is directed along the railway line and into the Tweefonteinspruit at this location.	-26.03075816	29.11241636
BOSR-2	On the Zaaiwaterspruit upstream of the Phoenix Dam	-26.07248434	29.17711151
BOSR-3	On a tributary, joining the Zaaiwaterspruit	-26.0302809	29.14191662
BOSR-4	Zaaiwaterspruit north of settlement	-26.07487275	29.1391109
BOSR-5	Eastern stream feeding Tweefontein Dam	-26.05689	29.15922257
BOSR-6	Upstream of Tweefontein Dam	-26.04857	29.17308363
BOSD-1	Pan to south-east of Waterpan plant (serves as PCD at Boschmans)	-26.03075816	29.11241636
BOSD-2	Pollution control dam	-26.04607876	29.139777.5
BOSD-3	Pollution control dam	-26.04607876	29.139777.5
BOSD-4	Pollution control dam	-26.04607876	29.139777.5
WATERPAN COLLIERY			
WASR-1	Upstream monitoring point for Waterpan Complex on the Waterpanspruit.	-26.00987093	29.1525274
WASR-2	On the Waterpanspruit	-26.02115109	29.15494456

[1] JKC, 2013

Monitoring point	Description	Co-ordinates[1]	
WASR-3	On the Tweefonteinspruit	-26.05196766	29.19819399
WASR-4	Upstream of Tweefontein Dam	-26.03819308	29.17044466
WASR-5	Upstream of Tweefontein Dam	-26.02773637	29.15847188
WASD-1	Waterpan PCD	-26.01627781	29.154139
WASD-2	Tweefontein dam	-26.04620876	29.18474994
WITCONS COLLIERY			
WISR-1	Witcons stream	-26.09426636	29.1515281
WISR-2	Witcons stream	-26.08939093	29.15280527
WISR-3	Tavistock stream	-26.09207964	29.16972199
WISR-4	Zaaiwaterspruit	-26.08161426	29.16569486
WISR-5	Tavistock Colliery Stream	-26.09243353	29.17586105
WISR-6	Klippoortjiespruit	-26.10061316	29.12133317
WISR-7	Upstream of discard dump	-26.08589545	29.12736125
WISR-8	Downstream of discard dump	-26.08849679	29.14458365
WISR-9	Downstream of discard dump	-26.07937397	29.15088923
WISD-1	Witcons Dam in Zaaiwaterspruit	-26.0924089	29.10950039
WISD-2	PCD below plant area	-26.09607285	29.15030587



COORDINATES LIST

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	Y	X
BOSR1	-11237.00	2880017.00
BOSR2	-17669.75	2884551.71
BOSR3	-14264.26	2880004.19
BOSR4	-15100.00	2885366.00
BOSR5	-15139.46	2883380.68
BOSR6	-17322.00	2882228.00
WASD2	-18002.00	2881848.00
WASR1	-15249.00	2877661.00
WASR2	-19835.32	2882319.74
WASR3	-18944.66	2882489.74
WASR4	-16660.87	2880508.63
WASR5	-15376.00	2879584.00
WISD1	-11078.00	2886657.00
WISD2	-14362.52	2887416.00
WISR1	-15173.00	2887215.00
WISR2	-15258.00	2886462.67
WISR3	-16188.32	2886836.00
WISR4	-16618.00	2885848.00
WISR5	-17611.00	2887015.00
WISR6	-11987.00	2887710.00
WISR7	-12771.00	2886379.00
WISR8	-14409.00	2886474.00
WISR9	-15495.00	2885652.67

LEGEND:

- Surface Boundary
- Mineral Boundary
- Water Monitoring Points

0 500 1000 2000 m

Cape Lo29

Jones & Wagener Engineering & Environmental Consultants	Xstrata South Africa (Pty) Ltd Tweefontein Optimisation Project Amendment **WATER MONITORING POINTS**	Job No: D367/00 **Figure11.1.1(a)**

11.1.2 Water quality sampling and analysis

The frequency of sampling and analysis is detailed in **Table 11.1.2(a)**.

Table 11.1.2(a) Surface water quality sampling and analysis

Constituents		Frequency
pH		Monthly
Electrical conductivity (EC)	mS/m	
Total dissolved solids (TDS)	mg/ℓ	
Suspended solids (SS)	mg/ℓ	
Total alkalinity (T Alk)	mg/ℓ	
Total hardness	mg/ℓ	
Nitrate (NO_3)	mg/ℓ	
Chloride (Cl)	mg/ℓ	
Fluoride (F)	mg/ℓ	
Zinc (Zn)	mg/ℓ	
Manganese (Mn)	mg/ℓ	
Sodium (Na)	mg/ℓ	
Magnesium (Mg)	mg/ℓ	
Calcium (Ca)	mg/ℓ	
Potassium (K)	mg/ℓ	
Sulfate (SO_4)	mg/ℓ	
Total chromium (Cr)	mg/ℓ	6 monthly
Chromium $^{6+}$ (Cr^{6+})	mg/ℓ	
Copper (Co)	mg/ℓ	
Cadmium (Cd)	mg/ℓ	
Iron (Fe)	mg/ℓ	
Vanadium (V)	mg/ℓ	
Aluminium (Al)	mg/ℓ	

Samples will be grab samples, which will include:

- Filtered and unfiltered samples
- Acid preservation of samples for metals analysis.

All samples will be analysed by an accredited laboratory.

11.2 Water quantity monitoring (water balance monitoring)

For efficient management of water on the site, a good understanding of the site water balance will be required. To achieve this, the following monitoring will be needed:

- Rainfall – to be measured daily on the site.
- Evaporation – this is not essential but would be useful for calibration of the water balance model.
- Dam water levels – to be measured weekly.
- Flows – including the following, to be measured weekly:
  - Make-up water drawn from all systems (process water, raw water and potable water).
  - Inflows to the Pollution Control Dams.
  - Water pumped from the Pollution Control Dams for reuse in the process.
  - Water circuits within the processing plant.
  - Moisture contents and tonnages of feed coal product.
  - Sewage volumes.

11.3 Data management and reporting

11.3.1 Monthly

The monthly report is an internal report which is used to keep records of changing water qualities at the site. The report will include:

- Sites that are sampled.
- Water qualities for the relevant constituents.
- Dam levels and flow rates on site.
- Highlight significant issues that require immediate corrective/ preventative action.

11.3.2 Quarterly

The quarterly report may be submitted to DMR/ DWA and consists of the following components:

- Brief compliance assessment description
- Brief description of monitoring actions performed
- Dam water level status report
- Highlight significant issues that require immediate corrective/ preventative action
- Historical and present source chemistry report
- Time dependent graphs for the relevant water quality variables.

11.3.3 Annually

The annual report consists of all the active environmental components, and for the chapter on surface water, the following components should be included:

- System audit

- Statutory/ regulatory requirements
- Monitoring infrastructure
- Data captured
- Information generation
- Management of system liquids
- Data audit
    - Verification of data
    - Compliance interpretation using SANS 241 Drinking Water Standard and management unit objectives
    - Setting of new objectives or recommendation of corrective measures
    - Historical and present source chemistry report
    - Dam level status report

11.4 Performance assessment/ audit

Annual audits should be carried out to determine the effectiveness of the water management systems that are in place. These should include a GN 704 audit.

12. EMERGENCY AND REMEDIATION PROCEDURE

This section is detailed in the main EMP.

13. CONCLUSION

The major concerns with regards to TOPA's surface water impacts revolve around the effective separation of clean and dirty water, effectively isolating the pits and plant area, adequate sizing of the dirty water facilities and effective use of dirty water so that the impact on the clean catchment remains minimal.

There will be a surplus of water at Tweefontein complex over the life of mine. Water will be pumped to available storage areas in the mined out workings for temporary storage prior to treatment.

The water balance will need to be regularly updated as the mine develops and the LOM changes.

The main plant and discard dump area will be able to be contained by the coal processing plant PCD with a capacity of 150 Ml, this dam being kept empty through pumping back to the Plant Holding Dam from where water will be reused in the plant.

Additional smaller dams will be provided at the ROM tip, MIA, Railway loop and Conveyor transfer house. All of the dams will be lined as detailed in this document, but typically with a synthetic liner underlain by a clay layer and a leakage detection system. Numerous clean and dirty canals are required to separate clean and dirty water, and all of these have been sized to have a 2% risk of spilling.

With the majority of the operation being conducted using opencast mining the potential impact on the surface water quality and quantity is significant. TOPA also has the potential to contribute significantly to the cumulative impacts in the catchment.

However, with the mitigation and management measures detailed in this document, these impacts will be minimised.

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14. REFERENCES

1. Adamson, P.T. (1981) "TR102 Southern African Storm Rainfall" Department of Environment Affairs, Directorate of Water Affairs.
2. Alexander, W.J.R. (2002) "SDF2: The Standard Design Flood – theory and practice" University of Pretoria, Dept Civil Engineering.
3. Alexander, W.J.R. (2002) "SDF3: Users manual – The Standard Design Flood – a new design philosophy" University of Pretoria, Dept Civil Engineering.
4. Alexander, W.J.R. (2001) "Flood Risk Reduction Measures" University of Pretoria, Dept Civil Engineering.
5. Daily Rainfall Extraction Utility, ICFR, BEEH University of Kwa-Zulu Natal, Pietermaritzburg.
6. DWEA (1996) "South African Water Quality Guidelines – Volume 8 Field Guide" Department of Water and Environmental Affairs, Pretoria.
7. Department of Water Affairs and Forestry (2004) "Flood Hydrology Course 5 – 7 April 2004" Institute for Water and Environment Engineering, University of Stellenbosch Dept Civil Engineering.
8. DWAF (1996) "South African Water Quality Guidelines – Volume 8 Field Guide" Department of Water Affairs and Forestry, Pretoria.
9. Government Notice No. 704, 1999: Regulations on use of water for mining and related activities aimed at the protection of water resources, dated June 1999, under the National Water Act, 1998, (Act 36 of 1998).
10. Government Notice R385, April 2006: National Environmental Management Act, 1998 (Act 107 of 1998). Environmental Impact Assessment Regulations.
11. Government Notice R386, April 2006: National Environmental Management Act, 1998 (Act 107 of 1998). Environmental Impact Assessment Regulations. National Water Act, 1998 (Act 36 of 1998)
12. Government Notice R387, April 2006: National Environmental Management Act, 1998 (Act 107 of 1998), Environmental Impact Assessment Regulations.
13. Government Notice R.527, April 2004: Minerals and Petroleum Resources Development Act, 2002 (Act 28 of 2002). Minerals and Petroleum Resources Development Regulations. Municipal Demarcation Board, 2006, Pretoria, South Africa
14. Hydrological Research Unit (1972) "Report No. 1/72, Design flood determination in South Africa" University of the Witwatersrand, Dept Civil Engineering.
15. Kovács, Z. (1988) "TR137 Regional Maximum Flood peaks in Southern Africa" Department of Water Affairs.
16. Midgley, D.C., Pitman, W.V. and Middleton, B.J. (1995) "Surface Water Resources of South Africa 1990 – Volume I" WRC Report No. 298/1.1/94, Water Research Commission
17. Minerals and Petroleum Resources Development Act, 2002 (Act 28 of 2002).
18. Minerals and Petroleum Resources Development Act, 2002 (Act 28 of 2002). Minerals and Petroleum Resources Development Regulations. Government Notice No. R.527, April 2004
19. National Environmental Management Act, 1998 (Act 107 of 1998)

20. National Environmental Management Act, 1998 (Act 107 of 1998). Environmental Impact Assessment Regulations. Government Notice R.385. April 2006.

21. National Environmental Management Act, 1998 (Act 107 of 1998). Environmental Impact Assessment Regulations. Government Notice R.386. April 2006.

22. National Environmental Management Act, 1998 (Act 107 of 1998). Environmental Impact Assessment Regulations. Government Notice R.387. April 2006.

23. National Water Act, 1998 (Act 36 of 1998)

24. Quality of Domestic Water Supplies (1998) Assessment Guide vol 1. DWAF, WRC, and Department of Health, Pretoria.

25. South African Committee on Large Dams (SANCOLD) (1990) Safety evaluation of dams. Interim Guidelines on Freeboard for Dams. Report No 3.

26. South African Committee on Large Dams (SANCOLD) (1991) Safety evaluation of dams. Guidelines on Safety in Relation to Floods. Report No 4.

Appendix A

TOPA STUDY AREA AND INFRASTRUCTURE LAYOUTS

WASR-2

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH		7.6	7.9	7.5	7.6	7.6	7.7	7.8		8.3		7.8	7.2	6.6
EC	mS/m	86.02	521.3824	167	286	337	425	468		538		270	542	633
Turb	NTU													
SS	mg/l						13			1			316	
TDS	mg/l	540	4627	1558	2815	3269	4191	4597		5121		2632	5258	5283
Ca	mg/l	70	492	224	330	462	382	489		742		322	600	497
Mg	mg/l	48	338	85	191	219	470	413		377		213	400	434
Na	mg/l	16	70	25	23	30	38	31		26		34	41	37
K	mg/l	7	9	11	10	10	11	11		10		11	9	9
Tot-Alk	mg/l CaCO3	70	92	162	152	110	108	112		72		112	22	28
Cl	mg/l	11.34	15.598	24	28	20	18	24		20		17	13	17
SO4	mg/l	316	2682	810	1512	2007	2486	2697		2932		1580	3147	3216
NO3	mg/l	1	4.255	1	3	9	4	12		10		4	6	6
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.2	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.1	0.5
Fe	mg/l	0.2	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.1	0.5
Mn	mg/l	0.1	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5

WASR-2

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08
pH		7.4		7.2	7.6	7	8.2	7.9		7.4	6.7	6.7	7.2	7.4	7.6	7.2
EC	mS/m	631		436	460	498	466	585		143	322	230	234	147	205	158
Turb	NTU														6	
SS	mg/l														26	
TDS	mg/l	6244		6009	5892	5432	5858	6857		1043	3228	2205	2308	1286	2030	1619
Ca	mg/l	656		706	606	682	604	568		137	338	266	205	138	216	126
Mg	mg/l	694		694	638	544	530	800		73	264	220	248	80	176	124
Na	mg/l	53		46	50	43	54	90		32	59	50	47	23	49	24
K	mg/l	11		12	24	12	15	19		13	6	0.5	6	0.5	9	8
Tot-Alk	mg/l CaCO3	8		34	8	4	80	246		50	6	16	22	28	34	32
Cl	mg/l	18		20	21	17	92	35		24	60	40	43	28	37	27
SO4	mg/l	4113		3653	3713	3534	3429	4051		501	1934	1381	1395	766	1173	739
NO3	mg/l	1		7	1	1	7	2		1	3	2	2	1	1	2
F	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.37	0.5	0.5	0.5	0.5
Al	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.03	0.5	0.5	0.5	0.5
As	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	0.5
B	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.08	0.5	0.5	0.5	0.5
Cd	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.003	0.5	0.5	0.5	0.5
Cr	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cu	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	0.5
Fe	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mn	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5
P	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.1	0.5	0.5	0.5	0.5
Pb	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	0.5
Se	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	0.5
Zn	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.01	0.5	0.5	0.5	0.5
Sr	mg/l	0.5		0.5	0.5	0.5	0.5	0.5		0.5	0.5	2.05	0.5	0.5	0.5	0.5

WASR-2

Tested	Unit	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09
pH		7.5	8.1	7.7	8.1	7.5	7.8	7.1	8.3	8.1	8.3	7.8	7.3	7.6	7.8	7
EC	mS/m	195	266	274	243	245	355	286	241	325	325	250	312	324	338	272
Turb	NTU		2			223			2			4			3	
SS	mg/l		4			21			18			12			64	
TDS	mg/l	181	2148	2363	2339	2223	3335	2703	2390	2913	2917	2345	2516	2309	2389	2527
Ca	mg/l	164	232	230	238	251	346	321	265	329	296	271	234	249	288	234
Mg	mg/l	27	236	219	201	195	327	243	274	307	299	231	215	217	225	233
Na	mg/l	7	43	45	41	41	56	48	40	60	73	54	57	52	49	56
K	mg/l	34	8	8	6	10	8	5	0.5	7	10	10	7	7	6	7
Tot-Alk	mg/l CaCO3		86	90	54	70	74	66	74	68	106	98	74	96	104	120
Cl	mg/l	26	41	47	45	47	57	50	35	64	61	51	44	48	51	33
SO4	mg/l	1134	1276	1425	1377	1489	2042	1586	1539	2037	1989	1399	1478	1419	1405	1511
NO3	mg/l	2	1	3	4	1	5	3	1	1	1	1	1	2	2	2
F	mg/l	0.5	0.61	0.5	0.5	0.28	0.5	0.5	0.48	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.03	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.09	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.2	0.5	0.5	0.1	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	1.8	0.5	0.5	1.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5

WASR-2

Tested	Unit	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10
pH		7.2	7.8	7.4	6.9	7.5		7.4	8.2	8.3	7.4	7.5	7.7	7.7	7.3	7.4
EC	mS/m	276	292	279	314	272		233	246	293	242	227	249	257	243	192
Turb	NTU		1						1			9			5	
SS	mg/l		79						6			14			393	
TDS	mg/l	2587	2845	2757	2877	2632		2051	2307	2074	2070	1982	2052	2135	2185	1397
Ca	mg/l	327	154	306	306	272		247	246	224	236	182	242	229	226	178
Mg	mg/l	267	247	295	260	248		200	210	197	184	143	195	178	242	153
Na	mg/l	92	63	64	62	52		49	49	48	45	109	55	50	49	32
K	mg/l	11	10	11	2	5		8	7	8	5	4	6	7	8	8
Tot-Alk	mg/l CaCO3	98	110	144	138	132		158	158	122	144	138	130	134	122	182
Cl	mg/l	47	57	61	50	38		40	37	41	45	44	45	50	50	26
SO4	mg/l	1558	1167	1904	1714	1745		1390	1435	1213	1180	1138	1220	1292	1343	974
NO3	mg/l	4	2	5	3	3		6	4	4	4	1	1	5	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.73	0.5	0.5	0.5		0.5	0.24	0.5	0.5	0.35	0.5	0.5	0.21	0.5
As	mg/l	0.5	0.028	0.5	0.5	0.5		0.5	0.02	0.5	0.5	0.023	0.5	0.5	0.006	0.5
B	mg/l	0.5	0.09	0.5	0.5	0.5		0.5	0.2	0.5	0.5	0.21	0.5	0.5	0.03	0.5
Cd	mg/l	0.5	0.01	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01	0.5
Cr	mg/l	0.5	0.02	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.05	0.5
Cu	mg/l	0.5	0.012	0.5	0.5	0.5		0.5	0.009	0.5	0.5	0.012	0.5	0.5	0.012	0.5
Fe	mg/l	0.5	0.04	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.04	0.5	0.5	0.06	0.5
Mn	mg/l	0.5	0.09	0.5	0.5	1.48		0.5	1.08	0.5	0.5	0.19	0.5	0.5	0.5	0.5
P	mg/l	0.5	1.658	0.5	0.5	0.5		0.5	0.865	0.5	0.5	1.134	0.5	0.5	0.031	0.5
Pb	mg/l	0.5	0.019	0.5	0.5	0.5		0.5	0.003	0.5	0.5	0.018	0.5	0.5	0.037	0.5
Se	mg/l	0.5	0.003	0.5	0.5	0.5		0.5	0.004	0.5	0.5	0.005	0.5	0.5	0.037	0.5
Zn	mg/l	0.5	0.007	0.5	0.5	0.5		0.5	0.61	0.5	0.5	0.647	0.5	0.5	0.094	0.5
Sr	mg/l	0.5	2.315	0.5	0.5	0.5		0.5	1.941	0.5	0.5	0.888	0.5	0.5	1.937	0.5

WASR-2

Tested	Unit	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12
pH		7.2	8.1			7.4	7.6	8	7.9	6.9	6.3	8	6.9	6.6		7.1
EC	mS/m	227	298			155	152	188	293	348	522	547	582	564		659
Turb	NTU		52			4			5			64				
SS	mg/l		176			27			49			1023				
TDS	mg/l	1789	2311			1364	1320	1867	2554	3143	4245	5233	5498	5201		6458
Ca	mg/l	206	316			149	131	188	267	274	364	392	430	365		543
Mg	mg/l	227	261			144	148	183	205	264	458	616	733	601		838
Na	mg/l	46	64			20	22	27	29	19	45	44	63	48		93
K	mg/l	11	2			4	6	7	7	10	18	10	9	5		4
Tot-Alk	mg/l CaCO3	140	236			96	102	152	190	82	270	376	426	298		354
Cl	mg/l	50	50			11	14	26	21	16	27	14	10	4		1
SO4	mg/l	1304	1617			877	966	1115	1582	1971	2880	3207	3619	3620		4638
NO3	mg/l	1	2			1	1	0.5		4	6	7	5	5		8
F	mg/l	0.5	0.5													
Al	mg/l	0.5	1.05									0.05	0.05			
As	mg/l	0.5	0.019									0.05	0.05			
B	mg/l	0.5	0.11									0.05	0.05			
Cd	mg/l	0.5	0.01									0.05	0.05			
Cr	mg/l	0.5	0.02									0.05	0.05			
Cu	mg/l	0.5	0.012									0.05	0.05			
Fe	mg/l	0.5	0.06									0.05	0.3			
Mn	mg/l	0.5	0.5									14.2	13.3			
P	mg/l	0.5	0.007									0.05	0.05			
Pb	mg/l	0.5	0.027									0.05	0.05			
Se	mg/l	0.5	0.016									0.05	0.05			
Zn	mg/l	0.5	0.138									0.05	0.05			
Sr	mg/l	0.5	1.928									2.8	4			

WASR-2

Tested	Unit	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		6.6	7.7	7.6			6.9
EC	mS/m	795	643	617			479
Turb	NTU		65				119
SS	mg/l		56				39
TDS	mg/l	8672	5386	6001			4453
Ca	mg/l	537	504	504			491
Mg	mg/l	874	781	739			405
Na	mg/l	93	50	58			265
K	mg/l	12	5	4			5
Tot-Alk	mg/l CaCO3	202	290	316			200
Cl	mg/l	9	4	10			1
SO4	mg/l	3946	3834	4073			3660
NO3	mg/l	8	5	6			6
F	mg/l						
Al	mg/l		0.05	0.05			0.05
As	mg/l		0.2				0.05
B	mg/l		0.05	0.05			0.05
Cd	mg/l		0.05	0.05			0.05
Cr	mg/l		0.05	0.05			0.3
Cu	mg/l		0.05	0.05			0.05
Fe	mg/l		0.05	0.05			0.05
Mn	mg/l		24.9	22.3			19
P	mg/l		0.3	0.2			0.05
Pb	mg/l		0.1	0.05			0.05
Se	mg/l		0.3	0.1			0.05
Zn	mg/l		0.06	0.05			0.05
Sr	mg/l		4.7	4.4			0.05

WASR-3

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH		7.1	6.8	7.1	6.9	7.2	7.3	7.1		7.9	7.6	7	7.6	6.9
EC	mS/m	161.5	325.632	325	352	453	404	395		509	511	296	437	596
Turb	NTU													
SS	mg/l						16			32			12	
TDS	mg/l	1420	3200	3153	3447	4212	3910	3871		4811	4947	2899	4152	4586
Ca	mg/l	207	430	403	364	375	432	420		508	546	346	444	475
Mg	mg/l	86	317	281	276	391	399	306		395	316	239	327	382
Na	mg/l	28	23	54	52	43	77	58		107	120	58	106	92
K	mg/l	0.5	10	11	12	11	12	10		9	5	6	0.5	6
Tot-Alk	mg/l CaCO3	8	14	38	24	26	24	30		32	60	18	32	44
Cl	mg/l	25.52	56.72	62	65	68	75	78		86	92	54	74	101
SO4	mg/l	919	2330.479	2012	2132	2483	2445	2377		2718	2882	1822	2444	2861
NO3	mg/l	1	3.795	5	3	7	3	8		5	5	3	3	5
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.2	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.3	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.1	0.5
Mn	mg/l	2.2	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.1	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5

WASR-3

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08
pH		7.5	7.8	6.6		7.3	7.4	7.7	7.3		6.4	6.4	6.6	6.8	7.4	7.3
EC	mS/m	384	465	280		286	74	91	101		313	230	232	145	205	158
Turb	NTU														17	
SS	mg/l														146	
TDS	mg/l	3790	4608	2770		2448	555	665	838		3168	2213	1868	1311	2073	1535
Ca	mg/l	375	414	294		341	84	93	99		329	279	206	157	214	132
Mg	mg/l	380	368	262		184	49	53	56		296	230	97	120	186	130
Na	mg/l	87	111	59		52	20	22	19		58	51	46	24	50	26
K	mg/l	6	13	13		36	5	5	5		5	5	7	5	6	7
Tot-Alk	mg/l CaCO3	12	74	16		36	26	64	22		10	20	28	22	34	30
Cl	mg/l	84	139	71		86	84	14	18		55			28	40	27
SO4	mg/l	2720	2702	1711		1559	342	484	542		1797	1380	1114	789	1210	772
NO3	mg/l	8	6	1		6	1	1	1		3	2	1	1	3	1
F	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.32	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.03	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.08	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.003	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.1	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.01	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.03	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5		0.5	2.08	0.5	0.5	0.5	0.5

WASR-3

Tested	Unit	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09
pH		7.3	8.1	7.8	8	7.6	8.2	7.1	8	8.1	8.2	8.2	7.6	7.7	7.9	8
EC	mS/m	196	266	273	240	263	617	287	241	331	175	227	269	307	314	268
Turb	NTU		2			223			1						1	
SS	mg/l		4			21			20			3			21	
TDS	mg/l	183	2123	2352	2255	2476	5401	2678	2422	3078	1398	2109	2180	2162	2122	2443
Ca	mg/l	162	257	234	245	267	489	372	275	332	157	223	191	236	269	222
Mg	mg/l	28	255	222	199	214	469	265	278	308	137	217	182	208	209	223
Na	mg/l	7	48	46	42	43	132	49	39	60	39	48	48	49	47	58
K	mg/l	36	9	8	6	11	23	6	0.5	7	8	9	8	8	7	10
Tot-Alk	mg/l CaCO3		84	46	54	70	296	70	72	66	52	78	80	102	106	118
Cl	mg/l	27	47	45	45	45	58	48	35	62	35	43	38	43	44	47
SO4	mg/l	1232	1387	1412	1367	1560	3152	1541	1536	2041	982	1247	1210	1334	1297	1406
NO3	mg/l	3	1	4	1	2	6	3	1	1	1	1	1	3	2	2
F	mg/l	0.5	0.65	0.5	0.5	0.24	0.5	0.5	0.49	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.03	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.09	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.2	0.5	0.5	0.1	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	1.9	0.5	0.5	1.9	0.5	0.5	0.5	0.5	0.5	0.5	0.5

WASR-3

Tested	Unit	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10
pH		7.8	8.2	7.3	7.5	7.9		7.7		7.4	7.8	7.8	7.7	7.6	7.5	7.3
EC	mS/m	264	272	227	291	218		94		319	200	201	231	233	224	251
Turb	NTU		1									1			3	
SS	mg/l		102									7			5	
TDS	mg/l	2419	2667	271	2619	2119		825		2292	1640	1921	1881	1921	2016	1839
Ca	mg/l	257	146	217	262	198		172		260	181	149	215	218	232	207
Mg	mg/l	235	213	54	245	199		140		206	151	128	188	160	225	227
Na	mg/l	59	60	7	56	40		36		52	38	104	50	44	48	49
K	mg/l	9	10	144	5	6		5		7	8	6	8	7	8	7
Tot-Alk	mg/l CaCO3	104	118		112	88		138		160	106	84	120	144	154	166
Cl	mg/l	58	52	1362	47	31		28		44	35	38	45	43	41	52
SO4	mg/l	1392	1094	3	1582	1355		975		1325	955	1098	1158	1167	1162	1368
NO3	mg/l	4	2	0.5	3	3		2		6	2	1	1	1	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.73	0.5	0.5	0.5		0.5		0.5	0.5	0.35	0.5	0.5	0.23	0.5
As	mg/l	0.5	0.025	0.5	0.5	0.5		0.5		0.5	0.5	0.012	0.5	0.5	0.005	0.5
B	mg/l	0.5	0.09	0.5	0.5	0.5		0.5		0.5	0.5	0.2	0.5	0.5	0.04	0.5
Cd	mg/l	0.5	0.01	0.5	0.5	0.5		0.5		0.5	0.5	0.01	0.5	0.5	0.01	0.5
Cr	mg/l	0.5	0.02	0.5	0.5	0.5		0.5		0.5	0.5	0.01	0.5	0.5	0.05	0.5
Cu	mg/l	0.5	0.012	0.5	0.5	0.5		0.5		0.5	0.5	0.012	0.5	0.5	0.011	0.5
Fe	mg/l	0.5	0.03	0.5	0.5	0.5		0.5		0.5	0.5	0.05	0.5	0.5	0.07	0.5
Mn	mg/l	0.5	0.5	0.5	0.5	0.5		0.5		0.5	0.5	0.5	0.5	0.5	0.34	0.5
P	mg/l	0.5	1.654	0.5	0.5	0.5		0.5		0.5	0.5	1.133	0.5	0.5	0.03	0.5
Pb	mg/l	0.5	0.018	0.5	0.5	0.5		0.5		0.5	0.5	0.02	0.5	0.5	0.037	0.5
Se	mg/l	0.5	0.003	0.5	0.5	0.5		0.5		0.5	0.5	0.004	0.5	0.5	0.016	0.5
Zn	mg/l	0.5	0.006	0.5	0.5	0.5		0.5		0.5	0.5	0.646	0.5	0.5	0.106	0.5
Sr	mg/l	0.5	2.127	0.5	0.5	0.5		0.5		0.5	0.5	0.811	0.5	0.5	1.858	0.5

WASR-3

Tested	Unit	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12
pH		7.3	7.7	7.5	7.4	7.3	6.9	7.8	8	7.3	6.9	8.1	7.5	7		
EC	mS/m	162	289	186	209	218	195	188	243	258	282	235	290	280		
Turb	NTU		14						102			17				
SS	mg/l		51						490			70				
TDS	mg/l	1341	2125	1844	1715	2030	1657	1759	1956	1955	2001	2113	2442	2464		
Ca	mg/l	166	309	215	198	224	191	209	242	231	232	252	281	245		
Mg	mg/l	134	254	171	159	185	168	162	154	166	173	177	215	197		
Na	mg/l	31	54	40	40	45	38	41	43	44	46	49	60	47		
K	mg/l	8	3	8	4	9	7	6	6	5	8	9	16	11		
Tot-Alk	mg/l CaCO3	144	84	54	110	84	56	66	100	104	102	128	152	132		
Cl	mg/l	16	28	35	31	44	30	34	38	37	37	48	50	43		
SO4	mg/l	784	1742	1075	1031	1320	1293	1204	1239	1227	1133	1262	1446	1472		
NO3	mg/l	1	2	1	1	1	1	1		2	2	3	1	1		
F	mg/l	0.5	0.5													
Al	mg/l	0.5	1.08									0.05	0.05			
As	mg/l	0.5	0.016									0.05	0.05			
B	mg/l	0.5	0.15									0.05	0.05			
Cd	mg/l	0.5	0.01									0.05	0.05			
Cr	mg/l	0.5	0.02									0.05	0.05			
Cu	mg/l	0.5	0.012									0.05	0.05			
Fe	mg/l	0.5	0.07									0.05	0.05			
Mn	mg/l	0.5	0.01									0.05	1			
P	mg/l	0.5	0.001									0.05	0.05			
Pb	mg/l	0.5	0.019									0.05	0.05			
Se	mg/l	0.5	0.011									0.05	0.05			
Zn	mg/l	0.5	0.131									0.05	0.05			
Sr	mg/l	0.5	1.853									1.9	2.2			

WASR-3

Tested	Unit	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH							
EC	mS/m						
Turb	NTU						
SS	mg/l						
TDS	mg/l						
Ca	mg/l						
Mg	mg/l						
Na	mg/l						
K	mg/l						
Tot-Alk	mg/l CaCO3						
Cl	mg/l						
SO4	mg/l						
NO3	mg/l						
F	mg/l						
Al	mg/l						
As	mg/l						
B	mg/l						
Cd	mg/l						
Cr	mg/l						
Cu	mg/l						
Fe	mg/l						
Mn	mg/l						
P	mg/l						
Pb	mg/l						
Se	mg/l						
Zn	mg/l						
Sr	mg/l						

WASR-4

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH														
EC	mS/m													
Turb	NTU													
SS	mg/l													
TDS	mg/l													
Ca	mg/l													
Mg	mg/l													
Na	mg/l													
K	mg/l													
Tot-Alk	mg/l CaCO3													
Cl	mg/l													
SO4	mg/l													
NO3	mg/l													
F	mg/l													
Al	mg/l													
As	mg/l													
B	mg/l													
Cd	mg/l													
Cr	mg/l													
Cu	mg/l													
Fe	mg/l													
Mn	mg/l													
P	mg/l													
Pb	mg/l													
Se	mg/l													
Zn	mg/l													
Sr	mg/l													

WASR-4

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08
pH								6.6			6.4	6.3	6.5	6.2	6.3	
EC	mS/m							58			314	383	406	325	376	
Turb	NTU														162	
SS	mg/l														812	
TDS	mg/l							356			3242	4009	3898	3242	4182	
Ca	mg/l							40			329	630	496	489	640	
Mg	mg/l							29			282	385	266	215	284	
Na	mg/l							30			61	123	128	92	136	
K	mg/l							17			0.5	31	35	14	29	
Tot-Alk	mg/l CaCO3							134			16	42	42	14	18	
Cl	mg/l							6			43	86	47	52	54	
SO4	mg/l							133			1947	2435	2712	2049	2571	
NO3	mg/l							1			2	4	10	6	4	
F	mg/l							0.5			0.5	0.2	0.5	0.5	0.5	
Al	mg/l							0.5			0.5	0.03	0.5	0.5	0.5	
As	mg/l							0.5			0.5	0.01	0.5	0.5	0.5	
B	mg/l							0.5			0.5	1.77	0.5	0.5	0.5	
Cd	mg/l							0.5			0.5	0.003	0.5	0.5	0.5	
Cr	mg/l							0.5			0.5	0.01	0.5	0.5	0.5	
Cu	mg/l							0.5			0.5	0.01	0.5	0.5	0.5	
Fe	mg/l							0.5			0.5	0.5	0.5	0.5	0.5	
Mn	mg/l							0.5			0.5	0.5	0.5	0.5	0.5	
P	mg/l							0.5			0.5	0.1	0.5	0.5	0.5	
Pb	mg/l							0.5			0.5	0.01	0.5	0.5	0.5	
Se	mg/l							0.5			0.5	0.01	0.5	0.5	0.5	
Zn	mg/l							0.5			0.5	0.05	0.5	0.5	0.5	
Sr	mg/l							0.5			0.5	5.78	0.5	0.5	0.5	

WASR-4

Tested	Unit	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09
pH																
EC	mS/m															
Turb	NTU															
SS	mg/l															
TDS	mg/l															
Ca	mg/l															
Mg	mg/l															
Na	mg/l															
K	mg/l															
Tot-Alk	mg/l CaCO3															
Cl	mg/l															
SO4	mg/l															
NO3	mg/l															
F	mg/l															
Al	mg/l															
As	mg/l															
B	mg/l															
Cd	mg/l															
Cr	mg/l															
Cu	mg/l															
Fe	mg/l															
Mn	mg/l															
P	mg/l															
Pb	mg/l															
Se	mg/l															
Zn	mg/l															
Sr	mg/l															

WASR-4

Tested	Unit	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10
pH																
EC	mS/m															
Turb	NTU															
SS	mg/l															
TDS	mg/l															
Ca	mg/l															
Mg	mg/l															
Na	mg/l															
K	mg/l															
Tot-Alk	mg/l CaCO3															
Cl	mg/l															
SO4	mg/l															
NO3	mg/l															
F	mg/l															
Al	mg/l															
As	mg/l															
B	mg/l															
Cd	mg/l															
Cr	mg/l															
Cu	mg/l															
Fe	mg/l															
Mn	mg/l															
P	mg/l															
Pb	mg/l															
Se	mg/l															
Zn	mg/l															
Sr	mg/l															

WASR-4

Tested	Unit	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12
pH				6.9	6.6		6.5	6.9	7.7	7	6.4	7.5	7	6.9	7.2	6.5
EC	mS/m			132	254		203	265	249	311	391	391	499	365	459	470
Turb	NTU								1			6			8	
SS	mg/l								16			13			25	
TDS	mg/l			1254	2244		1782	2448	2055	2491	2947	2991	4389	3508	4452	4323
Ca	mg/l			141	248		180	237	231	257	295	368	436	492	506	574
Mg	mg/l			113	208		187	209	169	207	283	368	474	317	446	430
Na	mg/l			31	46		38	47	46	53	69	91	102	61	100	96
K	mg/l			5	2		8	7	8	9	13	16	24	13	9	10
Tot-Alk	mg/l CaCO3			16	26		58	62	62	64	88	134	96	68	94	16
Cl	mg/l			20	24		30	43	44	43	44	62	62	28	38	30
SO4	mg/l			733	1404		1362	1518	1281	1521	1911	2372	2998	2277	3104	3219
NO3	mg/l			1	1		1	1		3	1	4	6	4	6	4
F	mg/l															
Al	mg/l											0.05	0.05		0.05	
As	mg/l											0.05	0.05		0.05	
B	mg/l											0.2	2.2		2	
Cd	mg/l											0.05	0.05		0.05	
Cr	mg/l											0.05	0.05		0.05	
Cu	mg/l											0.05	0.05		0.05	
Fe	mg/l											0.05	0.05		0.05	
Mn	mg/l											1.8	1.4		0.5	
P	mg/l											0.05	0.05		0.05	
Pb	mg/l											0.05	0.05		0.05	
Se	mg/l											0.05	0.05		0.05	
Zn	mg/l											0.05	0.05		0.05	
Sr	mg/l											3.2	4		4.1	

WASR-4

Tested	Unit	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		6.2	7.5	6.5	7		7.3
EC	mS/m	357	384	418	455		528
Turb	NTU		6		>1000		25
SS	mg/l		24		5159		67
TDS	mg/l	3419	3173	3928	4461		5122
Ca	mg/l	467	502	553	609		648
Mg	mg/l	288	315	366	404		488
Na	mg/l	50	58	72	83		109
K	mg/l	12	12	14	15		23
Tot-Alk	mg/l CaCO3	16	20	16	44		130
Cl	mg/l	37	47	52	60		69
SO4	mg/l	2375	2670	2940	3233		3800
NO3	mg/l	3	2	7	14		6
F	mg/l						
Al	mg/l		0.05	0.05	0.05		0.05
As	mg/l		0.1	0.05	0.05		0.05
B	mg/l		0.1	1.2	1.3		0.05
Cd	mg/l		0.05	0.05	0.05		0.05
Cr	mg/l		0.05	0.05	0.05		0.05
Cu	mg/l		0.05	0.05	0.05		0.05
Fe	mg/l		0.05	2	0.05		0.05
Mn	mg/l		2.3	4.2	8.4		12.5
P	mg/l		0.1	0.1	0.05		0.05
Pb	mg/l		0.05	0.05	0.05		0.05
Se	mg/l		0.2	0.1	0.05		0.05
Zn	mg/l		0.05	0.05	0.05		0.05
Sr	mg/l		3.9	3.9	4.4		0.05

WASR-5

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH														
EC	mS/m													
Turb	NTU													
SS	mg/l													
TDS	mg/l													
Ca	mg/l													
Mg	mg/l													
Na	mg/l													
K	mg/l													
Tot-Alk	mg/l CaCO3													
Cl	mg/l													
SO4	mg/l													
NO3	mg/l													
F	mg/l													
Al	mg/l													
As	mg/l													
B	mg/l													
Cd	mg/l													
Cr	mg/l													
Cu	mg/l													
Fe	mg/l													
Mn	mg/l													
P	mg/l													
Pb	mg/l													
Se	mg/l													
Zn	mg/l													
Sr	mg/l													

WASR-5

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	Apr-08
pH											7.6	7.8	6.7	6.8	7	
EC	mS/m										377	212	518	363	497	
Turb	NTU														29	
SS	mg/l														34	
TDS	mg/l										4106	2097	4889	3488	6443	
Ca	mg/l										756	277	0.5	309	451	
Mg	mg/l										324	224	944	395	692	
Na	mg/l										45	38	41	29	39	
K	mg/l										0.5	6	13	7	13	
Tot-Alk	mg/l CaCO3										232	144	12	70	70	
Cl	mg/l										21	16	17	17	10	
SO4	mg/l										2280	1166	3454	2484	3879	
NO3	mg/l										4	3	9	8	9	
F	mg/l										0.5	0.48	0.5	0.5	0.5	
Al	mg/l										0.5	0.04	0.5	0.5	0.5	
As	mg/l										0.5	0.01	0.5	0.5	0.5	
B	mg/l										0.5	0.14	0.5	0.5	0.5	
Cd	mg/l										0.5	0.003	0.5	0.5	0.5	
Cr	mg/l										0.5	0.01	0.5	0.5	0.5	
Cu	mg/l										0.5	0.01	0.5	0.5	0.5	
Fe	mg/l										0.5	0.5	0.5	0.5	0.5	
Mn	mg/l										0.5	0.5	0.5	0.5	0.5	
P	mg/l										0.5	0.1	0.5	0.5	0.5	
Pb	mg/l										0.5	0.01	0.5	0.5	0.5	
Se	mg/l										0.5	0.01	0.5	0.5	0.5	
Zn	mg/l										0.5	0.01	0.5	0.5	0.5	
Sr	mg/l										0.5	1.92	0.5	0.5	0.5	

WASR-5

Tested	Unit	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09
pH																
EC	mS/m															
Turb	NTU															
SS	mg/l															
TDS	mg/l															
Ca	mg/l															
Mg	mg/l															
Na	mg/l															
K	mg/l															
Tot-Alk	mg/l CaCO3															
Cl	mg/l															
SO4	mg/l															
NO3	mg/l															
F	mg/l															
Al	mg/l															
As	mg/l															
B	mg/l															
Cd	mg/l															
Cr	mg/l															
Cu	mg/l															
Fe	mg/l															
Mn	mg/l															
P	mg/l															
Pb	mg/l															
Se	mg/l															
Zn	mg/l															
Sr	mg/l															

WASR-5

Tested	Unit	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10
pH																
EC	mS/m															
Turb	NTU															
SS	mg/l															
TDS	mg/l															
Ca	mg/l															
Mg	mg/l															
Na	mg/l															
K	mg/l															
Tot-Alk	mg/l CaCO3															
Cl	mg/l															
SO4	mg/l															
NO3	mg/l															
F	mg/l															
Al	mg/l															
As	mg/l															
B	mg/l															
Cd	mg/l															
Cr	mg/l															
Cu	mg/l															
Fe	mg/l															
Mn	mg/l															
P	mg/l															
Pb	mg/l															
Se	mg/l															
Zn	mg/l															
Sr	mg/l															

WASR-5

Tested	Unit	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12
pH				6.5	6.5		6.7	6.4	6.6	6.1	5.8			6.9		
EC	mS/m			132	261		156	247	293	373	378			345		
Turb	NTU								305							
SS	mg/l								2669							
TDS	mg/l			1273	2326		1321	2032	2713	3263	3066			3192		
Ca	mg/l			144	249		144	222	318	37	314			410		
Mg	mg/l			114	211		134	191	203	244	278			255		
Na	mg/l			30	46		23	25	30	41	38			45		
K	mg/l			4	2		6	8	9	11	12			32		
Tot-Alk	mg/l CaCO3			16	22		20	30	14	24	44			92		
Cl	mg/l			23	30		17	24	24	21	23			7		
SO4	mg/l			741	1413		1073	1343	1772	1994	1855			2163		
NO3	mg/l			1	1		0.5	0.5		4	4			4		
F	mg/l															
Al	mg/l															
As	mg/l															
B	mg/l															
Cd	mg/l															
Cr	mg/l															
Cu	mg/l															
Fe	mg/l															
Mn	mg/l															
P	mg/l															
Pb	mg/l															
Se	mg/l															
Zn	mg/l															
Sr	mg/l															

WASR-5

Tested	Unit	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH							
EC	mS/m						
Turb	NTU						
SS	mg/l						
TDS	mg/l						
Ca	mg/l						
Mg	mg/l						
Na	mg/l						
K	mg/l						
Tot-Alk	mg/l CaCO3						
Cl	mg/l						
SO4	mg/l						
NO3	mg/l						
F	mg/l						
Al	mg/l						
As	mg/l						
B	mg/l						
Cd	mg/l						
Cr	mg/l						
Cu	mg/l						
Fe	mg/l						
Mn	mg/l						
P	mg/l						
Pb	mg/l						
Se	mg/l						
Zn	mg/l						
Sr	mg/l						

APPENDIX B1b

MONITORING DATA: BOSCHMANS COLLIERY

BOSR-1

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH		6.1	7.4	6.9									7.3	
EC	mS/m	56.26	59.21	65									50	
Turb	NTU													
SS	mg/l												6	
TDS	mg/l	371	436	528									322	
Ca	mg/l	58	60	81									31	
Mg	mg/l	19	30	20									18	
Na	mg/l	15	29	16									18	
K	mg/l	6	0.5	11									6	
Tot-Alk	mg/l CaCO3	34	122	86									66	
Cl	mg/l	8.51		23									6	
SO4	mg/l	216	188	212									107	
NO3	mg/l	1	1.265	1									1	
F	mg/l	0.5	0.5	0.5									0.5	
Al	mg/l	0.5	0.5	0.5									0.1	
As	mg/l	0.5	0.5	0.5									0.5	
B	mg/l	0.5	0.5	0.5									0.5	
Cd	mg/l	0.5	0.5	0.5									0.5	
Cr	mg/l	0.5	0.5	0.5									0.5	
Cu	mg/l	0.5	0.5	0.5									0.5	
Fe	mg/l	0.4	0.5	0.5									0.1	
Mn	mg/l	0.1	0.5	0.5									0.1	
P	mg/l	0.5	0.5	0.5									0.5	
Pb	mg/l	0.5	0.5	0.5									0.5	
Se	mg/l	0.5	0.5	0.5									0.5	
Zn	mg/l	0.5	0.5	0.5									0.5	
Sr	mg/l	0.5	0.5	0.5									0.5	
													0.5	

BOSR-1

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08
pH		8.5		7.4		6.6	7.5	7.6			6.7	5.7		
EC	mS/m	98		54		19	24	33			65	40		
Turb	NTU													
SS	mg/l													
TDS	mg/l	585		416		126	152	204			514	326		
Ca	mg/l	46		49		16	32	43			91	51		
Mg	mg/l	28		19		5	10	9			15	16		
Na	mg/l	38		16		5	6	16			20	12		
K	mg/l	12		14		5	6	7			0.5	7		
Tot-Alk	mg/l CaCO3	132		36		38	72	104			54	8		
Cl	mg/l	86		20		1	3	1			9	4		
SO4	mg/l	102		188		27	38	54			260	176		
NO3	mg/l	1		1		1	1	1			1	1		
F	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Al	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
As	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
B	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Cd	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Cr	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Cu	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Fe	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Mn	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
P	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Pb	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Se	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Zn	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		
Sr	mg/l	0.5		0.5		0.5	0.5	0.5			0.5	0.5		

BOSR-1

Tested	Unit	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09
pH		7.3	7	7.9	8.3	7.5	8.2	8	8.1	7.4	8.4	8.4	8.4	8.2
EC	mS/m	141	74	69	158	146	136	143	182	85	121	125	75	109
Turb	NTU	3			2			1						1
SS	mg/l	8			4			5			4			1
TDS	mg/l	1256	660	82	1090	981	948	1073	1105	611	1026	952	599	646
Ca	mg/l	228	89	24	132	99	90	129	139	89	115	95	74	74
Mg	mg/l	69	26	17	82	68	65	77	64	30	61	62	45	50
Na	mg/l	44	20	11	84	86	69	93	67	27	49	73	37	41
K	mg/l	12	10	98	16	14	12	14	13	10	10	11	8	6
Tot-Alk	mg/l CaCO3	102	94		138	118	68	100	134	80	58	190	72	88
Cl	mg/l	23	17	17	104	95	89	75	98	38	68	101	44	51
SO4	mg/l	644	318	212	568	496	1318	528	494	276	464	333	298	326
NO3	mg/l	1	1	1	1	3	3	1	1	1	1	1	1	1
F	mg/l	0.5	0.5	0.5	0.33	0.5	0.5	0.36	0.5	0.5	0.42	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5	0.02	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.1
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.5	0.5	0.3	0.5	0.5	0.1
Mn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.1
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5	0.5	0.9	0.5	0.5	0.5

BOSR-1

Tested	Unit	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10
pH		7.4	7.4	8.1	7.6	7.7	7.5	7.2	7.8	3.7	7.4	8.2	8.6	7.9
EC	mS/m	188	170	166	134	142	149	165	329	140	126	139	135	110
Turb	NTU			2			2						2	
SS	mg/l			28			10						15	
TDS	mg/l	1118	1018	960	934	1029	1139	1375	2778	1053	929	1215	1254	1021
Ca	mg/l	113	103	115	85	104	61	127	213	123	115	116	119	116
Mg	mg/l	77	70	71	66	77	79	98	165	88	86	87	89	75
Na	mg/l	94	80	72	76	84	97	112	289	79	72	88	94	70
K	mg/l	10	12	9	10	12	15	23	14	7	5	7	8	9
Tot-Alk	mg/l CaCO3	144	98	86	68	58	102	132	138	90	118	232	192	112
Cl	mg/l	109	95	84	28	47	115	174	129	89	79	119	122	81
SO4	mg/l	519	597	485	495	533	519	610	1469	645	625	468	489	488
NO3	mg/l	1	2	2	1	2	1	3	2	2	2	1	1	2
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5	0.5	0.5	0.73	0.5	0.5	0.5	0.5	0.5	0.24	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.025	0.5	0.5	0.5	0.5	0.5	0.018	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5	0.5	0.07	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.01	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5	0.5	0.01	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.007	0.5	0.5	0.5	0.5	0.5	0.005	0.5
Fe	mg/l	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.2	0.5	0.5	0.01	0.5
Mn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.68	0.5	0.5	0.05	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	1.647	0.5	0.5	0.5	0.5	0.5	0.88	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.016	0.5	0.5	0.5	0.5	0.5	0.003	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.008	0.5	0.5	0.5	0.5	0.5	0.014	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.005	0.5	0.5	0.5	0.5	0.5	0.61	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	1.086	0.5	0.5	0.5	0.5	0.5	1.009	0.5

BOSR-1

Tested	Unit	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		7.7	7.9	7.6	8	7.9	4.5	7.4	7.6	7.3	7.5	7.1	7.2	7.9
EC	mS/m	141	140	111	135	129	295	37	40	122	102	60	51	113
Turb	NTU		3			26		670						4
SS	mg/l		10			3		237						15
TDS	mg/l	992	962	916	891	942	2297	245	311	836	812	398	336	831
Ca	mg/l	103	77	111	92	96	283	33	53	85	76	70	58	92
Mg	mg/l	71	54	69	71	88	221	12	11	63	54	18	16	65
Na	mg/l	64	58	85	68	74	121	11	13	60	51	15	15	65
K	mg/l	7	5	7	7	9	29	6	7	7	11	5	5	7
Tot-Alk	mg/l CaCO3	96	72	72	64	78		20	80	156	68	76	62	60
Cl	mg/l	78	41	109	78	85	160	13	16	78	69	13	17	77
SO4	mg/l	462	487	614	464	598	1515	128	111	307	378	234	160	448
NO3	mg/l	1	1	1	1	1	1	1	1	1	1	0.5	0.5	
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.35	0.5	0.5	0.1	0.5	2.41						
As	mg/l	0.5	0.007	0.5	0.5	0.006	0.5	0.016						
B	mg/l	0.5	0.23	0.5	0.5	0.09	0.5	0.01						
Cd	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.01						
Cr	mg/l	0.5	0.01	0.5	0.5	0.05	0.5	0.5						
Cu	mg/l	0.5	0.01	0.5	0.5	0.013	0.5	0.009						
Fe	mg/l	0.5	0.02	0.5	0.5	0.02	0.5	1.36						
Mn	mg/l	0.5	0.11	0.5	0.5	0.04	0.5	0.01						
P	mg/l	0.5	1.123	0.5	0.5	0.038	0.5	0.004						
Pb	mg/l	0.5	0.016	0.5	0.5	0.032	0.5	0.017						
Se	mg/l	0.5	0.004	0.5	0.5	0.017	0.5	0.035						
Zn	mg/l	0.5	0.648	0.5	0.5	0.087	0.5	0.122						
Sr	mg/l	0.5	0.496	0.5	0.5	0.842	0.5	0.136						

BOSR-1

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		7.2	7.4	7.8	7.9	6.5	8.1	7.8	7.3	7.3				
EC	mS/m	77	334	91	131	127	101	99	73	32				
Turb	NTU			13			36			14				
SS	mg/l			22			6521			36				
TDS	mg/l	485	2175	834	1242	933	884	736	558	291				
Ca	mg/l	96	166	143	116	158	147	151	99	36				
Mg	mg/l	29	171	37	90	41	40	37	27	16				
Na	mg/l	20	153	39	99	37	39	34	24	12				
K	mg/l	6	26	9	12	12	8	10	10	9				
Tot-Alk	mg/l CaCO3	126	48	168	70	60	78	112	126	28				
Cl	mg/l	21	183	34	125	34	28	27	1	11				
SO4	mg/l	212	1145	432	765	557	414	392	278	176				
NO3	mg/l	1	3	0.5	1	0.5	1	2	0.5	1				
F	mg/l													
Al	mg/l			0.05	0.05		0.05			0.2				
As	mg/l			0.05	0.05		0.05			0.05				
B	mg/l			0.05	0.05		0.05			0.05				
Cd	mg/l			0.05	0.05		0.05			0.05				
Cr	mg/l			0.05	0.05		0.05			0.05				
Cu	mg/l			0.05	0.05		0.05			0.05				
Fe	mg/l			0.05	0.05		0.2			0.2				
Mn	mg/l			0.05	0.5		10.6			0.05				
P	mg/l			0.1	0.05		0.05			0.05				
Pb	mg/l			0.05	0.05		0.1			0.05				
Se	mg/l			0.05	0.05		0.05			0.05				
Zn	mg/l			0.05	0.05		0.05			0.05				
Sr	mg/l			1.5	1.1		1.2			0.05				

BOSR-2

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH		4	3.4		6.5	6.6	6.9	3.9		3.6	3.8	4.1	5.9	6.7
EC	mS/m	108.53	122.75		54	102	126	148		258	304	288	127	86
Turb	NTU													
SS	mg/l						35			12			5	
TDS	mg/l	533	1016		538	721	988	1146		2257	2652	2878	1030	429
Ca	mg/l	65	120		48	46	119	90		159	201	211	93	32
Mg	mg/l	48	87		29	49	73	71		118	151	169	63	25
Na	mg/l	16	60		58	60	116	155		241	332	299	113	48
K	mg/l	5	0.5		8	8	8	10		12	15	0.5	0.5	0.5
Tot-Alk	mg/l CaCO3				50	38	14						4	124
Cl	mg/l	31.2	41.12		50	58	86	112		184	214	177	50	0.5
SO4	mg/l	326	656		270	348	616	622		1225	1532	1496	507	145
NO3	mg/l	1	1.495		1	1	1	1		2	1	3	1	1
F	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.1	0.5
As	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.1	0.5
Mn	mg/l	2.3	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.1	0.5
P	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5		0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5

BOSR-2

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08
pH			7.9	7.2	7.8	5.7	5.5	5.8	6.8	7.5	6.8	6.4	7.2	6.7
EC	mS/m		104	117	132	368	277	304	87	1134	87	116	43	74
Turb	NTU													
SS	mg/l													
TDS	mg/l		762	799	879	2415	2154	2363	646		646	889	326	584
Ca	mg/l		55	65	64	219	159	176	76	477	76	85	53	98
Mg	mg/l		42	47	46	141	97	106	47	377	47	57	11	28
Na	mg/l		125	124	142	272	319	342	46	129	46	116	10	15
K	mg/l		6	8	11	5	21	23	5	108	5	0.5	0.5	5
Tot-Alk	mg/l CaCO3		174	222	242	4		4	26	158	26	36	26	68
Cl	mg/l		111	104	113	318	264	0.5	23	269	23	34	1	13
SO4	mg/l		248	209	235	1300	1145	274	378	4379	378	551	198	318
NO3	mg/l		1	1	1	2	1	1157	1	0.5	1	1	1	1
F	mg/l		0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	1.12	0.5	0.5
Al	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.04	0.5	0.5
As	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5
B	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.11	0.5	0.5
Cd	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.003	0.5	0.5
Cr	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5
Cu	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5
Fe	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Mn	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
P	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5
Pb	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5
Se	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5
Zn	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.04	0.5	0.5
Sr	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.88	0.5	0.5

BOSR-2

Tested	Unit	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09
pH		7.7	6.7	7.8	7.9	7.6	8.1	7.6	7.8	7.6	6.6	8.2	8.3	8.4
EC	mS/m	174	106	150	150	147	163	175	214	205	187	146	55	85
Turb	NTU	2			2			1			1			1
SS	mg/l	4			4			5			3			4
TDS	mg/l	1527	890	126	1093	1043	1292	1351	1358	1554	1693	1133	493	459
Ca	mg/l	179	81	81	106	108	122	132	138	156	173	101	54	57
Mg	mg/l	101	43	85	72	84	74	85	84	96	97	56	29	38
Na	mg/l	105	46	8	78	94	116	127	125	139	140	128	39	39
K	mg/l	5	9	110	9	7	7	8	7	7	0.5	2	9	5
Tot-Alk	mg/l CaCO3		94		168	164	92	112	104	122	2	76	80	122
Cl	mg/l	41	30	34	54	51	72	74	11	84	61	69	26	27
SO4	mg/l	851	402	757	616	557	597	810	733	810	912	592	209	198
NO3	mg/l	2	1	1	1	1	1	1	1	1	1	1	1	1
F	mg/l	0.5	0.5	0.5	1	0.5	0.5	1.05	0.5	0.5	0.52	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.1
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.15	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.5	0.5	0.3	0.5	0.5	0.1
Mn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.1
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	1.3	0.5	0.5	1.6	0.5	0.5	0.5

BOSR-2

Tested	Unit	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10
pH		7.5	8.1	8.1	7.3	7.3	7.3	7.3	6.5	7	7.2	7.9	7.9	8.1
EC	mS/m	67	95	115	128	141	140	160	261	67	43	26	46	43
Turb	NTU			2			1						5	
SS	mg/l			15			5						18	
TDS	mg/l	331	477	680	919	1014	1094	1376	2235	500	314	200	310	334
Ca	mg/l	35	51	70	82	100	58	133	214	53	33	37	37	40
Mg	mg/l	23	36	44	61	71	71	94	136	37	26	27	29	26
Na	mg/l	35	52	60	82	97	104	122	172	43	26	26	31	27
K	mg/l	7	8	7	10	11	12	12	4	3	1	5	5	7
Tot-Alk	mg/l CaCO3	104	150	140	96	80	104	58	24	78	116	154	220	86
Cl	mg/l	6	48	52	38	28	77	79	64	21	17	23	30	24
SO4	mg/l	102	106	268	451	580	514	880	1311	278	109	74	19	132
NO3	mg/l	1	1	1	1	2	1	2	4	1	1	1	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5	0.5	0.5	0.73	0.5	0.5	0.5	0.5	0.5	0.24	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.019	0.5	0.5	0.5	0.5	0.5	0.022	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.03	0.5	0.5	0.5	0.5	0.5	0.02	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.01	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5	0.5	0.01	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.009	0.5	0.5	0.5	0.5	0.5	0.009	0.5
Fe	mg/l	0.5	0.5	0.5	0.5	0.5	0.03	0.5	0.5	0.09	0.5	0.5	0.77	0.5
Mn	mg/l	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.07	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	1.671	0.5	0.5	0.5	0.5	0.5	0.881	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.017	0.5	0.5	0.5	0.5	0.5	0.004	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.007	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.009	0.5	0.5	0.5	0.5	0.5	0.608	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	1.163	0.5	0.5	0.5	0.5	0.5	0.343	0.5

BOSR-2

Tested	Unit	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11
pH		7.3	7.6	7.3	7.7	7.3	7.5	7.5	8	7.5	7.3	7.1	6.9	6.3
EC	mS/m	49	59	69	91	85	89	96	100	163	186	192	243	271
Turb	NTU		6			11			7			5		
SS	mg/l		23			10			16			18		
TDS	mg/l	288	359	567	575	576	609	740	725	1292	1431	1844	1850	2201
Ca	mg/l	30	29	56	63	60	55	66	68	155	158	207	216	227
Mg	mg/l	20	19	33	51	55	50	63	51	110	111	135	154	177
Na	mg/l	27	25	36	37	44	45	54	57	45	52	66	82	90
K	mg/l	7	5	8	8	10	8	10	9	10	11	13	15	13
Tot-Alk	mg/l CaCO3	84	78	62	64	120	110	108	166	40	34	36	28	16
Cl	mg/l	30	27	31	31	37	38	41	38	28	31	0	52	55
SO4	mg/l	92	120	289	324	239	326	348	298	805	841	1337	1237	1432
NO3	mg/l	1	1	1	1	1	1	1	1	1	1	0.5	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5					
Al	mg/l	0.5	0.31	0.5	0.5	0.1	0.5	0.5	1.07			0.05	0.05	
As	mg/l	0.5	0.013	0.5	0.5	0.009	0.5	0.5	0.024			0.05	0.05	
B	mg/l	0.5	0.25	0.5	0.5	0.08	0.5	0.5	0.02			0.05	0.05	
Cd	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01			0.05	0.05	
Cr	mg/l	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.02			0.05	0.05	
Cu	mg/l	0.5	0.01	0.5	0.5	0.011	0.5	0.5	0.012			0.05	0.05	
Fe	mg/l	0.5	0.5	0.5	0.5	0.05	0.5	0.5	0.5			0.05	0.05	
Mn	mg/l	0.5	0.13	0.5	0.5	0.01	0.5	0.5	0.01			0.2	0.3	
P	mg/l	0.5	1.122	0.5	0.5	0.047	0.5	0.5	0.002			0.05	0.05	
Pb	mg/l	0.5	0.017	0.5	0.5	0.041	0.5	0.5	0.023			0.05	0.05	
Se	mg/l	0.5	0.003	0.5	0.5	0.022	0.5	0.5	0.023			0.05	0.05	
Zn	mg/l	0.5	1.945	0.5	0.5	0.097	0.5	0.5	0.138			0.05	0.05	
Sr	mg/l	0.5	0.188	0.5	0.5	0.549	0.5	0.5	0.615			1.5	1.6	

BOSP-2

Tested	Units	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		7.9	7.4	6.6	4.2	8	7.5		
EC	mS/m	255	351	23	457	18	27		
Turb	NTU	4			58		140		
SS	mg/l	39			94		54		
TDS	mg/l	2421	3383	562	4012	558	250		
Ca	mg/l	292	449	9	598	7	11		
Mg	mg/l	201	275	11	359	9	10		
Na	mg/l	110	160	12	132	14	27		
K	mg/l	13	15	5	28	5	4		
Tot-Alk	mg/l CaCO3	34	34	54	0	32	38		
Cl	mg/l	54	47	4	67	3	10		
SO4	mg/l	1555	2046	25	2989	36	113		
NO3	mg/l	1	4	0.5	4	0.5	0.5		
F	mg/l								
Al	mg/l	0.05			5.2	57.3	13		
As	mg/l	0.05			0.2	0.05	0.05		
B	mg/l	0.1			0.05	0.05	0.05		
Cd	mg/l	0.05			0.05	0.05	0.05		
Cr	mg/l	0.05			0.05	0.05	0.05		
Cu	mg/l	0.05			0.05	0.05	0.05		
Fe	mg/l	0.05			0.05	21.7	4.1		
Mn	mg/l	0.1			6.4	0.05	0.05		
P	mg/l	0.05			0.2	0.05	0.05		
Pb	mg/l	0.1			0.05	0.05	0.05		
Se	mg/l	0.05			0.2	0.05	0.05		
Zn	mg/l	0.05			0.1	0.05	0.05		
Sr	mg/l	2			0.05	0.05	0.05		

BOSR-3

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Sep-06	Nov-06	Dec-06	Jan-07	Feb-07	Mar-07
pH		4.5	6.2	5.6	6.3	6.7	7.1	5.8	6.7	4.6	4.2	3.9	8.3	8
EC	mS/m	556.82	14.59	22	14	8	16	8	8	627	523	448	21	16
Turb	NTU													
SS	mg/l						193		70		452			
TDS	mg/l	5920	128	202	132	71	152	40	74	5911	5108	3535	194	108
Ca	mg/l	401	11	31	8	12	18	0.5	15	482	394	314	28	9
Mg	mg/l	730	6	14	18	0.4	7	0.5	0.5	500	422	290	6	8
Na	mg/l	99	13	10	8	6	13	9	5	118	149	52	11	5
K	mg/l	11	6	5	0.5	0.4	10	0.5	0.5	9	9	10	8	11
Tot-Alk	mg/l CaCO3		62	32	14	18	28	8	12				108	48
Cl	mg/l	58.14	2.84	20	7	7	7	9	9	75	121	43	11	17
SO4	mg/l	3849.28	17	92	78	16	68	5	30	3606	3015	2130	7	
NO3	mg/l	9.2	1.15	1	1	1	1	1	3	10	11	3	2	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.5	0.5	0.5
Mn	mg/l	6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

BOSR-3

Tested	Unit	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08	Mar-08	May-08
pH									5.7	6.6	7	7	7.3	7.3
EC	mS/m								15	442	124	77	392	23
Turb	NTU												151	
SS	mg/l												3234	
TDS	mg/l								131	5273	957	621	4532	14
Ca	mg/l								13	454	93	62	434	9
Mg	mg/l								0.5	614	94	39	458	7
Na	mg/l								17	89	104	42	109	6
K	mg/l								0.5	5	9	6	19	38
Tot-Alk	mg/l CaCO3								8	26	96	128	138	
Cl	mg/l								13	51	61			14
SO4	mg/l								41	3175	559	238	2491	30
NO3	mg/l								1	6	1	1	6	1
F	mg/l								0.5	0.2	0.5	0.5	0.5	0.5
Al	mg/l								0.5	0.04	0.5	0.5	0.5	0.5
As	mg/l								0.5	0.01	0.5	0.5	0.5	0.5
B	mg/l								0.5	0.05	0.5	0.5	0.5	0.5
Cd	mg/l								0.5	0.003	0.5	0.5	0.5	0.5
Cr	mg/l								0.5	0.01	0.5	0.5	0.5	0.5
Cu	mg/l								0.5	0.01	0.5	0.5	0.5	0.5
Fe	mg/l								0.5	0.5	0.5	0.5	0.5	0.5
Mn	mg/l								0.5	0.5	0.5	0.5	0.5	0.5
P	mg/l								0.5	0.1	0.5	0.5	0.5	0.5
Pb	mg/l								0.5	0.01	0.5	0.5	0.5	0.5
Se	mg/l								0.5	0.01	0.5	0.5	0.5	0.5
Zn	mg/l								0.5	0.01	0.5	0.5	0.5	0.5
Sr	mg/l								0.5	3.71	0.5	0.5	0.5	0.5

BOSR-3

Tested	Unit	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09
pH		7.1	6	6.9	6.9	7.5	6	7.2	7.5	7.7	6.8	6.6	6.3	6.7
EC	mS/m	11	11	11	11	13	12	9	12	10	11	11	13	13
Turb	NTU	2			1			1			2			3
SS	mg/l	4			5			4			5			12
TDS	mg/l	114	87	57	92	87	87	88	116	89	83	80	108	56
Ca	mg/l	6	6	0.5	0.5	5	5	7	4	9	0.5	5	6	0.5
Mg	mg/l	6	0.5	8	0.5	5	6	6	3	0.5	0.5	3	5	3
Na	mg/l	10	7	12	9	7	8	8	7	8	7	7	8	7
K	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3	0.5	0.5	2	2	2
Tot-Alk	mg/l CaCO3	8	14	10	6		4	6	8	6	10	14	4	6
Cl	mg/l	10	10	9	9	13	16	10	10	10	10	9	11	11
SO4	mg/l	4	2	4	6	4	3	32	4	30		22	42	13
NO3	mg/l	3	8	4	2	3	3	1	1	1	1	1	4	3
F	mg/l	0.2	0.5	0.5	0.2	0.5	0.5	0.2	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.03	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.5	0.2	0.5	0.5	0.3	0.5	0.5	0.1	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.5	0.1	0.5	0.5	1.4	0.5	0.5	0.1	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

BOSR-3

Tested	Unit	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10
pH		5.1	5.4	5.4	5.7	5.3	5.4	5.4	6	5.7	5.5	5.2	5.7	5.5
EC	mS/m	11	11	10	9	10	8	8	8	9	16	9	9	13
Turb	NTU									2			3	
SS	mg/l			3						15			8	
TDS	mg/l	86	78	91	63	76	52	57	61	82	92	77	66	111
Ca	mg/l	0.5	5	3	4	3	3	3	2	3	7	13	8	15
Mg	mg/l	4	4	4	4	3	2	3	2	3	3	2	2	9
Na	mg/l	8	11	9	7	8	7	7	5	6	7	6	6	1
K	mg/l	2	2	3	2	0.5	2	0.5	3	2	2	2	1	1
Tot-Alk	mg/l CaCO3	10	12	4	8	24	8	4	8	8	6	16	16	50
Cl	mg/l	13	13	13	18	11	9	9	9	4	11	7	11	10
SO4	mg/l	1	14	12	3	3	6	20	11	22	30	20	5	8
NO3	mg/l	4	2	3	7	3	2	4	1	2	1	1	2	2
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.69	0.5	0.5	0.48	0.5	0.5	0.1	0.5	0.5	0.19	0.5
As	mg/l	0.5	0.5	0.019	0.5	0.5	0.5	0.5	0.5	0.012	0.5	0.5	0.018	0.5
B	mg/l	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.26	0.5
Cd	mg/l	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5
Cr	mg/l	0.5	0.5	0.02	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.01	0.5
Cu	mg/l	0.5	0.5	0.014	0.5	0.5	0.5	0.5	0.5	0.008	0.5	0.5	0.011	0.5
Fe	mg/l	0.5	0.5	0.03	0.5	0.5	0.5	0.5	0.5	0.1	0.5	0.5	0.02	0.5
Mn	mg/l	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.01	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	1.662	0.5	0.5	0.5	0.5	0.5	0.882	0.5	0.5	1.134	0.5
Pb	mg/l	0.5	0.5	0.018	0.5	0.5	0.5	0.5	0.5	0.005	0.5	0.5	0.013	0.5
Se	mg/l	0.5	0.5	0.002	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.014	0.5
Zn	mg/l	0.5	0.5	0.001	0.5	0.5	0.5	0.5	0.5	0.599	0.5	0.5	0.649	0.5
Sr	mg/l	0.5	0.5	0.05	0.5	0.5	0.5	0.5	0.5	0.029	0.5	0.5	0.009	0.5

BOSR-3

Tested	Unit	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11
pH		6.4	5.4	5.3	5.1	6.4	7.6	6.9	6	6.3	6	7.1	6.9	6.4
EC	mS/m	10	10	13	10	10	133	269	36	12	8	29	14	21
Turb	NTU		2			1			137			>1000		
SS	mg/l		6			18			1657			6156		
TDS	mg/l	64	67	96	81	78	1239	2439	249	82	75	223	100	154
Ca	mg/l	3	4	5	8	4	143	237	20	6	3	20	11	6
Mg	mg/l	3	1	1	4	1	128	260	24	3	2	10	7	4
Na	mg/l	5	6	6	7	7	20	25	10	7	6	8	8	17
K	mg/l	2	3	2	3	2	4	4	1	3	1	<0.5	5	8
Tot-Alk	mg/l CaCO3	12	10	4	30	18	106	160	4	38	12	74	30	32
Cl	mg/l	11	13	13	10	10	10	11	13	7	10	13	10	16
SO4	mg/l	2	7	6	12	3	689	1427	159	6	2	28	22	29
NO3	mg/l	2	1	1	1	2	1	2	1	1	1		1	2
F	mg/l	0.5	0.5	0.5	0.5	0.5								
Al	mg/l	0.5	0.01	0.5	0.5	1.08								
As	mg/l	0.5	0.006	0.5	0.5	0.015								
B	mg/l	0.5	0.11	0.5	0.5	0.01								
Cd	mg/l	0.5	0.01	0.5	0.5	0.01								
Cr	mg/l	0.5	0.05	0.5	0.5	0.02								
Cu	mg/l	0.5	0.013	0.5	0.5	0.012								
Fe	mg/l	0.5	0.06	0.5	0.5	0.06								
Mn	mg/l	0.5	0.5	0.5	0.5	0.5								
P	mg/l	0.5	0.051	0.5	0.5	0.016								
Pb	mg/l	0.5	0.04	0.5	0.5	0.021								
Se	mg/l	0.5	0.033	0.5	0.5	0.023								
Zn	mg/l	0.5	0.08	0.5	0.5	0.121								
Sr	mg/l	0.5	0.011	0.5	0.5	0.009								

BOSR-3

Tested	Unit	Sep-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		6.7	4.3								
EC	mS/m	20	116								
Turb	NTU	12									
SS	mg/l	3021									
TDS	mg/l	130	905								
Ca	mg/l	9	73								
Mg	mg/l	6	78								
Na	mg/l	8	18								
K	mg/l	3	1								
Tot-Alk	mg/l CaCO3	54	0								
Cl	mg/l	9	4								
SO4	mg/l	4	558								
NO3	mg/l	0.5	0.5								
F	mg/l										
Al	mg/l	0.05									
As	mg/l	0.05									
B	mg/l	0.05									
Cd	mg/l	0.05									
Cr	mg/l	0.05									
Cu	mg/l	0.05									
Fe	mg/l	18.6									
Mn	mg/l	1									
P	mg/l	0.05									
Pb	mg/l	0.05									
Se	mg/l	0.05									
Zn	mg/l	0.05									
Sr	mg/l	0.1									

BOSD-1

Tested	Unit	Jan-06	Feb-06	Mar-06	Apr-06	May-06	Jun-06	Jul-06	Aug-06	Sep-06	Oct-06	Nov-06	Dec-06	Jan-07
pH														
EC	mS/m													
Turb	NTU													
SS	mg/l													
TDS	mg/l													
Ca	mg/l													
Mg	mg/l													
Na	mg/l													
K	mg/l													
Tot-Alk	mg/l CaCO3													
Cl	mg/l													
SO4	mg/l													
NO3	mg/l													
F	mg/l													
Al	mg/l													
As	mg/l													
B	mg/l													
Cd	mg/l													
Cr	mg/l													
Cu	mg/l													
Fe	mg/l													
Mn	mg/l													
P	mg/l													
Pb	mg/l													
Se	mg/l													
Zn	mg/l													
Sr	mg/l													

BOSD-1

Tested	Unit	Feb-07	Mar-07	Apr-07	May-07	Jun-07	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08	Feb-08
pH														
EC	mS/m													
Turb	NTU													
SS	mg/l													
TDS	mg/l													
Ca	mg/l													
Mg	mg/l													
Na	mg/l													
K	mg/l													
Tot-Alk	mg/l CaCO													
Cl	mg/l													
SO4	mg/l													
NO3	mg/l													
F	mg/l													
Al	mg/l													
As	mg/l													
B	mg/l													
Cd	mg/l													
Cr	mg/l													
Cu	mg/l													
Fe	mg/l													
Mn	mg/l													
P	mg/l													
Pb	mg/l													
Se	mg/l													
Zn	mg/l													
Sr	mg/l													

BOSD-1

Tested	Unit	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09
pH					7.9	7				7.7	8.5	7.7	8.5	7.8
EC	mS/m				252	267				342	271	319	270	292
Turb	NTU				2									
SS	mg/l				4						14			6
TDS	mg/l				1980	2126				2874	2407	2915	2162	1957
Ca	mg/l				267	210				272	216	223	238	160
Mg	mg/l				172	144				196	146	173	163	125
Na	mg/l				138	159				268	289	281	283	183
K	mg/l				14	12				14	9	14	15	9
Tot-Alk	mg/l CaCO				294	234				116	164	70	136	104
Cl	mg/l				71	74				122	122	130	116	95
SO4	mg/l				1166	1183				1641	1200	1618	1353	1120
NO3	mg/l				1	2				1	2	1	1	1
F	mg/l				1	0.5				0.5	2.68	0.5	0.5	0.5
Al	mg/l				0.01	0.5				0.5	0.5	0.5	0.5	0.1
As	mg/l				0.5	0.5				0.5	0.01	0.5	0.5	0.5
B	mg/l				0.5	0.5				0.5	0.13	0.5	0.5	0.5
Cd	mg/l				0.5	0.5				0.5	0.5	0.5	0.5	0.5
Cr	mg/l				0.5	0.5				0.5	0.01	0.5	0.5	0.5
Cu	mg/l				0.5	0.5				0.5	0.5	0.5	0.5	0.5
Fe	mg/l				0.5	0.5				0.5	0.2	0.5	0.5	0.1
Mn	mg/l				0.5	0.5				0.5	3	0.5	0.5	0.1
P	mg/l				0.5	0.5				0.5	0.1	0.5	0.5	0.5
Pb	mg/l				0.5	0.5				0.5	0.5	0.5	0.5	0.5
Se	mg/l				0.5	0.5				0.5	0.5	0.5	0.5	0.5
Zn	mg/l				0.5	0.5				0.5	0.5	0.5	0.5	0.5
Sr	mg/l				0.5	0.5				0.5	2.3	0.5	0.5	0.5

BOSD-1

Tested	Unit	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10
pH			7.4	8.2	8.1	7.5	8.4	7.8	7	7.7	8.2	8.8	9.3	8.7
EC	mS/m		367	371	300	272	306	297	113	278	272	260	280	357
Turb	NTU			3									1	
SS	mg/l			184			35						12	
TDS	mg/l		2390	2424	2493	2190	2768	2799	972	2060	2010	2258	2446	2320
Ca	mg/l		210	248	190	189	111	230	96	199	199	178	177	181
Mg	mg/l		144	149	143	132	163	175	65	164	165	141	148	146
Na	mg/l		270	244	275	254	301	296	77	264	268	248	262	277
K	mg/l		14	13	14	14	16	16	5	15	14	15	15	15
Tot-Alk	mg/l CaCO		120	146	172	150	100	166	54	120	104	94	78	68
Cl	mg/l		112	155	47	38	133	130	85	116	115	113	119	116
SO4	mg/l		1371	1353	1333	1284	1513	1535	438	1570	1750	1335	1371	1325
NO3	mg/l		2	2	2	3	1	3	1	2	2	1	1	2
F	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l		0.5	0.5	0.5	0.5	0.72	0.5	0.5	0.5	0.5	0.5	0.24	0.5
As	mg/l		0.5	0.5	0.5	0.5	0.023	0.5	0.5	0.5	0.5	0.5	0.019	0.5
B	mg/l		0.5	0.5	0.5	0.5	0.06	0.5	0.5	0.5	0.5	0.5	0.12	0.5
Cd	mg/l		0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.01	0.5
Cr	mg/l		0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5	0.5	0.01	0.5
Cu	mg/l		0.5	0.5	0.5	0.5	0.007	0.5	0.5	0.5	0.5	0.5	0.008	0.5
Fe	mg/l		0.5	0.5	0.5	0.5	0.04	0.5	0.5	0.5	0.5	0.5	0.03	0.5
Mn	mg/l		0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.01	0.5
P	mg/l		0.5	0.5	0.5	0.5	1.651	0.5	0.5	0.5	0.5	0.5	0.885	0.5
Pb	mg/l		0.5	0.5	0.5	0.5	0.017	0.5	0.5	0.5	0.5	0.5	0.006	0.5
Se	mg/l		0.5	0.5	0.5	0.5	0.012	0.5	0.5	0.5	0.5	0.5	0.023	0.5
Zn	mg/l		0.5	0.5	0.5	0.5	0.008	0.5	0.5	0.5	0.5	0.5	0.61	0.5
Sr	mg/l		0.5	0.5	0.5	0.5	2.681	0.5	0.5	0.5	0.5	0.5	2.056	0.5

BOSD-1

Tested	Unit	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11
pH		8.2	8.7	8.2	8.9	9.4	9.7	8.8	8.4				7.4	8.5
EC	mS/m	266	287	301	316	300	274	281	290				288	285
Turb	NTU		2			4			2					
SS	mg/l		8			8			13					
TDS	mg/l	2045	2241	2324	2412	2526	1998	2211	2113				2245	2220
Ca	mg/l	173	131	187	171	171	148	167	181				187	206
Mg	mg/l	116	104	151	144	201	156	189	147				140	129
Na	mg/l	116	205	253	284	304	233	262	254				217	230
K	mg/l	11	10	13	13	15	10	12	12				14	14
Tot-Alk	mg/l CaCO	124	76	128	86	60	60	64	78				106	122
Cl	mg/l	92	60	109	43	125	84	116	112				86	98
SO4	mg/l	1060	1189	1237	1337	1506	1325	1415	1365				1488	1359
NO3	mg/l	1	1	1	1	1	1	1	1				1	0.5
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5					
Al	mg/l	0.5	0.34	0.5	0.5	0.18	0.5	0.5	1.09					
As	mg/l	0.5	0.015	0.5	0.5	0.5	0.5	0.5	0.015					
B	mg/l	0.5	0.21	0.5	0.5	0.06	0.5	0.5	0.04					
Cd	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01					
Cr	mg/l	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.02					
Cu	mg/l	0.5	0.01	0.5	0.5	0.013	0.5	0.5	0.013					
Fe	mg/l	0.5	0.05	0.5	0.5	0.09	0.5	0.5	0.08					
Mn	mg/l	0.5	0.5	0.5	0.5	0.03	0.5	0.5	0.01					
P	mg/l	0.5	1.122	0.5	0.5	0.035	0.5	0.5	0.003					
Pb	mg/l	0.5	0.015	0.5	0.5	0.041	0.5	0.5	0.025					
Se	mg/l	0.5	0.003	0.5	0.5	0.023	0.5	0.5	0.008					
Zn	mg/l	0.5	0.021	0.5	0.5	0.1	0.5	0.5	0.135					
Sr	mg/l	0.5	1.189	0.5	0.5	2.206	0.5	0.5	1.774					

BOSD-1

Tested	Unit	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12
pH														
EC	mS/m	8.6	8.4	8.6	8.1	8.6	8.7	8.5	8.4	8.7	8.5	7.9	8.1	
Turb	NTU	292	3.5	334	288	296	292	272	304	309	316	319	320	
SS	mg/l	5			5			8			3		13	
TDS	mg/l	22		.	107			18			12		41	
Ca	mg/l	2214	2165	2319	2400	2368	2362	2312	2596	2747	2177	2338	2780	
Mg	mg/l	238	223	237	264	252	258	261	303	287	281	319	321	
Na	mg/l	127	133	130	129	139	156	153	167	166	167	179	178	
K	mg/l	241	227	217	231	216	232	238	290	265	234	265	268	
Tot-Alk	mg/l CaCO	14	14	15	12	12	11	11	13	12	11	12	11	
Cl	mg/l	124	134	140	142	120	94	70	66	68	78	92	100	
SO4	mg/l	96	96	89	94	94	92	98	101	102	106	104	7	
NO3	mg/l	1316	1285	1260	1580	1447	1503	1489	1576	1530	1594	1562	1751	
F	mg/l		1	1	0.5	1	1	5	3	3	1	0.5	3	
Al	mg/l													
As	mg/l				0.05	0.05		0.05			0.05	0.05	0.05	
B	mg/l				0.05	0.1		0.05			0.05	0.05	0.05	
Cd	mg/l				0.05	0.3		0.1			0.05	0.05	0.05	
Cr	mg/l				0.05	0.05		0.05			0.05	0.05	0.05	
Cu	mg/l				0.05	0.05		0.05			0.05	0.05	0.05	
Fe	mg/l				0.05	0.05		0.05			0.05	0.05	0.05	
Mn	mg/l				0.05	0.05		0.05			0.05	0.05	0.05	
P	mg/l				0.05	0.05		0.1			0.05	0.05	0.05	
Pb	mg/l				0.05	0.05		0.05			0.05	0.05	0.05	
Se	mg/l				0.05	0.05		0.1			0.05	0.05	0.05	
Zn	mg/l				0.05	0.1		0.05			0.1	0.05	0.05	
Sr	mg/l				0.05	0.05		0.05			0.05	0.05	0.05	
					2.8	2.6		2.7			0.05	2.9	3.4	

APPENDIX B1c

MONITORING DATA: WITCONS COLLIERY

WISD-1

Tested	Unit	Date												
		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10
pH		8.2	8.3	8.5	7.7	7.9	7.6	7.7	8	7.4	7	7.7	7.8	7
EC	mS/m	19	30	24	30	248	46	37	37	34	35	32	57	55
Turb	NTU	0.5	0.5	38	0.5	0.5	32	0.5	0.5	6	0.5	0.5	0.5	0.5
SS	mg/l	0.5	0.5	32	0.5	0.5	36	0.5	0.5	25	0.5	0.5	0.5	0.5
TDS	mg/l	148	188	192	180	23	220	226	226	217	244	240	482	408
Ca	mg/l	12	18	22	17	14	25	17	25	25	24	23	52	55
Mg	mg/l	10	10	11	10	20	14	15	17	12	17	15	33	34
Na	mg/l	12	17	19	15	6	22	22	26	10	22	22	21	19
K	mg/l	6	5	5	9	56	7	7	6	9	7	5	7	3
Tot-Alk	mg/l CaCO3	38	50	76	50	0.5	70	56	54	62	56	62	58	64
Cl	mg/l	10	20	16	14	60	24	21	24	23	24	21	13	10
SO4	mg/l	34	55	29	36	2	48	55	70	26	96	98	242	276
NO3	mg/l	1	1	1	1	0.5	1	1	1	1	3	1	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	2	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	1.3	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.19	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5

WISD-1

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		8.1	7.1	8	7.9	7.6	7.5	7.6	7.8	7.7	7.5	7.7			7.6	7.2	7.6	8
EC	mS/m	48	43	61	53	99	88	94	89	82	81	87			184	160	146	159
Turb	NTU	0.5	0.5	1	0.5	5	0.5	0.5	23	0.5	0.5	10						6
SS	mg/l	0.5	0.5	8	0.5	12	0.5	0.5	26	0.5	0.5	16						43
TDS	mg/l	418	368	532	340	753	765	639	679	624	565	683			1705	1312	1418	990
Ca	mg/l	49	49	69	43	79	105	32	85	71	66	83			209	186	194	205
Mg	mg/l	29	24	41	22	43	52	52	63	54	48	46			139	113	108	99
Na	mg/l	17	18	19	17	20	22	22	30	22	20	24			36	31	33	30
K	mg/l	5	6	4	6	5	7	7	8	7	6	7			8	8	9	8
Tot-Alk	mg/l CaCO3	74	54	90	46	32	32	34	40	48	50	48			60	78	80	78
Cl	mg/l	10	10	13	16	13	17	43	23	18	21	18			10	10	13	14
SO4	mg/l	190	179	246	167	354	410	370	386	356	372	396			1140	963	967	870
NO3	mg/l	1	1	1	1	1	2	1	1	1	1	1			1	1	1	
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.5	0.26	0.5	0.3	0.5	0.5	0.09	0.5	0.5	1.05						
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
B	mg/l	0.5	0.5	0.16	0.5	0.23	0.5	0.5	0.07	0.5	0.5	0.04						
Cd	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						
Cr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.02						
Cu	mg/l	0.5	0.5	0	0.5	0	0.5	0.5	0.03	0.5	0.5	0.01						
Fe	mg/l	0.5	0.5	0.04	0.5	0.01	0.5	0.5	0.06	0.5	0.5	0.07						
Mn	mg/l	0.5	0.5	0.5	0.5	0.07	0.5	0.5	0.1	0.5	0.5	0.04						
P	mg/l	0.5	0.5	0.6	0.5	0.4	0.5	0.5	0.7	0.5	0.5	0.58						
Pb	mg/l	0.5	0.5	0	0.5	0.02	0.5	0.5	0.03	0.5	0.5	0.02						
Se	mg/l	0.5	0.5	0	0.5	0	0.5	0.5	0.03	0.5	0.5	0.01						
Zn	mg/l	0.5	0.5	0.65	0.5	0.64	0.5	0.5	0.11	0.5	0.5	0.13						
Sr	mg/l	0.5	0.5	0.02	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						

WISD-1

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Jun-12	Jul-12
pH		8.5	7.8	8.6	7.8	7.8	8.2	8.4	8.4	8.2	8.2	8.4	8	7.9	8	7.9
EC	mS/m	164	180	147	154	187	181	196	139	144	140	138	151	131	151	131
Turb	NTU			4			7			5		4	3	6	3	6
SS	mg/l			9			13			20		7	10	7	10	7
TDS	mg/l	1423	1441	1143	1452	1566	1631	1714	1214	1071	1174	1081	1194	1176	1194	1176
Ca	mg/l	197	198	227	215	284	224	283	154	176	169	180	175	153	175	153
Mg	mg/l	104	105	112	117	102	125	143	88	93	89	94	117	112	117	112
Na	mg/l	31	33	37	36	39	42	48	21	27	26	29	29	27	29	27
K	mg/l	9	12	10	11	8	10	13	9	10	9	9	11	10	11	10
Tot-Alk	mg/l CaCO3	72	70	68	68	62	62	72	42	40	50	52	56	58	56	58
Cl	mg/l	21	17	17	13	17	18	18	14	13	13	13	14	14	14	14
SO4	mg/l	896	842	934	1031	1041	1017	1082	770	794	728	735	820	791	820	791
NO3	mg/l	1	1	1	2	1	1	0.5	1	1	1	1	1	1	1	1
F	mg/l															
Al	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
As	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
B	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.2	0.05	0.2	0.05
Cd	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cr	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cu	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fe	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Mn	mg/l			0.1	0.4		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
P	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.5	0.05	0.5	0.05
Pb	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Se	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Zn	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sr	mg/l			1.9	1.8		1.8			1	1	1.2	4.9	1.4	4.9	1.4

WISR-1

Tested	Unit	Date												
		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10
pH		8.5	8.1	7.7	3.2	7.4	5.8	8	7.9	7.9	7.6	8.2	8.2	7.9
EC	mS/m	189	330	211	449	393	407	272	225	340	352	236	309	90
Turb	NTU	0.5	0.5	189	0.5	0.5	0.5	0.5	0.5	7	0.5	0.5	0.5	0.5
SS	mg/l	0.5	0.5	601	0.5	0.5	6458	0.5	0.5	6	0.5	0.5	0.5	0.5
TDS	mg/l	1695	2978	1527	3205	2487	2947	2004	1511	2796	3075	2276	2789	662
Ca	mg/l	152	417	163	387	352	493	216	134	169	276	240	334	82
Mg	mg/l	57	94	52	72	66	95	60	26	131	144	109	144	37
Na	mg/l	177	253	214	259	303	288	277	337	416	456	243	257	81
K	mg/l	7	7	9	7	10	10	9	5	3	8	5	11	5
Tot-Alk	mg/l CaCO3	116	100	84	0.5	82	16	174	94	216	424	202	154	130
Cl	mg/l	86	128	91	109	156	69	44	34	216	240	126	111	38
SO4	mg/l	812	1678	830	1963	1436	1719	1037	817	1172	1603	1204	1705	336
NO3	mg/l	1	1	1	1	2	4	1	2	2	3	1	3	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.73	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.04	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	2.77	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5

WISR-1

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		8.2	7.2	8.5	7.8	7.8	8	8.3	7.9	7.9	8.4	8.5	6.3	8.1	7.4	8.3	7.6	8.4
EC	mS/m	81	113	216	148	164	137	311	339	107	397	180	118	183	98	88	118	140
Turb	NTU	0.5	0.5	1	0.5	110	0.5	0.5	6	0.5	0.5	13			213			12
SS	mg/l	0.5	0.5	20	0.5	34	0.5	0.5	27	0.5	0.5	9			43			28
TDS	mg/l	699	977	1740	1064	1254	1163	2465	3337	789	3492	1362	902	1572	704	593	871	1291
Ca	mg/l	73	121	238	122	114	117	360	437	83	384	150	101	196	89	65	82	147
Mg	mg/l	31	48	78	54	48	56	111	178	37	211	62	40	68	35	31	39	69
Na	mg/l	74	118	164	98	104	136	186	247	67	288	162	84	155	80	68	80	129
K	mg/l	7	8	8	8	6	9	11	14	10	14	5	7	7	5	4	13	6
Tot-Alk	mg/l CaCO3	160	144	114	126	110	122	122	136	98	98	86	72	98	90	82	66	120
Cl	mg/l	35	51	84	40	54	58	88	119	37	156	67	47	77	48	50	67	68
SO4	mg/l	282	485	958	528	515	662	1423	1805	426	2190	895	528	853	302	264	328	714
NO3	mg/l	1	1	1	1	1	1	2	1	1	1	1	1	0.5		1	1	0.5
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.5	0.27	0.5	0.3	0.5	0.5	0.22	0.5	0.5	0.59						0.05
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						0.05
B	mg/l	0.5	0.5	0.04	0.5	0.19	0.5	0.5	0.08	0.5	0.5	0.15						0.05
Cd	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						0.05
Cr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.01						0.05
Cu	mg/l	0.5	0.5	0.01	0.5	0	0.5	0.5	0.01	0.5	0.5	0.03						0.05
Fe	mg/l	0.5	0.5	0.05	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.02						0.1
Mn	mg/l	0.5	0.5	0.25	0.5	0.25	0.5	0.5	0.2	0.5	0.5	0.03						0.05
P	mg/l	0.5	0.5	2.16	0.5	0.99	0.5	0.5	4.32	0.5	0.5	1.82						0.05
Pb	mg/l	0.5	0.5	0	0.5	0.02	0.5	0.5	0.04	0.5	0.5	0.02						0.05
Se	mg/l	0.5	0.5	0.01	0.5	0	0.5	0.5	0.01	0.5	0.5	0.03						0.05
Zn	mg/l	0.5	0.5	0.65	0.5	0.65	0.5	0.5	0.11	0.5	0.5	0.13						0.05
Sr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						1.8

WISR-1

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		7.9	7.2	7.7	7.8	7.5	8.4	7.6	7.4	7.5	7.6	7.4	7.5	7.6
EC	mS/m	124	143	216	219	238	185	270	238	286	250	238	286	250
Turb	NTU			191			10		>1000	58	16	>1000	58	16
SS	mg/l			1098			33		5117	2163	6	5117	2163	6
TDS	mg/l	1118	1061	1772	1688	2052	1401	2106	1875	2144	2237	1875	2144	2237
Ca	mg/l	142	146	210	229	244	182	265	221	276	225	221	276	225
Mg	mg/l	60	59	99	105	122	88	135	101	162	151	101	162	151
Na	mg/l	114	57	164	204	133	126	195	239	215	193	239	215	193
K	mg/l	5	5	3	5	5	6	5	4	6	6	4	6	6
Tot-Alk	mg/l CaCO3	112	102	116	114	148	112	110	112	150	126	112	150	126
Cl	mg/l	60	28	68	75	71	58	89	104	99	98	104	99	98
SO4	mg/l	665	640	1083	1034	1249	776	1397	1164	1409	1335	1164	1409	1335
NO3	mg/l	1	1	1	3	1	1	6	1	1	0.5	1	1	0.5
F	mg/l													
Al	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
As	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B	mg/l	0.05		0.05			0.05	0.05	0.05	0.6	0.05	0.05	0.6	0.05
Cd	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cr	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cu	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fe	mg/l	0.05		0.1			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Mn	mg/l	0.8		3.4			0.05	2.8	2.1	0.05	0.05	2.1	0.05	0.05
P	mg/l	0.05		0.05			0.05	0.05	0.05	0.8	0.05	0.05	0.8	0.05
Pb	mg/l	0.05		0.1			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Se	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Zn	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sr	mg/l	1.6		2.3			1.7	2.6	2.2	10.1	3.1	2.2	10.1	3.1

WISR-2

Tested	Unit	Date												
		Jan-09	*Feb-09*	*Mar-09*	*Apr-09*	*May-09*	*Jun-09*	*Jul-09*	*Aug-09*	*Sep-09*	*Oct-09*	*Nov-09*	*Dec-09*	*Jan-10*
pH		8.2	8.5	7.4	3.8	7.1	6.9	7.9	8	8.4	7.6	8.1	7.9	7.8
EC	mS/m									360.6				
Turb	NTU			160			145			5				
SS	mg/l	284	154	200	398	390	360	274	222	201	381	153	232	92
TDS	mg/l	2,453.00	1,234.00	1,498.00	2,983.00	2,507.00	2,296.00	1,984.00	1,462.00	1,747.00	3,585.00	1,304.00	2,002.00	677
Ca	mg/l	340	126	174	350	335	351	186	125	170	341	134	258	85
Mg	mg/l	78	55	57	78	83	68	65	28	125	180	56	95	38
Na	mg/l	244	132	180	265	286	282	295	325	171	456	176	186	81
K	mg/l	7	7	10	6	9	9	8	4	10	8	4	8	5
Tot-Alk	mg/l CaCO3													
Cl	mg/l	119	68	75	113	147	105	27	82	98	218	85	81	37
SO4	mg/l	1,367.00	641	888	1,783.00	1,321.00	1,325.00	1,012.00	840	880	1,847.00	646	1,185.00	396
NO3	mg/l	1	1	1	1	2	1	2	2	2	4	1	3	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	458	0.5	0.5	3,138.00	0.5	0.5	158	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.17	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.73	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.04	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5

WISR-2

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		8	8.6	7.6	7.7	7.8	7.5	8.1	8.2	8	8.1	8.3				7.1	8	8.3
EC	mS/m		321.63			169.01			339.99			256.64				116	175	136
Turb	NTU		1			10			11			11						70
SS	mg/l	109	168	114	175	164	137	282	192	177	176	171						21
TDS	mg/l	948	1,567.00	1,016.00	1,248.00	1,243.00	1,188.00	2,186.00	1,572.00	1,217.00	1,379.00	1,315.00				908	1583	1057
Ca	mg/l	110	214	126	133	113	126	308	210	158	227	143				101	196	128
Mg	mg/l	41	71	49	57	49	64	101	103	82	85	58				41	69	59
Na	mg/l	92	145	114	142	103	143	166	128	99	65	149				87	137	99
K	mg/l	7	8	8	7	7	10	9	9	7	9	5				6	7	6
Tot-Alk	mg/l CaCO3															62	94	92
Cl	mg/l	45	75	51	61	55	57	81	62	52	33	62				45	72	61
SO4	mg/l	462	878	505	625	520	658	1,222.00	992	803	931	830				538	841	607
NO3	mg/l	1	1	1	1	1	1	1	1	1	1	1				2	2	
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
As	mg/l	0.5	23	0.5	0.5	9	0.5	0.5	19	0.5	0.5	11						
B	mg/l	0.5	0.06	0.5	0.5	0.19	0.5	0.5	0.06	0.5	0.5	0.15						
Cd	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						
Cr	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.03	0.5	0.5	0.01						
Cu	mg/l	0.5	0.27	0.5	0.5	0.34	0.5	0.5	0.13	0.5	0.5	0.98						
Fe	mg/l	0.5	0.05	0.5	0.5	0.01	0.5	0.5	0.15	0.5	0.5	0.04						
Mn	mg/l	0.5	0.02	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.02						
P	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.01						
Pb	mg/l	0.5	0.65	0.5	0.5	0.65	0.5	0.5	0.11	0.5	0.5	0.13						
Se	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.03	0.5	0.5	0.02						
Zn	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						
Sr	mg/l	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						

WISR-2

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		8.4	7.4	8.4	7.9	8	7.8	8.7	8.8	8.2	8.8	8.2	7.9	8
EC	mS/m	186	152	130	138	125	246	268	269	300	267	294	307	274
Turb	NTU			117			65			4		40	11	23
SS	mg/l			512			349			31		112	242	13
TDS	mg/l	1463	1098	1186	1261	870	2023	2137	2336	2214	2331	2449	2290	2446
Ca	mg/l	158	123	132	135	112	220	283	251	283	267	305	285	265
Mg	mg/l	71	57	65	71	50	116	136	130	114	135	157	169	167
Na	mg/l	155	110	121	123	82	212	252	174	246	199	234	232	207
K	mg/l	6	9	8	8	5	5	6	6	7	6	6	7	8
Tot-Alk	mg/l CaCO3	108	94	106	52	50	52	70	124	66	74	90	140	128
Cl	mg/l	81	61	69	64	34	85	89	89	108	88	104	108	115
SO4	mg/l	818	547	687	746	511	1280	1310	1344	1595	1402	1561	1489	1601
NO3	mg/l	1	1	0.5	1	0.5	1	2	2	1	3	2	1	1
F	mg/l													
Al	mg/l			0.05	0.4		0.05			0.05	0.05	0.05	0.05	0.05
As	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05
B	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.6	0.05
Cd	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05
Cr	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05
Cu	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05
Fe	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05
Mn	mg/l			0.05	0.4		0.05			0.05	0.05	0.05	0.05	0.05
P	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.8	0.05
Pb	mg/l			0.05	0.05		0.1			0.05	0.05	0.05	0.05	0.05
Se	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05
Zn	mg/l			0.05	0.05		0.05			0.05	0.05	0.05	0.05	0.05
Sr	mg/l			1.5	1.5		2.8			3.2	2.8	3.3	10.8	3.4

WISR-3

Tested	Unit	Date												
		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10
pH		8.3	8.4	8	7.3	7.9	7.5	7.6	7.7	8.4	7.9	7.4	7.7	7.4
EC	mS/m	146	255	197	321	386	436	337	327	358	319	325	189	136
Turb	NTU	0.5	0.5	0.5	0.5	0.5	15	0.5	0.5	3	0.5	0.5	0.5	0.5
SS	mg/l	0.5	0.5	2	0.5	0.5	32	0.5	0.5	18	0.5	0.5	0.5	0.5
TDS	mg/l	1166	2488	1668	2324	2760	3295	3181	3103	3467	3155	2948	1704	1001
Ca	mg/l	143	254	193	252	317	435	304	415	378	364	298	199	137
Mg	mg/l	92	187	129	182	246	272	244	266	321	320	239	142	92
Na	mg/l	70	111	85	114	128	134	139	204	134	121	130	70	78
K	mg/l	10	10	9	10	13	12	13	18	15	10	5	7	4
Tot-Alk	mg/l CaCO3	70	96	74	74	112	130	136	88	136	170	152	100	96
Cl	mg/l	45	48	216	48	50	52	71	45	47	31	24	24	45
SO4	mg/l	854	1438	1014	1506	1760	2023	1919	1976	2112	2244	1762	1110	820
NO3	mg/l	1	1	1	1	4	3	1	4	2	7	3	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.73	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.03	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.04	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.2	0.5	0.5	0.5	0.5	0.5	1.45	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3.08	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5

WISR-3

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		7.4	7.3	8	7.6	7.7	7.8	7.5	7.9	7.9	8.3	8.2	7.1	7.9	8.1	7.6	7.8	8.4
EC	mS/m	169	140	212	181	207	262	312	292	324	307	440	401	434	414	434	497	433
Turb	NTU	0.5	0.5	1	0.5	2	0.5	0.5	13	0.5	0.5	9			3			35
SS	mg/l	0.5	0.5	8	0.5	14	0.5	0.5	12	0.5	0.5	8			22			69
TDS	mg/l	1481	1335	1864	1346	1727	2149	2580	2841	2514	2315	3387	3702	3921	3845	3960	4225	3567
Ca	mg/l	185	161	214	155	153	210	277	297	290	256	410	352	436	417	373	399	427
Mg	mg/l	132	102	166	103	107	195	191	297	318	265	409	385	339	244	258	376	417
Na	mg/l	64	80	66	78	74	102	112	103	114	95	201	84	110	108	103	121	120
K	mg/l	9	10	9	8	7	11	10	10	9	8	12	20	18	17	16	22	22
Tot-Alk	mg/l CaCO3	118	96	114	102	98	106	146	172	120	126	172	128	156	150	158	146	190
Cl	mg/l	28	50	28	48	45	41	47	33	31	33	33	27	31	30	28	30	30
SO4	mg/l	1065	766	1227	740	795	1258	1530	1743	1982	1921	2873	2673	2393	2450	2361	2403	2652
NO3	mg/l	2	2	1	1	1	1	2	1	2	2	5	5	0.5		1	4	5
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.5	0.28	0.5	0.35	0.5	0.5	0.21	0.5	0.5	0.96						0.05
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						0.05
B	mg/l	0.5	0.5	0.19	0.5	0.24	0.5	0.5	0.11	0.5	0.5	0.06						0.05
Cd	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						0.05
Cr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.02						0.05
Cu	mg/l	0.5	0.5	0.01	0.5	0	0.5	0.5	0.01	0.5	0.5	0.5						0.05
Fe	mg/l	0.5	0.5	0.04	0.5	0.03	0.5	0.5	0.05	0.5	0.5	0.03						0.05
Mn	mg/l	0.5	0.5	0.01	0.5	0.22	0.5	0.5	4.48	0.5	0.5	1.02						2.5
P	mg/l	0.5	0.5	0.34	0.5	0.87	0.5	0.5	2.25	0.5	0.5	3.14						0.05
Pb	mg/l	0.5	0.5	0.01	0.5	0.02	0.5	0.5	0.04	0.5	0.5	0.02						0.05
Se	mg/l	0.5	0.5	0.01	0.5	0	0.5	0.5	0.01	0.5	0.5	0.5						0.05
Zn	mg/l	0.5	0.5	0.65	0.5	0.65	0.5	0.5	0.11	0.5	0.5	0.13						0.05
Sr	mg/l	0.5	0.5	0.02	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						3.8

WISR-3

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		8.3	7.5	8.3	7.6	7.9	8.5	7.7	7.3	7.4	7.7	7.3		7.4
EC	mS/m	493	478	350	311	317	331	296	246	225	296	246		225
Turb	NTU			2			3		208	67		208		67
SS	mg/l			12			21		800	165		800		165
TDS	mg/l	4810	4706	3463	2975	2863	2686	2427	2243	2215	2427	2243		2215
Ca	mg/l	434	436	368	384	312	354	326	324	283	326	324		283
Mg	mg/l	465	480	327	282	277	288	252	188	188	252	188		188
Na	mg/l	131	130	94	94	69	90	84	71	61	84	71		61
K	mg/l	22	15	11	13	11	13	10	9	9	10	9		9
Tot-Alk	mg/l CaCO3	184	206	144	128	152	160	170	182	204	170	182		204
Cl	mg/l	24	17	24	20	20	27	23	23	20	23	23		20
SO4	mg/l	2943	2945	2238	1851	1914	2018	1798	1474	1376	1798	1474		1376
NO3	mg/l	6	5	3	2	3	2	4	5	1	4	5		1
F	mg/l													
Al	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05		0.05
As	mg/l	0.05		0.05			0.1	0.05	0.05	0.05	0.05	0.05		0.05
B	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05		0.05
Cd	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05		0.05
Cr	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05		0.05
Cu	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05		0.05
Fe	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05		0.05
Mn	mg/l	1.5		4.3			1.4	1.1	1.4	3.6	1.1	1.4		3.6
P	mg/l	0.05		0.05			0.1	0.05	0.05	0.05	0.05	0.05		0.05
Pb	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05		0.05
Se	mg/l	0.05		0.05			0.2	0.05	0.05	0.05	0.05	0.05		0.05
Zn	mg/l	0.05		0.05			0.05	0.05	0.05	0.05	0.05	0.05		0.05
Sr	mg/l	3.9		2.5			2.1	2	1.8	2.2	2	1.8		2.2

WISR-4

Tested	Unit	Date												
		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10
pH		8.5	8.5	8.3	7.4	7.9	7.4	7.3	7.6	8.1	8	8.3	7.6	7.4
EC	mS/m	84	230	148	146	183	162	345	144	180	407	435	48	43
Turb	NTU	0.5	0.5	0.5	0.5	0.5	12	0.5	0.5	7	0.5	0.5	0.5	0.5
SS	mg/l	0.5	0.5	5	0.5	0.5	10	0.5	0.5	47	0.5	0.5	0.5	0.5
TDS	mg/l	766	2187	1156	853	1024	941	3124	1246	1674	4024	4154	372	317
Ca	mg/l	73	230	142	97	117	122	309	125	178	421	375	32	34
Mg	mg/l	40	165	79	51	69	69	238	77	134	388	321	26	26
Na	mg/l	9	107	87	89	110	75	151	147	109	226	215	30	26
K	mg/l	72	5	6	8	9	8	16	15	12	17	7	4	1
Tot-Alk	mg/l CaCO3	0.5	112	98	124	192	122	142	80	92	128	88	68	116
Cl	mg/l	340	35	47	47	72	54	71	47	64	94	84	20	17
SO4	mg/l	1	1266	693	454	509	500	1865	772	917	2789	2440	152	109
NO3	mg/l	0.5	1	1	1	2	2	4	2	1	9	4	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.73	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.03	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.04	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.75	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5

WISR-4

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		7.3	7.1	8	8	7.8	6.9	7.3	7.6	8.1	7.8	8.2	6.5	6.2	7.6	6.8	4.6	7.6
EC	mS/m	54	65	45	90	59	74	98	85	97	90	100	161	151	262	237	410	321
Turb	NTU	0.5	0.5	1	0.5	1	0.5	0.5	12	0.5	0.5	9			37			55
SS	mg/l	0.5	0.5	7	0.5	17	0.5	0.5	8	0.5	0.5	8			183			2361
TDS	mg/l	461	550	290	581	374	612	625	582	734	689	778	1498	1376	2174	1902	3272	2882
Ca	mg/l	45	64	37	68	32	78	71	62	64	56	70	165	145	240	190	319	311
Mg	mg/l	30	40	31	41	22	45	56	57	62	51	53	136	100	159	138	266	236
Na	mg/l	28	44	28	46	25	43	37	46	53	45	61	61	64	78	66	119	117
K	mg/l	6	6	6	7	6	10	9	10	10	8	9	9	9	14	14	20	20
Tot-Alk	mg/l CaCO3	184	114	184	110	66	62	80	114	104	114	176	64	48	68	60	4	260
Cl	mg/l	14	28	28	31	27	30	28	37	43	40	40	27	38	44	43	57	0
SO4	mg/l	110	238	51	256	135	366	348	275	338	282	324	1104	837	1353	1036	1804	1606
NO3	mg/l	3	1	1	1	1	1	1	1	1	1	1	1	1		1	5	4
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.5	0.28	0.5	0.35	0.5	0.5	0.03	0.5	0.5	1						0.05
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						0.05
B	mg/l	0.5	0.5	0.19	0.5	0.26	0.5	0.5	0.11	0.5	0.5	0.02						0.05
Cd	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						0.05
Cr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.02						0.05
Cu	mg/l	0.5	0.5	0.01	0.5	0	0.5	0.5	0.03	0.5	0.5	0.01						0.05
Fe	mg/l	0.5	0.5	0.04	0.5	0.04	0.5	0.5	0.04	0.5	0.5	0.03						6.5
Mn	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						18.4
P	mg/l	0.5	0.5	0.34	0.5	0.19	0.5	0.5	0.61	0.5	0.5	0.65						0.05
Pb	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.03	0.5	0.5	0.02						0.05
Se	mg/l	0.5	0.5	0.01	0.5	0	0.5	0.5	0.03	0.5	0.5	0.01						0.05
Zn	mg/l	0.5	0.5	0.65	0.5	0.65	0.5	0.5	0.11	0.5	0.5	0.14						0.05
Sr	mg/l	0.5	0.5	0.02	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						2.6

WISR-4

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	May-12	Jun-12	Jul-12
pH		8	7.9	4.4	7.8	3.1	8.2	7.4	7.8	3.1	8.2		7.4
EC	mS/m	381	411	395	307	433	740	602	307	433	740		602
Turb	NTU					4	6	25		4	6		25
SS	mg/l					126	43	30		126	43		30
TDS	mg/l	3287	3820	3671	2745	3370	8003	5850	2745	3370	8003		5850
Ca	mg/l	308	348	477	313	545	702	632	313	545	702		632
Mg	mg/l	289	360	368	263	255	729	387	263	255	729		387
Na	mg/l	136	164	144	65	87	302	288	65	87	302		288
K	mg/l	28	27	19	11	27	25	18	11	27	25		18
Tot-Alk	mg/l CaCO3	122	98	6	106	0	78	60	106	0	78		60
Cl	mg/l	85	92	20	23	0	139	61	23	0	139		61
SO4	mg/l	2009	2272	2501	1804	2759	4530	4089	1804	2759	4530		4089
NO3	mg/l	4	3	1	3	6	15	5	3	6	15		5
F	mg/l												
Al	mg/l	0.05				0.6	0.05	0.05		0.6	0.05		0.05
As	mg/l	0.05				0.2	0.05	0.05		0.2	0.05		0.05
B	mg/l	0.05				0.05	0.05	0.05		0.05	0.05		0.05
Cd	mg/l	0.05				0.05	0.05	0.05		0.05	0.05		0.05
Cr	mg/l	0.05				0.05	0.05	0.05		0.05	0.05		0.05
Cu	mg/l	0.05				0.05	0.05	0.05		0.05	0.05		0.05
Fe	mg/l	0.05				23.2	0.05	0.05		23.2	0.05		0.05
Mn	mg/l	0.8				16.7	0.05	0.05		16.7	0.05		0.05
P	mg/l	0.05				0.2	0.05	0.05		0.2	0.05		0.05
Pb	mg/l	0.05				0.1	0.05	0.05		0.1	0.05		0.05
Se	mg/l	0.05				0.2	0.05	0.05		0.2	0.05		0.05
Zn	mg/l	0.05				0.05	0.05	0.05		0.05	0.05		0.05
Sr	mg/l	2.7				3.6	6.3	5.6		3.6	6.3		5.6

WISR-5

Tested	Unit	Date												
		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10
pH		8.4	8.4	7.9	7.2								8.6	7.5
EC	mS/m	97	129	100	128								101	87
Turb	NTU	0.5	0.5	30	0.5								0.5	0.5
SS	mg/l	0.5	0.5	3	0.5								0.5	0.5
TDS	mg/l	874	1000	702	731								764	642
Ca	mg/l	70	136	68	61								73	70
Mg	mg/l	41	54	53	49								48	43
Na	mg/l	63	94	61	68								66	61
K	mg/l	19	5	7	36								27	16
Tot-Alk	mg/l CaCO3	74	120	50	38								70	60
Cl	mg/l	33	26	37	33								26	31
SO4	mg/l	390	566	318	449								452	446
NO3	mg/l	1	1	1	2								1	1
F	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Al	mg/l	0.5	0.5	0.1	0.5								0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Fe	mg/l	0.5	0.5	0.1	0.5								0.5	0.5
Mn	mg/l	0.5	0.5	0.1	0.5								0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5								0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5								0.5	0.5

WISR-5

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		8	7.4	8.1	7.8	7.7	7.7									7.2		
EC	mS/m	89	81	95	106	106	89									77		
Turb	NTU	0.5	0.5	2	0.5	10	0.5											
SS	mg/l	0.5	0.5	80	0.5	21	0.5											
TDS	mg/l	739	670	760	702	724	715									589		
Ca	mg/l	72	68	79	70	62	67									57		
Mg	mg/l	44	40	45	47	33	38									24		
Na	mg/l	62	66	79	56	58	70									59		
K	mg/l	21	34	24	23	17	28									16		
Tot-Alk	mg/l CaCO3	66	94	108	58	94	122									70		
Cl	mg/l	31	24	28	27	24	26									17		
SO4	mg/l	428	347	450	348	300	434									302		
NO3	mg/l	1	2	1	1	1	1									1		
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5											
Al	mg/l	0.5	0.5	0.25	0.5	0.35	0.5											
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5											
B	mg/l	0.5	0.5	0.19	0.5	0.25	0.5											
Cd	mg/l	0.5	0.5	0.01	0.5	0.01	0.5											
Cr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5											
Cu	mg/l	0.5	0.5	0.01	0.5	0.01	0.5											
Fe	mg/l	0.5	0.5	0.03	0.5	0.04	0.5											
Mn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5											
P	mg/l	0.5	0.5	0.61	0.5	0.32	0.5											
Pb	mg/l	0.5	0.5	0.01	0.5	0.02	0.5											
Se	mg/l	0.5	0.5	0.01	0.5	0.01	0.5											
Zn	mg/l	0.5	0.5	0.65	0.5	0.65	0.5											
Sr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5											

WISR-5

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH														
EC	mS/m													
Turb	NTU													
SS	mg/l													
TDS	mg/l													
Ca	mg/l													
Mg	mg/l													
Na	mg/l													
K	mg/l													
Tot-Alk	mg/l CaCO3													
Cl	mg/l													
SO4	mg/l													
NO3	mg/l													
F	mg/l													
Al	mg/l													
As	mg/l													
B	mg/l													
Cd	mg/l													
Cr	mg/l													
Cu	mg/l													
Fe	mg/l													
Mn	mg/l													
P	mg/l													
Pb	mg/l													
Se	mg/l													
Zn	mg/l													
Sr	mg/l													

WISR-6

Tested	Unit	Date												
		Jan-09	*Feb-09*	*Mar-09*	*Apr-09*	*May-09*	*Jun-09*	*Jul-09*	*Aug-09*	*Sep-09*	*Oct-09*	*Nov-09*	*Dec-09*	*Jan-10*
pH		8.4	8.4	8.1	7.2	7.5	7.4	7.1	7.5	7.9	7.3	7.6	7.7	7.2
EC	mS/m	43	24	31	46	62	55	51	49	49	59	44	30	27
Turb	NTU	0.5	0.5	1	0.5	0.5	13	0.5	0.5	1	0.5	0.5	0.5	0.5
SS	mg/l	0.5	0.5	2	0.5	0.5	18	0.5	0.5	44	0.5	0.5	0.5	0.5
TDS	mg/l	343	168	248	257	310	264	308	278	343	385	357	228	196
Ca	mg/l	35	14	27	32	26	18	18	20	26	28	24	18	18
Mg	mg/l	26	8	13	14	18	13	14	14	15	17	15	13	12
Na	mg/l	25	23	26	24	43	39	45	47	38	65	47	28	25
K	mg/l	8	5	6	8	16	17	16	17	20	21	9	4	2
Tot-Alk	mg/l CaCO3	78	78	118	120	124	64	86	74	68	112	48	110	106
Cl	mg/l	21	17	23	27	52	58	51	67	77	85	45	20	23
SO4	mg/l	73	2	4	7	10	54	42	45	35	56	149	12	5
NO3	mg/l	1	1	1	1	1	2	1	1	1	2	1	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.73	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.21	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5

WISR-6

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		8.1	7.3	8.1	7.5	8.2	8	8	7.5	8.2	6.4	7.5	7	7	7.5	6.9	8.5	6.9
EC	mS/m	40	28	39	43	47	38	54	58	60	92	33	54	44	40	60	58	66
Turb	NTU	0.5	0.5	1	0.5	10	0.5	0.5	23	0.5	0.5	10			50			239
SS	mg/l	0.5	0.5	9	0.5	13	0.5	0.5	26	0.5	0.5	13			88			107
TDS	mg/l	347	204	264	246	289	255	335	338	378	704	234	421	309	265	363	395	509
Ca	mg/l	27	17	25	19	15	22	25	31	21	68	14	34	27	16	25	34	38
Mg	mg/l	19	10	18	14	11	19	22	28	28	30	7	24	17	14	22	23	20
Na	mg/l	39	32	40	41	36	44	45	54	54	54	38	33	39	42	48	53	69
K	mg/l	8	10	9	9	7	11	12	14	13	19	2	13	15	14	16	19	25
Tot-Alk	mg/l CaCO3	168	88	158	122	122	146	186	212	208	10	46	202	166	96	178	176	70
Cl	mg/l	37	35	43	43	43	45	51	60	67	52	26	41	47	62	69	74	91
SO4	mg/l	2	16	3	20	16	4	6	2	21	352	78	3	4	13	10	20	142
NO3	mg/l	1	3	1	1	1	1	1	1	1	1	1	1	1		1	1	0.5
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.5	0.28	0.5	0.3	0.5	0.5	0.02	0.5	0.5	1.08						0.05
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						0.05
B	mg/l	0.5	0.5	0.2	0.5	0.26	0.5	0.5	0.13	0.5	0.5	0.01						0.05
Cd	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						0.05
Cr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.01						0.05
Cu	mg/l	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.03	0.5	0.5	0.02						0.05
Fe	mg/l	0.5	0.5	0.03	0.5	0.21	0.5	0.5	0.5	0.5	0.5	0.14						0.2
Mn	mg/l	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.5	0.07						0.9
P	mg/l	0.5	0.5	0.17	0.5	0.07	0.5	0.5	0.22	0.5	0.5	0.07						0.05
Pb	mg/l	0.5	0.5	0.01	0.5	0.02	0.5	0.5	0.08	0.5	0.5	0.02						0.05
Se	mg/l	0.5	0.5	0.01	0.5	0.5	0.5	0.5	0.03	0.5	0.5	0.02						0.05
Zn	mg/l	0.5	0.5	0.65	0.5	0.65	0.5	0.5	0.11	0.5	0.5	0.13						0.05
Sr	mg/l	0.5	0.5	0.03	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						0.3

WISR-6

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		7.9	8.4	7.8	7.5	7.9	8	7.8	9	7.5	8	7.8	9	7.5
EC	mS/m	81	93	120	53	42	44	52	35	77	44	52	35	77
Turb	NTU			123		7		46	17	200		46	17	200
SS	mg/l			423		36		41	83	117		41	83	117
TDS	mg/l	603	565	870	493	332	347	310	248	715	347	310	248	715
Ca	mg/l	55	40	64	41	34	41	46	19	55	41	46	19	55
Mg	mg/l	28	28	39	26	16	19	22	20	41	19	22	20	41
Na	mg/l	80	86	111	30	23	28	39	24	57	28	39	24	57
K	mg/l	29	31	33	15	11	11	12	9	14	11	12	9	14
Tot-Alk	mg/l CaCO3	106	92	92	194	126	138	152	106	170	138	152	106	170
Cl	mg/l	106	119	164	30	20	31	35	17	71	31	35	17	71
SO4	mg/l	207	177	268	24	56	51	147	41	242	51	147	41	242
NO3	mg/l	0.5	0.5	0.5	0.5	1	0.5	0.5	1	1	0.5	0.5	1	1
F	mg/l													
Al	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
As	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
B	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cd	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cr	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Cu	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Fe	mg/l	0.5		0.1		0.3	0.05	0.2	0.2	0.6	0.05	0.2	0.2	0.6
Mn	mg/l	1		0.05		1.8	0.05	0.05	0.05	2.4	0.05	0.05	0.05	2.4
P	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Pb	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Se	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Zn	mg/l	0.05		0.05		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sr	mg/l	0.5		0.6		0.05	0.05	0.1	0.4	0.5	0.05	0.1	0.4	0.5

WISR-7

Tested	Unit	Date												
		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10
pH		8.4	8.2	7.9		7.7	4.1	8.5	7.9	8.4		5.2		
EC	mS/m	175	316	173		311	282	331	462	513		241		
Turb	NTU	0.5	0.5	0.5		0.5	96	0.5	0.5	2		0.5		
SS	mg/l	0.5	0.5	2		0.5	469	0.5	0.5	111		0.5		
TDS	mg/l	1391	2759	1174		1732	1843	2369	4591	5023		2038		
Ca	mg/l	111	348	141		201	287	175	465	418		332		
Mg	mg/l	47	101	45		51	78	89	486	521		64		
Na	mg/l	183	297	175		310	155	406	273	189		126		
K	mg/l	6	9	7		5	5	6	9	8		3		
Tot-Alk	mg/l CaCO3	110	88	18		128	0.5	258	236	262		8		
Cl	mg/l	109	147	99		152	84	231	24	94		69		
SO4	mg/l	691	1457	573		1302	1049	1123	2861	2964		1208		
NO3	mg/l	1	1	1		2	2	1	4	4		4		
F	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5		0.5		
Al	mg/l	0.5	0.5	0.1		0.5	0.5	0.5	0.5	0.73		0.5		
As	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.5		0.5		
B	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.02		0.5		
Cd	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.01		0.5		
Cr	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.02		0.5		
Cu	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.02		0.5		
Fe	mg/l	0.5	0.5	0.1		0.5	0.5	0.5	0.5	0.04		0.5		
Mn	mg/l	0.5	0.5	0.1		0.5	0.5	0.5	0.5	0.01		0.5		
P	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	3.42		0.5		
Pb	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.02		0.5		
Se	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.02		0.5		
Zn	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.01		0.5		
Sr	mg/l	0.5	0.5	0.5		0.5	0.5	0.5	0.5	0.01		0.5		

WISR-7

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH																7.2	7	7.8
EC	mS/m															130	134	138
Turb	NTU																	10
SS	mg/l																	102
TDS	mg/l															986	1171	1198
Ca	mg/l															137	165	173
Mg	mg/l															83	84	89
Na	mg/l															30	31	29
K	mg/l															7	8	8
Tot-Alk	mg/l CaCO3															70	82	66
Cl	mg/l															14	18	17
SO4	mg/l															780	781	730
NO3	mg/l															0.5	1	
F	mg/l																	
Al	mg/l																	
As	mg/l																	
B	mg/l																	
Cd	mg/l																	
Cr	mg/l																	
Cu	mg/l																	
Fe	mg/l																	
Mn	mg/l																	
P	mg/l																	
Pb	mg/l																	
Se	mg/l																	
Zn	mg/l																	
Sr	mg/l																	

WISR-7

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		7.7	7.7	8.3	8.5	7.4	7.6		3.2	6	3.6	3.5		4
EC	mS/m	124	128	123	117	121	117		215	98	233	253		156
Turb	NTU			7			406			8		5		9
SS	mg/l			43			1343			23		7		15
TDS	mg/l	982	930	1226	1062	904	984		2012	707	2181	2214		1433
Ca	mg/l	127	122	164	137	143	116		286	96	286	352		167
Mg	mg/l	72	69	88	80	60	84		116	43	124	149		120
Na	mg/l	29	31	36	47	35	39		40	41	45	57		32
K	mg/l	8	16	12	13	7	1		15	11	20	19		13
Tot-Alk	mg/l CaCO3	72	62	102	110	104	104		0	4	0	0		0
Cl	mg/l	26	28	26	37	34	6		17	35	52	34		18
SO4	mg/l	494	585	751	709	487	570		1311	482	1361	1610		973
NO3	mg/l	1	1	0.5	1	0.5	1		2	0.5	3	4		0.5
F	mg/l													
Al	mg/l			0.05	0.05		0.05			0.05	12.6	7.2		0.05
As	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
B	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Cd	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Cr	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Cu	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Fe	mg/l			0.05	0.05		0.1			0.05	1.3	1		0.05
Mn	mg/l			0.3	0.7		1.1			4.2	13	14		3.9
P	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Pb	mg/l			0.05	0.05		0.1			0.05	0.05	0.05		0.05
Se	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Zn	mg/l			0.05	0.05		0.05			0.05	0.1	0.05		0.05
Sr	mg/l			1.4	1.2		1			0.3	1.6	2		1.2

WISR-8

Tested	Unit	Date												
		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10
pH		8.4	8.4	7.9	7.8	8	8.1	8.3	8		7.9	7.7	8	7.8
EC	mS/m	285	328	354	465	461	479	470	471		437	327	316	335
Turb	NTU	0.5	0.5	0.5	0.5	0.5	19	0.5	0.5		0.5	0.5	0.5	0.5
SS	mg/l	0.5	0.5	3	0.5	0.5	80	0.5	0.5		0.5	0.5	0.5	0.5
TDS	mg/l	2566	2982	3286	3650	3269	3531	4628	4640		4326	2963	3123	2470
Ca	mg/l	230	321	302	258	340	341	344	478		474	328	309	331
Mg	mg/l	207	282	279	320	322	327	443	472		485	225	296	337
Na	mg/l	158	145	158	184	176	153	176	276		183	115	129	157
K	mg/l	9	8	9	8	8	8	6	11		7	2	4	4
Tot-Alk	mg/l CaCO3	122	148	232	264	284	288	316	270		198	130	238	284
Cl	mg/l	96	79	95	96	102	92	94	35		75	44	45	72
SO4	mg/l	1539	1870	1792	2073	1620	1866	2670	2838		3094	1745	1990	2446
NO3	mg/l	1	1	1	1	2	3	5	6		9	3	1	7
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5		0.5	0.5	0.5	0.5

WISR-8

Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		8.3	7.4	8.6	8	8.4	8.1	8.1	7.9	8.1	7.9	8.1				7.6	7.6	7.6
EC	mS/m	350	410	378	377	423	452	489	549	592	459	369				462	503	141
Turb	NTU	0.5	0.5	1	0.5	2	0.5	0.5	17	0.5	0.5	5						6
SS	mg/l	0.5	0.5	12	0.5	16	0.5	0.5	9	0.5	0.5	21						62
TDS	mg/l	3083	2957	3753	3272	3729	4050	3073	4466	4321	4041	2808				4288	4736	1221
Ca	mg/l	320	299	332	329	265	316	400	388	345	354	332				394	467	162
Mg	mg/l	316	266	361	296	260	419	215	519	569	488	350				493	454	94
Na	mg/l	155	140	157	145	233	158	159	164	243	172	142				138	142	34
K	mg/l	7	8	7	7	6	7	7	8	14	6	5				9	7	9
Tot-Alk	mg/l CaCO3	266	272	306	330	312	334	344	300	264	256	248				314	320	62
Cl	mg/l	86	68	91	84	86	79	69	71	61	79	58				67	65	23
SO4	mg/l	2137	1665	2268	1800	2164	2345	1907	2903	3841	2922	2263				3006	2643	798
NO3	mg/l	9	5	1	7	2	10	3	3	1	4	5				4	1	
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.5	0.28	0.5	0.35	0.5	0.5	0.19	0.5	0.5	1						
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
B	mg/l	0.5	0.5	0.09	0.5	0.2	0.5	0.5	0.11	0.5	0.5	0.03						
Cd	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						
Cr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.02						
Cu	mg/l	0.5	0.5	0	0.5	0.02	0.5	0.5	0.04	0.5	0.5	0.02						
Fe	mg/l	0.5	0.5	0.05	0.5	0.04	0.5	0.5	0.08	0.5	0.5	0.06						
Mn	mg/l	0.5	0.5	0.03	0.5	0.94	0.5	0.5	0.5	0.5	0.5	0.5						
P	mg/l	0.5	0.5	3.66	0.5	1.92	0.5	0.5	3.47	0.5	0.5	2.35						
Pb	mg/l	0.5	0.5	0.01	0.5	0.02	0.5	0.5	0.03	0.5	0.5	0.02						
Se	mg/l	0.5	0.5	0	0.5	0.02	0.5	0.5	0.04	0.5	0.5	0.02						
Zn	mg/l	0.5	0.5	0.65	0.5	0.65	0.5	0.5	0.11	0.5	0.5	0.14						
Sr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						

WISR-8

Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		8.4	8.1	8.4	8.1	6.7	7.5	7.6	6.9	4.4	7.7	7.1		7.7
EC	mS/m	514	567	514	488	323	295	309	262	258	321	461		496
Turb	NTU			17			244			40		>1000		75
SS	mg/l			26			1718			60		1445		127
TDS	mg/l	4805	4743	4098	4705	3099	2695	2722	2347	1968	2769	4581		4529
Ca	mg/l	463	401	452	436	368	314	391	348	380	335	486		508
Mg	mg/l	313	487	542	459	265	195	190	161	141	278	439		388
Na	mg/l	147	153	164	146	85	169	206	44	45	98	156		255
K	mg/l	6	9	7	7	3	14	11	17	4	3	4		6
Tot-Alk	mg/l CaCO3	300	278	214	184	34	88	100	26	2	182	252		300
Cl	mg/l	58	57	62	54	26	75	75	30	0	38	65		50
SO4	mg/l	2802	2850	3126	3000	1995	1687	1726	1557	1646	1961	2954		3430
NO3	mg/l	7	5	8	8	2	1	0.5	2	2	3	8		7
F	mg/l													
Al	mg/l			0.05	0.05		0.05			4.4	0.05	0.05		0.05
As	mg/l			0.5	0.05		0.05			1	0.05	0.05		0.05
B	mg/l			1	0.05		0.05			0.05	0.05	0.05		0.05
Cd	mg/l			0.4	0.05		0.05			0.05	0.05	0.05		0.05
Cr	mg/l			0.3	0.05		0.05			0.05	0.05	0.05		0.05
Cu	mg/l			0.3	0.05		0.05			0.05	0.05	0.05		0.05
Fe	mg/l			0.05	0.05		0.1			1.5	0.05	0.05		0.05
Mn	mg/l			0.4	1.9		8.6			7.2	0.05	0.05		0.05
P	mg/l			0.4	0.05		0.05			0.1	0.05	0.05		0.05
Pb	mg/l			0.3	0.05		0.05			0.05	0.05	0.05		0.05
Se	mg/l			1.4	0.05		0.05			0.1	0.05	0.05		0.05
Zn	mg/l			0.4	0.05		0.05			0.2	0.05	0.05		0.05
Sr	mg/l			4.5	3.8		2.5			1.7	1.9	3.2		4.2

WISR-9

Tested	Unit	Date												
		Jan-09	Feb-09	Mar-09	Apr-09	May-09	Jun-09	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10
pH		8.4	8.6	7.9	7.7	7.7	7.7	7.3	7.5	8.2	7.4	6.5	7	7.8
EC	mS/m	30	111	38	43	85	60	56	72	60	71	114	150	34
Turb	NTU	0.5	0.5	120	0.5	0.5	10	0.5	0.5	1	0.5	0.5	0.5	0.5
SS	mg/l	0.5	0.5	1573	0.5	0.5	78	0.5	0.5	5	0.5	0.5	0.5	0.5
TDS	mg/l	247	862	310	210	454	306	410	486	459	498	1040	1254	260
Ca	mg/l	27	122	28	20	42	30	24	42	41	38	103	111	29
Mg	mg/l	17	54	20	11	39	23	28	43	22	50	70	86	17
Na	mg/l	19	52	30	21	35	28	29	39	42	52	70	109	25
K	mg/l	9	4	4	7	8	7	7	10	11	11	3	7	2
Tot-Alk	mg/l CaCO3	62	142	96	76	78	72	44	46	90	146	22	128	112
Cl	mg/l	16	28	22	23	33	28	78	37	44	51	44	69	18
SO4	mg/l	75	434	63	18	158	105	138	206	127	167	589	650	51
NO3	mg/l	1	1	1	1	2	1	1	1	1	1	1	1	1
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Al	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.73	0.5	0.5	0.5	0.5
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
B	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cd	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Cr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Cu	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Fe	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.04	0.5	0.5	0.5	0.5
Mn	mg/l	0.5	0.5	0.1	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
P	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.5
Pb	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Se	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.02	0.5	0.5	0.5	0.5
Zn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5
Sr	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.5	0.5

WISR-9

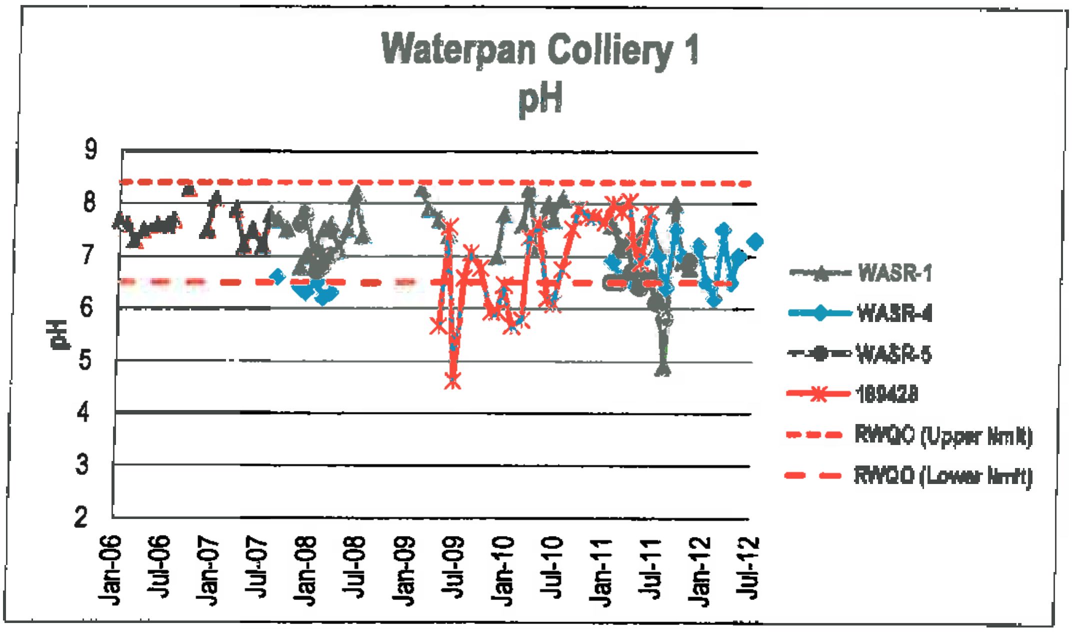
Tested	Unit	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10	Dec-10	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11
pH		7.8	6.8	8	7.6	8	7.5	7.6	7.9	7.9	7.4	8.3				7.2		
EC	mS/m	43	36	45	47	71	76	88	83	118	181	127				139		
Turb	NTU	0.5	0.5	1	0.5	35	0.5	0.5	10	0.5	0.5	1						
SS	mg/l	0.5	0.5	7	0.5	46	0.5	0.5	8	0.5	0.5	14						
TDS	mg/l	311	266	284	269	435	630	555	574	957	1516	991				1184		
Ca	mg/l	37	33	37	28	36	81	63	63	69	170	59				147		
Mg	mg/l	25	19	28	19	25	61	48	55	73	105	81				105		
Na	mg/l	23	22	27	28	25	31	35	42	66	95	94				33		
K	mg/l	6	7	6	7	6	17	9	10	7	8	7				8		
Tot-Alk	mg/l CaCO3	146	72	164	80	66	56	82	142	88	118	126				68		
Cl	mg/l	18	20	26	31	26	26	30	33	48	55	60				13		
SO4	mg/l	80	101	53	72	162	358	288	259	473	826	490				828		
NO3	mg/l	1	1	9	1	1	1	1	1	1	1	1				0.5		
F	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
Al	mg/l	0.5	0.5	0.28	0.5	0.3	0.5	0.5	0.01	0.5	0.5	1.01						
As	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5						
B	mg/l	0.5	0.5	0.21	0.5	0.26	0.5	0.5	0.11	0.5	0.5	0.04						
Cd	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						
Cr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.05	0.5	0.5	0.02						
Cu	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.04						
Fe	mg/l	0.5	0.5	0.04	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.07						
Mn	mg/l	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.01	0.5	0.5	0.08						
P	mg/l	0.5	0.5	0.01	0.5	0.21	0.5	0.5	0.58	0.5	0.5	0.41						
Pb	mg/l	0.5	0.5	0.01	0.5	0.02	0.5	0.5	0.04	0.5	0.5	0.02						
Se	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.04						
Zn	mg/l	0.5	0.5	0.65	0.5	0.65	0.5	0.5	0.11	0.5	0.5	0.14						
Sr	mg/l	0.5	0.5	0.01	0.5	0.01	0.5	0.5	0.01	0.5	0.5	0.01						

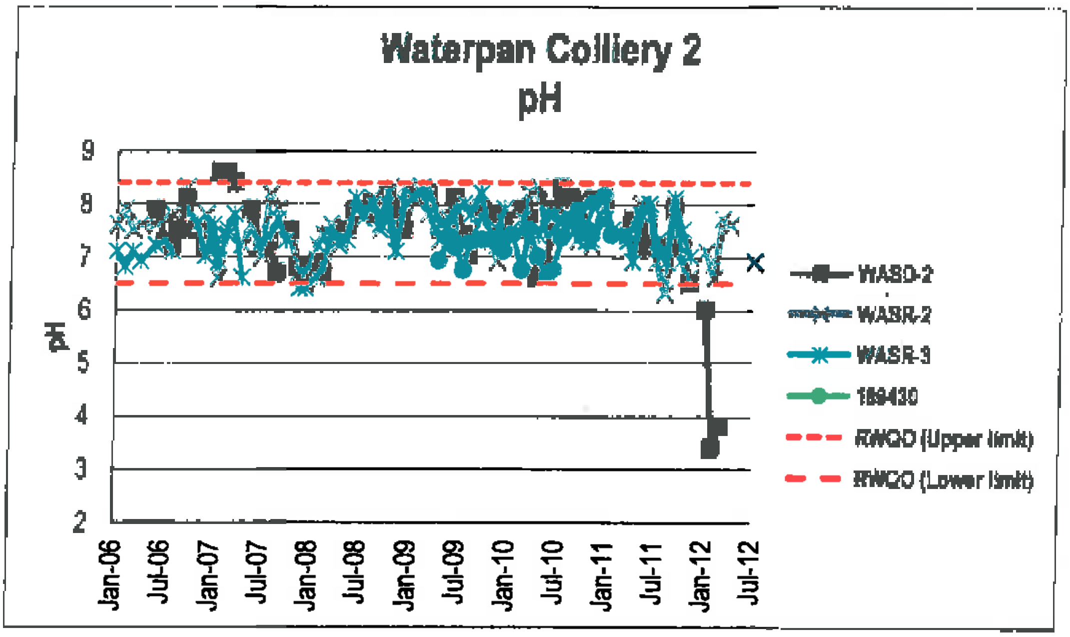
WISR-9

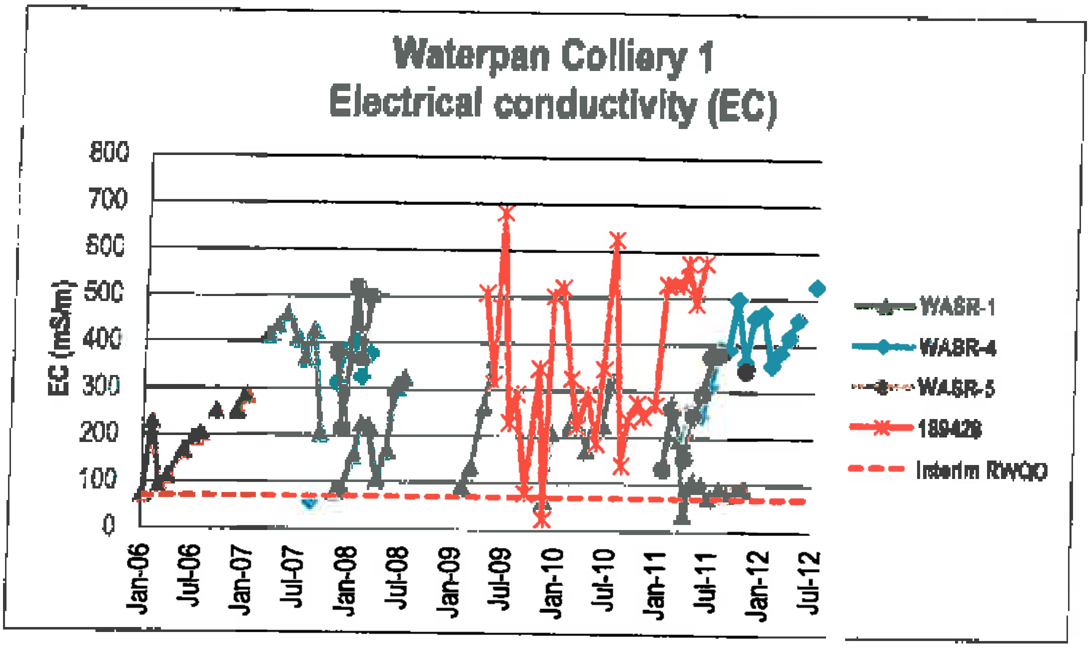
Tested	Unit	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12
pH		7.6	7.4	8.5	7.4	6.8	8.2	8	8.1	7.5	7.7	7.4		7.9
EC	mS/m	152	169	183	259	291	364	281	217	311	314	311		319
Turb	NTU			19			25			4		6		13
SS	mg/l			22			92			27		118		29
TDS	mg/l	1311	1394	1625	2092	2527	3530	2440	2644	2507	2570	2769		2732
Ca	mg/l	159	173	217	236	302	371	361	292	420	380	382		355
Mg	mg/l	100	110	126	167	185	345	223	211	188	183	187		206
Na	mg/l	36	45	75	88	148	134	108	77	111	153	163		169
K	mg/l	10	13	14	18	15	3	5	5	15	13	14		11
Tot-Alk	mg/l CaCO3	64	68	70	74	86	194	166	170	64	96	114		156
Cl	mg/l	23	27	41	54	67	41	34	37	54	79	85		81
SO4	mg/l	836	874	1050	1315	1508	2295	1523	1693	1753	1828	1851		1884
NO3	mg/l	1	1	1	2	2	4	1	1	2	4	6		1
F	mg/l													
Al	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
As	mg/l			0.05	0.05		0.05			0.1	0.05	0.05		0.05
B	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Cd	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Cr	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Cu	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Fe	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Mn	mg/l			0.05	1.2		0.05			0.05	0.05	0.05		0.05
P	mg/l			0.05	0.05		0.05			0.1	0.05	0.05		0.05
Pb	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Se	mg/l			0.05	0.05		0.05			0.2	0.05	0.05		0.05
Zn	mg/l			0.05	0.05		0.05			0.05	0.05	0.05		0.05
Sr	mg/l			1.7	1.9		2.6			2.8	3	3.3		4.3

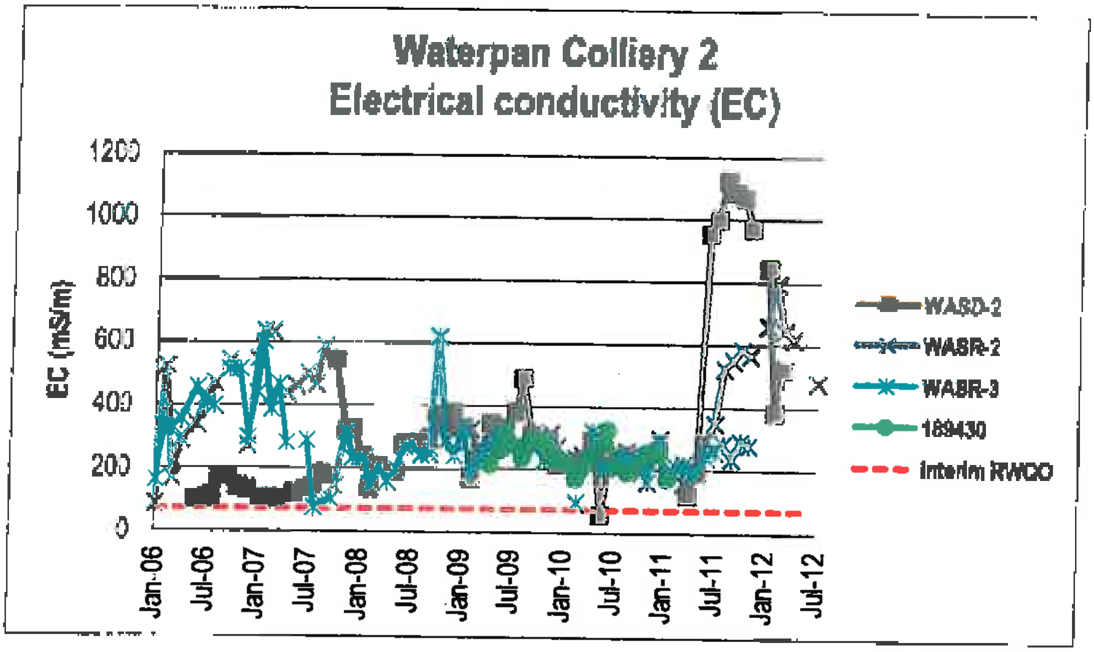
APPENDIX B2a

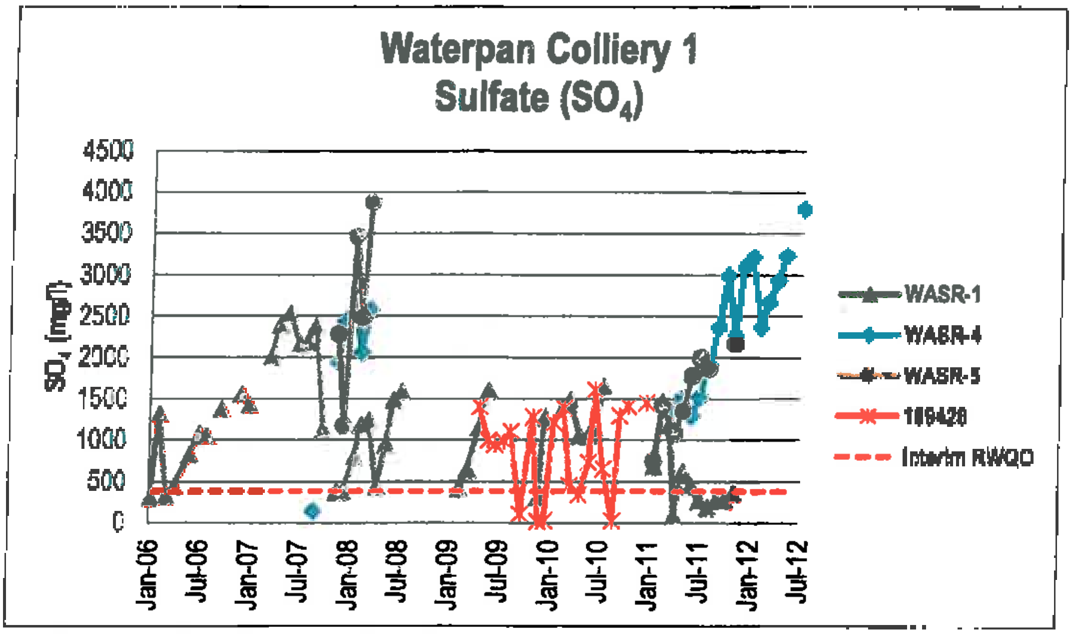
TIME SERIES GRAPHS: WATERPAN COLLIERY

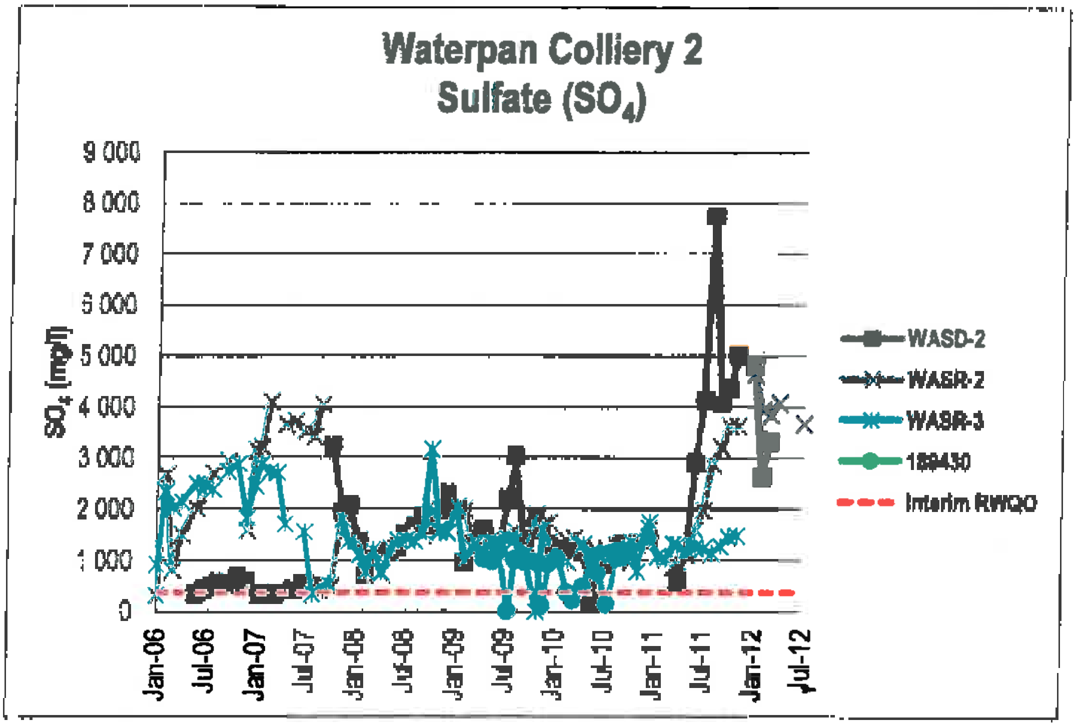

Waterpan Colliery 1
pH
9
8
7
6
5
4
3
2
pH
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
189428
RWQO (Upper limit)
RWQO (Lower limit)

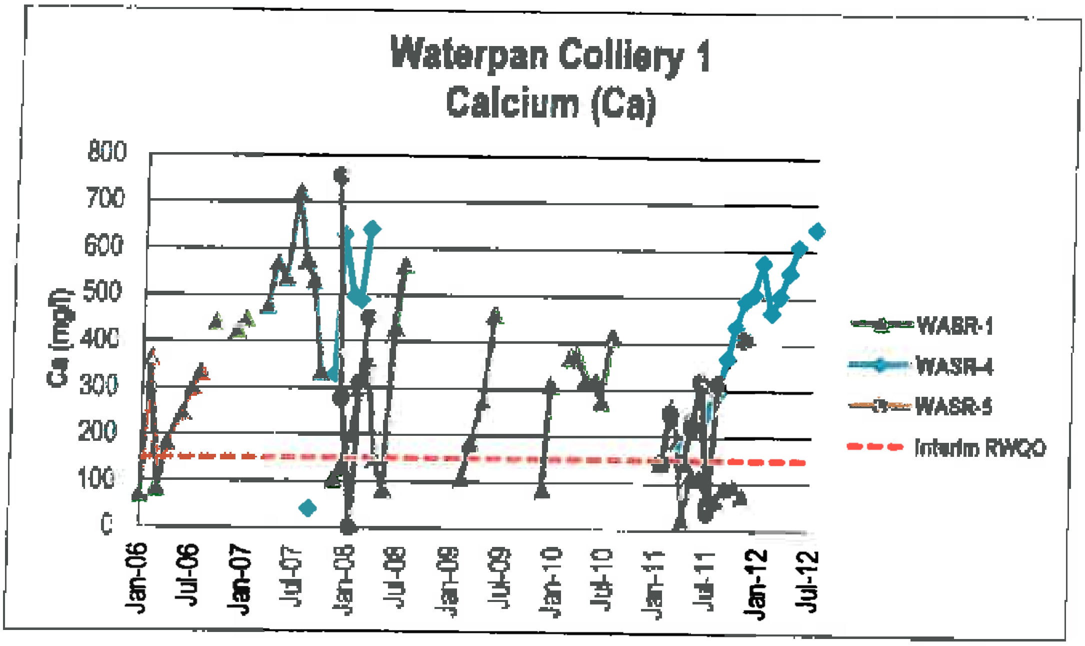

Waterpan Colliery 2
pH
9
8
7
6
5
4
3
2
pH
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
189430
RWQO (Upper limit)
RWQO (Lower limit)

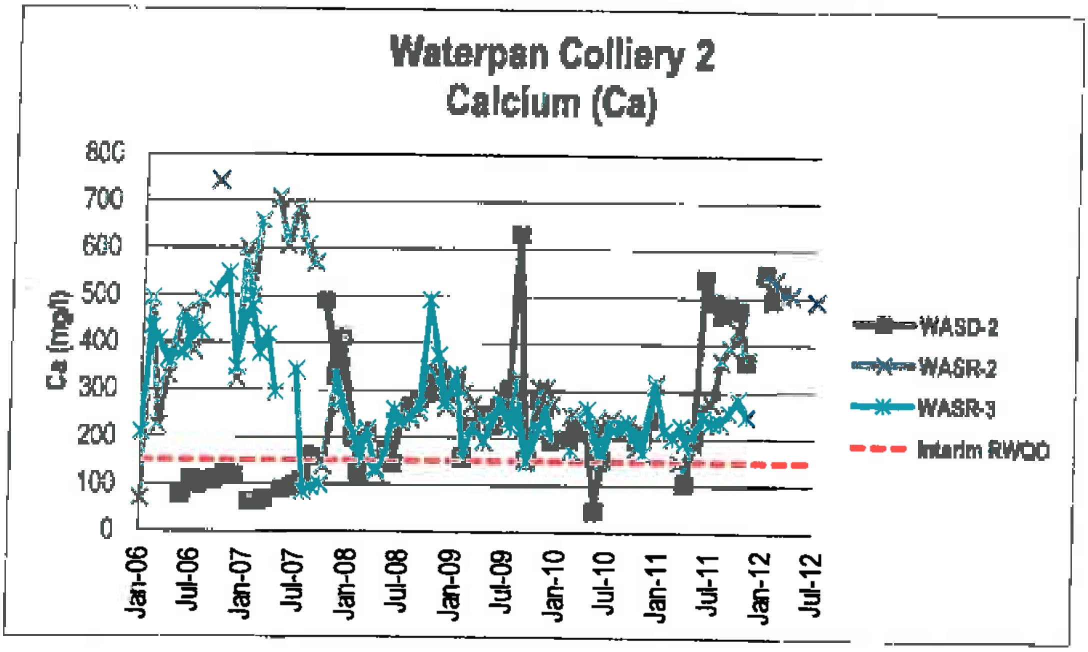

Waterpan Colliery 1
Electrical conductivity (EC)
EC (mS/m)
800
700
600
500
400
300
200
100
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
189429
Interim RWQO

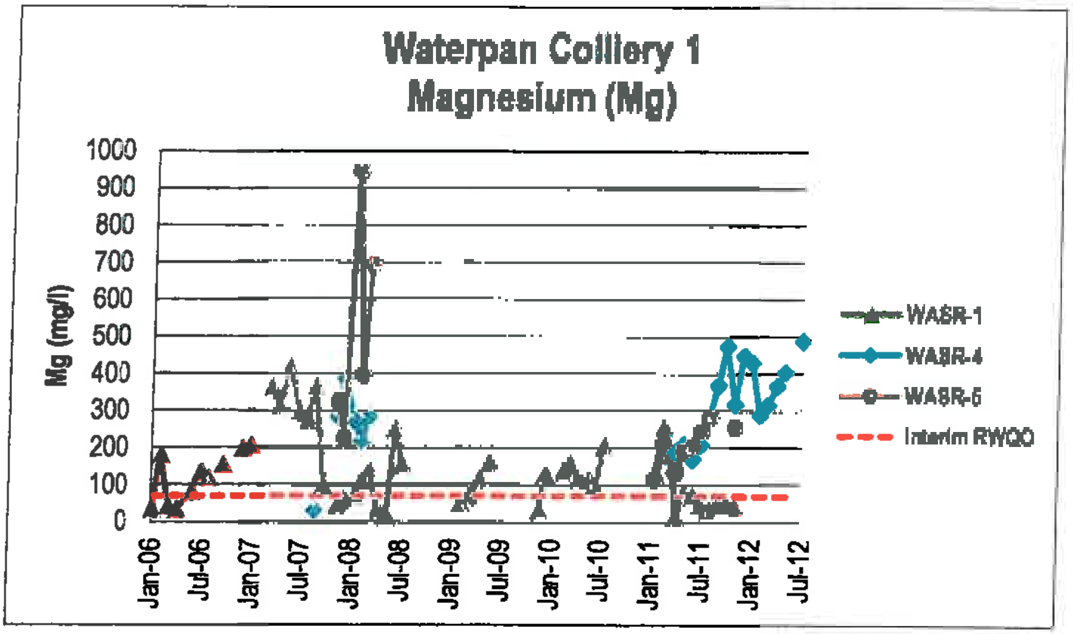

Waterpan Colliery 2
Electrical conductivity (EC)
EC (mS/m)
1200
1000
800
600
400
200
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
189430
Interim RWQO

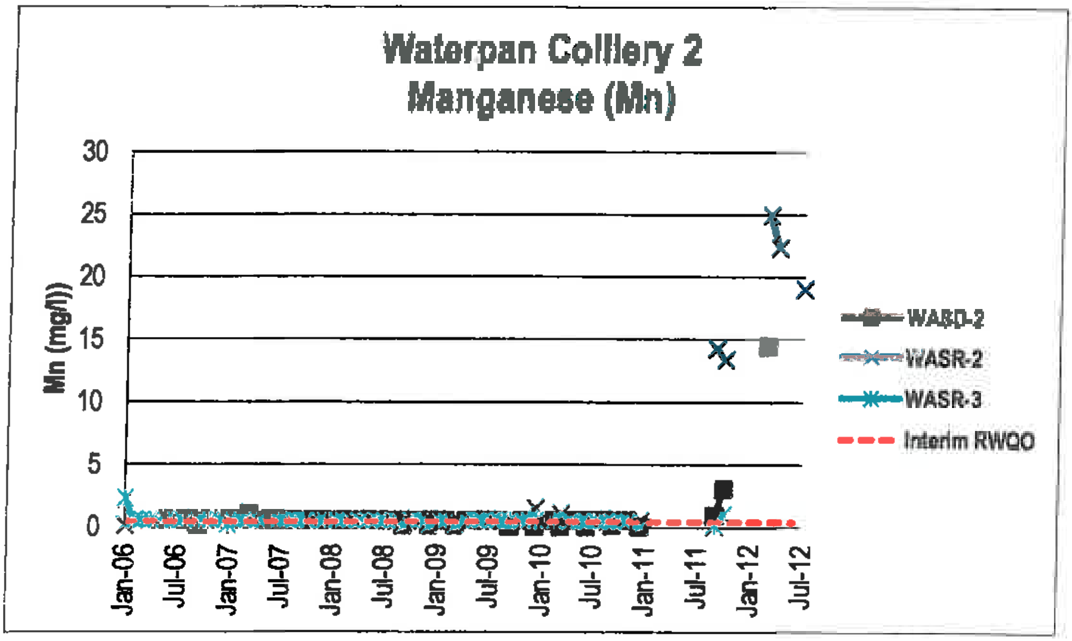

Waterpan Colliery 1
Sulfate (SO_4)
SO_4 (mg/l)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
189428
Interim RWQO

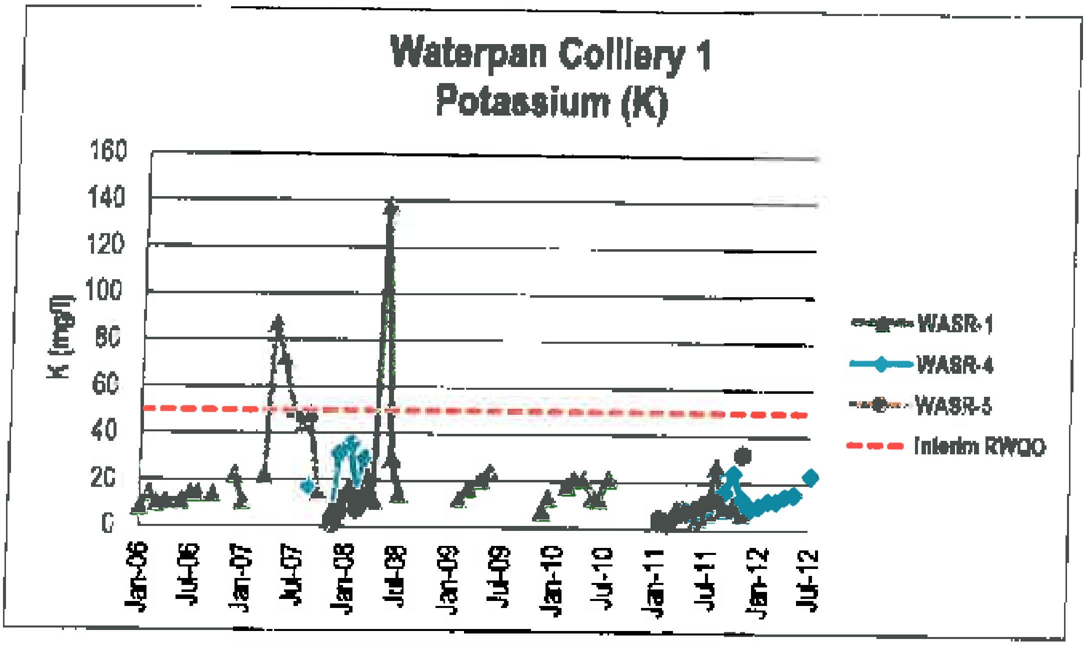

Waterpan Colliery 2
Sulfate (SO_4)
SO_4 (mg/l)
9 000
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
189430
Interim RWQO

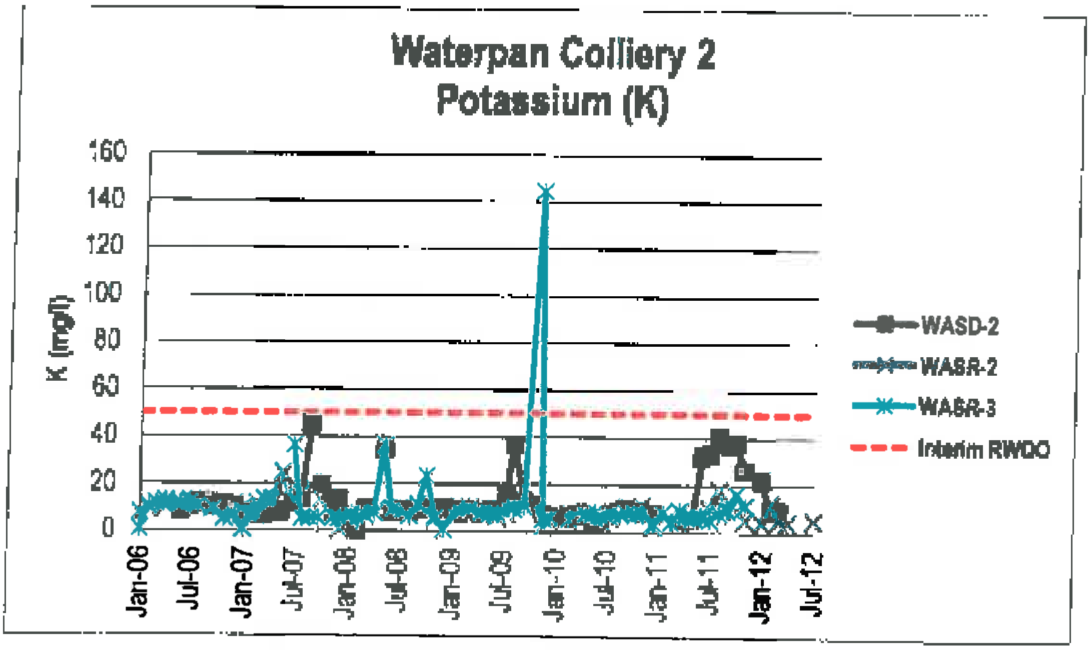

Waterpan Colliery 1
Calcium (Ca)
Ca (mg/l)
800
700
600
500
400
300
200
100
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
Interim RWQO

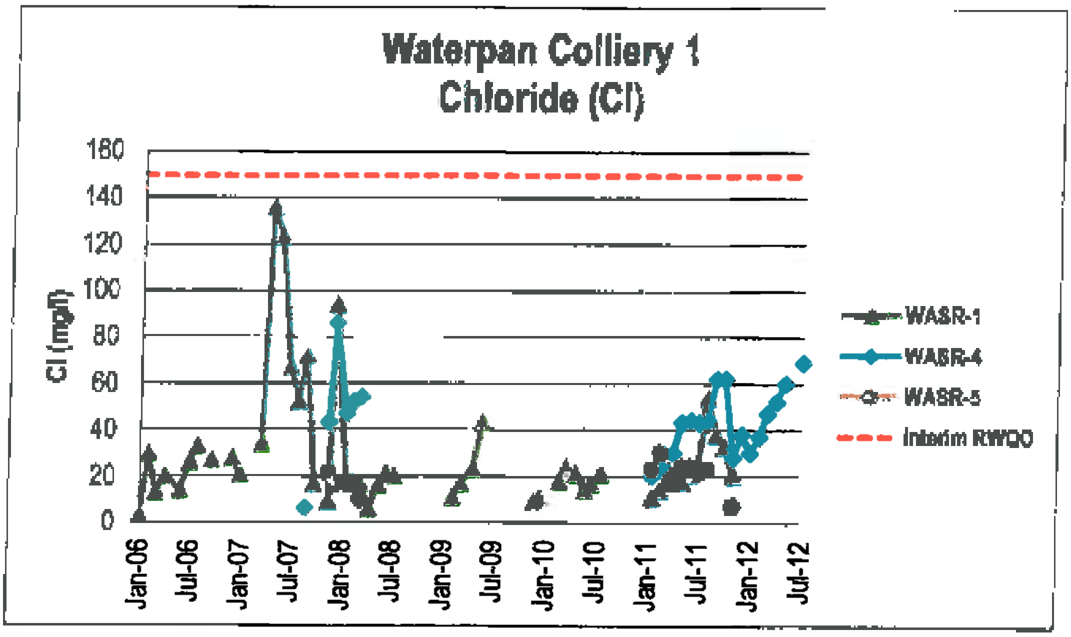

Waterpan Colliery 2
Calcium (Ca)
Ca (mg/l)
800
700
600
500
400
300
200
100
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
Interim RWQO

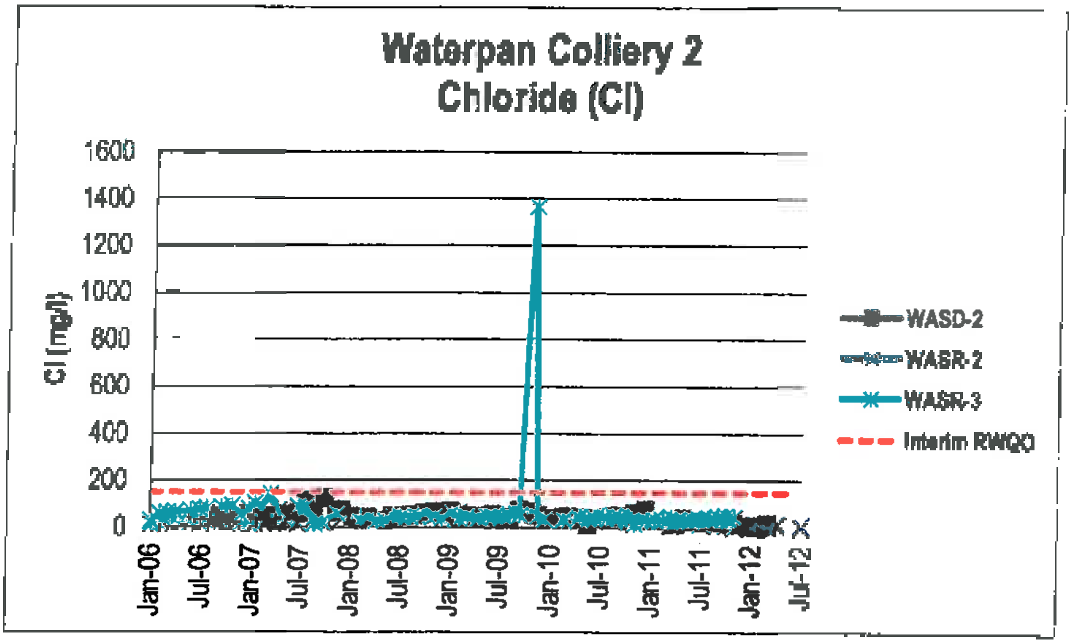

Waterpan Colliery 1
Magnesium (Mg)
Mg (mg/l)
1000
900
800
700
600
500
400
300
200
100
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
Interim RWQO

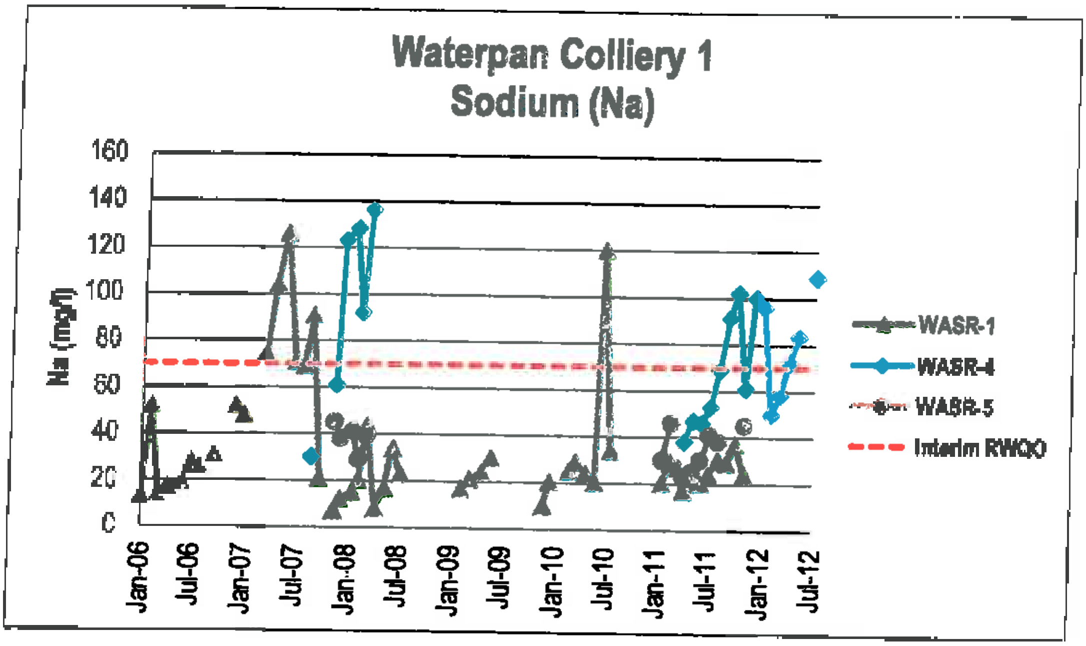

Waterpan Colliery 2
Manganese (Mn)
Mn (mg/l))
30
25
20
15
10
5
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
Interim RWQO


Waterpan Colliery 1
Potassium (K)
K (mg/l)
160
140
120
100
80
60
40
20
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
Interim RWQO

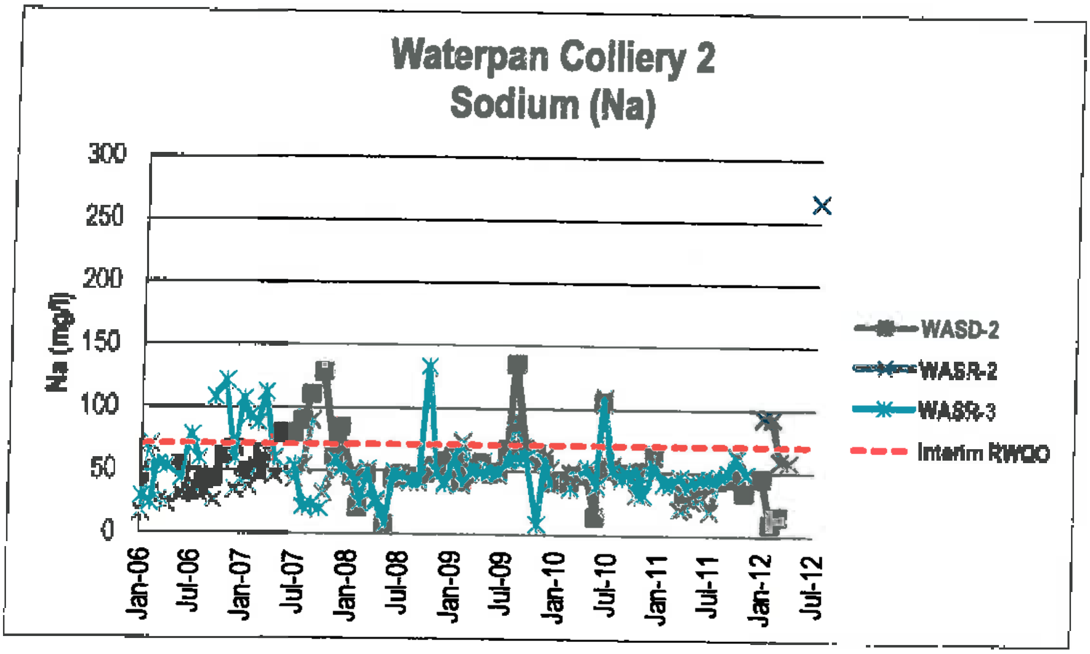

Waterpan Colliery 2
Potassium (K)
K (mg/l)
160
140
120
100
80
60
40
20
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
Interim RWQO


Waterpan Colliery 1
Chloride (Cl)
160
140
120
100
80
60
40
20
0
Cl (mg/l)
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
Interim RWQO

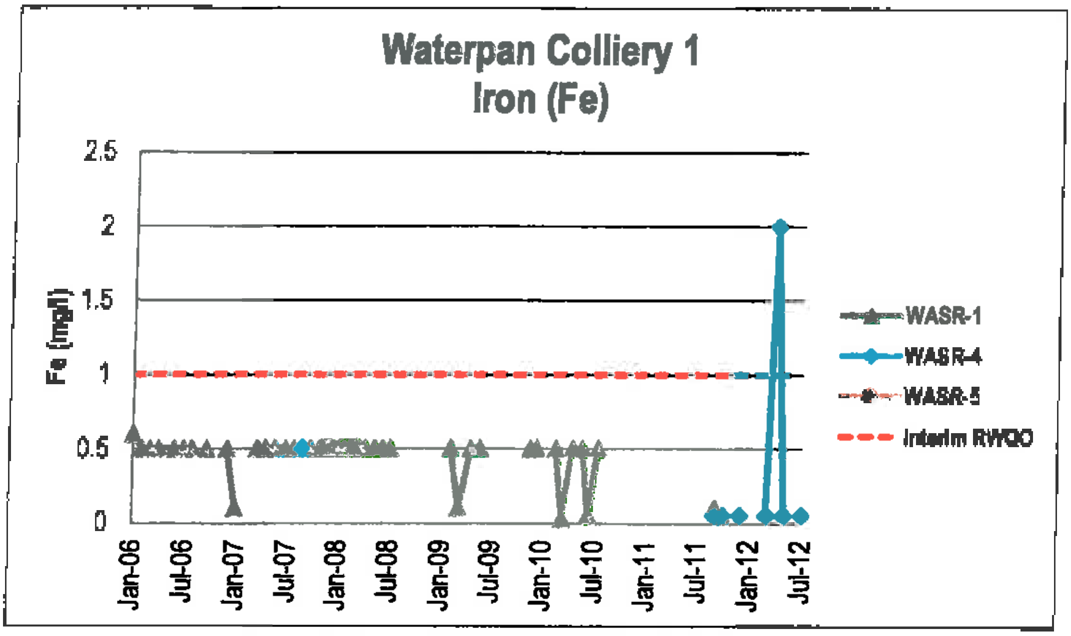

Waterpan Colliery 2
Chloride (Cl)
1600
1400
1200
1000
800
600
400
200
0
Cl (mg/l)
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
Interim RWQO



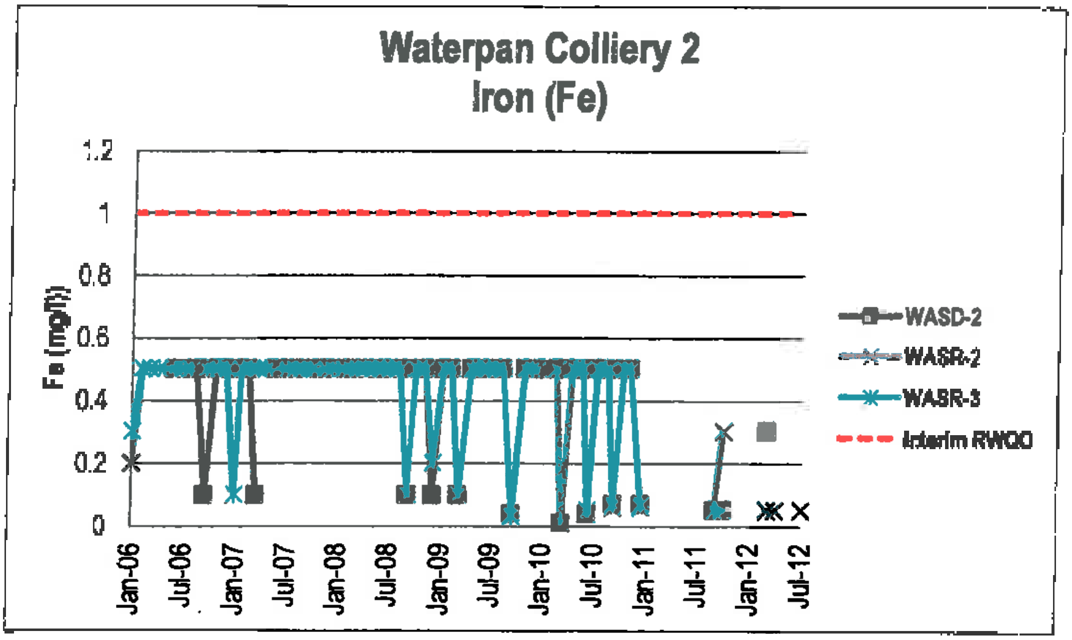
Waterpan Colliery 1
Sodium (Na)
160
140
120
100
80
60
40
20
0
Na (mg/l)
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
Interim RWQO



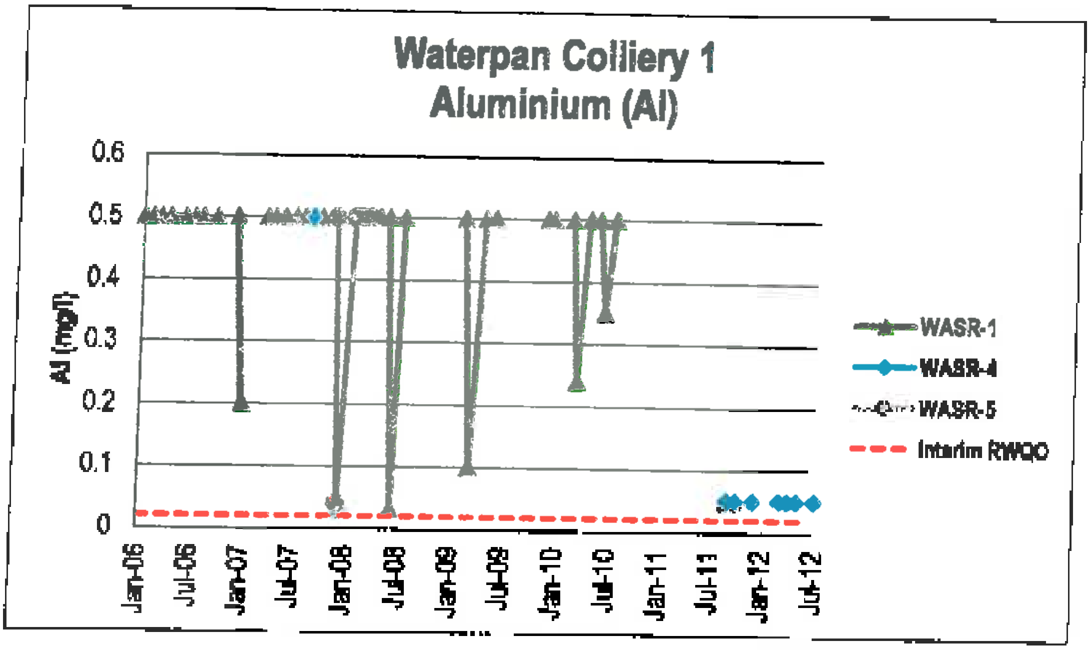
Waterpan Colliery 2
Sodium (Na)
300
250
200
150
100
50
0
Na (mg/l)
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
Interim RWQO

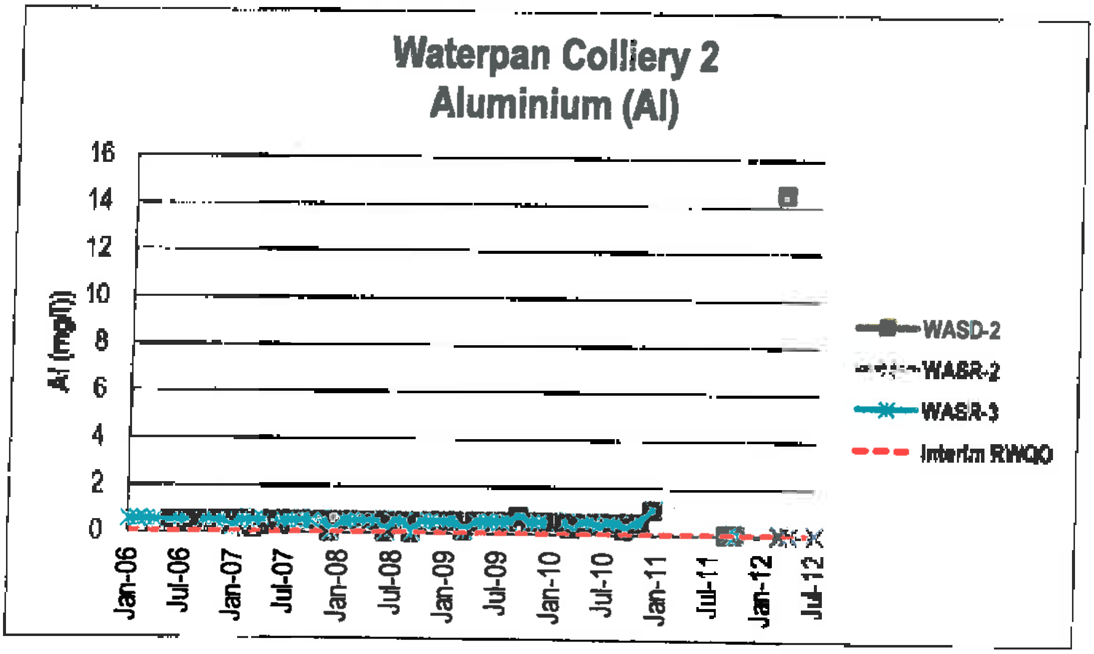


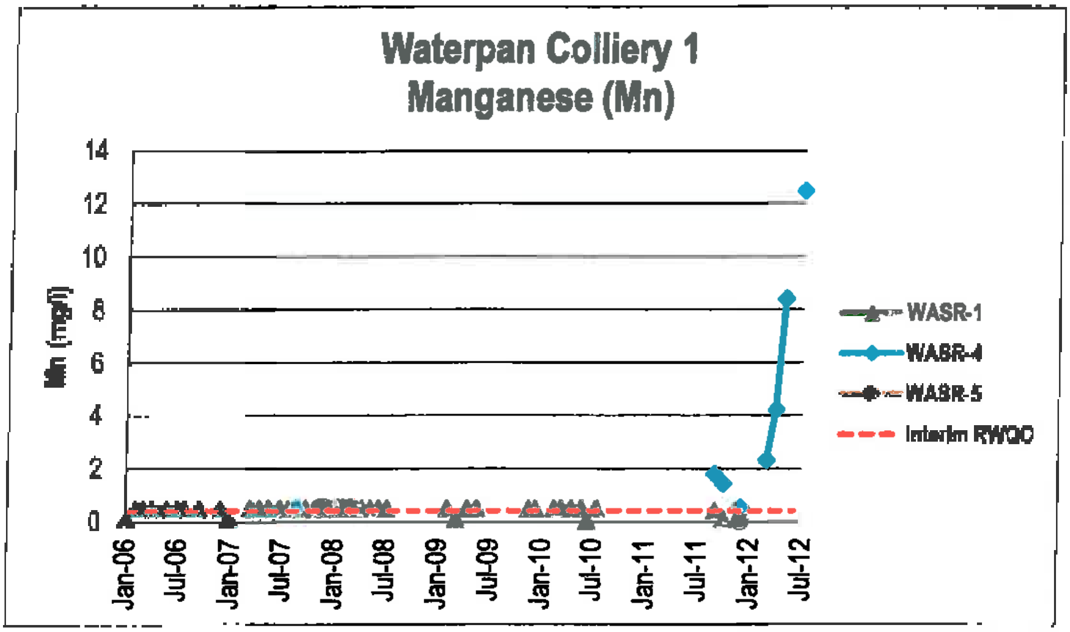
Waterpan Colliery 1
Iron (Fe)
Fe (mg/l)
2.5
2
1.5
1
0.5
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
Interim RWQO

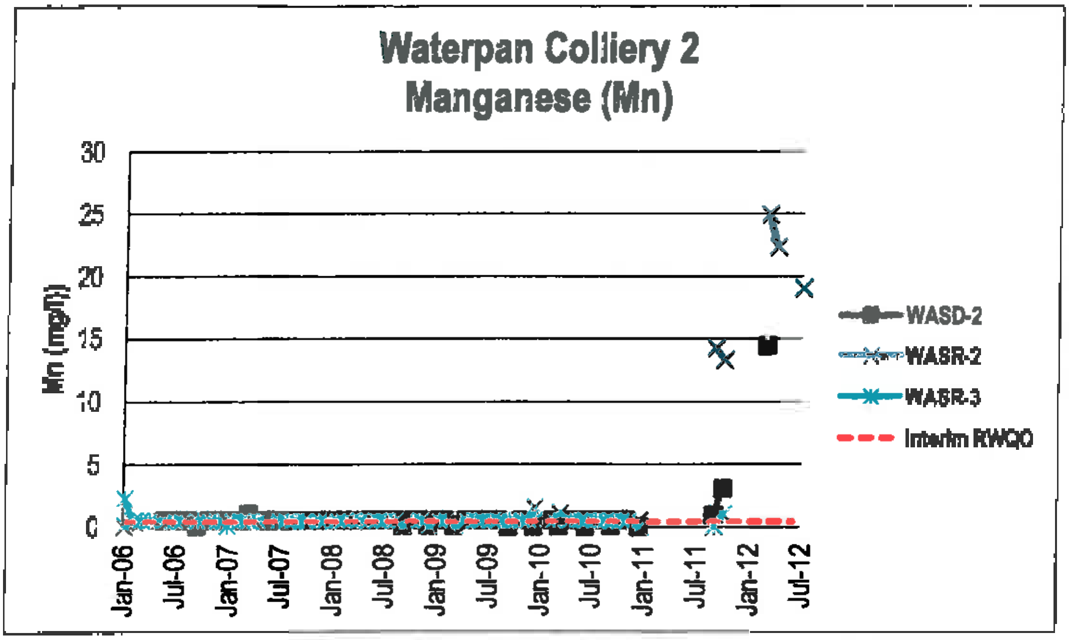


Waterpan Colliery 2
Iron (Fe)
Fe (mg/l)
1.2
1
0.8
0.6
0.4
0.2
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
Interim RWQO


Waterpan Colliery 1
Aluminium (Al)
Al (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
Interim RWQO

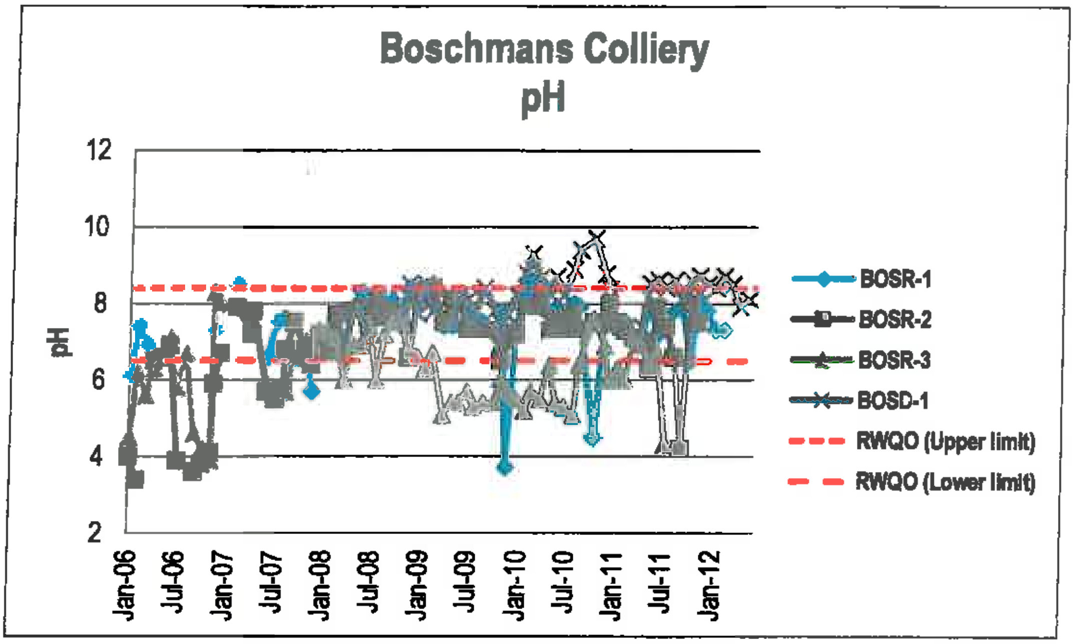

Waterpan Colliery 2
Aluminium (Al)
Al (mg/l)
16
14
12
10
8
6
4
2
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
Interim RWQO

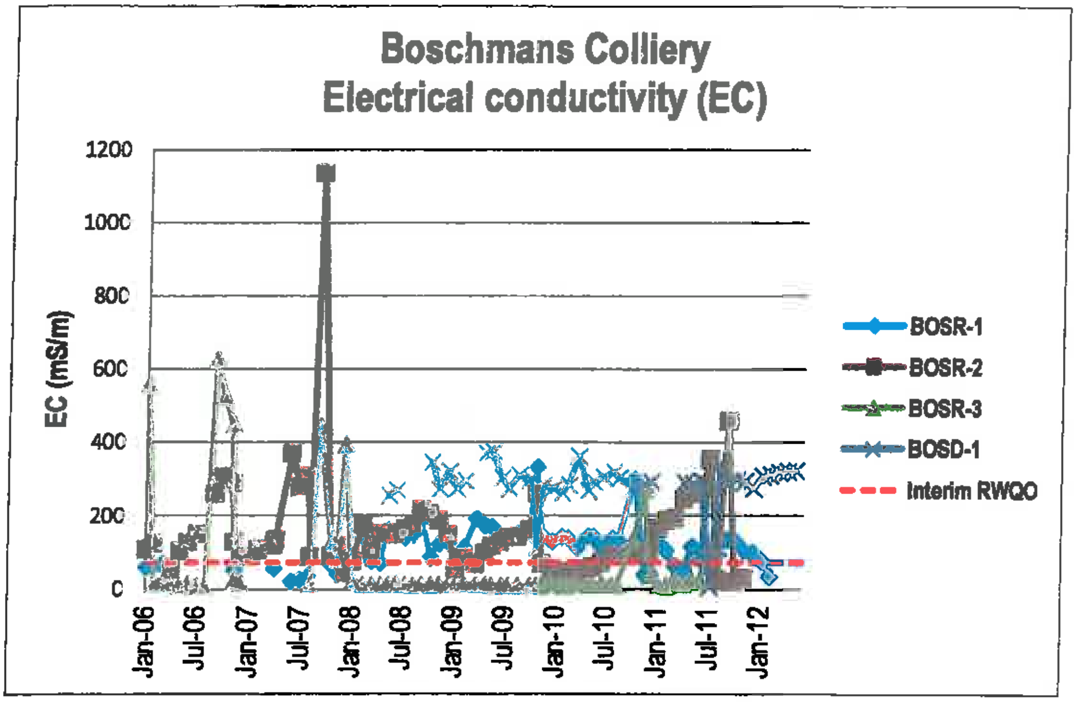

Waterpan Colliery 1
Manganese (Mn)
Mn (mg/l)
14
12
10
8
6
4
2
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASR-1
WASR-4
WASR-5
Interim RWQO

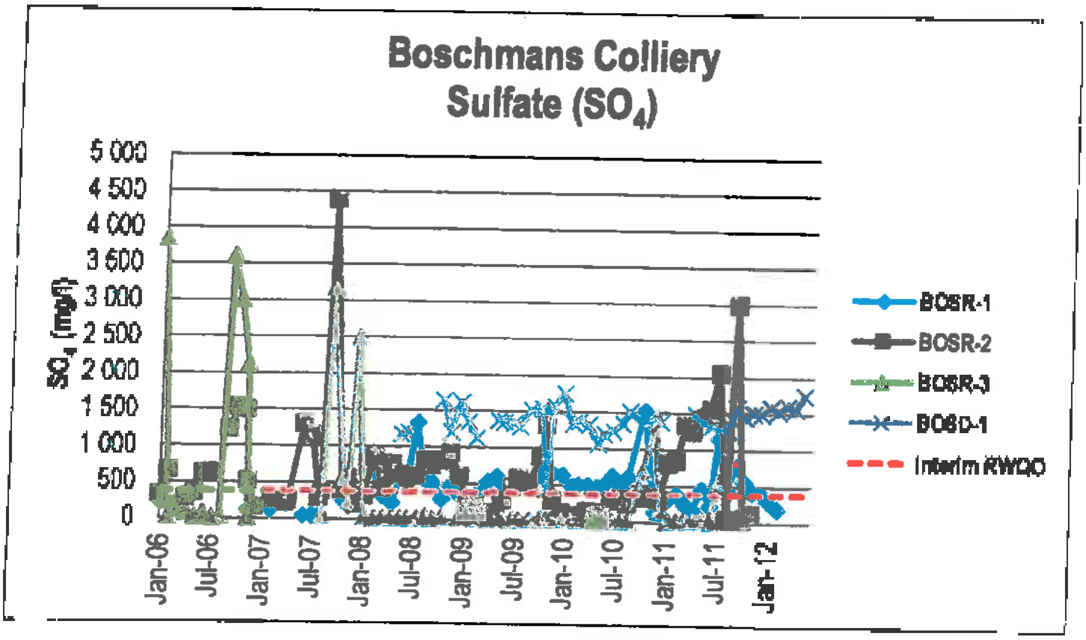

Waterpan Colliery 2
Manganese (Mn)
Mn (mg/l)
30
25
20
15
10
5
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
WASD-2
WASR-2
WASR-3
Interim RWQO

APPENDIX B2b

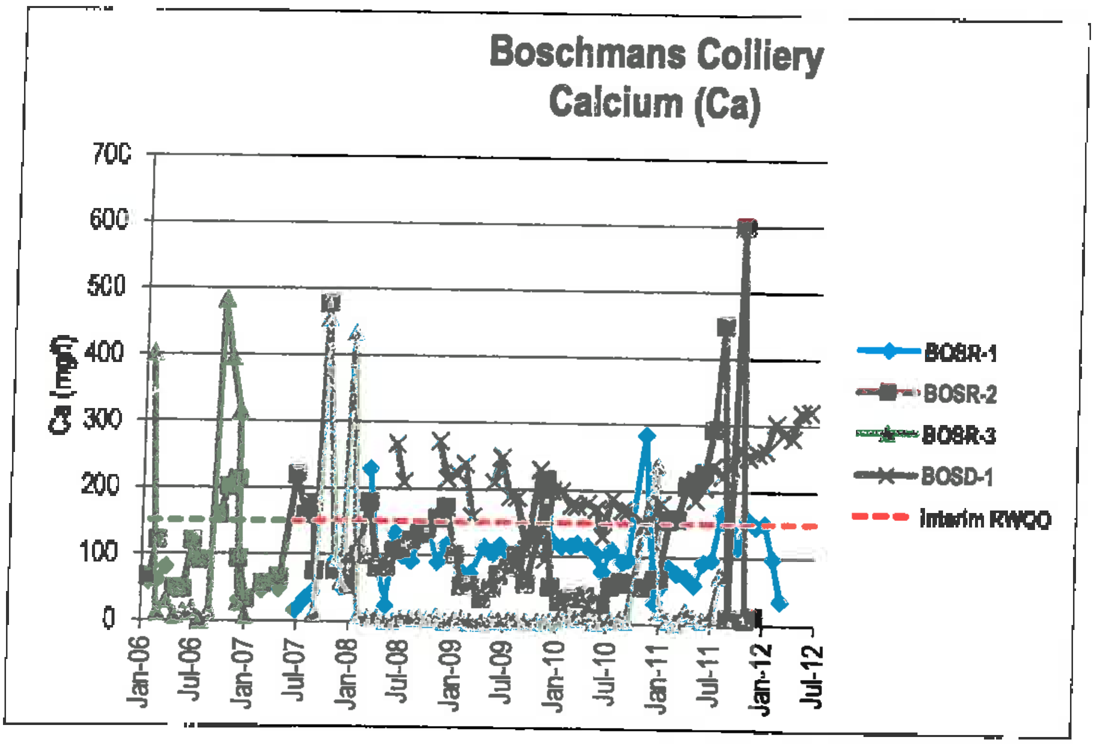
TIME SERIES GRAPHS: BOSCHMANS COLLIERY


Boschmans Colliery
pH
12
10
8
6
4
2
pH
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
RWQO (Upper limit)
RWQO (Lower limit)

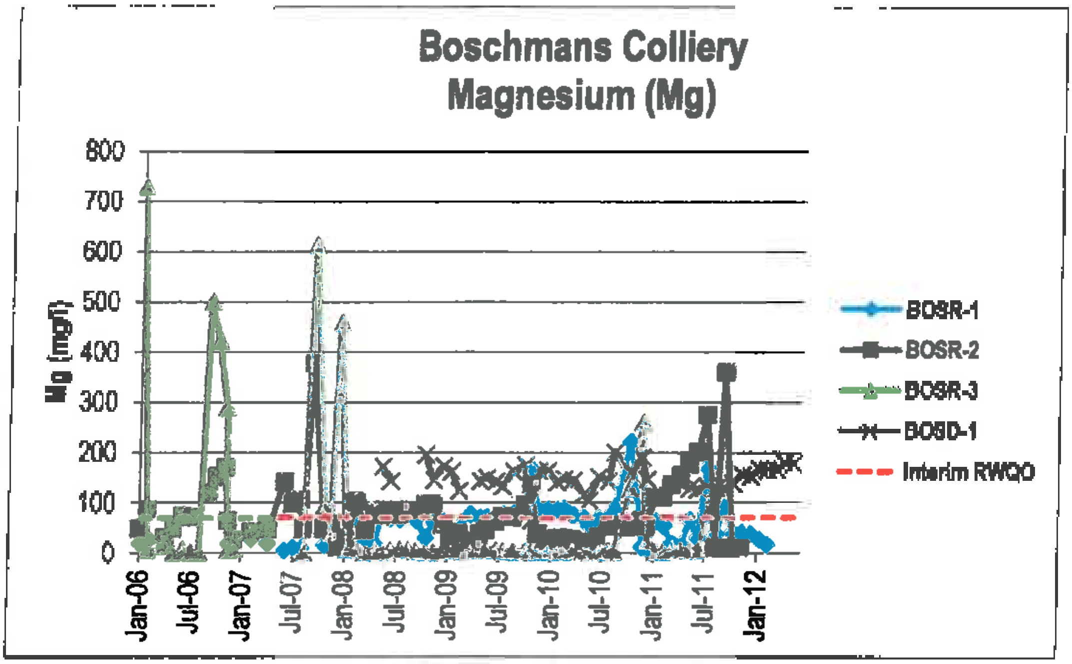

Boschmans Colliery
Electrical conductivity (EC)
1200
1000
800
600
400
200
0
EC (mS/m)
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO



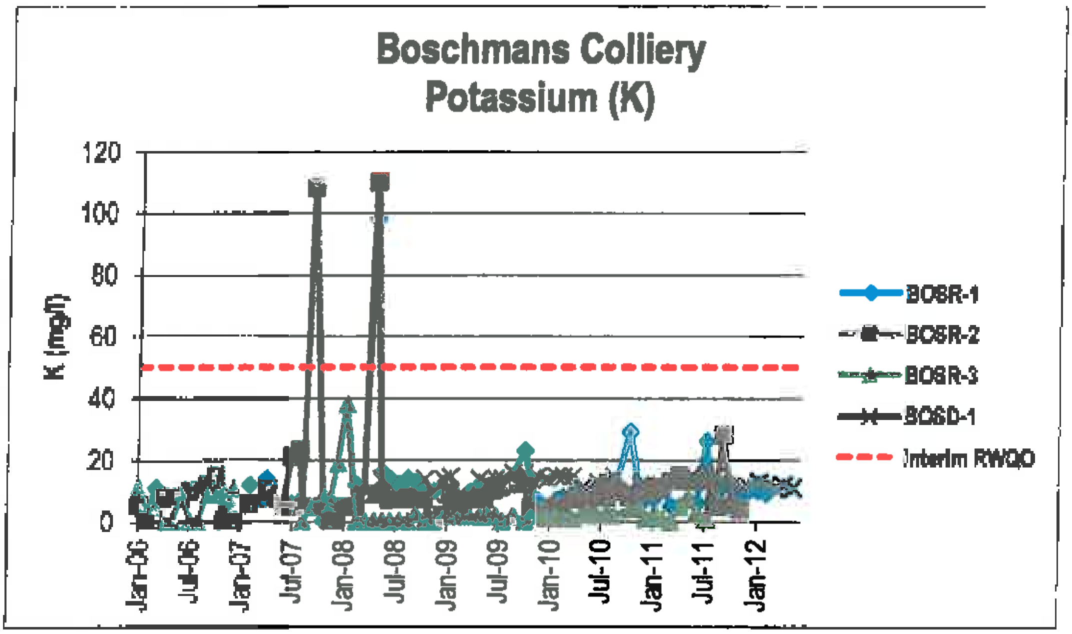
Boschmans Colliery
Sulfate (SO_4)
5 000
4 500
4 000
3 500
3 000
2 500
2 000
1 500
1 000
500
0
SO_4 (mg/l)
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO



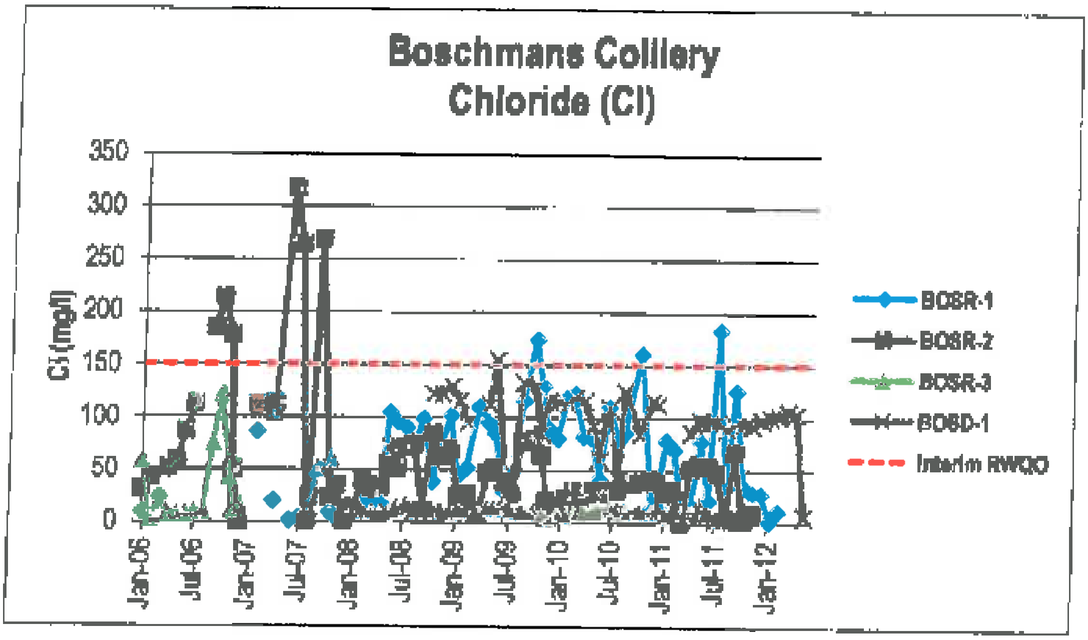
Boschmans Colliery
Calcium (Ca)
700
600
500
400
300
200
100
0
Ca (mg/l)
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
Jul-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO

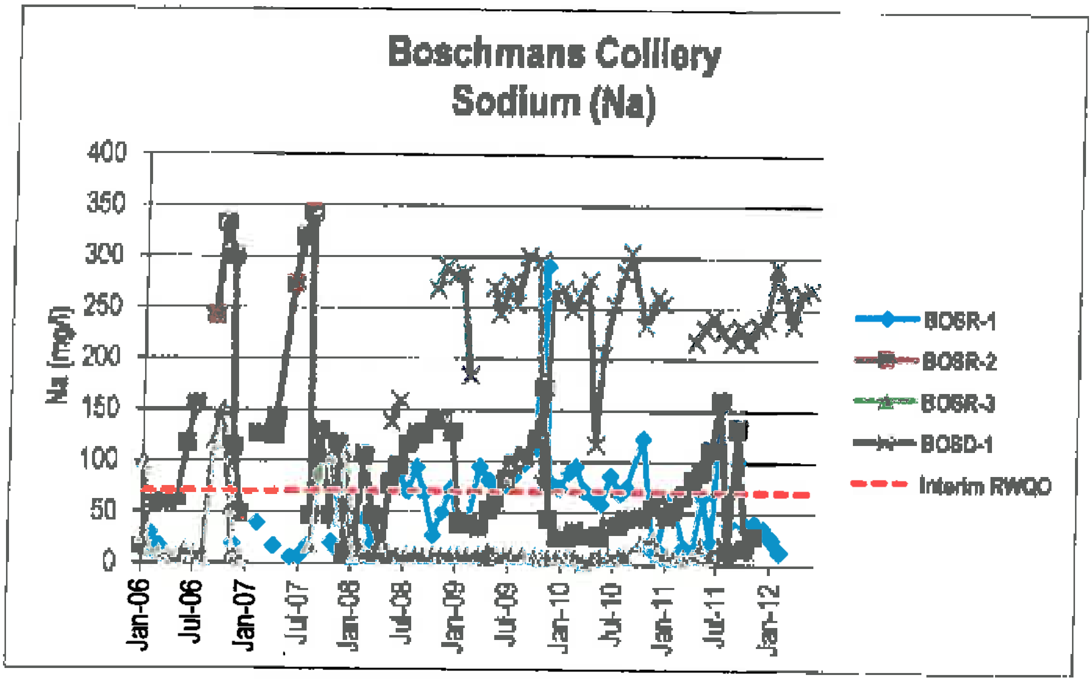


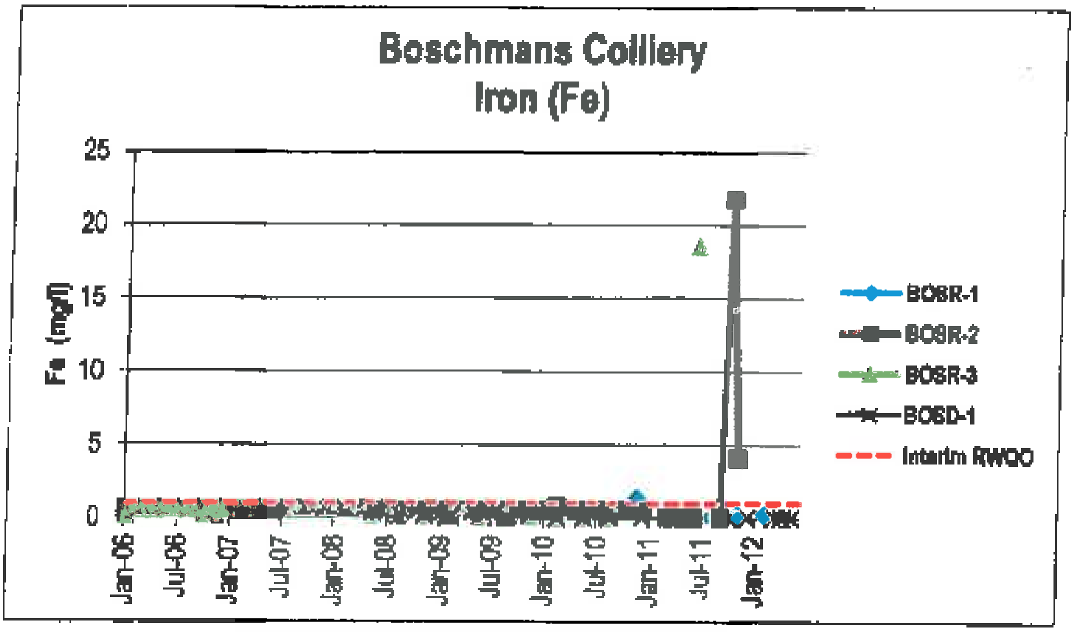
Boschmans Colliery
Magnesium (Mg)
Mg (mg/l)
800
700
600
500
400
300
200
100
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO



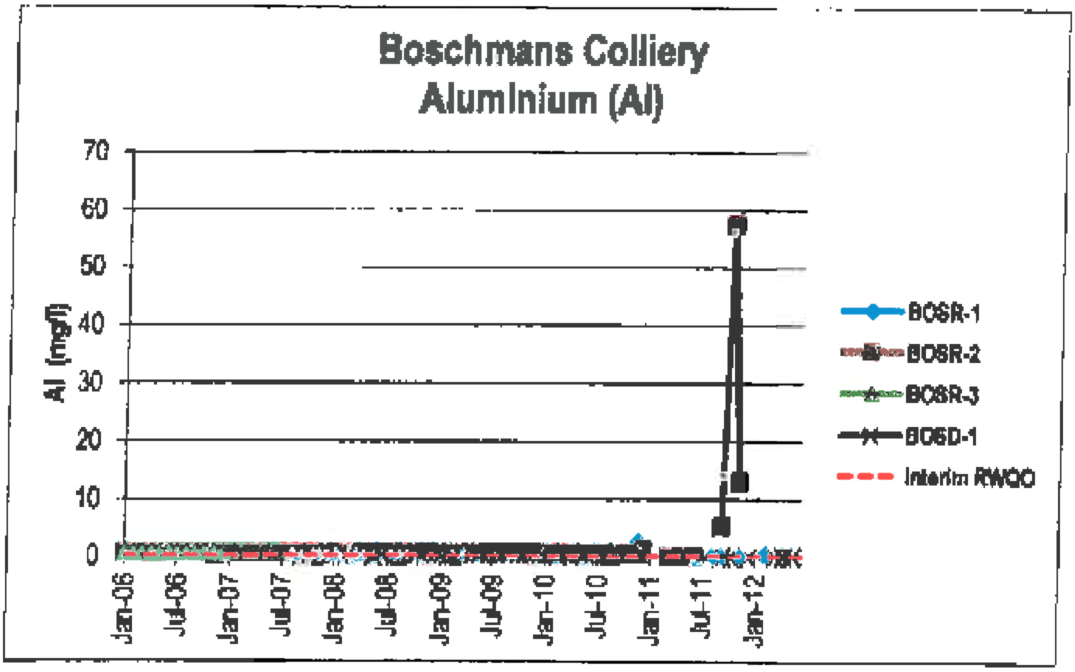
Boschmans Colliery
Potassium (K)
K (mg/l)
120
100
80
60
40
20
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO


Boschmans Colliery
Chloride (Cl)
Cl (mg/l)
350
300
250
200
150
100
50
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO

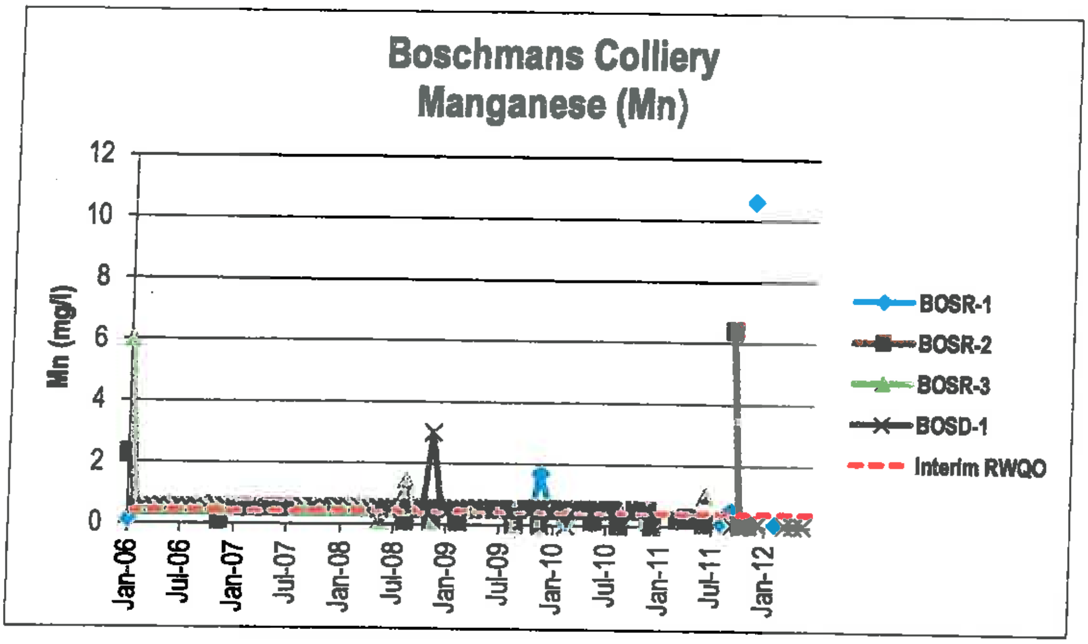

Boschmans Colliery
Sodium (Na)
Na (mg/l)
400
350
300
250
200
150
100
50
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO



Boschmans Colliery
Iron (Fe)
Fe (mg/l)
25
20
15
10
5
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO



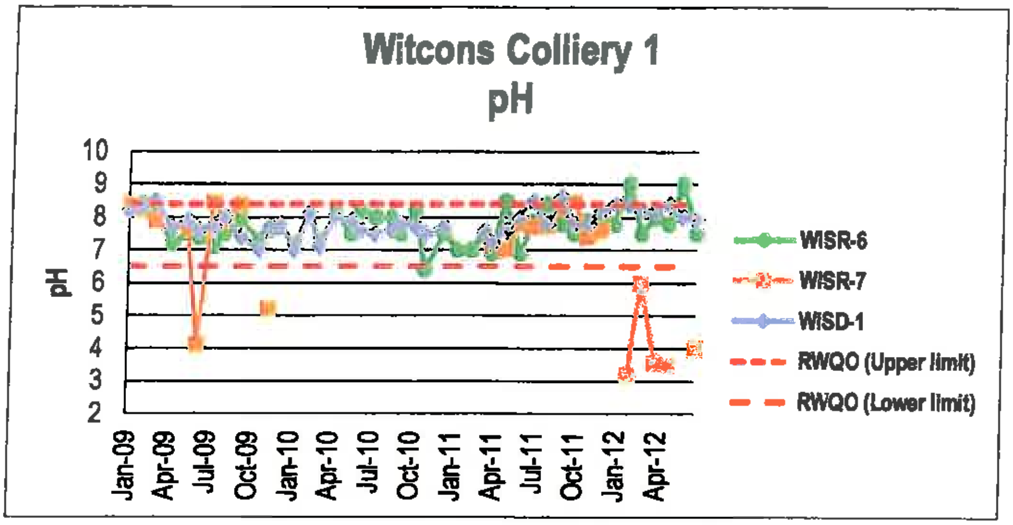
Boschmans Colliery
Aluminium (Al)
Al (mg/l)
70
60
50
40
30
20
10
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO

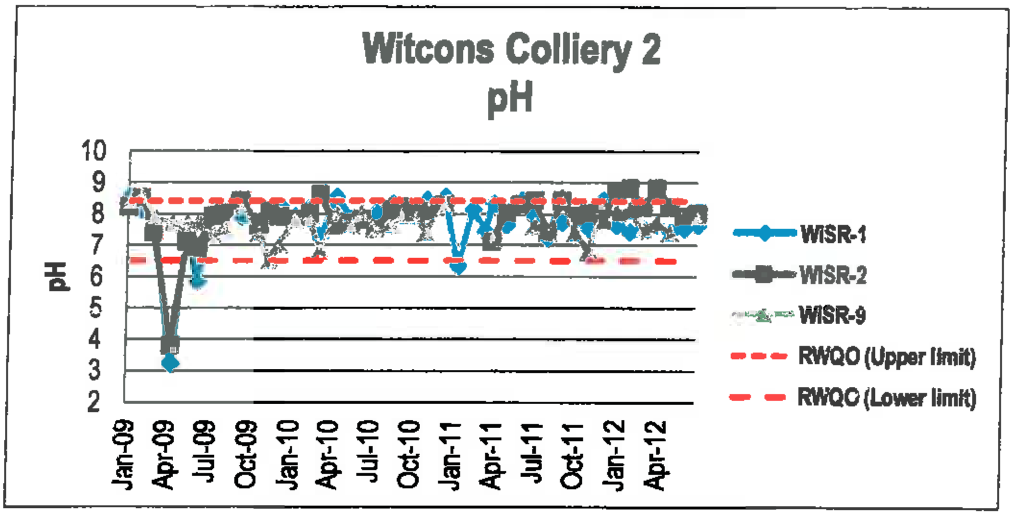


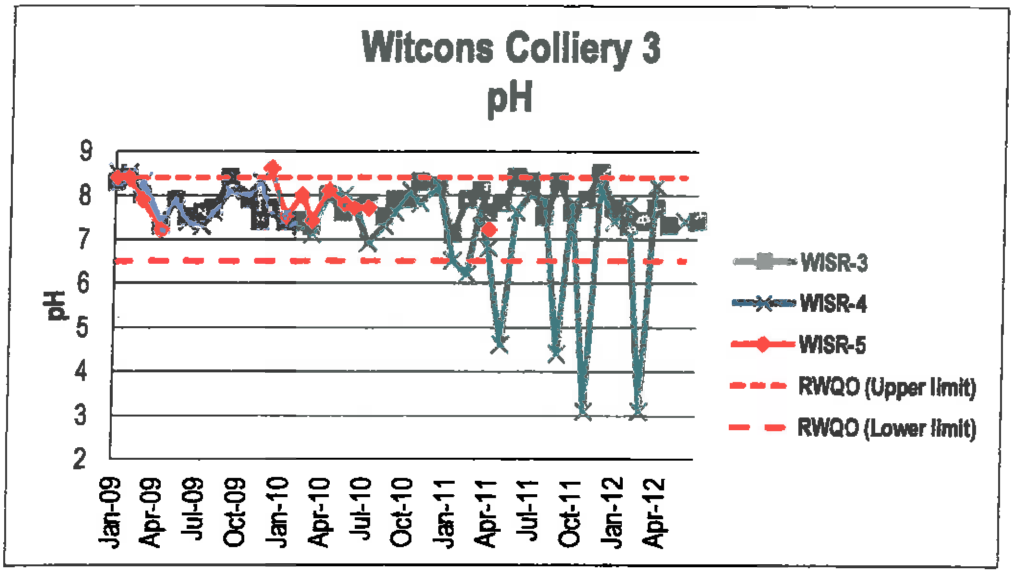
Boschmans Colliery
Manganese (Mn)
Mn (mg/l)
12
10
8
6
4
2
0
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08
Jan-09
Jul-09
Jan-10
Jul-10
Jan-11
Jul-11
Jan-12
BOSR-1
BOSR-2
BOSR-3
BOSD-1
Interim RWQO

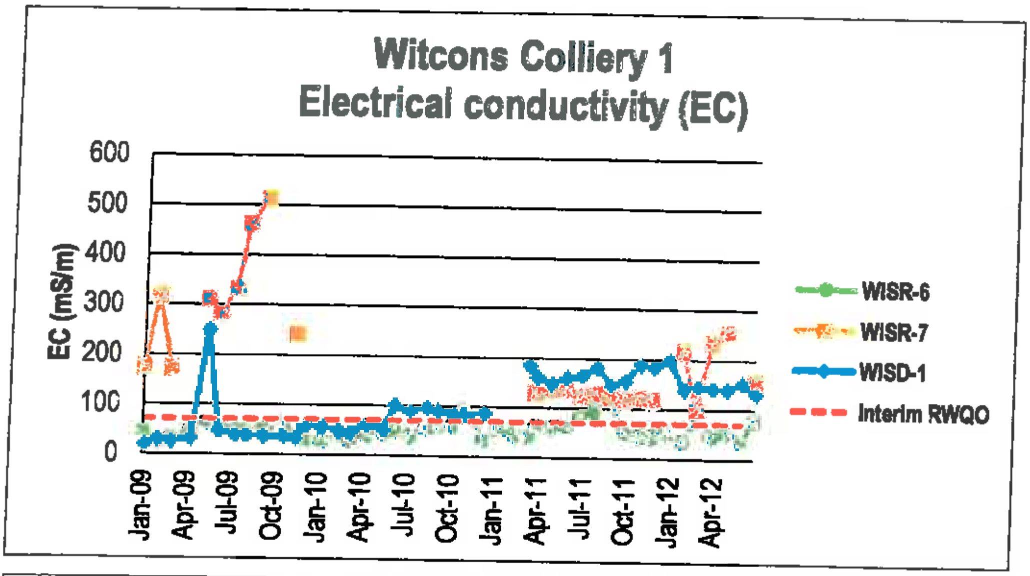
APPENDIX B2c

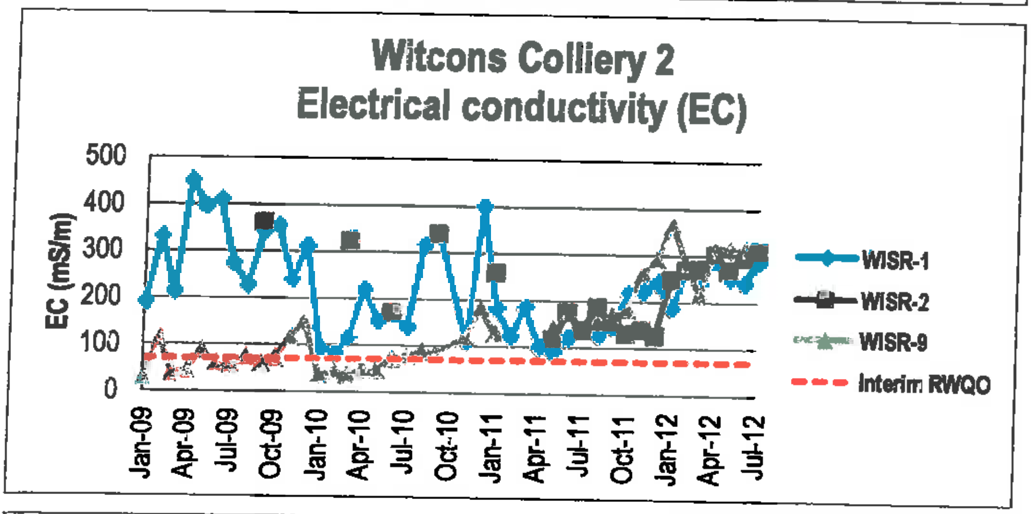
TIME SERIES GRAPHS: WITCONS COLLIERY

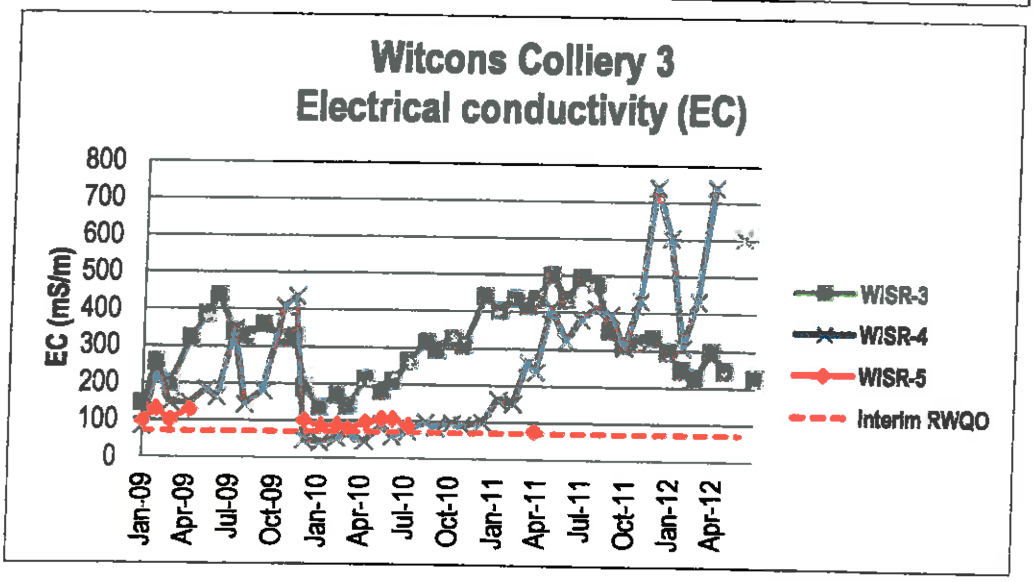

Witcons Colliery 1
pH
10
9
8
7
6
5
4
3
2
pH
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
RWQO (Upper limit)
RWQO (Lower limit)

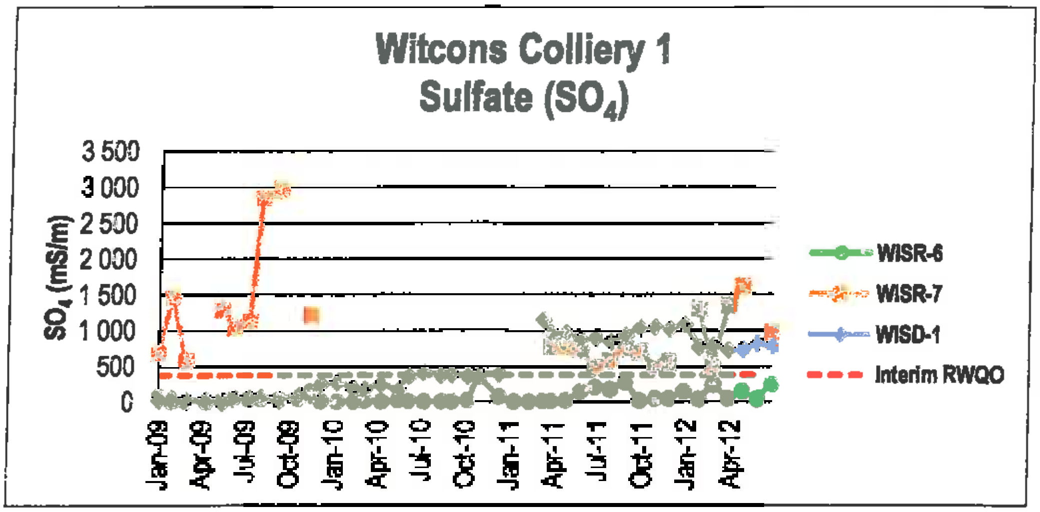

Witcons Colliery 2
pH
10
9
8
7
6
5
4
3
2
pH
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-1
WISR-2
WISR-9
RWQO (Upper limit)
RWQO (Lower limit)


Witcons Colliery 3
pH
9
8
7
6
5
4
3
2
pH
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
RWQO (Upper limit)
RWQO (Lower limit)

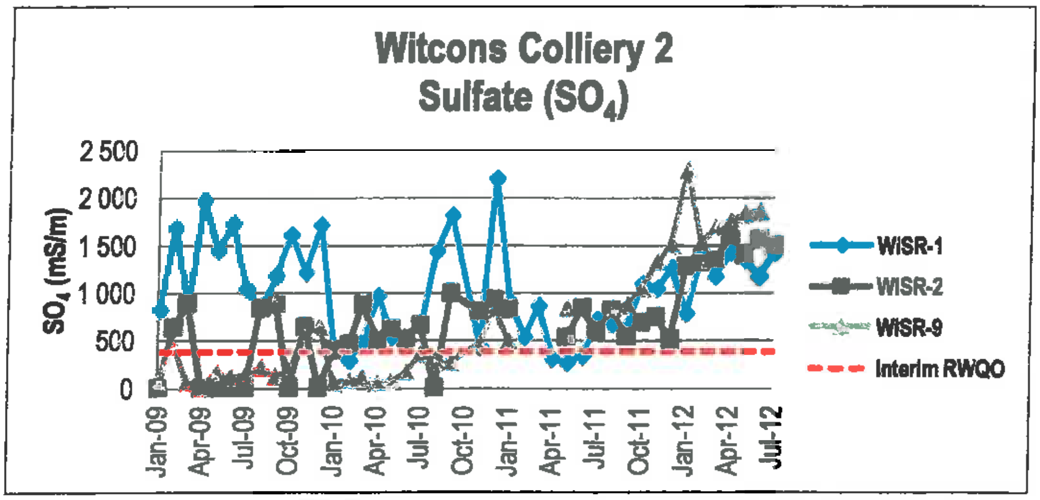

Witcons Colliery 1
Electrical conductivity (EC)
EC (mS/m)
600
500
400
300
200
100
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO


Witcons Colliery 2
Electrical conductivity (EC)
EC (mS/m)
500
400
300
200
100
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-9
Interim RWQO

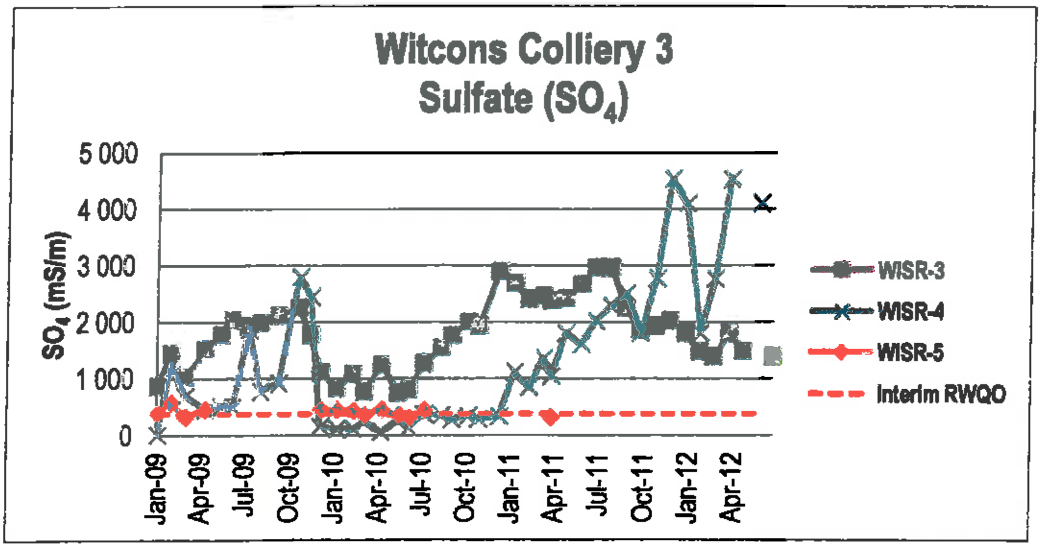

Witcons Colliery 3
Electrical conductivity (EC)
EC (mS/m)
800
700
600
500
400
300
200
100
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO



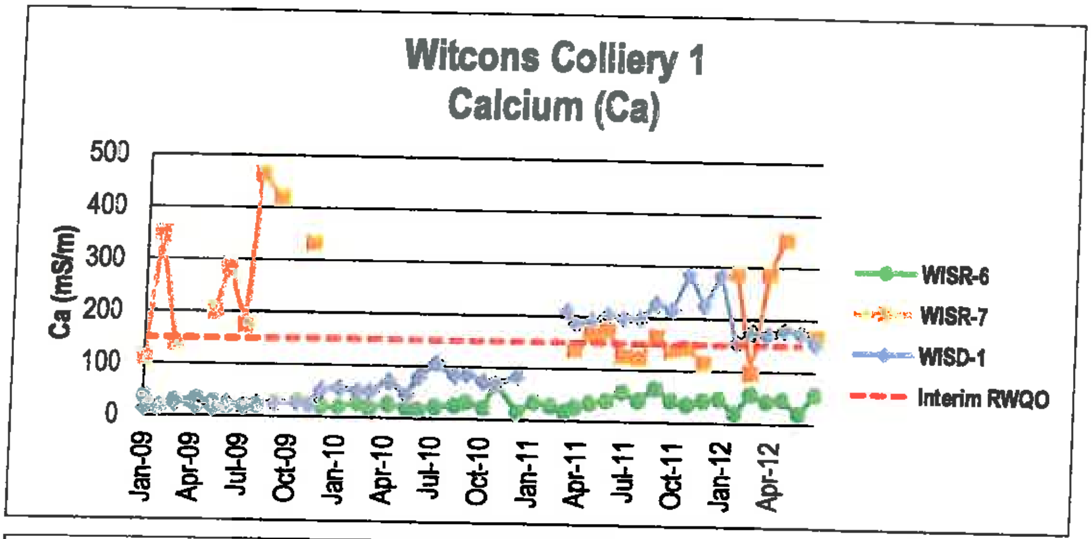
Witcons Colliery 1
Sulfate (SO_4)
SO_4 (mS/m)
3 500
3 000
2 500
2 000
1 500
1 000
500
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO



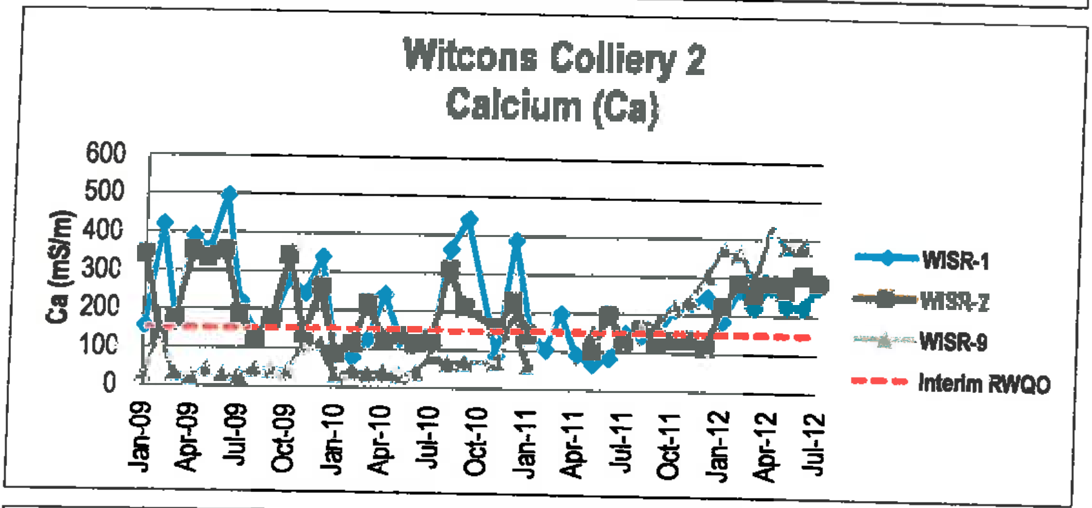
Witcons Colliery 2
Sulfate (SO_4)
SO_4 (mS/m)
2 500
2 000
1 500
1 000
500
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-9
Interim RWQO



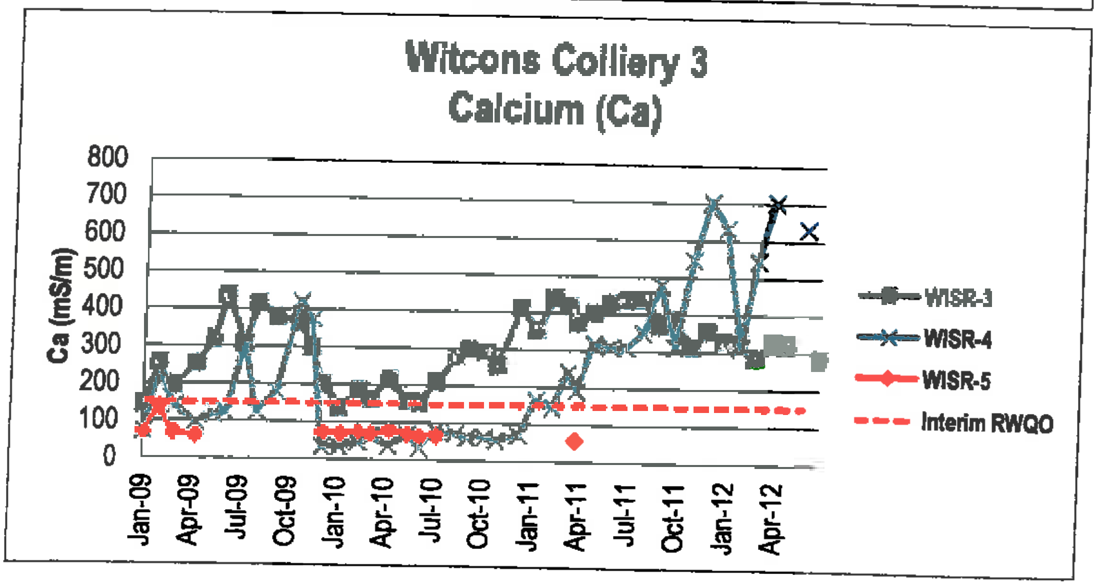
Witcons Colliery 3
Sulfate (SO_4)
SO_4 (mS/m)
5 000
4 000
3 000
2 000
1 000
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO



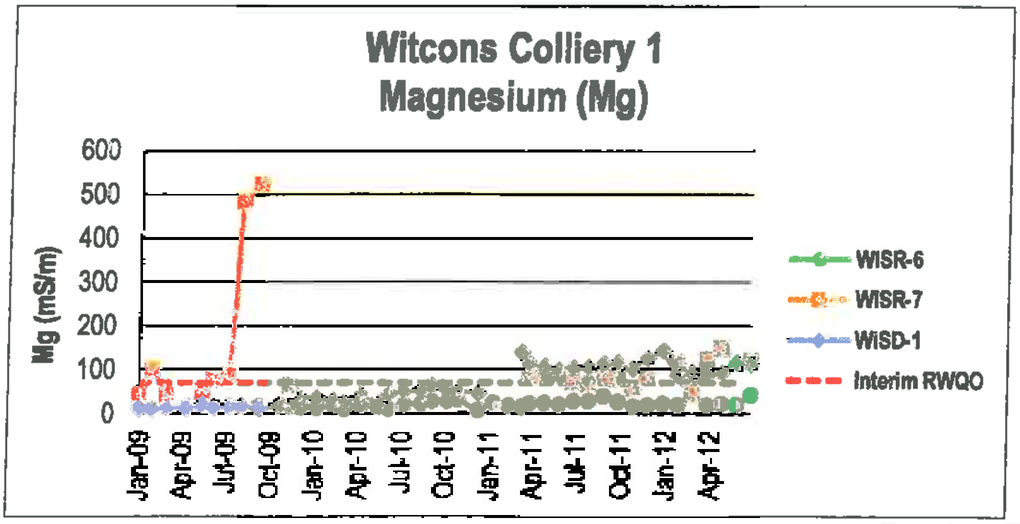
Witcons Colliery 1
Calcium (Ca)
Ca (mS/m)
500
400
300
200
100
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO

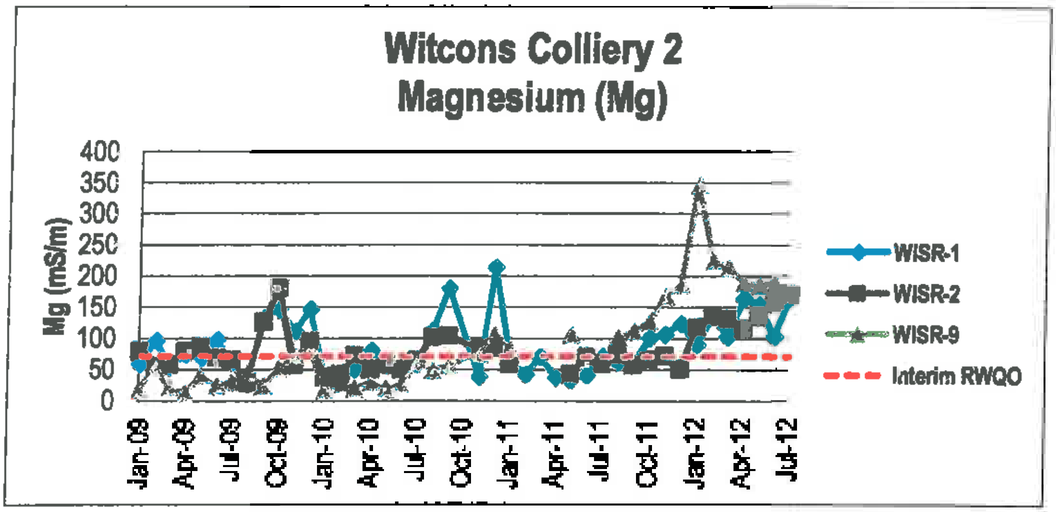


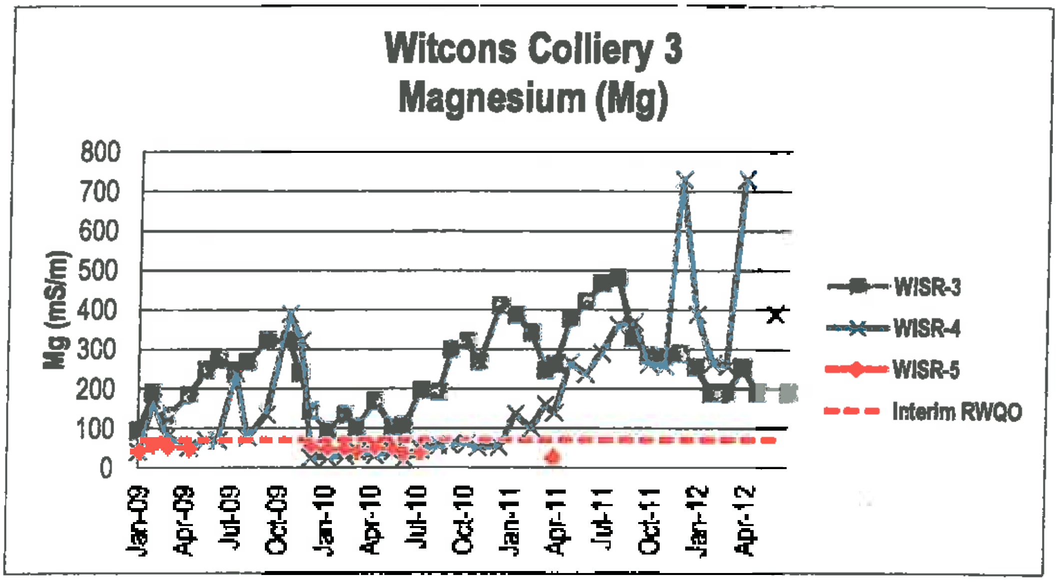
Witcons Colliery 2
Calcium (Ca)
Ca (mS/m)
600
500
400
300
200
100
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-9
Interim RWQO

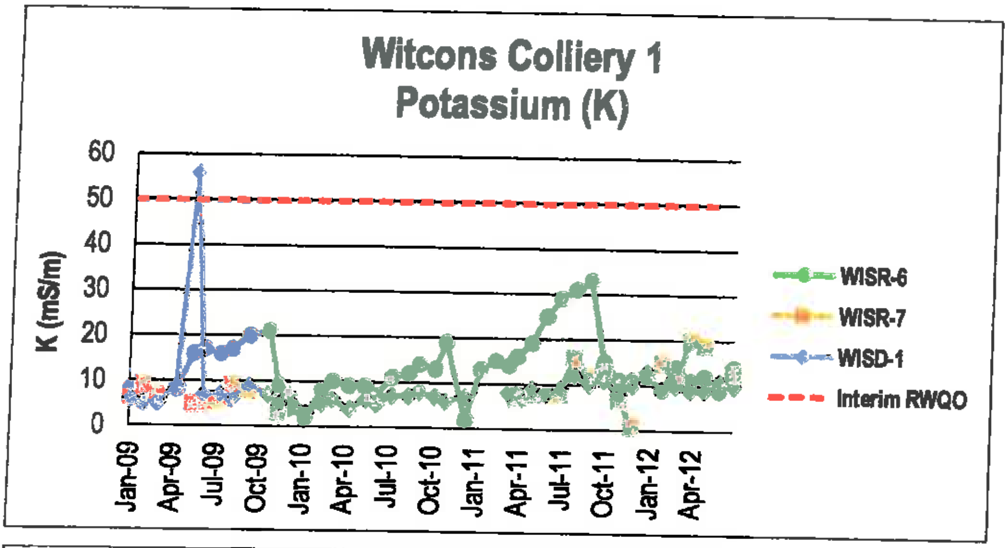


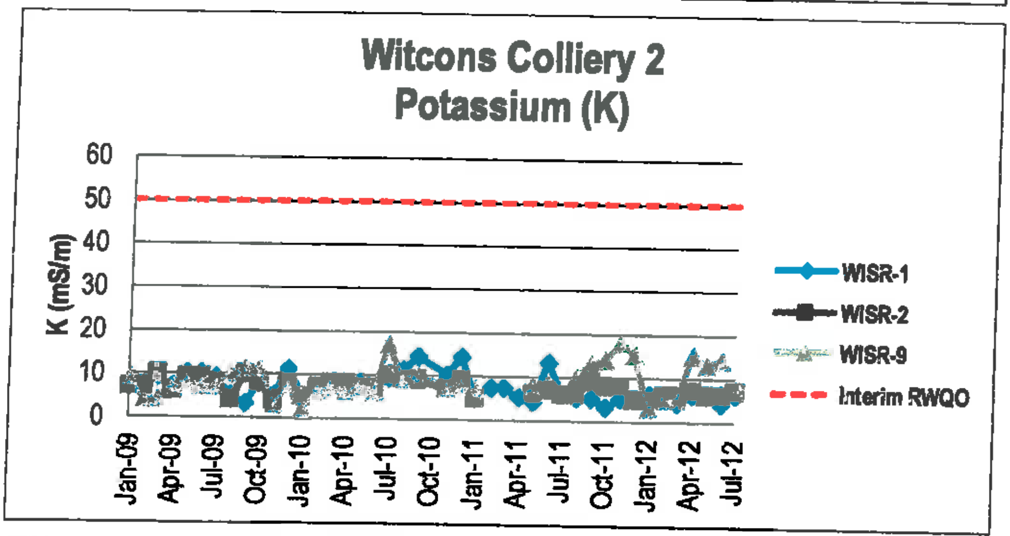
Witcons Colliery 3
Calcium (Ca)
Ca (mS/m)
800
700
600
500
400
300
200
100
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO

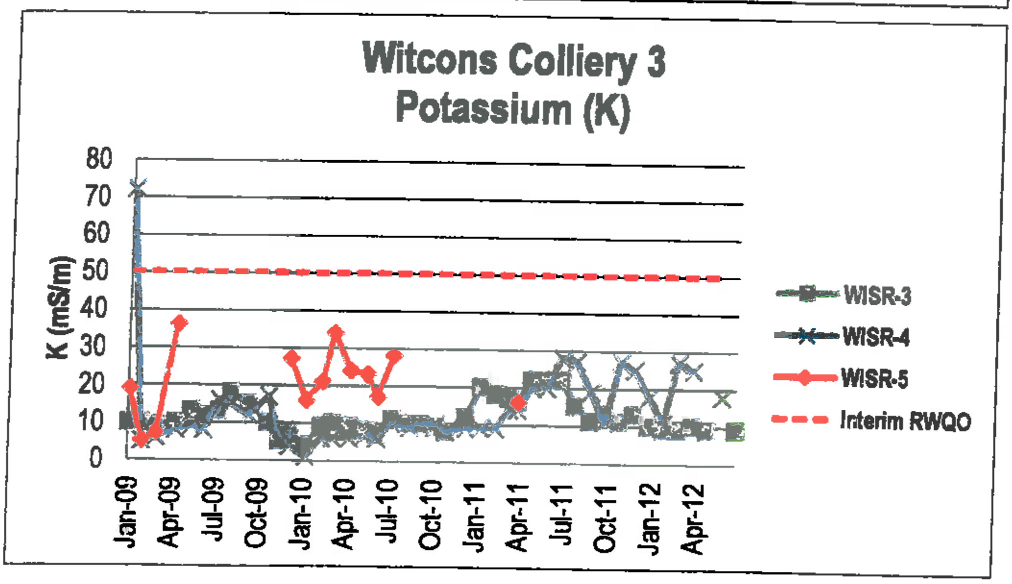

Witcons Colliery 1
Magnesium (Mg)
Mg (mS/m)
600
500
400
300
200
100
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO

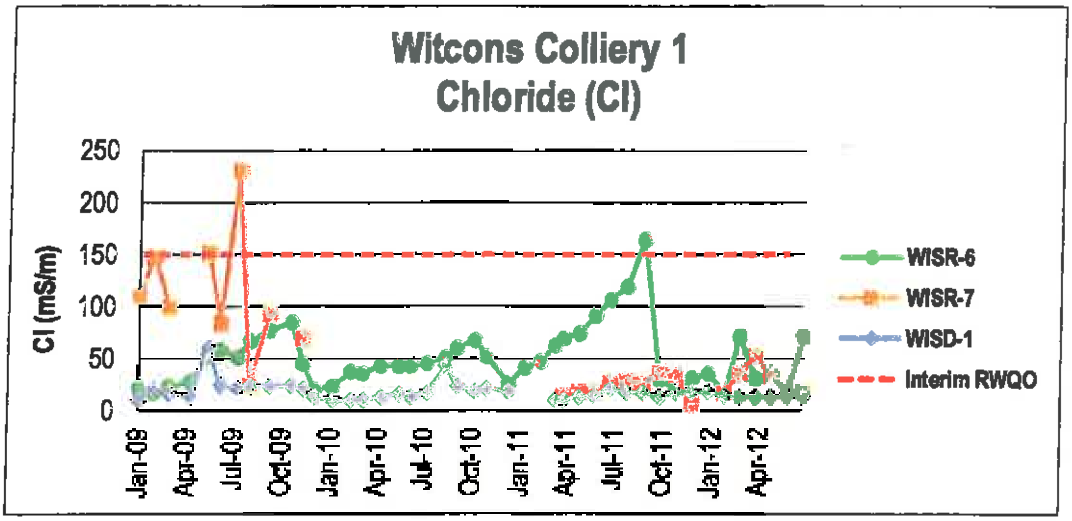

Witcons Colliery 2
Magnesium (Mg)
Mg (mS/m)
400
350
300
250
200
150
100
50
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-9
Interim RWQO


Witcons Colliery 3
Magnesium (Mg)
Mg (mS/m)
800
700
600
500
400
300
200
100
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO

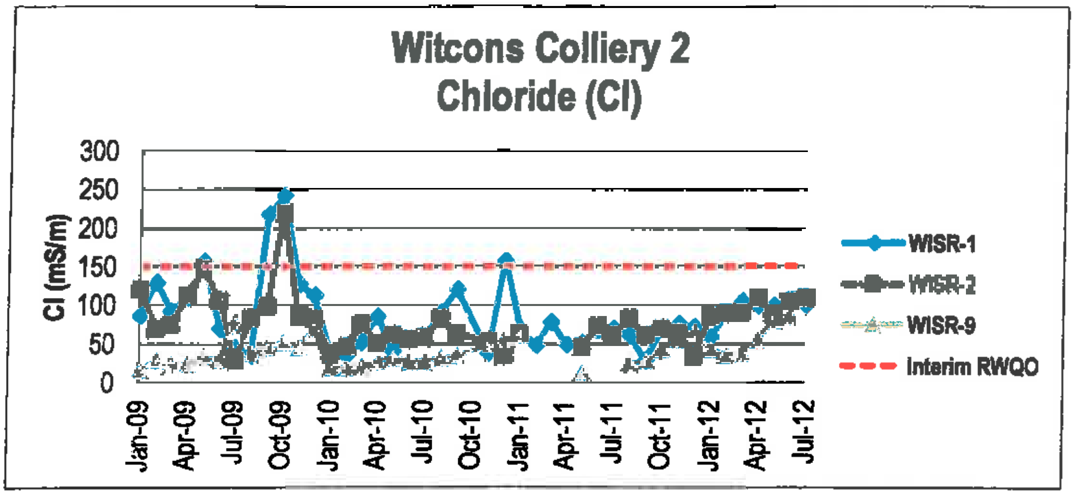

Witcons Colliery 1
Potassium (K)
K (mS/m)
60
50
40
30
20
10
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO


Witcons Colliery 2
Potassium (K)
K (mS/m)
60
50
40
30
20
10
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-9
Interim RWQO

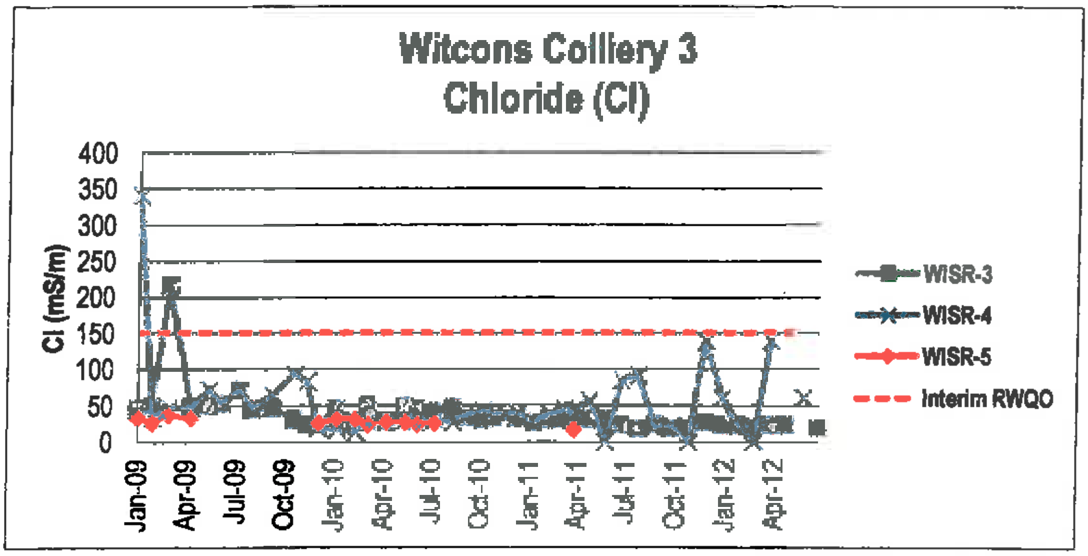

Witcons Colliery 3
Potassium (K)
K (mS/m)
80
70
60
50
40
30
20
10
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO



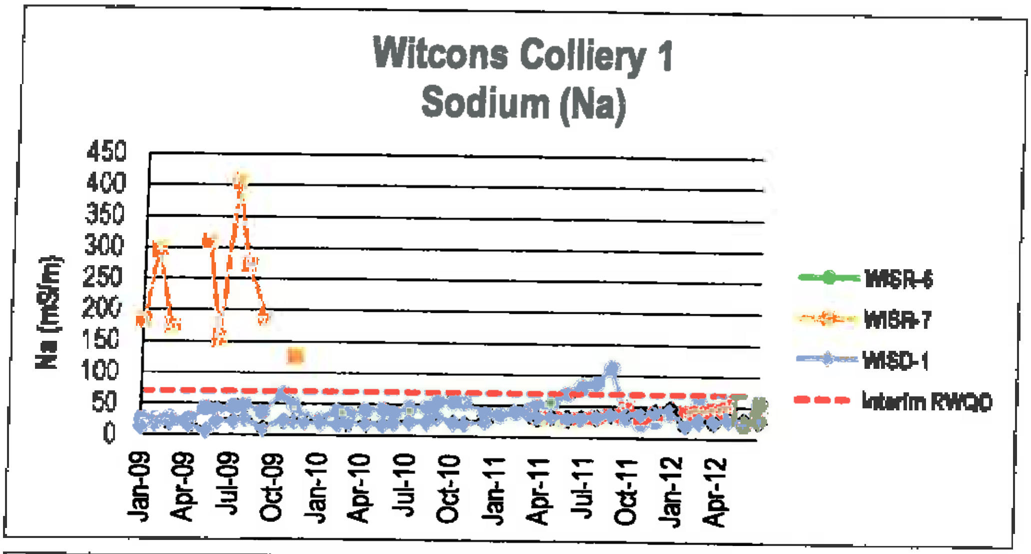
Witcons Colliery 1
Chloride (Cl)
Cl (mS/m)
250
200
150
100
50
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO

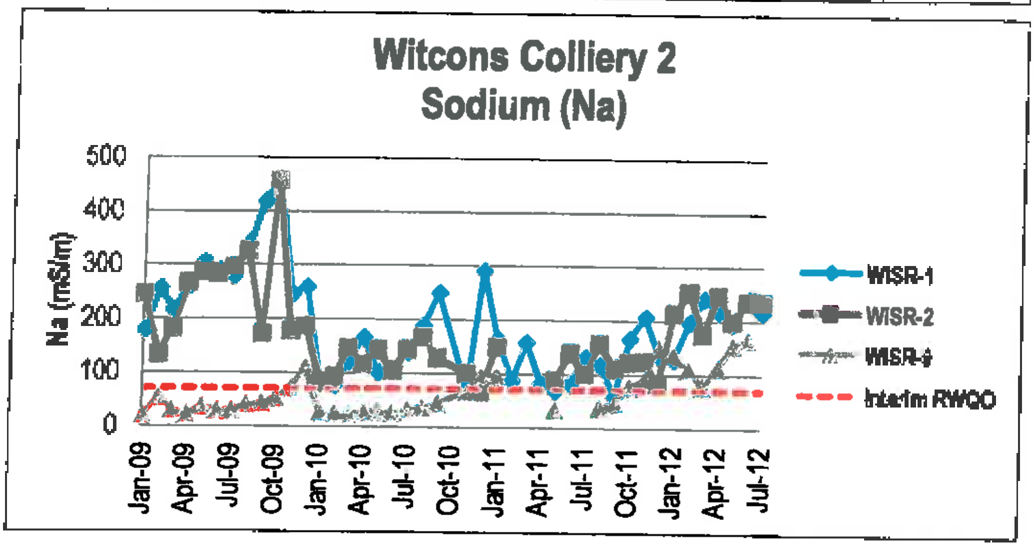


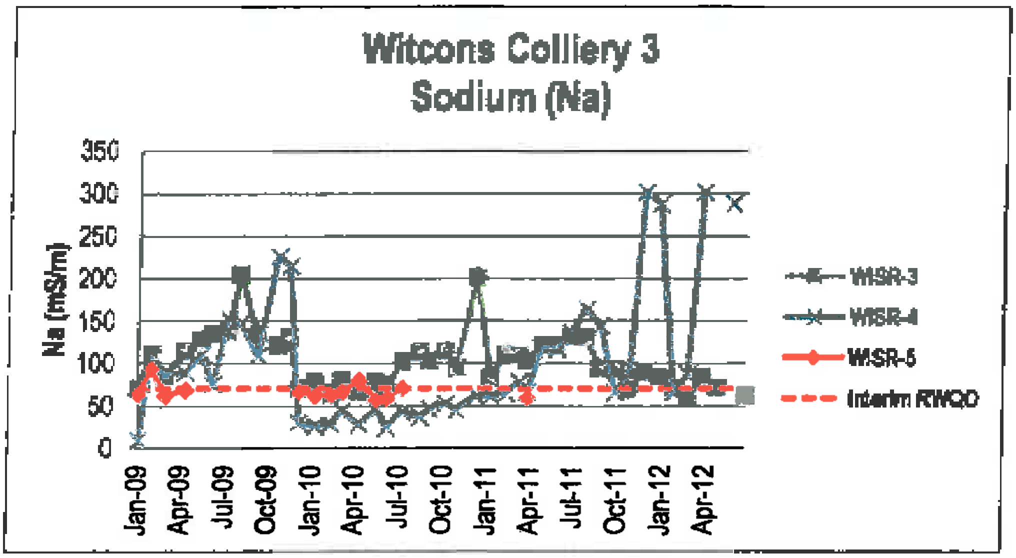
Witcons Colliery 2
Chloride (Cl)
Cl (mS/m)
300
250
200
150
100
50
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-9
Interim RWQO



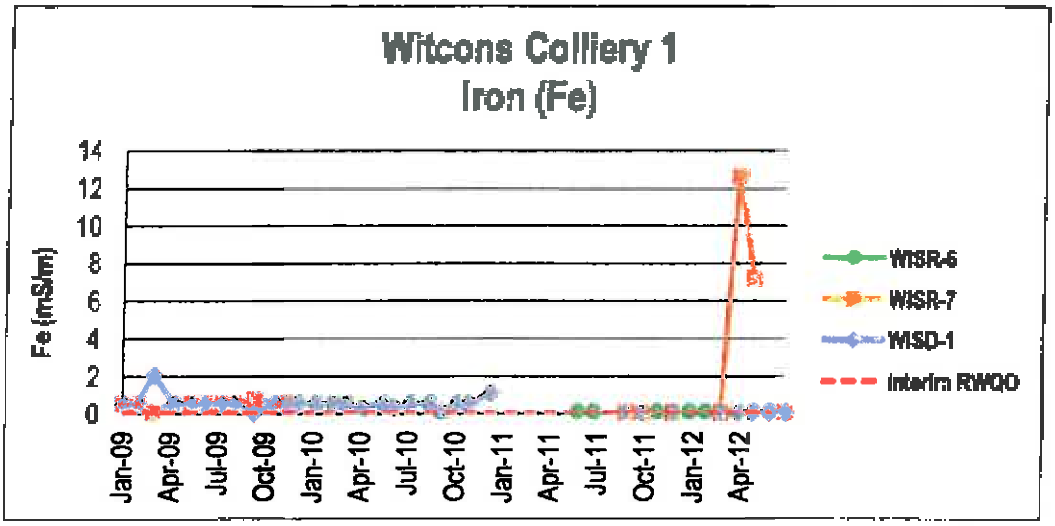
Witcons Colliery 3
Chloride (Cl)
Cl (mS/m)
400
350
300
250
200
150
100
50
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO


Witcons Colliery 1
Sodium (Na)
450
400
350
300
250
200
150
100
50
0
Na (mS/m)
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO

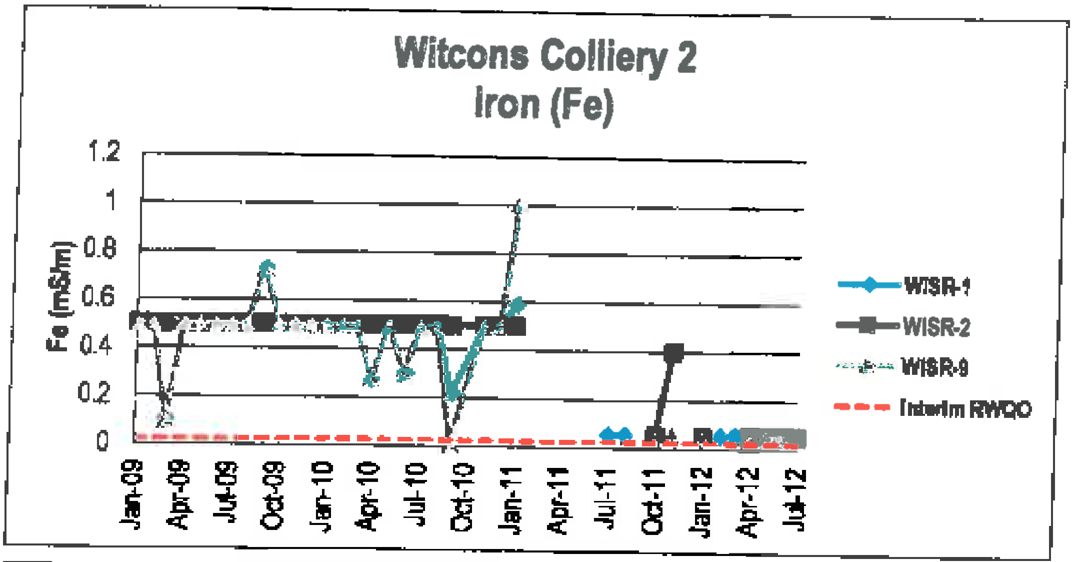

Witcons Colliery 2
Sodium (Na)
500
400
300
200
100
0
Na (mS/m)
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
Interim RWQO

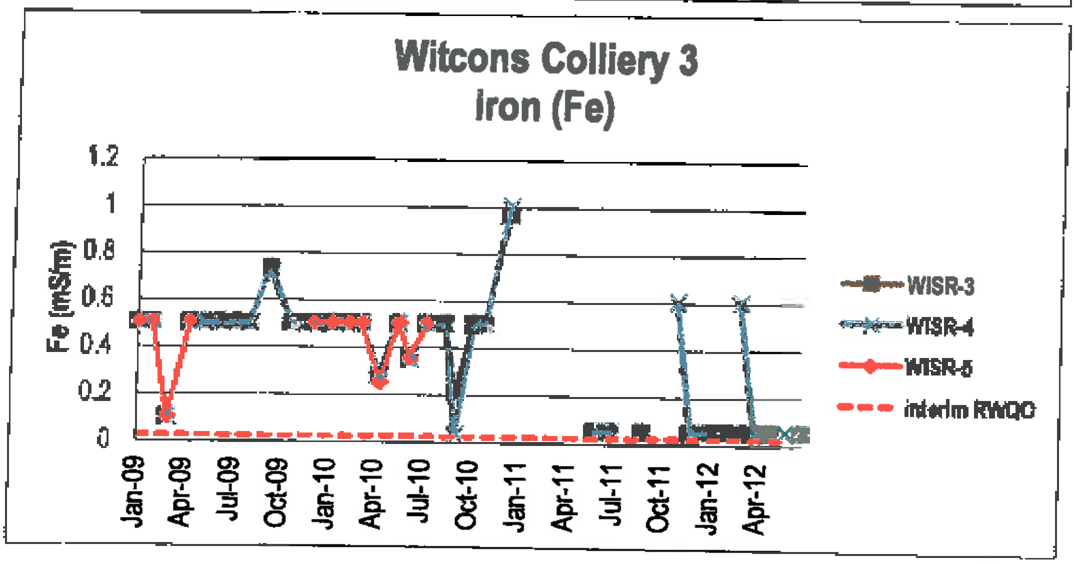


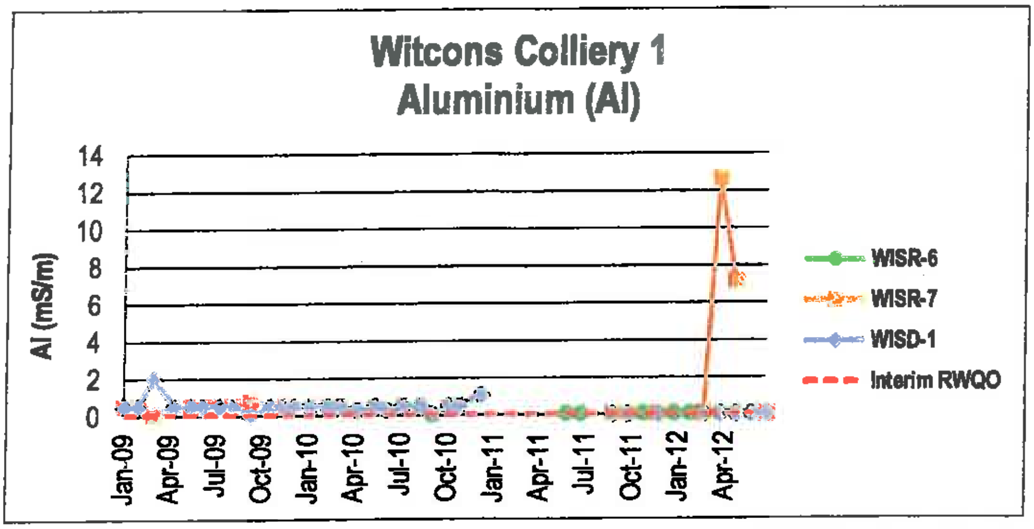
Witcons Colliery 3
Sodium (Na)
Na (mS/m)
350
300
250
200
150
100
50
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO



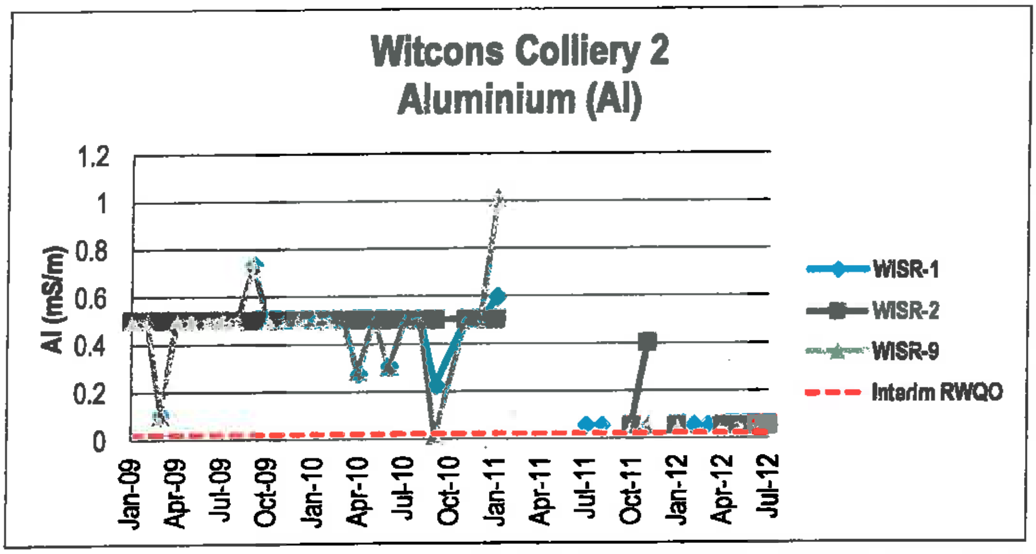
Witcons Colliery 1
Iron (Fe)
Fe (mS/m)
14
12
10
8
6
4
2
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO


Witcons Colliery 2
Iron (Fe)
Fe (mS/m)
1.2
1
0.8
0.6
0.4
0.2
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-9
Interim RWQO

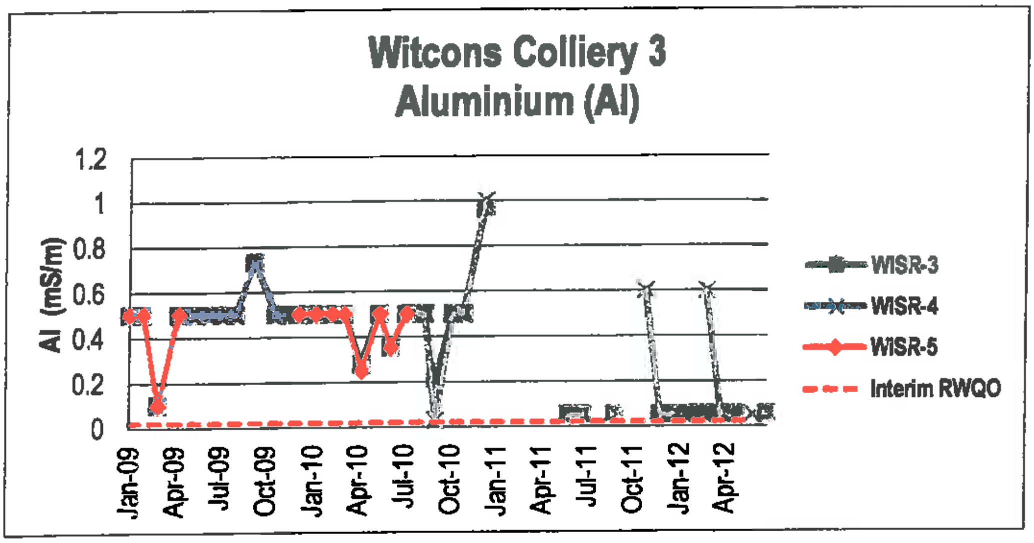

Witcons Colliery 3
Iron (Fe)
Fe (mS/m)
1.2
1
0.8
0.6
0.4
0.2
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO



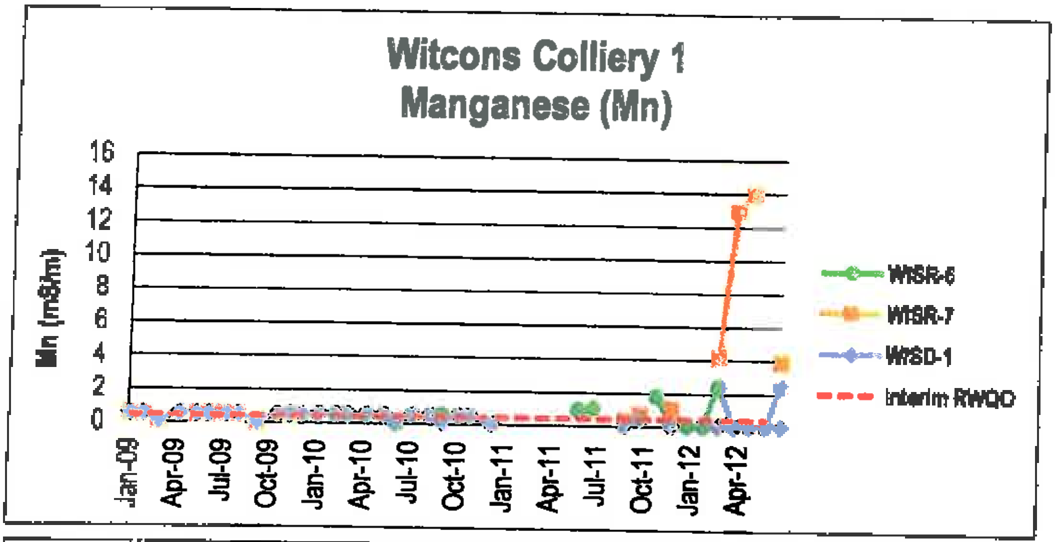
Witcons Colliery 1
Aluminium (Al)
Al (mS/m)
14
12
10
8
6
4
2
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO

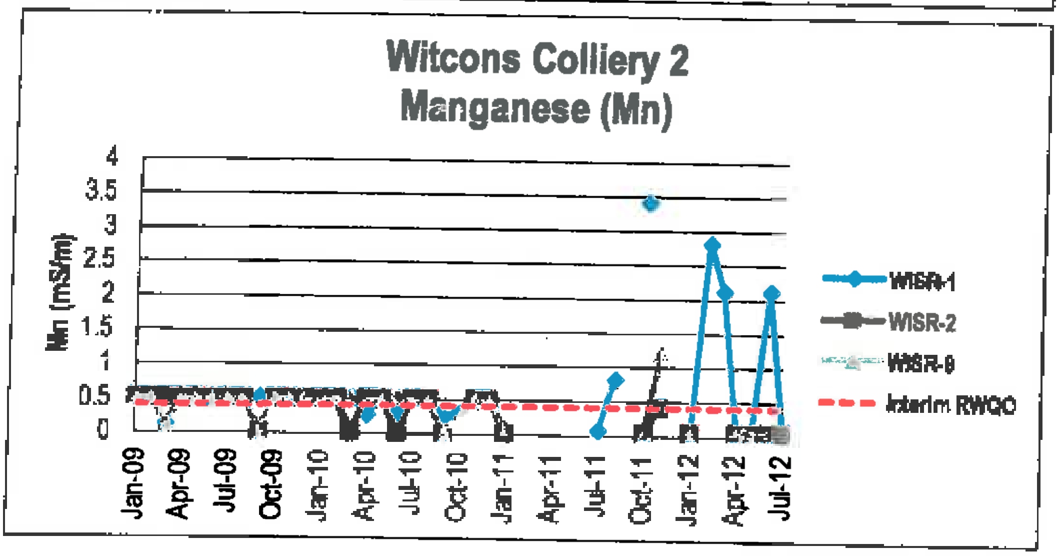


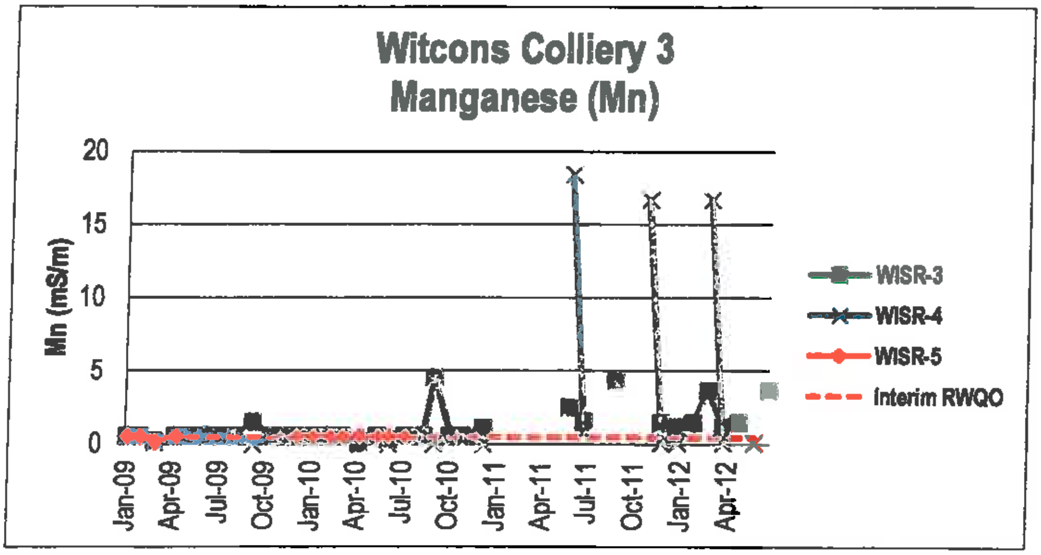
Witcons Colliery 2
Aluminium (Al)
Al (mS/m)
1.2
1
0.8
0.6
0.4
0.2
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-9
Interim RWQO



Witcons Colliery 3
Aluminium (Al)
Al (mS/m)
1.2
1
0.8
0.6
0.4
0.2
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO


Witcons Colliery 1
Manganese (Mn)
Mn (mS/m)
16
14
12
10
8
6
4
2
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-6
WISR-7
WISD-1
Interim RWQO


Witcons Colliery 2
Manganese (Mn)
Mn (mS/m)
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
Jul-12
WISR-1
WISR-2
WISR-8
Interim RWQO



Witcons Colliery 3
Manganese (Mn)
Mn (mS/m)
20
15
10
5
0
Jan-09
Apr-09
Jul-09
Oct-09
Jan-10
Apr-10
Jul-10
Oct-10
Jan-11
Apr-11
Jul-11
Oct-11
Jan-12
Apr-12
WISR-3
WISR-4
WISR-5
Interim RWQO

Appendix C

IMPACT RATING METHODOLOGY

ACTIVITY-FOCUSED ENVIRONMENTAL IMPACT ASSESSMENT MANAGEMENT AND ACTIONPLANS

1.1 APPROACH TO IMPACT ASSESSMENT AND MANAGEMENT

The EIAMAP[1] is a comprehensive tool used to manage the negative environmental impacts associated with mining and related activities and consists of two key aspects.

Firstly, the EIAMAP includes a full impact assessment according to activity (mining or mining-related), mining phase (construction, operational and decommissioning), and environmental component.

Secondly, an Environmental Management Programme (EMP) proposed for the expected impacts is also provided in the EIAMAP. This section of the EIAMAP includes proposed mitigation measures, time frames for implementation of the proposed mitigation measures and relative financial provisioning for the implementation of the proposed mitigation measure. These aspects comply with applicable legislation, as described in detail below.

1.1.1 Impact assessment methodology

Section 31(2)(k), Chapter 3 of the R. 543 (2010) in terms of the NEMA[2], 1998 requires an assessment of the extent, duration, probability and significance of the identified potential environmental impacts of the proposed mining operation. In order to comply with best practice principles, the evaluation of impacts was conducted in terms of the criteria presented in **Table 1.1**.

The significance of the current impacts, which exist even with mitigation measures in place, was determined using the methodology indicated below.

Table 1.1: Impact assessment criteria

Status		
Positive	+	Impact will be beneficial to the environment (a benefit).
Negative	-	Impact will not be beneficial to the environment (a cost).
Neutral	0	Where a negative impact is offset by a positive impact, or mitigation measures, to have no overall effect.

[1] EIAMAP: Environmental Impact Assessment and Management Action Plan.
[2] NEMA: National Environmental Management Act, 1998 (Act no: 107 of 1998).

Magnitude		
Minor	2	Negligible effects on biophysical or social functions / processes. Includes areas / environmental aspects which have already been altered significantly, and have little to no conservation importance (negligible sensitivity*).
Low	4	Minimal effects on biophysical or social functions / processes. Includes areas / environmental aspects which have been largely modified, and / or have a low conservation importance (low sensitivity*).
Moderate	6	Notable effects on biophysical or social functions / processes. Includes areas / environmental aspects which have already been moderately modified, and have a medium conservation importance (medium sensitivity*).
High	8	Considerable effects on biophysical or social functions / processes. Includes areas / environmental aspects which have been slightly modified and have a high conservation importance (high sensitivity*).
Very high	10	Severe effects on biophysical or social functions / processes. Includes areas / environmental aspects which have not previously been impacted upon and are pristine, thus of very high conservation importance (very high sensitivity*).
Extent		
Site only	1	Effect limited to the site and its immediate surroundings.
Local	2	Effect limited to within 3-5 km of the site.
Regional	3	Activity will have an impact on a regional scale.
National	4	Activity will have an impact on a national scale.
International	5	Activity will have an impact on an international scale.
Duration		
Immediate	1	Effect occurs periodically throughout the life of the activity.
Short term	2	Effect lasts for a period 0 to 5 years.
Medium term	3	Effect continues for a period between 5 and 15 years.
Long term	4	Effect will cease after the operational life of the activity either because of natural process or by human intervention.
Permanent	5	Where mitigation either by natural process or by human intervention will not occur in such a way or in such a time span that the impact can be considered transient.
Probability of occurrence		
Improbable	1	Less than 30% chance of occurrence.
Low	2	Between 30 and 50% chance of occurrence.
Medium	3	Between 50 and 70% chance of occurrence.
High	4	Greater than 70% chance of occurrence.
Definite	5	Will occur, or where applicable has occurred, regardless or in spite of any mitigation measures.

**Note for specialists – please use the sensitivity information / rankings you determine in your studies here.*

Once the impact criteria have been ranked for each impact, the significance of the impacts should be calculated using the following formula:

Significance = (Magnitude + Duration + Extent) x Probability

As is evident from the above equation, the extent (spatial scale), magnitude, duration (time scale) and the probability of occurrence of each identified impact should be assigned a value according to the impact assessment criteria (presented in Table 1.1, above) and used to calculate the significance of each impact.

A Significance Rating should then be calculated by multiplying the Severity Rating with the Probability, and is therefore a product of the probability and the severity of the impact. The maximum value that can be reached through the described impact evaluation process is 100 SP[3]. The scenarios for each environmental impact are rated as High (SP≥60), Moderate (SP 31-60) and Low (SP<30) significance as shown in **Table 1.2**.

Table 1.2: Definition of significance rating

Significance of predicted NEGATIVE impacts		
Low	0-30	Where the impact will have a relatively small effect on the environment and will require minimum or no mitigation.
Medium	31-60	Where the impact can have an influence on the environment and should be mitigated.
High	61-100	Where the impact will definitely influence the environment and must be mitigated, where possible.
Significance of predicted POSITIVE impacts		
Low	0-30	Where the impact will have a relatively small positive effect on the environment.
Medium	31-60	Where the positive impact will counteract an existing negative impact and result in an overall neutral effect on the environment.
High	61-100	Where the positive impact will improve the environment relative to baseline conditions.

Once the significance rating of an impact before mitigation has been determined, the reversibility of the impact, 'replaceability' of the affected resources and the potential of the impact to be further mitigated also need to be determined. These factors are explained in the table below, and play an important role in the determination of the level and type of mitigation performed or to be implemented. **Table 1.3**sets out the criteria that should be used to assess the reversibility, loss of rescources and potential for further mitigation.

Table 1.3: Mitigation prediction criteria

Reversibility of impact		
Reversible	1	The impact on natural, cultural and / or social structures,functions and processes is totally reversible.
Partially	2	The impact on natural, cultural and / or social structures,functions and processes is partially reversible.

[3]SP: Significant Points.

Irreversible	3	Where natural, cultural and / or social structures,functions or processes are altered to the extent that it will permanently cease, i.e. impact is irreversible.
Irreplaceable loss of resources		
Replaceable	1	The impact will not result in the irreplaceable loss of resources.
Partially	2	The impact will result in a partially irreplaceable loss of resources.
Irreplaceable	3	The impact will result in the irreplaceable loss of resources.

Potential of impacts to be mitigated		
High	1	High potential to mitigate negative impacts to the level of insignificant effects, or to improve management to enhance positive impacts.
Medium	2	Potential to mitigate negative impacts. However, the implementation of mitigation measures may still not prevent some negative effects.
Low	3	Little or no mechanism exists to mitigate negative impacts.

The EIAMAP(a template of which is attached for your use) also provides a column in the table that identifies a specific impact as an I&AP[4] concern and also indicates who raised the concern as well as cross referencing with the relevant public participation parts of this document for more detail (if you have this information, please include it, otherwise CSEC will do so once the Public Participation Process has come to a close).

The impacts expected to occur as result of the activities that are anticipated to take place at the proposed Project site may combine with those resulting from surrounding activities and land uses to form cumulative impacts, or to contribute to cumulative impacts that already exist. The EIAMAPs for cumulative impacts are slightly different from the others, since potential mitigation measures are excluded, as they will have been addressed in the other activity-specific EIAMAPs.

1.1.1.2. Environmental Management Plan (EMP)

Regulation 33 of the EIA Regulations GN R.543 (2010) under the NEMA (1998) sets out the requirements for an EMP. To address these requirements, the EIAMAP should include the following aspects:

- **The mitigation management objectives and principles**– these should be identified to enable the mine to set goals for the environmental management of the proposed mining operations. Carefully planned management objectives and principles are the foundations of an effective EMP[5].
- Design plays a large role in the mitigation process, thereby ensuring that the project. takes a proactive stance to environmental management. Therefore, **mitigation by design** is central to the implementation of this EMP. (Please use this column to briefly explain how the identified impact is expected to be mitigated through the design of the mine and / or infrastructure).

[4] I&AP: Interested and Affected Party/ies
[5] EMP: Environmental Management Programme.

- **Proposed mitigation measures**– please use this column to propose mitigation measures / make recommendations that, when implemented, would enable the project to achieve the environmental management goals / objectives you will have identified in one of the previous columns. Mitigation measures identified should modify, remedy, control or stop any action, activity or process that is identified as possibly impacting adversely on the environment.
- **Time Frames**– please give an indication of the acceptable timeframe for the implementation of the proposed mitigation measures.
- **Person responsible**– if you have an idea who should be responsible for the implementation of each mitigation measures, please include, but if not, please leave blank.

The EIA Map will be used as a tool by XSA[6] to ensure that the identified impacts resulting from / associated with t he Tweefontein Optimisation Amendment Project will be appropriately mitigated to an acceptable level.

[6] XSA: Xstrata South Africa, a member of the Glencore group of companies

CLEAN STREAM ENVIRONMENTAL CONSULTANTS

SPECIALIST SURFACE WATER REPORT AS INPUT TO THE
EIA FOR THE TWEEFONTIEN OPTIMISATION PROJECT AMENDMENT

Report: JW090/13/D367 – Rev 0

Appendix D

CLEANSTREAM 2010 SURFACE WATER USERS REPORT

XSTRATA COAL TWEEFONTEIN

VLAKLAAGTE PROJECT

HYDROCENSUS REPORT

MARCH 2010

1. INTRODUCTION

Clean Stream Scientific Services was commissioned to conduct a hydrocensus for the proposed Xstrata Tweefontein - Vlaklaagte Coal Mine, near Witbank in the Mpumalanga Province. During the hydrocensus field survey, the Clean Stream Field Scientists contacted various interested and affected parties (I&APs), within a two kilometer radius of the proposed development. Several landowners were informed of the development, and representative geohydrological boreholes on their relevant properties were surveyed. The hydrocensus took place from February 2010 to March 2010.

2. SCOPE OF WORK

The goal of a hydrocensus field survey is as follows:

- Locating and informing all I&APs of the proposed development.
- Gathering of personal information from the I&APs (Name, Telephone number, Address, etc.).
- Accurately logging of representative boreholes on the I&APs properties.
- Gathering of information of the logged boreholes (Yield, Age, Depth, Water level, etc.).
- Analysing representative groundwater samples from the I&APs properties.
- Establishing a baseline water quality for the hydrocensus area.
- Presenting the surveyed data on a GIS based map.

3. INTERESTED AND AFFECTED PARTIES

Contact was made with eleven (11) interested and affected parties, as shown in Table 3-1 below. Figure 3-1 indicates the position of all the surveyed localities in the hydrocensus area. Various borehole localities were logged (30 localities were surveyed), and water levels were taken (when possible). Water quality data for eighteen (18) localities were analysed, and water levels for twenty two (22) boreholes were logged. Table 3-1 is only a summarized version of the

I&APs gathered during the survey. For a complete list of the information, the hydrocensus forms in Appendix A may be viewed. As indicated in Table 3-1, the proposed Vlaklaagte Coal Mine is surrounded by mainly small holdings and farmers that mainly farm with cattle and maize.

4. FIELD RESULTS & FINDINGS

Twenty nine (29) boreholes were surveyed for the Vlaklaagte Coal Mine area. Table 3-1 indicates the water use and geohydrological information gathered for the boreholes. Figure 4-1 indicates the calculated percentage usage of all the surveyed localities.

As is clear from Figure 4-1, 45% of the surveyed borehole localities are used as a source for domestic water. Another 23% of the surveyed localities are used for livestock watering. For this reason, the water quality results will be measured against the DWAF's TWQGR for domestic use and Livestock watering. 26% of the boreholes surveyed were not being used for any watering purposes. The 6% Irrigation use recorded, was mainly for watering of gardens. Table 4-2 indicates the DWAF's Target Water Quality Guidelines (TWQGR) for Domestic use and Livestock watering. Analyses Certificates are available in Appendix B.

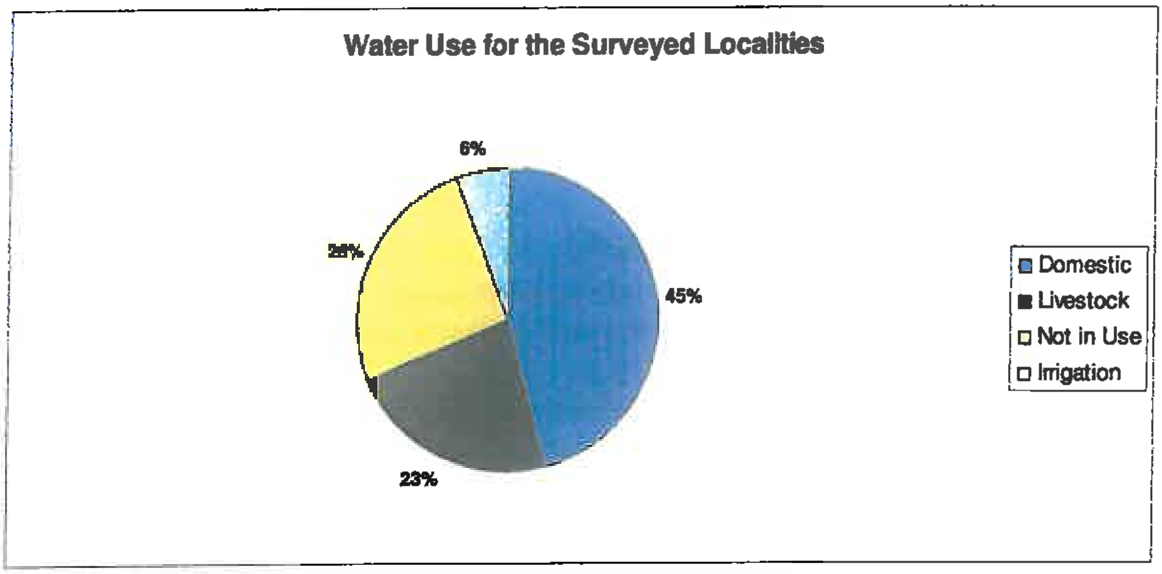


Figure 4-1: Calculated percentage usage of all surveyed hydrocensus localities for Vlaklaagte, March 2010.

Table 3-1: Summary of the personal contact information of the contacted I&APs during the hydrocensus

Locality	Owner / Contact Person	South	East	Elevation	Water level
Ad 1	Adistra 96 cc	-25.9718	29.13773	1592	2.60
Bo 1	MJ Botha	-25.96741	29.14095	1593	1.28
Botha01	T Botha	-25.99111	29.12757	1594	4.00
Crou 1	MM Croucamp	-25.9843	29.13001	1604	2.70
Crou 2		-25.98419	29.12954	1604	4.68
Crou 3		-25.98937	29.13026	1608	2.68
Crou 4		-25.99002	29.13817	1605	2.60
Duv 1	PSJ Duvenhage	-25.97521	29.14144	1593	1.40
Duv 2		-25.97541	29.14176	1592	2.68
Eng 1	EHJ Engelbrecht	-25.98801	29.12559	1608	0.95
Eng 2		-25.98902	29.12519	1607	0.82
Lab 2	J Labuschagne	-25.98018	29.13379	1598	2.64
Lab 3		-25.97935	29.13405	1595	0.82
Lab 4		-25.97914	29.13225	1600	22.78
Mo 1	M Masalela	-25.97001	29.13779	1595	2.00
Moyo 1	Remo Moyo	-25.96688	29.11739	1566	4.35
Moyo 3		-25.96904	29.118	1574	0.00
Roets 1	MR Roets	-25.96147	29.12991	1572	0.92
Roets 3		-25.96012	29.13109	1575	1.62
Uys 2		-25.99064	29.13764	1610	2.25
Windpomp	Unknown	-25.96648	29.13204	1585	0.00
WSW	Mine Monitoring Borehole	-25.96822	29.12028	1580	3.82
Average					3.07
Deepest					22.78
Shallowest					0.00

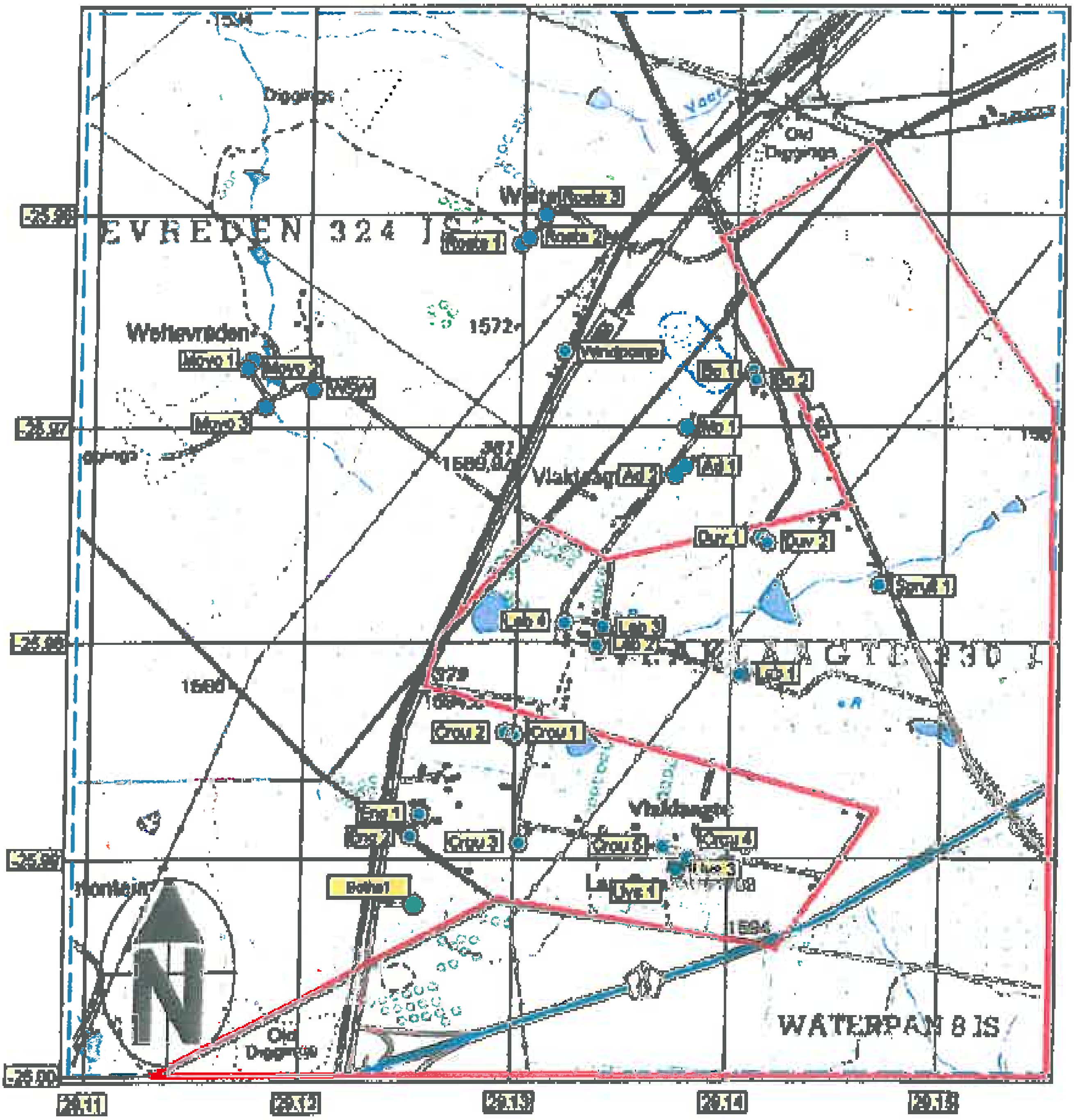


Figure 3-1: All localities surveyed during the Vlaklaagte Coal Mine hydrocensus, February to March 2010.

Table 4-1: The DWAF Targeted Water Quality Guidelines (TWQGR) for Domestic Use and Livestock Watering.

Variable	Unit	TWQGR Domestic tolerated	TWQGR Livestock Watering
pH		5 - 9.5	-
EC	mS/m	150	500
TDS	mg/l	1000	1000 in pig, 1000 in dairy, 1000 in poultry, 2000 in cattle, 3000 in sheep
Ca	mg/l	150	-
Mg	mg/l	200	500
Na	mg/l	200	2000
K	mg/l	50	-
M alk	mg/l	-	-
Cl	mg/l	200	3000
SO_4	mg/l	400	1000
NO_3	mg/l	10	-
F	mg/l	1.0	2.0
Al	mg/l	0.5	5
Fe	mg/l	1.0	10.0
Mn	mg/l	0.4	10
T hardness	mg/l	-	-
NH_3	mg/l	2	-
PO_4	mg/l	2	-
SAR	ratio	-	-

4.1 Water Quality Results

As mentioned, water quality results for selected hydrocensus localities will be compared against the DWAF's Target Water Quality Guidelines for Domestic Use and Livestock Watering. Table 4-2 and Table 4-3 illustrate the measured water quality results against the specified DWAF domestic use and Livestock Watering guidelines respectively.

In terms of Domestic use, all localities except Eng 1, Lab 1, and Lab 2, comply with the specified domestic use water quality guidelines and can be considered as good water quality. The three non-compliant localities are due to Hardness concentration, and high NO_3 concentrations (Lab 1 and Lab 2). The water quality can be considered as being marginal to poor, and exceeds the DWAF's target water quality guidelines for domestic use.

Table 4-2: Water quality results for selected Vlaklaagte hydrocensus localities, measured against the DWAF Domestic Use Target Water Quality Guideline (March 2010).

Variable	Unit	TWQR Domestic tolerated	Ad 1	Bo 1	Bethel	Crou 2	Crou 3	Duv 1	Eng 1	Lab1	Lab2	Mot	Moyo 1	Moyo 2	Moyo 3	Roots 2	Roots 3	Uys 1	Windpomp	WSW
pH		5 - 9.5	7.87	7.39	5.53	6.66	7.71	7.14	7.03	7.18	7.10	6.66	6.50	6.69	6.17	8.10	7.79	7.38	6.96	7.52
EC	mS/m	150	9.06	41.80	25.28	17.16	18.23	19.49	75.20	101.60	102.10	41.70	12.85	10.19	7.85	45.70	20.83	41.90	19.90	8.80
TDS	mg/l	1000	<65	201.00	84.00	<65	<65	114.00	567.00	521.00	524.00	192.00	<65	<65	<65	267.00	102.00	231.00	78.00	<65
Ca	mg/l	150	8.85	34.78	9.61	6.79	12.17	16.25	69.65	57.24	57.70	21.25	7.44	5.50	2.40	57.23	17.22	28.43	17.14	2.70
Mg	mg/l	200	1.13	11.62	8.00	5.45	4.89	8.46	48.69	49.82	49.97	13.56	6.55	3.73	1.85	21.16	9.37	20.64	11.48	1.51
Na	mg/l	200	1.88	28.21	12.07	4.16	3.96	8.37	17.11	91.15	92.31	27.72	-0.03	-0.03	-0.03	15.34	6.63	20.34	-0.03	5.42
K	mg/l	50	0.99	1.87	5.59	7.29	4.15	1.02	25.14	12.81	12.82	5.01	1.55	2.65	2.32	2.42	1.72	12.88	1.55	4.88
M alk	mg/l	-	28.10	61.80	-8.30	-8.30	28.50	34.90	35.30	85.45	86.50	[illegible]	21.80	12.90	-8.30	234.40	84.70	44.80	21.80	22.00
Cl	mg/l	[illegible]	8.40	29.30	34.20	25.80	11.30	18.90	45.30	177.10	178.60	[illegible]	7.80	5.60	5.60	6.40	2.14	58.20	2.80	7.00
SO_4	mg/l	[illegible]	-0.13	36.54	1.14	-0.13	2.21	38.81	311.87	54.61	53.78	18.51	14.38	4.34	4.44	24.04	12.77	84.10	18.36	-0.13
NO_3	mg/l	[illegible]	-0.06	8.17	6.12	4.76	3.43	0.08	8.44	38.55	36.73	0.65	-0.06	1.26	1.77	-0.06	-0.06	1.88	12.80	0.13
F	mg/l	[illegible]	-0.18	-0.18	-0.11	-0.13	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18	-0.11	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18
Al	mg/l	[illegible]	0.05	0.02	-0.01	0.01	0.01	0.05	-0.01	0.02	0.02	0.04	0.01	0.01	0.01	-0.07	0.01	0.01	0.04	0.03
Fe	mg/l	[illegible]	-0.01	-0.01	0.01	0.05	0.05	-0.01	0.06	-0.01	-0.01	-0.01	0.04	0.05	0.05	0.06	0.07	0.05	0.07	-0.01
Mn	mg/l	[illegible]	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.27	1.38	0.27	0.60	0.07	0.00	0.00	0.00	0.00
T hardness	mg/l	[illegible]	27.00	128.00	57.00	36.00	34.00	75.00	[illegible]	[illegible]	[illegible]	108.00	48.00	29.00	14.00	236.00	82.00	158.00	90.00	13.00
NH_4	mg/l	[illegible]	-0.01	0.05	-0.02	0.04	0.05	7.32	-0.01	0.04	0.02	0.03	-0.01	0.12	0.42	-0.07	-0.01	-0.01	-0.01	0.02
PO_4	mg/l	[illegible]	-0.03	-0.03	-0.03	-0.05	0.03	-0.03	-0.03	-0.03	-0.03	-0.09	-0.05	-0.03	-0.05	-0.03	-0.03	0.55	-0.03	-0.03
SAR	ratio	[illegible]	0.14	1.06	1.02	2.24	0.24	3.42	0.36	2.13	2.15	1.16	0.00	0.06	0.00	0.44	0.32	0.71	0.00	0.64

Table 4-3: Water quality results for selected Vlaklaagte hydrocensus localities, measured against the DWAF Livestock Watering Target Water Quality Guideline (March 2010).

Variable	Unit	TWQR Livestock Watering	Ad 1	Bo 1	Bethel	Crou 2	Crou 3	Duv 1	Eng 1	Lab1	Lab2	Mot	Moyo 1	Moyo 2	Moyo 3	Roots 2	Roots 3	Uys 1	Windpomp	WSW
pH		-	7.87	7.39	5.53	6.66	7.71	7.14	7.03	7.18	7.10	6.66	6.50	6.69	6.17	8.10	7.79	7.38	6.96	7.52
EC	mS/m	[illegible]	9.06	41.80	25.28	17.16	16.23	19.49	75.20	101.60	102.10	41.70	12.85	10.19	7.85	45.70	20.83	41.90	19.90	8.80
TDS	mg/l	1000 in pig, 1000 in dairy, 1[illegible]00 in poultry, 2000 in cattle, 3000 in sheep	-65.00	201.00	84.00	-65.00	-65.00	114.00	567.00	521.00	524.00	192.00	-65.00	-65.00	-65.00	267.00	102.00	231.00	78.00	-65.00
Ca	mg/l	-	[illegible]	34.78	9.61	6.79	12.17	16.25	69.65	57.24	57.70	21.25	7.44	5.50	2.40	57.23	17.22	28.43	17.14	2.70
Mg	mg/l	[illegible]	1.13	11.62	8.00	5.45	4.89	1.46	48.69	49.82	49.97	13.56	6.55	3.73	1.85	21.16	9.37	20.64	11.48	1.51
Na	mg/l	[illegible]	1.88	28.21	12.07	4.16	3.96	6.37	17.11	91.15	92.31	27.72	-0.03	-0.03	-0.03	15.34	6.63	20.34	-0.03	0.42
K	mg/l	-	0.99	1.87	5.59	7.29	4.15	1.02	25.14	12.81	12.82	5.01	1.55	2.65	2.32	2.42	1.72	12.88	1.55	4.88
M alk	mg/l	-	28.10	61.80	-8.35	-8.30	28.50	34.90	35.30	85.45	86.50	[illegible]	21.80	12.90	-8.30	234.40	84.70	44.80	1.55	4.88
Cl	mg/l	[illegible]	3.40	29.30	34.20	25.80	11.30	18.90	45.30	177.10	178.60	[illegible]	21.80	12.90	-8.30	234.40	84.70	44.80	21.80	22.00
SO_4	mg/l	1000	-0.13	36.54	1.14	-0.13	2.21	38.81	311.87	54.61	53.78	[illegible]	7.80	5.60	5.60	6.40	2.14	58.20	2.80	7.00
NO_3	mg/l	-	-0.06	8.17	6.12	4.76	3.43	0.08	8.44	38.55	36.73	18.51	14.38	4.34	4.44	24.04	12.77	84.10	18.36	-0.13
F	mg/l	2.0	-0.18	-0.18	-0.11	-0.14	-0.18	-0.18	-0.18	-0.18	-0.18	0.65	-0.06	1.26	1.77	-0.06	-0.06	1.88	12.80	0.13
Al	mg/l	5	0.05	0.02	-0.01	0.01	0.01	0.05	-0.01	0.02	0.02	-0.18	-0.18	-0.11	-0.18	-0.18	-0.18	-0.18	-0.18	-0.18
Fe	mg/l	10.0	-0.01	-0.01	0.01	0.05	0.05	-0.01	0.06	-0.01	-0.01	0.04	0.01	0.01	0.01	-0.07	0.01	0.01	0.04	0.03
Mn	mg/l	10	0.00	0.00	0.07	0.00	0.00	0.00	0.05	0.00	0.00	-0.01	0.04	0.05	0.05	0.06	0.07	0.05	0.07	-0.01
T hardness	mg/l	-	27.00	125.00	57.00	39.00	37.00	75.00	494.00	346.00	350.00	0.27	1.38	0.27	0.60	0.07	0.00	0.00	0.00	0.00
NH_4	mg/l	-	-0.01	0.05	-0.02	0.04	0.05	0.02	-0.01	0.04	0.02	108.00	48.00	29.00	14.00	236.00	82.00	158.00	90.00	13.00
PO_4	mg/l	-	-0.03	-0.05	-0.03	-0.05	5.05	-0.03	-0.09	-0.03	-0.03	0.03	-0.01	0.12	0.42	-0.01	-0.01	-0.01	-0.01	0.02
SAR	ratio	-	0.15	1.06	1.03	0.29	0.24	0.42	0.36	2.13	2.15	-0.09	-0.05	-0.03	-0.05	-0.03	-0.03	-0.03	-0.03	-0.03
												1.16	0.00	0.06	0.05	0.44	0.32	0.71	0.00	0.64

The raised hardness concentration does not have any health affects as such, but will lead to scaling of kettles and geysers. Impaired lathering of soap could also be caused.

The raised Nitrate (NO_3) concentration will not adversely affect healthy adults but could lead to some health risks in babies. These health risks include a reduced oxygen uptake by the red-blood cells in babies, leading to "blue baby" syndrome.

All localities were compliant with the livestock watering guidelines.

5. REGIONAL WATER QUALITY CONDITIONS

The regional water quality is discussed based on selected pollution indicator parameters i.e. pH, EC (salinity), SO_4, and NO_3 concentration. Water qualities on the Figures below are compared against the SANS:241 Potable Water Standards.

Four main factors usually influence groundwater quality in the aquifer, namely:

- annual recharge to the groundwater system,
- type of bedrock where ion exchange may impact on the hydrogeochemistry,
- flow dynamics within the aquifer(s), determining the water age and
- source(s) of pollution with their associated leachates or contaminant streams.

Where no specific source of groundwater pollution is present upstream of the borehole, only the other three factors play a role. For the selected parameters, maps are included indicating the recorded parameter concentrations at each surveyed locality. In evaluating the data presented on the maps, it must be noted that the size of the circle indicating the concentration or value at a monitoring locality is in relation to the values of the other monitoring localities on the map. A large circle therefore does not necessarily imply water of a poor quality or very high concentration for the specified variable. Compliance to the SANS 241 drinking water guideline is coloured according to compliance (green=compliant/good water quality, yellow=Non-compliant/marginal water quality, red=Non-compliant/poor water quality).

5.1 pH

pH is the logarithmic expression of the hydrogen ion concentration in water which reflects the degree of acidity ($pH < 7.0$) or alkalinity ($pH > 7$) of the water. The pH levels of most unpolluted waters are between 6.5 – 8.5. pH levels below 6.5 may be found in areas were acidification processes have occurred, the most dramatic being that of acid mine drainage where pH levels may drop to 3.5.

Health effects associated with pH can be direct or indirect. Direct causes include the irritation or burning of the mucous membranes with extreme acidic waters, and indirect causes are consequences of corrosion to cooking appliances and distribution pipes.

Figure 5.1-1 indicated the various recorded pH concentrations for the Vlaklaagte Coal Mine Project surveyed localities. As indicated by the Figure, all water qualities comply with the SANS241:2006 drinking water standards, and can be described as neutral.

5.2 Salinity (EC)

Salinity (EC) is the measurement of ease with which water conducts electricity, or the sum of dissolved salts (Cl, SO_4, etc) in the water. Distilled water (no salinity) conducts electricity poorly, whilst sea water (high salinity) is a good conductor of electricity. Health effects associated with high salinity (>370 mS/m) values are:

- Disturbance in the salt balance of infants
- Adverse effects on sensitive users such as individuals with high blood pressure and heart diseases
- Adverse effects on individuals with renal/kidney disease

Figure 5.2-1 indicates the spatial variation of the EC concentration across the hydrocensus area. Low salinity concentrations are recorded for the entire hydrocensus area. Salinity concentrations ranged between 7.65 mS/m to 102.1 mS/m indicating non-saline water quality conditions.

5.3 Sulphate (SO_4)

Sulphate is the oxy-anion of sulphur and forms salts with various cations such as magnesium (Epsom Salt). Consumption of excessive amounts of sulphate typically results in health effects such as diarrhoea. However, adaptation to high sulphate tends to occur with prolonged use. Sulphate imparts a bitter or salty taste to water. Corrosion of the distribution system is also likely in cases of high sulphate concentrations.

Figure 5.3-1 indicates the spatial variation of the SO_4 concentration across the hydrocensus area. Very low SO_4 concentrations are recorded for the hydrocensus area. The bulk of the sampling localities recorded SO_4 concentrations of below 100 mg/l, with only locality Eng 1 (312 mg/l) where higher sulphate concentrations were recorded. All localities are compliant with the SANS potable water standards.

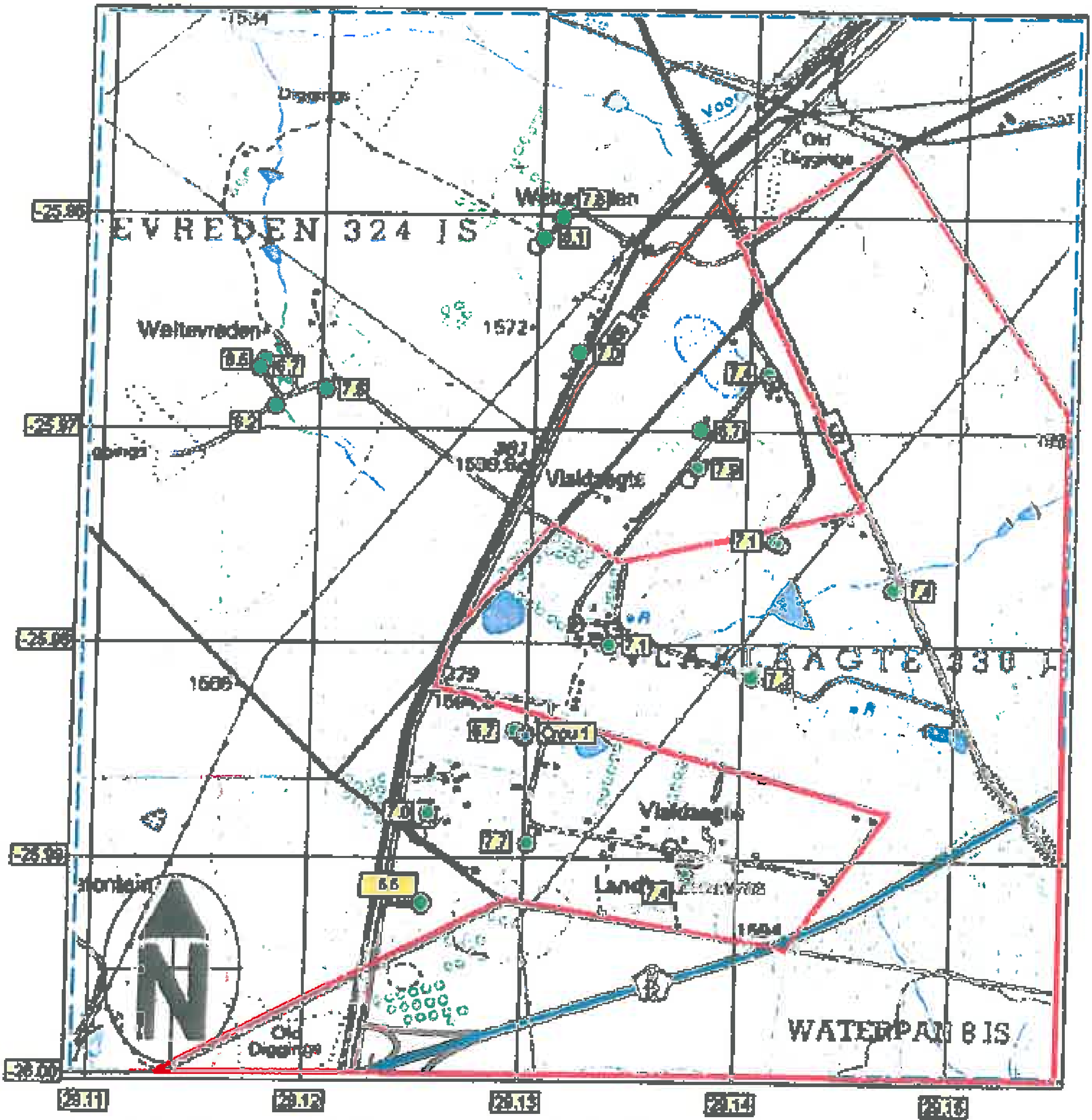


Figure 5.1-1: The recorded pH concentrations for the Vlaklaagte Coal Mine Project surveyed localities.

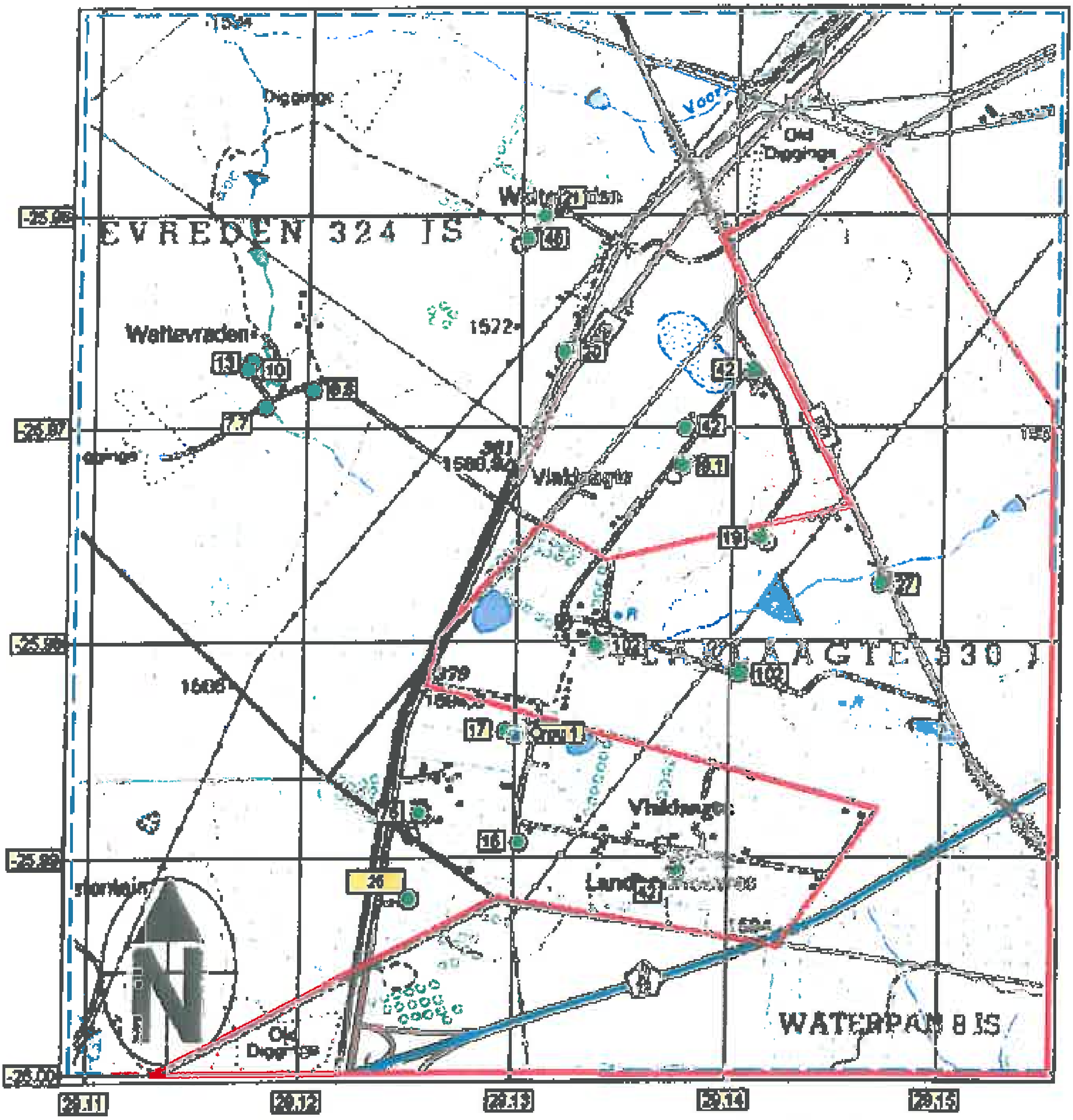


Figure 5.2-1: The recorded EC concentrations for the Vlaklaagte Coal Mine Project surveyed localities.

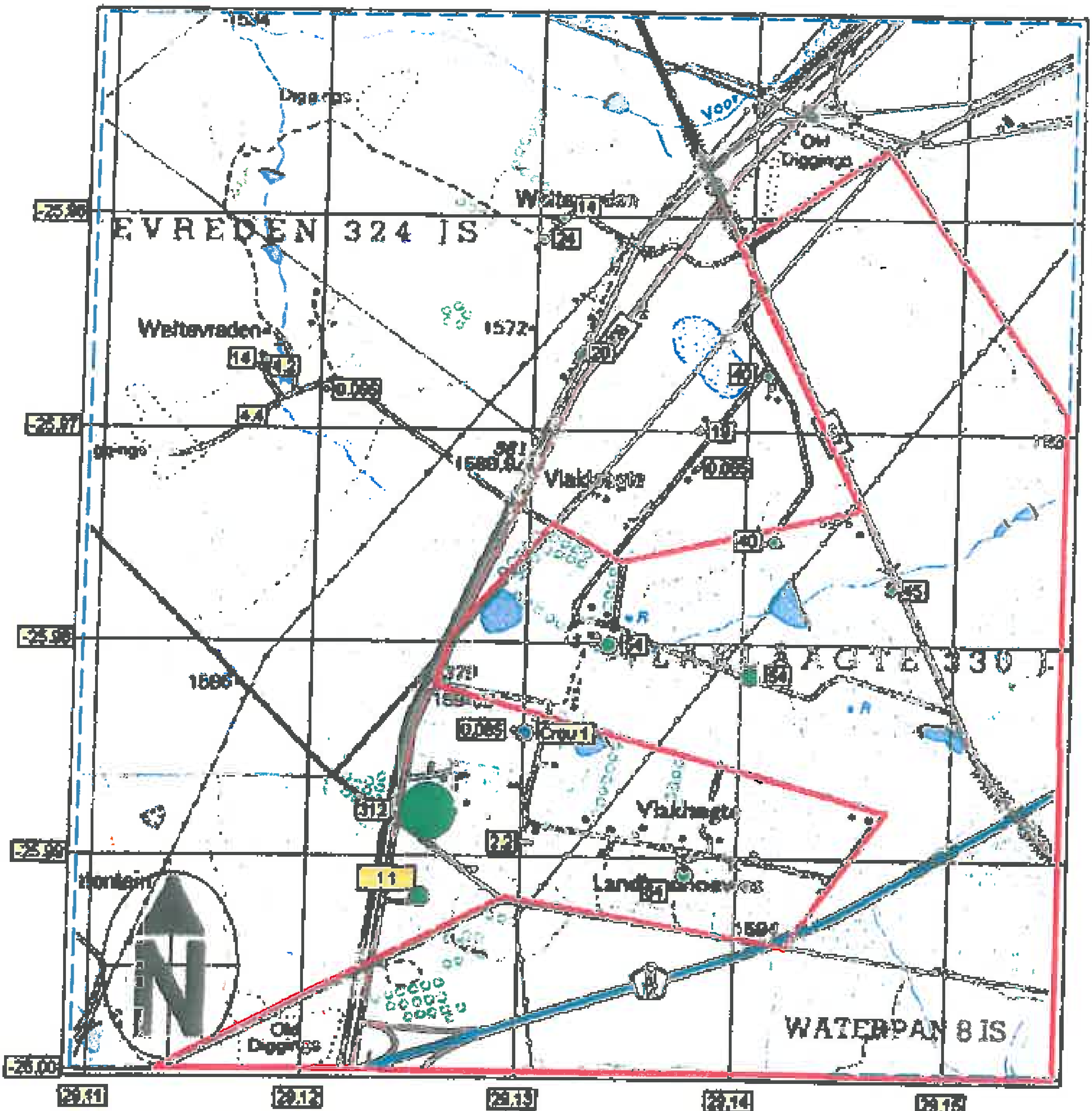


Figure 5.3-1: The recorded SO_4 concentrations for the Vlaklaagte Coal Mine Project surveyed localities.

5.4 Nitrate (NO_3)

In fresh unpolluted water, the NO_3 concentration is often below 2mg/l (as N). Nitrate concentrations are produced by the decay of plant, animal, and human waste, and nitrate pollution is often found wherever intensive land use activities take place. Nitrate concentrations exceeding 20mg/l are common in groundwaters where extensive land use takes place. Health effects associated with high NO_3 (>20mg/l) concentrations are impaired concentration, lack of energy, and the formation of methaemoglobin in blood cells. Individuals at risk are specifically infants under the age of 1 year.

From Figure 5.4-1 it is evident that all localities, except Lab 1 and Lab 2, comply with the SANS drinking water guidelines. The recorded NO_3 concentrations at localities Lab 1 and Lab 2 could have health effects in infants, as discussed earlier.

6. RECORDED WATER LEVELS

Recorded water levels for the hydrocensus localities are illustrated in Figure 6.1-1 and Figure 6.1-2. Table 4-1 and Table 6-1 indicate the measured water levels for the hydrocensus localities where access to the water level were possible. All water levels are given as meters below ground (surface) level. The static groundwater levels varied between 0m (various recorded fountains) and 22.78m. Indicated by both Table 4.1 and Figure 6.1-1, lower groundwater levels (<10m) were recorded for most of the hydrocensus area. The deeper groundwater levels (>20m) were recorded at one locality (Lab 4), which was actively pumping at the time of measurement.

Table 6.1-1: Recorded water levels for the surveyed hydrocensus localities at Hartbessfontein, March 2010.

Locality	Owner / Contact Person	South	East	Elevation	Water level
Ad 1	Adistra 96 cc	-25.9718	29.13773	1592	2.60
Bo 1	MJ Botha	-25.96741	29.14095	1593	1.28
Crou 1	MM Croucamp	-25.9843	29.13001	1604	2.70
Crou 2		-25.98419	29.12954	1604	4.68
Crou 3		-25.98937	29.13026	1608	2.68
Crou 4		-25.99002	29.13817	1605	2.60
Duv 1	PSJ Duvenhage	-25.97521	29.14144	1593	1.40
Duv 2		-25.97541	29.14176	1592	2.68
Eng 1	EHJ Engelbrecht	-25.98801	29.12559	1608	0.95
Eng 2		-25.98902	29.12519	1607	0.82
Lab 2	J Labuschagne	-25.98018	29.13379	1598	2.64
Lab 3		-25.97935	29.13405	1595	0.82
Lab 4		-25.97914	29.13225	1600	22.78
Mo 1	M Masalela	-25.97001	29.13779	1595	2.00
Moyo 1	Remo Moyo	-25.96688	29.11739	1566	4.35

Moyo 3		-25.95904	29.118	1574	0.00
Roets 1	MR Roets	-25.96147	29.12991	1572	0.92
Roets 3		-25.96012	29.13109	1575	1.62
Uys 2		-25.99064	29.13764	1610	2.25
Windpomp	Unknown	-25.98648	29.13204	1585	0.00
WSW	Mine Monitoring Borehole	-25.96822	29.12026	1580	3.82
Average					3.03
Deepest					22.78
Shallowest					0.00

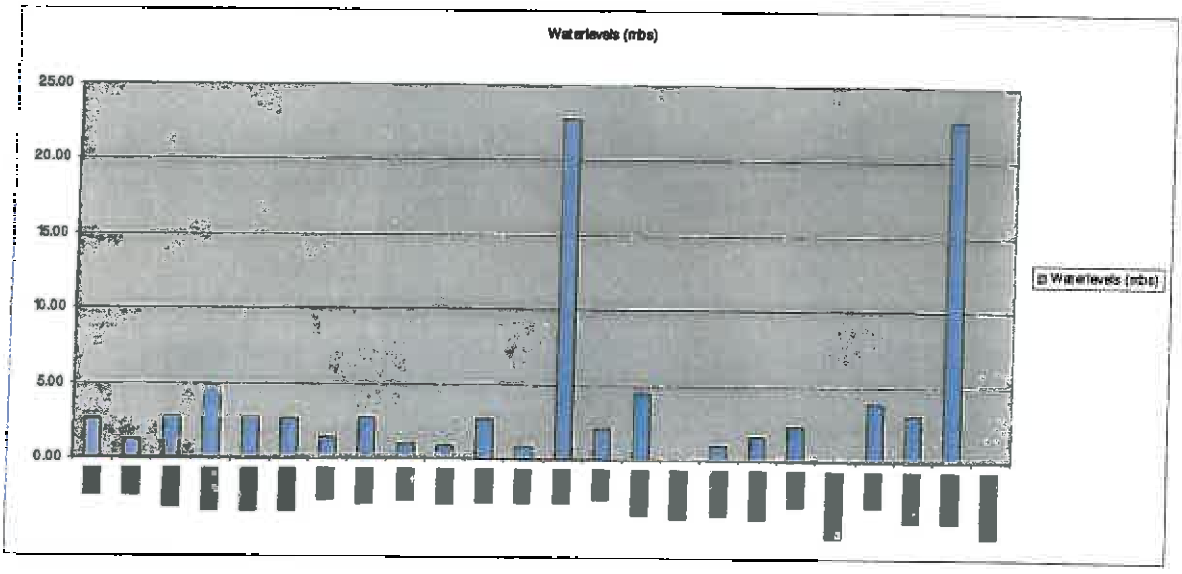


Figure 6.1-2: Recorded water levels for the Vlaklaagte hydrocensus localities, March 2010.

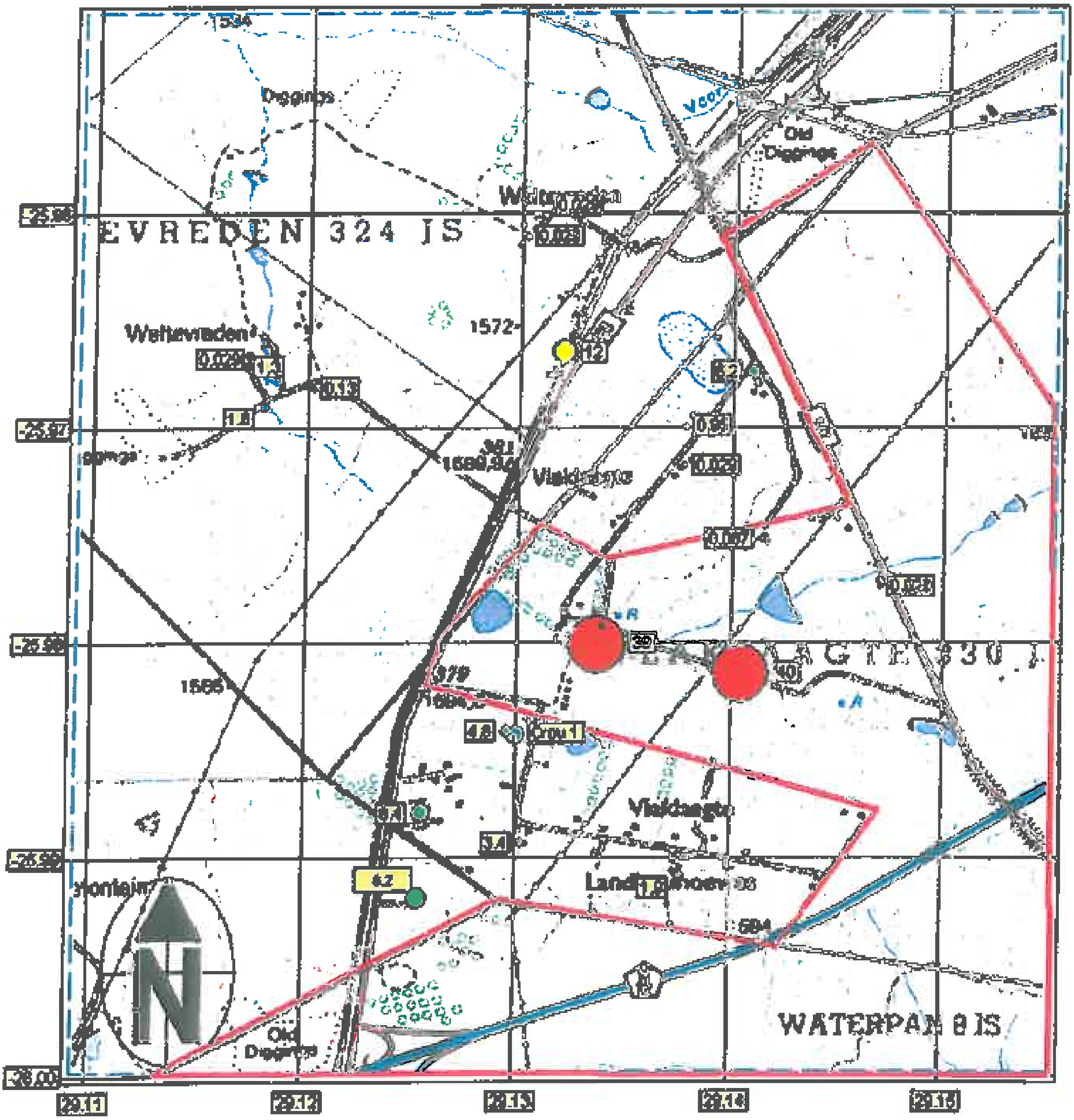


Figure 5.4-1: The recorded NO_3 concentrations for the Vlaklaagte Coal Mine Project surveyed localities.

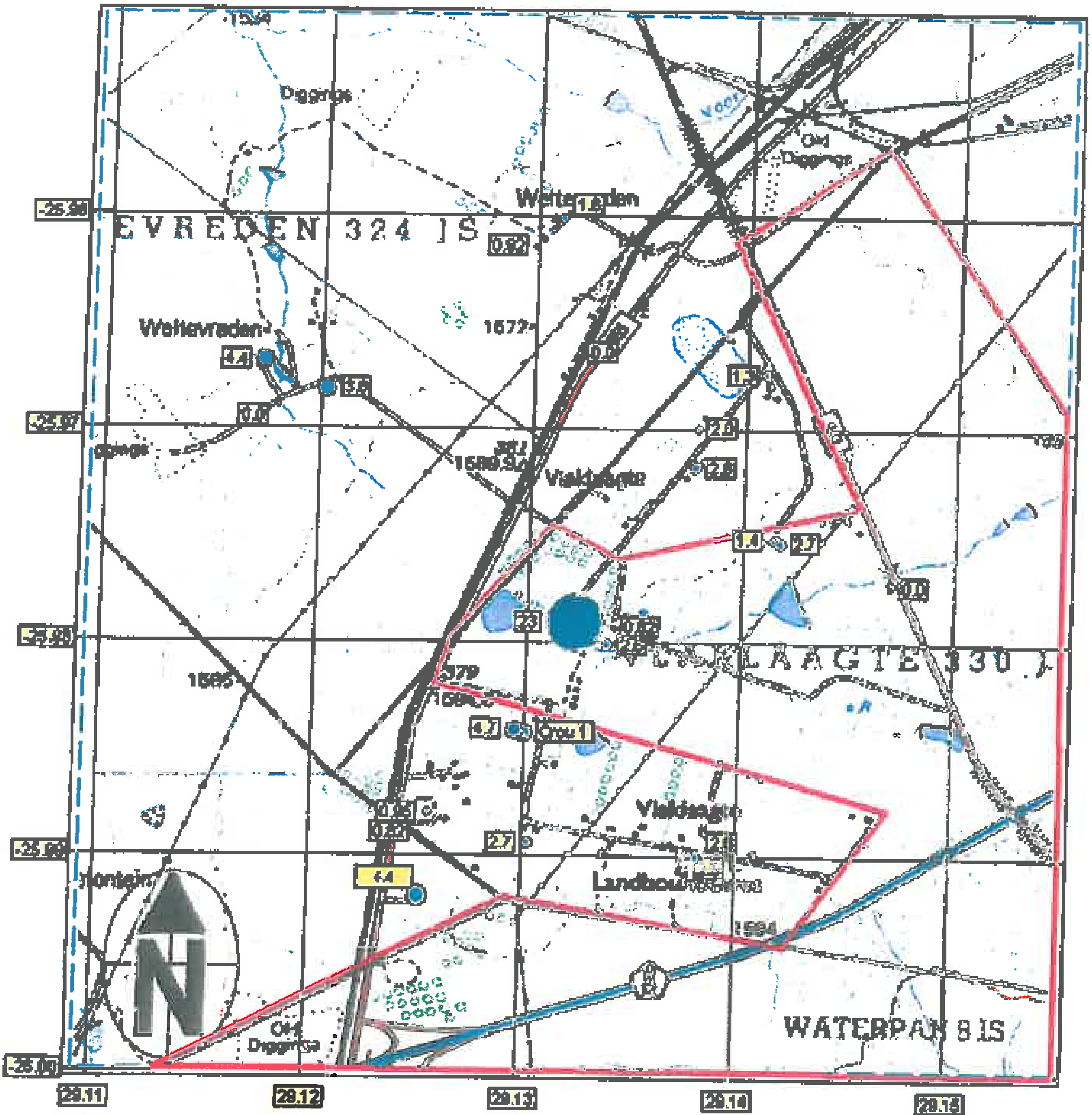


Figure 6.1-1: The recorded water levels (mbs) for the Vlaklaagte Coal Mine Project surveyed localities.

7. CONCLUSION

Clean Stream Scientific Services conducted a hydrocensus in March 2010 on the properties of landowners adjacent to the proposed Vlaklaagte Coal Mining area. The aim of the hydrocensus was to establish baseline water quality and water level data for the area for any future reference.

Contact was made with ten (10) interested and affected parties. 29 Borehole localities were logged and water levels were recorded. Water quality data for 17 localities and water level data for 22 localities were gathered. Various landowners farming with cattle and maize surround the proposed Vlaklaagte Coal Mine project. The water quality and water level data can be summarised as follows:

- Three localities recorded hard water concentrations.
- Except for localities Lab 1 and Lab 2, regional pH, EC, SO_4 and NO_3 concentrations were recorded as compliant with the SANS241 drinking water standards.
- The general water quality of the area can be described as good for domestic and livestock watering purposes.
- Static groundwater levels varied between 0m (various fountains) and 22m.
- Deeper groundwater levels (>20m) were recorded at one locality, which was actively pumping at the time of measurement.
- The surveyed ground water qualities generally reflect natural conditions without signs of contamination or pollution.

8. REFERENCES

Department of Water Affairs and Forestry (DWAF). Act N. 36 of 1998: National Water Act, 1998

Department of Minerals and Energy (DME). Act N 28 of 2002: Minerals and Petroleum Resources Development Act, 2002

The South African Bureau of Standards (SABS), ISO 5667-1 to 5667-15, First Edition, 1999

Department of Water Affairs and Forestry (DWAF). 2006: Best Practice Guideline N. G3. Water Monitoring Systems.

Department of Water Affairs and Forestry (DWAF). Targeted Water Quality Guidelines:

Domestic Use (Volume 01), Livestock Watering (Volume 05), Irrigation (Volume 04). 1998.