

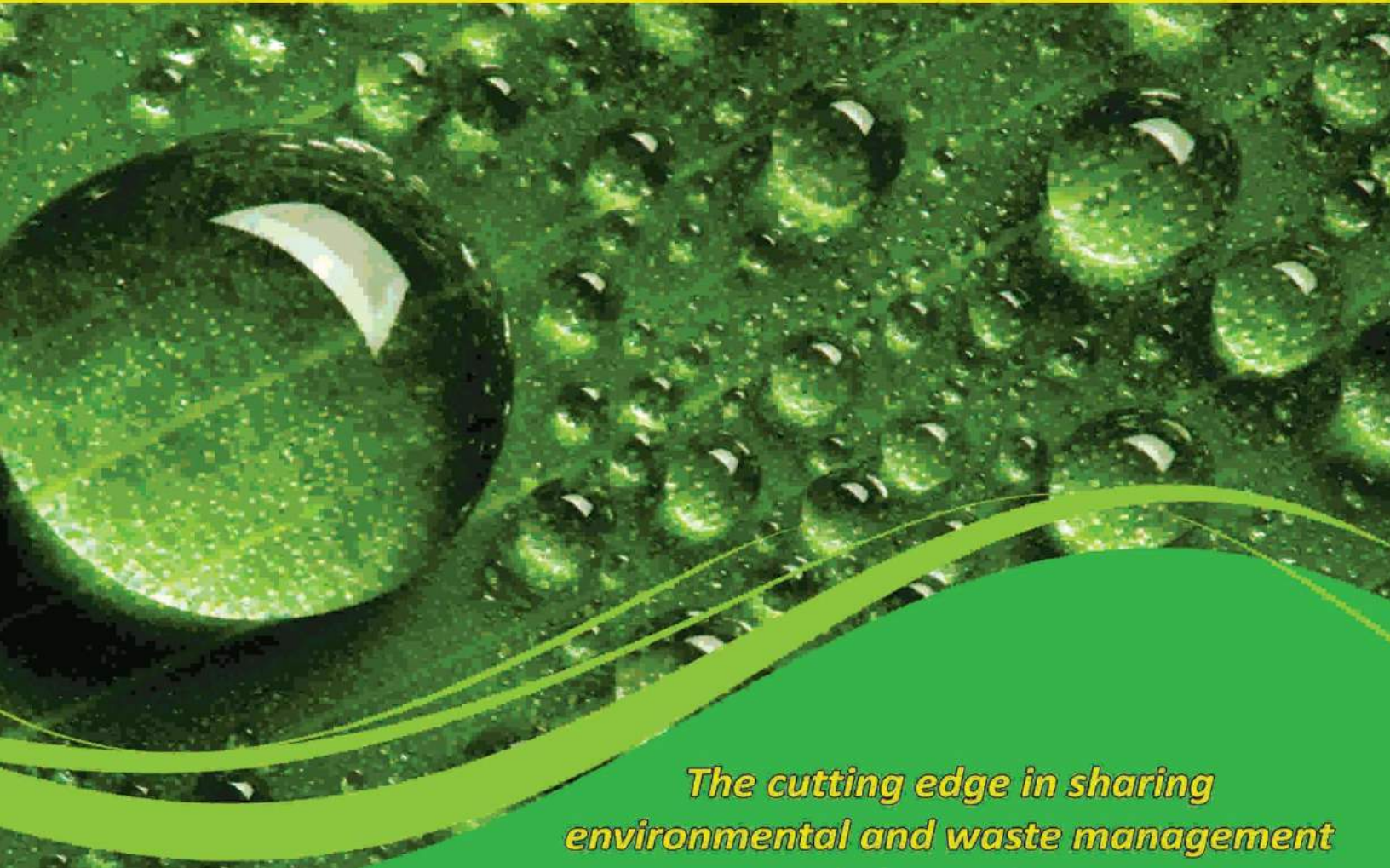


**TSHIKOVHA  
ENVIRONMENTAL &  
COMMUNICATION  
CONSULTING**

**COMPARATIVE ENVIRONMENTAL IMPACT ASSESSMENT FOR THE TAILING STORAGE FACILITY  
OPTIONS 1 AND 2 FOR THE PROPOSED PLATREEF UNDERGROUND MINE ON THE FARMS  
TURFSPRUIT 241 KR, MACALACASKOP 243 KR AND RIETFONTEIN 2 KS WITHIN MOGALAKWENA  
LOCAL MUNICIPALITY OF WATERBERG DISTRICT MUNICIPALITY**

**CLIENT: IVANPLATS (PTY) LTD**

**DATE: MAY 2015**



*The cutting edge in sharing  
environmental and waste management*

## **1 EXECUTIVE SUMMARY**

Digby Wells, the appointed Environmental Assessment Practitioner for Platreef, submitted a final EIA report for the Platreef project to the Competent Authority (Limpopo Department of Economic Development, Environment and Tourism - LEDET) for approval. On the 27th of June 2014, the department issued an Environmental Authorisation (Record of Decision) to Ivanplats (Pty) Ltd for the proposed project. On the 7th August 2014, Digby Wells compiled an application for the amendment of an Environmental Authorisation on behalf of Ivanplats (Pty) Ltd.

LEDET granted an amendment to the Environmental Authorisation with the exception of Ivanplats (Pty) Ltd.'s request for the department to amend the option for the Tailings Storage Facility from Option 1 to Option 2. A meeting was held on the 17th October 2014 to discuss reasons for Platreef's preference on option 2 instead of option 1. This was followed by a site visit after which the department reconsidered the request by Ivanplats (Pty) Ltd to amend the approved Tailings Storage Facility from Option 1 to Option 2. In order for LEDET to consider the request for amendment of the approved TSF option, they requested Ivanplats (Pty) Ltd to conduct a Comparative Environmental Impact Assessment (to consider potential impacts on either Option 1 and option 2) in terms of Section 24(a) of the National Environmental Management Act (Act 107 of 1998). A public Participation Process in terms of Regulation 54 of the Environmental Impact Assessment Regulation R 543 of 2010 has also been requested.

Ivanplats (Pty) Ltd has since then appointed Tshikovha Environmental and Communication Consulting (TECC) to conduct a Comparative EIA for TSF Option 1 and Option 2. At least two site visits have been conducted to date by TECC, which culminated in the compilation of the Comparative EIA Report.9/0

For the compilation of the comparative assessment report the following were considered:

- Site Suitability Studies – this focused on what on what a typical “dream site” would be for the location of a TSF. Thereafter this analysis was overlaid with the prevailing environmental parameters at TSF Option 1 and TSF Option 2, where an elaborate Risk Assessment would then make it easy to decide which option would be more appropriate.
- During the Risk Assessment Phase of the Comparative EIA the environmental parameters, as the baseline, were assigned suitable weighting accounts, upon which an alternative analysis matrix was constructed to determine the suitability of either TSF option 1 or 2. The parameters that were explored throughout the compilation of this report include; Technical Issues, Economic Issues, Aspects of the Physical Environment, Aspects of the Biological Environment, and Social and Cultural Aspects.




- Mitigations and Recommendations - In the end the report summarised all the aspects discussed above and provided resolutions as to which of either Option 1 or 2 should be considered for the construction of the Platinum TSF.

When used as reference this report should be cited as: Tshikovha Environmental and Communication Consulting (TECC). March 2015. Comparative Environmental Impact Assessment Report for the Tailing Storage Facility (TSF) Options 1 and 2 for the proposed Platreef underground mine on the farms Turfspruit 241 KR, Macalacaskop 243 KR and Rietfontein 2 KS within Mogalakwena Local Municipality of Waterberg District Municipality.

**COPYRIGHT RESERVED**

This Comparative Environmental Impact Assessment Report was produced for Ivanplats (Pty) Ltd. The intellectual property contained in this report remains vested in Tshikovha Environmental and Communication Consulting (TECC). No part of the report may be produced in any manner without written permission from Tshikovha Environmental and Communication Consulting (TECC) or Ivanplats (Pty) Ltd

**Quality Control**

	<b>Compiled By</b>	<b>Reviewed By</b>	<b>Approved By</b>
<b>Name</b>	Mpho Ramalivhana	Gift Mutonhere	Moudy Mudzielwana
<b>Designation</b>	Assistant Unit Manager	Operational Manager	Director
<b>Signature</b>			
<b>Date</b>	May 2015	May 2015	May 2015

## TABLE OF CONTENTS

<b>1</b>	<b>EXECUTIVE SUMMARY</b> .....	<b>2</b>
<b>2</b>	<b>INTRODUCTION</b>	
	<b>CHAPTER ONE</b> .....	<b>12</b>
1.1	Overview.....	12
1.2	Details of the Applicant and Environmental Assessment Practitioner .....	12
1.3	Expertise and experience of the EAP .....	13
	<b>PROJECT DESCRIPTION</b>	
	<b>CHAPTER TWO</b> .....	<b>16</b>
2.1.	Project Location .....	16
2.1.1.	Tailing Storage Facility Site 1 .....	16
2.1.2.	Tailing Storage Facility Site 2 .....	16
2.2.	Project description .....	16
2.3.	Project Scope.....	17
	<b>RELEVANT LEGISLATION</b>	
	<b>CHAPTER THREE</b> .....	<b>19</b>
3.1.	Constitution of the Republic of South Africa, 1996 Act No. 108 of 1996 .....	19
3.2.	Mineral and Petroleum Resources Development Act, Act No.28 of 2002 (as amended).....	19
3.3.	National Environmental Management Act, 1998 (Act No. 107 of 1998).....	20
3.4.	National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008).....	22
3.5.	National Water Act, 1998 (Act No. 36 of 1998) .....	23
3.5.1.	Government Notice GN R. 704 .....	23
3.6.	International Finance Corporation’s Performance Standards and the Equator Principles .....	24
3.7.	Other relevant legislations.....	25
3.7.1.	Water .....	25
3.7.2.	Heritage Resources .....	25
3.7.3.	Fauna and Flora .....	25
3.7.4.	Hazardous Materials.....	25
3.7.5.	Development.....	25

<b>SITE SUITABILITY ASSESSMENT</b>	<b>CHAPTER FOUR</b> .....	<b>27</b>
4.1.	<b>Methodology and Parameters to be considered</b> .....	<b>27</b>
4.2.	<b>Technical Issues</b> .....	<b>28</b>
4.2.1.	Dimensions of the Residue Facility.....	28
4.2.2.	Design and Dimensions of the Residue Pipeline.....	29
4.2.3.	Dimensions and Characteristics of the Residue Deposits.....	29
4.2.4.	Return Water management.....	30
4.2.5.	Monitoring and Maintenance.....	30
4.2.6.	Construction Considerations.....	31
4.2.7.	Technical Risk.....	31
4.3.	<b>Economic Issues</b> .....	<b>31</b>
4.3.1.	Capital Costs.....	31
4.3.2.	Annual Operating Costs.....	31
4.4.	<b>Aspects of the Physical Environment</b> .....	<b>32</b>
4.4.1.	Topography.....	32
4.4.2.	Geology.....	32
4.4.3.	Hydrology (Surface Water).....	33
4.4.4.	Geohydrology (Ground Water).....	34
4.5.	<b>Aspects of the Biological Environment</b> .....	<b>35</b>
4.5.1.	Fauna.....	36
4.5.2.	Flora.....	36
4.6.	<b>Social and Cultural Aspects</b> .....	<b>36</b>
4.6.1.	Community Considerations.....	36
4.6.2.	Heritage Considerations.....	37
<b>ALTERNATIVE ASSESSMENT</b>	<b>CHAPTER FIVE</b> .....	<b>39</b>
5.1.	<b>Project location</b> .....	<b>39</b>

5.1.1.	Tailing Storage Facility Site 1 .....	39
5.1.2.	Tailing Storage Facility Site 2 .....	39
<b>5.2.</b>	<b>Climatic conditions .....</b>	<b>41</b>
<b>5.3.</b>	<b>Geology and soil.....</b>	<b>42</b>
5.3.1.	TSF Site 1.....	42
5.3.2.	TSF Site 2.....	42
<b>5.4.</b>	<b>Fauna and flora.....</b>	<b>43</b>
5.4.1.	TSF site 1 .....	43
5.4.2.	TSF Site 2.....	43
<b>5.5.</b>	<b>Topography and visual aspects.....</b>	<b>44</b>
5.5.1	TSF 1 .....	44
5.5.2	TSF 2 .....	45
<b>5.6.</b>	<b>Surface water .....</b>	<b>45</b>
5.6.1	TSF 1 .....	45
5.6.2	TSF 2 .....	46
<b>5.7.</b>	<b>Groundwater .....</b>	<b>46</b>
5.7.1.	TSF Site 1.....	46
5.7.2.	TSF Site 2.....	46
<b>5.8.</b>	<b>Archaeology and heritage.....</b>	<b>47</b>
5.8.1.	TSF Site 1.....	47
5.8.2.	TSF site 2 .....	47
<b>5.9.</b>	<b>Social.....</b>	<b>47</b>
<b>ALTERNATIVES IMPACT ASSESSMENT METHODOLOGY    CHAPTER SIX .....</b>		<b>49</b>
<b>6.1.</b>	<b>Technical Criteria .....</b>	<b>49</b>
6.1.1.	Dimensions of the total TSF proposed area.....	49
6.1.2.	Slurry Delivery Line.....	49

6.1.3.	Overflow and Seepage Potential .....	49
6.1.4.	Water Management .....	50
6.1.5.	Monitoring and Maintenance.....	50
6.1.6.	Construction Considerations.....	51
6.1.7.	Technical Risk .....	51
<b>6.2.</b>	<b>Economic Issues .....</b>	<b>51</b>
6.2.1.	Capital Costs .....	51
6.2.2.	Annual Operating Costs.....	52
<b>6.3.</b>	<b>Aspects of the Physical Environment .....</b>	<b>52</b>
6.3.1.	Topography.....	52
6.3.2.	Geology and Risk of Potential Sinkhole Formation.....	53
6.3.3.	Hydrology.....	53
6.3.4.	Geohydrology and Risk of Ground water Contamination.....	53
<b>6.4.</b>	<b>Aspects of the Biological Environment.....</b>	<b>54</b>
6.4.1.	Fauna.....	54
6.4.2.	Flora.....	54
<b>6.5.</b>	<b>Social and Cultural Aspects .....</b>	<b>55</b>
6.5.1.	Community Considerations .....	55
6.5.2.	Heritage Considerations .....	55
<b>RISK ASEESSMENT</b>	<b>CHAPTER SEVEN .....</b>	<b>56</b>
<b>PUBLIC PARTICIPATION</b>	<b>CHAPTER EIGHTY .....</b>	<b>64</b>
<b>CONCLUSION AND RECOMMENDATIONS</b>	<b>CHAPTER NINE.....</b>	<b>68</b>
<b>REFERENCES</b>	<b>CHAPTER TEN .....</b>	<b>69</b>

**List of Tables**

Table 1: Details of the applicant.....13

Table 2: Project Environmental Assessment Practitioner .....13

Table 3: NEMA listed activities relevant to the construction of TSF .....21

Table 4: NEMWA listed activities triggered by the project.....22

Table 5: Site Suitability Assessment Parameters.....27

Table 6: Grading and rating systems of heritage resources.....38

**List of Figures**

Figure 1: Picture of a typical Tailing Storage Facility with H: H Lining .....18

Figure 2: Proposed location of the Tailing Storage Facilities, Digby Wells Environmental 2013 .....40

## List of abbreviations

BIC	BUSHVELD IGNEOUS COMPLEX
BID	BACKGROUND INFORMATION DOCUMENT
DEA	DEPARTMENT OF ENVIRONMENTAL AFFAIRS
EAP	ENVIRONMENTAL ASSESSMENT PRACTITIONER
EIA	ENVIRONMENTAL IMPACT ASSESSMENT
EMP	ENVIRONMENTAL MANAGEMENT PLAN
I&AP's	INTERESTED AND AFFECTED PARTIES
IFC	INTERNATIONAL FINANCING CORPORATION
IWMP	INTERGRATED WASTE MANAGEMENT PLAN
IWUL	INTERGRATED WATER USE LICENCE
LEDET	LIMPOPO DEPARTMENT OF ECONOMIC DEVELOPMENT, ENVIRONMENT AND TOURISM
MPRDA	MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT
NEMA	NATIONAL ENVIRONMENTAL MANAGEMENT ACT
NEMWA	NATIONAL ENVIRONMENTAL MANAGEMENT WASTE ACT
NGO	NON-GOVERNMENTAL ORGANISATION
NHRA	NATIONAL HERITAGE RESOURCE ACT
NWA	NATIONAL WATER ACT
OHS	OCCUPATIONAL HEALTH AND SAFETY
RSA	REPUBLIC OF SOUTH AFRICA
SAHRA	SOUTH AFRICAN HERITAGE RESOURCE ACT
TECC	TSHIKOVHA ENVIRONMENTAL AND COMMUNICATION CONSULTING

TOR	TERMS OF REFERENCE
TSF	TAILING STORAGE FACILITY
WBG	WORLD BANK GROUP
WMA	WATER MANAGEMENT AREA
WML	WASTE MANAGEMENT LICENCE

### 1.1 Overview

Digby Wells Environmental (hereafter Digby Wells) was appointed by Ivanplats (Pty) Ltd (hereafter Ivanplats), as the independent Environmental Assessment Practitioner (EAP) to conduct an Environmental and Social Impact Assessment (ESIA) and associated specialist studies for the proposed Platreef Underground Mining Project in line with the requirements of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA) for associated listed activities as stipulated in the NEMA Regulations (June 2010). As part of this Project, Ivanplats also intends to apply for an Integrated Water Use Licence (IWUL) in terms of the National Water Act, 1998 (Act No. 36 of 1998) (NWA) and a Waste Management Licence (WML) in terms of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) (NEM:WA); and in conformance with the framework provided in the World Bank Group (WBG), the International Finance Corporation (IFC) policies and the Equator Principles used for conformance with the IFC policies and guideline. Golder Associates Africa (Pty) Ltd (GAA) was appointed by Ivanplats to develop an Integrated Waste Management Plan (IWMP) and to undertake a Waste Management Licence Application process in terms of NEM: WA for the Project. The Waste License was approved by the Department of Environmental Affairs (DEA) on 16 March 2015, reference 12/9/11/L1224/5.

Limpopo Department of Economic Development, Environment and Tourism (LEDET) authorised the project in 2014 with the preferred location of the Tailing Storage Facility (TSF) from Ivanplats not authorised. The applicant appealed the authorisation of TSF and was then requested by LEDET to conduct a Comparative Environmental Assessment between TSF option 1 and TSF option 2.

To this end, Ivanplats (Pty) Ltd has then appointed Tshikovha Environmental and Communication Consulting to conduct a Comparative Assessment for TSF Option 1 and Option 2 which entail assessment of potential risk emanating from any potential spillages from the two TSF options and measures that will be implemented to minimize environmental negative impacts.

### 1.2 Details of the Applicant and Environmental Assessment Practitioner

Tshikovha Environmental and Communication Consulting (TECC) has been appointed by Ivanplats (Pty) Ltd to undertake the Comparative Assessment for TSF Option 1 and Option 2 in accordance with the requirements of the National Environmental Management Act (107 of 1998) as amended.

Table 1: Details of the applicant

Applicant	Ivanplats (Pty) Ltd
Contact Person	Gerick Mouton
Physical address	Old Industrial Area Mokopane 0601
Telephone number	+27 11 088 4300
Cell Number	+27
Email address	<a href="mailto:gerickm@ivanplats.com">gerickm@ivanplats.com</a>

Table 2: Project Environmental Assessment Practitioner

Environmental Impact Practitioner	Tshikovha Environmental & Communication Consulting
Contact Person	Moudy Mudzielwana
Physical address	747 Park Street, Arcadia Pretoria
Postal address	747 Park Street, Arcadia Pretoria
Telephone number	012 3439 820

### 1.3 Expertise and experience of the EAP

- **Moudy Mudzielwana, Director, Tshikovha Environmental and Communication Consulting**

Moudy Mudzielwana has Bachelor of Environmental Science Degree obtained from the University of Venda. He is a full member of IAISA and IWMSA. He was involved in the following projects: Development of General Waste Facilities Standards, Gauteng Department of Agriculture, Conservation and Environment, Capacity building on waste management for 91 local municipalities, Development of an integrated Waste Management Plan for Amajuba District Municipality, Basic Assessment for 46 sites in Motheo District Municipality, Environmental Basic Assessment for Transnet Yard Lighting, Environmental Scoping Impact Assessment for Tokologo Bulk Water Supply, Environmental Scoping Impact Assessment for Construction of a Gas pipeline for Sasol. He has worked for EnviroServ Waste Management as Site supervisor where he was responsible with the following projects: Margolis closed landfill site, Midrand closed landfill site, Nuttfield Closed site, Rosslyn H: h landfill site, Chloorkop general landfill site. He has

worked for BKS as an Environmental Scientist where he was involved in the following projects: Social audits to identify possible impacts as a result of relocation during construction of dams in KZN, EIA for the proposed construction of a Sulphonation Plant in Wadeville, Facilitation of Public meetings for the Cemetery development projects in Greater Tubatse and Develop Integrated Waste Management Plan. He also worked for Synergistic Environmental Services as an Environmental Scientist where he was responsible with the following projects: Public Participation coordination and logistic preparation for public meetings, Sishen South Mine and Public Participation coordination and logistic preparation for public meetings, Leeuwpan Coal Mine. He also works for Zitholele Consulting as an Environmental Consultant where he was responsible for the following projects: EIA Exemptions for Rufus Seakamela Molalagori, Mogalakwena Local Municipality, Menties, Segakgapeng roads upgrading in Mogalakwena Local Municipality, EIA Exemption Rooibok/ Rietfontein and Mushi water supply, Magalakwena Local Municipality, EIA Scoping for Mabula/ Irmansdale Water Supply, Mogalakwena Local Municipality, Audit Thulamela Landfill site, Thulamela Municipality, EIA Scoping for the relocation of Babsfontein Substation by Eskom, EIA for the proposed toll roads in N17 by SANRAL. He also works for Environ-fill Waste Management as Trainee Supervisor where he was responsible for the following project sites: Simmer and Jack, Weltevreden General Landfill Sites, Ekurhuleni Metropolitan, Lilbron Parys, Deelkraal, Ngwatl Local Municipality, Luipardsvle, Mogale City, Ngodwana (hazardous landfill site) SAPPI, Pappas Quarry (hazardous landfill site), MMC. He also worked for EMS Group of Company as an Environmental Associate where he was responsible with the following projects: EIA Scoping, Public Participation, EMP for Tsosoloso, Vlakfontein, Mololeki, Duduza, Putfontein Township developments, EIA Scoping, public participation for the Upgrading of Kraaipan Road , BVI Consulting Engineers, EIA Scoping and Exemption, Public Participation, EMP for Klipgat and Winterveldt water pipelines, Madisha and Associates, Remediation of polluted sites in Hluhluwe, Polokwane, Aquatic Club (Vaal River Vereeniging) Total.

- **Gift Mutonhere, Operational Manager at Tshikovha Environmental and Communication Consulting**

Gift Mutonhere, the Operational Manager, holds a BSc (Hons) Degree in Geography and Environmental Sciences obtained with the Midlands State University. With a background in Safety, Health and Environmental Coordination, he possesses experience in: Determination of Company Strategic Direction and Continuous Improvement Plans; Leading, Developing and Maintaining SHEQ Management Programmes and Systems; Retaining of SHEQ Accreditations and the Attainment of New Ones; Risk Assessment Facilitation; Disaster Preparedness and Emergency Response Planning; Safety, Health and Environmental Hazard/Risk - Aspect/Impact Assessment and Management; SHE Training; Internal SHE Auditing; Investigation and Recording of SHE Incidents and Accidents; and Legal Compliance Monitoring. He also has experience in Training, Implementation and Auditing of ISO Management Systems, with special notation to ISO 14001 (Environmental Management Systems), ISO 9001 (Quality Systems), and OHSAS 18001 (Occupational Health and Safety Assurance System) having been involved in several

ISO Integrated Management Systems Certification Processes. Gift Mutonhere has been among others, involved in the following projects: EIA for Proposed Filling Station and Associated Structures in Mashishing, Lydenburg, Mpumalanga; EIA for proposed Mixed Development (Residential, Business and Filling Station) in Willowmore, Eastern Cape; EMP for the proposed construction of a New Military Health Centre within the Polokwane CBD, EIA for proposed filling station and associated structures at Chavani, Limpopo.

- **Mpho Ramalivhana, Assistant Unit Manager at Tshikovha Environmental and Communication Consulting**

Mpho is the **ENVIRONMENTAL PROJECT MANAGER** with over 6 years' experience in the professional consulting with an Honours Degree in Bachelor of Science from the University of Limpopo. His recent experience has focused upon conducting terrestrial biodiversity and wetland delineation for a number of projects in Limpopo and Gauteng Provinces. He also has experience in formal authorisation for mining projects, energy projects including alternative energy (solar and wind) and power transmission projects as well as projects for social infrastructure including inter alia road, housing and waste management in South Africa, Malawi, Rwanda, Botswana, Mozambique and Namibia. Mpho is a member of the South Africa Council for Natural Scientific Professions (400395/14), South African Association of Botanists (SAAB) as well as the international Association of Impact Assessment – South Africa (IAIASa).

Some of his projects include: Assessed the social and environmental impacts associated with the Ncondezi Thermal Power Plant, preparation of the land management plan; and the biodiversity and natural resource management plan; Construction of Health Care Risk Waste, Namibia, City of Windhoek Municipality responsible for the compilation of scoping report, environmental impact assessment report and the compilation of Environmental Management Plan; Construction of the Transport Head office and ancillary infrastructure, Namibia, City of Windhoek Municipality.; Environmental Consultant responsible for the compilation of scoping report, environmental impact assessment report and the compilation of Environmental Management Plan; Countrywide electrical transmission lines and substations – lot 3, Rwanda, Energy, Water and Sanitation Authority in Rwanda. Environmental Consultant responsible for the preparation of project brief and the environmental impact assessment report. IBM South Africa property screening and environmental site assessment in Krugersdorp and Sandton

## **2.1. Project Location**

The Project area is located on the Northern Limb of the Bushveld Igneous Complex (BIC), approximately 280 km northeast of Johannesburg and 8 km northwest of the town of Mokopane in the Limpopo Province of South Africa. The Project will be located on the farms Macalacaskop 243 KR and Turfspruit 241 KR with the construction of a TSF on the farm Rietfontein 2 KS (as the preferred location). The farms fall within the Mogalakwena Local Municipal boundaries in the Waterberg District Municipality of Limpopo Province. The Project is located approximately 5 km south of Anglo Platinum's Mogalakwena Platinum Mine.

The Project area is accessible by two-lane tarred national highway, the N 11 road. The N11 runs through three farms of the Project area. From the N 11 the project area can be accessed by gravel roads or unpaved roads

### **2.1.1. Tailing Storage Facility Site 1**

Site 1 of the TSF is located on the Farm Turfspruit on the South-western section of the proposed mining area. The site is situated along the R518 road to Lephalale with the Mosadi village on the North to North-eastern side of the site whereas the Masehlaneng village is on the South to South-eastern side. Masodi village is within 150 metres of the proposed site. The site is situated at the following coordinates: S24° 07'28.94" and E028° 56'42.69"

### **2.1.2. Tailing Storage Facility Site 2**

Site 2 of the TSF is located on the Farm Rietfontein 240 KR on the North-eastern side for the proposed mining area. The site can be accessed through the N 11 road with Tshamahansi village on the Western side of the proposed TSF site. New housing developments at Tshamahansi village are being built towards the TSF area. The site is situated at the following coordinates: S24° 03'42.14" and E029° 00'01.04"

## **2.2. Project description**

Platreef is currently investigating the construction and operation of an underground platinum mine and associated surface infrastructure on the farms Turfspruit 241 KR and Macalacaskop 243 KR, Rietfontein 2 KS and potentially Bultongfontein 239 KR. Ivanplats plans to mine Platinum and other Platinum Group Metals (PGMs) such as

Palladium (Pd); Rhodium (Rh); Iridium (Ir); Ruthenium (Ru); and Osmium (Os) with the Life of Mine (LoM) expected to be 30 years with the potential to extend this period by another 30 years.

Table 3: Types of minerals to mined

<b>Type of mineral</b>	<p>The target minerals are:</p> <ul style="list-style-type: none"> <li>• PGM's Platinum (Pt), Palladium (Pd), Rhodium (Rh), Iridium (Ir), Ruthenium (Ru), and Osmium (Os).</li> </ul> <p>All other associated metals and minerals, including but not limited to:</p> <ul style="list-style-type: none"> <li>• Gold (Au), Silver (Ag), Nickel (Ni), Copper (Cu) Cobalt (Co) and Chrome (Cr).</li> </ul>
<b>Extent of the area required for mining</b>	Total area is 7 841.264 hectares
<b>Extent of the area required for infrastructure</b>	Approximately 2 247 hectares
<b>Depth of the mineral below surface</b>	The reef outcrops and dips to depth of approximately 1100 meters below surface

### 2.3. Project Scope

This project shall restrict itself to covering concerns regarding the location of a TSF at either option 1 or option 2. Various technical, physical and social parameters shall be explored in the process, but the end result shall be to determine which of the two sites is more suitable, after a risk assessment has been carried out, to locate the TSF.



Figure 1: Picture of a typical Tailing Storage Facility with H: H Lining

The following sections briefly introduce the principle South African legislation in terms of which the proposed Project must be compliant. This report is subjected to the requirements of NEMA, NEMWA, NWA and MPRDA.

### **3.1. Constitution of the Republic of South Africa, 1996 Act No. 108 of 1996**

Section 24 of the Constitutional Act states that everyone has the right to an environment that is not harmful to their health or well-being and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures, that –

- i. Prevents pollution and ecological degradation;
- ii. Promotes conservation; and
- iii. Secures ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

In support of the above rights, the environmental management objectives of proposed Project are to protect ecologically sensitive areas and support sustainable development and the use of natural resources, whilst promoting justifiable socio-economic development in the project areas.

### **3.2. Mineral and Petroleum Resources Development Act, Act No.28 of 2002 (as amended)**

Ivanplats must be in possession of an approved Mining Right for the mining of the PGMs and associated minerals on the respective farms, before mining operations may commence. In terms of the MPRDA various supporting documentation is required for the proposed project as part of the application for a Mining Right. In accordance with Section 23(5) of the MPRDA, the Mining Right will only come into effect on approval of the EMP.

The report contemplated in Regulation 49 is founded on the principle of consultation with interested and affected parties, which consultation process and its result is an integral part of the fairness process. The decision to grant a mining right cannot be fair if the administrator did not have full regard to precisely what happened during the consultation process in order to determine whether the consultation was sufficient to render the grant of the application procedurally fair.

Section 73 of Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA): Mineral and Petroleum Resources Development Regulations provides guidelines for Management of Residue Stockpiles and Deposits, including the fact that:

*“The assessment of impacts relating to the management of residue stockpiles and deposits, where appropriate, must form part of the environmental impact assessment report and environmental management programme...”*  
and that

*“The process of investigation and selection of a site for residue stockpiling and residue deposits must entail:*

- i. The identification of a sufficient number of possible candidate sites to ensure adequate consideration of alternative sites;*
- ii. Qualitative evaluation and ranking of all alternative sites;*
- iii. Qualitative investigation of the top ranking sites to review the ranking done in terms of (ii) above;*
- iv. A feasibility study to be carried out on the highest ranking site(s) involving:*
  - (aa) a preliminary safety classification;*
  - (bb) an environmental classification;*
  - (cc) geotechnical investigation; and*
  - (dd) groundwater investigations.”*

This is the legislation that shall form the basis of the site selection study.

### **3.3. National Environmental Management Act, 1998 (Act No. 107 of 1998)**

This project is subjected to the NEMA EIA Regulations published on the 18 June 2010 in GN R.543 and came into effect on 2 August 2010 (the NEMA EIA Regulations). This is because the whole mining EIA process began prior to the implementation of the 2014 EIA regulations. In the 2010 NEMA EIA Regulations, the Minister also published the following Regulations in terms of Sections 24 and 24D of the NEMA:

- Regulation GN R. 544 - Listing Notice 1: This listing notice provides a list of various activities which require environmental authorisation and which must follow the basic assessment process as described in Sections 21 to 25 of the NEMA Regulations;
- Regulation GN R. 545 – Listing Notice 2: This listing notice provides a list of various activities which require environmental authorisation and which must follow an environmental impact assessment process as described in Sections 26 to 35 of the NEMA Regulations; and
- Regulation GN R. 546 – Listing Notice 3: This notice provides a list of various environmental activities which have been identified by provincial governmental bodies which if undertaken within the stipulated provincial

boundaries will require environmental authorisation. The basic assessment process as described in Sections 21 to 25 of the NEMA Regulations will need to be followed

Table 4: NEMA listed activities relevant to the construction of TSF

<b>Government Notice Regulation (GN R.)</b>	<b>Listed Activity Number</b>	<b>The Proposed Activity</b>
GN R. 544, 18 June 2010	<b>12</b>	For the construction of Tailings Storage Facility (TSF).
GN R. 545, 18 June 2010	<b>15</b>	The Project area currently consists of formal and informal housing, as well as subsistence farming and grazing. Thus, undeveloped land will be altered for mining infrastructure construction and operation.
GN R. 546, June 2010 (Limpopo)	<b>19</b>	This activity will be triggered due to the combined area of disturbance in the construction of stormwater management facilities, pollution control dams and tailings storage facilities.
	<b>13</b>	To accommodate the construction of surface infrastructure, internal roads and waste storage facilities, clearance of indigenous vegetation will be required.

### 3.4. National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)

NEM:WA regulates waste management in order to protect health and the environment, and provides measures for the prevention of pollution and ecological degradation. As part of this Waste Act, all waste management facilities must be licenced, and this licencing procedure must be integrated with an environmental impact assessment process. On 3 July 2009, GN R.718 was published with stipulations regarding the waste management activities that require licensing. These activities are divided into Category A (activities requiring a Basic Assessment) and Category B (activities requiring a full EIA). The basic and full EIA processes to be followed are described in the EIA Regulations GN R.543.

The NEM:WA regulations include mining waste. However, residue deposits and residue stockpiles, which are regulated under the MPRDA, are excluded from NEM:WA. Also excluded are radio-active waste, which is regulated by the Hazardous Substances Act, 1973 (Act No. 15 of 1973), the National Nuclear Regulator Act, 1999 (Act No. 47 of 1999) and the Nuclear Energy Act, 1999 (Act No. 46 of 1999), and the disposal of explosives which is regulated by the Explosives Act, 2003 (Act No. 15 of 2003).

The waste management activities requiring a WML in accordance with Section 20(b) of the NEM:WA is indicated in two separate categories namely Category A and B:

- Category A describes waste management activities requiring a Basic Assessment process to be carried out in accordance with the EIA Regulations supporting an application for a waste management licence; and
- Category B describes waste management activities requiring an Environmental Impact Assessment process to be conducted in accordance with the EIA Regulations \ supporting a waste management licence application.

Table 5: NEM: WA listed activities triggered by the project

<b>Number and Date of the Relevant Notice:</b>	<b>Activity Numbers (as listed in the NEMA EIA Activity Lis) :</b>	<b>Describe Each Listed Activity:</b>
GN R718, 3 July 2009	Category B, Activity 4(1)	The storage including the temporary storage of hazardous waste in lagoons (contaminated water and leachate pond, pollution

		control dams).
GN R718, 3 July 2009	Category B, Activity 4(6)	The treatment of hazardous waste in lagoons (oil traps at washbay).
GN R718, 3 July 2009	Category B, Activity 4(11)	The construction of facilities for activities listed in Category B.

### 3.5. National Water Act, 1998 (Act No. 36 of 1998)

In accordance with Section 21 and 40 of the NWA a water use licence application will be submitted to the DWA. Investigations have to be undertaken in order to determine what activities will take place, as well as the impacts thereof. It is likely that a licence will be required for the following uses:

- Section 21 (b) – Storage of water for both raw and potable water use;
- Section 21 (c) – Impeding or diverting the flow of water in a water course for crossing of streams via causeways as there is a stream crossing the mining area;
- Section 21 (f) – Discharging waste or water containing waste into a water resource through a pipe or canal for the disposal of sewage works effluent (if constructed);
- Section 21 (g) – Disposing waste or water containing waste in a manner which may detrimentally impact on a water resource for the pollution control dams, overburden dumps, coal stockpiles and discard dumps;
- Section 21 (i) – Altering the bed, banks, course or characteristics of a watercourse; and
- Section 21 (j) – Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity for the safety of the people for the dewatering of the mining pits to facilitate mining and to provide a safe mining environment.

#### 3.5.1. Government Notice GN R. 704

Regulation 4 of this Government Notice states that no residue deposit, reservoir or dam may be located within the 1:100 year flood line, or less than a horizontal distance of 100 m from the nearest watercourse. Furthermore, person(s) may not dispose of any substance that may cause water pollution.

Regulation 5 states that no person(s) may use substances for the construction of a dam or impoundment if that substance will cause water pollution. Regulation 6 is concerned with the capacity requirements of clean and dirty water systems, while Regulation 7 details the requirements necessary for the protection of water resources.

Where any of the GN 704 Regulations are likely to be contravened, the user should apply for an exemption of Regulations 4 and 5 from the Minister.

### **3.6. International Finance Corporation's Performance Standards and the Equator Principles**

The International Finance Corporation (IFC) is a subsidiary of the World Bank and as a part of its Sustainability Framework; it has published a set of Performance Standards. Compliance with these Performance Standards is mandatory for any project proponent seeking project funding from the IFC. The Performance Standards were updated and revised with effect from January 2012.

The Equator Principles (EPs) are a credit risk management framework adopted by most large international funding institutions for determining, assessing and managing environmental and social risk in Project Finance transactions. Project Finance is often used to fund the development and construction of major infrastructure and industrial Projects such as the Project. Consistent with the current EP framework, the EP Association Steering Committee agreed that the revised IFC Performance Standards would also take effect for EP Association Members from 1 January 2012. EP Association Members have subsequently given support to EP III - the third and most robust version of the EP to date. The vote in favour of EP III means that from 4 June 2013 more deals will be assessed under a strengthened environmental and social risk management framework.

The EP III Principles are:

- Principle 1: Review and Categorisation;
- Principle 2: Environmental and Social Assessment;
- Principle 3: Applicable Environmental and Social Standards;
- Principle 4: Environmental and Social Management System and Equator Principles Action Plan;
- Principle 5: Stakeholder Engagement;
- Principle 6: Grievance Mechanism;
- Principle 7: Independent Review;
- Principle 8: Covenants;
- Principle 9: Independent Monitoring and Reporting; and
- Principle 10: Reporting and Transparency.

### **3.7. Other relevant legislations**

The comparative EIA study is not only subject to the terms and regulations of the MPRDA, NEMA, NEM:WA and the NWA, but must also comply with other applicable South African statutory requirements and guideline documents relevant to the Project.

#### **3.7.1. Water**

- DWAF: Best Practice Guideline A4: Pollution Control Dams (PCDs)
- DWAF: Best Practice Guideline GH: Water Reuse and Reclamation, June 2006
- DWAF: Minimum Requirements Guideline for the Handling, Classification and Disposal of Hazardous Waste, 1998
- DWAF: Minimum Requirements Guideline for the Water Monitoring at Waste Management Facilities

#### **3.7.2. Heritage Resources**

- National Heritage Resources Act, 1999 (Act No. 25 of 1999)

#### **3.7.3. Fauna and Flora**

- National Environment Management: Biodiversity Act, 2004 (Act No. 10 of 2004) (NEMBA)
- National Forest Act, 1998 (Act No. 84 of 1998)
- Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983)

#### **3.7.4. Hazardous Materials**

- Hazardous Substances Act, 1973 (Act No. 15 of 1973)
- Occupational Health and Safety Act, 1993 (Act No. 85 of 1993) Major Hazardous Installation Regulations (July 2001)
- Regulations for Hazardous Chemical Substances (GN R. 1179 GG 16596 of 25 August 1995)

#### **3.7.5. Development**

- Development Facilitation Act, 1995 (Act 67 of 1995)
- Electricity Act, 1987 (Act 41 of 1987)
- Electricity Regulations Act, 2006 (Act 4 of 2006)

- National Building Regulations and Building Standards Act, 1977 (Act No. 103 of 1977)

This chapter describes what a suitable site to construct/erect a tailing storage facility should look like.

**4.1. Methodology and Parameters to be considered**

The study shall make considerations for the TSFs based on 5 broad parameters:

1. Technical Issues
2. Economic Issues
3. Aspects of the Physical Environment
4. Aspects of the Biological Environment
5. Social and Cultural Aspects

These parameters shall be further broken down into sub-parameters for further analysis as follows:

Table 6: Site Suitability Assessment Parameters

Parameter	Resultant Sub-Parameters
Technical Issues	<ul style="list-style-type: none"> <li>• Dimensions of the Residue Facility</li> <li>• Dimensions of the Residue Pipeline</li> <li>• Dimensions of the Residue Deposits</li> <li>• Water management</li> <li>• Monitoring and Maintenance</li> <li>• Construction Considerations</li> <li>• Technical Risk</li> </ul>
Economic Issues	<ul style="list-style-type: none"> <li>• Capital Costs</li> <li>• Annual Operating Costs</li> </ul>
Aspects of the Physical Environment	<ul style="list-style-type: none"> <li>• Topography</li> <li>• Geology</li> <li>• Hydrology (Surface Water)</li> </ul>

Parameter	Resultant Sub-Parameters
	<ul style="list-style-type: none"> <li>• Geohydrology (Ground Water)</li> </ul>
Aspects of the Biological Environment	<ul style="list-style-type: none"> <li>• Fauna</li> <li>• Flora</li> <li>• Avi-Fauna</li> </ul>
Social and Cultural Aspects	<ul style="list-style-type: none"> <li>• Community Considerations</li> <li>• Heritage Considerations</li> </ul>

During the risk assessment phase of the Comparative EIA these parameters as the baseline shall be assigned suitable weighting accounts, upon which an alternatives analysis matrix shall be constructed to determine the suitability of either TSF option 1 or 2.

## 4.2. Technical Issues

### 4.2.1. Dimensions of the Residue Facility

According to an assessment done of the proposed Project to determine the minimum total capacity required for the storage of the platinum tailings, considerations were made with regards to the type of tailings material, the anticipated processing rates, deposition rates and design life, all of which were quantified as follows:

Criteria	Unit	Design Value/ Assumption
Tailings Material	Type	Platinum
Process Rate	Tonnes Per Annum (Pta)	3 million
Deposition Rate	Pta	2.85 million
Design Life	years	26
Total Storage Requirement	Dry tons	74.1 million

The result of the study determined that a final basin area of at least 200 hectares was required to facilitate a design life of at least 26 years.

#### **4.2.2. Design and Dimensions of the Residue Pipeline**

A tailings delivery system typically consists of the following:

**Pumps:** usually centrifugal in series with one variable speed pump to cater for surges. Pumps are usually rubber line to reduce impeller wear, and are made of cast iron;

**Pipelines:** delivery columns to the TSFs are supported on concrete plinths with vertical guide rods to control expansion and contraction. High Density Polythene (HDPE) and cement pipelines with lower friction and better wear characteristics are usually favourable.

**Valves:** types depend on pressure head and usually diaphragm valves which operate at low pressures can be implemented for platinum tailings. Should there be a chance of high pressures, then pinch valves are more adequate.

For the project in question, the following must be considered for the design and operation of the tailings pumping and piping systems:

- Avoidance of sharp bends and steep troughs in the pipeline route. Support the pipe on plinths to regulate vertical alignment and avoid fixing the pipes to the plinths;
- Provide measures to counter expansion and contraction of the pipelines;
- Allow for surging when deciding on the ratings of valves and flanges; and
- Provide pipe support that is high enough to prevent contact of the pipe with the ground or deposited tailings

Detailed design of the pipe and pipeline systems including the determination of aspects such as routes, size and elevation should be carried out by engineers with expertise in tailings transportation.

#### **4.2.3. Dimensions and Characteristics of the Residue Deposits**

In terms of percentage finer by mass, platinum tailings are usually between 0.01 to 0.1mm in particle size, which is comparable to the fineness of medium – coarse sand particles. Platinum tailings also have a high dry density mass of at least 1900kg/m<sup>3</sup>. No tailings samples are currently available for laboratory characterisation at the moment as the project hasn't been commissioned to start yet. However, desktop studies revealed that platinum tailings typically have varying concentrations of the following metals:

- Sulphates (SO<sub>4</sub>), which are usually the dominating constituents have a concentration of approximately 8000mg/kg;
- Iron (Fe<sup>+</sup>), approximately 2000mg/kg;
- Calcium (Ca<sup>+</sup>), approximately 300 mg/kg; and
- Magnesium, usually has the least concentration of approximately 200mg/kg.

This therefore means that platinum tailing residue facilities are typically classified as H: H and should thus be constructed according to the specifications of such a storage facility. The hazard assessment and safety classification of the facility should be carried out in accordance with SABS 0286:1998 and the design should be so that the TSF is maintained and operated so that it is not likely to spill more than once in 50 years.

#### **4.2.4. Return Water management**

Water should be stored on the top surface of the tailings dam and should ideally be decanted off the dam concurrently with deposition so as to maintain a minimum pool area and a depth that is sufficient to ensure adequate water clarity. The return water system for a TSF must re-use or treat the water at a rate at or above the rate at which the water can be decanted, or must provide adequate storage in a return water storage dam. The main considerations in the design and operation of an effective water management programme are:

- Minimisation of water loss which in turn minimises the cost of water; and
- Elimination of pollution caused by discharge of effluent that does not comply with statutory requirements.

In order to implement and maintain an effective water management system, a clear understanding of the plant and mine reticulation network must be obtained. Consequently, an understanding of the effluent generated must be obtained and with this information, the reticulation and storage facilities required to eliminate uncontrolled discharge (except in extreme weather conditions) can be designed. Hydrological models with a characterisation of inflows (water with the tailings, precipitation and any extraneous disposals such as sewage or concentrated effluents) and outflows (return water re-use, evaporation, seepage losses, interstitial water) can be used to anticipate and solve problems related to effluent generation as TSF's produce the most variable and unpredictable quantity of effluent at a mine.

#### **4.2.5. Monitoring and Maintenance**

The establishment of a monitoring system for especially the operational phase of the TSF ensures that the effectiveness of control measures can be evaluated and continuously improved. The purpose of the Environmental Impact Assessment and ensuing Monitoring programme helps to ensure that:

- All legislative requirements, especially with regards to risk and pollution management are met; and
- The environment can be protected from all risk in the short and long term

#### **4.2.6. Construction Considerations**

A conceptual design for each site should be formulated from which estimates of costs, construction, operation and closure should be made and tabulated. During the site investigation an appraisal of materials suitable for the construction of earth walls and filtering drains should be undertaken. This involves the determination of compaction characteristics and the grading of available sands and gravels.

#### **4.2.7. Technical Risk**

By virtue of their size, poor ability to resist wind and water erosion and the hydraulic fill method of construction, TSF's can pose serious long term risk problems if they are not managed diligently. More often than not, social development infrastructure such as housing tends to encroach on mine property boundaries in the long term making the extent and nature of potential pollution hazards to become an increasing concern.

Technical risk is thus an important factor in the siting of a TSF in the course of the evaluation of site suitability as issues such as predominant wind directions and meteorological characteristics of a specific area will be determined. Particular attention should be given to pollution control considerations and the ability for remediation of contaminated land should a potential risk for contamination manifest.

### **4.3. Economic Issues**

#### **4.3.1. Capital Costs**

The preferred site for the TSF should be one where the planning, construction, operation and rehabilitation costs are manageable, both legally and financially. The capital cost of providing the selected engineering options for pumps, routes slurry transportation and disposal processes etc. should be provided for each of the site options and the site with the lowest cost of the available two options should be considered.

#### **4.3.2. Annual Operating Costs**

Operating costs for each of the various scenarios highlighted above should be provided by as per the assessment done by the consulting engineers. Operating costs are estimated by applying a typical rate per tonne of residue handled for a spigotted tailings operation. Again the site with the lower operating costs must be considered.

## **4.4. Aspects of the Physical Environment**

### **4.4.1. Topography**

Topography can greatly influence tailings storage facility. Tailings disposal on land can take place on areas that range from nearly flat topography to valley or canyon. Filling a low topographic can provide site support, which allows greater efficiency in waste storage, primarily in the form of higher and steeper slopes angles. Hydrology (primarily run-off and flood control) as influenced by topography must be considered. Because topography is a site specific criterion, an area of flat topography was selected.

Appropriate topocadastral data must be provided in the form of a topographic map or maps. These must include all significant topographic features including surface contours. Most important are the drainage patterns, including seasonal and perennial streams and the distances to the nearest important water courses, wetlands and rivers. Rock outcrops and surface soil must also be recorded here, as well as the 1 in 50 year flood line, if there is one. Any evidence of surface instability should also be noted, as this could constitute a fatal flaw.

### **4.4.2. Geology**

As in designing the tailings storage facility site, the platinum tailings impoundment site need to be evaluated for geologic considerations. Criteria that relate to the determination of the competency of the foundation (underlying support) include:

- Depth
- Ground-water conditions
- Permeability
- Shear strength
- Strength
- Thickness and
- Type of rock

The Frequency, probability, and severity of seismic events must also be evaluated to ensure that the area is not prone to frequent seismic disturbances as this might affect the integrity of the TSF leading to issues such as overflow etc. that may affect groundwater or the surrounding environs. Geological maps show the rock formations underlying the site, below the surface soils. These are important as they often influence the type of soil developed on the site. Geological maps will also indicate the presence of features such as faults and dykes. No special conditions were considered in this evaluation.

#### **4.4.2.1. Soils – Agricultural Considerations**

A description is required of the surface soil types on the site as well as their fertility, erodibility and depth following a locally or internationally recognised agricultural soil classification. The dry-land production as well as the irrigation potential of the surface soils must be evaluated and reported. If the site is used for waste storage, this soil can be stripped, stockpiled and used in the eventual rehabilitation of the storage surface.

#### **4.4.2.2. Soils – Geotechnical Considerations**

- Access to the first 2m of the soil profile can usually be gained by test pits or trenches (properly shored if necessary). If greater depths are required, augering, wash-boring or sounding techniques, e.g. cone penetration or vane shear tests, may be used. Soil profiles must be carefully examined, described and recorded by a locally or internationally accepted method
- In situ permeability and other geotechnical tests – any natural soil layer that is suitable for use as an aquitard to prevent water pollution should be tested for permeability. Examples of suitable tests methods are borehole infiltration tests of various types, double ring infiltrometer tests and tests such as the Guelph in situ permeameter.
- Other tests may include soil indicator tests for the purpose of soil identification (particle size analysis, Atterberg limits and clay mineralogy), as well as compaction tests (standard Proctor) for future earth works

It may be necessary to measure the shear strength of soils to establish or design for the stability of the outer slopes of the waste storage.

#### **4.4.3. Hydrology (Surface Water)**

Information on the amount of surface water associated with the site is also necessary. This can be provided as a map of the main catchment area in which the site is located which shows the boundaries of the catchment, the boundaries of the sub-catchments for the site and the route of drainage from the site. Also the mean annual run-offs for the main catchment and the sub-catchment for the site, as well as normal flows in affected streams and water – courses during dry weather. We need also to peak flood levels and volumes for return periods of 1 in 20, and 1 in 50 and 1 in 100 years for the main and sub-catchments.

Surface water quality – background water quality sampling will be required. Surface water quality must be determined by sampling both upstream and downstream of the proposed site. Analysis of the samples must be performed to the

satisfaction of the regulatory authorities. These data will provide background information on surface water quality prior to any deposition of waste.

Surface water usage – a survey must be conducted to assess the purpose for which the surface water is used as well as the quantities used and to assess the strategic or community value of the water body.

#### **4.4.4. Geohydrology (Ground Water)**

All available geohydrological data and any restrictions affecting ground water use in the area must be identified and must form part of the investigation report.

- Ground Water morphology and flow – The depth of the ground water phreatic surface and its seasonal fluctuation, particularly the position of the wet season high elevation, including seasonal and perennial springs and seepages, as well as the presence of any perched water tables, must be determined. The gradient and general flow directions of the ground Water and other relevant data must be determined and possibly illustrated by appropriate maps and cross-sections. In addition, all significant geological features and inferred structures must be explored to determine the possible presence and importance of preferred ground water flow paths.
- Ground water quality – The background quality of the ground water, both up gradient and down gradient of the proposed site, must be determined prior to any waste deposition. A comparison of the pre-deposition and post-deposition ground water quality will provide an indication of the impacts of the waste storage on the ground water quality.
- Ground water usage – A census of existing boreholes and wells (hydro census) must be conducted. Abstraction rates, yield, depth, age, (by tritium test) and the purpose for which the water is used must also be obtained, with a view to assessing the strategic or community value of the water resource. A clear indication must be given of the perceived reliability of such census data and define distinction made between guesswork and factual information. Cognizance must also be taken of the source of the information, and this must be stated in the report.
- Sensitive sites – Where waste storages are considered or proposed in rates that are characterised by potentially strategic aquifers, or where ground water is, or may be used in the future, special caution must be exercised.
- Undermined areas – Existing underground mines must be identified, delineated and examined to establish the effect of their presence on ground water flows and potential subsidence
- Seismicity – The risks and implication of natural or mining induced seismicity must be addressed. If the waste storage is to be sited in an area where natural earthquakes are known to occur, the effect of the

maximum credible earthquake must be taken into account in design of the storage and its appurtenant works.

- Rehabilitated open-cast mines – Open-cast mines associated with the site, whether rehabilitated or otherwise, must be identified, delineated and properly described.
- Potential for future mining – The possibility of future mining activities should be assessed
- Sinkholes and surface subsidence – Areas where sinkholes or surface subsidence occur should be avoided during the site selection process as these constitute fatal flaws.

#### **4.5. Aspects of the Biological Environment**

Depending on the type and size of mine, the development and construction of a Tailing Storage Facility often require large space to be cleared off vegetation. The protection and conservation of biodiversity is fundamental to sustainable development. Integrating conservation needs and development priorities in a way that meets the land use needs of local communities is often a critical issue for mining projects.

Habitat alteration is one of the most significant potential threats to biodiversity associated with mining. Habitat alteration may occur during any stage of the mine cycle with the greatest potential for temporary or permanent alteration of terrestrial and aquatic habitats occurring during construction and operational activities. Additionally, exploration activities often require the development of access routes, transportation corridors, and temporary camps to house workers which may all result in varying degrees of land-clearing and population in- migration.

In dry arid, arid zones, fauna, in particular, migratory birds are attracted to open ponds especially in dry seasons. While stock fencing prevents land based fauna from accessing the contaminated water, migratory and resident birds have are attracted to tailings resulting in a number of fatality.

There are a number of factors to consider when locating a tailing storage facility or any other infrastructure relating to mining. Three factors include

- Siting facilities (in this case TSF) in locations that avoid impacts to critical terrestrial habitat, and planning exploration and construction activities to avoid sensitive times of the year;
- Whether any critical natural habitat will be adversely impacted or critically endangered or endangered species reduced;
- Whether the project is likely to impact any protected areas;
- Minimizing disturbance to vegetation and soils as they provide habitat and food for animals (*i.e.* avoiding or minimizing the creation of barriers to wildlife movement, or threats to migratory species (such as birds) and providing alternative migration routes when the creation of barriers cannot be avoided);

- Ensuring that the facility does not form a barrier that fragments one habit site;
- The potential for biodiversity offset projects (e.g. proactive management of alternative high biodiversity areas in cases where losses have occurred on the main site due to the mining development) or other mitigative measures;
- Whether the project or its associated infrastructure will encourage in-migration, which could adversely impact biodiversity and local communities;
- Consideration of undertaking biodiversity assessments, conduct ongoing monitoring, and manage biodiversity programs;
- Planning and avoiding sensitive areas and implementing buffer zones from those areas;
- Consultation with key stakeholders (e.g. government, civil society, and potentially affected communities) to understand any conflicting land use demands and the communities dependency on natural resources and / or conservation requirements that may exist in the area.

#### **4.5.1. Fauna**

For Fauna, information is required on the populations of

- Dominant species, and
- Endangered or rare species

#### **4.5.2. Flora**

All existing vegetation on the site must be described and mapped, whether it is original indigenous vegetation or exotic vegetation, such as plantations, crops or fallow agricultural land. For flora, information is usually required on:

- Dominant species
- Endangered or rare species
- Invader or exotic species

For a virgin site, a vegetation map is required

### **4.6. Social and Cultural Aspects**

#### **4.6.1. Community Considerations**

Before establishing or developing the new TSF adequate consultation should be undertaken with the community and interested and affected parties. There are a number of factors that should be considered for both TSF option 1 and

TSF option 2, which may directly affect the communities at site TSF option 1 and TSF option 2, these factors will be identified for both sites, as well as determining the TSF option or site with the least impact on the community. Factors that need to be considered include amongst others the following:

- Locality of TSF in relation to proximity of the community;
- Prevailing Wind direction taking into account the TSF location in relation to the community;
- Aesthetics of the TSF towards community;
- Possible Impacts on the community both social and health;
- Public participation for both TSF option 1 and TSF option 2

#### **4.6.2. Heritage Considerations**

Heritage environment as defined in the NHRA is a broad, generic term used to include all human made phenomena and intangible products that are the result of the human mind. Natural, technological and industrial features may also be part of heritage resources, as places that have made an outstanding contribution to the cultures, traditions and lifestyles of the people or groups of people of South Africa.

It should be kept in mind that archaeological deposits usually occur below ground level. Should archaeological artefacts or skeletal material be revealed in the area during development activities, such activities should be halted, and a university or museum notified in order for an investigation and evaluation of the find(s) to take place (Coetzee, 2013)

#### **Assessment Criteria**

An evaluation and or assessment criteria against which the proposed TSF 1 option and TSF option 2 will be measured, by means of determining its archaeological and heritage significance, will be based on the following:

- The unique nature of the site
- The amount/depth of archaeological deposits and range of features such as stone walls, activity areas etc.
- The wider historic, archaeological and geographic context of the site

#### **Site Significance**

Site significance classification standards prescribed by the South African Heritage Resources Agency (2006), approved by the Association for Southern African Professional Archaeologists (ASAPA) for the Southern African Development Community (SADC) region, will be used in determining the site significance for both TSF option 1 and TSF option 2.

Table 7: Grading and rating systems of heritage resources

FIELD RATING	GRADE	SIGNIFICANCE	RECOMMENDATION
National Significance (NS)	Grade 1	-	Conservation; National Site nomination
Provincial Significance (PS)	Grade 2	-	Conservation; Provincial Site Nomination
Local Significance (LS)	Grade 3A	High Significance	Conservation; Mitigation not advised
Local Significance (LS)	Grade 3B	High Significance	Mitigation (Part of site should be retained)
Generally Protected A (GP.A)	Grade 4A	High / Medium Significance	Mitigation before destruction
Generally Protected B (GP.B)	Grade 4B	Medium Significance	Recording before destruction
Generally Protected C (GP.C)	Grade 4C	Low Significance	Destruction

### 5.1. Project location

The Project will be located on the farms Macalacaskop 243 KR, Turfspruit 241 KR and Rietfontein 2 KS. The farms fall within the Mogalakwena Local Municipal boundaries in the Waterberg District Municipality of Limpopo Province. The nearest town is Mokopane (formerly known as Potgietersrus), situated approximately 8.8 km south-east of the study area. The Project is located approximately 5 km south of Anglo Platinum's Mogalakwena Platinum Mine.

The settlements Baloyi, Ga-Kgobudi, Ga-Sekgoboko, Hlongwane, Macheke, Madiba, Magongoa, Mahwelereng, Maroteng, Masehlaneng, Masodi, Michelle, Moshate, Mountain View, Mzombane, Parkmore, Pholar Park and Sekgakgapeng are situated within the study area. There are a number of other small settlements in the surrounding area.

The Project area is accessible all year-round by a two-lane tarred national highway, the N11. The N11 runs through three farms of the Project area. From the N11 the Project area can be accessed by all-weather gravel roads or by unpaved tracks.

#### 5.1.1. Tailing Storage Facility Site 1

Site 1 of the TSF is located on the Farm Turfspruit on the South-western section of the proposed mining area. The site is situated along the R518 road to Lephalale with the Mosadi village on the North to North-eastern side of the site whereas the Masehlaneng village is on the South to South-eastern side. Mosadi village is within 150 metres of the proposed site. **Refer to figure 2 below.**

#### 5.1.2. Tailing Storage Facility Site 2

Site 2 of the TSF is located on the Farm Rietfontein 240 KR on the North-eastern side for the proposed mining area. The site can be accessed through the N 11 road with Tshamahansi village on the Western side of the propose TSF site. New housing developments at Tshamahansi village are been built towards the TSF area. **Refer to figure 2 below for locality of TSF 2.**

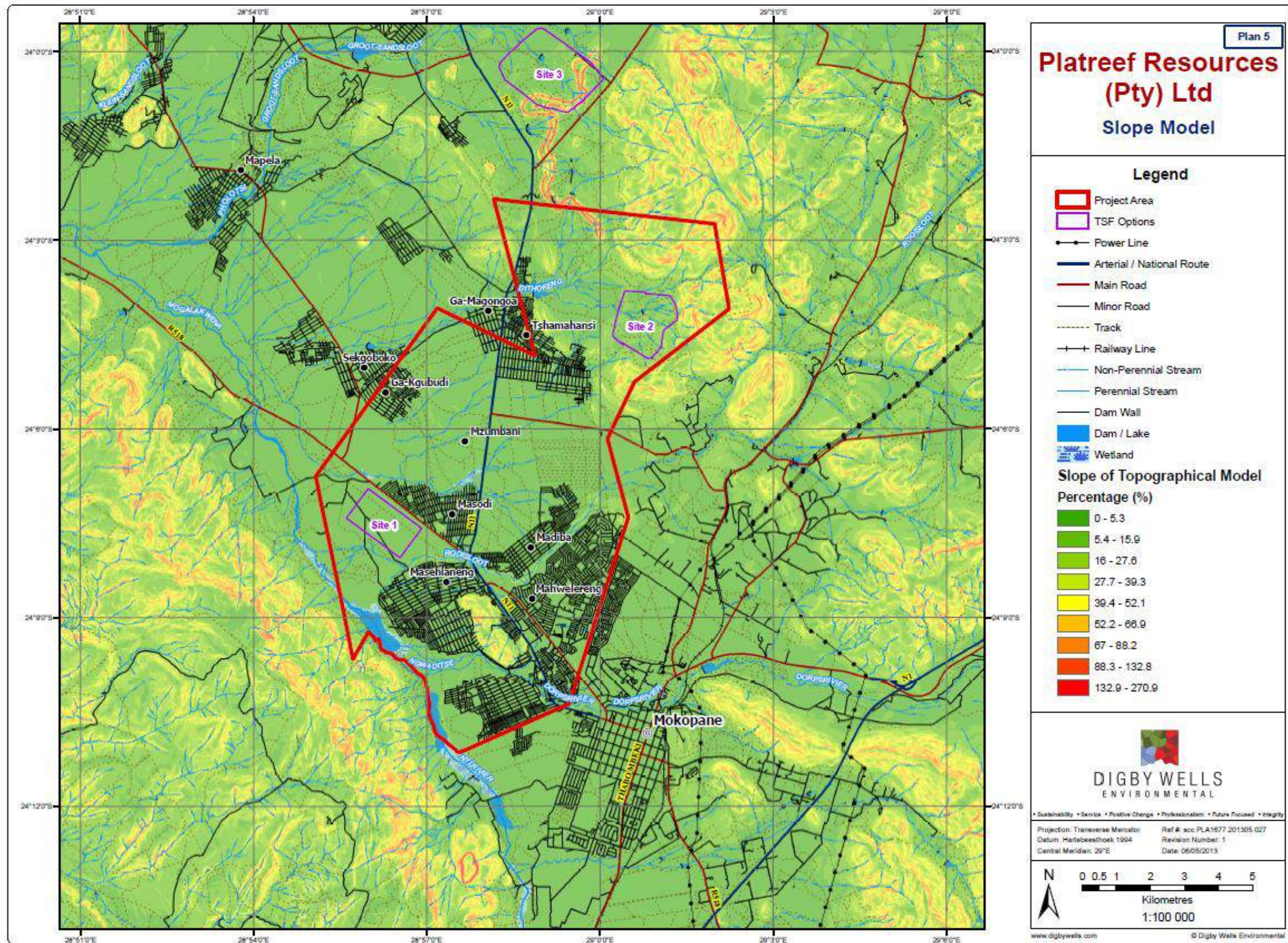


Figure 2: Proposed location of the Tailing Storage Facilities, Digby Wells Environmental 2013

## 5.2. Climatic conditions

The climate is semi-arid, with precipitation occurring as rain. Average annual rainfall is around 300 mm. Over 90% of the annual rainfall occurs between the months of October and March. The highest monthly averages typically occur in November and December, although January also receives precipitation above average. In terms of Koeppen Climate Classification, the area belongs to BSh (Arid Climate, Steppe, hot).

Precipitation reduces erosion potential by increasing the moisture content of materials. This represents an effective mechanism for removal of atmospheric pollutants and is therefore considered during air pollution studies. Rain-days are defined as days experiencing 0.25 mm or more rainfall.

The significant variation in the wind field in the Waterberg area is indicative of strong underlying topographical influence on the prevailing meteorological conditions. The Waterberg mountain range exercises its influence on the local scale, with its peaks and valleys.

The predominant wind direction is from northeast, with the secondary component from the east northeast and east. Contributions from the NW and SE quadrant are observed. Calm conditions (wind speeds < 0.5 m/s) occurred for 4.2% of the time. The predominant wind direction at the Platreef is from the northeast, frequent winds mainly from the NW and SE quadrant. Although wind speeds are generally moderate during this period (average 3.66 m/s), the predominant speeds ranged between 3.6 and 5.4 m/s and occurred 42% of the time. Wind speeds greater than 5.4 m/s (i.e. threshold friction velocity of 0.26 m/s) have the ability to generate fugitive dust from open areas and storage piles. Wind speeds greater than 5.4 m/s in the Ivanplats area account for 14.4% during the period.

At night time, wind field conditions are from the northeast (25.4% of the time) with secondary contributions from east northeast and east. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 53% and 18% of the time. The morning time is dominated by wind fields from the northeast, north northeast and north with secondary components from the east and east southeast directions. Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 37% and 18% of the time.

In the afternoon, the predominant wind was blowing from the northwest direction (17%), with 13% coming from the north northwest direction. Secondary components were observed from the south east sector. The evening wind field conditions were different from what was observed in the afternoon, with winds from the northeast (18%) and east northeast (16%). Wind speeds between 3.6-5.4 m/s and 5.4-8.8 m/s occurred 49% and 13% of the time.

In spring the predominant wind speed comes from the NE with secondary components from the NNE and ENE. Less infrequent winds were observed from the N, NNW and NW. The predominant wind direction did not change significantly in summer. However, there were changes in the frequency of winds from the NE which was

observed to have decrease and winds from ENE direction to have increased slightly. In autumn, strong winds, in order of dominance were coming from the E, ENE, NE, and ESE with secondary components from the SE and NE. In winter the influence from the NE sector diminished with the wind from the E, ESE, SE and SSE dominating.

### **5.3. Geology and soil**

Most of the development area is underlain by Precambrian igneous rocks of the Rustenburg Layered Suite of the Bushveld Complex. The south-west section part of the property is underlain by the Molendraai Magnetite Gabbro of the Rustenburg Layered Suite. The south-eastern portions of the property are underlain by the Duitschland Formation and the Malmani Subgroup of the Chuniespoort Group. To the extreme south-east, a small section of the property is underlain by the Uitloop Granites of the Mashashane Suite. The Bushveld Complex is a layered igneous intrusion containing a large reserve of platinum group metals (Lee, 1996; Eales & Cawthorn, 1996). Associated with this complex is the Rustenburg Layered Suite known to be the oldest mafic layered complex on earth (Wilson, 2012).

The mining project area is located on the Northern Limb of the BIC. The BIC intrudes the Transvaal Supergroup, forming a massive igneous province up to 7 km in thickness, extending over 60 000 km<sup>2</sup>. The BIC is the world's largest layered intrusion and the world's largest source of platinum (Cawthorn, 1999). The BIC is divided into four exposed sections, known as the Eastern, Western, Northern, and Southern Limbs. A fifth section, the Bethal Limb, is located under younger sedimentary cover and does not crop out.

Typically the BIC consists of a mafic-ultramafic layered suite, a granite suite, and a package of predominantly felsic volcanic rocks. Emplacement of the complex appears to have been rapid, with both intrusive and extrusive rocks dated to about 2 057 Ma (Harmer, 2000 cited in Kinnaird et al., 2005).

#### **5.3.1. TSF Site 1**

The proposed site 1 is characterised by the occurrence of homogeneous deep Oakleaf soil. Oakleaf soil consists of an orthic A horizon, overlying a neocutanic brown apedal B horizon. Oakleaf soils are considered to be good agricultural soils(arable) due to their sandy clay loam textures. These soils are cultivated easily, hold water and adsorb nutrients allowing optimal crop production. The topsoil layer should be stripped and stockpiled prior to the construction of the TSF to ensure that a source of soil is kept to cover and vegetate the TSF.

#### **5.3.2. TSF Site 2**

The proposed TSF site 2 is characterised and dominated by sandy shallow soils containing stones and rocks. The proposed location for TSF 2 is in a higher landscape position compared to the landscape positions of TSF 1. Drainage lines effectively divide the site. Drainage lines are characterised by heavy clay Valsrivier soil. The

sandy soils occupying TSF site 2 are difficult to manage due to their sandy nature. Stripping stockpiling and rehabilitation will be difficult to manage the prevention of erosion, due to the sandy nature of the soil and the high rainfall intensity present in the area.

#### **5.4. Fauna and flora**

The Project is situated within the Savanna biome, which is the largest biome in Southern Africa. It consists of a grassy ground layer and a woody plant upper layer. It is known as Shrubveld when the woody layer is close to the grass layer and as Bushveld in any intermediate phases. Factors that delimit this biome include sufficient rainfall, fires and grazing of animals.

Field investigations were conducted by Digby Wells during the dry season (June 2011) and during the wet season (September 2011). A second dry season survey was commissioned during August 2013, during which specific infrastructure placements were investigated. The findings and recommendations of these investigations are detailed below.

##### **5.4.1. TSF site 1**

Based on the fauna and flora study conducted, the site falls within the Makhado Sweet Bushveld vegetation type. The site was found to lie entirely within one vegetation community and thus the Secondary Grassland and Agricultural fields and occurs within the buffer zone of the wetlands.

###### **5.4.1.1. Secondary grasslands/Agricultural fields**

Secondary grasslands and agricultural fields have been placed together, due to the fact the secondary grasslands persists were previous agricultural activities ceased. The secondary grasslands consist predominantly of secondary/pioneer grasses such as *Eragrostis curvula*, *Melinis repens*, *Urochloa panicoides*, *Cynodon dactylon*, *Hyparrhenia hirta*, *Aristida congesta*, *Pogonarthria squarrosa*, *Dactyloctenium aegyptium* and exotic species such as *Tagetes minuta*, *Senecio latifolius*, *Xanthium strumarium\**, *Bidens pillosa*, *Solanum panduriform* and *Ricinus communis\**. Legally protected large *Combretum imberbe* and *Sclerocarya birrea* were found in this secondary grassland vegetation type as remnant vegetation of the previous dominating bushveld of this region. These species will require a licence to be removed.

##### **5.4.2. TSF Site 2**

According to the national vegetation map (Mucina & Rutherford 2006) TSF site 2 lies within two vegetation types, the Makhado Sweet Bushveld and the Mamobolo Mountain Bushveld. According to the fauna and flora assessment conducted for the site, the site has one vegetation community, the Degraded Mixed Bushveld/Unimpacted Bushveld.

#### 5.4.2.1. Degraded Mixed Bushveld

This vegetation community was found in between the base of ridges and residential areas/settlements, which was interrupted in certain sections by agricultural/secondary grasslands. This was also significantly impacted by removal of vegetation for firewood, grazing and dumping of domestic waste, bush encroachment have occurred extensively through *Dichrostachys cinerea*, most probably due to overgrazing through many years. Mining activities for sand mining were also found within this community with informal gravel roads that are used for this purpose. The grassy layer was dominated by *Melinis repens*, *Eragrostis plana* and *Eragrostis rigidior*. The tree/shrub layer includes *Acacia karroo*, *Acacia garrardii*, *Ziziphus mucronata*, *Aloe greatheadii*, *Aloe marlothii*, *Euphorbia ingens* and *Dichrostachys cinerea*. If the TSF does not encroach within the moderately-high to high BV areas of the Ridge bushveld boundaries as indicated, then TSF site 2 becomes the more attractive option, as it will then fall completely within degraded bushveld, with no protected species

### 5.5. Topography and visual aspects

The study area falls within mountainous areas that runs to the east and west of the project area, while the Project site itself. The Project area is relatively flat except for the mountainous area in the north-eastern corner and several isolated ridges. The land within the Project area is mainly used for agricultural activities and livestock.

The topographical model indicates that the elevation of the Project area increases from 1 030.5 metres above mean sea level (mamsl) in the Mogalakwena River floodplain in the south-western corner of the Project area to 1 759 mamsl on the ridges in the north-eastern corner of the Project area. The majority of the Project area has gentle slopes of between 0° and 5°. Moderate slopes of between 6° and 15° occur in some areas. Isolated steeper slopes of between 16° and 21° occur along the banks of the Rooisloot and Klein-Sandsloot Rivers. The steepest slopes occur on the ridges and range between 22° and 69°. The proposed Platreef Project will have a negative visual impact on the receiving environment. The greatest visual impact will be from the main shaft headgear, plant area, waste rock dumps and TSF as these are the tallest components of the infrastructure and in the case of the waste rock dumps and TSF, cover a large area.

The slope aspect/direction of the Project area is generally in a south-westerly direction towards the Mogalakwena River. Slopes of various other directions occur in isolated areas along the river valleys/channels and on the ridges. The relatively flat topography of the Project area will only provide minimal screening of the Project. The mountainous areas to the east and west of the project area will provide screening of the Project to those areas on the opposite sides of the mountains.

#### 5.5.1 TSF 1

Based on the topographical model conducted for the project, TSF Site 1 is situated at the topographical slope of 0-5.3% while TSF Site 2 is situated between 16-39.3%. This presents a site that is more or less flat and

considering the considerations for location of TSF as will be discussed later, would be more suitable for the location of tailings dam as it presents for ease of access and construction. However, it also has the disadvantage of containing thick alluvium soils because of the prevalence of chemical weathering, which would mean that the site is also more suitable for agriculture than it would be for industrial related functions.

### **5.5.2 TSF 2**

TSF Site 2 is situated next to a ridge and thus the topographical percentage is high. Soils here are thin as the area is more rocky and prone to exfoliation weathering as opposed to chemical weathering. This means that the area is in no way suited for agriculture, but would however be more suitable for industrial activities as it is less permeable to water. It should also be noted however, that construction costs may be higher for this site because of its topography, but maintenance will be much easier to manage.

## **5.6. Surface water**

The mining project area falls in the Limpopo Water Management Area (LWMA). The two quaternary catchments in which the project falls are A61F and A61G. The Nyl River is the headwaters of the Mogalakwena River. The Nyl River flows in a north easterly direction from Modimolle located in the headwaters of the Nyl River, towards Mokopane. At Mokopane, the Nyl River becomes the Mogalakwena River and turns to flow in a north westerly direction passed Mokopane and the project area. The Mogalakwena River flows to the west of the project area and ultimately flows into the Limpopo River.

The Mogalakwena River is characterised by the presence of vleis and wetlands along its drainage course on both the Turfspruit and Macalacaskop farms. The Sterk River is a major tributary of the Mogalakwena River and joins the Mogalakwena River from the west some 30 km below the project area. The Doorndraai Dam is located on the Sterk River. The Doorndraai Dam is the main water supply dam for Mokopane.

Both sites 1 and 2 fall within the A61F quaternary catchment of the Limpopo Water Management Area. A61F is drained by the Rooisloot River.

### **5.6.1 TSF 1**

The Rooisloot River is situated close to Site 1 and it is found on the South eastern side of the proposed site. While there was no ready evidence of surface hydrology on the site itself, the immediate proximity of the Rooisloot River is an obvious cause for concern should a high environmental risk activity such as a TSF need be situated close to it. That said, mitigation measures can still be provided together with monitoring provisions to check for impacts on the river, but this would be at great risk and cost to the mining company, as the river is an important part of the catchment, which should be preserved should the option be there.

## **5.6.2 TSF 2**

A number of drainage lines (Uitloop) join together on TSF site 2 to flow towards the Rooisloot. However these are non-perennial rivers and evidence gathered during the two site visits conducted by Tshikovha showed that there was no surface hydrology at the site or within its immediate vicinity.

## **5.7. Groundwater**

Two main aquifer types are present, i.e. primary and secondary within the mining project area. The two farms Turfspruit and Macalacaskop are mainly underlain by intergranular and fractured aquifers, associated with the Rustenburg Layered Suite. On the farm Rietfontein 2 KS, secondary aquifers are associated with formations of the Transvaal Sequence and basement granite.

Groundwater flow generally follows surface drainage with flow occurring from northeast to southwest and eventually northwest following the Mogalakwena River. Groundwater elevations are highest (1220mamsl) on Rietfontein 2KS and lowest (1030mamsl) on Turfspruit 241KR associated with the Rooisloot Alluvial Aquifer. This represents a hydraulic head of 190m across the study area. Zones of steep gradients indicate the presence of less permeable areas.

### **5.7.1. TSF Site 1**

Site 1 is found on the primary aquifer which is mostly restricted to the alluvium in the Mogalakwena River. Here alluvial thicknesses of up to 20 metres occur and borehole yields in excess of 10 l/s have been established. Minor alluvium occurrences are associated with the Rooisloot River drainage.

### **5.7.2. TSF Site 2**

Site 2 occurs at the main secondary aquifer occurs at a shallow depth of less than 45mbgl. Water level depths vary from 3 to 25mbgl. Water strike depths in the weathered bedrock range from 12 to 20mbgl, with strike yields between 0.1 to 1.0 l/s. Water interceptions in the shallow fractured bedrock occur at 20 to 42mbgl with strike yields between 1.0 to 10.0 l/s.

Rietfontein 2KS (to the north) is underlain by sedimentary rocks of the Transvaal Sequence (sandstone, shale and minor dolomite) and basement granite (Turffloop Granite (Rt)), forming the hills of the northern boundary. Dolomite and granite underlie sections of Rietfontein 2KS. The study has confirmed that groundwater within these formations is limited. Detailed studies on the Rietfontein 2KS TSF site confirm very low aquifer transmissivities ( $\ll 0.05\text{m}^2/\text{d}$ ) classifying the underlying Turffloop Granite (Rt) as an insignificant or nonaquifer.

A minor fractured aquifer is present at depth ( $>45\text{mbgl}$ ) with strike depths varying from 45 to 156mbgl and yields of between 0.1 and 0.2 l/s. Slug testing of six deep core holes indicate very low hydraulic conductivities, between

1 x 10<sup>-4</sup> m/d and 1 x 10<sup>-5</sup> m/d, considered representative of the bulk igneous rock matrix. Inspection of core samples indicates fracturing below approximately 680m above the mineralized contact zone.

## **5.8. Archaeology and heritage**

Previous impact assessments (Huffman, 1997; Fourie, 2002; Pistorius, 2002; Roodt, 2007; Roodt, 2008a; Roodt, 2008b) conducted within and surrounding the project area have all reported stone tool scatters associated with the MSA and LSA. Fourie (2002) also reported on a possible ESA core found on the surface. These finds are commonly associated with water sources, such as rivers and pans. LSA stone tools are commonly associated with hunter-gathers, but are also known to occur with Iron Age communities.

### **5.8.1. TSF Site 1**

Based on the Heritage Impact Assessment conducted for the whole mining project no heritage resources were identified. Though no heritage resources were found a plan should be put in place during ground clearance if sub-surface heritage resources are identified.

### **5.8.2. TSF site 2**

From the Heritage Impact Assessment conducted it was found there used to be a group of people living to the north of the present day of Tshamahansi in the area near the TSF Option 2 in the year 1938. According to Mr Maluleke, the area was undeveloped and was used to herd cattle owned by the group. He also stated that the group used ceramic pots, built stone walls and smelted iron.

A total of 11 isolated surface occurrences and one stone walled site were identified within the TSF Option 2. Of these 11 occurrences, three are Stone Age occurrences and eight are Iron Age occurrences. The smelting site identified at TSF location option 2 (S.35-006) may be a representation of a different group and time period, as the stone walling is different to that of the S.35-027 and S.35-071. Smelting sites are not common within the Mokopane region and this site has the potential to broaden the archaeological model of the Iron Age of the Limpopo Province. There are still community members within Tshamahansi who remember that a group was living in the hills behind the present day village and recall that they smelted iron. Should this site be considered as a suitable site due to consideration of other overwhelming factors, then an elaborate mitigation plan for the heritage resources found here should be in place before any work can be authorised.

## **5.9. Social**

The prospecting area covers approximately 107 km<sup>2</sup>, of which much is covered by existing human settlements. The extent of the prospecting area is outlined by the combined boundary of two contiguous properties: Turfspruit 241 KR and Macalacaskop 243 KR. Rietfontein 2 KS forms part of the study area. The majority of the prospecting area is under the custody of the Government of the Republic of South Africa, but is identified as

indigenous/traditional land. This means that the Traditional Authority (TA) has jurisdiction over the land and holds the land in trust for its people. It needs to be noted that several factions within the community do not recognise the TA and/or the local chiefs.

Land claims enquiry on the farms within the Platreef prospecting area showed that there are claims on Turfspruit 241 KR (TSF Site 1) and Rietfontein 2 KS (TSF Site 2); another land claim exists on Bultongfontein 239 KR, which one of the properties is considered for the placement of ancillary operational infrastructure. Claims for these properties are still pending on behalf of the Mokopane Trust and Mamahsela community. These are still in the process of being validated by the land commissioner. At the time of the enquiry the land claims had not been gazetted and the status of the claim was 'research' therefore the claim is still under investigation.

Villages directly surrounding the Platreef Project infrastructure include Tshamahansi, Ga-Magongoa, Ga-Kgobudi, Madiba, Masodi, Masehlaneng, Maroteng, Ga-Molekana, Sekgoboko, and Mzumbani. These villages all fall within the jurisdiction of Chief Kekana and the Mokopane Tribal Authority.

The area earmarked for TSF 1 coincides entirely with agricultural plots, and is situated within 170 m of Masodi village. The TSF 2 option is situated next to the Witvinger Nature Reserve; land uses on the proposed site are limited to a communal grazing. The pipeline option which connects to the TSF 2, it transects several agricultural plots, and runs past several residential structures and graves.

After considering the information discussed in the site suitability report, the following information shall be used in the quantitative ranking of the site using utility functions and weighting factors that enable the sites to be ranked on an impartial basis.

### **6.1. Technical Criteria**

#### **6.1.1. Dimensions of the total TSF proposed area**

*Rating*

1 = 150ha

2 = 200ha

3 = 250ha

4 = 300ha

5= 350ha

This shall be based on the total surface area from the site that can be made available for the whole TSF development, including deposition surfaces, plant and pump areas.

#### **6.1.2. Slurry Delivery Line**

*Rating*

1 = Unfavourable

2 = Moderately Unfavourable

3 = Moderately Favourable

4 = Favourable

5 = Highly Favourable

Factors that affect the slurry delivery line are length of the line, gradient, route, crossings etc.

#### **6.1.3. Overflow and Seepage Potential**

*Rating*

1 = Very pervious, solution cavities – very high

2 = Pervious, medium dense sands – high

3 = Slightly pervious dense sands – medium

4 = Impervious, very dense sands or shale – low

5 = Highly impervious rock – very low

Seepage potential depends on the permeability of the foundation materials and variability of permeability within each material that was quantified during the geotechnical investigation. Very pervious sub-surface conditions could lead to loss of water to the underground or even pollution of groundwater. Such a condition would be rated as 1, a very high risk. This evaluation is only a qualitative assessment of the risk.

#### **6.1.4. Water Management**

##### *Rating*

1 = Unfavourable

2 = Moderately Unfavourable

3 = Moderately Favourable

4 = Favourable

5 = Highly Favourable

Factors that affect water management shall include the size of the water management systems required, size of the catchments relative to the particular site and the factors affecting the supernatant ponds if applicable.

#### **6.1.5. Monitoring and Maintenance**

##### *Rating*

1 = Unfavourable – very high

2 = Moderately Unfavourable - high

3 = Moderately Favourable - medium

4 = Favourable - low

5 = Highly Favourable – very low

Factors that affect the monitoring and maintenance are the ease with which maintenance can be applied to each site and consequently the cost that is required for the provision of maintenance of the TSF. The ability to easily react when there is a maintenance issue such as an accidental discharge should also be considered

### **6.1.6. Construction Considerations**

#### *Rating*

1 = Unfavourable

2 = Moderately Unfavourable

3 = Moderately Favourable

4 = Favourable

5 = Highly Favourable

Considerations shall be made as to the ease at which construction work can be established and carried out on each site. A site that has more favourable natural occurrences such as impermeable rock that require limited artificial lining for instance will take precedence over an area that would require a lot of artificial work for the TSF to be established

### **6.1.7. Technical Risk**

#### *Rating*

1 = Very High

2 = High

3 = Medium

4 = Low

5 = Very Low

Slimes can liquefy and the resulting flow slide of the slime can flow over substantial distances causing loss of life and extensive property damage should the dams be built above natural ground level. Where tailings are not constantly liquefied on the surface, there is also potential for dust build up. Unsecure sites also lead to unwanted access which poses an imminent danger to neighbouring communities. Hence close proximity to high density housing or infrastructure would typically be rated as 1, very high, whereas sterile ground with no people and infrastructure would be rated as 5, very low.

## **6.2. Economic Issues**

### **6.2.1. Capital Costs**

#### *Rating*

1 = Very High

2 = High

3 = Medium

4 = Low

5 = Very Low

An assessment should be done by a specialist to determine what the optimal cost for establishing a TSF and its servitudes, plants and authorisations would be. Should the figure be say R2million, then a site whose capital costs would be around this figure would get a rating of 3, medium. Figures either side of the figure will be rated towards very low and very high as is applicable

### **6.2.2. Annual Operating Costs**

*Rating*

1 = Very High

2 = High

3 = Medium

4 = Low

5 = Very Low

The same criteria as used for the capital costs for establishment of a typical TSF would also be used for calculating the annual operating costs for a typical TSF. The designated figure would act as the medium optimal amount and figures either side of the optimal amount treated respectively towards very high or very low as the case may be

## **6.3. Aspects of the Physical Environment**

### **6.3.1. Topography**

*Rating*

1 = Highly Unsuitable - Valley or Canyon

2 = Unsuitable – Steep slopes and highly undulating terrain

3 = Acceptable – Slightly steep slopes and undulating terrain

4 = Suitable – Gently undulating terrain

5 = Highly Acceptable – Flat terrain

Tailings disposal on land can take place on areas that range from nearly flat topography to valley or canyon. Hydrology (primarily run-off and flood control) as influenced by topography must be considered. Because topography is a site specific criterion, an area of flat topography should be selected.

### **6.3.2. Geology and Risk of Potential Sinkhole Formation**

#### *Rating*

1 = Highly Unsuitable – Frequent seismic activity, low shear strength, cavities in dolomite, water table below level of cavity, no Karoo present

2 = Unsuitable – Infrequent seismic activity, low shear strength, water table at top of dolomite cavity, no Karoo present

3 = Acceptable – No seismic activity, good shear strength, water table above dolomite cavity, thin Karoo present

4 = Suitable – No seismic activity, high shear strength, no cavities in dolomite, water table at dolomite boundary, thin Karoo present

5 = Highly Acceptable – No seismic activity, no dolomitic presence, solid rock formations, thick Karoo present.

The risk of sinkhole formation is directly related to the presence of dolomite and characteristics of the dolomite in relation to the water table and the presence of cavities. The shear strength of the rock is related to the occurrence of faults while the potential for seismic activity will determine the stability of the rock formations on which the TSF would be located.

### **6.3.3. Hydrology**

#### *Rating*

1 = Very High – Extremely high density of surface water drainage

2 = High – High density of surface water drainage

3 = Medium – Medium density of surface water drainage

4 = Low – Low density of surface water drainage

5 = Very Low – Absence of surface water drainage

Drainage density shall be calculated by considering the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. It is a measure of how well or how poorly a watershed is drained by stream channels. The site Option with the highest drainage density shall receive a rating of very high while the Option with the least amount or complete absence of naturally occurring surface water drainage shall receive a rating of very low.

### **6.3.4. Geohydrology and Risk of Ground water Contamination**

#### *Rating*

1 = Very High – Water table within 3mbgl, no ferricrete, wad or Karoo present

2 = High – Water table below 5mbgl, no ferricrete, wad or Karoo present

3 = Medium – Water table below 15mbgl, thin ferricrete, wad or Karoo present

4 = Low – Water table below 25mbgl, thick ferricrete, wad or Karoo present above water table

5 = Very Low – Water table below 45mbgl, thick ferricrete, wad or Karoo present above water table

According to the geohydrological report conducted for the general project area, the main secondary aquifer occurs at a shallow depth of less than 45mbgl. Water level depths vary from 3 to 25mbgl. Water strike depths in the weathered bedrock range from 12 to 20mbgl, with strike yields between 0.1 to 1.0 l/s. Water interceptions in the shallow fractured bedrock occur at 20 to 42mbgl with strike yields between 1.0 to 10.0 l/s. With these considerations in mind, a depth of 3mbgl shall be set as the level with the highest risk of groundwater contamination. The option with the greatest depth to groundwater shall be chosen as the best location for the TSF.

#### **6.4. Aspects of the Biological Environment**

##### **6.4.1. Fauna**

###### *Rating*

1 = Highly Unsuitable – Area inhabited by protected fauna and their habitat

2 = Unsuitable – Area visited by protected fauna

3 = Acceptable – Area with few species of concern that could find habitats elsewhere

4 = Suitable – Disturbed area without species of special concern or their habitat

5 = Highly Acceptable – Bare area which does not inhabit any fauna nor their habitat

The rating of 1 (highly unsuitable) is given to an area that is habituated by faunal species of concern/protected species which need to be protected while the rating of 5 (highly acceptable) will be allocated to an area that is fully degraded and has no fauna or can be used by any faunal species.

##### **6.4.2. Flora**

###### *Rating*

1 = Highly Sensitive – The area is pristine with no interference of human activities and is dominated by indigenous and protected species

2 = Sensitive – The area looks natural with few indigenous and protected plants

3 = Moderately Sensitive – Area still natural with no protected plant species

4 = Low Sensitive – The area has few scattered plant species

5 = Very Low Sensitive - The area is dominated by alien invasive plants

The rating of 1 (highly sensitive) is given to an area that is still natural and falls under the critical biodiversity that is of highly concern, whereas the rating of 5 (very low sensitive) will be allocated to an area that is fully degraded due to human activities and therefore it does not contain species of concern/ protected.

## **6.5. Social and Cultural Aspects**

### **6.5.1. Community Considerations**

#### *Rating*

1 = Highly Unsuitable – Area immediately adjacent or within very close proximity to high residential / developed areas

2 = Unsuitable – Area within close proximity to high residential / developed areas

3 = Acceptable – Area within close proximity to residential / developed areas but not in direct contact with the community in question

4 = Suitable – Area distant from any residential / developed areas and not in direct contact with the community in question

5 = Highly Acceptable – Area very distant from any residential / developed areas and with no contact whatsoever with the community in question

The general distance of any site from residential or developed areas shall be considered as directly proportional to the potential of that particular option to have an impact on the community in question. Therefore a site which has very limited chances of interacting with a present community or development area shall be awarded a risk rating of 5, highly acceptable while an area within close proximity of a residential / development area shall be the least favourable option.

### **6.5.2. Heritage Considerations**

#### *Rating*

1 = Grade 1 – Areas with heritage or cultural features of very high significance where conservation is a must by way of national site nomination

2 = Grade 2 – Areas with heritage or cultural features of very high significance where conservation is a must by way of provincial site nomination

3 = Grade 3 – Areas with heritage or cultural features of high significance where mitigation may be partially recommended or not recommended at all

4 = Grade 4 – Areas with heritage or cultural features of medium to high significance where mitigation and recording may be recommended before destruction

5 = Ungraded – Absence of any features of cultural or heritage importance

Site significance classification standards prescribed by the South African Heritage Resources Agency (2006), approved by the Association for Southern African Professional Archaeologists (ASAPA) for the Southern African Development Community (SADC) region, will be used in determining the site significance for both TSF Options.

This chapter determines the risk associated with the construction of a tailing storage facility either on site 1 or 2. This will results in determine which site is more suitable for placing the TSF.

CONSIDERATIONS					ALTERNATIVE SITES				
Parameter	Required Parameter Weighting	Sub-Parameter	Indicator	Indicator Weighting Factor (W)	Site Ranking (U)		Weighted Ranking (WxU)		Comments
					Option 1	Option 2	Option 1	Option 2	
Economic Issues	10%	Capital Costs	Earthworks (starter walls, drains etc.)	3					TSF Site 1 has been estimated to cost at least R88 300 000.00 according to the prefeasibility study that was conducted for the site in 2014.
			Decanting system						
			Return water system						
			Existing services						
			Pumps and fittings						
			Surface rights						
			Alternative land use						
		<b>Sub-Parameter Value</b>				<b>3</b>	<b>2</b>	<b>9</b>	<b>6</b>

		Annual Operating Costs	TSF	7					According to a Trade-Off study conducted by the mine in 2013, the operational cost per annum for TSF 1 is R31, 000, 000.00. This figure is after a calculation for 2015 at an escalation of 10% per annum. This means that it would cost less to operate a TSF on Location one than it would on Location Choice Number 2.
			Tailings Pumping Costs						According to a Trade-Off study conducted by the mine in 2013, the operational cost per annum for TSF 1 is R37, 700, 000.00. This figure is after a calculation for 2015 at an escalation of 10% per annum. This means that it would cost less to operate a TSF on Location one than it would on Location Choice Number 2.
		Sub-Parameter Value			3	2	21	14	
		<b>TOTAL SCORE</b>					30	20	
		<b>SITE RANKING</b>					2	1	
Aspects of the Physical		Topography	General shape of terrain	5					TSF site 1 lies on a generally flat slope that is more suitable

<b>Environment</b>	35%		Height difference between lowest and highest ground level under tailings deposit						for the construction of a tailing dam.	
			Gradient across site						TSF site 2 is located on a kopje / hill and is thus undulating. The slope of the area is approximately <40%.	
		<b>Sub-Parameter Value</b>				5	3	25	15	
		Geology	Presence of geological features	10						TSF site 1 lies on highly weathered and thick colluvium soil. Water can easily percolate the soil which can lead on the collapse of the dam
			Competency of foundation (depth, permeability, shear strength, thickness, type of rock)							TSF site 2 has thin colluvium soil. Construction on this area will ensure that the TSF is more stable as it will be built on rocks that will lead to a strong foundation of the TSF
			Soils							
			Potential for acid mine drainage							
		<b>Sub-Parameter Value</b>				3	5	30	50	



									groundwater elevations are highest (1220mamsl) on Rietfontein 2KS. This is because of the presence on the Karoo underlying the site.	
		<b>Sub-Parameter Value</b>			3	5	30	50		
		<b>TOTAL SCORE</b>						115	155	
		<b>SITE RANKING</b>						1	2	
<b>Aspects of the Biological Environment</b>	35%	Fauna	Presence of threatened or endangered species of fauna	15					TSF site 1 has previously been disturbed through agricultural activities. Many plant species has been removed (though some currently growing back). This has led to the displacement of fauna as their source of food and habitat is removed.	
									The area is still intact and presents more habitats for fauna and their food sources.  The construction of the TSF on this site may not present a challenge to animals as habitat can be found in the surrounding	

								areas	
		<b>Sub-Parameter Value</b>			<b>4</b>	<b>3</b>	<b>60</b>	<b>45</b>	
		Flora	Presence of sensitive species of flora	20					TSF site 1 has a high number of marula and leadwood trees, of which they will have to be removed should this area is approved for construction of the TSF. Under the NEMBA, 2004 these trees are protected and may not be removed or cut except the proper licence is acquired.
									Though the TSF site 2 looks intact, no protected tree was located during the ecological assessment and also the site walks conducted by TECC team.
		<b>Sub-Parameter Value</b>			<b>4</b>	<b>3</b>	<b>80</b>	<b>60</b>	
		<b>TOTAL SCORE</b>					<b>140</b>	<b>105</b>	
		<b>SITE RANKING</b>					<b>2</b>	<b>1</b>	

Social and Cultural Aspects	20%	Community Considerations	Direct presence of community in project area	10						<p>TSF site 1 is located within 170 meters from Masodi Community. The construction of the TSF on this location will have major health (caused by dust and smell) impacts on the community.</p> <p>Noise and vibrations will easily be felt by the community during construction period and also should there be spillage, it will easily reach the community.</p> <p>Visually the TSF will have an impact on the community and also by-passers who are driving on the R 518 road.</p>
			Potential for dust, noise and other construction or operation nuisances to impact on the communities							
			Proximity of the TSF to local communities							
			Visual impacts and Impact of the land use changes on the sense of the community							
			Noise and							<p>TSF site 2 is located approximately 1.1 kilometres away from Hlongwane /Tshamahansi community.</p> <p>The location of the TSF will be minimal. This is because the TSF will be shadowing the kopjes/hills that are within the</p>

			vibrations						area.	
		<b>Sub-Parameter Value</b>			1	4	10	40		
		Heritage Considerations	Presence of archaeological remains	10					No heritage artefacts could be located on TSF site 1.	
									Signs of an old smelting site, clay pots making and a wall were located approximately 200 meters away on the south-eastern side of TSF 2.	
		<b>Sub-Parameter Value</b>			5	4	50	40		
		<b>TOTAL SCORE</b>					60	80		
		<b>SITE RANKING</b>					1	2		
<b>TOTAL COMBINED SCORE</b>								345	360	
<b>COMBINED SITE RANKING</b>								1	2	

Public participation is key to communication of the proposed project and provides an opportunity to the public to comment over the proposed project scope. Tshikovha Environmental and Communication Consulting believe public participation must be inclusive, empowering and clear on specific discussions. The proposed project is part of the Environmental Management Programme compiled by Digby Wells and the approach we used was to stick to the same stakeholders and expand to authorities.

The approach followed was as follows:

Placing of Documents in the following Public places on 07 May 2015:

- BALOYI (Mafanela Driving School)
- MATJEKE (Hlamalani Stadium)
- HLONGWANI (Dumazi Primary School) and (Makgalane Shop-Vice).
- MZOMBANE (Mobile clinic)
- KGOBUDI (CLO Office)
- MASEHLANENG (Taxi rank and Traditional Council)
- MASODI (Taxi Rank)
- MADIBA (Community Office)
- MAGONGOA (The Pulse)

The advert for the proposed project was advertised in the local newspaper Noordelike Nuus on the 14 May 2015 (Appendix B). The list of stakeholders has been attached in the appendices. Personalised letters were sent to all the stakeholders in the letters (Appendix C).

During the public participation process comments received were few

	Comment	Response
	SAHRA should be consulted when the graves that were identified during the Environmental Management Programme are to be removed and all mitigation measures should be submitted to	PGS is responsible for the process and will be advised to follow correct process

	SAHRA	
	<p>The mine should consider assisting the community with waste water treatment plant to ensure that community water is purified properly</p> <p>The current situation on water quality in the community is not good for human consumption and that cannot happen when the mine is able to assist</p>	Tshikovha Environmental and Communication will inform Phillip Ramphisa who is the Environmental Manager to consider the issue with the community and his employers
Lutendo Ndlovu of Department of Environmental Affairs	I am no longer working at Licensing, kindly liaise with Ms Zinhle Mbili	We will contact Zinhle. (Email was sent to Zinhle and no comment was received)
Karin Behr	Dear Pontsho, I have not been involved in any EIA studies before, but will pass it on the section within SANBI that might be able to assist.	Thank you. We will await comments from them
Pfumelani Tsedu	Good day, I Pfumelani Tsedu would like to put the record straight that I have never formed part of such activity. I have forwarded your letter to our operational team whom may have an idea of what you are talking about.	The email was sent to client relation and please send to relevant people
Tswelopele Beetha	Good morning, following our telephonic conversation this	This will be communicated to the mine

	<p>morning i have the following concerns:</p> <ul style="list-style-type: none"><li>• The whole entire village does not have clean running water.</li><li>• Boreholes are put up by those who can afford them.</li></ul> <p>We all use Pit Latrines. so if the mine starts to operate water will be scares and what about the same little water that we have underground becomes contaminated then the whole community will be exposed to diseases and there will be chaos, We need clean water for each and every household.</p> <p>We need proper infrastructure for sewage for all households.</p> <p>What are the social responsibilities of the mine towards the community in terms of the health of the people living in those communities.</p> <p>We request that if these issues are going to be</p>	
--	--	--

	<p>attended to, there must be a time frame as to when are they going to be attended to in my view it is a fruitless exercise to have a mine for 30 years in this community and people will still be living in poverty and their lives are still the same as in 40 years ago. Hope this comments will be considered. Stay blessed and thank you for giving us the opportunity to comment.</p>	
Aubrey (Community Leader)	The mine is ignoring PAJA as the Department of Economic Development, Environment and Tourism has rejected the appeal	There is no relevance in what you mentioning and you need to get the correct letter
Aubrey (Community Leader)	The mine community is angry at the mine as it is obvious that the company is moving the Tailings to option 2 because they do not want them to benefit	Option 2 is a technical decision not personal
Mr Nemukula of WESSA	Timeline must be extended for comment	In view that you were part of the stakeholders at the EMP it is clear you have background of the project and you can comment with allocated timeline

Should there be further comments they will be sent to Department

## **CONCLUSION AND RECOMMENDATIONS**

## **CHAPTER NINE**

Based only on the economic parameters of the position of the tailing storage facility, the capital cost and the operating cost for constructing the tailing storage facility at site 1 is cheaper than site 2. Site two is situated furthest from the mine and as such it is more expensive to construct the pipes to transport sludge including return water than site 1 which is closer to the mine.

Risk assessment for aspects of the physical environment (geology, hydrology and geohydrology) indicated that site 2 is more suitable than site 1 for the construction of TSF. This is because the site 2 is situated on soil that has thin colluvium which leads to stable foundation, the water table being highest due to the presence of Karoo underlying and also the site (2) is far from water sources. With the exception of the topography, site 1 is better than site 2 as it is flat and generally that is the preferred area for construction of the TSF.

The social and cultural risk assessment conducted showed that site 2 has low risks as compared to site 1. Even though that site 2 is located approximately 200 meters away from heritage site the impacts can be minimised or totally avoided on the heritage site as compared to the health and safety issues on the community nearby if TSF is located at site 1.

The overall risk assessment indicates that TSF option 2 scored a total of 360 point as compared to TSF option 1 which scored a total of 345 points. This means that TSF option 2 is more suitable for the construction of the tailing storage facility due to the reasons allocated on the table above.

1. ALLOWAY, B.J. 1995. Heavy Metals in Soils. Blackie. Glasgow
2. ANDERSON, A.J., MEYER, D.R., and MAYER, F.K. 1973. Heavy metal toxicities: levels of nickel, cobalt and chromium in the soil and plants associated with visual symptoms and variation in growth of an out crop. Aust. J. Agric. Res. 24: 557.
3. APAK, R. 2002. Encyclopaedia of Surface and Colloid Science. Hubbard, A. (ed.). Dekker. New York.
4. BANKS, M.K., SCWAB, A.P. & HENDERSON, C. 2005. Leaching and reduction of chromium in soil as affected by soil organic content and plants. Chemosphere, (forthcoming, article in press).
5. BAYTEK, S. and TURKER, R.A. 2005. Determination of Lead and Nickel in Environmental Samples by Flame Atomic Absorption Spectrometry after Column Solid-Phase Extraction on Ambersorb-572 with EDTA. Journal of Hazardous Material, 129: 130 – 136.
6. BERTI, W.R., JACOB, L.W., 1996. Chemistry and phytotoxicity of soil trace elements from repeated sewage sludge applications. Journal of Environmental Quality 25: 1025–1032.
7. BLUSKOV, S., AROCENA, J.M., OMOTOSO, O.O., and YOUNG, J.P. 2005. Uptake, distribution and speciation of chromium in Brassica Juncea. International Journal of Phytoremediation 7: 153 – 155.
8. BRADL, H.B. 2002. Encyclopedia of Surface and Colloid Science. Hubbard, A (ed.). Dekker. New York.
9. BRADY, N.C., and WEIL, R.R. 1999. The nature and properties of soil. Twelfth edition. Prentice Hall.
10. CATALDO, D.A., and WILDUNG, R.E. 1978. Soil and Plant Factors Influencing the Accumulation of Heavy Metals by Plants. Environmental Health Perspectives 47:149-159.
11. CATALDO, D.A., McFADDEN, K.M., GARLAND, T.R., and WILDUNG, R.E. 1988. Organic constituents and complexation of nickel (II), iron (III), cadmium (II) and plutonium (IV) in soybean xylem exudates. Plant Physiology 86: 734–739.
12. CHRISTIAN, G.D. 2006. Analytical Chemistry, 6th ed. Wiley.
13. DIGBY WELLS ENVIRONMENTAL. 2013. The proposed Platreef underground mine EIA/EMP.
14. GOUGH, L.P., SHACKLETTE, H.T., and CASE, A.A. 1979. Element concentrations toxic to plants, animals and man. U.S. Geol. Surv. Bull. 1466:80.
15. HILLEL, D. 1982. Introduction to soil physics. Academic Press, INC. Harcourt Brace Jovanovich, Publishers.
16. KINNIBURGH, D.G., and JACKSON, M.C. 1981. Cation Adsorption by Hydrous Metal
17. MACVICAR, C.N. et al. 1991. Soil Classification. A taxonomic system for South Africa. Mem.Agric. Nat. Resource. S.Afr. No.15. Pretoria.
18. McBRIDE, M.B. 1994. Environmental Chemistry of Soils. Oxford University Press. New York.
19. McMURRY, J. 2000. Organic Chemistry, 5th ed. Brooks/Cole. Thomsan Learning.
20. MORTVEDT, J.J., and GIORDANO, P.M. 1975. Response of corn to zinc and chromium in municipal wastes applied to soil. Journal of Environmental Quality 4:170-174.

21. NÉEL, C., SOUBRAND-COLIN, M., PIQUET-PISSALOUX, A., and BRIL, H. 2007. Mobility and bioavailability of Cr, Cu, Ni, Pb and Zn in basaltic grassland: Comparison of selective extractions with quantitative approaches at different scales. *Applied Geochemistry* 22: 724 – 735.
22. Oxides. In "Adsorption of Inorganic ions at Solid-Liquid Interface. (M.A. Anderson and D.F.J. Rubin, eds.) Ann. Arbor. Sci., Ann. Arbor, MI.
23. ROBSOM, A.D., 1993. Zinc in soils and plants. Kluwer Academic Publishers.
24. SAGNER, S., KNEER, R., WANNER, G., COSSON, J.-P., DEUS-NEUMANN, B., and ZENK, M.H. 1998. Hyper accumulation, complexation and distribution of Nickel in *Sebertia acuminata*. *Phytochemistry* 47: 339–343.
25. SCECHEL, K.G., SCHEINOST, A.C., FORD, R.G. and SPARKS, D. 2000. Stability of layered Ni Hydroxide Surface Precipitates – A Dissolution Kinetic Study. *Geochimica et Cosmochimica Acta*, 64: 2727 – 2735.
26. SPARKS, D.L., 2003. *Environmental Soil Chemistry*. 2nd edition. Academic Press. pp 54, 60, 67, 177, 259.
27. SPOSITO, G. 1981. *Chemistry of Soils*. Oxford Univ. Press. New York.
28. SPOSITO, G. 1984. *The Surface Chemistry of Soils*. Oxford University Press. London, UK.
29. STUMM, W. 1992. *Chemistry of the solid-water interface*. Wiley. New York.
30. VAN DER WALT, H.V.H, and VAN ROOYEN, T.H. 1990. *A Glossary of Soil Science*. Soil Science Society of South Africa, Pretoria.