INTEGRATED WATER AND WASTE MANAGEMENT PLAN FOR
ASSMANG CHROME, DWARSRIEVER MINE

Integrated Water and Waste Management Plan (IWWMP)

October 2010
INTEGRATED WATER AND WASTE MANAGEMENT PLAN (IWWMP)

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1. **EXECUTIVE SUMMARY**

Assmang’s Dwarsrivier Mine, in the interest of continually improving environmental management at the mine and achieving legal compliance through implementation of conditions set out in their Integrated Water Use License (IWUL), appointed EScience Associates (Pty) Ltd. (ESA) to compile an Integrated Water and Waste Management Plan (IWWMP) for the mine. The IWWMP is intended to be a simple, feasible, implementable plan for the Dwarsrivier Mine based upon site specific management action programmes, also taking into account the National Water Resource Strategy (NWRS), relevant Catchment Management Strategy (CS), Resource Quality Objectives (RQO) and the sensitivity of the receiving water resources and down-stream water users in the vicinity of the mine.

An Environmental Impact Assessment (EIA) of all potential mining related impacts on ground and surface water resources, together with observations / findings from site inspections, the professional judgement of various project team members, stakeholder inputs and inputs from various technical staff at the mine were used to assess where the focus of the IWMMP should be set in order to reduce the significance of those impacts deemed to be of moderate to high significance. The IWWMP has a three-fold focus on the following key management levels, in to ensure that maximum effect is derived from the IWWMP in achieving holistic, resource focused, water and waste management:

- Surface water management techniques and specific actions to separate clean and dirty storm water flows. The main focus of which is to minimise the amount of ‘dirty / contaminated’ water unnecessarily generated over the mining site, whilst encouraging natural infiltration of storm water into soil surfaces and the diversion of reasonable excesses thereof towards natural surface water resources;
- Water quality in the mine’s ‘closed’ loop water reticulation system, as well as ground water in the mine lease area and immediate surrounds contains excessive nitrate and ammonia, as well as salts of, *inter alia*, Magnesium (Mg) and (Ca). The Mine has, having exhausted all other mitigation options to improve mine water quality, identified the need to install a Reverse Osmosis Plant (ROP) and brine management infrastructure (evaporation ponds, spray bar evaporators, or similar such technologies) on the mine in order to remove a wide range of contaminants from underground mine water; thereby improving the quality of re-circulating mine water in the mine’s ‘closed’ loop water reticulation system; and
- Alignment of various industrial type mine water uses with already ‘contaminated’ sources for such, thereby reducing the overall demand on ground water resource through the extraction and utilisation of potable water for industrial purposes. The reuse of treated mine water for secondary purposes (offices, ablutions and change houses) on the mine, as proposed by this IWWMP, will also reduce the overall burden of mining operations on ground and surface water resources in the vicinity of the site.

In addition to the above, the appropriate rehabilitation of previously mined / disturbed areas (incl. Waste rock dumps) over the site will reduce the potential occurrence of soil erosion and associated potential for the siltation of surface water resources in the mine lease area and surrounds, as well as promoting biodiversity and the health of river system ecology. As such, a comprehensive rehabilitation plan, developed by a competent specialist, is required for the mine within 12 months of the acceptance of this plan by the DWA. In the interim, the mitigation actions proposed in this plan are aimed to curb erosion from waste rock dumps in particular.
The development of this IWWMP is also based on achieving compliance with the Dwarsrivier Mine’s existing Integrated Water Use License condition requirements (copy thereof in Appendix 1), which requires the mine to investigate and put into practice any water saving devices and purifying techniques to stimulate the re-use of water containing waste. This requirement is in terms of section 21 (Water Use), chapter 4 of the National Water Act (Act 36 of 1998). The project, furthermore, strives to comply with the provisions and objectives of the National Environmental Management Act, 1998 (Act no. 107 of 1998) [NEMA], National Environmental Management: Waste Act, 2008 (Act no. 59 of 2008) [NEMWA] and the Minerals and Petroleum Resources Development Act, 2002 (Act no. 28 of 2002) [MPRDA, as amended].

Truly integrated water and waste management planning relies on the productive input from all those stakeholders either directly or indirectly affected by, or with a mandate to administer, activities undertaken at the Dwarsrivier Mine that could impact negatively on ground and surface water quality and quantity. Comment was duly sought, during the development of this IWWMP from, inter alia, the following broad stakeholder groups /communities and utilised in the integrated development planning process:

- Local Government;
- Provincial Government;
- Community organisations;
- Non-governmental organisations;
- Community business forums;
- Local Tribal Authorities;
- Adjacent Landowners; and
- Neighbouring mines.

Comment to date has centred, inter alia, on the following issues and areas of concern:

- Management issues revolving around the salty brine waste to be produced from the proposed Reverse Osmosis Plant;
- Measures/lining to be established to ensure that no ground water contamination results from brine management lagoons;
- Decommissioning of the proposed ROP and associated brine management lagoons at mine closure;
- Potential impacts by Dwarsrivier Mine on the Dwars River, upon which neighbouring communities, such as Kalkfontein, are dependent on for their livelihood;
- Effectiveness of the current groundwater monitoring regime in place at the mine and requests to extend this monitoring network to include domestic use boreholes in the Kalkfontein community, located several kilometres west of the Mine;
- Disposal of membrane filters used in Reverse Osmosis Technologies; and
- Possible utilisation of surplus waste rock at mine closure for crushing and sale as aggregate by the local community.

It is the professional opinion of ESA that this IWWMP gives effects to the objectives of the National and relevant catchment level Water Resource Management objectives, as well as those specific management objectives of the mine itself, through...:

“...the implementation of measures to a) reduce the overall quantity of water abstracted for ongoing mining operations, b) reduce the volume of water contaminated through...
ongoing mining operations and c) significantly improve the quality of water already subject to contamination from ongoing mining operations”.

The IWWMP will require updating and amendment on an annual basis to ensure that the IWWMP is treated as a dynamic / working document that remains legislatively compliant and applicable to the stage at which mining is undertaken on site. The successful implementation of the IWWMP is underpinned by senior mine management’s commitment and support for the plan and particularly support for those parties mandated to ensure its implementation. The IWWMP also prescribes self and external regulation to review compliance by the mine in implementing the specific actions of the IWWMP. Reporting of audit findings to the Department of Water Affairs on an annual basis is also a provision of this IWWMP.
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ABBREVIATIONS

CMA  Catchment Management Agency
CMS  Catchment Management Strategy
BPEO  Best Practise Environmental Option
BPG  Best Practise Guideline
CA  Competent Authority
DEA  Department of Environmental Affairs
DEDET  Department of Economic Development, Environment and Tourism
EBP  Environmental Best Practise
EMP  Environmental Management Plan
DWA  Department of Water Affairs
EMS  Environmental Management System
LRWD  Lower Return Water Dam
IWRM  Integrated Water Resource Management
MPRDA  Minerals and Petroleum Resources Development Act, Act No. 28 of 2002
NEMA  National Environmental Management Act, Act No. 107 OF 1998
NWA  National Water Act, No. 36 of 1998
RO  Reverse Osmosis
ROP  Reverse Osmosis Plant
ROM  Run of Mine
URWD  Upper Return Water Dam
IWWMP  Integrated Waste and Water Management Plan
WMA  Water Management Area
DEFINITIONS

**Alien species** - Plants and animals which do not arrive naturally in an area - they are brought in by humans. Alien plants often force indigenous species out of the area.

**Alternative** - A possible course of action, in place of another, that would meet the same purpose and need defined by the development proposal. Alternatives considered in the EIA process can include location and/or routing alternatives, layout alternatives, process and/or design alternatives, scheduling alternatives or input alternatives.

**Anions** - An anion, is an ion with more electrons than protons, giving it a net negative charge (since electrons are negatively charged and protons are positively charged).

**Aspect** - Element of an organisation’s activities, products or services that can interact with the environment.

**Auditing** - A systematic, documented, periodic and objective evaluation of how well the environmental management plan is being implemented and is performing with the aim of helping to safeguard the environment by: facilitating management control which would include meeting regulatory requirements. Results of the audit help the organisation to improve its environmental policies and management systems.

**Biodiversity** - The rich variety of plants and animals that live in their own environment.

**Brine** - Water which is saturated or nearly saturated with salt.

**Cations** - A cation, is an ion with more protons than electrons. Thereby, giving it a net positive charge.

**Contamination** - Polluting or making something impure.

**Corrective (or remedial) action** - Response required to address an environmental problem that is in conflict with the requirements of the EMP. The need for corrective action may be determined through monitoring, audits or management review.

**Degradation** - The lowering of the quality of the environment through human activities, e.g. river degradation, soil degradation.

**Environment** - Our surroundings, including living and non-living elements, e.g. land, soil, plants, animals, air, water and humans. The environment also refers to our social and economic surroundings, and our effect on our surroundings.

**Environmental Impact Assessment (EIA)** - An Environmental Impact Assessment (EIA) refers to the process of identifying, predicting and assessing the potential positive and negative social, economic and biophysical impacts of a proposed development. The EIA includes an evaluation of alternatives; recommendations for appropriate management actions for minimising or avoiding negative impacts and for enhancing positive impacts; as well as proposed monitoring measures.

**Environmental Management System (EMS)** - Environmental Management Systems (EMS) provide guidance on how to manage the environmental impacts of activities, products and services. They detail the organisational structure, responsibilities, practices, procedures, processes and resources for environmental management. The ISO14001 EMS standard has been developed by the International Standards Organisation.

**Environmental policy** - Statement of intent and principles in relation to overall environmental performance, providing a framework for the setting of objectives and targets.

**Evaporation ponds** - Storage ponds constructed to contain liquid effluent by-product (brine) of the Reverse Osmosis processes (usually lined with an impermeable liner to ensure that brine does not seep into exposed soil surfaces, thereby potentially contaminating...
Ferrochrome - (FeCr) is an alloy of chromium and iron containing between 50% and 70% chromium. The ferrochrome is produced by electric arc melting of chromite, an iron magnesium chromium oxide and the most important chromium ore.

Hazardous waste - Waste, even in small amounts, that can cause damage to plants, animals, their habitat and the well-being of human beings, e.g. waste from factories, detergents, pesticides, hydrocarbons, etc.

Impact - A description of the potential effect or consequence of an aspect of the development on a specified component of the biophysical, social or economic environment within a defined time and space.

Infrastructure - The network of facilities and services that are needed for economic activities, e.g. roads, electricity, water, sewerage.

Integrated - Mixing or combining all useful information and factors into a joint or unified whole. See Integrated Environmental Management.

Integrated Environmental Management (IEM) - A way of managing the environment by including environmental factors in all stages of development. This includes thinking about physical, social, cultural and economic factors and consulting with all the people affected by the proposed developments. Also called "IEM".

Local relief: The difference between the highest and lowest points in a landscape. For the purposes of this study, the local relief is based on a scale of 1:50 000.

Mitigation - Measures designed to avoid, reduce or remedy adverse impacts

Policy - A set of aims, guidelines and procedures to help you make decisions and manage an organisation or structure. Policies are based on people's values and goals. See Integrated Metropolitan Environmental Policy.

Phyto-remediation - Is the treatment of environmental problems (bioremediation) through the use of plants which mitigate the environmental problem without the need to excavate the contaminant material and dispose of it elsewhere.

Process - Development usually happens through a process - a number of planned steps or stages.

Proponent - Developer. Entity which applies for environmental approval and is ultimately accountable for compliance to conditions stipulated in the Environmental authorisation (EA) and requirements of the EMP.

Recycling - Collecting, cleaning and re-using materials.

Resources - Parts of our natural environment that we use and protect, e.g. land, forests, water, wildlife, and minerals.

Reverse Osmosis - A separation process that uses pressure to force a solvent through a membrane, retaining the solute on one side and allowing the pure solvent to pass to the other side. Typically a reverse osmosis plant is used to treat liquid effluent and separate chemical impurities from waste water to yield concentrated brine which must be disposed of and water. A reverse osmosis plant can be designed to deliver treated water of different levels of purity.

Solute - A solute is dissolved in another substance, known as a solvent.

Solvent - A solvent is a liquid, solid, or gas that dissolves another solid, liquid, or gaseous solute, resulting in a solution that is soluble in a certain volume of solvent at a specified temperature.
Stakeholders - A subgroup of the public whose interests may be positively or negatively affected by a proposal or activity and/or who are concerned with a proposal or activity and its consequences. The term includes the proponent, authorities and all interested and affected parties.

Storm water management - Strategies implemented to control the surface flow of storm water such that erosion, sedimentation and pollution of surface and ground water resources in the immediate and surrounding environments are mitigated. This is specifically important during the construction and decommissioning phases of a project.

Sustainable development - Development that is planned to meet the needs of present and future generations, e.g. the need for basic environmental, social and economic services. Sustainable development includes using and maintaining resources responsibly.

Sustainability - Being able to meet the needs of present and future resources.

Waste Management - Classifying, recycling, treatment and disposal of waste generated during construction and decommissioning activities.
UNITS OF MEASURE

°C: (Degree) Celsius

g: Gram

kg: Kilogramme (1 kg = 1000 g)

l: Litre

m³: Cubic meter (typically under operating conditions without normalisation)

mg/kg: Milligrams per kilogram

Nm³: Normal cubic metre (101.3 kPa, 273 °K, 11% O²)

ppb: Parts per billion

ppm: Parts per million

t: Tonne (metric)

tpa: Tonnes per annum (year)

y: Year
2. INTRODUCTION TO INTEGRATED WATER AND WASTE MANAGEMENT PLANNING

This Integrated Water and Waste Management Plan (IWWMP) is compiled in order to promote the environmentally sustainable and equitable use of water in relation to the existing mining operations at the Dwarsrivier Mine. The IWWMP is intended to be a simple, feasible, implementable plan for the Dwarsrivier Mine based upon site specific programmes, also taking into account the National Water Resource Strategy (NWRS), relevant Catchment Management Strategy (CS), Resource Quality Objectives (RQO) and the sensitivity of the receiving water resources and down-stream water users in the vicinity of the mine (Figure 2-1).

This plan consolidates a number of so-called ‘sectoral’ water and waste management programmes, relating to specific mine water and waste management aspects, into a single stand alone document for ease of implementation by the mandated parties at the Dwarsrivier Mine (Figure 2-1). The ‘sectoral’ programmes referred to above cover, inter alia, the following aspects:

- Pollution prevention;
- Water re-use and reclamation;
- Water treatment;
- Storm Water Management; and
- Salt and Water Balances.

The consolidation of the above has been done taking cognisance of the resource quality objectives of the National Water Resource Strategy, as well as the relevant Catchment Management Strategy. The formulation of the IWWMP is, furthermore, based on an understanding of the above objectives in conjunction with an impact assessment for all those on site activities that have the potential to impact upon receiving water resources and users in the vicinity of the mine.

![Figure 2-1: Approach to Integrated Waste and Water Management Planning (Adapted from DWAF IWWMP Operational Guidelines, 2008).]
The objective of this IWWMP is not to merely compile all existing site knowledge from prior EIA processes or EMPRs into a single unmanageable document (DWA, 2008). It rather, however, applies the principles of the hierarchy for Water Quality Management (WQM) to focus mine management’s attention on dealing expressly with those site activities that impact either directly, or indirectly, on water resources and sets clear action plans for the control of water (containing waste) and waste as sources of pollution (Figure 2-2). The hierarchy makes use of precautionary principles and sets an order of priority for mine water and waste management decisions and actions.

**Figure 2-2:** Hierarchy of Water Quality Management (DWAF, 2006).

This plan also considers, to the greatest extent possible, the waste and water management actions required for implementation through the entire Life of Mine (incl. post closure and rehabilitation phase), whilst remaining dynamic enough to respond to changes in the receiving environment and available Best Practise Environmental Technology alternatives.

The National Water Resource Strategy describes the central objective of managing water resources as follows (DWAF, 2004):

“...to ensure that water is used to support equitable and sustainable social and economic transformation and development.”

The Dwarsrivier Mine falls within the Steeplpoort Sub-area of the Olifants Water Management Area (WMA). The Department of Water Affairs’ Internal Strategic Perspective for the Olifants Water Management Area (2004) described groundwater as an important source of supply in the Steeplpoort Sub-area for irrigation and domestic use.
The aforementioned document further stated that water resources in the Steelpoort sub-area are under threat from the mining and agricultural industries in the Sub-area.

“"The water problems (quality) in the Steelpoort Sub-area are salinity, eutrophication, toxicity and sediment. The salinity and eutrophication problems are due to irrigation return flows, mining impacts and sewage treatment plant discharges. Pesticides and herbicides have been cited as the cause of the toxicity problems."

DWA Internal Strategic Perspective for Olifants WMA, 2004.

**Figure 2-3**: Figure showing the placement of the Steelpoort Sub-area within the greater Olifants WMA (DWAF, 2004).

Strategic Water Resource Management requires the party mandated to manage water and waste at the Dwarsrivier Mine to have an informed understanding of the existing development pressures and water resource quality and quantity issues within the greater catchment. The potential impacts of the Mine’s activities can then be managed to minimise not only the local / direct impacts of the Mine’s operations on localised water resources, but also to ensure that Dwarsrivier’s activities do not further exacerbate existing catchment management issues through indirect and cumulative impacts (E.g. cumulative salinity and eutrophication impacts, as identified in the Department of Water Affairs’ Internal Strategic Perspective for the Olifants River Water Management Area).
2.1 OBJECTIVES OF THE IWWMP

In light of the above, the National Water Resource Strategy, as well as the Dwarsrivier Mine’s own strategic objectives, the overall objectives of the IWWMP can be described, inter alia, as follows:

To ensure that, through the implementation of appropriate pollution and storm water control and prevention measures and the efficient re-use and recapture of ‘dirty’ water on site, that the Mine does not unnecessarily overburden ground and surface water resources (quality and quantity) on which adjacent communities and industry in the catchment are dependent on for their livelihood and / or well being.

The specific conditional requirements of the Mine’s existing Integrated Water Use License should be seen as the so-called ‘minimum requirements’ to this IWWMP and this plan seeks to, inter alia, support the implementation of the aforementioned requirements.

2.2 BACKGROUND

The approach adopted in the compilation of this IWWMP is detailed in the previous section. The predominant drivers towards the commissioning of the IWWMP by Dwarsrivier for the site are two-fold:

- Dwarsrivier is legally obligated to develop an IWWMP, as stipulated in the Mine’s integrated water use license (Appendix 1); and
- Assmang’s Dwarsrivier Mine is an ISO 14001 accredited facility that aims for continual environmental improvements through adopting Best Practise Environmental Principles.

In light of the above, Dwarsrivier Mine duly appointed EScience Associates (Pty) Ltd. (ESA), as Independent Environmental Assessment Practitioners (EAP), to compile an Integrated Water and Waste Management Plan (IWWMP) for the mine that will seek to manage water and waste, including waste water, on site to ensure that such waste does not detrimentally impact on the environment (particularly ground and surface water resources). This IWWMP is required as part of condition 12 of the Water Use License issued to the mine, as follows (refer to Section 2.4 for further details on existing Water Use Licenses and exemptions, as well as mining permits):

12 INTEGRATED WATER MANAGEMENT AND REHABILITATION PLAN

12.1 The licensee must develop and compile a comprehensive integrated water and waste management plan (IWWMP), a rehabilitation strategy as well as associated implementation programme. A framework with time schedules for the development of these plans shall be submitted to the Regional Director for approval within one (1) year of approval of this licence. This plan shall include at least, but not be limited to, the following investigations:

12.1.1 The plan referred to in 12.1 shall be updated annually and submitted to the Regional Director for approval.

12.1.2 The licensee shall make full financial provision for all the investigations, design, construction, operation and maintenance for a water treatment plant should it become a requirement as a long-term groundwater management strategy.

12.1.3 General waste must be disposed of in accordance with the provisions of Section 20(1) of the Environment Conservation Act (Act 73 of 1989).

12.1.4 Measures must be provided to avoid disposal or spillage of any material which could destroy or degrade the in-stream or riparian habitat.
2.3 LOCATION OF PROPERTY
Dwarsrivier Mine is situated on the `Remaining Extent of Portion 1` and the `Remaining Extent` of the Farm Dwarsrivier 372 KT, approximately 20km south of Steelpoort. Access to the mine from Steelpoort is via the Sekhukhuneland-Lydenburg Road (R577).

2.3.1 JURISDICTIONS
Magisterial District: Lydenburg
Local Municipality: Tubatse
District Municipality: Sekhukhune
Province: Limpopo

2.3.2 NEIGHBOURING TOWNS
Steelpoort is located 30 kilometres, by road, to the north of the site. Lydenburg is situated approximately 60 kilometres, by road, to the east of the site.

2.3.3 INFRASTRUCTURE
There is a district tar road between Sekhukhuneland and Lydenburg (R577), from which the mine is accessed.

2.3.4 SERVITUDES
Gravel roads, telephone lines, electricity lines and irrigation canals traverse the site.

2.3.5 LAND USE
Several of the neighbouring farms, Tweefontein 380 JT, Thomcliffe 374 KT, De Grooteboom 373 KT and Dwarsriver 372 KT are owned by mining houses with existing chrome and platinum mines that are operational. On the remainder of the neighbouring farms, agricultural activities take place, in the form of stock grazing and the production of vegetables, lucerne and cotton.

2.3.6 WATER CATCHMENTS
The mine is located in the Olifants River Water Management Area (Steelpoort Sub-area thereof - Figure 2-3). All surface water draining from the properties ultimately flows into the Groot Dwars River and the Klein Dwars River, the confluence of which is located on the property. The Dwarsrivier flows northwards into the Steelpoort River. Dwarsrivier mine is exempted from not being allowed to undermine a river and is, therefore, allowed to undermine the Groot Dwars River, by the Department of Water Affairs and Forestry, exemption reference number 16/2/7/B400/C83/1 (attached as Appendix 1).

2.4 ADMINISTRATIVE INFORMATION
2.4.1 NAME AND ADDRESS OF APPLICANT
Mine
Dwarsrivier Mine
PO Box 567
LYDENBURG
1120
Telephone No: (013) 230 5300
2.4.2 MINERAL AND SURFACE RIGHTS HOLDERS

Name and Address of Mineral Rights Holder
Assmang Chrome Limited
PO Box 62379
MARSHALL TOWN
2107

Name and Address of Mining Authorisation Holder
Assmang Chrome Limited
PO Box 62379
MARSHALL TOWN
2107

Name and Address of Landowner
Assmang Chrome Limited
PO Box 62379
MARSHALL TOWN
2107
3. LEGAL AND POLICY FRAMEWORK

The following section is intended to provide the relevant parties at Dwarsrivier Mine responsible for the implementation of this plan, as well as relevant Government officials responsible for the review and potential approval of this plan, with an overview of the Legislation, guidelines, policies and frameworks applicable to the legally compliant and strategically aligned (in terms of NWRS and catchment management objectives) operation of the Dwarsrivier Mine in a sustainable manner.

3.1 CURRENT APPROVALS

The first Dwarsrivier Mine Environmental Management Programme Report (EMPR) was authorised on 14 December 1999 by Dirk van der Merwe, Acting Deputy Director: Mine Rehabilitation and Environment on behalf of The Director: Mineral Development in the Mpumalanga Region, for the Department of Minerals & Energy (DME). This followed approval of the Mining Licence, number 21/99, on 12 October 1999 by DME in Witbank (Appendix 1).

In addition to the above, and of relevance to this IWWMP, the Mine also has Water Use Licenses / Exemptions issued by the Department of Water Affairs - DWA (then known as the Department of Water Affairs and Forestry) for numerous water uses over the mining site (Appendix 1). The Licenses / Exemption issued by DWA are as follows:

- Exemption 16/2/7/B4000/C83/1 - “Dwars River Chrome Mine is hereby exempted in terms of Regulation 3 of Government Notice 704 as published in the Government Gazette for the undermining of the Dwars River on the properties set out in 3 (a) below and subject to the conditions set out in Appendix A of the license” (Appendix 1); and
- License 24053346 - to undertake the following listed water uses:
  o “Taking water from the Groot Dwars River a surface water resource, subject to...”;
  o “Impeding or diverting the flow of water in a watercourse subject to...”;
  o “Disposing of waste or water containing waste in a manner that may detrimentally impact on a water resource, subject to...”;
  o “Altering the beds, banks, course and characteristics of a watercourse, subject to...”; and
  o “Taking water from a groundwater resource, and removing water from underground, subject to...”.

This project is also based on achieving compliance with the Dwarsrivier Mine’s existing Integrated Water Use License condition requirements (copy thereof in Appendix 1), which requires the mine to investigate and put into practice any water saving devices and purifying techniques to stimulate the re-use of water containing waste. This requirement is in terms of section 21 (Water Use), chapter 4 of the National Water Act (Act 36 of 1998). The project, furthermore, strives to comply with the provisions of the National Environmental Management Act, 1998 (Act no. 107 of 1998)[NEMA] and the Minerals and Petroleum Resources Development Act, 2002 (Act no. 28 of 2002)[MPRDA].
3.2 CONSTITUTION OF SOUTH AFRICA


The Constitution of the Republic of South Africa (Act No. 108 of 1996) has significant implications for environmental management.

The main effects are the protection of environmental and property rights, the drastic change brought about by the sections dealing with administrative law such as access to information, just administrative action and broadening of the locus standi of litigants. These aspects provide general and overarching support and are of major assistance in the effective implementation of the environmental management principles and structures of the ECA, NEMWA and NEMA. Section 24 in the Bill of Rights of the Constitution specifically states:

- “Everyone has the right - to an environment that is not harmful to their health or well-being”;
- “To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that - Prevent pollution and ecological degradation;
- Promote conservation”; and
- “Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.”

3.3 WASTE


In the past, waste management activities were regulated under the Environment Conservation Act (ECA), 1989 (Act 73 of 1989), specifically Section 20(1), which states that “no person shall establish, provide or operate any disposal site without a permit issued by the Minister of Water Affairs”. Based on strict interpretation applied by authorities, any waste handling facility, including waste storage and treatment, also required permitting (or at least exemption) in terms of Section 20(1). These requirements have however been replaced by the National Environmental Management: Waste Act (Act 59 of 2008) (NEMWA), which was enacted on 10 March 2009 and came into force on 01 July 2009.

The NEMWA defines ‘Waste’ as “any substance, whether or not that substance can be reduced, re-used, recycled and recovered –

(a) that is surplus, unwanted, rejected, discarded, abandoned or disposed of;
(b) which the generator has no further use of for the purposes of production;
(c) that must be treated or disposed of; or
(d) that is identified as a waste by the Minister by notice in the Gazette, and includes

waste generated by the mining, medical or other sector, but- (i) a by-product is not considered waste; and (ii) any portion of waste, once re-used, recycled and recovered, ceases to be waste”.

Other key definitions in NEMWA are:
Hazardous Waste: Any waste that contains organic or inorganic elements or compounds that may, owing to the inherent physical, chemical or toxicological characteristics of that waste, have a detrimental impact on health and the environment.

General Waste: Waste that does not pose an immediate hazard or threat to health or to the environment, and includes (a) domestic waste; (b) building and demolition waste; (c) business waste; and (d) inert waste.

Inert Waste: Waste that (a) does not undergo any significant physical, chemical or biological transformation after disposal; (b) does not burn, react physically or chemically biodegrade or otherwise adversely affect any other matter or environment with which it may come into contact; and (c) does not impact negatively on the environment, because of its pollutant content and because the toxicity of its leachate is insignificant.

According to Section 19(1) and 19(3) of the NEMWA, the Minister may publish a list of waste management activities that have, or are likely to have, a detrimental effect on the environment, and must specify whether a waste management licence is required to conduct these activities. Under these provisions, a list of ‘Category A’ and ‘Category B’ waste management activities, which require a Waste Management Licence in terms of Section 20(b) of NEMWA, were published via General Notice No: 718 on 3 July 2009 as Schedule 1 to NEMWA.

In terms of this notice, a person who wishes to commence, undertake or conduct any of these listed activities must, as part of the Waste Management Licence application, conduct either a Basic Assessment process (for Category A activities), or a Scoping and EIA (for Category B) as stipulated in the EIA Regulations (GN R.385). The licensing process for waste management activities and the supporting information required is therefore the same as for activities listed in GN R.386 and R.387 that require an Environmental Authorisation (see Section 5.2). In order to avoid duplication by requiring two approvals for the same activity, waste activities listed in the EIA Regulations were removed by means of General Notice No: 719 on 3 July 2009, which means that currently, waste activities only require a Licence in terms of NEMWA, and not an Environmental Authorisation in terms of NEMA too.

In terms of Section 43(1)(a) of NEMWA, the Minister (i.e. national DEA) is the licensing authority where the waste management activity involves the establishment, operation, cessation or decommissioning of a facility at which hazardous waste has been or is to be stored, treated or disposed of.

The above waste licensing requirements are of particular importance to Dwarsrivier Mine’s establishment of a Reverse Osmosis Water treatment Plant (ROP) on site to treat water emanating from underground mine workings, for which a stand-alone waste licensing EIA process has been commissioned by the Dwarsrivier Mine. This EIA aims, during the Impact Analysis phase of the EIA process, to seek out the Best Practise Environmental Option (BPEO) for the potential re-use and possible disposal of the final waste product resultant from the potential approval of the project (solid salt waste from the proposed Evaporative Crystalliser Unit Plant).

Given that effluent/wastewater proposed to be captured from underground workings at the mine and passed through the ROP is ‘contaminated’ to a great degree, it is assumed
the brine produced at the ROP, will be classified as ‘Hazardous’, in terms of DWAF’s Minimum Requirements for the Handling, Classification & Disposal of Hazardous Waste (1998). Assmang’s application for waste licensing is, therefore, made to the National Department of Environmental Affairs and not the Limpopo Department of Economic Development, Environment and Tourism (LEDET), as would have been the case if waste licensing was being applied for any waste activity involving only general / domestic waste, as defined in DWAF’s Minimum Requirements for the Handling, Classification & Disposal of Hazardous Waste (1998).

The Waste Act seeks to, inter alia, encourage the prevention and reduction / minimisation of waste generation, whilst promoting re-use and re-cycling of the waste and only consider disposal of waste as a last resort (waste hierarchy - Figure 3-1). Some waste management experts have recently incorporated a 'fourth R': "Re-think", with the implied meaning that the present system may have fundamental flaws, and that a thoroughly effective system of waste management may need an entirely new way of looking at waste. Source reduction involves efforts to reduce hazardous waste and other materials by modifying industrial production and mining method. Source reduction methods involve changes in manufacturing technology, raw material inputs, and product formulation. At times, the term "pollution prevention" may refer to source reduction.

![Figure 3-1: Diagram of the so-called ‘Waste Hierarchy’ (Wikipedia, 2010).](image)

### 3.4 WASTE CLASSIFICATION

Waste classification and management in South Africa has since the late 1990’s been informed by a series of documents called the Minimum Requirements 2nd Edition, which was published by the Department of Water Affairs and Forestry in 1998 (Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste; Minimum Requirements for Waste Disposal by Landfill; and Minimum Requirements for the Monitoring of Water Quality at Waste Management Facilities). The Minimum Requirements were aimed at providing a norm by means of which authorities, waste generators, permit holders and other interested and affected parties can differentiate acceptable waste handling and disposable practices from unacceptable practices. The existing classification and management provisions in the Minimum Requirements Series have no legal standing in itself, although certain provisions have historically been formalised and enforced in varying degree through inclusion into the conditions of waste

Through the implementation of the Minimum Requirements waste classification system over the past 12 years, a number of shortcomings have been identified by regulatory authorities, industry and waste managers alike. In an attempt to address these issues, a draft 3rd Edition of the Minimum Requirements was published in 2005, but the revised system was never finalised and implemented.

The Department of Environmental Affairs (DEA) has therefore initiated a project in 2009 to develop a revised waste classification system, which would support the move away from landfill towards waste management options which favour waste recovery and re-use, and address some of the concerns that have been raised with respect to implementing the current Minimum Requirements 2nd Edition. It is the intention that this new National Waste Classification and Management System would be formalised into Regulations under NEMWA, with associated Schedules and/or Norms and Standards in terms of the Act as appropriate.

In terms of the latest draft framework (Figure 3-2), the revised system would include provisions under three main sections (or Components A, B and C):

A. Waste Classification: Identifying the specific hazardous properties, characteristics and components of waste in terms of SANS 10234, and assigning a corresponding hazard class and category to the waste as appropriate.

B. Waste Management: Prescribing procedures, requirements and guidelines for the evaluation and implementation of appropriate waste management options.

C. Waste Categorisation & Reporting: Setting specific parameters for reporting on waste generation and management to the Department of Environmental Affairs’ (DEA) Waste Information System (WIS).

The revised classification system currently in draft proposes several significant changes to the Minimum Requirements applied to date, with the result that the wastes from the proposed smelter complex would be subject to different classification and management requirements than currently in force. As the DEA project would be at an advanced stage by mid-2010, with promulgation of the new Regulations expected at the end of the year, the EIA will consider the provisions (even in draft form) of the system, particularly as it relates to classifying waste as hazardous or general, as well as revised landfill disposal requirements, in order to ensure alignment and ultimate compliance with the new system.

3.5 WATER


The National Water Act (NWA), 1998 (Act 36 of 1998), aims to manage national water resources in order to achieve sustainable use of water for the benefit of all water users. This requires that the quality of water resources is protected, and integrated management of water resources takes place.
In terms of the National Water Act, a water use licence application (WULA) is required for:

(a) taking water from a water resource;
(b) storing water;
(c) impeding or diverting the flow of water in a watercourse;
(d) engaging in a stream flow reduction activity contemplated in section 36;
(e) engaging in a controlled activity identified as such in section 37 (1) or declared under section 38 (1);
(f) discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
(g) disposing of waste in a manner which may detrimentally impact on a water resource;
(h) disposing in any manner of water which contains waste from, or which has been
heated in, any industrial or power generation process;
(i) altering the bed, banks, course or characteristics of a watercourse;
(j) removing, discharging or disposing of water found underground if it is necessary for the
    efficient continuation of an activity or for the safety of people; and
(k) using water for recreational purposes.

Other provisions of the NWA should also be taken into account, specifically relating to
Part 4 (Section 19), which deals with pollution prevention, in particular situations where
pollution of a water resource occurs or might occur as a result of activities on land. A
person who owns, controls, occupies or uses the land in question is responsible for taking
measures to prevent pollution of water resources. If these measures are not taken, the
catchment management agency concerned may itself do whatever is necessary to
prevent the pollution or to remedy its effects, and to recover all reasonable costs from
the persons responsible for the pollution.

The Dwarsrivier Mine appointed appropriately qualified consultants to compile an
Integrated Waste and Water Management Plan (IWWMP) for the mine that will seek to
manage waste, including waste water, on site to ensure that such waste does not
detrimentally impact on the environment (particularly ground and surface water
resources). This IWWMP is required as a condition of the Water Use License issued to the
mine, as follows:

12 INTEGRATED WATER MANAGEMENT AND REHABILITATION PLAN
12.1 The licensee must develop and compile a comprehensive integrated water and waste
    management plan (IWWMP), a rehabilitation strategy as well as associated implementation
    programme. A framework with time schedules for the development of these plans shall be
    submitted to the Regional Director for approval within one (1) year of approval of this licence. This
    plan shall include at least, but not be limited to, the following investigations:
12.1.1 The plan referred to in 12.1 shall be updated annually and submitted to the Regional
    Director for approval.
12.1.2 The licensee shall make full financial provision for all the investigations, design, construction,
    operation and maintenance for a water treatment plant should it become a requirement as a
    long-term groundwater management strategy.
12.1.3 General waste must be disposed of in accordance with the provisions of Section 20(1) of
12.1.4 Measures must be provided to avoid disposal or spillage of any material which could
destroy or degrade the in-stream or riparian habitat.
4. EXISTING MINING OPERATIONS

In order to appropriately designate and then implement management options for mining activities that could potentially impact upon water resources, it is prudent to firstly have an informed understanding of the current and proposed activities on the site. The following section, therefore, provides a comprehensive overview of the mine’s activities. The description of those activities, structures and infrastructure that have direct relevance to water supply, management and/or the potential to impact upon water resources are particularly detailed.

![Figure 4-1: Photograph at Dwarsrivier Geo-site](image)

The Dwarsrivier Geo-site, a few kilometres north-west of Dwarsrivier Chrome Mine. Here, a small canyon cut by the Dwars River has exposed the rare combination of black chromite seams, finely layered and split, within white anorthosite. This outcrop of a portion of the Bushveld Igneous Complex shows both the magnificent nature of the geology of this 2 billion year old igneous intrusion, and hints at the immense mineral wealth contained in similar (but thicker) chrome seams.

4.1 MINERAL DEPOSIT

The Bushveld Igneous Complex is the largest layered igneous intrusion in the world and contains the world’s largest deposits of chromite, vanadiferous magnetite and platinum group minerals. Near the base of the Complex occurs the Critical Zone, in which the...

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EScience Associates
most important resources of both the chromite and platinum group ores, in the world, occur (Figure 4-1). The Critical Zone comprises pyroxenite, norite and anorthosite layers, with substantial chromite seams, which have been divided into Lower, Middle and Upper Group chromite seams. There are up to seven (7) chromite layers in the Lower Group, of which LG 6 averages 1.8m thick and is the most important economically. Dwarsrivier Mine exploits the LG 6 chrome seam. Underground mining is presently conducted down to a depth of 350 metres below ground level (mbgl).

**4.2 MINING METHOD**

During the second phase of mining activities at Dwarsrivier, an underground mine was developed from a box-cut in the southern open cast pit. A decline shaft was sunk on a minor dip of 8° using a 3-road layout until development is beyond the barrier pillar. From there, development continues using seven (7) roads, with development along strike also utilising the same pattern. The underground mining layout is based on a board-and-pillar method using 7-road sections, with 6x6m pillars and 12m boards. Lateral road widths are approximately 8m.

Ore is delivered to surface by electric LHD (Load, Haul, Dump vehicle – Figure 4-2) to the strike conveyors, via a feeder breaker, in order to control the top-size of the broken ore. There would typically be three (3) production sections underground and one development section (at a full tonnage of 1Mt/annum), delivering the ore to a 1 050mm decline conveyor, which in turn delivers Run of Mine (ROM) to the processing plant via an overland conveyor.

**Figure 4-2: Photographic examples of LHDs**

A mining suite has been identified which comprises electro-hydraulic drill rigs, roof bolters and electric LHDs. The development section will utilise diesel-powered machines due to their superior flexibility. At certain areas, mining was conducted by open-cast mining methods, using the truck and shovel lateral roll-over mining technique. The open-cast mining on site has been completed and most of the mined out areas already rehabilitated. A decline shaft (northern decline shaft) is to be sunk from the southern side of the existing northern open-cast pit. This shaft will be sunk once dewatering of the aforementioned open-cast pit is complete.

Reclamation of the tailings dam is being conducted utilising truck and shovel methods (Figure 4-3). The reclaimed material is loaded on the trucks and taken to the new spirals plant. The tailings dam contains approximately 1.6Mt of material of which 40% of is chromite. The reclamation rate is estimate to be around 16kt per month. Currently, the so-called ‘North pit’ on site is used to dispose of tailings from the Mine’s processing plant.
The Water Use License (WUL) necessary to undertake this activity has been issued by the Department of Water Affairs (Appendix 1).

Figure 4-3: Dwarsrivier Mine Tailings Reclamation

4.3 PROCESSING PLANT

The Dwars River Mine has a processing plant, consisting of dense medium, cyclone and spiral separation units, established between the R577 (immediately west thereof) and the site’s existing tailings facility to the west (presently being reclaimed). A summary of the processing and beneficiation activities undertaken at this plant is provided below, as well as in Figure 4-4.

Feed from the underground mining operations is fed to the plant ROM stockpile via a single overland conveyor. Separate feeder breakers underground and in the open pits reduce the ore to -300mm. The plant ROM stockpile has a two (2) day live capacity of 10 000t to enable weekend work if necessary and provide buffer capacity in the event of no feed from the mine.

Conveyor feed from the ROM stockpile is then subjected to a crushing and screening process, whereby the size of the material is reduced, such that it can either be suitably fed into either the cyclone or dense medium separators within the plant. Alternatively, the crushed and screened material will be conveyed to a mill feed stockpile, from where it will be subjected to milling, in order to further reduce particle size for entry into the植物 spiral separation units.

Crushed and screened material that enters either the cyclone or dense medium separation units within the plant is then effectively separated into small chrome lumpy and conventional chrome lumpy respectively, as well as discard. This separation process results, in both instances, in the development of discard rock, which is subsequently conveyed to a discard bin that is emptied to the site’s waste rock discard dump by a tractor drawn trailer as required.

Material from crushing and screening, that is further subjected to milling in the plant’s milling section, is then fed through a complex and inter-linked system of spiral separation
units (spiral section - six units in total) to produce the following products, as well as waste tailings:

- Chemical grade chrome;
- Metallurgical grade chrome; and
- Low grade metallurgical chrome.

### 4.3.1 NEW SPIRALS PLANT

The material from the old tailings dump is fed into the recently completed new spirals plant. This plant will accept 16kt/month from the old tailings dump and 24kt/month from the existing main plant. The old tailings dump has a life of up to 8 years, after which, the new spirals plant will only treat feed from the existing main plant.

The material from the old tailings dump is taken to a stockpile, with about 1200t capacity, fed via a new feeder box and belts, whereas the material from the existing plant goes into a milling circuit on the new spirals plant. The new spirals plant is a two stage plant similar to the existing plant. High grade metallurgical grade (HG) is recovered from the 1st stage and low grade metallurgical grade (LG) from the 2nd stage. Final tailings after the 2nd stage is pumped to the tailings deposition facility.

### 4.4 SURFACE INFRASTRUCTURE

The mine infrastructure presently consists of, inter alia, the following structures and infrastructure (Figure 4-5):

- Administrative offices and parking;
- Weighbridge;
- Main plant area;
- Discard dumps;
- Stockpiles (topsoil, product, etc.);
- Haul roads;
- Tailings dam;
- Waste rock dumps;
- Salvage yard;
- Lay down areas;
- Water management structures / infrastructure (Pollution control dams, clarifier, storm water diversion berms / trenches, sewage treatment plants and associated pumps / piping);
- Conveyor belt system;
- Emulsion tanks;
- Above ground diesel tanks;
- Dis-used open pits (north and south);
- Northern (planned) and southern (existing) decline shafts;
- Decline and portal to the underground workings; and
- Numerous ventilation shafts.
4.5 WATER

4.5.1 WATER SUPPLY

Potable water for drinking and ablutions is presently obtained from various groundwater sources (Water Use License issued by DWAF – Appendix 1) and distributed to different parts of the mine as follows:

- borehole 1 (in alluvium next to Groot Dwars River) supplies the clinic, processing plant and mine security office in the old farmhouse;
- borehole 2 (next to borehole 1) supplies the plant exclusively; and
- boreholes 4 & 5 (on the east of the R577) supply the main mine offices and workshops.

**Figure 4-4:** Simplified process flow diagram for processing plant activities
A water softener and chlorinator has been installed at the main offices (Figure 4-5), to treat the water from boreholes 4 & 5, to improve the water quality and ensure the water is safe to drink. Water for the plant is also obtained from the Upper Return Water Dam (URWD), Lower Return Water Dam (LRWD) and Dam 26, which are fed by water from the plant process, run-off water (storm water) and underground mine dewatering via the site clarifier. If required, water is pumped from the Groot Dwars River (using Borehole BH1 & BH2 and stored in the LRWD) to the amount that is allocated by the old Dwarsrivier Irrigation Board (in the process of being converted into the Dwarsrivier Water User Association).

Abstraction of water from the Groot Dwars River is a last resort option once all other available water resources within the mine water circuit have been utilised to their full capacity (not anticipated).

Water for dust suppression is obtained from the Lower Return Water Dam, except for the crusher area adjacent to the processing plant, where potable water is used.

4.5.2 SEWAGE TREATMENT FACILITIES

There are two sewage treatment works on the site, as follows (Appendix 3):

- A larger works located south of the Springkaanspruit, receiving sewage from the main offices, workshops, change rooms and underground; and
- A second, smaller, works located south of the processing plant, for the change rooms at that location.

The larger works, built in 2002, is designed for 300 people and is fed by pipeline from the office area as well as sewage from underground, brought to surface in a tank of approximately 3m$^3$ and discharged directly into the treatment plant. It consists of two parallel sets of closed tanks for anaerobic digestion and sludge accumulation, aerobic digestion, settling, followed by chlorination, and some finishing ponds. The final effluent is pumped to Dam 26, part of the mine water management system, where it becomes highly diluted.

The smaller works, built first in 2000, is south of the processing plant and has a design capacity for 200 people. It consists of a buried concrete chamber for digestion, a rotating bio-filter/settling tank, some finishing ponds and a chlorinator. The effluent goes to the URWD, also part of the mine water management system, where it too is highly diluted.
Figure 4-5: Dwarsrivier Mine Layout Plan (Appendix 3 for enlarged version)
4.5.3 POLLUTION CONTROL DAMS

Several dams are used to manage water on the mine. On the surface, there are three (3) major dams (Figure 4-5):

- ‘Dam 26’;
- Upper Return Water Dam (URWD); and
- Lower Return Water Dam (LRWD).

Underground there are also several dams, including, inter alia, the following:

- Dewatering Dam (not actually underground – located at the portal to the South Decline Shaft);
- Water Accumulation Lower Point;
- North Zero Dam;
- South 51 Dam; and
- North 4A Dam.

The pollution control dams (return water dams) are aimed at hold all the potentially contaminated water on site. This includes surface run-off inside the so-called “dirty area” as well as ground water seepage from underground mine workings. The dams must be able to accommodate the volume of water that could arise from the 1:50 year 24 hour flood event, as well as groundwater seepage and direct rainfall.

Dwarsriver Chrome Mine operates on the strategy of maximising the utilisation of “dirty water” in the mining area and has a policy of zero discharge of contaminated water to the environment. In order to achieve this, the LRWD and URWD collect all contaminated water from the mining area, and together with Dam 26 are appropriately lined to prevent potential contamination of soils and groundwater resources.

The proposed ROP to be installed on site is intended to alleviate the extent to which current license conditions are exceeded at present. The effectiveness thereof to do so will need to be proven through continued ongoing, regular, surface and ground water quality monitoring.

4.5.4 SITE WATER BALANCE

Water balance objectives

Figure 4-8 provides a figurative summary of the Mine’s water inputs, losses and major flow pathways. This figure shows all water inputs and outputs essentially informing the overall site water balance calculation. This figure, as well as site water balance calculations made to date (preliminary indications of a positive site water balance) do not, however, account for fugitive losses, for which appropriate mitigation is prescribed as part of this plan to abate such losses.

The Dwarsrivier Mine have installed a number of critical flow meters, at all necessary major water pathways, to supplement existing flow meters on the site in order to accurately quantify the site’s water balance. A single water meter remains to be installed to complete the above task (Plant run-off to URWD). It is anticipated that this remaining meter will be installed by September 2010 (or at least within one month of the
Department’s acceptance of this plan), at which time the Mine commits itself to the submission of the final water balance data to the Department of Water Affairs (DWA).

4.5.5 STORM WATER

The 2009 Dwarsrivier Mine Storm Water Management Report (Appendix 5) lays out the principles of proper storm water management on site, including:

- separate clean and dirty storm water;
- maximise the amount of clean storm water and direct it to natural watercourses;
- minimise the disruption to natural/pre-existing runoff and surface water flows;
- minimise the amount of dirty storm water;
- manage the dirty storm water in the mine/process water system;
- meet the legal requirements relating to storm water; and
- minimise specific impacts such as erosion and siltation.

Specific storm water interventions, such as channels, culverts and silt traps, are laid out in the 2009 report. Some of these will remain for the life of mine, but many will have to be revised and changed as the surface operations at the mine change over time.

4.5.6 GROUNDWATER

Groundwater inflow into mine

Mining (open-cast as well as underground) will largely take place below the regional groundwater level. Groundwater will flow into these structures when geological fractures intersect with underground shafts and strikes. Dewatering measures are currently implemented on site, in order to ensure that underground mining activities take place in a safe and feasible manner. A water use license for this dewatering has been issue to Dwarsrivier Mine by the Department of Water Affairs (Appendix 1). Seepage of groundwater into underground mine workings is currently collected and pumped into Dam 26 at surface, as well as back to underground operations, after having been passed through a clarifier. Settling will also take place in this dam, after which this water is used as supplementary water source for the plant.

At present, approximately 1 500m³ of underground water is pumped to surface by the mine on a daily basis (from the southern decline and associated underground workings). All of this water is passed though a clarifier at surface to settle out suspended solids in the water. Following the clarifier, approximately 700m³ of the aforementioned water is diverted to Dam 26/day and the remaining 700m³ is piped back underground and used in mining operations (daily). It is anticipated that the mine will need to dewater an additional 1 500m³ from underground workings associated with the planned northern decline shaft (immediately north of the R577) once this is fully operational. Again, approximately half thereof will be passed through the ROP for treatment, making approximately 1 500m³ of overall treatment capacity required.

Southern Portal - Decline area

The decline shaft starts at the high wall of the southern opencast pit. Water entering the pit will, therefore, also be collected during underground operations. Figure 4-6 indicates the expected average groundwater inflow rates at different underground periods.
Average pit inflow for the 20 year period is 120 m³/day. This value does not include direct rainfall and infiltration.

**Figure 4-6**: Modelled groundwater inflow into the Southern Opencast Pit during underground mining, from commencement of mining in 1999.

**Underground workings**

Figure 4-7 indicates the total expected groundwater influx and also the seepage from the riverbed. The average inflow into the underground workings from the Dwars River alone is approximately 400 m³/day. During the latter half of the 20 year mine life, the inflow will increase rapidly due to mining at shallow depth to the east of the Groot Dwars River. From year 18, a relatively large increase in water influx could also be expected as a result of shallow mining to the south, close to the Groot Dwars River. This will also result in higher seepage from the river.
**Figure 4-7**: Anticipated water influx into the underground workings.
Figure 4-8: Water flow diagram for the entire Dwarsrivier Mine (Krige, 2009).
4.6 SOLID WASTE

4.6.1 DOMESTIC AND INDUSTRIAL WASTE MANAGEMENT

All non-recyclable domestic and industrial waste is contained in a skip and transported and disposed off site, at Lydenburg. This is done according to a letter of agreement from the Local Authority (Appendix 8). Recycling of various materials is undertaken by a variety of appropriately licensed contractors:

- used oil – For example, Oil-X;
- plastics – For example, Potchefstroom Plastics; and
- metals (ferrous, aluminium alloys, etc.) – For example, Lydenburg Scrap.

4.6.2 MINE RESIDUE MANAGEMENT

Three types of mineral residue are generated at Dwarsrivier Mine:

- waste rock – from mining of non-ore bearing sections, for access, vent shafts, etc. (this goes direct from the mining operation to the waste rock dump on site);
- discard rock – reject rock from the plant, early in the plant process, that goes to the discard dump; and
- tailings – fine reject from the plant in slurry form, at the end of the plant process.

The waste rock and discard rock are of the same rock types, namely:

- anorthosite;
- pyroxenite;
- chromite pyroxenite; and
- gabbro.

Currently almost no waste rock is being produced, as the mine is not in a development phase - all rock extracted is ROM and goes to the plant. The tailings from the plant was until recently (June 2010) being pumped to the south pit (Figure 4-10). Tailings is now pumped to the north pit located north of road R577. An EIA process and relevant environmental applications are presently underway for the establishment of a new Tailings Storage Facility. Importantly, a free-board has been retained at the southern pit to accommodate clarifier sludge disposal in the foreseeable future.

The existing tailings dam contains approximately 1.6Mt of material of which 40% is chromite. This dump will be totally re-worked at a rate of 16kt/month, giving the tailings dump a life of about 8 years. The new spirals plant will be used to recover the chromite from the tailings.

An EIA is currently underway for the establishment of a new tailings facility with a capacity of 1 800 000m³. The specifications for this facility are as follows:

- The TSF has to make provision for the disposal of tailings for the next 23 years;
- Deposition will take place at a rate of between 3 000 and 7 000 tonne per month;
- The average rate of rise will not exceed 2m/yr; t
- Maximum height of the TSF is 46m;
The TSF is proposed to accommodate a total of approximately 5.05 million tonne of tailings;
To provide for the required tailings deposition a total airspace of 2.4 million m³ will be required;
The TSF is anticipated to cover a footprint area of approximately 12—18 hectares; and
At this stage it is proposed that wet tailings be disposed according to either the conventional cyclone or spigot system.

4.6.3 TAILINGS CHARACTERISTICS

Several tests have been conducted on tailings material, with the following conclusions:

- the chromium content of the tailings is very high (>10%), but the chromium is in chromite, an inert oxide mineral – leaching and acid-base-accounting tests have confirmed that negligible chromium will move into groundwater or surface water. Acid-base accounting indicates that the tailings is relatively inert and has low levels of potential acid generation or neutralising potential, but the neutralising potential exceeds the acid generating potential in all cases and in most cases by several times; and
- sulphides are present, but in very small quantities, and their weathering will produce negligible acidity.

The waste rock material removed from the underground workings is transported to the Waste Rock Dump indicated on the Surface Infrastructure Plan (Figure 4-5, Appendix 3).

4.6.4 DISCARD ROCK CHARACTERISTICS

Discard rock from the plant is deposited on the Discard Rock Dump at the north-western end of the site. This discard rock will shortly be sold off to a nearby mining operation for use in the construction of their own tailings facility. Studies conducted (Appendix 7) on the discard rock have proven it to be highly suitable as aggregate, for the following reasons:

- aggregate tests for use in concrete (and pre-stressed concrete) revealed that the anorthosite, pyroxenite and chromite pyroxenite are all suitable for aggregate (Figure 4-9);
- values for chloride, sulphate/sulphide and soluble salts are all below any level of concern for the three above rock types;
- the chromium content of the discard rock is high (>1%), but the chromium is in chromite, an inert oxide mineral – leaching and acid-base-accounting tests have confirmed that negligible chromium will move into groundwater or surface water;
- acid-base accounting indicates the discard rock is relatively inert and has low levels of potential acid generation or neutralising potential, but the neutralising potential exceeds the acid generating potential in all cases and in most cases is several times more;
- in the long-term, neutral conditions are expected and these will preclude any significant quantities of metals from going into solution from the discard rock and therefore dissolved metal concentrations will remain low in surface and groundwater; and
- sulphides are present, but in extremely minor quantities and in highly competent, impermeable rock and hence sulphate concentrations in surface and groundwater will remain low.
Figure 4-9: Example of reuse of waste/discard rock from one of the mines in the area (the exact source of this rock material is not known).
Figure 4-10: Photographic comparison of remaining South Pit back-fill capacity

June 26, 2009

February 24, 2010
5. PUBLIC PARTICIPATION PROCESS

The fundamental principles of any transparent and effective stakeholder engagement process include the provision of sufficient and transparent information to IAPs on an ongoing basis, to allow them to comment, and ensuring the participation of historically disadvantaged individuals, including women, the disabled and the youth.

IAPs representing the following sectors of society have been identified and invited to provide comments and register as IAPs for the project:

- National, provincial and local government;
- Agricultural sector, including local landowners;
- Community Based Organisations (CBO);
- Non-Governmental Organisations (NGO);
- Water bodies;
- Industry and mining;
- Commerce;
- Research institutes; and
- Other.

5.1 STAKEHOLDER NOTIFICATION

The public and stakeholder participation process to date have entailed the following (Refer to Appendix 2 for further detail on the public participation process to date):

- Pre-identification of interested and affected parties (I&APs) using existing databases from previous projects and environmental application processes at Assmang’s Dwarsrivier Mine;
- Advertising the proposed project in “The Steelburger Newspaper” (English and Sepedi) on 16 April 2010. The advertisements indicated where written comments may be directed to;
- Placement of two (4) site notices [Two (2) in English and two (2) in Sepedi] at prominent locations along the district tar road between Sekhukhuneland and Lydenburg (R577), from which the mine is accessed.;
- Distribution of letters of notification and Background Information Documents (BID) to surrounding landowners, Interested and Affected Parties (IAPs), key stakeholders and other commenting Authorities on 13 April 2010;
- Making the draft IWWMP available for comment by I&APs and other key stakeholders for a period of 30 days at three (3) easily accessible public locations;
- A Public Meeting convened on 22 June 2010 at the Dwarsrivier Mine Training Facility. This was attended by representatives from the local communities of Steelpoort and Kalkfontein, as well as representatives from the Masha Royal Council, Xtrata-Lion Ferrochrome Smelter and the Dwarsrivier Mine itself.

The initial comments received from IAPs and other key stakeholders to date, following the advertisement of the project on site / in the press, distribution of BIDs and a Public Meeting, is as follows (Table 5-1):

- Management issues revolving around the salty brine waste to be produced from the Reverse Osmosis Plant;
• Measures/lining to be established to ensure that no ground water contamination results from brine management lagoons;
• Decommissioning of the proposed ROP and associated brine management lagoons at mine closure;
• Potential impacts by Dwarsrivier Mine on the Dwars River, upon which neighbouring communities, such as Kalkfontein, are dependent on for their livelihood;
• Effectiveness of the current groundwater monitoring regime in place at the mine and requests to extend this monitoring network to include domestic use boreholes in the Kalkfontein community, located several kilometres west of the Mine;
• Disposal of membrane filters used in Reverse Osmosis Technologies; and
• Possible utilisation of surplus waste rock at mine closure for crushing and sale as aggregate by the local community.
### Table 5-1: Comments and Responses Report relevant to IWWMP development and stakeholder engagement

<table>
<thead>
<tr>
<th>ASPECT</th>
<th>DATE &amp; FORMAT OF CORRESPONDENCE</th>
<th>COMMENT/ QUERY / CONCERN</th>
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<tr>
<td>Groundwater</td>
<td>Public Meeting, 20100622</td>
<td>A query was raised as to what measures are to be put in place to ensure that the lining used for proposed brine management lagoons will be adequate to prevent groundwater pollution?</td>
<td>The containment layers/liners put in place for the proposed lagoons will be chosen in accordance with the requirements for such specified in the Department of Water Affairs and Forestry’s Minimum Requirements for ‘Waste Disposal by Landfill’, 1998 (now the Department of Water Affairs). The containment layer (liner) requirement amendments proposed as part of the development of the Waste Classification and Management Regulations (to be gazetted for comment in October 2010) will also need to be considered, as project implementation will realistically occur following the promulgation of the aforementioned Regulations to the National Environmental Management: Waste Act (Act No. 59 of 2008)[NEMWA]. Appropriate leak detection systems will also be installed to act as an early warning system for accidental leakage through the lagoon liners. Typically, lagoons such as those proposed, require the installation (at a minimum) of two (2) HDPE/Geo-membrane layers (2mm and 1mm thickness respectively) coupled with compacted clay layers of 600mm and 300mm in extent respectively.</td>
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<td>Public Meeting, 20100622</td>
<td>A request was made for the chemical composition of the ‘brine’ to be made known to affected parties.</td>
<td>The Mine presently has a tender out to appoint a service provider for provision of a Reverse Osmosis, or other similar such, water treatment technology for the site. The Mine will be better positioned to provide the requested information once the treatment technology has been decided upon and corresponding waste streams confirmed. The water quality of input feed into such a plant was provided in the attached Scoping Report – Section 6.1).</td>
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<td>Public Meeting, 20100622</td>
<td>A representative of the Masha Royal Council stated that the local community (Kalkfontein) is dependent on ground and river (Dwarsrivier) water for their livelihood. The local community water their cattle from the Dwarsrivier and are concerned that potential ground and surface water pollution potentially resultant from the project will have significant negative impacts.</td>
<td>Comment noted. A specialist groundwater (geo-hydrological) assessment undertaken for the Mine area was used to inform the positioning of ground and surface water monitoring points on and around the mine, based on the geo-hydrology (groundwater flow) of the site. Such monitoring points are intended to identify any potential pollution plumes resultant from ongoing mining operations such that appropriate remedial action can be initiated wherever required. Ground and surface water quality monitoring is undertaken by an independent consultant on a quarterly basis, on the Mine’s behalf, and the results submitted to the Department of Water Affairs (as required by the Mine’s integrated Water Use License). The initiation of the ‘Reverse Osmosis Plant project’ stems from the identification of elevated salt and nitrate concentrations in site groundwater and pollution control dams, as identified through the water quality monitoring regime in place for the</td>
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<td>Public Meeting, 20100622</td>
<td>Understanding / consensus was reached among the attendees at the public meeting that various options for brine management are still being investigated by the Mine at this Scoping phase of the EIA. The local communities did, however, request that before they could take an informed decision that they be informed of the ‘final solution’, with respect to brine management, being sought by the Mine.</td>
<td>A commitment was made by the Mine to have a preferred water treatment technology alternative, as well as brine management &amp; disposal option, available for perusal once the EIA/EMPR Report is made available for comment to registered stakeholders. The final decision on technology and management alternatives will be made on the basis of an in depth alternatives analysis in the EIA phase of the project (through discussion and collaboration between the EAP, Dwarsrivier Mine and relevant Water Treatment Plant service provider(s)). Numerous alternatives have been identified for this purpose in the Scoping Report, but in depth investigation into the suitability for purpose is ongoing at this stage. The need, however, to treat mine process and underground water remains clear to the applicant.</td>
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<td>Public Meeting, 20100622</td>
<td>A request was made by the Masha Royal Council for the Kalkfontein borehole(s) (utilised for domestic purpose) to be included in the Mine’s groundwater monitoring programme. This request was re-iterated by numerous attendees in light of the Mine’s possible impact on such domestic boreholes through mining activities.</td>
<td>Silas Hlalaphosa indicated that the responsibility for monitoring Kalkfontein borehole water quality lies with the Dept of Water Affairs and/or the municipality; however Dwarsrivier may consider including this borehole in its monitoring regime and report the results to a community representative. Abdul Ebrahim and Remember Mmbengwa stressed that the water quality at the Kalkfontein borehole should not be assumed to be directly related to operations at Dwarsrivier mine. Boreholes and water sampling at the mine will show the impact of the mines activities on water quality, furthermore the Kalkfontein borehole is on the other side of the Dwarsrivier and thus it is likely that groundwater at the mine and at Kalkfontein are flowing in opposite directions (i.e. both flowing towards the river). Remember Mmbengwa asked the Masha Royal Council Representatives to supply the details of the person(s) to whom the results should be proffered. It was noted that Dwarsrivier has undertaken dust outfall monitoring for the Kalkfontein community but there has been no representative identified to receive the information.</td>
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<td>Written comments via fax, 20100605</td>
<td>Lerale Mining Services requested to know, “how contamination of water underground will be monitored”? (Original correspondence, as well as response letter by the EAP, are included for perusal in Appendix 4)</td>
<td>A specialist groundwater (geo-hydrological) assessment undertaken for the Mine area was used to inform the positioning of ground and surface water monitoring points on and around the mine, based on the geo-hydrology (groundwater flow) of the site. Such monitoring points are intended to identify any potential pollution plumes resultant from ongoing mining operations such that appropriate remedial action can be initiated wherever required. Ground and surface water quality monitoring is undertaken by an independent consultant on a quarterly basis.</td>
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<td>Mine Closure</td>
<td>Public Meeting, 20100622</td>
<td>A query was raised as to the ‘post closure’ requirements applicable to the brine management lagoons. A concern in this regard was raised that groundwater pollution would result if the mine simply left the lagoons full and in place upon closure.</td>
<td>Abdul Ebrahim stated that a mine rehabilitation plan is in development and that the mine already has a rehabilitation provision set aside to ensure that the mine is rehabilitated upon closure. This provision has been acknowledged by the DMR.</td>
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<td>Public Meeting, 20100622</td>
<td>A request was made for the Mine and their environmental consultants to please consider any possible opportunities available to the local community/ies at Mine closure (e.g. crushing of waste rock for sale as aggregate by the local community).</td>
<td>Remember Mrmbengwa stated that the public participation process allows information to be disseminated so that opportunities can be identified with stakeholders for input to the mines social and labour investment plans.</td>
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<td>Public Meeting, 20100622</td>
<td>&quot;The local community/ies will remain in the area long after the mining activities cease and the mining houses move on. The Mine must, therefore, make every attempt to provide opportunities to local community/ies first at the time of closure and to ensure that no pollution remains&quot;.</td>
<td>Abdul Ebrahim stated that the public participation process allows information to be disseminated so that opportunities can be identified with stakeholders and that the community and the mine should consider coming to an agreement on how the community can benefit from the mine closure, in particular the mine may leave built structures and facilities for the community to use otherwise the mine will be required to completely remove these.</td>
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<td>Mining Rights</td>
<td>Public Meeting, 20100622</td>
<td>A query was raised over the status of the Mine’s ‘Mining Right Conversion’ application?</td>
<td>Remember Mrmbengwa indicated that an application for conversion of the Mine’s existing / ‘old order’ mining rights had been lodged with the DMR within the required time-frames for such, as specified in the MPRDA, but that the Polokwane DMR had not yet fully administered this application. The review of the application by the Department of Mineral Resources (DMR) is believed to be at an advanced stage.</td>
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<td>Cumulative Impacts</td>
<td>Public Meeting, 20100622</td>
<td>An attendee made a request for the cumulative impacts potentially resultant from establishment of a Reverse Osmosis Plant, brine lagoons and vent shafts to be appropriately assessed at EIA stage.</td>
<td>Comment noted. Abdul Ebrahim stated that the cumulative assessment had been undertaken where possible, for example the noise impact assessment considered existing measured noise plus the additional noise modelled for the proposed shafts, and that the reverse osmosis plant impact would also show a positive cumulative impact.</td>
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<tr>
<td>Traffic / Transport</td>
<td>Public Meeting, 20100622</td>
<td>An attendee requested that the impacts of additional transport/haulage requirements on site, as pertains to potential dust generation, be considered and evaluated at potential dust generation.</td>
<td>The results of the air quality impact assessment were presented, showing that the impact of dust from existing operations is within the standards promulgated in terms of NEMQA.</td>
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<td>Waste Management</td>
<td>Public Meeting, 20100622</td>
<td>A query was raised as to whether the proposed treatment plant membranes will be re-generated or disposed of and for any potential disposal requirements (legal and environmental management related) to be appropriately considered by the Environmental Assessment Practitioner (EAP).</td>
<td>Membranes will most likely be ceramic in nature and flushed with an acid/base mixture regularly to extend the operational life-span thereof. Any membranes requiring disposal will be made subject to the appropriate waste classification Regulations/Minimum Requirements in place at that time and disposed of accordingly in an environmental responsible manner. Options for the reuse, recycling and recovery of the chosen membrane systems (if any) will be investigated appropriately prior to disposal, as required in terms of the initial drafts of the Waste Classification and Management Regulations in terms of NEMWA.</td>
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<td>Noise</td>
<td>IAP Registration sheet via Email, 20100415</td>
<td>Anglo Platinum (Der Brochen) raised concern over the potential noise impact associated with establishment of the Reverse Osmosis Plant, brine management lagoons and three (3) additional vent shafts. Original IAP comment and registration sheet attached within Appendix 4.</td>
<td>Noise impacts resultant from the proposed project have been determined to be well within acceptable limits (as put forward in SANS 10103 of 2008) for both industrial and residential areas (day &amp; night time) through the undertaking of a specialist noise impact study over the Dwarsrivier Mine Site.</td>
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<td>Visual</td>
<td>IAP Registration sheet via Email, 20100415</td>
<td>Anglo Platinum (Der Brochen) raised concern over the potential visual impact associated with establishment of the Reverse Osmosis Plant, brine management lagoons and three (3) additional vent shafts. Original IAP comment and registration sheet attached within Appendix 4.</td>
<td>The visual and aesthetic character of the site is already subject to much disturbance. The proposed addition of a Reverse Osmosis Plant and brine management infrastructure is not anticipated to contribute significantly to the cumulative visual impact of Dwarsrivier Mine within the valley. The height of proposed structures and infrastructure is also not such that they are anticipated to create additional visual disturbance beyond existing view-shed disturbances from current mining operations.</td>
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<td>Worker Safety (Mine Health &amp; Safety)</td>
<td>Written comments via fax, 20100605</td>
<td>Lerale Mining Services queried the safety of employees working underground in relation to, “inhaling smell for contaminated water”, and queried whether employees will undergo perpetual clinic tests to, “check life and diseases due underground”. Lerale Mining Services furthermore queries whether, “staff underground can be checked by their own doctors rather than mine doctors to compare the blood and body contamination” (Original correspondence, as well as response letter by the EAP, are included for perusal in Appendix 4).</td>
<td>ESA are, unfortunately, not in a position to answer your queries relating to Mine Health &amp; Safety matters (diseases, health check-ups, etc.), as well as Dwarsrivier Mine’s BBBEE and Corporate Social Responsibilities. ESA duly provided Lerale Mining Services with the contact details of the Mine’s Environmental and Quality Manager (Remember Mrnbengwe) in this regard.</td>
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<td>Written comments via fax, 20100605</td>
<td>Lerale Mining Services queried what chemicals are used underground and what diseases can affect employees at Assmang Dwarsrivier Mine? (Original correspondence, as well as response letter by the EAP, are included for perusal.</td>
<td>Limited chemicals are used underground in ongoing mining operations. Nitrate based explosives, however, used underground in blasting operations are anticipated to have contributed to elevated Nitrate and Ammonia levels in water contained in underground storage dams and...</td>
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<td>General</td>
<td>Written comments via fax, 20100505</td>
<td>Leralie Mining Services made a request to establish an Environmental Committee with the EAP, as well as Dwarsrivier Mine, during and after the project to “do mining and environmental watch” (Original correspondence, as well as response letter by the EAP, are included for perusal in Appendix 4).</td>
<td>The Dwarsrivier Mine already has an Environmental Monitoring Committee (EMC) that monitor the mine’s activities on an ongoing basis. ESA do not feel that the nature (deemed preliminarily to be largely positive) or scale of the projects warrant establishing a separate EMC.</td>
</tr>
<tr>
<td></td>
<td>Written comments via fax, 20100505</td>
<td>Leralie Mining Services requested copies of the EIA, IWWMP and EMP Reports to have full information on the project (Original correspondence, as well as response letter by the EAP, are included for perusal in Appendix 4).</td>
<td>All register IAPs and stakeholders will be notified in due course by the EAP of the availability of the aforementioned reports for comment at locally accessible public locations</td>
</tr>
</tbody>
</table>
6. DESCRIPTION OF THE ENVIRONMENT AND POTENTIAL IMPACTS

6.1 CLIMATE

The area is defined as sub-humid and is normally warm and dry. The area falls within the summer rainfall zone and receives most of its annual rainfall during the period October to March. The mean monthly rainfall is 38mm and the mean annual rainfall is 462mm. Mean monthly evaporation is on average 5.7mm per 24 hour period. The yearly evaporation is 2080mm and the net evaporation is 1618mm per year. Frost and hail are rare. The wind speed averages about 4.1 metres per second, and is generally either north-west or south-east, but due to the mountainous terrain wind directions cannot be accurately predicted based on data from Lydenburg and Graskop.

Error! Reference source not found. lists some climate statistics for the area, based on records from the nearest South African Weather Services station at Lydenburg.

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<td>0</td>
<td>1.0</td>
<td>1.9</td>
<td>1.1</td>
<td>0.9</td>
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Table 6-1: Mean monthly climate statistics for Lydenburg, the closest available full weather station.

6.2 TOPOGRAPHY

The farm Dwarsrivier, on which the mine is located, is traversed by the Groot Dwars River and the Klein Dwars River. The confluence of these rivers is also located on the property. The eastern portion of the property, where the chrome reserves outcrop, generally slopes in a westerly to south-westerly direction, towards the Groot Dwars River. Adjacent to the river, slopes are gentle, around 3°. Further upslope from the river, slope angles increase to
as much as 40°. However, the slopes are not always planar, with frequent, small to relatively large koppies or hills formed from more resistant rock. Elevations on the farm Dwarsrivier vary from 900m to 1200m; see Figure 4-5 & Appendix 3.

The area generally drains in a northerly direction, via the Groot and Klein Dwars Rivers. There are, however, a number of small, westerly flowing, non-perennial tributaries of the Groot Dwars River in the vicinity of the old open cast sections. There is approximately 40 metres elevation change across the mine site, with elevations between 940m asl and 975m asl. The contours can be seen on Figure 4-5.

6.3 GEOLOGY

The regional geology as represented on the 1:250 000 Geological Series Map, 2430 Pilgrim’s Rest. The chrome ore deposits form part of the Critical Zone of the Bushveld Igneous Complex. The chrome horizon to be mined is the LG 6 (Lower Group 6) horizon. This is predominantly overlain by anorthosite and pyroxenite. The layers have a regional dip of 13 degrees west in this area, towards the centre of the Bushveld Igneous Complex. However, local variations in dip are common.

The Dwarsrivier ore body represents an open-ended structural synform, with a north-south oriented axis that plunges gently to the south. The mine is situated on the eastern limb of this synform.

There are a number of north-south trending dolerite dykes located in the area. The majority of these do not fall within the proposed underground workings. Two small dykes occur on the far east and the far west of the workings. A number of minor faults do occur in the area.

6.4 SOIL

The soils of the area were mapped using standard procedures. A 1:500 scale contour plan of the area together with 1:10 000 scale aerial photographs were used to provide an overview of the area as well as forming the base map for the detailed soil survey.

The field work comprised traversing of the areas on a staggered grid with a grid spacing of approximately 200 to 300 metres, using a conventional 1,25m bucket auger to investigate and log the soil profiles. A limited number of soil samples were also taken to aid in the classification of the soils and to determine the nutrient status of the soils.

The identification and classification of soils was carried out in terms of the Soil Classification "A Taxonomic System for South Africa" (MacVicar et al, 1991). This is a relatively simple system that has two levels of classification, an upper, fairly general level comprising Soil Forms and a lower, more specific level comprising Soil Families. Each of the Soil Forms in the classification is defined by a vertical sequence of diagnostic horizons. All forms are further divided into two or more Families, which have the same vertical sequence of diagnostic horizons, but are differentiated within the Form on the basis of certain physical and/or chemical properties.

6.4.1 DESCRIPTION OF IDENTIFIED SOILS

The forms that were identified in the area are predominantly a close association of the Glenrosa and Mispah Form soils together with scattered rock outcrop. Within these soils there are also small pockets of Hutton Form soils. On the lower, gentler slopes adjacent
to the rivers and streams traversing the site, soils identified include those of the Hutton, Clovelly and Augrabies Forms. The soils immediately adjacent to the streams and drainage lines are Katspruit Form soils. Where gully erosion has occurred adjacent to some of the streams, Valsrivier Form soils are found.

The soils of the area generally comprise Orthic topsoil overlying a Lithocutanic B horizon or hard rock, or a Red Apedal B horizon or, occasionally, a Yellow Brown Apedal B horizon, except in the valley bottoms, where the Orthic topsoil overlies a G horizon or a Pedocutanic B horizon. In some areas, the subsoil horizon comprises a Neocarbonate B horizon. The Hutton and the Glenrosa/Mispah Form soils are generally the dominant soils in the area of the tailings dam site, rock waste dump site and the associated plant. They are frequently associated with rock outcrop.

The Glenrosa and Mispah Form soils are not bleached in the A horizon and are non-calcareous with no signs of wetness. The Clovelly and Hutton Form soils are eutrophic and non-luvic, that is, little leaching has taken place, and there is not a marked increase in clay content with depth. The Augrabies Form soils are red, not bleached in the A horizon and are non-luvic. The Katspruit and Valsrivier Form soils are associated with streams and may be saturated with water for long periods of time.

6.4.2 SOIL DEPTH

The Glenrosa and Mispah Form soils are generally less than 0.3 metres deep, but may be as much as 0.6 metres deep. The Hutton, Clovelly, Augrabies, Katspruit and Valsrivier Form soils are generally in excess of 0.6 metres deep, to as much as 1.5 metres, but shallower examples occur, especially adjacent to the Glenrosa Form soils.

6.5 SURFACE WATER

6.5.1 WATER QUALITY

Surface water samples are taken quarterly from the Dwarsrivier and the Klein Dwarsrivier to assess the water quality of the upstream and downstream conditions of these rivers. The February 2010 surface water quality monitoring results showed the in-stream sample (S1) of the Dwarsrivier to contain high concentrations of Nitrate (NO₃) before the river enters the Dwarsrivier Mine property (ESS, 2010); however, these concentrations are further elevated as the river moves through the area and reach a high of 19.50mg/l at the Dwarsrivier down-stream sampling point (S3). It is, therefore, in the February 2010 results that the combined mining activities in this area are having a cumulative impact on the water quality of the Dwarsrivier.

A toxicity analysis of the various in-stream sampling point (S1- S4) performed in February 2010 showed that sampling point S2 contains elevated concentrations of Free Residual Chlorine (Figure 6-1). The levels measured can have considerable negative consequences for the health of aquatic ecosystems, even over a short period, in terms of the death and disappearance of sensitive species or communities from aquatic ecosystems (ESS, 2010).

The toxicity analysis results for samples S1, S3 and S4 indicated elevated concentrations of Aluminum. The concentrations measured fell within a concentration range where there is expected to be a significant probability of measurable chronic effects to up to 5 % of the species in the aquatic community (ESS, 2010-paraphrased). If such chronic effects persist for some time and/or occur frequently, they can lead to the eventual death of
individuals and disappearance of sensitive species from aquatic ecosystems (ESS, 2010). This can have considerable negative consequences for the health of aquatic ecosystems, since all components of aquatic ecosystems are interdependent.

The February 2010 surface water monitoring results also showed a slight increase in Nitrate concentrations in sampling points S3 and S4 (Figure 6-1)(ESS, 2010). These results raise concern that Nitrate contamination from underground water pathways [as is evident from high Nitrate concentrations found in boreholes (DRM1, DRM2, DRM4, DRM5 and DRO4)] has reached the Dwars River (ESS, 2010).

![Figure 6-1: Aerial view of mine showing relevant surface water monitoring positions (ESS, 2010).](image)

Although the aforementioned results are concerning, it should be noted that the source of the high concentrations of Chlorine and Aluminum are upstream of the Dwarsrivier mine and, therefore not caused by the mining and related activity (ESS, 2010).

### 6.6 FLOOD LINES

A study was commissioned in July 2009 to determine the flood lines with statistical return periods of 50 and 100 years for the Groot and Klein Dwars Rivers as well as the small tributary of the Dwars River, the Springkaanspruit, traversing the mine lease area (Appendix 5).

The Groot Dwars River has its origin on the farm, De Berg 71 J Tsome 33.75 Km (measured in a straight line) to the south of the confluence of the Groot Dwars River with the Klein...
the Klein Dwars River has its origin on the farm, Uysedoorns 47 JT, approximately 25.3 Km (measured in a straight line) to the south of this river’s confluence with the Groot Dwars River. The Springkaanspruit enters the Groot Dwars River from the east some 1.6 Km upstream from the confluence of the Groot and Klein Dwars Rivers, and has its origin on the watershed between the farms Zwakwater 377 KT and Schuins 378 KT, some 15.4 Km (measured along its longest collector) to the east of its confluence with the Groot Dwars River.

After the confluence of the Groot Dwars River, with the Klein Dwars River, the river continues as the Dwars River for another 15.3 Km (measured along the course of the river) up to its confluence with the Steelpoort River on the farm, Kennedy’s Vale 361 KT. The Steelpoort River is a tributary of the Olifants River, which ultimately leaves the Republic of South Africa and flows into the Limpopo River in Mozambique before the latter river discharges its contents into the Indian Ocean near Xai-Xai. The Limpopo River is approximately 1 750 Km long (compared to the Dwars River’s 33.75 Km) and has a drainage basin of 415 000 Km². Its mean annual discharge is some 174.288 m³/s at its mouth making it the second largest river in Africa discharging eastwards into the Indian Ocean, the Zambezi River being the largest.

To accurately model the flood lines it was required to divide the rivers into five separate sections as described hereunder (Table 6-2). Each of these sections was modelled individually. The flood lines for each section were also determined individually and then joined together to produce the final product.

1. Klein Dwars River from where it enters the mine boundary up to its confluence with the Groot Dwars River. This catchment has a surface area of 122.527 Km² and includes the entire Klein Dwars River catchment;

2. Springkaanspruit from where it enters the mine boundary up to its confluence with the Groot Dwars River. This catchment has a surface area of 32.558 Km² and includes the entire Springkaanspruit catchment;

3. Groot Dwars River from where it enters the mine boundary up to its confluence with the Springkaanspruit. This catchment has a surface area of 320.58 Km² and comprises of the entire Groot Dwars River catchment up to the Springkaanspruit;

4. Groot Dwars River between the Springkaanspruit and its confluence with the Klein Dwars River. This catchment has a surface area of 353.138 Km² and comprises of the above catchment (Catchment 3) as well as the catchment of the Springkaanspruit and a small section of the Groot Dwars River catchment between the Springkaanspruit and the Klein Dwars River; and

5. Groot Dwars between its confluence with the Klein Dwars River and the point where it leaves the mine’s northern boundary shortly after passing under the main provincial road bridge. This catchment has a surface area of 483.389 Km². This catchment comprises of the entire Dwars River catchment, the entire Klein Dwars River catchment, the Springkaanspruit catchment as well as the part of the Dwars River catchment downstream from the Klein Dwars River confluence up to the point where the river leaves the mine boundary.

The discharges produced by a 50- and 100-year storm falling over each of the catchments are shown in Table 6-2. This table also...
includes the catchment surface areas of each of the catchments as well as the duration of the storm that produced the highest discharge.

<table>
<thead>
<tr>
<th>Catchment:</th>
<th>Catchment Area (Km²)</th>
<th>Discharge 50-year Storm: (m³/s)</th>
<th>50-yr Flood Storm Duration (Hours)</th>
<th>Discharge 100-year Storm: (m³/s)</th>
<th>100-yr Flood Storm Duration (Hours)</th>
</tr>
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<td>Klein Dwars River from where it enters the mine boundary up to its confluence with the Groot Dwars River</td>
<td>122.527</td>
<td>181.7</td>
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<td>221.5</td>
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<td>Sprinekaanspruit from where it enters the mine boundary up to its confluence with the Groot Dwars River</td>
<td>32.558</td>
<td>61.1</td>
<td>3</td>
<td>62.2</td>
<td>3</td>
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<tr>
<td>Groot Dwars River from where it enters the mine boundary up to its confluence with the Sprinekaanspruit</td>
<td>320.580</td>
<td>409.0</td>
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<td>506.8</td>
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<tr>
<td>Groot Dwars River between the Sprinekaanspruit and its confluence with the Klein Dwars River</td>
<td>353.138</td>
<td>434.2</td>
<td>4</td>
<td>524.6</td>
<td>5</td>
</tr>
<tr>
<td>Groot Dwars between its confluence with the Klein Dwars River and the point where it leaves the mine boundary shortly after passing under the main provincial road bridge</td>
<td>483.389</td>
<td>540.6</td>
<td>5</td>
<td>663.1</td>
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Table 6-2: The discharge produced by each of the storms for each of the sub-catchments.

Figure 6-2: The catchment of the different stream-sections.

During the modelling of the Springkaanspruit 50-year storm discharge and flood line elevations, it was found that, for all intents and purposes, the 50- and 100-year flood lines...
plotted on top of each other. In Table 6-3 it is shown that there is a maximum of 2-cm variation between the vertical elevations produced by the two storms. In 40% of the cross sections, the 50- and 100-year flood lines plotted exactly on top of each other. The software used operated down to a resolution of 1 cm (vertical elevation) and can, therefore, not calculate decimal places of centimetres. This phenomenon is by no means unexpected as, in almost all cases, the smaller the catchment, the closer the 50- and 100-year flood lines are to each other.

As summarised in Table 6-3, the 50-year storm in the Springkaanspruit catchment produced a maximum discharge of 61.1 m$^3$/s, while the 100-year storm produced a discharge of only 1.1 m$^3$/s more, i.e. 62.2 m$^3$/s. This equates to a 1.77% difference between the 50- and 100-year flood discharge values.

For this reason it is not possible to plot two different flood lines for the Springkaanspruit and the 100-year flood line also doubles up as the 50-year flood line.

<table>
<thead>
<tr>
<th>Cross Section</th>
<th>50-Year Flood (mamsl)</th>
<th>100-Year Flood (mamsl)</th>
<th>Elevation Difference (cm)</th>
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Table 6-3: The elevation difference between the 50- and 100-year flood lines for the Springkaanspruit ranging from 0 to 2 cm vertical elevation.

It is therefore accepted that, for all practical reasons, there is no difference between the 50- and 100-year flood lines. The flood lines produced by storms with return periods of 50- and 100-years were developed using the WG31° coordinate system (i.e. the Hartbeeshoek 94 datum and the 31° east meridian as the centre meridian).
Figure 6-3: 1:50 and 1:100 year flood lines relevant to Dwarsrivier Mine’s operations

Figure 6-4: Figure showing the digital elevation of the Dwarsrivier site (Mine boundary depicted in red)
6.7 GROUNDWATER

6.7.1 HYDROCENSUS

A hydro-census investigation was performed within the surroundings of the Dwarsrivier mine, in the catchment affected by the mining activities, to update the existing database of groundwater users, abstraction volumes and current groundwater levels (Ivusi Environmental, 2009). Groundwater levels and general characteristics of groundwater, as part of the aforementioned investigation, were obtained from existing monitoring and production boreholes located on and around the Dwarsrivier Chrome Mine. Please kindly refer to Appendix 6 to view the comprehensive geo-hydrological study and groundwater flow numerical model.

6.7.2 REGIONAL GROUNDWATER LEVELS

Usually a linear relationship exists between the groundwater table and the topography of an area (Ivusi, 2009). In order to establish what the relationship is, a plot graph was drawn up by Ivusi Environmental Consulting, as indicated in Figure 6-5. Water level measurements that were obtained during the most recent hydro-census investigation by Ivusi (2009) were used to plot the borehole collar elevation against the measured groundwater elevation.

If a linear correlation exists, it can be assumed that the groundwater table would mimic the topography. As indicated in the figure below, a 86.5% linear correlation exists between topography and static water level for the study area. As indicated, borehole DRM 9 had a significantly lower water level recorded than the remainder of the boreholes (14.77 mbgl). This borehole was drilled into a major fault zone, which is expected to have a significantly higher transmissivity value that the surrounding fractured rock aquifer. Higher conductance of groundwater along this preferential flow path causes a drop in hydraulic head, which causes this deviation in the correlation factor between the surface topography and regional static water level, as oppose to the other boreholes. This also raises the question regarding the permeability of the dolerite dyke intersecting this fracture, as dolerite dykes are usually perceived as impermeable structures (aquicludes) which causes a build up of water, causing elevated water levels or even artesian conditions.

Water levels that were measured ranged between 0.39 and 14.77 mbgl. The geometric mean for depth to groundwater in the study area is 4.22 m.

6.7.3 REGIONAL GROUNDWATER QUALITY

DRM 1, DRM 2, DRM 3 and DRO 4 (Figure 6-6) are situated down slope of the Historic Tailings Management Facility and are positioned so as to provide data which can be used as an early warning system to possible groundwater pollution from the ‘historic’ tailing facility. The February 2010 ground water monitoring results showed Nitrate and Magnesium concentrations in all the above mentioned boreholes to be elevated. From historical data (November 2000 to November 2009) it can be seen that the Nitrate concentration increased significantly in these boreholes, especially in boreholes DRM1 and DRM2 (Figure 6-7). It can be seen that during 2000 and 2001 the Nitrate concentrations was well below the current levels. After 2004 the Nitrate concentrations increased rapidly and are now well above the SANS Class III maximum allowable limits (ESS, 2010). These results may indicate that the tailings facility and/or the return water dam/s are having an impact on the groundwater quality of the site (ESS, 2010).
Figure 6-5: Graph showing relationship between groundwater and topography (Ivusi, 2009)

Figure 6-6: Aerial image of groundwater sampling positions at Dwarsrivier Mine (ESS, 2010)
6.7.4 GROUNDWATER FLOW

The simulated flow directions and calibrated flow model produced by Ivusi Environmental Consulting (2009) are presented in Figure 6-8. As is evident, the regional groundwater flow directions are towards the Dwarsrivier underground mining activities, as a result of the dewatering impact at this location, causing a so-called cone of depression towards the southern decline shaft where dewatering to the clarifier at surface currently takes place.

6.8 SOCIO-ECONOMIC ENVIRONMENT

The mining and agricultural sectors provide the bulk of employment opportunities within the Tubatse Local Municipality. Subsistence agriculture is also widely practised in the general area.

According to the Greater Tubatse Local Municipality (GTM), the following summary of agricultural production can be made for the Municipal area (2010):

```
Farming is an important economic resource, as a wide range of products are cultivated owing to good soil conditions, the sub-tropical climate and reasonable access to water. The following type of products is produced: fruit, vegetables, grain, cotton, citrus, maize, tobacco and meat.

The main resources that encourage agricultural production are the Olifants, Steelpoort and Spekboom Rivers, which provide water to the region. These sources of natural water are essential for present and long term irrigation of crops. No other region in the GTM reveals a higher potential for desertion, resultant from overgrazing over a pro-longed period by a highly impoverished rural population that struggles to plan and control their area. Their lack of skills prevents them from managing their resource for long-term production. This type of farming makes the region vulnerable to periodic droughts that affect both the regional resources and the potential to generate work opportunities for the unemployed.
```
Figure 6-8: Groundwater Flow Model developed for Dwarsrivier Mine (Ivusi, 2009 – Appendix 6)
Contd. - The minimal contribution of the Steelpoort, Spekboom and Olifants Rivers towards overall irrigation of crops in the northern region is critical due to the declining potential of dry-land cultivation. Irrigation is expensive and underground water supply is not necessarily sustainable in the long term. The total value of agricultural products is marginal.

According to the Greater Tubatse Local Municipality (GTM), the following summary of mining activities can be made for the Municipal area (2010):

“...there is the abundance of precious mineral deposits in a north-south direction on west part of the study area. The mining related development follows the eastern limb of the Bushveld complex from the de Broheten in the south to Twickenham mines in the north and beyond the local authority boundary. The eastern limb of the Bushveld complex (mining belt) is emerging as important structuring element of the GTM spatial development, which will be increasingly dominant in future. The mining activities will affect mainly the western quadrant of the study area. With a number of mining activities throughout the local municipality more pressure is exacted on the provision of housing and infrastructure needs, the existence of the nodal point in Mecklenburg, Driekop, Burgersfort and Steelpoort, further add to the housing and infrastructure provision needs. It is expected that retail and the service businesses will respond to the opening of mines and the development of housing by also locating close to these areas. In time, this may eventually alter the current fragmented spatial pattern by creating few large urban settlements, if the expected scale of mining activities materialise.

The proposed Dikolong SDI corridor which builds on the energy generated by the new mines viz, Marula, Twickenham, Modikwa starts to exhibit how the location of the platinum group metal is to reconfigure the spatial structure of GTM. The anticipated housing, rental and industrial development in Burgersfort and Steelpoort will reinforce these two towns as foci of urban development in GTM. In fact the anticipated development will transform the two small towns beyond recognition.”
7. **IMPACT ASSESSMENT**

An Environmental Impact Assessment (EIA) is an assessment tool at a project level and is defined as the process of identifying, predicting, evaluating and mitigating the biophysical, social and economic impacts of development proposals prior to major decisions being taken. It identifies the environmental impacts of a proposed project and assists in ensuring that a project will be environmentally acceptable and integrated into the surrounding environment in a sustainable way.

7.1 **GUIDING PRINCIPLES FOR AN EIA**

There are eight guiding principles that govern the entire process of EIA and they are as follows (Figure 7-1):

- **Participation**: An appropriate and timely access to the process for all interested parties.
- **Transparency**: All assessment decisions and their basis should be open and accessible.
- **Certainty**: The process and timing of the assessment should be agreed in advance and followed by all participants.
- **Accountability**: The decision-makers are responsible to all parties for their action and decisions under the assessment process.
- **Credibility**: Assessment is undertaken with professionalism and objectivity.
- **Cost-effectiveness**: The assessment process and its outcomes will ensure environmental protection at the least cost to the society.
- **Flexibility**: The assessment process should be able to adapt to deal efficiently with any proposal and decision making situation.
- **Practicality**: The information and outputs provided by the assessment process are readily usable in decision making and planning.

![Diagram showing guiding principles for an Environmental Impact Assessment](image)

**Figure 7-1**: Guiding principles for an Environmental Impact Assessment
A Scoping EIA process is considered as a project management tool for collecting and analysing information on the environmental effects of a project. As such, it is used to:

- identify potential environmental impacts;
- examine the significance of environmental implications;
- assess whether impacts can be mitigated;
- recommend preventive and corrective mitigating measures,
- inform decision makers and concerned parties about the environmental implications; and
- advise whether development should go ahead.

The EIA must take an open participatory approach throughout. This means that there should be no hidden agendas, no restrictions on the information collected during the process and an open-door policy by the proponent.

Technical information must be communicated to stakeholders in a way that is understood by them and that enables them to meaningfully comment on the project.

There should be ongoing consultation with interested and affected parties representing all walks of life. Sufficient time for comment must be allowed. The opportunity for comment should be announced on an on-going basis.

There should be opportunities for input by specialists and members of the public. Their contributions and issues should be considered when technical specialist studies are conducted and when decisions are made.

### 7.2 ENVIRONMENTAL IMPACTS BY PHASE

The following section is intended to provide a summary, per project phase, of the anticipated environmental impacts on water resources resulting from ongoing mining operations at the Dwarsrivier Mine.

#### 7.2.1 OPERATIONAL PHASE IMPACTS

During operational phase, open-cast and then underground mining commenced. Access to the opencast workings was by ramp and to the underground by decline through part of the disused South Pit. The following activities, which may impact on the health of people and the environment (water resources in particular), are occurring at the mine during the operational phase:

- systematic removal of the LG-6 chrome seam by underground mining methods;
- stockpiling of ROM material and transportation to the beneficiation plant;
- operation of beneficiation plants;
- disposal of residue material (tailings) into the open-cast sections (north and south pits);
- disposal of mine affected water into pollution control dams;
- installation and operation of Reverse Osmosis Plant (ROP) and brine management infrastructure;
- installation and use of the emulsion and diesel tanks;
- excavation of additional ventilation shafts;
- operation of two (2) sewage treatment plants; and
- reclamation of material from the tailings dam.
The following are the major environmental impacts that occur from these activities:

- extraction of the LG-6 chrome layer;
- resource consumption (energy, water abstraction and materials);
- hydrological changes, including potential siltation and erosion;
- hydro-geological changes from abstraction, dewatering, changed surface types and mine pit voids;
- poor water quality from high salinity and high nitrate water from underground and the plants;
- pollution risks from storage and management of brine solution from ROP; and
- pollution risk from spills of hydrocarbons, explosives, other chemicals and dirty mine water.

7.2.2 CLOSURE PHASE IMPACTS

Partial closure will not be applied for in this project. Closure for all rehabilitated areas will be applied for under the closure application for the whole mining operation.

During closure, most surface and underground infrastructure will be dismantled and removed from site and all disturbed areas will be rehabilitated, except a few roads remaining to provide access for monitoring and follow-up rehabilitation. Activities during closure that can potentially cause environmental impacts include:

- dismantling and decommissioning of infrastructure and buildings (incl. pollution control dams and brine management ponds);
- removal of re-usable items, scrap and waste;
- earth moving, shaping and ripping of ground; and
- cessation of labour contracts.

The likely environmental impacts related to closure are:

- resource consumption (largely energy);
- noise and dust pollution;
- job losses; and
- reduced economic activity.

During and after closure, certain residual impacts from the mining are also anticipated to potentially occur. These include:

- hydrological changes, including siltation and erosion;
- hydro geological changes from changed infiltration potential of the ground and residual impacts from dewatering; and
- residual poor water quality due to high salinity and high nitrate waters.

The mining operation is proceeding in a stepwise manner with new mining sections being developed as old sections are mined out. Surface infrastructure is also under continual upgrading and additions. Currently, a new underground section is being planned, with
three new vent shafts, a new decline, a new tailings dam and changes and additions to the processing plant, including the recently completed spirals plant. Construction related impacts are therefore continually occurring as the mine develops.

Rehabilitation is also an ongoing exercise, with mined out areas and waste piles being rehabilitated progressively. This is best practice, as it avoids having large spoiled areas awaiting rehabilitation for years, and encourages the ecosystem to reclaim the rehabilitation areas. Therefore closure related impacts also occur throughout the mine’s operational life.

As a result of the stepwise mine development and the progressive rehabilitation, environmental impacts related to construction, operation and closure phases actually occur throughout the mine’s operational life. Therefore, the discussion and evaluation of environmental impacts that follows in this chapter, has not been split into these three ‘phases’ of development, but rather all possible impacts are dealt with under each medium.

7.3 IMPACT ASSESSMENT METHODOLOGY
A number of criteria that are commonly used to evaluate impact significance and which are further referred to in the Department of Environmental Affairs & Tourism’s Environmental Impact Assessment Guideline Document (DEAT 1998), were chosen and defined. The significance criteria which were employed are as follows:

1. Geographical extent of resulting impact.
2. Duration of the resulting impact.
3. Intensity of the resulting impact.
4. The severity of the impact (derived from 1, 2, and 3 above).
5. The frequency of occurrence of the aspect.

7.3.1 GEOGRAPHICAL EXTENT
This is a measure of how wide-reaching the impact resulting from a particular aspect will be. Ratings are assigned as shown in Table 1: Ratings for Geographical Extent.

<table>
<thead>
<tr>
<th>Geographical Extent</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Site</td>
<td>1</td>
</tr>
<tr>
<td>Local: &lt; 2 km from site</td>
<td>2</td>
</tr>
<tr>
<td>Regional: &lt; 300 km from site</td>
<td>3</td>
</tr>
<tr>
<td>National: within the country</td>
<td>4</td>
</tr>
<tr>
<td>International</td>
<td>5</td>
</tr>
</tbody>
</table>

7.3.2 EXAMPLES FOR GEOGRAPHICAL EXTENT RATING
Groundwater flow is typically very slow; consequently, contamination will mostly be restricted to within a short distance of the source. Subsequently groundwater contamination generally attracts a score of 2.
Surface water contamination, resulting in flow of pollutants into river and catchments systems, will result in riverine pollution over an area spanning several kilometres from the source, thus surface water contamination generally attracts a score of 3.

7.3.3 DURATION

This is a measure of how long the impact on the environment will persist. Ratings are assigned as shown in Table 2: Ratings for Impact Duration

<table>
<thead>
<tr>
<th>Duration</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary: &lt;1 year</td>
<td>1</td>
</tr>
<tr>
<td>Short term: 1 to 5 years</td>
<td>2</td>
</tr>
<tr>
<td>Medium term: 5 to 10 years</td>
<td>3</td>
</tr>
<tr>
<td>Long term: 10 to 20 years</td>
<td>4</td>
</tr>
<tr>
<td>Permanent: longer than 20 years</td>
<td>5</td>
</tr>
</tbody>
</table>

7.3.4 EXAMPLES FOR DURATION RATING

The burning of veldt during a veldt fire event results in the loss of vegetation which is regenerated on a seasonal basis and as such scores 1.

When particulates below PM10 and PM2.5 are inhaled, they are lodged deeply in the lungs and cannot be expelled; consequently the dispersion of particulates attracts a score of 5.

Groundwater pollution, unless remediated, will typically take more than 20 years to be attenuated, thus groundwater contamination scores 5.

7.3.5 INTENSITY

This is a measure of the effect of an aspect on the functioning of the receiving environment, as shown in Table 3: Ratings for Intensity.

<table>
<thead>
<tr>
<th>Intensity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>The impact alters the affected environment in such a way that the natural processes or functions are not affected</td>
<td>1</td>
</tr>
<tr>
<td>The affected environment is temporarily altered, but function and process continue, albeit in a modified way</td>
<td>2</td>
</tr>
<tr>
<td>The affected environment is permanently altered, but function and process continue, albeit in a modified way</td>
<td>3</td>
</tr>
<tr>
<td>Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases</td>
<td>4</td>
</tr>
</tbody>
</table>

7.3.6 EXAMPLES

The responsible disposal of small quantities of general waste such as conveyor belting for instance has little or no significant effect on the functioning of the environment, thus a score of 1 is assigned.
Once inhaled small particulates become permanently lodged in the lungs, and thus the receiving organism is permanently altered although it continues to function, hence a rating of 3 is assigned to particulate emissions.

7.3.7 SEVERITY

The concept of severity is introduced as a result of combining the previous 3 criteria. The reason for calculating severity is that it allows one to identify aspects which may have a significant effect on the environment, even though the likelihood of occurrence of such an aspect is low. This facilitates the formulation of a preventative action, or risk management, plan. Severity is calculated as follows:

\[
\text{Severity} = \frac{(\text{Extent} + \text{Duration}) \times \text{Intensity}}{4}
\]

This gives a range of values from 1 to 10, indicating the severity of each impact.

7.3.8 FREQUENCY

This is a measure of how often an aspect occurs. The ratings for Frequency are shown in Table 4: Ratings for Frequency of Occurrence of Aspect.

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continually occurring</td>
<td>5</td>
</tr>
<tr>
<td>Once or more per month</td>
<td>4</td>
</tr>
<tr>
<td>Once or more per year</td>
<td>3</td>
</tr>
<tr>
<td>Once or more in 10 years</td>
<td>2</td>
</tr>
<tr>
<td>Once or more in 100 years</td>
<td>1</td>
</tr>
</tbody>
</table>

7.3.9 EXAMPLES

Tailings deposition into the South Pit, for example, takes place continually and thus attracts a score of 5.

Failure /rupture of a Return Water Dam liner is unlikely to occur more than once or twice in 10 years (if at all), thus attracts a conservative score of 2.

7.3.10 ASPECT SIGNIFICANCE

Environmental Significance is calculated by determining the product of the Severity and the Frequency ratings using the formula below.

\[
\text{Significance} = \frac{\text{Severity} \times \text{Frequency}}{2}
\]

This gives significance rating values from 1 – 25.

In line with Best Practise Environmental Principles and ISO14001 reporting requirements, these ratings are given the ratings shown in Table 5: Significance Ranking, and colour coded accordingly.
7.4 IMPACT ANALYSIS

The above method is applied in the following section to assess, semi-quantitatively, the impact significance of site activities on ground and surface water resources (quality and quantity). This is intended to provide insight into the relative significance of impacts in relation to one another. The determination of relative significance allows for mitigation to be focused on impacts of greatest significance, such that they can be avoided, or appropriately mitigated where avoidance is not possible, to ensure that the realised impacts (following mitigation) are reduced to environmentally acceptable levels.

A summary of the calculated impact significance for identified impacts is as follows:

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Impact</th>
<th>Impact (Without Abatement)</th>
<th>Significance Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CUMULATIVE IMPACT of poor groundwater and surface water quality from mine pollution</td>
<td>8.75 - Medium</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Reduced groundwater availability due to abstraction (including de-watering)</td>
<td>7.5 Medium</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Changed post-mining water table</td>
<td>7.5 - Medium</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Various impacts on groundwater quality</td>
<td>7.5 - Medium</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Nitrate contamination of surface water / soil / groundwater from waste/discard rock and tailings</td>
<td>7.5 - Medium</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Siltation of natural watercourses (Dwars River and Springkaanspruit)</td>
<td>6.75 - Medium</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Increase in flood peaks in natural watercourses</td>
<td>6.0 - Medium</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Acid mine drainage, leaching of chromium and other metals</td>
<td>4.4 - Low</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Reduced flow in the Groot Dwars River</td>
<td>4.4 - Low</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Overflows of mine dirty water (from pollution control dams), ‘contaminated’ storm water flows and spills of hydrocarbons</td>
<td>4.0 - Low</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Decant of polluted groundwater from drowned mine workings into surface waters</td>
<td>3.75 - Medium</td>
<td></td>
</tr>
</tbody>
</table>

Table 7-1: Summary of Impact Significance for identified ‘Waste and Water’ Impacts

From the above table, it becomes evident that the following broad levels of mitigation are required to manage the impacts of the site on the environment, and in particular, ground and surface water resources:
• Pollution prevention;
• Water re-use and reclamation;
• Water treatment; and
• Storm Water Management.

7.4.1 WASTE

Activities: Open cast and underground mining produces waste rock. ‘Ore’ sent to the processing plant includes non-ore rocks that become discard rock. The plant also produces tailings. Lesser waste streams result from industrial and administrative activities.

Impacts:
• Waste rock, discard rock and tailings piles (known cumulatively as mining residues) may leach into soil, surface water or groundwater;
• Mining residues piles may create a visual impact; and
• Industrial and administrative wastes represent resource consumption.

Discussion:
Extensive work has been conducted on the nature of the mining residues, to determine the risk they pose to the environment. The findings of this work are summarised below.

Based on a single rock sample sent to the Nuclear Energy Corporation of South Africa in 2006, radiation levels for uranium, thorium and potassium, as well as overall radioactivity of the sample, are below the levels that require adherence to nuclear legislation.

Aggregate testing conducted in 2009 by Soillab in Pretoria on three rock types, anorthosite, pyroxenite and chromite pyroxenite, revealed that these rocks are suitable for use as aggregate in concrete. Where standards for pre-stressed concrete exist, these rock types meet these higher standards as well. Values for chloride, soluble salts and sulphide/sulphate are all low and will not cause any problems when using these rocks for aggregate.

Waste rock and tailings all contain substantial quantities of chromium, however it is all in the form of chromite, an oxide mineral that is relatively inert chemically. Results of laboratory testing by leaching and acid-base accounting have been interpreted in the light of the field conditions and geochemical behaviour of chrome, to conclude that the potential for chrome moving into solution and into the groundwater or surface water is very low.

Acid-base accounting indicates that the tailings and waste rock is relatively inert and has low levels of potential acid generation or neutralising potential. In addition, the neutralising potential exceeds the acid generating potential in all cases and in most cases is several times more.

In the long-term, neutral conditions are expected and these will preclude any significant quantities of metals from going into solution from the waste rock or tailings. Dissolved metal concentrations will therefore remain low in surface and ground waters.
Sulphides are present, but in extremely minor quantities and in highly competent, impermeable rock and hence sulphate concentrations in surface and ground waters will remain low.

Leaching from the actual waste rock and tailings is not problematic, as outlined in the above findings, however, nitrogen-containing residues from blasting adhere to much of the waste rock and ore. Being highly soluble, these nitrates (and other nitrogen species such as ammonia) are quickly leached from the surface of the waste rock in the dumps and the ore passing through the plant, and enter both the environmental waters and mine dirty water systems, respectively.

The results of the seepage analysis shows that the potential impact of the salt load from the backfilling of pits, to the Dwarsrivier is low, but it is emphasized that if the nitrate/ammonium values in the process water remain at current levels, the potential health and environmental impacts of the plume would be far more significant than the total salt load.

**Mitigation:**

- Careful management of the tailings backfill, maximizing the water recovery, to minimize the salt load transferred to the north and south pits;
- Usage of waste rock for aggregate is recommended, as this will minimise the rehabilitation requirements on site as well as prevent the need for quarrying of aggregate at another location;
- Monitoring of mine and natural waters to measure nitrate and ammonium concentrations;
- Rehabilitation of waste rock dumps and
- Recycling, to the greatest extent possible of administrative and industrial wastes, as well as the suitable / environmentally acceptable temporary storage thereof on site prior to removal from site.

![Figure 7-2: Graph showing the 12 samples tested for ABA (acid base accounting) plotted on a graph of NPR (neutralising potential ratio) versus sulphide as S. The samples clearly lie outside the acid generating area. Note the logarithmic scales.](image)
Impact | Acid mine drainage, leaching of chromium and other metals.
---|---
Criterion | Extent (E) | Duration (D) | Intensity (I) | Frequency
Rating | Regional | Long term | Weekly
Scores | 3 | 4 | 1 | 5
Calculation of Severity (S) | S=[(E+D) X I] / 4 |
Severity Score | 1.75
Calculation of significance | Impact Significance = (S X F) / 2 |
Impact Significance = (1.75 X 5) /2
Final Score | Impact Significance = 4.4 = Low

Impact | Nitrate contamination of surface water /soil / groundwater from waste/discard rock and tailings.
---|---
Criterion | Extent (E) | Duration (D) | Intensity (I) | Frequency
Rating | Regional | Medium term | Weekly
Scores | 3 | 3 | 2 | 5
Calculation of Severity (S) | S=[(E+D) X I] / 4 |
Severity Score | 3
Calculation of significance | Impact Significance = (S X F) / 2 |
Impact Significance = (3 X 5) /2
Final Score | Impact Significance = 7.5 = Medium

7.4.2 GROUNDWATER QUANTITY

Activities:
Dewatering of the underground mining area to allow mining. Abstraction of groundwater from various boreholes for potable and plant water use. Various activities leading to changes in quality and quantity of recharge.

Discussion:
Groundwater levels above and around the mine will start to recover once underground production stops. Underground workings, as well as rehabilitated opencast areas will fill up with groundwater seepage and rain water that infiltrates the back-filled material. Figure 7-4 indicates the recovery of water levels in the different mining areas. These graphs are based on an average recharge of 6% of MAR and storage coefficient of 0.15.

The northern opencast pit will take approximately 15 years to fill up. Factors that influence the rate of recovery in the pit are the underground workings to the west (separated by a 15m wall) and poor aquifers in the region of the pit. There exists a small chance that surface decanting of water could take place after 15 years, during the wet season, at a rate of 8m³/d. This will, however, depend on rehabilitation and the rainfall infiltration rate.
The southern opencast pit could recover within ten (10) years, based on the assumption that the entrance to the underground workings is sealed off. Surface decanting at a level of 937mamsl at the south western corner is more likely than at the northern opencast pit. Surface decanting in the wet season could take place at a maximum rate of 21m³/d.

The surface decant point of the underground workings is at the Southern Opencast Pit decant level. Calculations at this stage indicate that the water level in the underground workings will reach equilibrium in ~35 years at a level of ~931mamsl, below the surface decant point; see Figure 7-4. This is on an assumption that all entrances to the mine are sealed and the average void ratio is 70%.
As shown in Figure 7-3, the maximum zone of drawdown will be towards the south. The lesser drawdown in the north is most likely due to the vertical leakage from the Dwars River itself. The daily inflow volume from this source is about 400m³/day.

All sources that contribute towards the current inflow volumes into the underground workings are outlined in Table 7-2. Currently, the disposal of tailings into the South Pit (approximately 1000m³/d), may further enhance inflow contributions into the mine. However, the existence and nature of fracture zones, which may act as preferential flow paths, in this area is uncertain. As outlined in the table, this contribution makes up part of the “upper exchange”, which totals 633m³/day. Since backfilled tailings have not reached the contact between the weathered zone and fractured rock aquifer, this contribution only comes from the second layer.

<table>
<thead>
<tr>
<th>Source</th>
<th>Model Layer</th>
<th>Inflows (m³/d)</th>
<th>Outflows (m³/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>horizontal exchange</td>
<td>1 (weathered zone</td>
<td>286</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>and soil)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lower exchange</td>
<td></td>
<td>42</td>
<td>705</td>
</tr>
<tr>
<td>rainfall exchange</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>river leakage</td>
<td></td>
<td>538</td>
<td>126</td>
</tr>
<tr>
<td>horizontal exchange</td>
<td>2 (fractured rock)</td>
<td>1880</td>
<td>55</td>
</tr>
<tr>
<td>upper exchange</td>
<td></td>
<td>633</td>
<td></td>
</tr>
<tr>
<td>mine dewatering</td>
<td></td>
<td></td>
<td>2548</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>3409</strong></td>
<td><strong>3410</strong></td>
</tr>
</tbody>
</table>

*Table 7-2: Model groundwater flows.*

The disposal of tailings into the South Pit will cease in late 2010 as the Pit becomes full, but then tailings may be disposed into the North Pit, as underground mining similarly progresses northwards, and so greater groundwater flow into the underground workings will again be expected.

The cone of depression of the Dwarsrivier mine would not affect the neighbouring Thomcliffe or Tweefontein Mines. For more details on the groundwater, refer to Appendix 6 – Ivusi 2009 report.

**Impacts on Groundwater Quantity:**
- A cone of depression surrounding the underground mining works may impact on nearby boreholes;
- The cone of depression from dewatering will reduce base flow into the Groot Dwars River;
- The cone of depression may result in leakage from the Groot Dwars River into the ground;
- Abstraction of groundwater for use as potable water and in the plant;
- Evaporation of water from brine solution;
- Enhanced recharge in pits when surface water is flowing into pits;
- Enhanced recharge from waste rock dumps;
- Reduced recharge in paved or lined areas (tailings dams); and
- The long term equilibrium water table may differ from the pre-mining water table, due to disruption of the aquifer.
Mitigation:
- Clean storm water must be directed away from open pits and towards natural watercourses;
- Thorough rehabilitation with substantial soil placement onto waste rock piles and substantial re-vegetation will result in interception and storage of moisture on plants and in the soil, thereby slowing infiltration into the waste rock pile and reducing unnaturally high recharge to groundwater;
- Minimise paved areas that prevent groundwater recharge;
- Continuous measuring of static water levels of surrounding boreholes;
- Any major fractures through which groundwater can flow preferentially could be grouted; and
- If it can be proven that the mining operation is indeed affecting the quantity of groundwater available to certain users, the affected parties should be compensated. This may be done through the installation of additional boreholes for water supply purposes, an alternative water supply, or financial compensation.

<table>
<thead>
<tr>
<th>Impact</th>
<th>Reduced groundwater availability due to abstraction (including dewatering).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion</td>
<td>Extent (E)</td>
</tr>
<tr>
<td>Rating</td>
<td>Local</td>
</tr>
<tr>
<td>Scores</td>
<td>2</td>
</tr>
<tr>
<td>Calculation of Severity (S)</td>
<td>S = [(E + D) X I] / 4</td>
</tr>
<tr>
<td>Severity Score</td>
<td>3</td>
</tr>
<tr>
<td>Calculation of significance</td>
<td>Impact Significance = (S X F) / 2</td>
</tr>
<tr>
<td>Final Score</td>
<td>Impact Significance = 7.5 = Medium</td>
</tr>
</tbody>
</table>

7.4.3 GROUNDWATER QUALITY

Activities:
The processing of chrome containing mined ore at the Mine’s processing plant, to extract the targeted mineral (chrome), results in the production of significant volumes of waste
tailings / slurry. This slurry is presently pumped to backfill the so-called ‘South Pit’ on the site. The South pit is essentially an open-cast pit resultant from surface chrome mining activities at the beginning of the Life of Mine and is anticipated to be entirely backfilled within the next couple of years, at which time tailings will be pumped to backfill the so-called ‘North Pit’ (north of the R577), until such time as a potential environmental authorisation / EMPR amendment is granted for Dwarsrivier’s new tailings facility.

The tailings referred to above contains significant volumes of contaminated water from processing, which passes through a prominent geological fracture in the base of the South Pit and presently flows into the underground workings of the Mine through this geological feature. This contaminated water entering into the underground workings through the above mentioned fracture, as well as clean water entering the underground workings through other groundwater flows intersecting the mine shaft, is further contaminated when it comes into contact with nitrates. The source of the aforementioned nitrates is the explosives used in blasting activities undertaken during normal underground mining operations.

**Discussion:**

Over time, there has been a substantial build up of divalent cations, such as Magnesium (Mg\(^{2+}\)) and Ferrous Iron (Fe\(^{2+}\)) as well as nitrates and Ammonia in the site’s groundwater, as well as the Mine’s process water, for the following reasons (as well as combinations thereof):

- Disposal of ‘contaminated’ slurry into the South pit and the resultant contaminated groundwater flow, through a prominent geological fracture in the base of the South pit, into the underground workings of the mine;
- Nitrate based explosives use in underground blasting operations;
- De-watering of underground workings and pumping of resultant contaminated water into return water / pollution control dams at surface and ultimately back into the processing plant from which the contaminated tailings / slurry emanated; and
- Naturally ‘hard’, alkaline, waters in the general area (used in processing plant and mine operations), associated with the geology of the site (Bushveld Igneous Complex) and upstream activities.

**Impacts on Groundwater Quality:**

- Evaporation from pollution control dams, increasing salinity;
- Explosives residues underground and on waste rock piles causing elevated nitrate levels;
- Possible leakage from various pollution control dams and the tailings dam;
- Possible leakages from sewage treatment plants;
- Groundwater contamination through disposal of tailings into the north and south pits; and
- Possible contamination from hydrocarbon or other chemical spills (eg. explosives emulsion tanks, diesel tanks, vehicle wash bays and workshops).

**Mitigation:**

- Pits must be filled in, at least to above the water table to prevent evaporation of groundwater;
- Freeboard of 0.8m must be maintained in all pollution control dams;
- Liners in pollution control dams must be intact and monitored regularly;
- Installation of a Reverse Osmosis Plant at surface to treat contaminated ground water dewatered from underground operations; and
- Spills of hydrocarbons or any other chemicals must be promptly cleaned up.

<table>
<thead>
<tr>
<th>Impact</th>
<th>Various impacts on groundwater quality (see list above).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion</td>
<td>Extent (E)</td>
</tr>
<tr>
<td>Rating</td>
<td>Local</td>
</tr>
<tr>
<td>Scores</td>
<td>2</td>
</tr>
<tr>
<td>Calculation of Severity (S)</td>
<td>S=[(E+D) \times I] / 4</td>
</tr>
<tr>
<td>Severity Score</td>
<td>3</td>
</tr>
<tr>
<td>Calculation of significance</td>
<td>Impact Significance = (S \times F) / 2</td>
</tr>
<tr>
<td>Final Score</td>
<td>Impact Significance = 7.5 = Medium</td>
</tr>
</tbody>
</table>

7.4.4 SURFACE WATER

Activities:
- Alteration of the surface through soil and vegetation clearing and construction;
- Accidental releases of mine dirty water into natural watercourses; and
- Groundwater abstraction for dewatering of the underground mining area.

Discussion:
As a result of undermining the Groot Dwarsrivier and the cone of depression from dewatering the underground workings, potential river loss could occur. Original modelling conducted in 1998 shows the expected average river loss during different stages of mining, as shown in Figure 7-5. The river loss includes loss from the river bed. River loss could increase during the wet season. The average river loss is approximately 0.03% of the normal dry weather flow in the Groot Dwarsrivier, close to the confluence with the Klein Dwarsrivier. If the Der Brochen Dam is also taken into account, this could increase to 0.09% of the normal dry weather flow. The expected effect of river loss is therefore small. The amount of seepage flowing into the underground workings, below the river should however be closely monitored during mining.

Mining will result in less groundwater flow towards the Groot Dwarsrivier. Water balance calculations, using the 1998 numerical flow model, indicate that this could be around 200m$^3$/day (0.16% of river flow). Therefore, the total maximum impact on flow is in the region of 250m$^3$/day.

The latest numerical flow model (IVUSI, 2009) simulated inflow volumes, contributed by different sources, into the underground workings. The total daily inflow was calculated to be in the order 2 400m$^3$/d. Of this volume, 400m$^3$/d is contributed by leakage from the Groot Dwars River. An additional source of artificial recharge into the underground workings, is probably as a result of the disposal of tailings into the South Pit area.
Impacts on Surface Water Quantity and Flows:

- Waste rock dumps, even once rehabilitated, are likely to be more permeable and lead to an increase in infiltration and therefore a decrease in runoff;
- Pit voids will capture run-off and, therefore, also lead to a decrease in runoff;
- Dirty storm water is directed into the pollution control dams and, therefore, reduces the amount of run-off going into the natural watercourses;
- Paved or hardened areas, such as roads and storage yards may increase the speed of runoff;
- Areas surfaced with small rocks may increase infiltration and decrease runoff;
- The net result of the increases and decreases in run-off will likely be sharper flood peaks in natural watercourses; and
- Groundwater abstraction for dewatering of the underground workings will reduce base flow into the Groot Dwars River and may result in leakage from the river into the aquifer/s.

Mitigation:

- Ensure rehabilitation areas are well managed to encourage vegetation to take hold and prevent erosion;
- Bare areas must either have berms and channels directing water into silt traps or attenuation ponds, or be surfaced with small rocks to encourage infiltration and reduce sharp storm water peak flows; and
- Run-off must be diverted away from open pits and highly permeable waste rock dumps, towards natural watercourses. The diversion channel must have a silt trap or attenuation pond if such are necessary.
Impact | Increase in flood peaks in natural watercourses.
---|---
**Criterion** | **Extent (E)** | **Duration (D)** | **Intensity (I)** | **Frequency**
---|---|---|---|---
**Rating** | Regional | Temporary | Once per year
**Scores** | 3 | 1 | 4 |
**Calculation of Severity (S)** | S=\((E+D) \times I\) / 4
**Severity Score** | 4
| S=\((3 + 1) \times 4\) / 4
**Calculation of significance** | Impact Significance = (S X F) / 2
| Impact Significance = (4 X 3) /2
**Final Score** | Impact Significance = 6 = Medium

Impact | Reduced flow in the Groot Dwars River.
---|---
**Criterion** | **Extent (E)** | **Duration (D)** | **Intensity (I)** | **Frequency**
---|---|---|---|---
**Rating** | Regional | Long term | Continual
**Scores** | 3 | 4 | 1 | 5
**Calculation of Severity (S)** | S=\((E+D) \times I\) / 4
**Severity Score** | 1.75
| S=\((3 + 4) \times 1\) / 4
**Calculation of significance** | Impact Significance = (S X F) / 2
| Impact Significance = (1.75 X 5) /2
**Final Score** | Impact Significance = 4.4 = Low

Impacts on Surface Water Quality:
- Bare areas and rehabilitating ground will erode and generate silt more easily than natural areas;
- All dirty water is captured in the mine dirty water system, but overflows from this system can result in mildly polluted water (elevated nitrate and salinity levels) entering natural watercourses;
- Hydrocarbon or other chemical spills outside of the dirty storm water areas may contaminate clean storm water; and
- Explosives residues on waste rock piles results in leaching of nitrate into surface waters, but this is so diluted by storm water and natural water flows that the effect is negligible.

Mitigation:
- Bare areas must either have berms and channels directing water into silt traps or attenuation ponds, or be surfaced with small rocks to encourage infiltration and reduce silt generation;
- Ensure rehabilitation areas are well managed to encourage vegetation to take hold, prevent erosion and thereby prevent silt generation;
- All hydrocarbon and other chemical spills, but especially those occurring outside of the dirty storm water areas, must immediately be cleaned up; and
- The pollution control dams must be managed with 0.8m freeboard in all dams.
<table>
<thead>
<tr>
<th>Impact</th>
<th>Siltation of natural watercourses.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact</strong></td>
<td>Siltation of natural watercourses.</td>
</tr>
<tr>
<td><strong>Criterion</strong></td>
<td>Extent (E)</td>
</tr>
<tr>
<td><strong>Rating</strong></td>
<td>Local</td>
</tr>
<tr>
<td><strong>Scores</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Calculation of Severity (S)</strong></td>
<td>( S = \frac{(E + D) \times I}{4} )</td>
</tr>
<tr>
<td><strong>Severity Score</strong></td>
<td>4.5</td>
</tr>
<tr>
<td><strong>Calculation of significance</strong></td>
<td>Impact Significance = ( \frac{S \times F}{2} )</td>
</tr>
<tr>
<td><strong>Final Score</strong></td>
<td>Impact Significance = 6.75 = Medium</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impact</th>
<th>Overflows of mine dirty water (from pollution control dams), ‘contaminated’ storm water flows and spills of hydrocarbons.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact</strong></td>
<td>Overflows of mine dirty water (from pollution control dams), ‘contaminated’ storm water flows and spills of hydrocarbons.</td>
</tr>
<tr>
<td><strong>Criterion</strong></td>
<td>Extent (E)</td>
</tr>
<tr>
<td><strong>Rating</strong></td>
<td>Regional</td>
</tr>
<tr>
<td><strong>Scores</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>Calculation of Severity (S)</strong></td>
<td>( S = \frac{(E + D) \times I}{4} )</td>
</tr>
<tr>
<td><strong>Severity Score</strong></td>
<td>2</td>
</tr>
<tr>
<td><strong>Calculation of significance</strong></td>
<td>Impact Significance = ( \frac{S \times F}{2} )</td>
</tr>
<tr>
<td><strong>Final Score</strong></td>
<td>Impact Significance = 4 = Low</td>
</tr>
</tbody>
</table>

Once mining has ceased, groundwater levels will recover and the underground workings will be drowned. The quality of this groundwater may be affected by explosives residues and other contaminants from the mining operation. At some point, this groundwater will possibly decant into surface water bodies, however the times and places where this will occur are not known, as the full mining plan for the life of the mine changes as the mine develops. The degree of contamination is not likely to be serious, due to the relatively inert nature of the ore and host rocks. The explosives residues will dissolve easily and should be leached away in a period of years or less. The impact of nitrates on the surface water ecosystem is temporary and the ecosystem should recover quickly.
Impact Decant of polluted groundwater from drowned mine workings into surface waters.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Extent (E)</th>
<th>Duration (D)</th>
<th>Intensity (I)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating</td>
<td>Regional</td>
<td>Medium term</td>
<td>Continual</td>
<td></td>
</tr>
<tr>
<td>Scores</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Calculation of Severity (S)

\[
S = \frac{(E + D) \times I}{4}
\]

\[
S = \frac{(3 + 2) \times 2}{4}
\]

Severity Score 1.5

Calculation of significance

Impact Significance = \(\frac{S \times F}{2}\)

Impact Significance = \(\frac{2.5 \times 5}{2}\)

Final Score Impact Significance = 3.75 = Low

7.4.5 CUMULATIVE IMPACTS

This section of the environmental impact assessment will attempt to determine if mining activities will contribute towards any cumulative impacts. For the purpose of this document, cumulative impacts will be taken as those impacts that have been assessed as being insignificant but would be significant when combined with the same impact arising from other mining activities within the area.

It must, however, be mentioned that the assessment of the cumulative impacts requires a combined effort from the different industries or mines that will contribute to the various cumulative impacts. Data from the contributing parties will be required for a thorough and accurate impact assessment.

The only significant cumulative impact in the long term is the pollution of groundwater and surface water by the water in the mine’s dirty water system.

During the impact assessment it was identified that groundwater will not be polluted during the operational phase since water will be pumped out of the aquifer and circulated in the mine’s dirty water system. It is only after closure, when groundwater flow conditions have re-established, that the polluted water can migrate away from the rehabilitated areas. Through the use of a numerical model, it was shown that the groundwater plume migration would be towards the mine from the east and away from the mine in a general northerly direction. The expansion of the plume is predicted to be very slow due to the low hydraulic conductivity and the relatively low hydraulic gradients in the area.

Assuming that the same conditions apply to the nearby mines, it can be concluded that the different migration plumes, although not moving in the same directions and at the same speeds, will accumulate into a more significant impact on both the surrounding groundwater and surface water bodies. Since different mines at different locations are considered and that no proper overall study was conducted, the worst-case scenario will be that the groundwater will be polluted quicker than anticipated in this report and that the pollution plume will reach the surface water environment quicker and in a more polluted state than anticipated in this report.

As described before, this impact can only be accurately quantified if enough data is collected from other parties within the area. However, an educated opinion is given in the
impact calculation below, based on the assumption that other mines in the area have similar water quality pollution problems to Dwarsrivier.

<table>
<thead>
<tr>
<th>Impact</th>
<th>CUMULATIVE IMPACT of poor groundwater and surface water quality from mine pollution.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criterion</td>
<td>Extent (E)</td>
</tr>
<tr>
<td>Rating</td>
<td>Regional</td>
</tr>
<tr>
<td>Scores</td>
<td>3</td>
</tr>
<tr>
<td>Calculation of Severity (S)</td>
<td>$S = \frac{(E+D) \times I}{4}$</td>
</tr>
<tr>
<td>Severity Score</td>
<td>3.5</td>
</tr>
<tr>
<td>Calculation of significance</td>
<td>Impact Significance $= \frac{S \times F}{2}$</td>
</tr>
<tr>
<td>Final Score</td>
<td>Impact Significance $= 8.75 = \text{Medium}$</td>
</tr>
</tbody>
</table>

The overall impact remains medium, largely due to the moderate intensity, based on the assumption that the water quality issues at all the mines involve mild increases in salinity and some high nitrate values. These types of pollution will diminish quickly after mining ceases and the impacts they cause in aquatic ecosystems can generally be reversed.
8. WATER AND WASTE MANAGEMENT

The following Integrated Water and Waste Management (IWWMP) mitigation tables are compiled using the following concepts and implementation requirements so that the higher principles of sustainable development, as well as the objectives of the NWRS, CMS and principles of the Integrated Water Management Hierarchy, are realised:

- **Continuous improvement.** The project proponent (or implementing organisation) must commit to review and to continually improve integrated water and waste management, with the objective of improving overall environmental performance.

- **Broad level of commitment.** A broad level of commitment is required from all levels of management, as well as the workforce, in order for the development and implementation of this IWWMP to be successful and effective.

- **Flexible and responsive.** The implementation of the IWWMP must respond to new and changing circumstances, i.e. rapid short-term responses to problems or incidents. The IWWMP is a dynamic “living” document and thus regular planned review and revision of the IWWMP must be carried out.

- **Integration across operations.** This IWWMP must integrate across existing line functions and operational units such as health, safety and environmental departments at Dwarsrivier Mine. This is done to change the redundant mindset of seeing environmental management as a single domain unit.

- **Legislation.** It is understood that any development project during its construction phase is a dynamic activity within a dynamic environment. The Proponent, Engineer, Contractor and Sub-contractor must therefore be aware that certain activities conducted during construction may require further licensing or environmental approval, e.g. river or stream diversions, bulk fuel storage, waste disposal, etc. Any contractor or section manager must consult the SHEQ officer and EO on a regular basis in this regard. There are a few major sources of legal guidance, with respect to water management at Dwarsrivier Mine, that need to also be adhered to and incorporated into integrated management planning. These are:
  - GNR 704: Regulations on Use of Water for Mining and Related Activities Aimed at the Protection of Water Resources, issued in June 1999, under the NWA;
  - The Department of Water Affairs’ Best Practice Guideline Series for Water Management, issued by DWAF in 2006; and
  - Dwarsrivier Mine Water Use Licence (No. 24053346) of January 2008, issued in terms of the NWA.

8.1 APPROACH

Various site activities undertaken during ongoing mining operations at the Dwarsrivier Mine have the potential to negatively impact on both the quality and quantity of ground and surface water resources in the vicinity of the mine. To assist the relevant parties responsible for implementing the mitigation actions necessary to either avoid or minimise such impacts (considering that this responsibility might rest with different parties on the mine), an approach has been adopted whereby mitigation actions are aligned with either specific site activities, or physical areas of responsibility, on site where mitigation measures are required for implementation.
The activities/areas referred to above, for which mitigation actions have been prescribed, are described under the following table headings:

- **Surface Storm Water Management areas (pollution prevention and erosion reduction –Appendix 3):**
  - Administrative offices/ Workshops/ stores;
  - Waste Skips and storage area;
  - Processing plant;
  - Clarifier to Dam 26;
  - Main sewage plant;
  - Vent shaft area;
  - Central mine area (incl. Upper Return Water Dam and roads);
  - Ore stockpile and waste rock dump;
  - Vent shaft area;
  - Conveyer over Springkaanspruit; and
  - Northern pit and surrounds.

- **Water Treatment Activities:**
  - Clarifier;
  - Reverse Osmosis Plant (incl. Brine management);
  - Pollution Control Dams; and
  - Sewage treatment plants.

- **General Water Management; and**
- **Riparian Area Management.**

The mitigation tables that have been compiled consist of seven (7) criteria, as follows:

- **“Activity / Area”** - This row will identify the issue being addressed, e.g. Activities potentially impacting on ground water resources at the processing plant;
- **Mitigation Actions** - This column will include all the necessary mitigation measures for each activity and /or area under scrutiny;
- **Management objectives** - indicate what the management objectives to be achieved for prescribed mitigation measures are;
- **Measurable targets** - indicate what evidence is to be used as an indication to whether, or not, the ‘Management objectives’ have been implemented and hence achieved;
- **Frequency of action** - This column provides time guidelines for the ‘Responsible party’ by which he/she is to action or manage the required mitigation;
- **Responsible Party** - Indicates that party who is ultimately responsible for ensuring that the prescribed mitigation measures are appropriately implemented within the specified time-frames;
- **Level of Mitigation** - Indicates at which level of the Water Resource Management Hierarchy mitigation has been applied.

### 8.2 Storm Water Management

The detailed storm water management plan follows; however, due to the changing operations on the mine, some general principles are given here, to allow easier revision and updating of this IWWMP in the future.

The following principles will be applied when doing detailed design of any component of the storm water system.
8.2.1 SOLVING PROBLEMS AT THEIR SOURCE

Although repair and reactive solutions are often unavoidable, the ultimate source of the problem will be traced and a solution found to that. For example, erosion of road surfaces can be reactively dealt with by placing culverts under the road to channel water flows, however, the source of the problem may be excessive runoff from certain areas. Solutions to this could include:

- delineating those areas and changing the surface type to encourage infiltration;
- installing flood attenuation ponds; and
- re-routing runoff to avoid the road.

8.2.2 MAXIMISING USE OF NATURAL SYSTEMS

The environment is self-managing, within certain limits. Making use of these natural, self-renewing systems can reduce dependence upon engineering interventions. Naturally vegetated slopes and channels/watercourses are better able to manage storm water than those which are degraded or bare. Wherever possible, the environment will be maintained in a healthy state and use will be made of these 'ecosystem services'. Such ecosystem services include:

- enhanced interception and infiltration;
- increased removal of soil moisture through evapo-transpiration;
- increased soil stability from leaf litter and roots, thereby preventing erosion and large amounts of silt generation during sheet wash events; and
- flood attenuation in naturally winding streamlines with irregular beds (pools and rapids).

8.2.3 MINIMISING ENGINEERED SOLUTIONS AND OVER-ENGINEERING

This is a corollary to the above, in that by increasing reliance upon natural systems, engineered works will be less needed. Although engineered structures will be required, their use will be minimised and where used, more natural options will be preferred over heavier, larger works. This approach will also reduce the need for rehabilitation of concrete and other hard interventions. The following are examples of preferable interventions:

- use of gabions as retaining walls;
- use of packed stone to line roadside and other channels;
- small, frequent runoff diversion channels, as opposed to larger, less frequent structures; and
- using rock cobbles to surface roads, encouraging infiltration rather than run-off.

8.2.4 USING FLEXIBLE APPROACHES

The mining operation is continually changing and therefore certain parts of the storm water system will need to be changed over time. In areas where changes are expected in particular, but also across the site generally, the storm water system will be designed with removal of structures and changes in mind.
8.2.5 KEEPING MAINTENANCE SIMPLE

Storm water systems need cleaning and repair and will be designed so that these tasks are as simple as possible. This will save time and allow the system to be kept operational more easily. The following methods will be used to simplify maintenance:

- areas requiring cleaning will be easily accessible;
- materials for repair will be readily available; and
- construction methods will not require any offsite materials or skills.

8.2.6 INTEGRATED MINE PLANNING

Environmental concerns, including storm water, will be present from the start of all planning processes on the mine. All planning will incorporate storm water issues and allow storm water concerns to influence the final decisions around the following:

- location of new development;
- layout of new development;
- choice of technology and construction materials; and
- operational procedures, including storage and handling of materials.

8.3 WATER TREATMENT

The processing of chrome containing mined ore at the Mine’s processing plant, to extract the targeted mineral (chrome), results in the production of significant volumes of waste tailings / slurry. This slurry was until recently (Mid 2010) pumped to backfill the so-called ‘South Pit’ on the site. The South pit is essentially an open-cast pit resultant from surface chrome mining activities at the beginning of the Life of Mine and is now entirely backfilled with tailings.

The tailings referred to above contains significant volumes of water from processing which passes through a prominent geological fracture in the base of the South Pit and presently flows into the underground workings of the Mine through this geological feature. Water in the tailings has elevated levels of nitrate, ammonia and various salts, as a result of residue from underground blasting as well as the ingress of water from the Groot Dwarsrivier, which also contains elevated levels of various pollutants.

This ‘contaminated’ water entering into the underground workings through the above mentioned fracture, as well as water entering the underground workings through other groundwater flows, and ingress from undermining the Groot Dwarsrivier, intersecting the mine shaft, is further contaminated when it comes into contact with nitrates. The source of the aforementioned nitrates is the explosives used in blasting activities undertaken during normal underground mining operations.

This contaminated groundwater is dewatered to a clarifier at surface, from where half thereof is pumped to pollution control dams and the other half back underground for mining operations.

Over time, there has been a significant build up of divalent cations, such as Magnesium (Mg^{2+}) and Ferrous Iron (Fe^{2+}) as well as nitrates and Ammonia in the site’s groundwater, as
well as the Mine’s process water and pollution control dams, for the following reasons (as well as combinations thereof);

- Disposal of ‘contaminated’ slurry into the South pit and the resultant contaminated groundwater flow, through a prominent geological fracture in the base of the South pit, into the underground workings of the mine;
- Nitrate based explosives use in underground blasting operations;
- De-watering of underground workings and pumping of resultant contaminated water into return water / pollution control dams at surface and ultimately back into the processing plant from which the contaminated tailings / slurry emanated;
- The aforementioned pollution control dams (particularly the Lower Return Water Dam) are suspected of leaking their ‘contaminated’ contents into groundwater resources underlying the site. Although lined, it is suspected, through an evaluation of groundwater quality monitoring results, that the liners have in part failed and created a pollution pathway to groundwater; and
- Naturally ‘hard’, alkaline, waters in the general area (used in processing plant and mine operations), associated with the geology of the site (Bushveld Igneous Complex) and river contamination from upstream mining and/or farming activities.

The above factors have lead to a substantial ‘hardening’ of the underground and process water associated with the Mine. As a result, Assmang propose to establish a Reverse Osmosis Plant (ROP) at surface. The ROP is proposed to treat all contaminated / hard water pumped via a high pressure pump from the underground workings; that would have ordinarily been pumped into pollution control dams at surface and back underground for use in mining operations (after being passed through a clarifier).

The Mine’s intention is thus, to significantly dilute the concentration of contaminants in the ‘leaking’ return water dam in order to stem the flow of contaminants into groundwater resources. This is also proposed to ‘flush’ any potential groundwater pollution plume with water from the ‘leaking’ return water dam that conforms to applicable National quality standards and thresholds. Although the old adage, “Dilution is not the solution to pollution”, holds true in most instances, the above strategy in combination with the progressive removal of contaminants, through treatment by reverse osmosis, is anticipated to significantly improve groundwater quality at the Mine by:

- Removing the ‘source’ of any potential groundwater pollution;
- Removing existing contaminants in the groundwater environment through the treatment thereof in a ROP;
- Reducing the concentration of existing contaminants in the groundwater through dilution effects, such that the potential impacts thereof through chronic exposure to the receiving environment will be mitigated; and
- Reducing borehole abstraction demand through the partial diversion of treated groundwater into mining applications.

The ROP will require capacity to treat a maximum of 1,500 m³ of ‘dirty’ water daily. The plant is proposed to yield not less than 75% recovery [that is to say that, “of the water put through the plant, at least 75% thereof should be treated to an acceptable quality for reuse on the mine (Figure 8-1) and the remaining 25% (or less) thereof will exist in a concentrated brine solution resultant from the ROP” (Approximately 375 m³ daily)]. The proposed project initially included provision for brine evaporation ponds, civil works, electrical and mechanical facilities, oil removals and filtration systems. Brine ponds/lagoons
where subsequently removed from the project proposal, in favour of ECUs, which remove any potential for re-contamination of groundwater through leaks in brine pond containment barriers.

The waste product from the ROP is a highly concentrated ‘brine’ solution. This brine will be pumped through Evaporative Crystalliser Units from the ROP, where the liquid fraction of the brine will be evaporated, leaving behind a concentrated salt mass requiring appropriate disposal at a hazardous landfill site (likely to be Enviro-serve’s Holfontein Hazardous Waste Disposal Facility). The imminent promulgation (early 2011) of the so-called ‘Waste Classification and Management Regulations’ may impose a ban on the land filling of brines and salts. Alternative disposal and re-use options will thus also need to be evaluated within the next 2 years in order to achieve a sustainable ‘disposal’ solution for the project.

Treated water from the ROP (permeate) will partially be pumped under pressure to a proposed new surface built clean water reservoir in close proximity to the ROP, from where it will then either be re-distributed to the processing plant or to ablution facilities on site (drinking / toilets). The proposal by Assmang at this stage is to place the permeate reservoir /tank on top of an existing waste rock stockpile immediately south west of the clarifier. Treated water to be re-introduced / circulated back into the ore processing activities on site will be far less ‘hardened / polluted’ than it was prior to installation of the propose ROP. Much of the permeate will also be pumped into the pollution control dam circuit at surface in order to dilute the concentrations of contaminants in this circuit. The potential accumulation of salts and other pollutants in the process water is thus anticipated to be largely eliminated due to the high separation efficiency of an ROP. The majority of the treated water will be fed into the lower return water dam to dilute the concentration of contaminants contained therein.

The ROP will require capacity to treat a maximum of 1,500m³ of ‘dirty’ water daily. The plant is proposed to yield not less that 75% recovery (that is to say that, “of the water put through the plant, at least 75% thereof should be treated to an acceptable quality for re-use on the min and 25% thereof will exist in the contaminated / concentrated brine solution resultant from the ROP”). The proposed ROP is presently subject to a Waste Licensing EIA process and an application for waste licensing has been submitted to the National Department of Environmental Affairs (DEA), in terms of the National Environmental Management Act 2008 (Act 59 of 2008)[NEMWA]. Although the technical project specifications and brine management options for the project may be subject to minor amendment due to, inter alia, the following;

- Specific management requirements specified in the waste license to potentially be issued by the DEA; and
- Minor amendments and changes in technical project specifications through choice of final BPEO following completion of waste licensing EIA.
A waste product from the ROP is a highly concentrated ‘brine’ solution. This brine will be pumped to a coal-fired Evaporative Crystalliser Unit Plant from the ROP, where the liquid fraction of the brine will be evaporated, leaving behind a concentrated salt mass requiring appropriate disposal at a hazardous landfill site (likely to be Enviro-serve’s Holfontein Hazardous Waste Disposal Facility). The immanent promulgation (early 2011) of the so-called ‘Waste Classification and Management Regulations’ is likely to impose a ‘ban’ on the land filling of brines and salts. Alternative disposal and re-use options will thus also need
to be evaluated for the project in order to achieve a sustainable ‘disposal’ solution for the project.

Treated water from the ROP (permeate) will be pumped under pressure to a proposed new surface built clean water reservoir in close proximity to the ROP, from where it will then either be re-distributed back to the processing plant or to ablution facilities on site (drinking / toilets).

Figure 8-2: Flow Diagram of Proposed Project (Brine Management)

The poor groundwater quality measured on site (2010 Groundwater monitoring results), as well as present non-compliance with Water Use Licensing conditions, would continue unabated if no concerted and urgent effort is placed into remedying the current and potential groundwater contamination known to exist at the mine (particularly Nitrates). These nitrates are believed to result from blasting activities, as well as the continual recirculation of dewatered sources through the mine’s ‘closed’ loop reticulation system.
8.3.1 WATER TREATMENT ALTERNATIVES

Technology Alternatives
The end goal of the proposed project component is to improve plant process and ground water quality. There are a variety of different water treatment technologies that can be established and utilised on site to achieve this end goal. Different reverse osmosis technologies were evaluated during the EIA phase of the project against, inter alia, the following criteria:

- Efficacy, with respect to the ability of the technology / ROP to purify the ‘contaminated’ water;
- Space requirements for establishment of the technology / ROP;
- Cost of the technology / ROP;
- Treatment capacity (m$^3$/day) of the technology / ROP; and
- Track record of the technology / ROP.

Phyto-remediation
In a Status Report prepared for the U.S. EPA Technology Innovation Office (Chappell, 1997), it was indicated that the potential use of plants to remediate contaminated soil and groundwater has recently received a great deal of interest. In addition to evaluating alternative ROP technologies, Phyto-remediation was therefore considered initially as a potential alternative to the establishment of a ROP on site (potential reduced capital cost and no brine production). Phyto-remediation is a form of bio-remediation which treats environmental contamination using plants to mitigate water quality issues on site, without having to remove the material (salt from brine) and dispose of it elsewhere.

Phyto-remediation is a bio-remediation process that uses various types of plants to remove, transfer, stabilize, and/or destroy contaminants in the soil and groundwater. There are several different types of phyto-remediation mechanisms (Centre for Public Environmental Oversight website, February 2010) that could be considered. These are:

1. **Rhizosphere biodegradation.** In this process, the plant releases natural substances through its roots, supplying nutrients to microorganisms in the soil. The microorganisms enhance biological degradation;
2. **Phyto-stabilization.** In this process, chemical compounds produced by the plant immobilize contaminants, rather than degrade them;
3. **Phyto-accumulation** (also called phyto-extraction). In this process, plant roots sorb the contaminants along with other nutrients and water. The contaminant mass is not destroyed but ends up in the plant shoots and leaves. This method is used primarily for wastes containing metals.

4. **Hydroponic Systems** for Treating Water Streams (Rhizofiltration). Rhizofiltration is similar to phyto-accumulation, but the plants used for clean-up are raised in greenhouses with their roots in water. This system can be used for ex-situ groundwater treatment. That is, groundwater is pumped to the surface to irrigate these plants. Typically hydroponic systems utilize an artificial soil medium, such as sand mixed with perlite or vermiculite. As the roots become saturated with contaminants, they are harvested and disposed of.

5. **Phyto-degradation**. In this process, plants actually metabolize and destroy contaminants within plant tissues.

At the Scoping phase it was initially thought that a determination of whether, or not, the implementation of the above measures would be practical and economically justifiable in improving ground and process water quality at the Mine would centre around, inter alia, the following criteria:

- Space requirements for establishment of possible phyto-remediation systems Vs. suitable space availability on the Mine;
- Capacity of such systems, in terms of % recovery, to purify ‘contaminated’ water Vs. the Mine’s requirements to treat approximately 1, 500m³/day of contaminated water;
- Costs for establishment of such systems;
- Impacts of such systems on groundwater availability, through uptake and transpiration of water; and
- Time taken to purify ‘contaminated’ water Vs. ROP technologies; and
- Track record of phyto-remediation system’s ability to treat ‘contaminated’ water for anticipated Life of Mine.

Subsequent review of applicable literature revealed that there is no base of evidence that is conclusively supportive of the use of phyto-remediation mechanisms to improve contaminated groundwater quality under South African conditions. Furthermore, much of the literature consulted makes no reference to the use of locally indigenous species in phyto-remediation efforts and is centered predominantly on the use of exotic species (e.g. Poplar sp., Alfalfa, Poplar hybrids, juniper, fescue, duckweed, parrot-feather, etc.) to either hyper-accumulate salts and various heavy metals from contaminated soils and shallow groundwater conditions.

The urgency with which the Dwarsrivier Mine intends to treat contaminated groundwater on the Mine site does not lend itself to the lengthy time-frames loosely sited in literature for phyto-remediation efforts. The volumes of contaminated groundwater that are to be treated by the mine also appear to be far in excess of the practical capabilities for treatment using phyto-remediation. Evapotranspiration rates for exotic Eucalyptus sp., for example, are sited as being anywhere between 25-500l/day. Assuming a maximum evapotranspiration rate of 500l/day, it would mean that the approximately 3,000 of these highly invasive species would need to be planted strategically on site to approximate a water uptake equivalent to that of what would typically be pumped to an ROP for treatment. Apart from the fact that locally applicable species would exhibit evapotranspiration rates significantly less than 500l/day, given their adaptation to local (water stressed) climatic conditions, evapotranspiration implies a near total loss of uptake water to the atmosphere. This anticipated water loss, coupled with the lengthy time-frames
associated with groundwater bio-remediation, do not outweigh the capital cost savings and removal of the need for brine management that would be realized through the implementation of a groundwater phyto-remediation project on the Mine.

Some South African mining houses are presently involved in extensive research, in collaboration with credible Tertiary Institutes such as the University of the Witwatersrand (Wits), into the use of phyto-remediation to rehabilitate TSF’s and coal mining operations on Gauteng’s Gold Reefs and the Highveld respectively. It is recommended that similar such research is entered into between the Assmang Dwarsrivier Chrome Mine and a locally based Tertiary Institute as part of a MSc. or Phd. study. Such a study would need to take cognizance of the site’s location with the Sekhukhune Centre of Endemism within the Sekhukhune Mountain Bushveld. It is further recommended that such a study be aimed at identifying locally applicable floral species for long-term, continued, groundwater remediation post closure of the Mine.

**Brine Management / disposal**

Given that ROP technologies were deemed to be most suitable to the required application, the various means of managing the concentrated brine solution produced from the ROP technology were evaluated. This evaluation initially assessed, inter alia, the following brine management mechanisms:

- **The use of evaporative ponds** - such pond systems make use of large surface areas, and typically black liners, to promote the evaporation of water from the concentrated brine solution to leave behind salts for re-use or disposal as a last resort. The use of such ponds is becoming more and more unfavourable within the industrial community due to their potential to ‘re-pollute’ ground and surface water resources, where failure to consider site water balances results in poor overall evaporation rates and overtopping of the said ponds/ lagoons;

- **Spray evaporators** - Spray evaporators (Figure 8-4– top left) are designed to reduce the particle size of a water droplet (60 to 500 microns) so that the water is able to volatilize quickly while in the air, leaving only the salt to fall to the ground;

- **Fan sprayer systems** - involves the use of various evaporative surfaces, nozzles, materials, and equipment to evaporate concentrated brine solutions (Figure 8-4 right hand side), in order to recover the salts, and control the salt drift from the sprayers;

- **Brine pond circulators** - pond circulators work by drawing water from the evaporation pond bottom and spreading it along the surface in a near laminar fashion; thereby keeping the pond continuously mixed, controlling algae, and keeping the overall pond temperature higher (Figure 8-4, bottom left); and

- **Alternative uses / disposal options** for the solid salt mass (regarded as hazardous waste) resultant from evaporation of water from the brine solution in evaporation ponds. The imminent promulgation of the Waste Classification and Management Regulations (anticipated for early 2011) is expected to impose restrictions on the land-filling of wastes with excessive salt loads. In anticipation of this, sustainable / legally compliant alternative means for disposal, such as treatment to a level that is acceptable for disposal at sea, is to yet be assessed for the project.

One of the key factors influencing the design of evaporation ponds is the evaporation rates they achieve relative to the surface areas thereof. The evaporation rates for water are readily available for various catchments in South Africa. The high salinity of the brine however will reduce this evaporation rate (Golder Associates Africa). The Dwarsrivier Mine’s need to manage a maximum of 375m³ daily will require either brine pond
circulators or thermal evaporation systems, in conjunction with conventional evaporation pond systems, to increase the evaporation rate to levels capable of handling the aforementioned volumes of brine on a daily basis. The space requirements for brine lagoons on the existing site were deemed to be restrictive to their use. Spray evaporators were deemed to be too financially restrictive, in terms of ongoing operational costs, for implementation at the mine. Climatic conditions, in terms of wind, were also not suited to brine management through ‘spray’ technologies.

The most environmentally suitable and practical method of managing the resultant brine from the ROP was not one initially considered during the scoping phase. The mine made a strategic decision to move away from brine lagoons and the groundwater pollution risk that they pose, in favour of coal fired Evaporative Crystalliser Units (ECU) and thin film evaporators. Water will be evaporated from the brine through the application of steam generated in a coal fired boiler. Three (3) crystalliser units will be established in a ECU plant, together with a single stage thin film evaporator plant.

The proposed ECU Plant will be coal fired, whereby (Figure 8-2):
- Coal will be brought in by truck;
- Coal will be stored in bunker fed to the ECU Plant boiler by conveyor;
- Ash from the boiler will be quenched and appropriately stored in hoppers; and
- Ash will be collected by truck and removed to waste an appropriately licensed waste disposal site. Various potential bottom ash uses will be considered by the mine.

Dried salt from the ECU and thin film evaporator plant will be stored in hoppers, then fed to into appropriate bags. These bags will be stored in a shed with roof and concrete floor, and then collected by truck for disposal at an appropriately licensed landfill site (Figure 8-2).
Figure 8-4: Photographic examples of alternatives that were previously considered for brine handling
### 8.4 Mitigation Tables

**Table 8-1: Surface Water Management Mitigation Table**

<table>
<thead>
<tr>
<th>Surface Water Management</th>
<th>Mitigation Actions</th>
<th>Objectives</th>
<th>Targets</th>
<th>Responsible Party</th>
<th>Time-frames</th>
<th>Level of Hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>separate clean and dirty storm water;</td>
<td>To prevent the infiltration of potentially contaminated water into exposed soil surfaces and ground water resources.</td>
<td>No bare soil surfaces observed within the workshop, wash bay and refuelling bay compound</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td></td>
<td>maximise the amount of clean storm water and direct it to natural watercourses;</td>
<td></td>
<td>All potentially contaminated water at this site diverted into the oil-water separator during rainfall events, as well as routine operation</td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td>Pollution prevention / Treatment</td>
</tr>
<tr>
<td></td>
<td>minimise the disruption to natural/pre-existing run-off and surface water flows;</td>
<td></td>
<td></td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>minimise the amount of dirty storm water generated on site;</td>
<td></td>
<td></td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>manage the dirty storm water in the mine/process water system;</td>
<td></td>
<td></td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>meet the legal requirements relating to storm water; and</td>
<td></td>
<td></td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>minimise specific impacts such as erosion and siltation.</td>
<td></td>
<td></td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Administrative offices, change rooms, workshops / wash bays / re-fuelling bays and stores** - The workshops, wash bays and refuelling area are located to the south of the mine offices and stores, and to the north of the south-eastern waste rock dump. The area comprises a large workshop shed in the south-eastern corner, outdoor servicing and wash bays in the south-west and the diesel pumps and diesel storage tanks in the north-western corner. LHDs and other vehicles are also stored in the middle of the area. The area slopes down moderately to the north-west. The stores are located between the offices and the workshop area. Two large sheds are on the northern side of the area, with a few small sheds for gases and paints in the middle of the area. Most of the area is bare ground and has lots of items of machinery standing around, such as motors, axles, fans and transformers. The area slopes gently to the north-west.

Concrete aprons within the workshop, wash bay and refuelling bay compound must be extended to cover all bare soil surfaces at this location.

The concrete aprons referred to above must be constructed such that contaminated storm water run-off flows into the existing storm water channels and ultimately into the existing oil-water separator at this location.

The outlet drains from the two (2) bunded degreaser and solvent storage areas within the workshop and refuelling bay area need to be re-directed away from bare soil surfaces, onto concrete aprons and ultimately into the oil-water separator.
<table>
<thead>
<tr>
<th>Surface Water Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>All storm water diversion drains (open and covered) within the above mentioned area need to kept clear of any obstructions and / or debris</td>
</tr>
<tr>
<td>The oil-water separator at the above location needs to be monitored and maintained, as necessary, in terms of function and the adequacy of the capacity thereof</td>
</tr>
<tr>
<td>Oils and greases within the oil-water separator need to be collected by a reputable, appropriately licensed, waste disposal contractor as required</td>
</tr>
<tr>
<td>The appropriate Waste Manifests (proof of responsible disposal/re-use) need to be maintained for any oily waste removed from site</td>
</tr>
<tr>
<td>Water from the oil-water separator needs to be piped to the clarifier and subsequently into Dam26 when the water level in this structure rise so as to avoid the impairment of its functioning.</td>
</tr>
<tr>
<td>Any plant and machinery (e.g. motors, axles, fans and transformers) housed in the store area needs to be placed under an appropriate, water proof, cover to avoid generating dirty storm water from any potential hydrocarbon leakages from the plant and machinery</td>
</tr>
<tr>
<td>Similarly, bunded storage areas for fuel and oil tanks within the refuelling yard need to be appropriately roofed to avoid the unnecessary generation of contaminated storm water within the bund wall</td>
</tr>
</tbody>
</table>
### Surface Water Management

**Waste skips and storage areas** - There are three (3) parts to this area that are all located north of the southern decline:

- an open air storage area sloping gently to the north;
- a waste skip and recyclables storage area with little gradient; and
- an open area with an old explosives emulsion tank, various skips and drums (slopes to the east)

Ensure that any potentially contaminating wastes, explosives mixtures, etc. are contained in covered, leak-proof, skips at this location.

To minimise the amount of dirty storm water generated on site, as well the potential for 'leachate' generation and leakage from waste skips.

No visible leakages from the waste skips. Skips observed to be covered, with no evidence of storm water within skips.

Mine Management, Environmental Manager

Ongoing

Pollution prevention

Complete the surfacing of the area with rock cobbles to enhance infiltration and reduce surface water run-off into the southern decline portal.

To prevent the unnecessary movement of storm water into underground workings where it may become contaminated, as well as to promote infiltration of storm water to avoid potential erosion.

Surface area completely covered with rock cobbles. No evidence of storm water flows into southern decline portal.

Mine Management, Environmental Manager

Once off: Within 3 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP

Reclamation

Install a continuous berm to the east and south-east of the road that passes by the waste skips.

To intercept any surface run-off and allow it to infiltrate the soil surface at this location.

Berm installed appropriately.

Mine Management, Environmental Manager

Once off: Within 3 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP

Pollution prevention / Reclamation

Install a storm water diversion ‘hump’ at the top of the roadway leading down into the southern decline to prevent runoff from heading to the pit / underground.

To minimise the amount of dirty storm water generated on site.

Storm water diversion ‘hump’ installed appropriately.

Mine Management, Environmental Manager

Once off: Within 3 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP

Pollution prevention / Reclamation

### Area:

**Processing Plant** - The Processing Plant is located between the public road (R577) and the existing tailings dam. The ground slopes gently to the south west, towards the Upper Return Water Dam (URWD). Other than the actual plant buildings, there is the main ore conveyor coming from the south-east, leading to firstly the ROM stockpile, then to the jaw-crusher, the ore bins and the fines stockpile. There is a laboratory, offices, welding yard, security, change rooms and weighbridge to the east and south, several product stockpiles on concrete pads to the west and new expansions to the north, newly completed construction. Pockets of natural bush occur east of the offices and east of the fines stockpile.

A storm water diversion berm must be constructed along the entire length of the northern, north-eastern and south eastern boundaries of the plant area (between the office buildings and the laboratory, to exclude the security and change room areas at the plant site).

To minimise the amount of dirty storm water generated on site.

Storm water diversion berm installed appropriately.

Mine Management, Environmental Manager

Once off: Within 3 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP

Pollution prevention / Reclamation
### Surface Water Management

<table>
<thead>
<tr>
<th>Description</th>
<th>Action</th>
<th>Responsibility</th>
<th>Timetable</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>All storm water falling south of the above berm (‘clean’ storm water) must be allowed to flow naturally across the area, or be routed to the storm water culvert south of the ROM stockpile</td>
<td>To maximise the amount of clean storm water and direct it to natural watercourses, as well as to minimise the disruption to natural/pre-existing run-off and surface water flows</td>
<td>No clean storm water observed to flow through the plant area during rainfall events</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing</td>
</tr>
<tr>
<td>All storm water falling within the ‘bermed’ plant area that is then deemed to be contaminated, must be appropriately channelled south westerly towards the existing product aprons, via the silt trap, and into the URAW</td>
<td>To manage the dirty storm water in the mine/process water system</td>
<td>‘Contaminated’ storm water within the plant area is observed to flow into mine ‘dirty’ water management system during rainfall events</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 3 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
</tr>
<tr>
<td>Storm water run-off from the area between the weighbridge, plant and offices must be diverted away from the site ‘dirty’ water system by encouraging run-off, through installation of a storm water diversion berm, to flow to the low point near the waste (discard rock) bin and not into ‘dirty’ water channels</td>
<td>To maximise the amount of clean storm water and direct it to natural watercourses, as well as to minimise the disruption to natural/pre-existing run-off and surface water flows</td>
<td>Storm water diversion berms installed appropriately to channel water away from site ‘dirty’ water streams</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 3 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
</tr>
<tr>
<td>In the vicinity of the fines stockpile and sub-station, clean run-off flows into the plant area at the thickener. This should be diverted northwards, away from the plant area.</td>
<td>To maximise the amount of clean storm water and direct it to natural watercourses, as well as to minimise the disruption to natural/pre-existing run-off and surface water flows</td>
<td>Clean run-off appropriately diverted away from the thickener and hence ‘dirty’ water system</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 3 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
</tr>
<tr>
<td>The area to the north of the plant must be divided into clean and dirty water areas. All clean storm water must be prevented from entering the dirty water areas on the plant. This must be done by installing channels that direct this water northwards towards the streamline that runs north of the Tailings Dam. A silt trap must be installed to prevent excessive silt from flowing into the stream line</td>
<td>To separate clean and dirty storm water affectively on site, as well as to maximise the amount of clean storm water and direct it to natural watercourses</td>
<td>Required channels and silt traps installed appropriately and observed to direct water towards the streamline to the north thereof.</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 3 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
</tr>
</tbody>
</table>
### Surface Water Management

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
<th>Action</th>
<th>Frequency</th>
<th>Monitoring</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare areas of ground around the Load-Out area</td>
<td>Drain into a stone-pitched channel to the URWD</td>
<td>Monitor for potential erosion and blockages</td>
<td>Monthly</td>
<td>Repair within 2 working days</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>The newly constructed concrete apron</td>
<td>Protect from contamination</td>
<td>Monitor regularly</td>
<td>Ongoing, particularly during rainfall events</td>
<td>Pollution prevention</td>
<td></td>
</tr>
</tbody>
</table>

#### Area: Clarifier to Dam 26

- The clarifier is located to the north-west of the portal to the southern decline shaft. An HDPE lined open channel presently allows the clarifier effluent to flow by gravity to Dam 26. This channel is on the edge of a rehabilitating rock dump to the north-west.

- The HDPE lined channel that directs flow between the clarifier and Dam 26 must be replaced with a PVC pipe.

- Rehabilitation of the waste rock dump to the north-west of the clarifier must be improved and appropriately completed. A 1:3 gradient must be achieved in this regard and indigenous grass species appropriate to the specific management unit identified in the BAP must be used.

- To reduce erosion and silt laden run-off from the waste rock stockpile, bare soil surface reduced to 10% of total surface area on the dump. No visible signs of erosion.”

- To prevent accidental overflow of contaminated water streams onto bare soil surface where they may subsequently impact on ground and surface water resources, as well as to minimise the occurrence of erosion.”

- HDPE channel replaced with PVC piping. No observable leakages from pipe or pipe connections.

- To manage the dirty storm water in the mine/process water system.

- To prevent accidental overflow of contaminated water streams onto bare soil surface where they may subsequently impact on ground and surface water resources, as well as to minimise the occurrence of erosion.”

- Mine Management, Environmental Manager.

- Monthly inspections and required maintenance kept on file.

- Records of monthly inspections and required maintenance kept on file.

- Within 2 working days.

- Ongoing, particularly during rainfall events.

- Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP.

- Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP.

- Ongoing: Rehabilitation to be completed within 12 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP.

- Pollution prevention.

- Pollution prevention.

- Pollution prevention.

- Pollution prevention.
## Surface Water Management

### Main Sewage Plant
- The main sewage plant is located to the north-west of the South Pit, close to the Springkaanspruit. The area slopes down to the north-west and is largely naturally vegetated, with the access road coming from the south.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Action</th>
<th>Responsible Party</th>
<th>Timeframe</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>A rock and earth berm should be constructed along the northern and north-western side of the area to capture any silt laden run-off from the road to the plant</td>
<td>To encourage infiltration thereof into the soil, rather than run-off into the Springkaanspruit to the north thereof</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>Sludge ponds should be appropriately roofed to limit rainfall infiltration into these ponds</td>
<td>To minimise the amount of ‘dirty’ water generated on site, i.e. storm water entering contaminated water stream from the treatment plant</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
</tbody>
</table>

### Area:
- Central mine areas between the clarifier, the ROM conveyor and the Springkaanspruit

<table>
<thead>
<tr>
<th>Activity</th>
<th>Action</th>
<th>Responsible Party</th>
<th>Timeframe</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage ditches at the side of the various roads in this area need to be dry packed (to allow infiltration and capture silt) with stones to limit erosion of the roadsides</td>
<td>To limit the occurrence of erosion within storm water drainage ditches and along gravel roadways</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>Storm water culverts need to be installed at two locations, as follows:</td>
<td>To limit erosion of roadways</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>- at the ‘T-junction’ opposite the steep rehabilitating rock dump; and</td>
<td>Storm water culverts appropriately installed. No observable erosion along applicable roadways</td>
<td>Mine Management, SHEQ Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>- at the ‘T-junction’ leading to the sewage treatment works.</td>
<td>Storm water culverts appropriately installed. No observable erosion along applicable roadways</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>Silt traps need to be installed at two locations, as follows:</td>
<td>To prevent the silting up of drainage ditches, storm water culverts and the Springkaanspruit</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention / Treatment</td>
</tr>
<tr>
<td>- at the former ‘T-junctions’; and</td>
<td>Silt traps appropriately installed. No sedimentation observed in applicable drainage ditches and storm water culverts</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention / Treatment</td>
</tr>
<tr>
<td>- at the ‘T-junction’ where the road crosses the Springkaanspruit.</td>
<td>Storm water run-off from the MCC area (dis-used, fenced storage area north of Dam 26) must be channelled in such a way that it either flows through the second silt trap recommended above, or into the natural bush surrounding this area where it will infiltrate soil surfaces more naturally</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
</tbody>
</table>

To prevent sheet wash over the adjacent roads and siltation into the Springkaanspruit.

No erosion observed at applicable road sections

No sedimentation observed in applicable drainage ditches and storm water culverts

No observed erosion along applicable roadways

No visible erosion of roadbeds along the applicable road section

No erosion observed at applicable road sections
## Surface Water Management

**ROM Stockpile and South Western Waste Rock Dump area** - This area comprises the partly rehabilitated south-eastern (main) waste rock dump, with the ore stockpile to the north-west and another rehabilitating area towards the west. A mine road from the workshop area runs to the south, between the ore stockpile and waste rock dump, past the explosives container burning area, a soil stockpile, the ramp to the waste rock dump and finally past a remaining open pit and leading to the explosives magazine.

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
<th>Responsible Party</th>
<th>Duration</th>
<th>Type of Prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The existing storm water diversion channel located between the aforementioned road and waste rock dump must be extended in a southerly direction along the eastern side of the above road to</strong></td>
<td>To prevent sheet wash over the adjacent road from the waste rock dump and to channel 'clean' storm water into natural watercourses and away from site ‘dirty’ water streams</td>
<td>Mine Management, Environmental Manager</td>
<td>Within 12 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention / Reclamation</td>
</tr>
<tr>
<td><strong>Two (2) silt traps should be installed along the aforementioned channel,</strong> as follows:</td>
<td>To reduce the potential for siltation of surface water resources</td>
<td>Mine Management, Environmental Manager</td>
<td>Within 12 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>1. near the sub-station; and</td>
<td>Silt traps installed correctly and observed to indeed be removing silt from storm water flows</td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. immediately south of the road, as the channel leads into bushland.</td>
<td></td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>This second silt trap should be large enough that it acts as a flood attenuation basin</strong></td>
<td>To slow the velocity of storm water and thereby reduce the potential for erosion</td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td>Pollution prevention</td>
</tr>
<tr>
<td><strong>The aforementioned storm water diversion channel must be dry packed (to allow infiltration and to capture silt) with stones to limit erosion of the roadsides</strong></td>
<td>To limit erosion of the roadsides</td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td>Pollution prevention / Treatment</td>
</tr>
<tr>
<td><strong>Water running off the aforementioned road and waste rock dump should be discouraged from entering the open pit area (southern decline portal)</strong></td>
<td>To minimise the amount of dirty storm water generated on site, whereby this water is prevented from entering underground workings and becoming part of the mine ‘dirty’ water circuit</td>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td>Pollution prevention / Reclamation</td>
</tr>
<tr>
<td><strong>Waste rock that was accidentally spread into the 1:50 year flood line of the ‘un-named’ stream to the south of the waste rock dump must be removed from this location (back onto the waste rock dump) and the disturbed areas rehabilitated with appropriate indigenous vegetation suitable to the relevant Biodiversity Management Unit of the mine</strong></td>
<td>To ensure that the hydrology of the affected stream is restored. Compliance with GN. 704.</td>
<td>Mine Management, Environmental Manager</td>
<td>Within 12 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention / Reclamation</td>
</tr>
</tbody>
</table>

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**Page 101**
### Surface Water Management

#### Vent Shaft Area
- **This area** lies south of the current clarifier discharge channel and includes a bunded diesel storage tanks, the explosives emulsion tanks, two vent shafts and some roads and other bare areas. The slope of the general area is westward, towards the Groot Dwars River. Limited storm water run-off is generated in this area, and the gradient is moderate. Rock cobbles have been placed over some of the areas to reduce runoff generation and to absorb any runoff that comes from the road and cleared areas.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Action</th>
<th>Responsible Officer</th>
<th>Timeline</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berms must be constructed with rock cobbles along the downslope (western edge) of all cleared / developed areas</td>
<td>To intercept any run-off with high TDS /silt loads and to prevent erosion of soils or any silt from entering the Dwars River</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>Berms installed appropriately as required</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Conveyor crossing over Springkaanspruit
- **This area** features a road and the ROM conveyor, running parallel to one another in a north-westerly direction. There is a topsoil stockpile east of the said road and a bare area between the road and ROM conveyor. The area slopes gently to the north-west.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Action</th>
<th>Responsible Officer</th>
<th>Timeline</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>The bare area between the road and ROM conveyor has been bermed at the conveyor, to prevent storm water run-off from entering the south pit. This berm must be regularly inspected and maintained as necessary</td>
<td>To prevent storm water run-off from entering the south pit and thereby contributing to the site’s ‘contaminated’ water stream</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Monthly</td>
<td>Pollution prevention / Reclamation</td>
</tr>
<tr>
<td>Records of monthly inspections kept on file, together with records of ad hoc maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The aforementioned berm diverts storm water run-off northwards to the Springkaanspruit, where a slipway and gabions lead into the river. Substantial run-off from the road and bare areas lead to extensive siltation in the Springkaanspruit. As such, run-off from this area should be directed into a silt trap prior to discharge into the Springkaanspruit</td>
<td>To prevent siltation of the Springkaanspruit</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>Silt trap established as required and observed to be operating efficiently</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### North pit and surrounds
- **There are two (2) remaining open-cast pit areas** on the northern side of Road R577: a southern pit, in close proximity to the public road (northern decline portal) and a northern one close to the conical hill on site (so-called North Pit). There is a large rehabilitated area running from the R577, past the eastern side of the hill, with a haul road running through the rehabilitated areas in the southern parts and then on the eastern side of the rehabilitated areas further north. New clearing is happening in the south-east of this area. In the far north, a subsoil stockpile, some roads and rehabilitated areas are located to the north of the stream.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Action</th>
<th>Responsible Officer</th>
<th>Timeline</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure the new developments (offices, workshop, stores, etc) in the southern part of this area have appropriate ‘clean’ and ‘dirty’ storm water controls by encouraging infiltration through use of rock cobbles to ‘pave’ area used daily during mining activities</td>
<td>To minimise the generation of dirty storm water and conversely maximise the amount of clean storm water allowed to infiltrate soil surfaces and enter natural surface water resources</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Monthly</td>
<td>Pollution prevention / Reclamation</td>
</tr>
<tr>
<td>Appropriate clean / dirty storm water separation effected</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Surface Water Management

<table>
<thead>
<tr>
<th>Action</th>
<th>Objective</th>
<th>Responsible Party</th>
<th>Status</th>
<th>Pollution Prevention / Reclamation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berms to direct storm water into naturally vegetated areas and berms and channels to prevent ‘clean’ storm water from moving into any ‘dirty’ water areas must be constructed as appropriate</td>
<td>To minimise the generation of dirty storm water and conversely maximise the amount of clean storm water allowed to infiltrate soil surfaces and enter natural surface water resources</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing</td>
<td>Pollution prevention / Reclamation</td>
</tr>
<tr>
<td>Make regular (every 150m), stone packed / pitched, storm water drainage furrows to re-direct surface storm water run-off from the north-south haul road into the naturally vegetated areas to the east thereof</td>
<td>To prevent erosion of the side of this road and excessive siltation and erosion of the veld and the stream in this valley.</td>
<td>Mine Management, Environmental Manager</td>
<td>Storm water drainage furrows established along haul road approximately every 150m. No visible signs of erosion on haul road or edges thereof</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP.</td>
</tr>
<tr>
<td>At the points where drainage furrows (as required above) discharge storm water from the haul road surface into naturally vegetated areas, beds of course aggregate / stone-pitching / stone cobbles (at least 6m x 6m) must be laid out in order to reduce the final velocity of storm water passing into naturally vegetated areas.</td>
<td>To prevent erosion at the point where storm water is diverted from the road surface into naturally vegetated areas</td>
<td>Mine Management, Environmental Manager</td>
<td>Aggregate beds established appropriately. No visible signs of erosion where water is diverted into naturally vegetated areas</td>
<td>Once off, together with above action item</td>
</tr>
</tbody>
</table>
Table 8-2: Mine Water Treatment Mitigation Tables

<table>
<thead>
<tr>
<th>Aspect: Reverse Osmosis Plant</th>
<th>Mitigation Actions</th>
<th>Objectives</th>
<th>Targets</th>
<th>Responsible Party</th>
<th>Time-frames</th>
<th>Level of Hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permeate from ROP must be used to satisfy surplus demand for 'domestic use' (toilets/showers) on site</td>
<td>Reduce demand on groundwater resources through the reduction in abstraction from such sources for domestic use</td>
<td>Domestic water demand to be met through use of treated underground water from ROP</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Daily</td>
<td>Treatment</td>
</tr>
<tr>
<td></td>
<td>Water quality parameters of the permeate from the ROP must be regularly tested against the relevant standards set for drinking water by the Department of Water Affairs (SANS 241)</td>
<td>Ensure the preservation of human health and avoidance of human health impacts due to poor potable water quality</td>
<td>Water used for domestic purposes on the mine to confirm to applicable SANS 241 standards</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Monthly</td>
<td>Treatment</td>
</tr>
<tr>
<td></td>
<td>Domestic use of permeate to be stopped immediately and replaced with borehole abstraction when the above standards are not met. Appropriate rectification to be implemented to improve treatment until permeate quality again meets SANS 241 drinking standards.</td>
<td>Ensure the preservation of human health and avoidance of human health impacts due to poor potable water quality</td>
<td>Water used for domestic purposes on the mine to confirm to applicable SANS 241 standards</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: As soon as it is detected that domestic water supply standards do not comply with SANS 241</td>
<td>Treatment</td>
</tr>
<tr>
<td></td>
<td>Surplus permeate (following partitioning for domestic uses on site) must be directed into the Return Water Dams.</td>
<td>Dilution of contaminant load within Pollution Control Dams over time</td>
<td>Water quality standards, as prescribed in the Mine’s Water Use License, not exceeded</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Daily</td>
<td>Pollution prevention</td>
</tr>
</tbody>
</table>

Goals

- to significantly reduce contaminant load in water emanating from underground workings;
- to reduce water demand through beneficial re-use of treated water on the Mine;
- to reduce scaling in processing plant as a result of high concentration of salts in re-circulated mine ‘dirty’ water system; and
- to mitigate potential impacts on ground and surface water quality through a significant dilution of pollutants within the Mine’s ‘closed’ loop water management system.
<table>
<thead>
<tr>
<th>Aspect: Mine Water Treatment</th>
<th>A water flow meter must be installed between the ROP and domestic sources, as well as between the ROP and Return Water Dams</th>
<th>To inform site water balance and associated management requirements</th>
<th>Flow meter appropriately installed at required locations</th>
<th>Mine Management, Environmental Manager</th>
<th>Immediately upon commissioning of the ROP</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area: Brine Management Infrastructure (ECU Plant)</td>
<td>A flow meter must be installed between the ECU Plant and applicable output flows to reservoirs and pollution control dams.</td>
<td>To inform site water balance and associated management requirements</td>
<td>Flow meter appropriately installed at required locations</td>
<td>Mine Management, Environmental Manager</td>
<td>Immediately upon commissioning of the ECU Plant</td>
<td>N/A</td>
</tr>
<tr>
<td>The ECU Plant must be placed on a gently sloping concrete apron that is appropriately bunded and fitted with an oil water separator system on the down-slope thereof.</td>
<td>To ensure that potentially contaminated surface run-offs are appropriately contained and managed</td>
<td>Concrete apron and storm water containment system appropriately installed</td>
<td>Mine Management, Environmental Manager</td>
<td>Prior to the construction and commissioning of the ECU Plant</td>
<td>Pollution prevention</td>
<td></td>
</tr>
<tr>
<td>The coal used to generate energy for the operation of the ECU Plant must be stored in appropriately designed bunkers and protected from surface and storm water flows</td>
<td>To prevent the contamination of otherwise ‘clean’ storm water flows through coal storage areas</td>
<td>Coal storage bunkers appropriately installed. No evidence of storm water through flow, or ponding, in coal storage areas</td>
<td>Mine Management, Environmental Manager</td>
<td>Immediate: Ongoing</td>
<td>Pollution prevention</td>
<td></td>
</tr>
<tr>
<td>The Ash generated from the ECU Plant must be quenched and appropriately stored in a hopper/s</td>
<td>To ensure the minimisation of wind entrained ash and possible leaching of ash contaminants</td>
<td>Ash appropriately quenched for storage. Hoppers utilised for the storage of waste ash from boilers</td>
<td>Mine Management, Environmental Manager</td>
<td>Immediate: ongoing</td>
<td>Pollution prevention</td>
<td></td>
</tr>
<tr>
<td>Ash and dried salt waste must be regularly collected by an appropriately qualified waste disposal contractor and disposed of at an appropriately licensed landfill facility.</td>
<td>Ensure responsible disposal and minimisation of impacts on water resources through dubious waste management practises</td>
<td>Copies of respective waste contractor’s license/s kept on file at the Mine. Copies of waste manifests maintained by the Mine for all waste collected and disposed of.</td>
<td>Mine Management, Environmental Manager</td>
<td>Immediate: ongoing. Collection at least once a month.</td>
<td>Pollution prevention</td>
<td></td>
</tr>
<tr>
<td>The Mine must consider implementing projects for the possible beneficial reuse of the ash where it would be reasonable and feasible to do so.</td>
<td>To minimise the use of non-renewable resources in applications where ‘waste’ could feasibly used as a substitute for such</td>
<td>Ash reuse feasibility study implemented by the mine.</td>
<td>Mine Management, Environmental Manager</td>
<td>Within 24 months of the DMRs approval of the EMPR amendment</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Dried salt generated at the ECU Plant must be appropriately stored in hopper/s, then fed to into durable/impermeable storage</td>
<td>To ensure that highly soluble wastes are not leached into surface</td>
<td>Storage bags used for the storage of salt waste</td>
<td>Mine Management, Environmental Manager</td>
<td>Storage facility built prior to commissioning</td>
<td>Pollution prevention</td>
<td></td>
</tr>
</tbody>
</table>
**Aspect:** Mine Water Treatment

<table>
<thead>
<tr>
<th>Bags</th>
<th>Bags must be stored in a shed with roof and concrete floor.</th>
<th>Dedicated, roofed and concreted storage area built for dried salt waste</th>
<th>Environmental Manager of the ECU Plant. Storage requirements: Ongoing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash and dried salt waste</td>
<td>The Mine must have the ash and dried salt waste that will be generated on site classified (General Vs. Hazardous), in terms of the appropriate system for waste classification used in South Africa.</td>
<td>Ash and dried salt wastes classified. Classification document/report kept on file at the Mine.</td>
<td>Mine Management, Environmental Manager Within 6 months of commissioning of the ECU Plant</td>
</tr>
<tr>
<td>Safety Data Sheets (SDS)</td>
<td>The Mine must develop Safety Data Sheets (SDS) for the ash and dried salt waste generated.</td>
<td>SDS developed and kept on file at the Mine</td>
<td>Mine Management, Environmental Manager Within 6 months of commissioning of the ECU Plant</td>
</tr>
<tr>
<td>Hazardous waste</td>
<td>The Mine must register as a generator of hazardous waste (with respect to boiler ash and dried salts) on the South African Waste Information System (SAWIS).</td>
<td>Waste generator reference number assigned by DEA.</td>
<td>Mine Management, Environmental Manager Within 1 month of the enactment of the South African Waste Information Regulations by the DEA and EMPR amendment approval by the DMR.</td>
</tr>
</tbody>
</table>

**Area:** Clarifier

<table>
<thead>
<tr>
<th>All piping to, and connections with, the clarifier, as well as the actual clarifier units themselves, must be inspected for leaks and spillages and maintenance applied when leaks and spillages are detected</th>
<th>To prevent soil and groundwater contamination from ‘contaminated’ clarifier water</th>
<th>No leaks or spillages observed from clarifier unit. Records of weekly inspections, as well as any required maintenance, kept on record</th>
<th>Mine Management, Environmental Manager Ongoing: Weekly</th>
<th>Pollution prevention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation of the clarifier must be optimised to ensure minimal outflow of chromite rich silt / sediments into Dam 26</td>
<td>To reduce the unnecessary siltation of Dam 26</td>
<td>TDS of clarifier outflow kept below 632mg / l</td>
<td>Mine Management, Environmental Manager Ongoing</td>
<td>Treatment</td>
</tr>
</tbody>
</table>

**Area:** Sewage Treatment Plants

| The Mine must ensure that the operators of the respective plants are technically trained to operate the specific plants | To ensure that optimal treatment of sewage takes place on the Mine | Records of training applicable to “class” of each plant kept | Mine Management, Ongoing | Pollution prevention |

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INTEGRATED WASTE AND WATER MANAGEMENT PLAN – ASSMANG DWARSRIVIER
| Aspect: Mine Water Treatment | and that effluent is treated to qualities suitable / safe for environmentally acceptable deposition into the URW and LRW Dams | Parameters with associated guideline limits for effluent discharge that must be achieved include:  
- pH: 5.5 – 9.5;  
- Feecal Coliform: 0 cfu / 100ml;  
- Chemical Oxygen Demand: 75 mg/l;  
- Conductivity: 250 ms/m;  
- Suspended solids: < 90 mg/l;  
- Residual Chloride: 0.1 mg/l; and  
- Ammonia: 1 mg/l. | Environmental Manager |
| Screenings and sludge from the sewage plants must be temporary stored as hazardous waste, in terms of the guidelines provided for in the Department of Water Affairs’ Minimum Requirements for the Classification, Management, Handling and Disposal of Hazardous Waste (1998), and legally disposed of – obtain safe disposal certificates from the appropriately licensed waste disposal contractor. | To prevent the unnecessary contamination of soil, surface and ground water resources with ‘hazardous’ waste | Safe disposal certificates kept on file. Copy of waste contractors company profile and appropriate licenses kept on file | Mine Management, Environmental Manager |
| Further to the above, sewage sludge disposal practices shall comply with the following legal documents —  
(b) Guide L – Permissible utilization and disposal of treated sewage effluent, 1978, Department of National Health and Population Development Report No 11/2/5/3. | To prevent the unnecessary contamination of soil, surface and ground water resources with ‘hazardous’ waste, as well as to promote the environmentally acceptable, beneficial reuse of sewage sludge | Compliance with all appropriate Acts, Regulations and other legal documents | Mine Management, Environmental Manager |

Environmental Manager will monitor and ensure compliance with the above requirements.
**Aspect:** Mine Water Treatment

Note, DWA is in the process of issuing revised guidelines for the utilisation and disposal of waste water sludge. (Refer to the DWA&F website: [www.dwaf.co.za](http://www.dwaf.co.za))

Note 2. The DEA is also in the process of preparing Waste Classification and Management Regulations, in terms of the National Environmental Management: Waste Act (Act 59 of 2008) that will further regulate the application of hazardous wastes to land.

**Area:** Pollution Control Dams – Dam 26, Upper Return Water Dam (URWD) and Lower Return Water Dam (LRWD)

<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
<th>Frequency</th>
<th>Responsible Party</th>
<th>Compliance Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>A free board of at least 0.8m (depth) must be maintained in all pollution control dams. This must be monitored weekly between September and March and monthly between April and August.</td>
<td>To prevent overtopping of the dams and subsequent pollution of soils, as well as ground and surface water resources, during extreme rainfall events (1:50 year flood events)</td>
<td>Ongoing: Weekly or monthly, as relevant to time of year</td>
<td>Mine Management, Environmental Manager</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>All piping and open spillways to, as well as between, pollution control dams must be well maintained and regularly inspected for leaks and spillages</td>
<td>To prevent soil and groundwater contamination from ‘contaminated’ water circuit</td>
<td>Ongoing: Monthly inspections</td>
<td>Mine Management, Environmental Manager</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>All alien invasive species must be removed from areas within, as well as adjacent to (within 25m from the dam perimeter), the pollution control dams and replaced with appropriate indigenous vegetation applicable to the relevant management unit identified in the BAP</td>
<td>To promote biodiversity and reduce impact on groundwater resources. To prevent damage from occurring, however small the probability of occurrence, to dam liners as a result of root action associated with alien invasive plant species</td>
<td>Once off initial clearance within 1 month of the Department of Water Affairs’ acceptance of the Mine’s IWWMP. Ongoing removal, ad hoc, thereafter. Rehabilitation within 3 months from initial clearance</td>
<td>Mine Management, Environmental Manager</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>All silt currently deposited in the Upper Return Water Dam must be removed in consultation with an appropriately qualified engineer, taking the utmost care not to damage the pollution control liner thereof</td>
<td>Maintenance of known/designed dam capacity to facilitate management of site salt and water balance</td>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of</td>
<td>Mine Management, Environmental Manager</td>
<td>Pollution prevention</td>
</tr>
<tr>
<td>Aspect: Mine Water Treatment</td>
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<tr>
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</tr>
<tr>
<td>The Mine must ensure the safe and legal disposal of the silt removed if appropriate chemical analysis (As prescribed in the Department of Water Affairs’ Minimum Requirements for the Classification, Management, Handling and Disposal of Hazardous Waste (1998)) shows it to be of a hazardous nature for disposal. It must be disposed of appropriately as hazardous waste.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>To ensure legal compliance with the NEWMWA, as well as the environmentally acceptable disposal of silt.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt analysed appropriately and results interpreted by a suitably qualified waste management consultant. Disposal records/manifests kept for any silt disposed of, either to general or hazardous landfill, as prescribed by specialist, are kept on file.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Once off for chemical analysis of silt and interpretation of results by appointed consultant. Ongoing for silt disposal.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollution prevention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A silt trap must be installed at the bottom end of each of the two open spillways/channels (two of these identified) that gather contaminated storm water from the processing plant, product aprons and Load Out areas and divert it into the Upper Return Water Dam (URWD).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To prevent the ongoing siltation of the URWD.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt trap installed appropriately. No evidence of silt entering the URWD via this pathway.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Once off: Within 6 months of the Department of Water Affairs’ acceptance of the Mine’s IWWMP.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The surface water monitoring programme must be amended by an appropriately qualified Water Quality Specialist to include parameters for bacteriological monitoring at all pollution control dams.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To assess the potential risks associated from current effluent disposal practises (e.g. health risks) and allow for responsive management actions where bacterial counts exceed allowable discharge standards.</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Surface monitoring plan amended accordingly to include bacteriological monitoring. Company profile for appointed specialist kept on file.</td>
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</tr>
<tr>
<td>Mine Management, Environmental Manager</td>
<td></td>
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<tr>
<td>Once off initial amendment within 1 month of the Department of Water Affairs’ acceptance of the Mine’s IWWMP. Monitored monthly thereafter.</td>
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<tr>
<td>N/A</td>
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<tr>
<td>Identify all impoundments/pollution control dams containing poisonous, toxic or injurious substances and –</td>
<td></td>
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</tr>
<tr>
<td>Protection of pollution control measures from vandalism and unmandated maintenance.</td>
<td></td>
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</tr>
<tr>
<td>Pollution Control Dams fenced off and kept under lock and key. Appropriate signage clearly displayed warning of potential hazards and dangers associated with the fenced off area (e.g. Drowning hazard, ‘do not drink’ and ‘no fishing’).</td>
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<tr>
<td>Mine Management, Environmental Manager</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Once off initial action within 1 month of the Department of Water Affairs’ acceptance of the Mine’s IWWMP. Monitored monthly thereafter.</td>
<td></td>
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</tr>
<tr>
<td>Pollution prevention</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### General Mine Water Mitigation Tables

<table>
<thead>
<tr>
<th>Area: Underground Workings</th>
<th>Objectives</th>
<th>Targets</th>
<th>Responsible Party</th>
<th>Time-frames</th>
<th>Level of Hierarchy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All plant, vehicles and machinery operating underground at the mine must be kept in good working order. All such plant, vehicles and equipment must be regularly inspected for evidence of hydrocarbon leaks and spillages and immediately rectified / serviced at the surface work bays or workshop upon identification of any such leaks</td>
<td>To prevent possible hydrocarbon contamination of water within underground mine workings.</td>
<td>No evidence of hydrocarbon leaks and spillages in underground workings</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Weekly</td>
</tr>
<tr>
<td></td>
<td>Any major geological fractures identified, or exposed, during underground mining operations, through which groundwater can flow preferentially, must be grouted sealed</td>
<td>To minimise the ingress of groundwater into underground workings, where it could mix with contaminated underground water sources</td>
<td>Less than 400 m² / day of groundwater entering the underground mine workings (northern and southern declines and strikes) through geological fractures</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing</td>
</tr>
<tr>
<td></td>
<td>Ensure that the contractor responsible for the management of sewage facilities underground provides the mine with proof that the sewage transportation and disposal activities comply with the applicable environmental legal requirements for such [including, inter alia, NEM:WA, DWAF Min. Requirements series (1998) and SANS10228]</td>
<td>To ensure legal compliance and by virtue thereof, avoidance of potential impacts on underground water in mine workings</td>
<td>Required proof provided by contractor and kept on file</td>
<td>Mine Management, Environmental Manager</td>
<td>Once off: within 1 month of the Department of Water Affairs’ acceptance of the Mine’s IWWMP</td>
</tr>
<tr>
<td></td>
<td>Ensure that the contractor responsible for underground sewage management regularly removes such waste to prevent any health risk to employees working underground</td>
<td>Avoidance of potential impacts on underground water in mine workings and reduction in volumes of dirty water generated on the mine</td>
<td>Waste manifests for removal and disposal kept on file and prove responsible disposal, in line with applicable waste management legislation and guidelines</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Weekly</td>
</tr>
<tr>
<td>General Mine Water Management</td>
<td>Water borne services and infrastructure</td>
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<td>--------------------------------</td>
<td>----------------------------------------</td>
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</tr>
<tr>
<td><strong>Aspect:</strong> General Mine Water Management</td>
<td><strong>Water borne services and infrastructure</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>A review all water reticulation / recycling facilities (which includes all sumps, pumps and pumping installations, catchment facilities, which shall include cut-off trenches, storm water drainage ditches, sumps and Return Water Dams) by an appropriately qualified Engineer must be undertaken to ensure that their design and capacity is adequate to prevent spillages, seepages and over-flows (during standard operation, as well as 1:50 year flood events). The Mine must also ensure that any deviations from current practise identified by the appointed Engineer are appropriately effected.</strong></td>
<td><strong>To ensure that appropriate separation of clean and dirty storm water occurs on site, such that the mine manage the dirty storm water in the mine/process water system effectively without environmental incidences.</strong></td>
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</tr>
<tr>
<td><strong>All three (3) remaining water flow meters, as required by the Mine’s Integrated Water Use License, have been installed, and the design and capacity of referenced structures and infrastructure assessed by an appropriately qualified civil engineer in relation to the final calculation of the site water balance.</strong></td>
<td><strong>Records kept of weekly and monthly maintenance inspections /schedules. No evidence of leaks, spillages and over-flows from the said structures, infrastructure and catchment facilities.</strong></td>
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</tr>
<tr>
<td><strong>Regular maintenance on all above structures, infrastructure and containment facilities (as well as silt traps) must be undertaken.</strong></td>
<td><strong>Co-ordination of response to, as well as management of, emergency incident with relevant Provincial Authorities. To maintain legal compliance with NWA, NEMWA and associated Regulations.</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Contact details for the Regional Director readily available at the Mine (SHEQ office). Reporting and management requirements for emergency incidents (e.g. bulk fuel tank failure, over-flow of pollution control dam into Dwars River), are thoroughly described in the Mine’s EMS.</strong></td>
<td><strong>Within 24 hours of incident</strong></td>
<td></td>
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</tbody>
</table>

**Aspect:** **Spillages of Hazardous Materials**

| Any incidence that causes, or may cause, water pollution shall immediately be reported in writing and verbally to the Regional Director of the Department of Water Affairs, Director General of the DEA, South African Police Services and relevant fire prevention service, Relevant Provincial Municipality, LEDET HoD, as well as all persons whose health may be affected by the incident, within 24 hours. | Co-ordination of response to, as well as management of, emergency incident with relevant Provincial Authorities. To maintain legal compliance with NWA, NEMWA and associated Regulations. |
| **Contact details for the Regional Director readily available at the Mine (SHEQ office). Reporting and management requirements for emergency incidents (e.g. bulk fuel tank failure, over-flow of pollution control dam into Dwars River), are thoroughly described in the Mine’s EMS.** | **Within 24 hours of incident** | **N/A** |

Pollution prevention / Reclamation and Reuse
<table>
<thead>
<tr>
<th>General Mine Water Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>DrizT spill management kits must be kept and maintained on site wherever fuels and oils are stored and where refuelling and/or servicing of plant, vehicles and machinery takes place, in order to manage potential hydrocarbon spillages effectively.</td>
</tr>
<tr>
<td>To pro-actively prevent spilled hydrocarbons from entering into ground and surface water pathways, where they may potentially cause significant contamination of such resources.</td>
</tr>
<tr>
<td>DrizT spill kits placed at all appropriate locations and maintained as necessary. Records of spill kit utilisation/maintenance/‘replenishment’ kept on file.</td>
</tr>
<tr>
<td>Mine Management, Environmental Manager</td>
</tr>
<tr>
<td>Ongoing</td>
</tr>
<tr>
<td>Pollution prevention</td>
</tr>
</tbody>
</table>

| Training, in the use and maintenance of the abovementioned kits, as well as any contaminated waste products, must be provided to ALL staff either directly, or indirectly, involved in any of the activities identified above. |
| To pro-actively prevent spilled hydrocarbons from entering into ground and surface water pathways, where they may potentially cause significant contamination of such resources. |
| List of all affected parties kept on site and aligned with records of appropriate training. |
| Mine Management, Environmental Manager |
| Once off initial training: within 1 month of the Department of Water Affairs’ acceptance of the Mine’s IWWMP with annual refresher training thereafter. |
| Pollution prevention |

<table>
<thead>
<tr>
<th>Aspect: Water Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Mine has installed water flow meters at the majority of the major flow pathways within, as well as losses and entries to, the mine’s water reticulation system. The single remaining flow meter between the plant and URWD must be installed in order to ensure that flow metering is comprehensive and robust enough to inform future management actions and completion of a site water balance.</td>
</tr>
<tr>
<td>To quantify water source demand, critical flow pathways and losses from the mine’s water reticulation system for improved management thereof and final (accurate) calculation of the mine’s water balance.</td>
</tr>
<tr>
<td>ALL flow meters installed accordingly.</td>
</tr>
<tr>
<td>Mine Management, Environmental Manager</td>
</tr>
<tr>
<td>Once off: Within 1 month of the Department of Water Affairs’ acceptance of the Mine’s IWWMP.</td>
</tr>
<tr>
<td>N/A</td>
</tr>
</tbody>
</table>

| Dwarsrivier Mine must calculate a comprehensive, quantified, water and salt balance, indicating all areas of use, make-up from run-off, seepage etc, loss through evaporation, dust suppression, discharge etc. [inclusive of monthly volumetric flows (Kl/month)]. This water balance must cover both plant and mining activities. |
| To allow for the mine to fully understand their water demands and to quantify water flow within the mine water reticulation (Figure 4-8), with a view to improving practical reuse and recapture of ‘dirty’ water streams to alleviate pressure on current supply sources. To allow for applicable ‘loss’ accounting to determine potential leaks and spillages from water reticulation system. |
| Site Water balance calculated and submitted to DWA and DMR for consideration, as an addendum to the Mine’s EMPR & IWWMP. Monthly records on all water consumption, flow and losses on site kept on record according to the water and salt balance workbook created by African Environmental Development. |
| Mine Management, Environmental Manager |
| Once off calculation of water balance within 1 month of the Department of Water Affairs’ acceptance of the Mine’s IWWMP. Ongoing, monthly capturing of consumption and flow figures from all installed flow meters. |
| Water Reuse / Recapture |

<table>
<thead>
<tr>
<th>Aspect: General matters</th>
</tr>
</thead>
<tbody>
<tr>
<td>The static groundwater levels in all boreholes within a distance of 2km from the underground workings must be measured monthly.</td>
</tr>
<tr>
<td>To inform management actions relating to the mine’s potential impact on groundwater levels.</td>
</tr>
<tr>
<td>Records of appropriate static borehole level monitoring kept on file.</td>
</tr>
<tr>
<td>Mine Management, Environmental Manager</td>
</tr>
<tr>
<td>Monthly: Ongoing</td>
</tr>
<tr>
<td>N/A</td>
</tr>
</tbody>
</table>
### General Mine Water Management

<table>
<thead>
<tr>
<th>Description</th>
<th>Promotion of self-regulation to ensure appropriate mine water management and legal compliance by Dwarsrivier Mine</th>
<th>Annual internal IWWMP Compliance Audits undertaken as required and results documented and kept on file</th>
<th>Mine Management, Environmental Manager</th>
<th>Ongoing: Annual</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dwarsrivier Mine must undertake annual internal audits of compliance to the conditions of their IWWMP. The results of such internal audits must be kept on file at the mine and provided to DEA, DWA, DMR and LEDET upon request</td>
<td>To ensure legal compliance with conditions of all other applicable licenses /permits</td>
<td>Annual EMPR, IWUL and IWWMP compliance audits undertaken by appropriately qualified Auditor. Audit reports kept on file, together with CV and company profile of the relevant auditors. Proof of delivery of Audit Reports to DMR and DWA kept on file</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Annual</td>
<td>N/A</td>
</tr>
<tr>
<td>In addition to complying with the conditions (specific and general) set out in this EMPR and the Mine’s IWWMP, Dwarsrivier Mine remains legally bound to the implementation of the conditional requirements (once off and ongoing) prescribed in the Mine’s Integrated Water Use License (IWUL) issued by the DWA and as such, annual external auditing of compliance to the conditions of the IWUL and IWWMP is required. Results of such audits must be submitted to the DWA annually</td>
<td></td>
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</tr>
<tr>
<td>It is the responsibility of the Mine to ensure that the Mine’s EMPR and IWWMP are amended / updated on a regular basis where, inter alia:</td>
<td>To ensure that the EMPR and IWWMP are treated as a dynamic / working document s that remain legislatively compliant and applicable to the stage at which mining is undertaken on site</td>
<td>EMPR and IWWMP updated a required.</td>
<td>Mine Management, Environmental Manager</td>
<td>Ongoing: Every two years</td>
<td>N/A</td>
</tr>
<tr>
<td>- Legislation applicable to environmental and mine water and / or waste management has changed, and</td>
<td></td>
<td></td>
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<tr>
<td>- Where mitigation actions proposed in the latest approved EMPR and IWWMP have proven ineffective, or are no longer required.</td>
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</tbody>
</table>
9. MONITORING

During an appropriate environmental impact assessment, potential impacts on water resources were identified. Mitigation measures were also then specified for prevention and management of these impacts. These mitigation measures need to be monitored in two ways – to determine if they are being done and to determine if they are being effective, in other words, actually reducing the environmental impact.

This monitoring programme is described below. Records of the monitoring programme will be kept for future reference.

9.1 SURFACE WATER

Surface water mitigation must be monitored as follows:
- silt traps must be inspected monthly during the wet season (September – April) and a record made of how full of silt they are;
- record each time the a silt trap is emptied/dredged of sediment; and
- an updated plan of the layout of the storm water channels and silt traps must be kept.

The mine dirty water system must be monitored as follows:
- water levels in the pollution control dams (Dam 26, URWD, LRWD) taken weekly;
- flow rates/volumes in all dirty water circuits must be measured;
- records of any overflows from the pollution control dams; and
- water quality monitored at S1-S4.

Surface water quality of natural water bodies will be monitored for the constituents as outlined in Error! Reference source not found.. This table must be updated when the WUL is amended.

9.2 GROUNDWATER

To determine if any drops in the water table occur or there is any groundwater quality deterioration. Static water levels will be monitored on a quarterly basis in boreholes DRM1–7, 9, 10, DRO1, 3, 4, MCC, BH-AM 21.

Groundwater quality samples will be taken quarterly and analysed as outlined in Error! Reference source not found.. This table must be updated whenever the WUL is amended.

This will ensure that any decline in the quality or yield of groundwater in the area is detected in time, whilst also providing a necessary database for future studies or disputes.

9.3 INTERESTED AND AFFECTED PARTIES

Dwarsrivier Chrome Mine will have regular meetings with the interested and affected parties and these meetings will be held on a six monthly basis. The mine also uses an open door approach with its surrounding inhabitants and landowners. This allows the mine to deal timeously with any perceived complaint from its neighbours, thus ensuring that the situation is resolved quickly.
<table>
<thead>
<tr>
<th>Medium</th>
<th>Position</th>
<th>Parameter</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural surface water</td>
<td>S1</td>
<td>pH, TDS, EC, alkalinity, Ca, Na, Mg, K, Cl, SO4, NO3, NH4, PO4, turbidity (or suspended solids), Conductivity at 25 degrees celsius in mS/m, F, Nitrates as N, Mn, Orthophosphate as P, oil, grease and soaps.</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S5</td>
<td>Total Cr, Cr (vi), Fe, Mn, Pb, Cu, Cd, V, Cb, Zn</td>
<td>6-monthly</td>
</tr>
<tr>
<td></td>
<td>S1</td>
<td>I HAS</td>
<td>Once each in wet season &amp; dry season (6-monthly)</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>SASS</td>
<td></td>
</tr>
<tr>
<td>Groundwater</td>
<td>DRM1–7, 9, 10, DRO1, 3, 4, MCC, BH-AM 21</td>
<td>Water levels</td>
<td>Monthly</td>
</tr>
<tr>
<td>DRM1–6</td>
<td></td>
<td>pH, TDS, EC, alkalinity, Ca, Na, Mg, K, Cl, SO4, NO3, NH4, PO4, turbidity (or suspended solids), Conductivity at 25 degrees celsius in mS/m, F, Nitrates as N, Mn, Orthophosphate as P, oil, grease and soaps.</td>
<td>Quarterly</td>
</tr>
<tr>
<td>DRO1</td>
<td></td>
<td>Cr, Fe, Mn</td>
<td>6-monthly</td>
</tr>
<tr>
<td>Wastewater &amp; storm water</td>
<td>S6</td>
<td>pH, TDS, EC, alkalinity, Ca, Na, Mg, K, Cl, SO4, NO3, NH4, PO4</td>
<td>Monthly</td>
</tr>
<tr>
<td>S7</td>
<td></td>
<td></td>
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<tr>
<td>S8</td>
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<td></td>
<td></td>
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<tr>
<td>S9</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Taillings</td>
<td></td>
<td>Cr, Fe, Mn</td>
<td>6-monthly</td>
</tr>
<tr>
<td>Effluent</td>
<td>Sewage plants</td>
<td>pH, EC, NO3, NH4, PO4, COD, faecal coliforms, suspended solids</td>
<td>monthly</td>
</tr>
</tbody>
</table>

Table 9-1: Water monitoring plan (adapted from 2008 WUL and 2008 EMPR).

9.4 RECORDING AND SUBMISSION OF MONITORING RESULTS

9.4.1 COMPLAINTS REGISTER

Copies of the complaints register will be submitted on a yearly basis to the Department of Mineral Resources and Department of Water Affairs. If there are no complaints registered, a note/letter to this affect will be forwarded to the said Department.
9.4.2 MINUTES OF MEETINGS

Minutes of all Interested and Affected Parties’ meetings will be submitted to the Department of Mineral Resources on a yearly basis, if requested. All issues raised will be attended to as soon as possible, and feedback will be given to the aggrieved party and DMR, and the outcome will be reported in the next meeting.

9.4.3 MINING PLAN

An updated mining plan will be submitted to the Department of Mineral Resources on an annual basis, indicating extent of the workings, reserves mined and the total extent of the mining area and rehabilitated areas.

9.4.4 WATER QUALITY MONITORING REPORTS

The current water monitoring program requires water quality analysis. The surface and groundwater-monitoring programme is assessed on a yearly basis. Based on these assessments, new monitoring sites may be included in the monitoring programme. Chemical analyses to be conducted include, inter alia: TDS, pH, EC, Alkalinity, SO₄, Ca, Mg, K, Cl, Na, Fe, Mn.

A bi-annual report will be generated detailing water quality trends experienced during the operational phase, and highlighting areas of concern. This report will be submitted to the Department of Water Affairs, Department of Mineral Resources, National Department of Agriculture and the Limpopo Department of Economic Development, Environment and Tourism.
10. CONCLUSION

This IWWMP, if implemented appropriately and within the time-frames required, will achieve, inter alia, the following key water and waste management improvements on the Dwarsrivier Chrome Mine:

- Water utilisation on the site appropriate to the quality of that water for the specific use and allowed for by the Mine’s implementation of a ‘closed loop water system through the recirculation of ‘dirty’ water through plant processes;
- Storm water management measures are provided for that minimise the amount of ‘dirty / contaminated’ storm water generated on site;
- Storm water management measures are provided to promote the diversion of ‘clean’ storm water to natural surface water resources, as well as the infiltration of storm water into soils surfaces;
- The ‘Beneficial Reuse’ of waste material (discard rock from the plant) is promoted as an aggregate for road building and similar other such applications (waste rock proven to have negligible impact on ground and surface water resources in such uses);
- The Mine discharges ‘zero’ effluent into any natural surface water resources;
- Treatment is appropriately applied to contaminated water, where pollution prevention is not possible, in order to ensure compliance with the threshold values for priority pollutants in the mine water circuit and surrounding ground water resources, as set out in the Mine’s Water Use License and the Department of Water Affairs’ Best Practise Guideline on “Water Reuse and Reclamation” (2006); and
- Treated water is to be re-used on the Mine, as promoted in the Department of Water Affairs’ Best Practise Guideline on “Water Reuse and Reclamation” (2006);

The above improvements will align the undertakings and objectives of the Dwarsrivier Chrome Mine more closely to the National Water Resource Strategy, as well as conditions of approval under the site’s Integrated Water Use License.
11. UNDERTAKING

I, __________________________________________________________________________

the undersigned, and duly authorised thereto by Assmang Chrome Dwarsrivier Mine, have studied and understand the contents of this IWWMP in its entirety and hereby duly undertake to adhere to the conditions as set out therein in tables 8-1 to 8-3.

Signed at ________________________________________________

this _____ day of ____________________, 2010

Applicant’s name:

Designation:

Signature:
12. REFERENCES


13. **APPENDIX 1: CURRENT APPROVALS**
14. APPENDIX 2: PUBLIC PARTICIPATION
15. APPENDIX 3: SURFACE INFRASTRUCTURE PLAN
16. APPENDIX 4: STORM WATER MANAGEMENT REPORT
17. APPENDIX 5: FLOOD LINE ASSESSMENT REPORT
18. APPENDIX 6: GEO-HYDROLOGICAL REPORT
19. **APPENDIX 7: WASTE ROCK / TAILINGS CHARACTERISTICS REPORTS**
20. APPENDIX 8: WASTE DISPOSAL ACCEPTANCE LETTER FROM LOCAL MUNICIPALITY
21. APPENDIX 9: BACKGROUND INFORMATION DOCUMENT FOR PROPOSED TAILINGS STORAGE FACILITY (TSF)
22. APPENDIX 10: EARTH SCIENCE SOLUTIONS’ FEBRUARY 2010 GROUND AND SURFACE WATER MONITORING REPORT