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Khwara Mine

Basic Water Balance

SLR Project No.: 720.14007.00013

Report No.: 1

August 2017

Khwara Manganese (Pty) Ltd

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KHWARA MINE
BASIC WATER BALANCE

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KHWARA MINE

1 INTRODUCTION

A steady state, site wide water balance model has been developed to understand the flows at the Khwara mine project operational water circuit during average dry seasons and average wet seasons for different phases of the project.

The project is owned by Khwara Manganese (Pty) Ltd and is situated in the Northern Cape Province on the farms Wessels 227 and Dibiaghomo 226. There is an existing mining right and an approved environmental management programme (EMP) at the adjacent farm (Portion 1 of Lehating 741), the Lehating project. The Khwara project will access mineral resources via the existing Lehating mine infrastructure which will remain unchanged. No surface infrastructure will be located on the farms Wessels and Dibiaghomo.

2 WATER BALANCE

The water balance presented in TWP's 2013 annual average water balance for the Lehating portion remains largely unchanged for the process flow components; however more recent and accurate input values are now available for the following flows:

- Groundwater inflow rates informed by modelling performed by SLR Consulting for different operations phases. In this model the highest groundwater inflows estimate is taken to represent the peak of mining operations for Khwara Mine; and
- An estimation of storm water runoff volumes into the Pollution Control Dam with consideration of the wet and dry conditions.

The modelled water balance circuit includes water inflows, losses and transfers for the following aspects of the operation:

- Underground Workings;
- Storm water from Shaft and Stockpile areas;
- Portable water usage by staff members and sewage treatment plant;
- Process Plant; and
- Slimes Dam.

2.1 METHODOLOGY

The water balance reviews all relevant design work by the wider project team, estimates the typical flows, and volumetric requirements of make-up water or discharge of surplus water. A Microsoft Excel spreadsheet model was used to represent the flows within the operational water circuit using information taken from the following studies:

- Lehating Mine Surface Water Management Plan, (SLR, June 2013).
- Groundwater Model outputs (SLR, June 2017)
- Lehating Process Water Balance (TWP's Annual Average Water Balance, 2013).

Water sources (inflows) were taken as:

- Groundwater ingress into the underground workings;
- Storm water collected from the dirty catchment and conveyed to the Pollution Control Dam (PCD);
- Direct rainfall into the PCD; and
- Makeup and potable water from external sources.

Water sinks (losses) were taken as:

- Evaporation from the PCD, the slimes dam and the return water dam;
- Seepage and interstitial lockup from the slimes dam;
- Dust suppression including road dust control;
- Potable water consumption from the Reverse Osmosis treatment plant; and
- Sewage treatment plant losses.

2.2 ASSUMPTIONS AND INPUT PARAMETERS

The water balance assumes the following:

- The majority of flows are taken from TWP's 2013 annual average water balance and remain valid and representative of the proposed mining operation;
- Rainfall related inflows and evaporation related losses for the wet and dry season scenarios were estimated based on: i) average values during the three driest months of the year; and ii) average values during the three wettest months of the year;
- Runoff and evaporation coefficients for each surface were fixed and not influenced by antecedent climatic conditions, likewise all catchment areas are constant;
- Evaporation from the PCD will only occur if there is water in the dam and evaporation is prioritised before abstraction;
- Evaporation losses from the return water dam have been included as 10% of total inflows, whilst the PCD evaporation is estimated based on the calculated footprint area as they are not specified in existing TWP water balance;
- TWP estimated an annual average return from the slimes dam of 50% of tailings inflow. This annual average has been seasonally adjusted to 35% return during the dry season, and 65% during the wet season when the slimes dam will also collect rainfall;

- The make-up water requirements of the processing plant can be supplied in part or whole by recycled water from the sewage treatment plant;
- Water usage for mining services is derived from recycled underground seepage and is excluded from the model;
- Where practicable, priority is given to the reuse of dirty water before abstraction of makeup water from an external source in accordance with best practices and GN704 regulation 7; and
- This water balance model is run for only steady state average wet season and average dry season conditions and no consideration is given to storage of water at any aspect of the infrastructure modelled i.e. flow in = flow out

The Rainfall input parameters were derived from 3 stations presented in Table 2-1.

TABLE 2-1: MONTHLY RAINFALL AT NEARBY STATIONS

Station name	**Winton**	**Milner**	**Kuruman**	
Station No.	392148 W	393083 W	D4E004	
Latitude	27°29' S	27°22' S	27°28' S	
Longitude	22°37' E	23°02' E	23°26' E	
Altitude (m)	1180	1118	1320	
Years of Record	72	67	54	
	Monthly Rainfall (mm)			**Average Rainfall (mm)**
January	62.1	66.1	85.6	71.3
February	61.2	61.4	82.9	68.5
March	58	66.4	86.5	70.3
April	31.8	35.5	45.1	37.5
May	13.9	16.1	21.5	17.2
June	4.2	6	7.4	5.9
July	2.5	1.9	2.8	2.4
August	4.9	4.2	9.8	6.3
September	6.2	6.2	7.8	6.7
October	16.2	19	26.3	20.5
November	25.7	32	45	34.2
December	43.3	46.8	44.9	45.0
Annual Total	**330.1**	**361.6**	**465.7**	**385.8**

Input parameters used for the water balance update are presented in Table 2-2

TABLE 2-2: WATER BALANCE INPUT PARAMETERS

Component	**Parameter / Assumption**	**Source**
Climate Data	• Average wet month rainfall = 62mm • Average wet month evaporation = 166mm • Average dry month rainfall = 5mm • Average dry month evaporation = 67mm	• SLR, 2013

Component	Parameter / Assumption	Source
Underground Groundwater Ingress	• Year 10: 199 m^3/d=9.55 m^3/hr • Recirculation o Mining services =1.55 m^3/hr	• SLR, June 2017 • TWP, 2013
Water Demands	• Potable water= 2.29 m^3/hr • Assumes 90% of water at the sewage treatment plant is recovered for recycling • Dust suppression =1.25 m^3/hr • Road dust control = 2.50 m^3/hr • Flocculant make up water = 0.13 m^3/hr • Process Plant inflow assumed the same as Tailings + Flushing Water= 8.38 m^3/hr	• TWP, 2013
Pollution Control Dam	• PCD: o Catchment area = 0.264 km^2 o Capacity = 50 000m^3 o Assumed Depth = 2.5m o Calculated Footprint = 20 000m^2 o Runoff Coefficient = wet season: 5%, dry season = 0%	• SLR, 2013 • SLR, 2013 • Assumed
Processing Plant system	• Recirculation o Thickener overflow=75.38 m^3/hr o Spray water=69.47 m^3/hr o Spillage washing=10.12 m^3/hr • Plant Outflows o Tailings + Flushing Water= 8.38 m^3/hr o Road dust control = 2.50 m^3/hr	• TWP, 2013
Slimes Dam and RWD	• Inflows o Tailings + Flushing Water= 8.38 m^3/hr o Direct rainfall (15% of tailings inflows) = 1.26 m^3/hr wet season and 1% = 0.08 m^3/hr dry season • Losses o Return water dam =10% of inflows o Slimes Dam wet season= 50% of tailings inflows o Slimes Dam dry season = 65 % of tailings inflows o All direct rainfall • Outflows Slimes Dam o Wet season = 65% o Dry Season = 35%	• TWP, 2013 • Assumed
Time components	• TWP worked on 20.8 operational hours per day • Assumed a month is average 30.4 days	• TWP , 2013 • Assumed

2.3 RESULTS

The water balance for the wet and dry seasons for the peak of mining operation are presented in Figure 2-1 through to Figure 2-2.

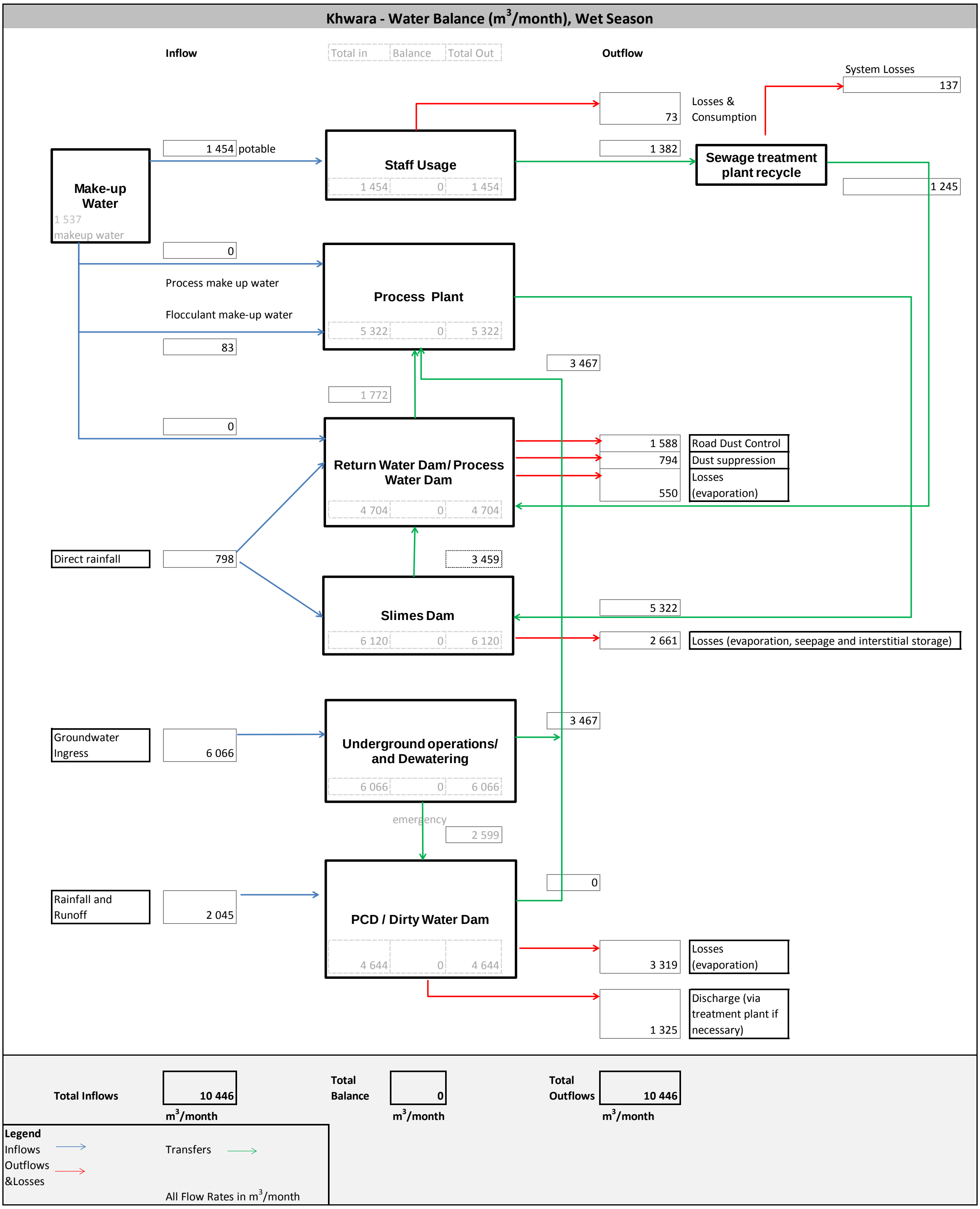

FIGURE 2-1: WATER BALANCE - PEAK OF MINING OPERATION, WET SEASON

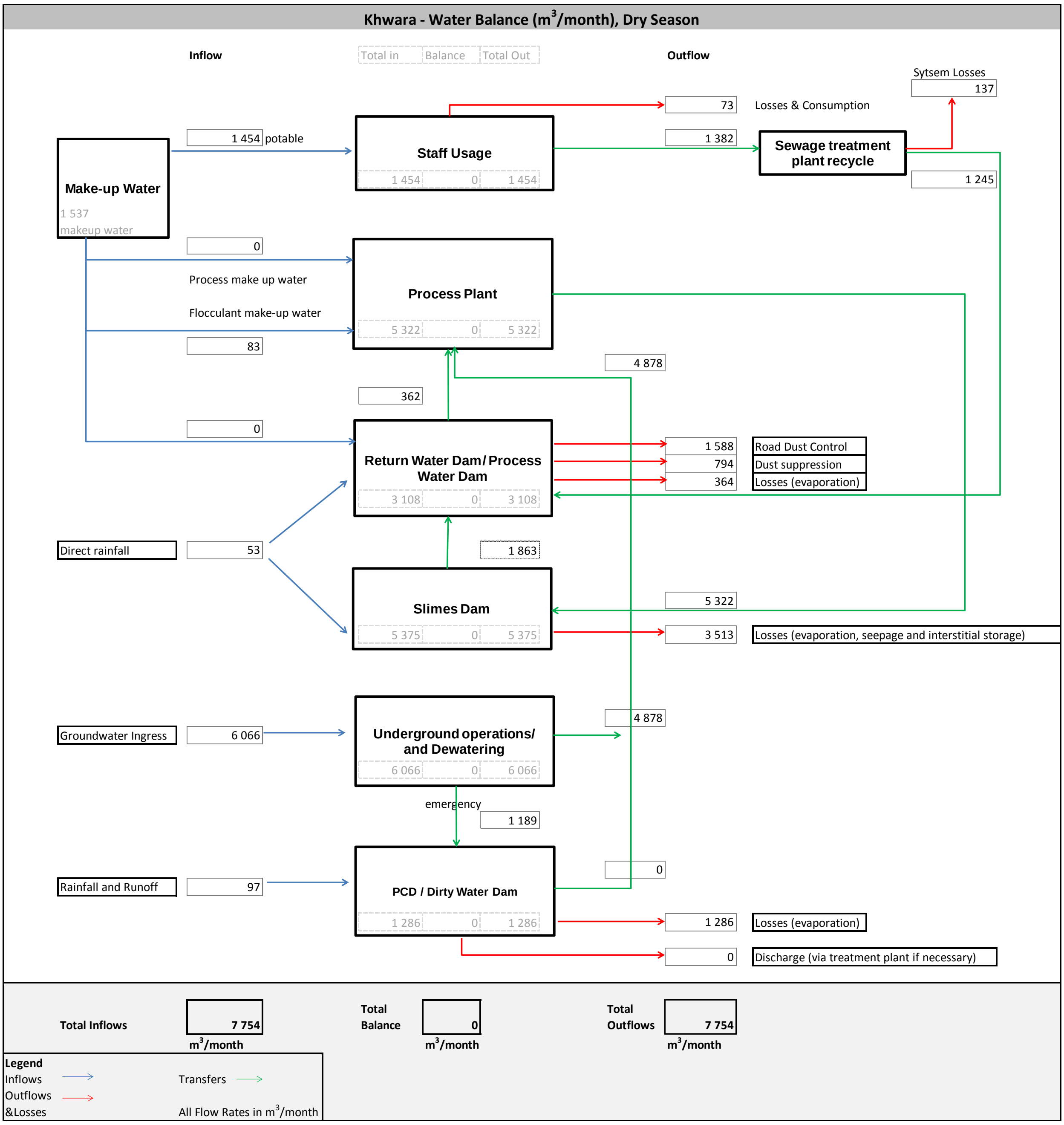

FIGURE 2-2: WATER BALANCE - PEAK OF MINING OPERATION, DRY SEASON

The water balance results show little variation in the wet and dry season because the surface infrastructure which will be seasonally influenced has a relatively small footprint and the rainfall is typically low in the area.

Groundwater inflow to the underground workings is the most significant aspect of the water circuit, and will need to be dewatered to allow for safe mining. According to the water balance, the mine will be water positive and there may be a requirement to discharge up to 1 325 m^3/month during the wet season. Any discharge from the site will be subject to water quality analysis and water may require treatment prior to discharge. Approximately 1 537 m^3/month of make-up water will be required for potable water and flocculant make up water. To avoid discharge, consideration should be given to creating a larger storage capacity on site for drier periods. However, the ingress volumes will be monitored during operations and the water balance refined to determine more accurately if excess water will need to be dealt with.

2.4 LIMITATIONS AND FURTHER WORK

This study makes use of various assumed and estimated parameters, and should be updated whenever better information becomes available. The majority of flows are taken from TWP's 2013 water balance and have not been reviewed or confirmed as part of this study.

Water meters should be installed to measure the major flow components identified above, and monitoring data should be recorded monthly. Based on the water circuit mapped out above, a spreadsheet based operational water balance should be developed and updated on an annual basis during the operational phase of the project to improve the accuracy of the mine's makeup water and discharge requirements.

Groundwater inflow to the underground mine workings form critical parts of the mine's water circuit and is the main source of water. Groundwater inflows are based on the available modelled data and it is recommended that groundwater ingress volume measurements are collected and used to calibrate the water balance model. The results of the calibrated groundwater model coupled with water quality monitoring data can be used to assess the requirement for a discharge and possible water treatment plant.

As discussed in Section 2.2, this water balance is run on a steady state basis and no consideration is given to storage of water at any of the water components modelled. When monitoring data is available, consideration could be given to undertaking a dynamic simulation water balance to improve understanding of the mine's water balance and how it varies in response to climatic variations, improve certainty on the makeup water requirements, excess water generation and identify water conservation and water demand management measures.

Chenai Makamure	**Paul Klimczak**	**Paul Klimczak**
(Report Author)	**(Project Manager)**	**(Project Reviewer)**

APPENDIX A: NEMA APPENDIX 6 SPECIALIST REPORTING REQUIREMENTS

NEMA Regs (2014) - Appendix 6	Relevant section in report
Details of the specialist who prepared the report	Appendix C
The expertise of that person to compile a specialist report including a curriculum vitae	Appendix C
A declaration that the person is independent in a form as may be specified by the competent authority	Appendix B
An indication of the scope of, and the purpose for which, the report was prepared	Section 1
The date and season of the site investigation and the relevance of the season to the outcome of the assessment	Not applicable
A description of the methodology adopted in preparing the report or carrying out the specialised process	Section 2.1
The specific identified sensitivity of the site related to the activity and its associated structures and infrastructure	Not applicable
An identification of any areas to be avoided, including buffers	Not applicable
A map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Not applicable
A description of any assumptions made and any uncertainties or gaps in knowledge;	Section 2.2
A description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives, on the environment	Section 2.3
Any mitigation measures for inclusion in the EMPr	Not applicable
Any conditions for inclusion in the environmental authorisation	Not applicable
Any monitoring requirements for inclusion in the EMPr or environmental authorisation	Section 2.4
A reasoned opinion as to whether the proposed activity or portions thereof should be authorised and	Not applicable
If the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan	Not applicable
A description of any consultation process that was undertaken during the course of carrying out the study	Not applicable
A summary and copies if any comments that were received during any consultation process	Not applicable
Any other information requested by the competent authority.	Not applicable

APPENDIX B: DECLARATION OF INDEPENDENCE

The specialist appointed in terms of the Regulations

I, **Paul Klimczak** , declare that -- General declaration:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

____

Signature of the specialist

Name of company (if applicable): SLR CONSULTING LTD

Date: 6 SEPTEMBER 2017

APPENDIX C: CURRICULUM VITAE

Position: Senior Hydrologist

Name: Paul Klimczak

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Curriculum Vitae

Qualifications and Education

2000	Batchelor of Science (BSc) with Honours (Hons): Geology
2002	Master of Science (MSc): Hydrology for Environmental Management
2002	Diploma Imperial College (DIC)

Employment Record

2011 - Present	SLR Consulting Ltd, Johannesburg, South Africa
2008 - 2011	SLR Consulting Ltd, Bristol, United Kingdom
2005 - 2007	RPS Bowman Bishaw Gorham, Perth, Western Australia
2002 - 2005	RPS Group Ltd, Chepstow, United Kingdom

Professional Affiliations and Registrations

C.WEM – Chartered Water and Environmental Manager and Member of the Chartered Institution of Water and Environmental Management (CIWEM)

Cenv – Chartered Environmentalist

PrSciNat – Professional Natural Scientist in the field of Water Resource Science

Summary of Experience and Capability

Paul is a Senior Hydrologist based in Johannesburg, and has thirteen years of consultancy experience on variety of mining, energy, infrastructure, waste and urban development projects across the UK, Australia and Africa.

With a broad understanding of environmental issues in Africa, Australia and the UK, Paul works closely with clients, regulators and other technical specialists (e.g. hydrogeologists, engineers, ecologists, town planners and architects) to seek cost effective and sustainable strategies for minimising a projects impacts on the water environment.

Paul is professionally registered / chartered through CIWEM, SocEnv, and SACNASP. He is an approved technical reviewer under SLR's ISO9001 Quality Management Systems and responsible for undertaking and reviewing specialist various studies climate characterisation, flood hydrology, water balances and stormwater management plans.

Paul's input is provided across various stages of a project from initial constraints appraisal and risk identification at scoping stages, to layout / design optimisation during pre-feasibility studies, through environmental impact assessment and management plans, to working with engineers during detailed feasibility studies and construction phases, ultimately to compliance monitoring in operational stages.

African Project Experience

Date	Location	Client	Deliverable	Services Provided
2015	Panda Hill Project, SW Tanzania	Cradle Resources Ltd	Site Water Management for Pre-Feasibility Study and Feasibility Study	• Climate Characterisation • Flood-Line Mapping • River Diversion • Stormwater Management Plan • Water Balance • Flood-Lines Mapping
2015	Jeanette Project, Free State, RSA	Taung Gold	Surface Water Study for EIA	• Climate Characterisation • Baseline Hydrology • Flood-Line Mapping • Stormwater Management Plan • Water Balance
2015	Lake Albert Infrastructure Project, Uganda	EleQtra	Water Resources Specialist Study for EIS	• Baseline Hydrology • Hydrocensus • Water Quality Monitoring • Impact Assessment
2014	Kudumane Project, Northern Cape, RSA	Kudumane Manganese Resources	Surface Water Study for EIA	• Climate Characterisation • Baseline Hydrology • Flood-Line Mapping • River Diversion • Stormwater Management Plan • Water Balance
2014	Letlhakane Project, Botswana	A-Cap Resources	Surface Water Study for EIA	• Climate Characterisation • Baseline Hydrology • Flood-Line Mapping • River Diversion • Stormwater Management Plan • Water Balance
2013	Hinda Phosphate Project, Congo-Brazzaville	Cominco Resources	Site Water Management for Pre-feasibility Study	• Climate Characterisation • Baseline Hydrology • Flow Monitoring • Water Quality Monitoring • Flood-Line Mapping • River Diversion • Stormwater Management Plan • Water Balance
2013	Magazynskraal, North-West Province, RSA	Pilanesburg Platinum Mines	Surface Water Study for EIA	• Climate Characterisation • Baseline Hydrology • Flood-Line Mapping • Stormwater Management Plan • Water Balance
2013	Leeuwkop Project, North-West Province, RSA	Impala Platinum	Surface Water Study for EIA	• Climate Characterisation • Stormwater Management Plan • Water Balance • North-West Province, RSA
2012	Sedibelo West, North-West Province, RSA	Pilanesburg Platinum Mines	Surface Water Study for EIA	• Baseline Hydrology • Stormwater Management Plan • Water Balance

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