Contaminated Land Assessment and Remediation Strategy for Anglo Platinum Lease Area, Rustenburg

Anglo Platinum

December 2008
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<th>Revision 1</th>
<th>Revision 2</th>
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<td>Dr J McStay</td>
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1 Terms of Reference

1.1 INTRODUCTION AND PROJECT MOTIVATION

The rapid expansion programmes associated with increased production at Anglo Platinum in Rustenburg has drawn attention to the status of contaminated land and regulatory requirements to provide reporting on the environmental risks posed by historic pollution impacts and measures to be taken to remediate the land ahead of new construction.

Failure to identify contamination issues ahead of project planning can result in delays on implementation of new business activities by slowing down the regulatory authorisation process. In addition new timelines have to be allowed for remediation activities to be completed before any new build can commence.

In the past the clean-up of land contaminated with mine waste residues or leakage of mine effluents has resulted in large volumes of soil being disposed of off-site as hazardous waste. This is a conservative approach and represents a ‘last resort’ which is assured of getting approval from the regulator. It is however an expensive option that is not consistent with the hierarchy of waste management which favours minimisation of waste to landfill.

The Waste Management Bill is in draft for further public consultation at present and there are reliable indications that the Bill will be passed in an amended form into law within the next year.

In the preamble to the Waste Management Bill it states that ‘sustainable development requires that the generation of waste is avoided and where it cannot be avoided, that it is minimised, re-used, recycled or recovered…’

Waste minimisation is a key strategy and it is recognised that ‘waste is a resource and offers certain economic opportunities.’ It is therefore important to recognise any mine residues that may have economic potential as a resource and manage them as by-product and not as a waste material.

The Best Practicable Environmental Option for contaminated land in the mining sector should be site specific and risk-based. Only materials that pose a significant risk of significant harm to the environment or human health should be disposed of as hazardous waste. A number of on-site remediation options need to be developed with simple guidance criteria for regulatory approval and efficient implementation. The use of generic target and intervention levels from various international administrations is not recommended for the long term remediation objectives for an entire mining footprint. These levels often represent a site condition that is fit for all future land–uses, and are based on exposure pathways and human activity patterns that are not consistent with the local conditions or the closure objectives of the mine footprint for future land-use. These criteria should be adopted as a ‘fail-safe’ interim emergency measure for rapid remediation on high priority construction projects only.

There are a series of contamination issues that are not adequately covered in existing environmental management systems presently in use at Anglo Platinum. These issues were discussed at a Workshop with key staff on 4 March 2008 in Rustenburg.

Key areas of concern were identified:

- Define status of contamination. There is a need to evaluate the entire lease area and to identify and prioritise areas which are likely to require remediation now and into the future. There is a historic legacy of mining that has impacted on the land and the water resource, and a legal requirement to address contamination issues, which
attracts regulatory attention during the authorisation process. There may also be re-licensing applications and directives issued that may result in legal requirements to undertake remediation activities to prevent pollution.

It is acknowledged that mine closure planning is based on a 60 year life of mine and that remediation activities are thus likely to be triggered by business expansion programmes rather than closure plans. There is a need to clearly define what constitutes contaminated land in the context of the lease area and to negotiate site specific clean-up objectives and target levels for contaminants of concern with the regulators. At present it is recognised that certain soils could be termed highly contaminated with a high risk profile that require treatment and or disposal but there are also areas of low level contamination that need to be properly assessed, classified and ‘signed off’ as acceptable to remain on-site. It is necessary to address these issues in a spatial context, as space for stockpiling and treatment is limited and to identify opportunities for re-processing as a by-product, and re-use as bulk fill of soil materials.

- Chemical spills and accidental releases. On-going activities that pose a risk of contaminant release to the environment require a protocol for remediation. Although the initial emergency response activities on site are probably adequate for immediate minimisation of the hazard to human health the long term environmental clean-up protocols are under developed. Evaluation of remediation options for hydrocarbon spillages is typical of the activities that need to be addressed.

- Closure planning. Although not an issue of immediate concern the remediation of contaminated land on site has to be developed in a manner consistent with the closure plans for the lease area. The risk-based approach to the management of contaminated land is largely based on protecting the quality of land and natural resources (particularly the water resource) for future land use. Remediation objectives are thus closely tied to closure requirements.

- Sources of Contamination

The Workshop noted a series of contaminated areas, which require a risk assessment and a remediation plan.

- Contaminated soils as legacy from previous operations encountered in bulk earthworks for new infrastructure. Often large volumes of soil with relatively low levels of contamination with heavy metals and high sulphate concentrations.

- Hydrocarbon spillages both historic and operational incidents.

- Hazardous wastes from Central Salvage

- Leakage from Acid Plants

- Old Tar Pits

- Area 242: Tailings scavenging project

- Pollution Dam

- Seepage classification Channel and silt build up at return water dams

- Tailings dam erosion

- Existing waste dumps, including Old RAM landfill

- Groundwater contamination plumes associated with contaminated land and waste dumps.
2 Technical Approach

2.1 SOIL AND GROUNDWATER REMEDIATION IN THE MINING SECTOR

The following technical approach has been prepared to develop an assessment of the contamination footprint of the Anglo Platinum Lease Areas, and to develop a remediation master plan together with practical guidelines for implementation of future remediation activities. An overall strategy for contaminated land must be developed with local regulators and we are currently in favour of adopting the contaminated land clauses of the Draft Waste Management Bill within the framework of a voluntary agreement to be negotiated with the three principle government bodies: Department of Mineral Affairs and Energy, Department of Environmental Affairs and Tourism, and Department of Water Affairs and Forestry.

It is clear that at present that there is considerable uncertainty amongst regulators on the implementation of remediation plans in the mining sector and it thus important to take a proactive lead in developing a strategy that meets the aims and objectives of the Waste Management Bill. The strategy should aim to provide a consistent approach, which defines a sustainable benchmark that represents a long term commitment to best international practice and satisfies Anglo Platinum’s company vision and environmental standards. The practical outcome of such a strategy should be to reduce timeframes on re-development of contaminated sites and to accurately predict and control remediation costs.

2.2 CONTAMINATED LAND - OVERVIEW OF KEY CONCEPTS

- The discussion that follows is a rapid overview of key constraints and opportunities that need to be understood in order to develop a consistent, cost effective and sustainable approach to remediation.
- Below are the Frequently Asked Questions we encounter when dealing with remediation issues.
- ‘What is Contaminated Land?’

According to the Waste Management Bill, ‘contaminated’ in terms of the Act ‘means the presence in or under land, site, buildings or structures of a substance or micro-organism above the concentration which is normally present in or under that land which substances directly or indirectly affect or may affect the quality of soil or the environment adversely’

This is a somewhat broad, catch-all, definition. Points of differentiation can be recognised and need to be defined. There are natural background levels of commonly occurring trace compounds in soil that can be used to define the status of contamination. The soil quality requirement suggests that remediation should be related to land use and be deemed ‘fit for purpose’ and protection of the environment in its broadest sense.

- ‘Is the Site Contaminated?’

According to the Waste Management Bill the site activity is regarded as high risk, with large quantities of potentially hazardous substances in stockpile or as wastes generated during production. Sites such as the Anglo Platinum Lease Area will be defined as contaminated until proven otherwise. Assessment reports need to consider

- whether the contamination has already caused harm
The substances are toxic, persistent, bioaccumulative, or are present in large quantities or high concentrations
- there are exposure pathways
- the uses of the land and land adjoining increases the risk of harm
- the substances have migrated or are likely to migrate
- the acceptable exposure for human and environmental receptors has been exceeded
- any standards set by the Minister or MEC have been exceeded.

All of the above require definition and raise the key questions to be addressed.

- Has the contaminated already cause harm?
  
  A straightforward question, but important to understand in the context of long term residual contamination that is slow to migrate but requires eventual clean-up to achieve long term land use objectives. Remediation projects thus tend to be reactive to emergency incidents of accidental release, where the environmental harm is immediate and obvious, and remediation is proactive and precautionary when dealing with legacy contamination.

  ‘Harm’ is unfortunately governed by perceptions and thus becomes a point of argument with regulators and neighbouring communities. ‘Risk’ for the proponent can be one of legal compensation for actual damages, legal compliance and dispute with regulators, or reputational risk to the business at a local or international level.

- Are the substances harmful?

  Heavy metals are persistent environmental toxins and therefore can be harmful to all forms of receptors at threshold concentrations in soil, water or air.

  Organic contaminants are environmentally persistent to varying degrees. Chemical and biological decay may occur and can be enhanced.

  Contaminants in large quantities and high concentrations. The most important issue facing Anglo Platinum is the high level of salts, particularly sodium sulphate impacting on the site footprint. Although non-toxic to human health the levels of sodium sulphate pose a risk to soil quality as a growing medium and provide a source of soluble salts that has a major impact on the quality of surface water and groundwater.

- Exposure pathways and receptors

  The most important theoretical component of risk-based remediation planning involves the development of the exposure model for the different receptors. This is dealt with in detail in Section 5. In simple terms certain contaminants are either highly immobile and remain concentrated at source and pose no significant risk of harm, or are mobile in the natural environment and pose a risk to various environmental media : soil, surface water, groundwater, air. The receptors can be human or ecosystem based, specific to the level of individuals or species and can even be related to corrosion potential of concrete structures.

- Land Use

  The land use defines the relevant receptor activity patterns and can be applied for the existing scenario and for future planning. The land use nominated in the Closure Plan would provide the motivation for remediation objectives to be set and met. There are fundamental differences in permissible levels of contaminants in soil that can be related to particular forms of land use. It is usually the lowest acceptable risk level of a particular contaminant in relation to land use that defines the risk of harm and thus sets the soil remediation target for clean-up actions. Different exposure scenarios will
generate very different safe target levels. Do not expect standards developed on the basis of aquatic toxicology (e.g., ARLs in DWAF ‘Minimum Requirements’) to be fully protective of human health, similarly human health based targets are not applicable for water resource management purposes.

Migration of contaminants

In the context of Anglo Platinum Rustenburg Lease Area the migration of soil contaminants, wastes and effluents to surface water and groundwater has to be assessed and properly understood. Off-site migration of contaminants on to neighbouring properties is a significant liability issue and is usually the trigger for regulatory intervention or third party claims and litigation. Although mainly considered to be a soil to water resource migration problem, migration of dust by airborne dispersion could be significant on the scale of Lease Area and is a pathway that needs to be assessed.

Acceptable Exposure Levels

At present there are no South African guidelines or standards available for the assessment of contaminated land, or the enforcement of existing legislation pertaining to soil pollution. The approach followed to date is either to adopt an appropriate international standard or to calculate site specific risk based exposure levels and then motivate the remediation criteria with the regulator and stakeholders. It is a fallacy that any particularly international guidelines have been adopted by South African regulators as best practice or have been issued as legally binding compliance criteria other than when specifically motivated by the proponent of a remediation plan.

It is anticipated that South Africa will eventually produce guidelines. These will be risk-based, receptor specific and land use related.

As Anglo Platinum Lease Areas can define its core contaminants of concern at source, can define its exposure pathways and receptor activity patterns and has clear Closure Plan objectives for future land use a series of soil contamination target values can be developed that meets the requirement of sustainability as envisaged in NEMA and would be compliant with the Draft Waste Management Bill.
2.3 ANGLO PLATINUM ENVIRONMENTAL VISION AND OBJECTIVES

The approach to remediation masterplanning should be consistent with the vision, objectives and company philosophy, and should follow the same general concepts as outlined in the site closure plan.

Anglo Platinum – Rustenburg Operations will aim for a sustainable post closure environment that is not harmful to the Safety and Health of surrounding communities or the environment.

Ensure adherence to local, provincial and national regulatory compliance (third party liability and corporate legal).

To develop landforms and land uses that are stable, sustainable and aesthetically acceptable on closure.

Achieve agreed quality targets set by CMA/DWAF as far as practical relative to impacts and reasonability to achieve.

Contaminated soils will be treated/disposed/remediated in-situ, in consultation with the authorities, to meet the requirements of final land use plan, without unduly negatively impacting on the health of surrounding communities or impacting on local ecology.

2.4 BEST PRACTICABLE ENVIRONMENTAL OPTION

The remediation strategy selected for a particular contamination concern should provide an appropriate level of environmental protection but also be practically achievable at an acceptable level of cost. A best practicable environmental option (BPEO) should be determined for all potential remediation activities.

Technical practicability needs to demonstrated, this should include the immediate health and safety requirements that need to be met. Some situations result in contamination levels that cannot be satisfactorily remediated and a state of technical impracticability results (the US EPA uses the term TI waiver, to classify the status of sites that cannot be cleaned-up to pre-determined target levels and requires custodial care and measures such as isolate control and monitor to be put in place).

Short medium and long term environmental objectives need to be assessed on the basis of sustainability. The removal and disposal of contaminated soil is often favoured as a simple fast-track method of meeting short term remediation objectives. Longer term environmental impacts are often not assessed as the disposal site may be on off-site facility and thus the duty of care for the contaminated material has been transferred to a third party.

2.5 SUSTAINABLE REMEDIATION

The concept of sustainable remediation implies an entirely positive environmental impact with removal of environmental risk and no legacy contamination and with no landfilling. This involves assessing the wider environment. A typical feature would be using a carbon calculator to assess the carbon emissions associated with different remediation options. Techniques which favour in-situ chemical treatment, bioremediation or monitored natural attenuation are the most favoured form of sustainable remediation. Long timeframes for sustainable remediation may be an advantage in achieving remediation target values and thus could find acceptance within the mining sector.

It is important to be able to deal with actual risks rather than perceived risks and to aim for substantial betterment of a situation (ie reduction of risk) rather than absolute remediation.
3 Contaminated Land - Hotspots

Large sites tend to have a relatively diffuse ambient level of contamination usually associated with dust migration in addition to the natural background level of soil constituents. In mining areas the natural ground is anomalously enriched in certain metals as a result of the geological conditions that gave rise to the ore-bodies that are mined. High natural backgrounds are to be expected and should not be regarded as contamination.

Areas with high concentration or high quantities of contaminants are referred to as ‘hotspots’.

Soil quality in some areas may be affected by contamination arising from mining and processing activities. It is likely the disposal of processing residues and effluent has had the largest impact on soil and groundwater but it is suspected that contamination is present at mine shafts, waste rock dumps and tailings facilities.

Contaminants of concern

- Metals from mined ore – nickel, copper, zinc and other heavy metals.
- Salts from processing activities – sodium and calcium sulphate
- Acid spillage and leakage of sulphuric, hydrochloric and nitric acid and their secondary salts.
- Leakage and spillage of petroleum and diesel
- Airborne dispersion of sulphur dioxide
- Hydrocarbon residues in the tar dams

The following ‘hotspots’ are identified in the Closure Plan and are summarised below:

3.1 RPM-R SHAFT AREAS

The accumulation of mining process water in shafts and workings is the main source of contaminants entering the subsurface. The excess water has a high suspended solid load and is termed shaft bottom sludge. The sludges often are acidic with high salt levels, elevated heavy metals and hydrocarbon residues. The shaft bottom sludges pose a risk to deeper rock aquifers in the underground workings and can contaminated surface soils, surface water and shallow groundwater when disposed of at surface in shaft sludge ponds.

The ponds are un-lined and could be generating leachate. Dry sludges are stockpiled on the open veld adjacent to the dams.

These wastes require proper waste handling and storage facilities to minimise impacts to soil and groundwater. The impacted ad-hoc storage facilities may require remediation.

Waste rock dumps should not normally be regarded as soil contamination ‘hotspots’ as these materials are comparatively inert and there is no significant risk of acid mine drainage developing in the rock dumps.

Old or off-spec’ explosives are destroyed by controlled burning at a dedicated burning ground at each saft, the burning ground ash may result in soil and groundwater contamination.

Groundwater associated with underground workings is likely to be contaminated to varying degrees. The requirement for remediation should be based on the risk of
contaminant migration via the groundwater to productive aquifers or to surface water bodies.

Redundant shafts are present and may have similar issues to those associated with the working shafts.

### 3.2 RPM-R CONCENTRATORS

The concentrators generate an underflow sludge that goes for disposal to the tailings dams. Contamination of soils results from spillages and accidental release and from temporary stockpiling of wastes. Frank Concentrator has been identified as a ‘hotspot’ in terms of heavy metal contamination via accidental release. Other concentrators may have salt contamination problems.

Waterval and UG2 Concentrators are within 50m of the Klipfonteinspruit water course and thus have a relatively short migration pathway to the aquatic receptor environment and thus can be regarded as high risk contamination sources.

### 3.3 WATERVAL SMELTER

The smelter produces slag as a waste product. The re-processing of a portion of the slags release SO\(_2\) gases and particulates to the atmosphere. There is likely to be a build-up of sulphates and metals on adjoining land. Temporary material stockpiles and accidental release may also result in soil contamination. The site is within 100m of the nearest water course. The facility is presently operated by a third party and is considered to be a legacy issues to be dealt with a mine closure.

### 3.4 RUSTENBURG BASE METAL REFINERY

Sodium sulphate is generated by a by-product of the refining process. Historically the sulphate was stored in encapsulation dams. Significant soil contamination occurs around the sodium sulphate plant. Heavy metal and salts are associated with solid and liquid waste storage areas.

The site is situated approximately 100m from the nearest water course.

### 3.5 PRECIOUS METAL REFINERY

The process generates acid and alkaline effluents which are disposed in evaporation ponds. Spillages and accidental release of effluents and seepage from both lined and unlined dams are considered to pose a contamination risk. Due to the high value (high PGM content) of the process liquids strict controls are applied and the volume of accidental discharge is very limited.

The facility is situated within 100m of the nearest water course.

### 3.6 TAILINGS DAMS

There are four tailings dams presently in operation:

- Hoedspruit tailings dam – active dam receiving tails from WLTR plant and from Klipfontein Concentrator
- Paardekraal Tailings Dam – active dam receiving tails from all concentrators except Klipfontein. This dam also receives slag from the smelter.
- Waterval dams. No longer active as tailings dams. Builders rubble has been disposed off on the eastern dam. Re-mining the residues may occur in future.
Klipfontein Tailings dam – no longer in use and is being re-processed. The facilities may cause contamination by runoff from slopes, by overtopping the pool, by overtopping of the return water dams, or by seepage to groundwater from the tailings dams and the return water dams.

3.7 OLD TAR PITS

During road construction unused tar was disposed of in three tar dams located within the Klipfontein Concentrator. Tar in two dams to the north of the concentrator have been removed. These coal tar derivatives are highly toxic but tend to be relatively immobile and thus the impacts tend to be of limited extent.

3.8 GENERAL INFRASTRUCTURE

There is always a risk of spillage and accidental release associated with road and rail infrastructure, including fuel storage areas and maintenance workshops. There are thus a number of smaller ‘hotspots’ that may exist throughout the mine lease area.

4 Existing and Future land use

The existing status quo for land use can be termed mining and associated industrial processing. It is however important to note that the mine is part of an integrated community and that there are residential communities that surround the working areas and thus define a receptor activity pattern that needs to be evaluated in order to determine target levels for contaminants. The main exposure pathway would be cumulative exposure to dust, with inhalation being the key mechanism of exposure. It is wrong to assume that the effects field of the contaminated footprint only impacts on mine workers who can be protected by wearing of appropriate protective clothing. The exposure concentrations in ambient air in the adjacent residential communities would define a point of compliance for human health based risk assessments.

With an extended life of mine remediation projects need to establish interim risk based criteria but where possible these criteria must acknowledge the proposed future land use of closure to be regarded as environmental sustainable.

For the purpose of closure planning the following categories of future land use have been considered:

- informal agriculture – grazing livestock
- formal agriculture – crop production
- green belt – ecological reserves
- no development zones

It is possible to consider that these proposed land uses as the basis for determining potential risk to human and environmental receptors. As the expected human settlement patterns associated with the mine footprint is very low density it is likely that direct exposure to soil borne contaminants is very low. Inhalation and dermal contact with particulate releases from non-vegetated soil areas would be the primary route of potential human exposure, with secondary ingestion of contaminated crops or meat from grazing animals also representing potential pathways to be considered.
Protection of the water resource is dependant on receiving water quality objectives now and into the future. As water resources are a limited finite natural resource there is already considerable water demand from users. At present this is manifest on allocation of water by volume but in future water quality may be as significant to terms of water resource policy and enforcement.

Before proceeding to develop the land use based soil quality issues which may form the basis of a remediation masterplan it is necessary to critically evaluate the status of water resource protection and its importance in remediation planning.

5. Water Resource Protection

The most contentious issue in the development of a remediation masterplan for a large mine footprint is understanding the relationship between contaminated soils, other solid wastes and mine residues and water quality in surface water and groundwater.

The legislation in the National Water Act is clear on the Duty of Care responsibility on the prevention of pollution. Remedial activities required to prevent pollution and remediate water quality and enforceable by directive or can be conditional to water use licenses. These statuses are often cited in risk analysis to be the driving mechanism for remediation projects, ie an illegal activity that would cause statutory risk of closure, associated financial loss and reputational damage.

The legal definition of pollution in terms of triggering a regulatory intervention in South Africa is not well defined by means of actual legal precedent and unfortunately has become a matter of scientific contexture and legal uncertainty. This state of affairs has arisen by the lack of progress in achieving detailed water quality objectives for the various regional catchments and establishing the reserve for protection of the water resource.

DWAF has issued a draft Integrated Water Use License for the Anglo Platinum Rustenburg Lease Area. Although this documentation is likely to receive further review and amendment from both parties there are elements to the IWUL that are relevant.

Remediation objectives for the clean-up of soil or groundwater that are based on the protection of the water resource need to be consistent with the general water quality standards required for the surface water catchment at local and regional level. No double standards should exist between the management of diffuse contaminant discharge and the so-called ‘end of pipe’ discharge consent criteria for effluent release to surface water bodies.

DWAF discharge standards are highly generic and are generally stipulated as General Authorisation or Site Specific Standards for more sensitive or impacted receiving water bodies.

Table 1 - The compliance criteria for discharge to surface water applied by DWAF General Authorisation are listed below together with the preliminary receiving water quality objectives for the Hex River. Contaminants of concern are highlighted.
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</tr>
<tr>
<td>Cyanide</td>
<td>mg/l</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Iron</td>
<td>mg/l</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/l</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Lithium</td>
<td>mg/l</td>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td>Manganese</td>
<td>mg/l</td>
<td>0.4</td>
<td>0</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/l</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>mg/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Selenium</td>
<td>mg/l</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>Silica</td>
<td>mg/l</td>
<td></td>
<td>0-5</td>
</tr>
<tr>
<td>Uranium</td>
<td>mg/l</td>
<td></td>
<td>0-0.1</td>
</tr>
<tr>
<td>Vanadium</td>
<td>mg/l</td>
<td></td>
<td>0-0.1</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/l</td>
<td>5.0</td>
<td>0.3</td>
</tr>
<tr>
<td>Chemical oxygen demand</td>
<td>mg O₂/l</td>
<td>75</td>
<td>30</td>
</tr>
<tr>
<td>Dissolved organic carbon</td>
<td>mg C/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissolved carbon</td>
<td>% saturation</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Oxygen absorbed</td>
<td>mg/l</td>
<td>(N/80 KMnO₄)</td>
<td>10</td>
</tr>
<tr>
<td>Phenols</td>
<td>mg/l</td>
<td>0.1</td>
<td>0.01</td>
</tr>
</tbody>
</table>

The preliminary receiving water quality objectives were listed on the basis of the most stringent water quality criteria for a variety of water uses including aquatic ecosystem protection, drinking water, livestock watering, irrigation, industrial use and aquaculture. This approach although stringent cannot be regarded as scientifically valid for assessing the water quality the Hex River water course. Nor is it entirely compatible with either the general or special standards for effluent discharge. Specific receiving water quality objectives have thus been determined by DWAF for the more common contaminants and are highlighted.

In Annexure 4 of the Water License Interim Resource Objectives and Standards are presented. The Preliminary Management Class of the Hex River is presently rated as...
being Class D - Poor, ie an unacceptably degraded resource. The target for water quality would be to raise the standard to Class C by improving the ecological status of the water course, which presently poor for macro-invertebrates and fish.

The water quality of the largest surface water resource on the lease area and recommended receiving water quality objectives provides a theoretical point of compliance which can be used to model risk to downstream water users. The fate and transport of soil contaminants to the water course via surface run-off, seepage via groundwater and sediment erosion can be used to derive multi-media mass balance equations from which safe soil contaminant levels for achieving compliance with water quality objectives can be derived.

At present we would regard the receiving water quality objectives for the Hex River as potentially too conservative given the volumes of flow and the frequency of drought conditions. The relationship between seasonal flow and water quality needs to be established before a realistic carrying capacity can be established for this semi-perennial system.

4.1 GROUNDWATER RESOURCES

The consensus developed from all the specialist studies that consider impacts on the groundwater resources is that there are no groundwater users on site or within close proximity of the site boundary. This hydrocensus needs to be reviewed and updated from time to time but at present it is a reasonable assumption to conclude that despite soil contamination and groundwater pollution incidents there is a low priority for remediation of groundwater on this site.

4.1.1 The conceptual groundwater model

The conceptual hydrogeological regime is made up of three aquifer units. The first water table encountered is a unconfined to semi-confines system that occurs in the soil cover and the upper weathered zone of fractured rock and occurs at depths between 5m and 25m below the ground surface. There is a deeper fractured rock aquifer unit where groundwater flow occurs along major joints and fault zones. Yields are not known with certainty and relatively few boreholes have been drilled to intercept the deep fracture flow.

At locations close to the Hex River and other non-perennial streams there are porous alluvial deposits which are from 2m to 15m in thickness and these form local primary aquifers of limited extent.

The overall ambient groundwater quality in the shallow aquifers is good but salinities are naturally quite high with magnesium and bicarbonate being the dominant or signature ions in the groundwater. In the deeper aquifers the natural salinity is much higher and major and trace element concentrations are high. This is indicative of a low flow regime where the volume of groundwater is relatively low and the system is controlled by long residence times in the rock formation. This favours a dissolution equilibria to be established with the soluble components of the rock. Pollution plumes are noted in proximity to shafts, this is because of rapid transport of contaminated water into the deeper fractured rock which has a low capacity for dilution. Thus relatively low volume releases of contaminants have a distinctive impact on the chemistry of groundwater in the boreholes. Much of the deeper groundwater may be static or stratified in the monitoring boreholes and water chemistry is often an artefact of sampling.

Despite the number of monitoring boreholes installed at Rustenburg mine lease areas there is a need to establish a comprehensive and scientifically based monitoring programme.
The most common problem associated with integrating groundwater monitoring is that many boreholes are drilled for the purposes of hydrogeological investigation to provide data for various reports and to support permit applications. Some of these boreholes may not provide ideal monitoring boreholes for longer term work and should be sealed and grouted. This is particularly true of low yielding boreholes with stagnant water. Once the flow regime is determined there is little value to be gained from observing the water chemistry in such wells. The chemical signature is too localised with respect to the host rock formation and the borehole construction to be used to provide input to predictive hydrogeological models for regional flow within the aquifer.

In both the upper weathered zone aquifer and the deeper fractured rock aquifer there will be preferential flow paths.

The surface soils consist of low permeability black clays and more permeably red colour clayey and silty sands. In general these soils have high natural attenuation capacity for leachable contaminants. Despite the clay cover materials the effective aquifer recharge has been estimated to be 1.5 to 2% of the mean annual precipitation.

Borehole yields and aquifer pump tests have shown that the areas of deeper weathering have higher conductivities and therefore facilitate higher flow and contaminant transfer rates. Therefore the likelihood of pollution migration via groundwater is greatest in the weathered valleys and should follow the drainage paths of Kilpfontein and Klipgat streams.

Any de-watering exercises will have localised influence on hydraulic gradients and artificial recharge from large wet storage dams is likely to result in artificial recharge and have the most significant control on groundwater flow and water quality in the upper weathered zone aquifer.

4.1.2 Water Quality concerns

The assessment of groundwater pollution impacts in natural aquifers with variable and naturally elevated dissolved components has to be undertaken with care. The overall trends in groundwater quality are summarised below:

- Sulphate is a prominent and widespread contaminant in the base metal processing areas at occurs at the RBMR, Waterval Processing Complex, the PMR, and the Klipfontein Concentrator. Sulphates are present at the tailings facilities.
- Magnesium is the dominant cation associated with the host norite bedrock and is associated with both ambient background and mining related activities.
- Chloride occurs in the groundwater at most of the processing areas
- Nitrate contamination is associated with shaft areas and may be related to explosive residues.
- pH is neutral to basic and heavy metals tend to have a low solubility.

Ambient and contaminated levels in groundwater boreholes

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Typical Background concentration in fractured rock aquifer</th>
<th>Concentration from boreholes likely to be impacted by mining activities</th>
<th>DWAF Discharge Standard</th>
<th>Surface Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium</td>
<td>45 mg/l</td>
<td>120 – 600 mg/l</td>
<td>400 mg/l</td>
<td></td>
</tr>
<tr>
<td>Sulphate</td>
<td>45 mg/l</td>
<td>800 – 1 600 mg/l</td>
<td>200 mg/l</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>60 mg/l</td>
<td>1000 mg/l</td>
<td>100 mg/l</td>
<td></td>
</tr>
<tr>
<td>Nitrate</td>
<td>2 mg/l</td>
<td>38 – 430 mg/l</td>
<td>6 mg/l</td>
<td></td>
</tr>
</tbody>
</table>

In high yielding boreholes in the upper weathered zone and fractured rock aquifers there is some opportunity for developing a reliable source of additional water supply. The ambient quality may be slightly too high to meet all potable requirements but is in general suitable for irrigation needs and could be treated to meet specific processing water requirements. There are boreholes with yields measured to be between 4l/s and 8l/s. These productive boreholes are rare and represent localised water resources and thus need to be properly tested with trial abstraction undertaken to determine the long term sustainable yields.

In the specific context of groundwater remediation there is strong motivation to protect and conserve the groundwater resource once it has been developed for beneficial purposes. The remediation of groundwater in deep aquifers with no direct migration pathway to human and environmental receptors has a low priority and should be discouraged.

We therefore would motivate that integrated remediation planning is undertaken in areas where potentially productive boreholes have been identified so that resource quality protection measures have direct economic benefits, and remediation objectives and quality criteria are consistent with the intended water use. Potable water quality criteria may not be applicable or desirable for all forms of groundwater abstraction and should not be cited as compliance criteria if unwarranted or technically impracticable.

The shallow weathered zone aquifer is generally situated above the underground mine workings and therefore is less impacted and has a higher recharge from meteoric water than the deeper fractured rock aquifer. The shallow weathered zone aquifer is more likely to be impacted by artificial recharge from tailings dams and effluent release. It appears that the uppermost water table is too deep to provide any baseflow to the tributary streams in the catchment.

The migration pathway from groundwater to downstream surface water receptors is considered to be a theoretical concept with no proven link established from either monitoring data or plume models to date.
5 Determination of Soil Remediation Objectives

In terms of the envisaged future land-use planning, agricultural, grazing or general open space land-uses would all be associated with limited direct human exposure to contaminated soils.

As a precautionary approach, however, we consider a scenario in which poorly vegetated soils result in relatively high levels of particulate release and assess safe soil levels for key contaminants of concern based on the assumption that a human receptor resident in close proximity to these impacted areas would represent a worst case exposure scenario. This exposure scenario is thus defined based on exposure via inhalation and dermal contact only.

We have calculated safe levels following international standard best practice guidance for developing risk-based remediation objectives using conservative recommended exposure parameters throughout.

We have included platinum group elements as although these were not identified specifically as contaminants of concern, they are obviously present and an indication of safe levels for protection against particulate inhalation exposure thus needs to be considered.

It is noted that the calculated remediation objectives represent a highly conservative approach based on extended exposure periods. In case of potential human exposures for the proposed land-uses, exposure frequency and duration would be limited to short ad hoc periods whilst on the property and hence the safe levels in terms of remediation objectives could be set above the conservative limits calculated.

### Exposure Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight (kg)</td>
<td>70</td>
</tr>
<tr>
<td>Exp. Frequency (days/year)</td>
<td>350</td>
</tr>
<tr>
<td>Exp. Duration (years)</td>
<td>30</td>
</tr>
<tr>
<td>Soil to Skin Adherence (mg/cm²)</td>
<td>0.14</td>
</tr>
<tr>
<td>Exp. Skin Surface (cm²)</td>
<td>5700</td>
</tr>
<tr>
<td>Dermal Absorption</td>
<td>0.1 (10%)</td>
</tr>
<tr>
<td>Inhalation Rate (m³/hr)</td>
<td>0.83</td>
</tr>
<tr>
<td>Particulate Emission Factor (m³/kg)</td>
<td>$1.07 \times 10^8$</td>
</tr>
</tbody>
</table>

In terms of food chain related exposure routes such as ingestion of crops produced on the site it is assumed that commercial root crop production is not viable on the land and that this is thus not a potential pathway of concern. Uptake of metals associated with crops such as maize or sunflower would not be considered to be a significant issue at the average levels reported for the site, however, salt loading from the effluent irrigation may well be a limiting factor for such activities. Similarly, we would consider impacts to surface water run-off in respect of salt loading to be the primary issue of concern related...
to livestock grazing on the site. In this regard, the DWAF livestock watering guidelines should be applied as remediation objectives.

**Remediation Objectives**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Remediation Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGE Group Metals</td>
<td>mg/kg</td>
<td>2300</td>
</tr>
<tr>
<td>Ni</td>
<td>mg/kg</td>
<td>4500</td>
</tr>
<tr>
<td>Co</td>
<td>mg/kg</td>
<td>100</td>
</tr>
<tr>
<td>Cu</td>
<td>%</td>
<td>3</td>
</tr>
<tr>
<td>Zn</td>
<td>mg/kg</td>
<td>n/a</td>
</tr>
<tr>
<td>Pb</td>
<td>mg/kg</td>
<td>3000</td>
</tr>
<tr>
<td>Cr (VI)</td>
<td>mg/kg</td>
<td>10</td>
</tr>
</tbody>
</table>

6 On-site treatment of hydrocarbon contaminated soils

The motivation for on-site treatment of hydrocarbon spills and leaks has occurred in a number of specialist reports. It would therefore be regarded as a progressive and proactive step to instigate such a facility at least at a pilot scale and apply for a license to remediate soils that are suitable for bioremediation and/or chemical treatment. These include gasoline and diesel but can also include heavier hydrocarbons such as fuel oils, lubricants and tar residues. It is very cost effective to treat small to medium volumes of contaminated soil in a purpose built soil farm or treatment pad, for larger spills the treatment methods are best applied in-situ to reduce the internal haulage costs.

In order to provide an assessment of technical alternatives and select suitable locations and pilot projects will be necessary to investigate and analyse know areas of hydrocarbon contamination. At present there is a knowledge gap on the status of hydrocarbon contamination across the Lease Area, other than the preliminary work that has been undertaken on the old tar pits. Other than acknowledging that there are likely to be areas requiring remediation the total volume and chemical composition of the impacted soils and groundwater is unknown.

Most bioremediation techniques involve mild chemical oxidation under moist condition to encourage microbial breakdown of hydrocarbon molecules as a food source. Addition of organic material as a nitrogen source and to improve soil texture, porosity and aid in moisture retention is commonly applied to increase the natural breakdown time.

It is considered that there may be benefits in using saline sulphate-rich effluent in an aerobic bioremediation process, particular for remediation of diesel contaminated soils.
It is recommended that lined cells for soil treatment are located within close proximity of a suitable water source and preferably on an area of contaminated land.

There are many potential treatment methods available for hydrocarbon remediation and a thorough cost benefit analysis should be undertaken before proceeding with soil remediation. Most commercial approaches for remediation of hydrocarbons are fast track techniques where clean-up is driven by the need to transfer the land without liability to a new owner, or to comply with regulatory directives. At Anglo Platinum Rustenburg it may be cost effective to treat over much longer time periods. Remediation target values are discussed below, at a preliminary stage we would consider that remediated hydrocarbon contaminated soil would be fit for use as a topsoil growing medium and suitable for landscaping particularly on waste dumps.

7 Remediation of Spills and Accidental Releases

In this section we provide a simple protocol for dealing with hazardous chemical spills, and particularly petroleum hydrocarbons.

An immediate requirement is to recover product and prevent contact with surface waters. A petroleum contaminated soil is considered an immediate hazard (and a hazardous waste) when it exhibits any of following:
- Ignitability
- Corrosivity
- Reactivity
- Toxicity – Benzene and organic lead compounds in petroleum are particularly toxic.

5.1.1 Priority and types of response

The status of an accidental release can be categorised as a high, moderate or low impact. Environmental risk and appropriate responses are summarised below:

**High Impact**
- Immediate threat to human health and property
- Where the incident poses a direct threat to a water resource
- Where the incident has the potential to seriously contaminate soil and groundwater
- Where the incident could cause significant harm to native fauna and flora
- Where the incident creates an immediate observable harm to environmental receptors
- Any chemical spill exceeding 10 000 l.

Immediate response and notification, a remediation function, environmental monitoring required.
Moderate Impact

- Significant, but not immediate, threat to human health and property
- Where the incident poses a long-term risk to a water resource
- Where the incident has the long-term potential to contaminate soil and groundwater
- Where the incident may result in chronic or long-term harm to native fauna and flora
- Where the incident creates a long-term risk to environmental receptors
- When a chemical spill is between 10,000 l and 100 l.

Response within 4 hours, regulatory notification within 24 hours, remediation function, environmental monitoring based on effectiveness of response.

Low Impact

- No perceived threat to human health and property
- Where the incident poses no risk to a water resource
- Where the incident poses no risk of soil or groundwater contamination
- Where the incident poses no risk to environmental receptors
- When a chemical spill is less than 100 l.

Response within 24 hours, notification depending on effectiveness of response, no requirement for remediation, no requirement for environmental monitoring.

5.1.2 Remediation of Petroleum Spills

- Excavate contaminated soil in a timely manner.
- Containerise, or place on and cover with high density plastic sheeting (minimum thickness 10mm) and berm area to prevent run-off from the waste pile.
- If soil must be moved for reasons of security or access it must be stored at a permitted landfill, or other acceptable location, until test results are obtained and appropriate remediation authorisation is obtained, alternatively dispose of the soil as hazardous waste.

5.1.3 Site characterisation after removal

- Contaminated soil should be excavated until spill is visibly clean.
- If heavy odours are still present screen the area with a vapour detection/photo-ionisation device, to detect remaining ‘hot- spots’.
- Soil samples should be taken from the spill area. For a large spill take samples from the four corners of the excavation and the middle of the base of the excavation. For trenches sampling density should be one sample per 10m of contaminated length. Samples can be composite if entire soil volume is removed off-site.
- Excavated area should not be backfilled until the residual soil is confirmed as meeting the ‘clean’ soil guideline, as further remediation may be required.
- Temporary backfill measures are advisable if physical hazards are related to the excavations.
5.1.4 Chemical Testing

- **Known diesel release:** TPH - modified diesel range organics (DRO), and BTEXN (benzene not normally >2% for diesel, naphthalene is often an important benchmark contaminant for compliance).
- **Known gasoline release:** TPH - modified gasoline range organics (GRO), and BTEX. Total lead for leaded gasoline.
- **Unknown petroleum product:** TPH – modified DRO and GRO, BTEXN, GC/MS for purgeables/extractables.

5.1.5 Notification – Reportable Quantities

There is no absolute *de minimis* level of concern in existing South African environmental legislation. In general a small spill of less than 100 l of gasoline or diesel may not require remediation, but there may be circumstances which could cause concern, ie a local flammable hazard. For highly toxic compounds even low volume spills could represent a significant risk. For example a PCB spill from transformer insulation oil with a concentration of >50ppm for 5 kg of soil would require appropriate emergency hazard response and regulatory notification.

5.1.6 Remediation of Residual Contamination

After immediate rapid response and there may be residual contamination of soil that may require further assessment and remediation.

In hydrocarbon spills it is important to assess the environmental risk posed by the most toxic contaminants of concern in terms of human health impacts and for protection of the water resource. Where no surface water or groundwater risk is present risk-based soil target levels should be based on human health direct exposure. The inhalation of volatile organic compounds is the most commonly cited exposure pathway.

For disposal to landfill compliance with DWAF ‘Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste’ is required. Safe disposal guidelines based on Acceptable Risk Levels (ARLs) have not been developed for generic DRO and GRO hydrocarbon test results (although revisions are in draft in edition 3 of ‘Minimum Requirements’).

Following general guidance levels for safe disposal can be assumed:

- TPH>1000 mg/kg to be regarded as hazardous waste
- TCLP for TPH<1000 mg/l to delist to general waste category

5.1.7 On-site Remediation

- If it is proposed to biotreat the excavated contaminated soil as an alternative to disposal as waste, or as a pre-treatment prior to safe disposal, a Remediation Plan should be submitted for regulatory authorisation. There is an advantage of developing and licensing a specialised hydrocarbon remediation facility and operating to a pre-agreed set of operational procedures and environmental management plan, and monitoring protocol.
6 Conclusions and Recommendations for Remediation of Contaminated Soils

- This report represents a high level strategic overview of soil contamination impacts associated with the Anglo Platinum Rustenburg lease area. It evaluates environmental risk and proposes preliminary remediation objectives for consideration in the planning of future sustainable remediation activities.

- The most significant environmental risks to the existing environment and intended future land use is due to accumulation of salts, particularly sodium sulphate derived from accidental discharge, leakage and seepage of mineral processing effluents.

- Salt impacts will provide a diffuse source of contaminants to surface water bodies and severely impact on the naturally limited agricultural potential of the surface soils.

- There are minor amounts of heavy metals, including nickel, cobalt and copper that are considered to represent a minor human health risk associated with exposure via inhalation of airborne dust to neighbouring residential communities.

- Safe levels for the contaminants of concern in soil have been determined on the basis of human health risk for the dust inhalation exposure scenario. These target levels are consistent with future land use planning associated with the site closure plan.

- Impacts on surface water and groundwater associated with heavy metal contaminated soil are assessed as being very low in terms of aquatic ecotoxicology, and subordinate to the risk posed by salt contaminants, such as sulphates, chlorides and nitrates.

- Groundwater aquifers are generally low yielding and the background water quality is marginal to poor as a potable resource. Groundwater associated with underground workings and shafts is contaminated by sulphates, chlorides and nitrates. This is due to very low flows and poor recharge (low dilution factors) resulting in near-stagnant conditions in monitoring boreholes.

- Groundwater remediation should be assessed on the basis of resource development and should be concerned with higher yielding fault controlled fractured rock aquifers where sustainable sources of groundwater can be developed for beneficial use.

- There is no indication of a significant migration pathway between weathered zone aquifer or deeper fractured rock aquifer and surface water resources. This pathway should therefore not be considered as a causative risk factor in assessing remediation objectives.

- Hydrocensus studies should be updated on a regular basis to understand the use of groundwater on the neighbouring properties. At present there is no recorded use of groundwater within a 2km radius of the lease area.

- A preliminary protocol for the remediation of accidental spills and releases of petroleum hydrocarbons has been proposed.

- It is strongly recommended that a licensed on-site soil treatment facility is established for the remediation of hydrocarbon contaminated soils.

- The information contained within this document should be regarded as a position paper advising on sustainable remediation policy objectives for dealing with both
legacy contamination and accidental release. Detailed site characterisation and
development of remediation plans in compliance with the soon to be implemented
Waste Management Bill will become the future norm and standard for good practice
in the remediation of contaminated land in South Africa.

Dr Jon McStay
Director

Sean Doel
Technical Director
INTRODUCTION

The rapid expansion programmes associated with increased production at Anglo Platinum in Rustenburg has drawn attention to the status of contaminated land and regulatory requirements to provide reporting on the environmental risks posed by historic pollution impacts and measures to be taken to remediate the land ahead of new construction.

Failure to identify contamination issues ahead of project planning can result in delays on implementation of new business activities by slowing down the regulatory authorisation process. In addition new timelines have to be allowed for remediation activities to be completed before any new build can commence.

Anglo's vision, objectives and company philosophy in terms of contaminated land is as follows:

- Anglo Platinum – Rustenburg Operations will aim for a sustainable post closure environment that is not harmful to the Safety and Health of surrounding communities or the environment.
- Ensure adherence to local, provincial and national regulatory compliance (third party liability and corporate legal).
- To develop landforms and land uses that are stable, sustainable and aesthetically acceptable on closure.
- Achieve agreed quality targets set by CMA/DWAF as far as practical relative to impacts and reasonability to achieve.
- Contaminated soils will be treated/disposed/remediated in-situ, in consultation with the authorities, to meet the requirements of final land use plan, without unduly negatively impacting on the health of surrounding communities or impacting on local ecology.

Anglo Platinum (Pty) Ltd (Anglo) appointed WSP Environment & Energy (WSP) to assess whether a full contamination investigation is required at the Klipfontein and Frank Concentrators prior to decommissioning of the two operations. If it is established that the areas require remediation, then authorisation through a Basic Assessment will be required for the decommissioning. If the areas are contamination to an extent that no remediation is required (within local context), then no authorisation for the decommission phase will be required.

The aim of this report was to establish whether a comprehensive Phase I assessment would suffice, within Anglo’s local context, in identifying contaminated areas of concern at the two concentrators. If contaminated area were to be identified and addressed appropriately through a Phase I assessment, then time required for a Phase II assessment to achieve the same objective would be saved. Therefore, the aim of this report was to move straight from a Phase I site characterisation to Phase II remediation plan should it be needed.

A site visit to both concentrators was undertaken on the 11th of May 2011 during which the current infrastructure was assessed and the visual evidence of significant land contamination was investigated.

BACKGROUND IN TERMS OF CONTAMINATED LAND AND REMEDIATION WITHIN THE ANGLO LEASE AREA

WSP undertook a Contaminated Land Assessment and Remediation Strategy for the Anglo Platinum Rustenburg Lease Area in 2008 (WSP, 2008). The investigation identified issues within the Anglo Lease area in terms of contaminated land
and developed a conceptual framework to address legacy contamination as well as potential future impacts in internationally and nationally appropriate ways.

**Current Situations**

The 2008 investigation (WSP, 2008) identified the following key concerns in terms of land contamination within the Lease Area:

- *The Status Quo in terms of Land Contamination is not defined.*

There is a need to clearly define what constitutes contaminated land in the context of the Lease Area and to negotiate site specific clean-up objectives and target levels for contaminants of concern with the regulators. At present, it is recognised that certain soils could be termed highly contaminated with a high risk profile that require treatment and or disposal but there are also areas of low level contamination that need to be properly assessed, classified and ‘signed off’ as acceptable to remain on-site. It is necessary to address these issues in a spatial context, as space for stockpiling and treatment is limited and to identify opportunities for re-processing as a by-product, and re-use as bulk fill of soil materials.

- *Chemical Spills and Accidental Releases.*

On-going activities that pose a risk of contaminant release to the environment require a protocol for remediation. Although the initial emergency response activities on site are probably adequate for immediate minimisation of the hazard to human health, the long term environmental clean-up protocols are under developed. Evaluation of remediation options for hydrocarbon spillages is typical of the activities that need to be addressed.

- *Closure Planning.*

Although not an issue of immediate concern, the remediation of contaminated land on site has to be developed in a manner consistent with the closure plans for the mine lease area. The risk-based approach to the management of contaminated land is largely based on protecting the quality of land and natural resources (particularly the water resource) for future land use. Remediation objectives are thus closely tied to closure requirements and need to be addressed.

- *Future Land-Uses*

For the purpose of closure planning Anglo considers the following categories of future land use:

- Informal agriculture – grazing livestock
- Formal agriculture – crop production
- Green belt – ecological reserves
- No development zones

In terms of the identified future land-uses, it is envisaged that all uses would be associated with limited direct human exposure to contaminated soils.
Frank Concentrator has been identified by Anglo as a contaminated land ‘hotspot’ in terms of heavy metal contamination via accidental release. It was noted during the site visit that apart from the heavy metal contamination, the concentrator is generally well kept with minor concerns identified (compared to the surrounding activities): The following was identified as concerns:

- Soil pile situated at the bottom of the concentrator premises next to the fence line.

  Visual inspection of the pile suggests that the soil may contain high salt and metal concentrations (precipitated salt was observed in soil lumps removed from the pile). After heavy rains the pile will apply an increased hydraulic head to the underlying soils and groundwater that may promote contaminant migration.

- Hydrocarbon contamination outside the dedicated oil storage bunded area.

  A potentially extensive hydrocarbon spillage occurred from the bund discharge tap. During the site visit, minor leakage was still occurring from the tap. The leakage over time has resulted in a relatively saturated hydrocarbon stain on the soil in an area of approximate 1-2m from the tap. A hydrocarbon run-off stain extends from the saturated area to approximately 5m downgradient. The run-off stain is however not seen as significantly contaminated.

- Suspected hydrocarbon products within the storm water collection sumps situated within the plant area.

  The pump infrastructure in the run-off collection sumps has not been removed and is now submerged. Consequently it seems that oil and other lubricant products have been released from the electrical pumps resulting on hydrocarbon sheens on the water surface.

KLIFPONTEIN CONCENTRATOR

During road construction in the past, unused tar was disposed of in three tar dams located within the Klipfontein Concentrator site. The Klipfontein Concentrator is consequently also classified by Anglo as a contaminated land “hotspot”. Tar in two dams to the north of the concentrator has been removed. However, one is still remaining.

Apart from the tar pit, the site is well kept and very little visual contamination was observed (compared to the surrounding activities). The entire storm water infrastructure that had free standing water in it was free of any discolouration, odour and floating sheens.

Minor contamination issues were identified which predominantly included:

- Minor hydrocarbon spillages from the dedicated oil storage bunded area.

DISCUSSION

There are natural background levels of commonly occurring trace compounds in soil that can be used to define the status of contamination. In mining areas, the natural ground is anomalously enriched in certain metals as a result of the geological conditions that gave rise to the ore-bodies that are mined. High natural backgrounds are to be expected and should not be regarded as contamination.
Further, soil quality requirement suggests that remediation should be related to land use and be deemed ‘fit for purpose’ and protection of the environment in its broadest sense. Assessments should establish whether:

- The contamination has already caused harm;
- The substances are toxic, persistent, bioaccumulative, or are present in large quantities or high concentrations;
- There are exposure pathways;
- The uses of the land and land adjoining increases the risk of harm;
- The substances have migrated or are likely to migrate;
- The acceptable exposure for human and environmental receptors has been exceeded; and
- Any standards set by the Minister or MEC have been exceeded

From the site visit undertaken at the concentrators as well as experience with Anglo and the region, the following can be concluded in terms of the above points.

- **Whether the contamination has already caused harm.**
  
  No records exist stating that any environmental or human health aspects were affected due to the present soil contamination at each of the concentrators. Further, the concentrators are controlled areas within an industrial environment where appropriate personal protective equipment (PPE) and other applicable safety measures need to be adhered to.

- **The substances are toxic, persistent, bioaccumulative, or are present in large quantities or high concentrations.**
  
  Constituents of concern at the Frank Concentrator include heavy metal concentrations due to accidental spillages etc. Potentially hazardous process additives were stored in dedicated bunded areas at both concentrators. All of the storage vessels were empty during the site visit. The bunds were filled with rain water with no leakages were observed trough the bund walls.

  The soil pile situated at the Frank Concentrator may consist of large quantity of soils elevated in salts and heavy metals concentrations compared to typical background soil concentrations.

  Hydrocarbon spillages within the vicinity of the oil storage areas could have potential contamination implications in terms of the underlying groundwater regime.

  Tar derivatives in the remaining tar dam at the Klipfontein Concentrator are highly toxic.

- **There are exposure pathways.**
  
  Possible pathways for soil contaminants from the Klipfontein and Frank Concentrators include dust migration as well as surface water run-off and infiltration to the receiving groundwater regime.

  During the site visit it was noted that concentrate/processed product spillages were predominantly within the process area (thickener and mills). Surfaces in these areas are covered by hardstanding and are also predominantly roofed. In minor instances it was found that small amounts of product were stored in unlined open areas. Therefore, migration of
dust containing high metals concentrations is seen as a limited pathway to the receiving environment due to the fact that potential sources of such dust are sheltered from wind during typical climatic conditions.

Concrete storm water infrastructure is in place at both sites and run-off water reports to the collection sumps in the middle of the process area or in sumps situated on the site boundaries. Bund walls for potentially hazardous additives were in good condition. No seepage of rainwater was evident from the walls and discharge taps were closed and not leaking. All of the bunded areas are constructed on hardstanding.

Areas on the concentrator sites that are not covered by hardstanding will promote run-off water infiltration. However, the surface soils consist of low permeability black clays and more permeably red colour clayey and silty sands. In general these soils have high natural attenuation capacity for leachable contaminants (WSP, 2008).

Nevertheless, the shallow weathered zone aquifer has a higher recharge from meteoric water than the deeper fractured rock aquifer and is more likely to be impacted by artificial recharge from tailings dams and effluent release (WSP, 2008). Therefore, the soil stockpile situated at the Frank Concentrator is seen as the only potential sources of groundwater pollution.

Due to controlled storm water management at the Klipfontein and Frank Concentrators, surface run-off to any receiving surface water resources is seen as limited.

- **The use of the land and land adjoining increases the risk of harm.**

Both the concentrators are situated within a mining/industrial region. Therefore, in terms of ‘fit for purpose’ and protection of the environment in its broadest sense, the land on which the concentrators are situated as well as and in the vicinity is not seen as sensitive.

In terms of surrounding water use, consensus developed from all the specialist studies that consider impacts on the groundwater resources is that there are no groundwater users on Anglo Lease area. This hydrocensus needs to be reviewed and updated from time to time but at present it is a reasonable assumption to conclude that despite soil contamination and groundwater pollution incidents, there is a low priority for remediation of groundwater within the Anglo mine Lease Area (thus the Klipfontein and Frank Concentrators included). With regards to surface water, it appears that the uppermost water table is too deep to provide any baseflow to the tributary streams in the catchment (WSP, 2008).

- **The substances have migrated or are likely to migrate.**

It was not part of the scope for this assessment to determine emission rates from the two concentrators in terms of fugitive dust. However, from visual inspection, the generation of potentially hazardous dust from the Klipfontain and Frank concentrators is suspected to be low.

No groundwater quality information for monitoring wells in the vicinity of the concentrators was available during the preparation of this report. However, based on the regional soil distribution, geology, geohydrology, on site conditions and regional land-use, no significant groundwater contamination from the Klipfontein and Frank Concentrators is expected. The soil pile situated on the Frank Concentrator property is, however, seen as a potential source of contamination that needs to be address. Surface water contamination is expected to be negligible.

In terms of the tar dam at the Klipfontein Concentrator, the coal tar derivatives are highly toxic but tend to be relatively immobile and thus the impacts tend to be of limited extent. The attenuation tendency of the soil on both concentrator sites will aid in limiting the mobility of toxic constituents.
Have the acceptable exposure for human and environmental receptors and/or Government Standards has been exceeded.

WSP does not find it practical at this point of time for Anglo to undergo a Phase II intrusive investigation to determine whether soil constituents within the subsurface strata exceed any applicable guideline or standard concentrations. Both sites have been identified as Anglo contaminated land “hotspots” and is therefore considered as contaminated. These sites will be remedied during the closure planning for the site.

CONCLUSIONS AND RECOMMENDATIONS

Both the Klipfontein and the Frank Concentrators have been identified by Anglo as contaminated land “hotspots”. However, compared to surrounding activities, site visits and an assessment of available literature found that the sites are generally well kept and are reasonably isolated in terms of any potential pathways for contaminant migration.

However, three concerns have been identified that require attention, namely:

- Potentially contaminated soil stockpile at Frank Concentrator;
- Hydrocarbon soil contamination at Klipfontein and Frank Concentrator; and
- Contaminated sump water at Frank Concentrator.

In light of Anglo’s objectives in terms of contaminated land and the regional context of the Klipfontein and Frank Concentrators, WSP does not find it necessary for Anglo to undertake a Phase II intrusive investigation. WSP finds that the environmental and human risks associated with decommissioning of the two concentrators are acceptable if the following remediation measures are put in place:

- Processed product remaining on site is removed from site and reprocesses; and
- The soil stockpile at Frank Shaft must be sampled and analysed to determine disposal requirements and removed from site. Disposal should be undertaken in a responsible manner at a licensed waste facility (compliance with DWAF ‘Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste’);
- Sump water within the concentrator process areas must be tested to determine whether the water requires hazardous disposal or whether disposal at a conventional waste water treatment site will suffice. The water should be removed from site in a responsible manner (DWAF Minimum Requirements) prior to backfilling of the sumps;
- Hazardous waste identified during decommissioning is removed and disposed of by a registered waste management company; and
- With regards to hydrocarbon spills at both Klipfontein and Frank Concentrators:
  - Contaminated soil must be excavated until spill is visually clean;
  - If heavy odours are still present, the area should be screened with a vapour detection/photo-ionisation device, to detect remaining ‘hot- spots’;
Soil samples should be taken from the spill area. For a large spill take samples from the four corners of the excavation and the middle of the base of the excavation. For trenches sampling density should be one sample per 10m of contaminated length. Samples can be composite if entire soil volume is removed off-site;

Excavated area should not be backfilled until the residual soil is confirmed as meeting the ‘clean’ soil guideline, as further remediation may be required;

Temporary backfill measures are advisable if physical hazards are related to the excavations;

Soil samples should be analysed for the following:

- Total Petroleum Hydrocarbons (TPH) – modified Diesel Range Organics (DRO) and Gasoline Range Organics (GRO), BTEX and GC/MS for purgeables/extractables;

Contaminated areas that require remediation have been identified at both concentrators and therefore a basic assessment will be required prior to removal of any material from site during the decommissioning process. The required sampling and laboratory testing will also be compulsory to ensure that treatment and disposal requirements are well understood and that all contamination has been removed.

Soil remediation needs to be undertaken at a licensed hydrocarbon remediation facility. Based on the footprint of the Anglo Lease area and the likelihood of similar contamination, as observed at the Frank and Klipfontein concentrators, being present at other sites within the lease area, there is an advantage of developing such a facility for the Anglo Lease area. Please note that such a facility requires a waste license according to the National Environmental Management: Waste Act (No. 58 of 2009) must be obtained prior to the commencement of any remediation activities.
4.2 The specialist appointed in terms of the Regulations

I, Dr Jon McStay, declare that —

General declaration:

- I act as the independent specialist in this application
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant
- I declare that there are no circumstances that may compromise my objectivity in performing such work
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity
- I will comply with the Act, regulations and all other applicable legislation
- I have no, and will not engage in, conflicting interests in the undertaking of the activity
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of Section 24F of the Act.

Signature of the specialist:

WSP Environmental (Pty) Ltd
Name of company (if applicable):

Date: 6 May 2014

Signature of the Commissioner of Oaths:

Date:

Designation:

Official stamp (below)