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DEBSWANA

MORUPULE COLLIERY

MORUPULE COLLIERY EXPANSION PROJECT

FINAL ENVIRONMENTAL IMPACT STATEMENT

Volume 2

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APPENDIX 1: SOCIO-ECONOMIC IMPACT ASSESSMENT

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1 EXECUTIVE SUMMARY

This report presents findings of a Social Impact Assessment of the proposed expansion of the Morupule Colliery.

The colliery is owned and operated by the Debswana Diamond Company through the Morupule Colliery Limited (MCL) and it was commissioned in 1973. It is situated 12 km west of Palapye village in the Central District of Botswana.

Increasing demand for coal particularly for the proposed expansion of the Morupule Power Station has necessitated a corresponding growth of the mine. Subsequent to this, the Morupule Colliery Limited has proposed to expand the mine from current production of 1 million tonnes to 4 million tonnes of coal per year during the first phase and ultimately to 12 million tonnes during the second phase. Key activities that will be undertaken during the expansion include:

- Development of the existing shaft production capability from one continuous miner section to four and twelve, i.e. upgrading from 1 million tonne to 4 million tonnes and 12 million tonnes respectively;
- Replacement of the surface screening and crushing facilities at the existing location;
- Expansion of a coal wash plant;
- Construction of new workshops and offices;
- Construction of new housing units at the Morupule Staff Village.

Methodology

This SIA employed the following combination of methods that identified impacts and guided the assessment and mitigations:

- Review of existing project information that was supplied by the Morupule Colliery (MC) and review of relevant reports and baseline socio-economic data on the area drawn from Consultant's library and Central Statistics Office (CSO) publications;
- Assessment of the key social issues identified during the Scoping phase;
- Visit to the project area to facilitate participatory assessment of key impacts through interviews and informal discussions with selected stakeholders
- International Association for Impact Assessment principles for Social Impact Assessment (IAIA, 2003).

Identified impacts

The above methodologies led to the identification of the following impacts that the proposed mine expansion might bring about:

Construction phase

- Increased employment opportunities
- Increased business opportunities

- Transitory population increase due to an influx of approximately workers and job seekers
- Safety impacts;
- Increased risk of communicable diseases such as HIV/AIDS and other Sexually Transmitted Infections
- Illegal settlement

Operational phase

- Creation of employment opportunities
- Creation of business opportunities
- Influx of job seekers
- Increased risk of communicable diseases such as HIV/AIDS
- Risk of accidents and fatalities from incidents such as subsidence
- Loss of livelihoods due to land appropriation

Decommissioning phase

- Risk of accidents and fatalities from incidents such as subsidence

Most of the social impacts such risk of HIV infections, increased business and employment opportunities are likely to be felt as a cumulative effects of both the mine and the adjacent Botswana Power Corporation Morupule Power Station expansion.

A Resettlement and Action Plan should be drawn up to guide the MCL when dealing with Project Affected Parties that would need to be moved out of the area to make way for the mine expansion.

Both the increased risk of Sexually Transmitted Infection, particularly HIV, and possible displacement of people that settled the area for generations are identified as areas of concern.

Recommendations

This SIA recommends that the proposed development can proceed once certain critical social aspects have been addressed. Emphasis should be placed on drawing up a Resettlement and Action Plan that is grounded on a comprehensive and Project-Affected Persons (PAPs) oriented Stakeholder/Public Engagement Plan before commencement of the construction phase. It is critical for the MCL to take full cognisance of social implications of the project which include displacement of people from an area that has supported their livelihoods for many generations.

2 INTRODUCTION

The Morupule Colliery (MC) which is owned and operated by the Debswana Diamond Company (DDC) through the Morupule Colliery Limited (MCL) was commissioned in 1973). It is situated 12 km west of Palapye village in the Central District of Botswana. Currently it is the only coal mine in the country but this will soon change as another mine will be opened at Mmamabula and an exploration phase for a possibly third one at Mmamantswe is underway. Coal is accessed through a box-cut, inclined at 7° and conveyed to the surface by means of a series of conveyor belts. No surface activities are undertaken outside the area enclosing mine surface infrastructure.

The mine supplies coal to a number of clients that include major manufacturing industries, Selibe-Phikwe copper-nickel mine and the adjacent Morupule Power Station. Burgeoning demand for coal particularly for the proposed expansion of the Morupule Power Station has necessitated a corresponding growth of the mine. Subsequent to this, the Morupule Colliery Limited has proposed to expand the mine from current production of 1 million tonnes to 4 million tonnes of coal per year. In line with the requirements of the EIA Act of 2005, MCL commissioned an EIA exercise to identify, assess and propose any environmental and social impacts that the proposed expansion might effect. The EIA took cognisance of the following activities relating to the expansion:

- Development of the existing shaft production capability from one continuous miner section to four, i.e. upgrading from 1 million tonne to 4 million tonnes;
- Construction of another incline shaft with twelve continuous miner sections some 4.5 km to the North of the existing shaft;
- Replacement of the surface screening and crushing facilities at the existing location;
- Expansion of a coal wash plant;
- Construction of new workshops and offices;
- Construction of new housing units at the Morupule Staff Village.

This reports presents output of the Social Impact Assessment that was undertaken as part of the broader EIA of the proposed project.

The need for a Social Impact Assessment

The MC is close to Palapye village (which plays host to some major national developments and experiences a growing population). People settled in the area long before the mine started operating. Subsequent to the mine lease area dermacation some of the residents had to be included within the area. The recently extended lease area has included even more people and their properties within an area controlled by MCL. Most derive their livelihoods from the area. Any activities that are undertaken within the area by either the MC or the community within the lease area would have an impact on the other party. It is therefore likely that the proposed expansion will affect people and their livelihoods both at the local and national levels. Construction and operational phases of the proposed mine will bring in 850 and 600 workers into the area respectively and the workers will be accommodated in a contractors camp

that will established within a short distance from the construction site. It is in this context that a social impact assessment is needed for the proposed expansion of the mine.

3 METHODOLOGY

This SIA employed the following activities that were meant to elicit background information:

Review of existing project information that was supplied by the Morupule Colliery (MC);

Collection and review of relevant reports and baseline socio-economic data on the area drawn from Consultant's library and Central Statistics Office (CSO);

Assessment of the key social issues identified during the Scoping phase;

Visit to the project area to facilitate participatory assessment of key impacts through interviews and informal discussions with selected stakeholders

The above activities led to data that were used for the assessment of identified impacts. A standard methodology (for the EIA team) was used to assess the identified impacts. The author's past experience with the study area also informed this report.

In the absence of national guidelines and principles, approach to this SIA borrowed from the following internationally accepted International Association for Impact Assessment principles (IAIA, 2003):

- In all planned interventions and their assessments, avenues should be developed to build the social and human capital of local communities and to strengthen democratic process.
- In all planned interventions, especially where there are unavoidable impacts, ways to turn impacted peoples into beneficiaries should be investigated.
- Full consideration should be given to the potential mitigation measures of social and environmental impacts, even where there are likely to be unavoidable impacts.
- Local knowledge and experience and acknowledgement of different local cultural values should be incorporated in any assessment.
- There should be no use of violence, harassment, intimidation or undue force in connection with the assessment or implementation of a planned intervention.
- Developmental processes that infringe the human rights of any section of society should not be accepted.

3.1 Limitations

The Central Statistics Office (CSO) data that were available during this study were generalised to the broader Serowe-Palapye enumeration area and therefore no specific data are available for Palapye. Effort was made to plug this gap through sourcing data from some Serowe-Palapye Sub-District Council departments. In some cases this did

not help as some Serowe-Palapye Sub-District Council departments were uncooperative and therefore did not assist with the required data.

4 EXISTING SITUATION

4.1 The study area

4.1.1 Socio-Economic environment

4.1.1.1 National

Botswana is a land locked country in Southern Africa with a population of about 1.7 million persons with an annual growth rate of 3.6% (2001 Population census). The country has enjoyed a stable democracy since independence in 1966. Local government has been subdivided into ten district and five town councils.

There are four planning regions established in order to harmonise the planning, provision and maintenance of infrastructure and services. These are; Eastern, South eastern, Western, and Northern regions. Land use in Botswana has been divided into four categories namely settlement, agriculture and wildlife and forest reserves. On the other hand, land tenure has been divided into three categories which are tribal, state and freehold. Tribal land accounts for about 71% of the land whilst state land and freehold are 23% and 6% respectively.

The country has one of the fastest growing economies in Africa. The economy is boosted mostly by natural resources such as diamonds and soda ash, industries such as textiles and beef processing. There are also other major drivers of the economy such as tourism which contributed about 12% to the GDP in 2003 – 2004 period (www.state.gov/r/pa/ei/bgn/1830).

The Government of Botswana provides health and education services which are provided to all Botswana citizens. Primary school education is provided for free whilst a subsidy is place for secondary education. Tertiary education is provided through a grant-loan scheme offered to students. The adult literacy rate for the Republic of Botswana currently stands at 81%. However, there is a small cost recovery fee charged for provision of other services such as refuse collection, and tertiary education.

Transport and communications infrastructure is well developed as most parts of the country are connected through tarred roads. Telephone communications are also available in most parts with services rendered by Botswana Telecommunications Corporation as well as two cellular phone providers.

The Morupule Colliery, located in the Central District near Palapye, is currently the only coal mine in the country.

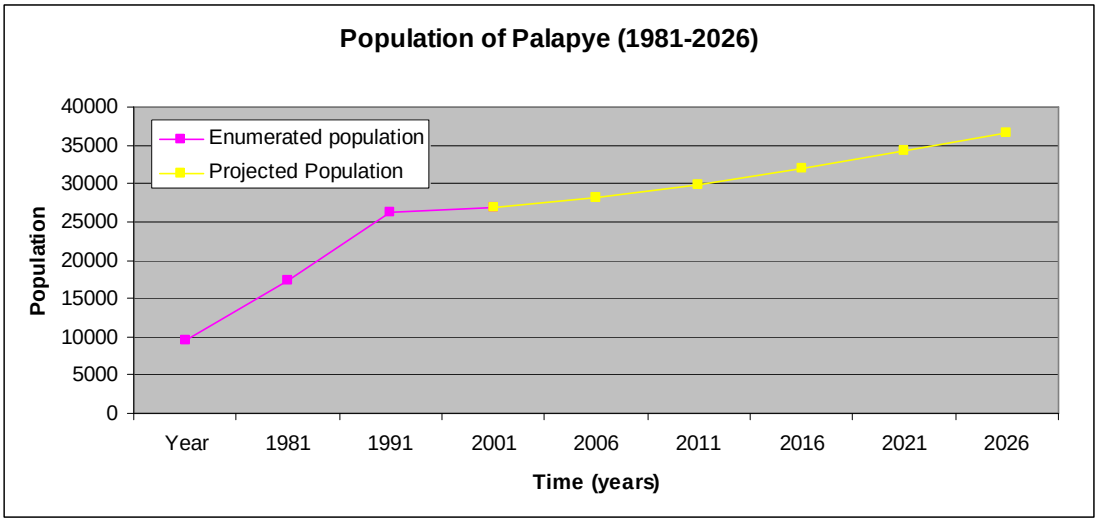
4.1.1.2 Local and Regional

The project area, Morupule Colliery, is located Palapye village which is both the administrative and service centre for the Serowe-Palapye Sub-District Council.

The settlement hierarchy classifies Palapye as a Primary III centre in the Central District and falls within the eastern planning region. Planning regions were done in order to harmonise the planning, provision and maintenance of infrastructure and services.

Population

Population for Central District stood at 501 381 (2001 Census) and Serowe – Palapye sub district has the highest number of 153 035 persons. The sub district has an area of 30 925km^2 and this caters for 5 persons/km^2. Palapye had a population of 26 293 in the 2001 Population Census. Population growth in Palapye has increased significantly over the years partly due to a number of factors which include the designation of the village as the Serowe – Palapye Sub District headquarters, and the existence of the Morupule Coal Mine and the Power Station. The Palapye population has been increasing since the 1981-1991 census but the percentage growth for the 1991-2001 census shows that there was a drop down of population growth. The population for the area is projected to increase in the next +10 years. (Source: CSO 2001).



Housing

Housing structures in Palapye as well as most villages in Central District are predominantly modern structures with tin roofing. However, there are still traditional housing structures made from mud and grass thatch scattered throughout the village.

Settlement patterns

Central district is divided in traditional settlement patterns of village, lands and cattle posts. In Palapye, the older residential areas are mostly of a nucleated pattern while the newer areas have a linear pattern. Most businesses are located along the A1 trunk road and also along the tarred roads within the village.

Social Amenities

Palapye is serviced by one police station and there are plans to build a bigger one as the village has grown. There are four clinics and one primary hospital. Water supply form the national supply for the residents is through community standpipes as well as private connections. There are three cemeteries, but only one of these is in use.

Transport and communication

The main mode of transport in the Palapye area is road. The A1 trunk road (Francistown – Gaborone) links the south and the north parts of the country. There is

also the B14 road, which links Central and Ngamiland Districts. There is an airstrip in the village for aircrafts of limited size. Telecommunications in the area are served by Botswana Telecommunications Corporation (BTC) and cellular phone service providers. Botswana Post provides postal services.

Education

The literacy rate for Central District was about 62% during the 2001 census. There are nine government-owned primary schools and one privately owned school in Palapye. Preschools are also available throughout the village. There are three junior secondary schools and one senior secondary school in the village. There is also a vocational training centre, and non formal education centre.

Employment

Employment opportunities are created through a varied range of economic activities, which include agriculture (arable and pastoral), mining, industrial and commercial, manufacturing, and construction. The existence of the Morupule coal mine and the BPC Power Station has boosted employment opportunities in the Palapye area.

The average unemployment rate for the Serowe Palapye sub district is about 14% with females accounting for the 16.5 and males accounting for the 11.6. About 8977 of the population of Palapye is unemployed, the highest number being for females at 5173 and males at 3804.

Figures for unemployment by age group in Central District

Age Groups	12-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-60	60-64	65+
Total	-	4997	7023	5017	3906	3374	2633	2169	1215	848	270	1040
Male	-	1961	2865	1892	986	1314	809	120	634	116	134	481
Female	-	3036	4157	3125	2919	2060	1825	2049	582	732	136	558

Health

Health facilities within the Serowe Palapye Sub District include a total of 20 clinics with about 9 having maternity services, 24 health post with 13 offering ARV's and 24 mobile stops. The delivery of health services in Palapye is done through a primary hospital, four clinics, and four mobile stops. The primary hospital is under the Ministry of Health while clinics are coordinated by the Ministry of Local Government. There are specialised centres such as anti – retroviral drugs distribution centres. There are also private medical practitioners in the village.

HIV/AIDS has been identified as an issue in Palapye. In 2004 the number of people who tested HIV AIDS Negative was about 81.8% of the tested population, while those who tested HIV positive were about 78511. This revealed that 18.2% of the total tested population is HIV positive and represents prevalence higher than the national

one of 17.1%. Males account for 14.4% while females stand at 21.2%. (The Botswana HIV/AIDS Impact Survey II 2004).

4.1.2 Land Use

The proposed project will be located some 12 kilometres west of Palapye village. The Morupule Colliery is within the Palapye planning area that encloses tribal land which has to cater for different uses including residential, commercial, mining, power generation, agriculture and industrial. The area earmarked for the expansion includes the current mine and a significant size of agricultural land. Crops cultivated on agricultural land include maize, sorghum, beans and sunflower. Some of the people within and just outside the MCL area rear cattle, sheep, donkeys and goats. There are a few small scale commercial farmers who are concentrated along a 2km radius from the main Serowe-Palapye road.

5 LEGAL AND PLANNING FRAMEWORK

This study has been informed by a number of policies and legislation documents:

Palapye Development Plan

Due to its status as a planning area Palapye planning requirements are addressed through a development plan. The plan sets the development direction and objectives for the Palapye Planning Area from 2007 to 2031. Since the Morupule Colliery is within the Palapye Planning Area it is quite important for the colliery development initiatives to take cognisance of the plan.

Debswana HIV Policy

The policy is derived from a HIV/AIDS Impact Management Strategy that spells out the following vital areas that Debswana and its service providers' HIV/AIDS programmes should address:

- Work place policy on HIV/AIDS
- Work place education/training programme
- Facilities and enabling structures
- Participation in Debswana HIV structures

Further, the policy stipulates that companies wishing to conduct business with Debswana will be required to actively support Debswana's policies and efforts in the promotion of health and safety and specifically in the fight against the spread of HIV/AIDS. Debswana reserves the right to conduct audits in order to establish compliance with its own HIV/AIDS Policy.

The existence of the policy is of utmost relevance to the proposed expansion activities as it will involve a considerably large and predominantly migrant labour that will bring about a transitory population increase. The contract workers presence in the area might increase the risk of new HIV and other Sexually Transmitted Infections (STIs). The policy should inform any STIs and HIV/AIDS response plans that the contractors might draw up.

Botswana HIV Policy (1998)

The policy is implemented by the Ministry of Health through the AIDS/STD Unit. It outlines the national response strategy to HIV/AIDS in Botswana. It also describes the role of all stakeholders that include: national leaders, government ministries, private sector, people living with HIV and individual community members. As with the Debswana HIV Policy any STIs and HIV/AIDS response plans that the contractors might draw up should be informed by this policy.

Botswana National HIV/AIDS Framework 2003-2009

The framework complements the National HIV Policy and goes further to provide synergy between national AIDS response programme and other important national

planning documents that include National Development Plans and Vision 2016. It acknowledges and outlines respective roles of the following stakeholders in the national response:

- Districts
- Public Sector
- Civil Society
- Private Sector and Media
- Parastatals
- Development Partners

The framework also sets Districts response plans and both DDC and the Contractor would need to be conversant with the following Serowe-Palapye District's objectives:

- Promote the establishment of mobile counselling and testing and increase the utilisation of services
- Resuscitate and strengthen HIV/AIDS workplace programmes
- Encourage the formation of support groups in the district
- Develop educational materials and which emphasise positive living with HIV/AIDS
- Any health initiatives undertaken by both the Contractors and MCL should be consistent with this framework.

6 FINDINGS

This section provides key social impacts (negative and positive) associated with the proposed expansion of the Morupule mine. The identification of key social issues and impacts was based on:

- Review of project information supplied by the MCL;
- Output of the Scoping phase
- Review of relevant socio-economic baseline for the area;
- Discussions with selected stakeholders to establish data such as relationship between the mine and stakeholders and to facilitate a participatory impact mitigation process

The above activities identified impacts that might be brought about by the proposed development's construction, operation and decommissioning phases. The impacts associated with these phases are as follows:

Construction phase

- Increased employment opportunities
- Increased business opportunities
- Transitory population increase due to an influx of approximately workers and job seekers
- Safety impacts;
- Increased risk of communicable diseases such as HIV/AIDS and other Sexually Transmitted Infections
- Illegal settlement

Operational phase

- Creation of employment opportunities
- Creation of business opportunities
- Influx of job seekers
- Increased risk of communicable diseases such as HIV/AIDS
- Risk of accidents and fatalities from incidents such as subsidence
- Loss of livelihoods due to land appropriation

Decommissioning phase

- Risk of accidents and fatalities from incidents such as subsidence

The above impacts are discussed in more detail in Section 7 below.

7 IDENTIFIED IMPACTS, ASSESSMENT AND MITIGATIONS

7.1 ISSUES RAISED DURING STAKEHOLDER DISCUSSIONS

7.1.1 Local businesses

Discussions were held with businesses involved in retailing (furniture, fast food outlet, fuel) and hospitality industry. Each one of the business interviewed have operated in the village for more than 5 years and employ an average of more than 10 people. All their employees reside in Palapye.

Three out of five businesses interviewed indicated that they do have direct business links with the mine. They did note that the proposed mine expansion, would benefit local businesses as the customer base would widen.

Identification of existing potential issues, concerns and opportunities

The businesses indicated that a cordial relationship exists between them and the mine. They attributed this to the MCL's commitment to procure most of the goods and services within Palapye.

Identification of potential future issues, concerns and opportunities

All the business operators interviewed pleaded their awareness of the proposed expansion of the mine which they learnt about from the media and some consultative meetings convened by the MCL. They acknowledged the positive economic impact of the mine on the local economy. It emerged during the interviews that the mine has direct business deals with most of the local suppliers. Business owners were concerned about possible increase in crime in the town due to the influx of people.

Potential mitigation and enhancement measures

Business operators advised that contractors should use local facilities for services.

7.1.2 Property owners within the Morupule Lease Area

Interviews were conducted with property owners within the area earmarked for the expansion programme. Data were drawn from the Scoping phase and follow up consultations undertaken during the detailed EIA phase.

Identification of existing potential issues, concerns and opportunities

Interviewees indicated that they do not have direct economic links with the mine however some of them work at the mine and their earnings contribute to the livelihoods. They further acknowledged MCL initiatives to enter into a dialogue with them concerning the implications of their coexistence with the mine within the lease

area. Their concern was that it has never been spelt whether they will be asked to relocate from their area

Identification of potential future issues, concerns and opportunities

Residents expressed hope that jobs will be created during the construction period.

Potential mitigation and enhancement measures

The residents pointed out that local labour should be used for non-skilled areas. They further advised that consistent update on mine/lease expansion programme should be maintained.

7.2 CONSTRUCTION PHASE

7.2.1 Creation of employment opportunities

Description of the effect

The construction phase is expected to last 3 years and will employ approximately 850 and 1200 personnel during the 4 million tonnes and 12 million tonnes expansion phases respectively. The estimated capital expenditure associated with the construction phase is approximately P3 billion. This is expected to effect a significant wage bill.

Assessment of the impact

The employment opportunities associated with the proposed development are likely to represent a significant positive socio-economic opportunity for the local economy. This scenario will translate into significant investment into the local economy as multiplier effects such as remittances to families and transactions with the local businesses will take place. The potential employment opportunities for some Palapye residents and those of residents within the lease area may be somewhat reduced by the shortage of appropriate skills levels.

The majority of the unskilled and semi-skilled jobs could easily be filled by both women and men. The Serowe Labour Office (The recently opened Palapye Labour Office will soon deal with all labour issues for the village) indicated that the number of job seekers increases on yearly basis. The office registers an average of 120 workers per month between January 2007 and June 2008. The same period saw an almost equal number of males and females register with the office and most of the job seekers are in the 20-35 age bracket. This corroborates well with the National 2005/2006 Labour Force Survey findings that identified the same age group (CSO, 2007). Since the impact is positive, no mitigations are proposed but rather further initiatives to enhance the impact are necessary.

Table 1: Assessment of employment creation opportunities during the construction phase

	Without Mitigation	**With Mitigation**
Nature	Positive	Positive
Extent	Regional	Regional
Intensity	Low	Low
Duration	Short term	Short term
Probability	Definite	Definite
Confidence	High	High
Consequence	Low	Low
Significance	High	High

7.2.1.1 Mitigations

MCL should inform Palapye traditional authorities and civic leaders whose respective areas of jurisdiction cover residents within the lease area about the project and the potential job opportunities for locals;

Recruitment of local people should be carried in an open and democratic manner such as use of Kgotla through the Headman and the fair chance system employed by the local labour office

The employment selection process should seek to promote gender equality and the employment of women wherever possible;

Contractors should give preference for unskilled labour to permanent residents of Palapye and those residing in nearby villages;

Use of local labour office is imperative. This will be invaluable as the office could arbitrate over incidents such as employer-employee disputes.

7.2.2 Creation of increased business opportunities

Description of the effect

The construction phase is expected to last 3 years and the estimated capital expenditure is estimated to be P3.2 billion 4 million tonnes. This represents a significant injection into the local economy. Further multiplier effects such as remittances to families and transactions with the local businesses that will be brought about during this short term will take place.

Assessment of the impact

Local and national businesses stand to reap financial benefits more from services that are already outsourced to them by the MCL through predetermined preferred service providers. Interviews with selected businesses showed that MCL conducts a lot of businesses with local (Palapye) service providers. Some of the construction materials needed could easily be supplied locally. Since the impact is positive no mitigations are necessary. However, further initiatives will serve to enhance the impact.

Table 2: Assessment of increased business opportunities during the construction phase

	Without Mitigation	**With Mitigation**
Nature	Positive	Positive
Extent	Regional	Regional
Intensity	Low	Low
Duration	Short term	Short term
Probability	Definite	Definite
Confidence	High	High
Consequence	Low	Low
Significance	High	High

7.2.2.1 Mitigations

In line with the Debswana Diamond Company Citizen Economic Empowerment Policy, MCL should encourage Contractors to use pre-existing list of local companies (based in Palapye) that qualify as potential non-specialised service providers prior to the commencement of the tender process. These companies should be notified of the tender process and invited to bid for project related work through a prequalification process.

7.2.3 Influx of job seekers

Description of the effect

The construction phase will see 1200 workers come into the area over a XX year period. They will be housed in camp that will be constructed near the existing mine. More people are expected

Assessment of the impact

The effect is likely to be felt as a cumulative from both the Morupule Colliery and expansion of the adjacent power station which is expected to bring in 2000 workers (Ecosurv and GIBB, 2008). The combined increase of approximately 3200 workers will be a significant change to the Palapye population structure. However, the effect

will be a transitory one as the construction workers will move out of the area as soon as construction of both projects is over. Both the job seekers and construction workers will lead to a transitory population increase. It is unlikely that it will be possible to stop job seekers from coming to the area in search of a job.

Table 3: Assessment of influx of job seekers during the construction phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Negative
Extent	Regional	Regional
Intensity	Medium	Medium
Duration	Short term	Short term
Probability	Probable	Probable
Confidence	Medium	Medium
Consequence	Medium	Medium
Significance	Medium	Medium

7.2.3.1 Mitigations

The local labour office and the Palapye Kgotla should be used for recruitment of non-skilled and some unskilled labour. The labour office would be invaluable as the office could arbitrate over incidents such as employer-employee disputes.

Information flow between contractors and local labour office is imperative. The labour office will in turn facilitate further information flow to job seekers regarding employment opportunities.

Code of Conduct for workers should be availed to the Palapye Police Station, Serowe-Palapye Sub-district Assistant Council Secretary and the Palapye Main Kgotla. Construction workers who breach the code of good conduct should be dismissed immediately.

Basic faciltities such as medical, accommodation and recreational should be provide to the workers.

7.2.4 Safety impacts

Description of the effect

The Morupule Colliery mining area straddles the Serowe-Palapye main road and is surrounded by cattle posts and lands areas. The main road receives a significant volume of traffic and is accessed through dirt roads and tracks by farmers within the area.

Assessment of the impact

Construction will necessitate movement of heavy vehicles within the site and Palapye. This will create safety impacts for other road users and residents within the vicinity of the construction site.

Table 4: Assessment of safety impacts during the construction phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Neutral
Extent	Local	Local
Intensity	Low	Low
Duration	Short term	Short term
Probability	Probable	Probable
Confidence	Medium	Medium
Consequence	Low	Low
Significance	Low	Low

7.2.4.1 Mitigations

There should be visible signage at road junctions that are used by the heavy construction vehicles to warn other road users.

7.2.5 Increased risk of communicable diseases

Description of the effect

There will definitely be an influx of job seekers from outside the area at the commencement of the project. However, the number of job seekers is definitely less than those that will come into the area during the mine operation phase. The influx will result in both intra camp and camp-local people interactions that might even become sexual in nature.

Assessment of the impact

The influx of job seekers, their interaction with both the construction workers and the rest of the host community can create a number of negative social impacts in the host community (Palapye and nearby settlements) with the most notable being the transmission of HIV/AIDS and other sexually transmitted diseases. Data on the latter supplied by the Serowe-Palapye Sub-District Health Team (DHT) indicated an increase in infections between 2004 and 2006. There was a slight decrease in 2007 which could be attributed to the national initiatives such as free anti-retroviral treatment available at public health facilities. No data on HIV prevalence in Palapye

village were available from the DHT. The impact will definitely be felt as the Serowe-Palapye Sub-District prevalence (37.3%) is higher than the national one (17.1%). The figures are derived from the results of the 2007 Ante-Natal Clinic Sentinel Survey (supplied by the DHT) and the Botswana AIDS Impact Survey (BAIS) II respectively (CSO, 2004).

Table 5: Assessment of increased risk of communicable diseases during construction phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Neutral
Extent	National	Regional
Intensity	High	Medium
Duration	Long term	Medium term
Probability	Highly Probable	Probable
Confidence	High	Medium
Consequence	High	Medium
Significance	High	Medium

7.2.5.1 Mitigations

Contractors working on the expansion programme should work closely with the District Health Team to assist with the drawing up of an HIV/AIDS programme that will ensure provision of condoms and awareness material at the camp.

If a self-contained camp is set up, camp residents' spouses should be allowed to come in on weekends and on other days when the entire camp is on a short leave.

MCL's occupational clinic services should be extended to the contractors.

7.2.6 Illegal settlement

Description of the effect

The construction phase is likely to act as a pull factor for job seekers from within Palapye, its surrounding settlements and beyond.

The influx of job seekers, their interaction with both the construction workers and the squatting as some of the job seekers that do not have homes in Palapye might put up temporary housing structures within a walking distance of the construction area.

Assessment of the impact

Some of the job seekers will be absorbed by the contractors while those not absorbed will linger around the contractors' camp with the hope that they will get jobs. Their hope will ultimately compel them to stay within a walking distance to the camp (it is assumed that they will have no money to commute to the site everyday) and they are likely to put up temporary housing structures. This scenario will lead to an illegal (squatter) settlement mushrooming around the camp and even pose planning problems for the Serowe-Palapye Sub-district Council.

The influx of job seekers to the area will place pressure on local services and facilities, such as housing, clinics and schools. However, some of the Sub-district Council departments such as the DHT have indicated that their resources would cope with this impact as some of the health facilities will soon be upgraded. The impact could also lead to tension and conflict over available construction jobs and resources within the Palapye community.

Table 6: Assessment of illegal settlement during construction phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Neutral
Extent	Regional	Local
Intensity	Medium	Low
Duration	Short term	Short term
Probability	Probable	Probable
Confidence	High	High
Consequence	Medium	Low
Significance	Medium	Low

7.2.6.1 Mitigations

MCL and the Contractor should be proactive in dealing with illegal settlement through reporting people that put up temporary housing structures near the camp as early as possible. MCL could use the Public Affairs Unit. This calls for collaboration with the Palapye Sub-Land board.

7.3 OPERATIONAL PHASE

The key social issues during the operational phase are linked to

- Creation of employment opportunities
- Creation of business opportunities
- Influx of job seekers
- Increased risk of communicable diseases such as HIV/AIDS
- Risk of accidents and fatalities from incidents such as subsidence
- Loss of livelihoods

These impacts are discussed in more detail below.

7.3.1 Creation of employment opportunities

Description of the effect

The operation phase is expected to commence as soon as the target market, particularly the new Morupule Power Station, is ready to receive coal. An additional 1200 workers will be needed and thus more employment opportunities for both skilled and unskilled cadres would be created.

Assessment of the impact

The additional workforce will strength the mine's current economic impact on the local economy. The total wage bill is expected to rise significantly and will be subsumed under enormous operating costs envisaged to be approximately P65 million/tonne (mine expected to be expanded to 12 million tonnes).

The potential local employment opportunities associated with the proposed development may be somewhat reduced by the shortage of appropriate skills levels in the area. If majority of the workers are from outside the area, their impacts will be felt beyond Palapye as they will send remittances to their relatives.

Table 7: Assessment of employment opportunities during the operation phase

	Without Mitigation	**With Mitigation**
Nature	Positive	Positive
Extent	Regional	Regional
Intensity	Low	Low
Duration	Short term	Short term
Probability	Definite	Definite
Confidence	High	High

Consequence	Low	Low
Significance	High	High

7.3.1.1 Mitigations

This SIA acknowledges that MCL currently has recruitment procedures in place. However, a closer look at the mine wage bills reveals that sex distribution of staff has been consistently skewed towards males. The number of females at the mine never exceeded 50/year during the last 5 years (2002-2007) whilst for males it has always exceeded 200/year. It is therefore imperative for the MCL to adopt an affirmative policy that will steadily ensure that work areas that do not necessarily need masculinity are given to females.

MCL should use the Palapye Labour Office for recruitment of non-skilled labour.

7.3.2 Creation of increased business opportunities

Description of the effect

The operational phase is expected to give impetus to the need for support services and materials. The likely sources for both are locally, nationally and abroad. This will translate into significant investment into the local and national economies and multiplier effects such as wages and remittances to families and transactions with local businesses will take place.

Assessment of the impact

The additional workforce will strengthen the mine's current economic impact on the local economy. The total wage bill is expected to rise significantly and will be subsumed under enormous operating costs envisaged to be approximately P65 million/tonne (mine expected to be expanded to 12 million tonnes). With a significant number of the MCL workers staying in Palapye village, the number is expected to grow substantially during the operation phase. Businesses beyond Palapye also stand to benefit as some of the services can not be provided locally. No mitigations are necessary since the impact is positive. Any mitigative initiatives will serve to enhance the impact.

Table 8: Assessment of increased business opportunities during the operation phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Negative
Extent	Regional	Regional
Intensity	Medium	Medium
Duration	Short term	Short term
Probability	Probable	Probable

Confidence	Medium	Medium
Consequence	Medium	Medium
Significance	Medium	Medium

7.3.2.1 Mitigations

The existence of a predetermined list of preferred service providers is a laudable initiative on the part of MCL. However, MCL should encourage contractors to continue doing business with local service providers.

7.3.3 Influx of job seekers

Description of the effect

The existence of the new mine might lure job seekers to the area. Majority of the job seekers would be in the semi-skilled and non-skilled cadres as the skilled are likely to respond to advertised job openings. Job seekers would also trigger multiplier effects of the mine as some of them might be hired by the mine employees.

Assessment of the impact

This impact would be pronounced during the initial year of operation of the mine before job seekers could realise that job opportunities are dictated by predetermined mine operation needs. Job seekers are also likely to flood the Palapye Labour Office and this might exert some strain on staffing requirements at the office. Some of the job seekers might resort to making a living through crime in order to acquire basic needs. The influx of workers and job seekers will also result in additional spending in the local economy. The influx of workers will, therefore, also have a positive socio-economic benefit.

Table 9: Assessment of influx of job seekers during the operation phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Negative
Extent	Regional	Regional
Intensity	Medium	Medium
Duration	Short term	Short term
Probability	Probable	Probable
Confidence	Medium	Medium
Consequence	Medium	Medium
Significance	Medium	Medium

7.3.3.1 Mitigations

It is impossible to stop people from coming into the area looking for jobs. However, MCL and contractors should put up notices for non-skilled and semi-skilled labour vacancies at the Palapye Labour Office.

7.3.4 Increased risk of communicable diseases

Description of the effect

As with the construction phase the operation phase will see intra mine workers interaction and with those not working for the mine. Absence of preventive measures against sexually transmitted diseases will lead to new infections and reinfections.

Assessment of the impact

Sexual interactions are likely to lead to an increase in HIV/AIDS prevalence in the village. This scenario would spell disaster for the MCL that is already badly affected by the epidemic as evidenced by the results of the 2007 Colliery HIV Prevalence Survey (Evian, 2007). The survey found out that prevalence among workers on permanent employment is 32.1% whilst for those on contracts is 28.6%. Ramifications of this impact will be national in scope as further sexual interactions are likely to take place with people not working at the mine. This will increase impact on local population that is already affected by HIV (37.3% prevalence rate for the Serowe-Palapye Sub-District which is way above the national rate of 17.1).

Table 10: Assessment of impact of increased risk of communicable diseases during operation phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Neutral
Extent	National	Regional
Intensity	High	Medium
Duration	Long term	Medium term
Probability	Highly Probable	Probable
Confidence	High	Medium
Consequence	High	Medium
Significance	High	Medium

7.3.4.1 Mitigations

The MCL management should forge closer ties with the District Health Team (DHT) for a concerted effort. Discussions with the DHT revealed that the DHT is concerned

lack of timely reporting of data by the Colliery clinic. Current initiatives by the MCL such as internal Sentinel Surveys are quite sufficient to mitigate this impact and they should be maintained and undertaken regularly. It is also quite important that internal initiatives are complemented with national initiatives such District and National Ante-Natal Surveillance and the Debswana HIV Policy.

7.3.5 Risk of accidents and fatalities

Description of the effect

The impact will be effected by subsidence that might occur in some areas. The lease area encloses a significant number of cattleposts and lands areas and there is therefore movement of people within the area.

Assessment of the impact

Any collapse or subsidence will result in accidents or even fatalities to people, animals and their properties.

Table 11: Assessment of impact of risk of accidents and fatalities during operation phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Neutral
Extent	Local	Local
Intensity	Medium	Low
Duration	Long term	Short term
Probability	Highly Probable	Probable
Confidence	High	High
Consequence	Medium	Low
Significance	Medium	Low

7.3.5.1 Mitigations

MCL should continue using the current External Complaints Register to log in complaints from affected persons. The register could be linked with a Stakeholder Engagement Plan (described below) to define lines of communication for affected persons.

7.3.6 Loss of livelihoods

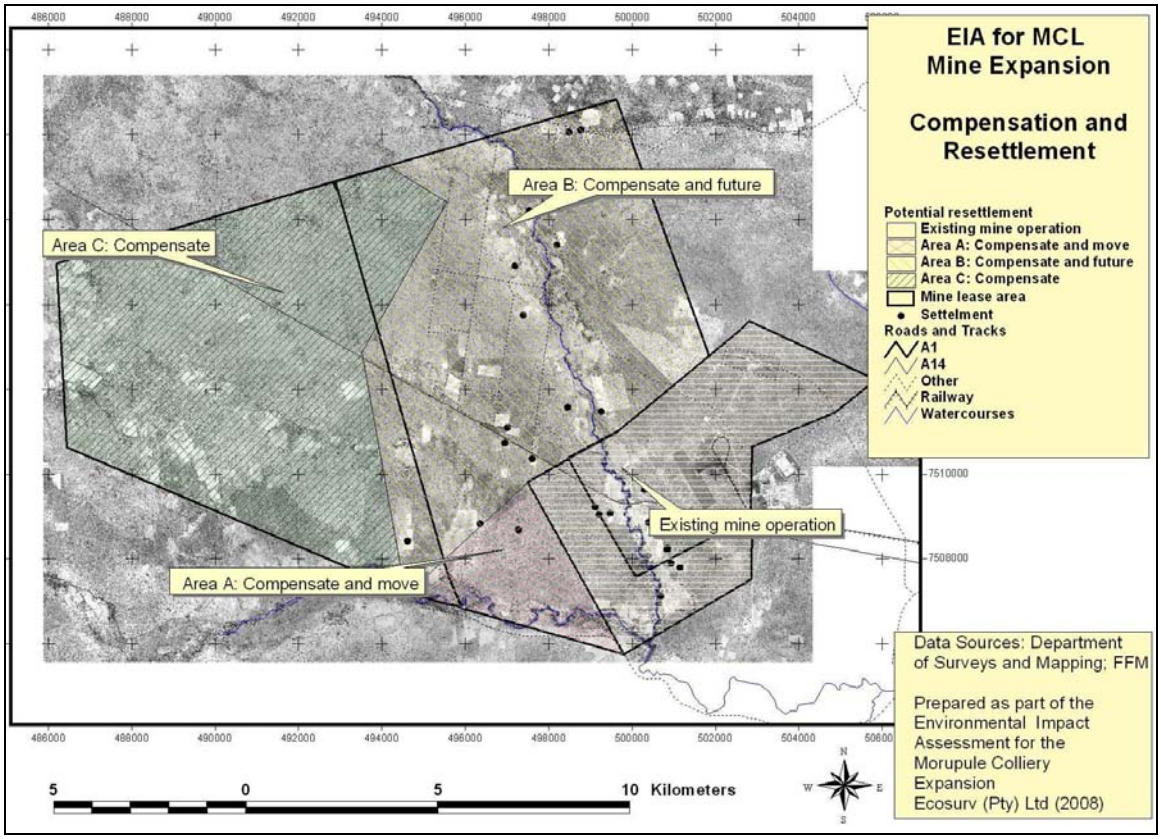
Description of the effect

The history of the mine in relation to the surrounding lands areas and cattleposts has to be appreciated within the description of this impact. Interviews with cattlepost and lands owners revealed that the area has a long history of settlement that predates the inception of the mine and they therefore have a sentimental attachment to the area. Some of the interviewees indicated that they settled in the area before the 1950s and they have been practising mixed farming. Farming is their source of livelihoods and some households within the area subsist solely on agricultural products. Any mining activities that will result in the displacement or relocation of the local people will affect their livelihoods.

Assessment of the impact

Data supplied by the MCL indicated that the proposed mine expansion area has been demarcated into three areas with each area reflecting a likely scenario for mining implications and its inhabitants (Figure 1).

Figure 1: Demarcation of resettlement options available to MCL



Areas A and B are treated as worst case scenarios as they will involve relocation or displacement of people from their historical areas as described below:

Area A: People will be compensated and requested to move for safety reasons but light subsistence farming such as cattle grazing and light farming will continue with strict controls from the mine.

Area B: This is where the new shaft/mine will be. The people will be compensated but there is no immediate need for the mine to move people, until the mine knows what the BPC is planning for phase two as well as the mining method it will employ. If it is open cast then it will be a different story altogether.

Area C: People will be compensated and they will be allowed to continue with their ploughing and cattle grazing.

It is therefore evident from the above scenarios that the mine expansion programme will lead to the displacement of people and ultimately affect their livelihoods. Impoverishment of the affected people that have lived in the area for generations is therefore a likely scenario. Total area of property is estimated to be 1703.8 hectares with most ploughing found in area C as shown in table 12.

Table 12: Arable land within the proposed expansion area

	Number of Arable Lands			
Level of Resettlement	**Active**	**Fallow**	**Recent fallow**	**Grand Total**
Area A	7	5	1	13
Area B	34	19	18	71
Area C	43	14	15	72
Existing mine operation	18	1		19
Grand Total	**102**	**39**	**34**	**175**

Approximately 23 households will be moved and 285 ha of land will be taken up to make way for the 4 Mtpa expansion. It is further expected that 67 households will be moved and 1030 ha of land will be taken up. If the MCL game park is expanded, there will be 1200 to 5750 ha loss of grazing land.

Table 13: Assessment of impact of loss of livelihoods during operation phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Positive
Extent	Regional	Local
Intensity	High	Low
Duration	Long term	Short term
Probability	Highly Probable	Highly Probable
Confidence	High	High
Consequence	High	Low
Significance	High	Low

7.3.6.1 Mitigations

There is a need to put in place effective processes for engaging with the community within the lease area. MCL could broaden their current Stakeholder Management and Communication Plan (McMorran, 2008) to include a broader stakeholder engagement strategy. In its current format the plan serves to direct the Project Management team in the execution of the duties i.e. it merely serves to define lines of communication. It should clearly articulate Project-Affected Persons' (PAPs) rights through out the project cycle. Emphasis should be placed on the implications of their co-existence with the mine within the lease area. A more comprehensive plan will engender a community support for the mine which is critical largely because of the history of the mine against that of the surrounding communities.

The relocation ramifications that are likely to affect Areas A and B clearly call for a Resettlement Action Plan. The Plan should set out ways to address livelihoods restoration of the PAPs and identify the ideal area for resettlement. It should also be participatory in approach to allow PAPs to identify options for resettlement. Lastly since the relocation would be involuntary, the plan should adopt some of the internationally-accepted principles such as the World Bank Involuntary Resettlement Policy. The plan should strive to maximise positive benefits to the local people from the mine expansion to offset loss of livelihoods.

7.4 DECOMMISSIONING PHASE

7.4.1 Risk of accidents and fatalities due to incidents such as subsidence

Description of the effect

Once the mine ceases operating, some areas might still be susceptible to subsidence and therefore pose danger to people.

Assessment of the impact

The impact will be felt in area where mining has taken place and it is likely to affect residents within Area C as those within Areas A and B would have relocated under a Resettlement and Action Plan.

Table 14: Assessment of risk of accidents and fatalities during decommissioning phase

	Without Mitigation	**With Mitigation**
Nature	Negative	Neutral
Extent	Regional	Local
Intensity	Medium	Low
Duration	Long term	Medium term
Probability	Probable	Definite

Confidence	High	Medium
Consequence	High	Low
Significance	High	Low

7.4.1.1 Mitigations

Areas affected by subsidence should be cordoned off and rehabilitated.

8 EMP, MONITORING AND AUDITING REQUIREMENTS

This section outlines EIA activities that an Environmental Management Plan that will be drawn up will cover. These are intended to guide the Contractors, MCL and any other stakeholders in the implementation of mitigations proposed in this SIA.

Construction

MCL should assist Contractors to draw up a comprehensive HIV/AIDS awareness programme for construction workers. This should be done in collaboration with local health authorities and must be in line with the Serowe-Palapye Sub-District Council, Regional (e.g. District Multi Sectoral AIDS Committee and National initiatives (e.g. National AIDS Strategic Framework and National AIDS Policy). This should be carried out before construction commences.

Operation

The existing Stakeholder Engagement and Communication Plan should be reviewed to align it with the requirements for the impending and inevitable involuntary resettlement that will occur to residents who have properties within the area earmarked for expansion. The plan should clearly articulate lines of communication and facilitate a two-way process between the MCL and the community. It should be reviewed regularly (every 2 years) throughout the operation phase of the project.

A Resettlement Action Plan should be drawn up as soon as possible. It should at a minimum conform to internationally accepted principles such as the World Bank Involuntary Resettlement Policy. It should also adopt a Project Affected Persons (PAPs) oriented approach to accord them an opportunity to define resettlement options available to them. The plan should be embarked on once the MCL has made final decisions on which area would warrant relocation of people and before construction commences.

Decommissioning

The mined area should be reclaimed and rehabilitated in an environmentally sustainable manner to minimise risk of accidents and fatalities due to incidents such as subsidence. A plan to achieve this should be drawn up before the mine ceases complete operation.

9 CONCLUSIONS AND RECOMMENDATIONS

This SIA recommends that the proposed development can proceed once certain critical social aspects have been addressed. It is critical for the MCL to appreciate social implications of the project which include displacement of people from an area that has supported their livelihoods for many generations. Emphasis should be placed on drawing up a Resettlement and Action Plan that is grounded on a comprehensive and Project-Affected Persons (PAPs) oriented Stakeholder/Public Engagement Plan.

The impact of risk of communicable diseases such as HIV/AIDS would high during both construction and operation phases. The latter phase could be mitigated with existing MCL initiatives such regular Sentinel Surveys. MCL should make it mandatory for Contractors to drawn up site specific AIDS impact reduction plans and these should take cognisance of initiatives such as the Debswana HIV Policy and District AIDS Framework.

Most of the social impacts such risk of HIV infections, increased business and employment opportunities are likely to be felt as a cumulative effects of both the mine and the adjacent Botswana Power Corporation Morupule Power Station expansion.

10 REFERENCES

Botswana Government	1998	National Settlement Policy
Central Statistics Office	2001	Summary Statistics on Small Areas, Volume 1
Central Statistics Office	2001	Population of Towns, Villages and Associated Localities
Central Statistics Office	1997	Population Projections 1991-2021
Department of Town and Regional planning	2007	Draft Palapye Development Plan (2007-2031)
Evian C.	2007	Morupule Colliery 2007 HIV Prevalence Survey
International Association for Impact Assessment	2003	Social Impact Assessment International Principles
McMorran P.	2008	Morupule Colliery Expansion Project Stakeholder Management and Communication Plan
Ministry of Health	1998	Botswana National Policy on HIV/AIDS
National AIDS Coordinating Agency	2004	Botswana AIDS Impact Survey II Popular Report
National AIDS Coordinating Agency	2003	Botswana National HIV/AIDS Strategic Framework 2003-2009

APPENDIX 2: NOISE IMPACT ASSESSMENT

Prepared by

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NOISE IMPACT ASSESSMENT OF THE PLANNED MORUPULE COLLIERY EXPANSION PROJECT

FIRST DRAFT

(August 2008)

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NOISE IMPACT ASSESSMENT OF THE PLANNED MORUPULE COLLIERY EXPANSION PROJECT

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MORUPULE COLLIERY EXPANSION PROJECT
EXECUTIVE SUMMARY

Morupule Colliery Limited (MCL) is planning an expansion of the existing Morupule Colliery, which lies approximately 9 kilometres west of Palapye Village. The Project site is located in the Central District of Botswana, approximately 280 kilometres north of Gaborone and just to the west of the village of Palapye. Refer to Figure 1. Palapye is classified as a secondary centre and is located on the main Gaborone-Francistown road (Road A1) and railway.

The planned expansion of the colliery will allow a production level of approximately 12 million tons per annum (tpa), from the current 1 million tons per annum level. This expansion will take place in two phases: an initial expansion to approximately 4M tpa (Phase 1) and a subsequent expansion of 8M tpa to 12M tpa (Phase 2). The expansion of mining capacity to 4M tpa can be accommodated by the existing mine and related infrastructure with minor upgrading. Phase 2 will require the development of a new shaft complex and mining operation approximately 3,5km to the north-west of the existing shaft and the construction of additional crushing and coal washing facilities in the vicinity of the existing shaft.

As the noise from the expansion of the colliery is considered to be a potential problem, a noise impact investigation was undertaken by Jongens Keet Associates. Botswana in general applies the World Health Organisation (WHO) and World Bank (WB) environmental standards and procedures. There are South African National Standards (SANS) codes of practice and procedures which have been developed based on the requirements of the WHO and WB as well as those of the International Standards Organisation (ISO). As the South African documents are more detailed, more prescriptive and often apply more stringent standards it is recommended that the South African as well as the international standards be applied on this project. The general procedure used to determine the noise impact was guided by the requirements of the South African National Standard (SANS) 10328:2003: *Methods for Environmental Noise Impact Assessments.* The level of investigation was the equivalent of an EIA. The noise impact criteria used specifically take into account those as specified in the South African National Standard SANS 10103:2004, *The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and Speech Communication* as well as those in relevant Noise Control Regulations.

The investigation comprised the following:

i) Determination of the existing situation (prior to the planned colliery expansion project).

ii) Determination of the situation during construction and after commissioning of the planned colliery expansion project (Phase 1 and Phase 2).

iii) Determination of impacts during the decommissioning phase.

iv) Assessment of the change in noise climate and impact.

v) Identification of mitigating measures.

The existing noise climate of the proposed Morupule Colliery expansion project study area was established form a noise survey. The findings were as follows:

i) The main sources of noise in the area are from:
   a) Traffic on Road A1 North, Road A1 South and Road A14.
   b) Morupule Power Station.
   c) Morupule Colliery.
   d) The colliery trains.

ii) The main noise sensitive areas/sites/receivers in the study area are:
   a) Palapye Village.
   b) Morupule Colliery Village (residential).
   c) Numerous homesteads throughout the study area.
   d) Contractor village adjacent to the Kgaswe Primary School.
   e) Kgaswe Primary School

iii) Noise levels in Palapye Village are high and are typical of an urban complex. The existing *noise climate* alongside the main roads in Palapye is degraded with regard to acceptable urban residential living standards (SANS 10103 noise impact criteria), that is noise exceeds acceptable levels particularly at night. Residences in some areas are negatively impacted from traffic noise (night-time standard) for up to 220 metres from the main roads. In general the daytime conditions are acceptable (SANS 10103).

iv) The areas outside Palapye and remote from the main roads and the power station/colliery are very quiet and reflect a rural character.

v) The existing *noise climate* alongside Road A14 outside Palapye Village is degraded with regard to acceptable rural residential living standards (SANS 10103 noise impact criteria). Any residences within 2000 metres of the road are negatively impacted from traffic noise (particularly at night).

vi) The impact of the Morupule colliery on noise sensitive sites in the surrounding area is relatively minor. Noise levels from the colliery exceed 35dBA (the maximum allowable night-time level for rural residential use) up to a distance of about 2600 metres from the

facility. Seven homesteads lie within this area of influence. The Colliery Village lies just outside this zone and is thus not impacted by the colliery noise.

vii) Noise levels from traffic on Road A14 at the Kgaswe Primary School are slightly higher than desirable for an educational environment. The outdoor ambient noise level should not exceed 50dBA. Noise from vehicles passing over the rumble strips on the power station access road just to the west of the school is a significant noise nuisance factor.

viii) Noise from the colliery does not have a significant impact on the activities at the Kgaswe Primary School.

ix) The overall impact of the noise from the coal trains on noise sensitive sites in the area is not significant. There is a minor nuisance effect at the school from the warning horn sounding when the train approaches the level crossing with the power station access road.

There will be a potential for noise impacts during the construction phase. The level and character of the construction noise from the various sites of the expansion project will be highly variable as different activities with different plant/equipment take place at different times, over different periods, in different combinations, in different sequences and on different parts of the construction site. It should be noted that for residential land uses, higher ambient noise levels than recommended as maxima in SANS 10103 are normally accepted as being reasonable during the construction period, provided that the very noisy construction activities are limited to the daytime and during the week, and that the contractor takes reasonable measures to limit noise from the work site. Note that it has been assumed that surface facility construction will generally take place from 07h00 to 18h00 with no activities (or at least no noisy construction activities) at night. The volumes of construction generated traffic will be small and are unlikely to be a problem. From the details presently available, it appears that the construction noise impact is unlikely to be too severe at noise sensitive receptors in the study area.

Once Phase 1 of the expansion project becomes operational the noise situation is predicted to be as follows:

i) Noise levels near to the main roads will remain high and will continue to increase as traffic volumes increase.

ii) The proposed Phase 1 upgrading required at the existing Shaft 1 complex will increase the area of influence from this source area only marginally.

iii) The additional ventilation shafts to the south-west of Shaft 1 will introduce a very loud source of noise to an area which is fairly quiet, but the impact from the traffic from Road A14

would still be significant. It should be noted that, during the night-time, when the traffic noise is intermittent, the noise from the ventilation shafts will be continuous.

iv) The situation in the study area is predicted to be as follows:
   a) The residences on the western edge of Palapye (*urban residential*) lie well outside the colliery's 45dBA+ impact zone and thus will not be negatively affected.
   b) The Colliery Village (*suburban residential*) lies well outside the colliery's 40dBA+ zone and thus will not be negatively affected.
   c) Some 11 homesteads (*rural residential*) fall within the area where the noise levels exceed 35dBA.
   d) The noise from the colliery will not significantly worsen the noise climate at the Kgaswe Primary School. The noise climate at the school is already significantly degraded from road traffic noise.
   e) Night-time noise levels in the "contractor's" village are already degraded from road traffic noise and the anticipated increase from the planned colliery expansion will be minor.

v) The volume of traffic generated by the operations by the Phase 1 expansion will only marginally increase the ambient noise levels along the road corridor between the colliery and Palapye.

vi) Colliery trains travelling at night have the potential to have a high impact in some areas

Once Phase 2 of the expansion project becomes operational the noise situation is predicted to be as follows:

i) Noise levels near to the main roads will remain high and will continue to increase as traffic volumes increase.

ii) The proposed Phase 2 upgrading required at the existing Shaft 1 complex will increase the area of influence from this source area by a radius of about 600 metres.

iii) The additional ventilation shafts to the south-west of Shaft 1 will continue to be a very loud source of noise. It should be noted that, during the night-time, when the traffic noise is intermittent, the noise from the ventilation shafts will be continuous and will form the main component of the noise intrusion where relevant.

iv) The construction of the Shaft 2 complex will introduce a very loud noise source to an area which is very quiet.

v) The noise situation in the study area after the commissioning of the Phase 2 expansion, is predicted to be as follows:
   a) The residences on the western edge of Palapye (*urban residential*) lie well outside the colliery's 45dBA+ impact zone and thus will not be negatively affected.

b) The Colliery Village (*suburban residential*) lies just outside the colliery's 40dBA+ zone and thus will not be negatively affected.

c) Some 21 homesteads (*rural residential*) fall within the area where the noise levels exceed 35dBA. These noise sensitive receptors are shown in Figure 5. The noise contours in Figure 5 are the cumulative noise values from all three elements of the Phase 2 Colliery Expansion Project.

d) The noise from the colliery will not significantly worsen the noise climate at the Kgaswe Primary School. The noise climate at the school is already significantly degraded from road traffic noise.

e) Night-time noise levels in the "contractor's" village are already degraded from road traffic noise and the anticipated increase from the planned colliery expansion will be minor.

vi) Noise impact from ancillary works and equipment (such as the conveyor belts) will in general be low and localised. The drive houses for the conveyor belt system, however, will be sites of high noise levels.

vii) The volume of traffic generated by the operations by the Phase 2 expansion will only marginally increase the ambient noise levels along the road corridor between the colliery and Palapye.

viii) Colliery trains travelling at night have the potential to have a high impact in some areas.

The following conclusions may be drawn from the foregoing analysis:

i) Although not all of the final baseline noise design data was available for the analysis, the assumptions made are considered adequate to give a meaningful analysis of the noise impact situation, taking into account the fact that the proposed expansion project was modelled on the data from measurements at the existing Morupule Colliery and at other similar operational collieries, and that a conservative (worst case scenario) approach was used.

ii) Road traffic noise will continue to have a major negative impact in the areas immediately adjacent to the main roads.

iii) Although the existing general noise climate of much of the study area is still fairly representative of a quiet rural/farming district, ambient noise levels in the corridor between Palapye and Morupule Colliery are already severely degraded near to the colliery as well as at power station and near to the main roads.

iv) The commissioning of the Morupule B Power Station will introduce a very loud new source of noise into the eastern sector of the study area.

v) The predicted noise from the colliery expansion project has to potential to negatively affect several homesteads in the area, particularly at night. At the commissioning of Phase 1 some 11 homesteads could be impacted. At the commissioning of Phase 2, the number of homesteads impacted will increase to about 21.

vi) Noise mitigating measures intended for the proposed expansion project will further reduce its area of potential negative impact.

There are noise control management measures (mitigating measures) that should be applied during the construction and the operational phases. For the construction phase, the restricting of construction activities to the day (07h00 to 18h00) would be the main issue. For the operational phase, the latest technology incorporating maximum noise mitigating measures for all plant and equipment should be designed into the system.

From the details presently available, it may be concluded that noise impact from Phase 1 and Phase 2 of the proposed expansion project will not be significant provided that appropriate mitigating measures are applied.

NOISE IMPACT ASSESSMENT OF THE PLANNED MORUPULE COLLIERY EXPANSION

1. INTRODUCTION

1.1. Background and Locality

Morupule Colliery Limited (MCL) is planning an expansion of the existing Morupule Colliery, which lies approximately 9 kilometres west of Palapye Village. The Project site is located in the Central District of Botswana, approximately 280 kilometres north of Gaborone and just to the west of the village of Palapye. Refer to Figure 1. Palapye is classified as a secondary centre and is located on the main Gaborone-Francistown road (Road A1) and railway.

The planned expansion of the colliery will allow a production level of approximately 12 million tons per annum (tpa), from the current 1 million tons per annum level. This expansion will take place in two phases: an initial expansion to approximately 4M tpa (Phase 1) and a subsequent expansion of 8M tpa to 12M tpa (Phase 2). The expansion of mining capacity to 4M tpa can be accommodated by the existing mine and related infrastructure with minor upgrading. Phase 2 will require the development of a new shaft complex and mining operation approximately 3,5km to the north-west of the existing shaft and the construction of additional crushing and coal washing facilities in the vicinity of the existing shaft.

Ecosurv (Pty) Ltd is undertaking the environmental and social impact assessment study of the project while Jongens Keet Associates has undertaken the investigation of the potential noise impact of the colliery upgrading project. The work was undertaken by Mr Derek Cosijn who was assisted by Dr Erica Cosijn. This report documents the approach, findings and recommendations for the noise impact investigation.

1.2. Terms of Reference

The terms of reference (TOR) were as follows:

i) A sufficiently detailed quantitative (by measurement) and qualitative assessment within the area of influence of the planned expansion of the Morupule Colliery was to be undertaken in order to enable a full appreciation of the nature, magnitude, extent and implications of the potential noise impact of the project.

ii) The initial level of investigation was to that of an EIA.

iii) All aspects of the investigation were to conform to the requirements of relevant environmental legislation and noise standards.

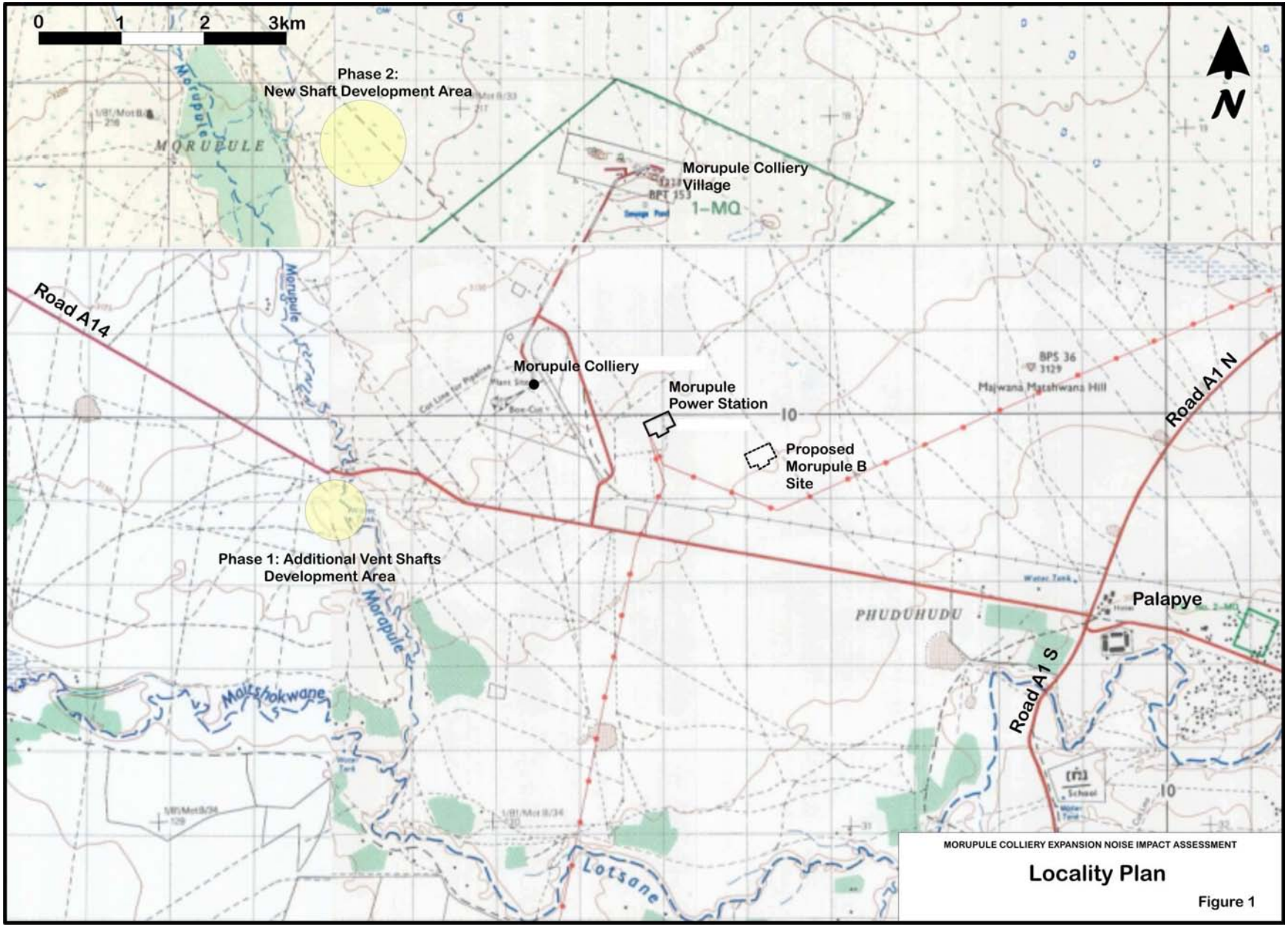
iv) The potential impacts of the pre-construction, construction and operational phases of the project were to be assessed.

v) Where relevant, appropriate noise mitigating measures were to be identified. These need only be conceptual at this stage.

vi) No meetings related to the public involvement programme were to be attended by JKA.

1.3. Study Area

The study area is that within the area of influence of the noise generated by the operations of and traffic generated by the planned Morupule Colliery Expansion Project.


0
1
2
3km
N
Phase 2:
New Shaft Development Area
Morupule Colliery
Village
1-MQ
Road A14
Morupule Colliery
Morupule
Power Station
Proposed
Morupule B
Site
Road A1 N
Phase 1: Additional Vent Shafts
Development Area
Palapye
PHUDUHUDU
Road A1 S
Matshokwane
Lotsane
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASSESSMENT
Locality Plan
Figure 1

1.4. Details of the Morupule Colliery Expansion Project

1.4.1. General

The Morupule Colliery Limited (MCL), a subsidiary of Debswana Diamond Company (Pty) Ltd has been operating a coal mine since 1973 and is currently producing 1 million tonnes of coal per annum. The coalfield within the mining lease area is immense and contains good quality coal, with the estimated overall coal presence exceeding 5 billion tonnes. Production has increased steadily over the years from 145 000 tonnes per annum in 1973 to a total of 985 000 tonnes of coal mined and 964 000 tonnes sold in 2005. The Botswana Power Corporation (BPC), which operates a coal-fired power station nearby has been the main consumer of the MCL coal, consuming about 66 % of the MCL annual production.

Other major industries supplied by the MCL mine include a copper mine in Selibe Phikwe, Botswana Ash Plant in Sowa Pan, Botswana Meat Commission, Botswana Breweries, Foods Botswana, Makoro Bricks, and two retail coal distributors. In addition, the mine also supplies graded coal to Zimbabwe, Zambia and the Democratic Republic of Congo.

The Morupule Colliery Expansion Project will allow the expansion of Morupule Colliery to allow a production level of approximately 12 million tons per annum (12M tpa) from the current 1 million tons per annum level. The expansion of the colliery will take place in two phases:

- Phase 1: (2010 – 2012) will increase the output to 4M tpa from the existing mining complex and can be accommodated by the existing shaft (Shaft 1) and infrastructure with minor upgrading. It will also require an additional intake and outtake ventilation shaft approximately 3,5km to the south-west of the existing mine shaft.
- Phase 2: (2012 – 2015) will increase the output to 12M tpa and will require a new mining area with a new shaft complex (Shaft 2) approximately 3,5km to the north-west of the existing shaft.

The purpose of the overall expansion is:

- To cater for an increase in power generating capacity at the Botswana Power Corporation power station site at Morupule. This is expected to be 600MW for Morupule Power station B Phase 1, and 600 MW for Morupule Power station B Phase 2, together with the current 132MW of generating capacity. The coal required to meet these requirements has been established as 5.8 million tons per annum.
- To produce beneficiated coal that has been processed through washing plants, for the local coal market and for export (2.7m tons of beneficiated coal).

- To produce non-beneficiated coal of power station grade coal to existing and new customers (3.5 million tons per annum).

A number of additional houses (at least 20) will be constructed at the Morupule Colliery Village to accommodate senior personnel involved in the operation of the proposed expansion project.

1.4.2. Phase 1 Expansion

This expansion will focus on increasing capacity of the existing mine and plant to be able to provide approximately 4M tpa to BPC power station B phase 1 and to existing customers who consist of: washed coal customer base, BPC power station A, BCL and Soda-ash.

1.4.2.1. Mining

The mining expansion will consist of developing additional continuous miner sections in the existing shaft to allow tonnage capacity to be reached. The ventilation of the existing shaft will need to be improved to provide for the production increase, and this will see the development of two ventilation shafts (one upcast and one downcast) approximately 3km to the south-west of the existing decline shaft. The trunk conveyors will be upgraded to cater for increased production levels. The shaft entry roads will need to be expanded to allow for increase traffic, and support facilities will be provided on surface for underground activities. Production from this shaft will be able to continue to ca 2028 before the resource is depleted.

1.4.2.2. Surface Plant and Infrastructure:

There is an existing coal crushing and screening plant, and a coal washing plant in production at the existing colliery. Both the screening plant and crushers are too small to accommodate the 4M tpa expansion, and will be replaced with new equipment housed in new buildings. The existing washing plant will not be replaced or expanded during phase 1. Coal from underground will be transported to surface using a series of conveyor belts to the crushers, the screens and the coal washing plant.

The expansion will also include the provision of new or expanded workshops, change-rooms, dining facilities, lamp-room, stores, offices, laboratory facilities, weighbridge and access control systems.

1.4.3. Phase 2 Expansion

The Phase 2 expansion will increase the output of the colliery from 4 to 12 M tonnes per annum.

1.4.3.1. Mining

The existing shaft will not be able to be expanded further, and therefore a new shaft will need to be constructed to allow the mining of an additional 8M tpa. This shaft is likely to be located some 3.5km to the north of the existing shaft (refer to Figure 1). The mine will be developed in the same style as the existing shaft, and the same mining method will be utilised.

The boxcut and associated offices, and plant will encompass a footprint of 10ha to the west of the shaft location.

The mine will take approximately 3 years to develop to full capacity due to section scheduling constraints. Initially ventilation will be provided from ventilation fans at the shaft entrance. At a point in time when the main header is sufficiently advanced (approximately 2.5km from shaft entrance), a set of additional ventilation fans will be installed. This is not being dealt with in this report.

Ore from the underground production section will be transported to surface using conveyor belts. This ore will be deposited into a silo near the mouth of the shaft. From the silo, ore will be drawn into an open circuit crusher to reduce its size to less than 75mm. from the crusher the ore will be deposited onto an overland conveyor and transported to the vicinity of the existing plant. This overland conveyor will be covered to prevent dust being blown off the conveyor.

1.4.3.2. Surface Plant and Infrastructure

The Phase 2 expansion will require the following infrastructure:

- processing plant at the new site (crushers)
- coal crushing screening and washing plant at the existing colliery
- conveyor system between the two shaft complexes as well as distribution conveyor systems at the existing site.
- A road and railway line between the two sites.

This expansion will also be accompanied with the provision of new or expanded workshops, change-rooms, dining facilities, lamp-room, stores, offices, laboratory facilities, weighbridge and access control systems to accommodate the additional people and activities required.

2.0. DETAILS OF THE STUDY AREA

Only the aspects, which have an influence on the potential noise impact are dealt with in this Section.

2.1. Topography

The Morupule Colliery property is at an elevation of approximately 950 metres above mean sea-level (mamsl). The land to the northwest of the site (e.g. the rocky country around Serowe) rises to an elevation of 1100 mamsl. In general there is a gentle gradient falling away to the southeast. There are a few topographical features in the area that attain elevations of approximately 100 metres above the surrounding countryside. These features include the Tswapong hills, which lie about 10 kilometres to the southeast and the two small “koppies”, to the north of the site.

The Project site lies within the Lotsane River Catchment. This is a major ephemeral river in the area. This catchment is slightly hilly, but predominantly undulating. The area is drained by a series of seasonal rivers that form the Lotsane River. The regional drainage direction is to the east and southeast (Colquhoun, O’Donnell & Partners, 1979). The Lotsane River flows in a west to east direction through the southern sector of the study area approximately 5000 metres south of the existing power station. The Morupule River drains the area in a north to south direction and has its confluence with the Lotsane River approximately 4000 metres west of the existing power station.

2.2. Roads

The main roads influencing the study area are:

i) Road A1: The main road from Gaborone to Palapye to Francistown. It is aligned in a south to north direction through the centre of Palapye. For convenience in the report this road has been divided into two sections:
   a) Road A1 North is the section of the A1 north of Road A14 (from Palapye to Francistown).
   b) Road A1 South is the section of the A1 south of Road A14 (from Palapye to Gaborone).

ii) Road A14: The main road from Palapye to Serowe. It is aligned in an east to west direction through the central sector of the study area. It intersects with Road A1 in the centre of Palapye.

2.3. Railway Lines

There are two railway lines in the study area:

i) The mainline from Gaborone to Francistown is aligned in a south to north direction on the eastern side of Palapye.

ii) The spur-line from the Morupule Colliery to Palapye is aligned in a west to east direction just south of the Morupule Power Station. It links to the Gaborone-Francistown mainline in Palapye.

2.4. Land Use

2.4.1. Existing Situation

The Morupule Coal Mine is owned and operated by Morupule Colliery Limited, subsidiary of Debswana Diamond Company (Pty) Ltd. The mine holds ownership of the mineral rights in respect of the mining areas in the Serowe/Palapye Sub-District. The lease area covers an area of approximately 142km^2. Subsistence agriculture as well as the Morupule Colliery and the Palapye Village dominate the land that is immediately adjacent to the property.

The existing land uses in the area are:

i) Residential:
   a) Village of Palapye. The nearest section of the town to the study area lies approximately 5500 metres to the east of the existing Morupule Power Station.
   b) The Morupule Colliery Village is situated approximately 2850 metres north-west of the existing power station.
   c) Numerous homesteads throughout the study area. This includes the settlement ("Molapu Wapitsi") just north of the Lotsane River. Refer to Figure C1 in Appendix C.
   d) The "Contractor" village is located approximately 2500 metres south-east of the Morupule Colliery, just to the north of Road A14 and adjacent to the Kgaswe Primary School.

ii) Educational: The Kgaswe Primary School is located approximately 2500 metres south-east of the colliery and just to the north of Road A14.

iii) Industrial: Morupule Power Station.

iv) Mining. The Morupule Colliery.

v) Agriculture. The main land use in the study area and its environs is crop growing (sorghum, maize, millet and beans) and livestock (cattle, goats and sheep). There are numerous kraals in the area surrounding the colliery.

It is the existing residential areas and the school in the study area that may defined as noise sensitive land uses.

2.4.2. Planned Land Use

There are presently no known developments in the study area that could be adversely affected by the planned colliery expansion project.

2.5. Aspects of Acoustical Significance

The terrain across the study area is flat falling gently to the south-east towards the Lotsane River. There are no natural features that will assist in the attenuation of noise.

The main meteorological aspect that will affect the transmission (propagation) of the noise is the wind. The wind can result in periodic enhancement downwind or reduction upwind of noise levels. Analysis of the wind records for the area indicates that overall (day and night average) the main prevailing winds blow from a north and a north-easterly direction, but the area does experience winds from the southeast, a condition which is associated with thunderstorms in summer months and cold fronts during winter months.

3. METHODOLOGY

3.1. General

Botswana in general applies the World Health Organisation (WHO) and World Bank (WB) environmental standards and procedures. There are South African National Standards (SANS) codes of practice and procedures which have been developed based on the requirements of the WHO and WB as well as those of the International Standards Organisation (ISO). As the South African documents are more detailed, more prescriptive and often apply more stringent standards it is recommended that the South African as well as the international standards be applied on this project. The general procedure used to determine the noise impact was guided by the requirements of the Code of Practice SANS 10328:2003: *Methods for Environmental Noise Impact Assessments.* The level of investigation was the equivalent of an EIA. A comprehensive assessment of all noise impact descriptors (standards) has been undertaken. The noise impact criteria used specifically take into account those as specified in the South African National Standard SANS 10103:2004, *The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and Speech Communication* as well as those in relevant Noise Control Regulations.

The investigation comprised the following:

i) Determination of the existing situation (prior to the planned colliery expansion project).
ii) Determination of the situation during construction and after commissioning of the planned colliery expansion project (Phase 1 and Phase 2).
iii) Determination of impacts during the decommissioning phase.

iv) Assessment of the change in noise climate and impact.

v) Identification of mitigating measures.

3.2. Determination of the Existing Conditions

This phase comprised the following:

i) The relevant technical details of the existing and the planned colliery expansion, the existing traffic patterns and the existing and planned land use in the study area were reviewed in order to establish a comprehensive understanding of all aspects of the project that influence the existing noise climate and will influence the future noise climate in the study area.

ii) Using these data, the limits of the study area of the development site were determined and the potential noise sensitive areas, other major noise sources and potential problems in these areas were identified.

iii) Applicable noise standards and codes of practice were established. In the absence of local noise standards and codes of practice, the World Health Organisation Standards, the South African National Noise Control Regulations, and the SANS 10103:2004 standards were applied. These standards and codes of practice are consistent with the World Bank Group guidelines for thermal power plants.

iv) The existing *noise climate* of the Study Area was determined by means of a field inspection and a noise measurement survey. The measurement survey appropriately covered the whole of the study area, focussing specifically on the identified noise sensitive/problem areas. Measurements were taken at 19 monitoring sites in the study area. Both the daytime and night-time conditions were measured. The sound pressure level (SPL) (noise) measurements were taken in accordance with the requirements of the Code of Practice SANS 10103:2004, *The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and to Speech Communication*. Type 1 Integrating Sound Level meters were used for the noise measurements. All measurements were taken under dry weather and normal traffic (that is mid-week/school term) conditions. Refer to Appendix B.

v) On the general field inspection and at the same time as each individual measurement was being taken, the qualitative nature of the *noise climate* in the area of the measurement site was assessed and recorded. This comprised an appraisal of the general prevailing acoustic conditions based on the subjective response to the sounds as perceived by the listener (i.e. *auditory observation* by the surveyor), as well as identifying those noise incidents, which influenced the noise meter readings during that measurement period. This procedure is essential in order to ensure that that there is a *human* correlation between the noise as perceived by the human ear and that, which is

measured by the meter, as well as to establish any anomalies in the general ambient noise conditions.

vi) The noise profile of the existing Morupule Colliery operation was determined from measurement and calculation. The parameters for the calculation were determined from a baseline noise measurement of the various plant and equipment at the colliery. These in turn were used as input to an appropriate noise propagation calculation model.

vii) The existing noise climates along the main roads as related to the current traffic volumes and patterns were established. These traffic noise levels were calculated using the South African National Standard SANS 10210 (SABS 0210) *Calculating and Predicting Road Traffic Noise*. The Year 2007 traffic was used as the baseline reference. The calculated 24-hour period noise indicators, as well as those for the daytime period and night-time period provided the main data for the impact assessment.. The measured data provided a field check of the acoustic conditions.

3.3. Assessment of the Construction Phase Impacts

Aspects of the construction activities that potentially will have a noise impact were identified and, where appropriate, mitigating measures have been recommended.

3.4 Assessment of Operational Phase Impacts

The main focus of the operational phase assessment was to establish the nature, magnitude and extent of the potential change in *noise climate* in the study area directly related to and within the area of influence of the planned colliery site. This was done as follows:

i) The noise profiles of both the planned Phase 1 and Phase 2 expansions were calculated. The noise impact of the planned colliery expansion with its ancillary operations was established, and then its cumulative effects with the existing power station as well as the planned Morupule B power station were calculated. Refer to Appendix C.

ii) Based on the findings, appropriate noise mitigating measures (site scale) have been investigated and recommendations made. These are conceptual and not detailed to final design level.

4. FINDINGS AND ASSESSMENT OF IMPACT

The following conditions were observed in the study area and the following aspects were determined from the surveys, calculations of noise indicators and the predictive modelling undertaken for the assessment of the noise impact of the planned colliery expansion project.

4.1. General Details

General aspects of note were as follows:

i) The main sources of noise in the area are from:
   a) Traffic on Road A1 North, Road A1 South and Road A14.
   b) Morupule Power Station.
   c) Morupule Colliery.
   d) The colliery trains.

ii) The main noise sensitive areas/sites/receivers in the study area are:
   a) Palapye Village.
   b) Morupule Colliery Village (residential).
   c) Numerous homesteads throughout the study area.
   d) Contractor village adjacent to the Kgaswe Primary School.
   e) Kgaswe Primary School

4.2. The Existing Ambient Noise Climate

Measurements and *auditory observations* were taken at nineteen monitoring sites during the noise impact investigation in order to establish the ambient noise conditions of the study area. These were taken at appropriate sites at varying distances from the colliery. For a description of all of the measurement sites and for more technical details of the measurement survey, refer to Appendix B. Briefly the main sites are (refer to Figure B1 in Appendix B):

i) Site 1: At location of proposed new shaft (Shaft 2)
ii) Site 2: At location of proposed additional ventilation shafts for the existing mine
iii) Site 3: In Morupule Mine Village outside No. 29
iv) Site 4: In Morupule Mine Village in Mokowe Crescent (Assembly Point 4)
v) Site 5: In Morupule Mine Village outside Guesthouse (2 Monyane Close)
vi) Site 6: At entrance gate to Morupule Mine Village on eastern side of access road
vii) Site 7: Coal wash plant to the south-west of the power station at 63m
viii) Site 8: On road to coal washing plant, 1024m from washing plant, directly opposite the power station
ix) Site 9: Just outside the main colliery offices (on mine shaft side) 336m from crusher
x) Site 10: On road to and north of colliery site, at junction to village at 787m from crusher
xi) Site 11: At coal conveyor crossing over the Colliery access road
xii) Site 12: Opposite stonedust silo on main road (Road A14) at 1708m from crusher
xiii) Site 13: On the western boundary of Kgaswe Primary School, at approximately 30m from centre line of access road to the Morupule Power Station
xiv) Site 14: At remote settlement (“Molapu Wapitsi”) just north of the Lotsane River. (Approximately 3500m south of Road A14)

xv) Site 15: On road to settlement (Site 14) at approximately 750m south of Road A14

xvi) Site 16: At the entrance gate to the Morupule Golf Course to the southeast of the Morupule Power Station

xvii) Site 17: At the north-east corner of the game fence of the Morupule Colliery Game Park, approximately 4865m north-east of Shaft 1 at the Colliery

xviii) Site 18: On the south side of the road to Serowe (Road A14) just west of Palapye. The site is at the north-west boundary of the Palapye Development Trust houses. The site is approximately 30m from the centre-line of Road A1

xix) Site 19: In residential area of Palapye to east of Road A1. The site is at the north of the Desert Sands Motel and is approximately 100m east of the centre-line of Road A1.

Conditions for the daytime and evening periods were ascertained. The summary of all the noise measurements taken at the main sites is given in Table 1. The equivalent sound pressure (noise) level (L_{Aeq}), the maximum sound pressure level (L_{Amax}) and the minimum sound pressure level (L_{Amin}) are indicated. Note that the equivalent sound pressure (noise) level may, in layman's terms, be taken to be the average noise level over the given period. This "average" is also referred to as the residual noise level (excluding the impacting noise under investigation) or the ambient noise level (if the impacting noise under investigation is included). The definitions/details of the noise descriptors for the measurements are given in Appendix A and Appendix B.

TABLE 1: MEASURED CURRENT NOISE LEVELS IN THE MORUPULE COLLIERY STUDY AREA (YEAR 2007 AND 2008)

Measurement Site	Survey Date	Measured Sound Pressure Level (Noise) (dBA)					
		Daytime Period			Evening Period		
		L_{Aeq}	L_{max}	L_{min}	L_{Aeq}	L_{max}	L_{min}
Site 1	June 2008	28.6	45.0	19.3	n	n	n
Site 2	June 2008	39.5	51.3	25.9	n	n	n
Site 3	June 2008	45.8	71.8	27.4	41.5	54.9	36.3
Site 4	Sept 2007	47.5	68.0	32.3	39.2	52.0	23.0
Site 5	June 2008	33.8	46.8	22.5	31.5	42.8	22.3
Site 6	Sept 2007	39.8	52.8	27.1	28.8	45.1	21.1
	June 2008	39.6	52.2	25.6	39.4	55.2	29.2
Site 7	June 2008	68.8	70.5	67.3	n	n	n
Site 8	June 2008	54.8	65.1	45.5	n	n	n
Site 9	June 2008	56.1	61.1	51.8	n	n	n
Site 10	June 2008	46.0	56.6	37.8	n	n	n
Site 11	June 2008	51.0	58.2	46.0	n	n	n
Site 12	June 2008	*	*	*	42.9	58.5	37.6
Site 13	Sept 2007	57.9	76.6	38.8	49.8	54.6	44.8
Site 14	Sept 2007	45.4	58.3	29.5	30.8	38.5	28.2
Site 15	Sept 2007	43.5	57.6	33.0	n	n	n
Site 16	Sept 2007	46.6	54.4	39.9	n	n	n
Site 17	Sept 2007	35.2	50.1	30.5	n	n	n
Site 18	Sept 2007	62.4	79.0	43.6	46.2	52.0	41.3
Site 19	Sept 2007	56.8	76.0	43.9	51.0	58.7	39.6

Notes: n indicates that no night-time measurements were taken at the site
* no daytime measurements were taken due to interference of traffic noise

The details of the sites where measurements were taken to isolate the Morupule Colliery noise are given in Table B2 in Appendix B. The current noise profile of the existing colliery is shown in Table 2 and in Figure 2.

TABLE 2: EXSITING AMBIENT NOISE CLIMATE GENERATED BY THE MORUPULE COLLIERY (2008)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	62.2	**1200**	45.0	**2000**	38.4
500	55.1	**1300**	44.0	**2100**	37.8
600	53.1	**1400**	43.0	**2200**	37.1
700	51.4	**1500**	42.1	**2300**	36.5
800	49.9	**1600**	41.3	**2400**	35.9
900	48.5	**1700**	40.6	**2500**	35.4
1000	47.2	**1800**	39.8	**3000**	32.8
1100	46.0	**1900**	39.1		

The noise levels given are the unmitigated values. A conservative approach has been taken in the estimate of the number of cooling fans and the rated sound power level of these fans. A conservative approach has also been taken for the propagation of the sound in that a hard intervening ground condition has been modelled. The thick vegetation in the area will however generally result in greater attenuation with distance than shown. There will also be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

In order to complement the short-term noise measurements in the study area, the existing 24-hour residual noise levels related to the average daily traffic (ADT) flows on Road A1 and Road A14 were also calculated. These data provide an accurate base for the SANS 10103 descriptors. The noise levels generated from the traffic on these roads were calculated using the South African National Standard SANS 10210 (SABS 0210), *Calculating and Predicting Road Traffic Noise*. Typical situations for the roads in the area, namely the cross sections are at grade, were used for the calculation sites. The Year 2007 traffic was used as the baseline for the calculations. The traffic data were obtained from the Botswana Department of Transport.

The noise levels at various offsets from the centreline of these main roads are summarised in Table B3 in Appendix B. The noise levels given are the unmitigated values. A conservative approach has been taken in that a hard intervening ground condition has been modelled to simulate winter conditions (burnt veld). The thick vegetation in the area will generally result in greater attenuation with distance than shown. There will also be greater attenuation with distance than shown where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

The number of coal trains on the line from the Morupule Colliery to Palapye varies and generally averages three trains per week. The noise from the passing of a freight train (drawn by a diesel

locomotive) travelling at 45km/h peaks in the vicinity of 92dBA at a 30 metre offset from the track. There are level crossings at the Colliery access road, the power station access road and Road A1 N where it is mandatory that the trains sound a warning horn. Noise from these horn soundings can be as loud as 105dBA at 30 metres and 84dBA at 350 metres from the train.

In overview, the existing situation with respect to the *noise climates* in the study area was found to be as follows:

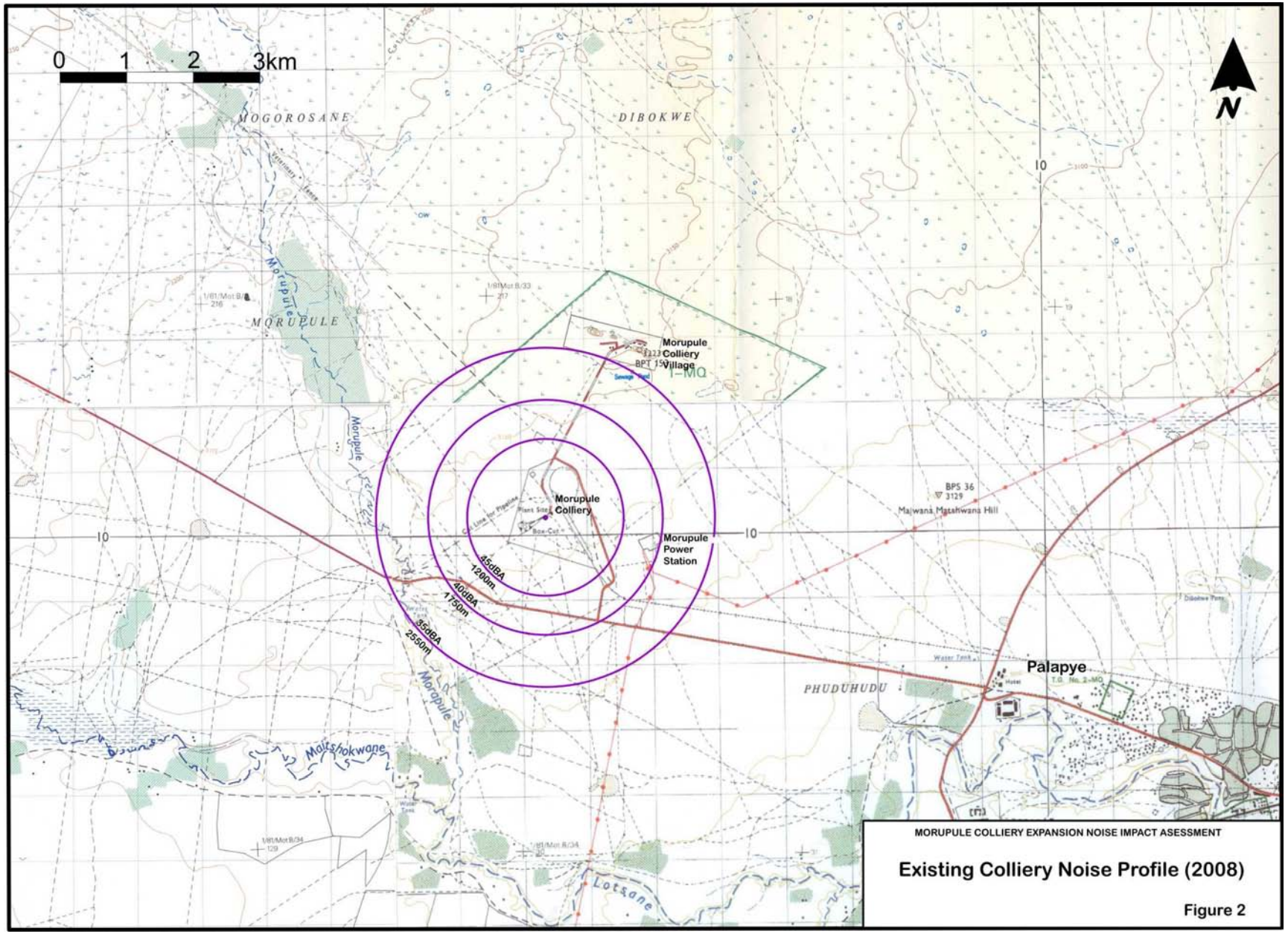
i) The main sources of noise in the area are from:
   a) Traffic on Road A1 North, Road A1 South and Road A14.
   b) Morupule Power Station.
   c) Morupule Colliery.
   d) Colliery railway line.

ii) The main noise sensitive areas/sites/receptors in the study area are (refer also to Figure C1 in Appendix C):
   a) Palapye Village.
   b) Morupule Colliery Village (residential).
   c) Scattered homesteads in the study area, including the settlement ("Molapu Wapitsi") just north of the Lotsane River.
   d) Contractor village adjacent to the Kgaswe Primary School.
   e) Kgaswe Primary School

iii) Noise levels in Palapye Village are high and are typical of an urban complex. The existing *noise climate* alongside the main roads in Palapye is degraded with regard to acceptable urban residential living standards (SANS 10103 noise impact criteria), that is noise exceeds acceptable levels particularly at night. Residences in some areas are negatively impacted from traffic noise (night-time standard) for up to 220 metres from the main roads. In general the daytime conditions are acceptable (SANS 10103).

iv) The areas outside Palapye and remote from the main roads and the power station/colliery are very quiet and reflect a rural character.

v) The existing *noise climate* alongside Road A14 outside Palapye Village is degraded with regard to acceptable rural residential living standards (SANS 10103 noise impact criteria). Any residences within 2000 metres of the road are negatively impacted from traffic noise (particularly at night).


0 1 2 3km
N
MOGOROSANE
DIBOKWE
MORUPULE
Morupule
Morupule Colliery Village
I-MQ
Morupule Colliery
Morupule Power Station
45dBA 1200m
40dBA 1750m
35dBA 2550m
BPS 36
3129
Malwana Matshwana Hill
Palapye
T.O. No. 2-MO
PHUDUHUDU
Motshokwane
Lotsane
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASESSMENT
Existing Colliery Noise Profile (2008)
Figure 2

vi) The impact of the Morupule colliery on noise sensitive sites in the surrounding area is relatively minor. Noise levels from the colliery exceed 35dBA (the maximum allowable night-time level for rural residential use) up to a distance of about 2600 metres from the facility. Seven homesteads lie within this area of influence. The Colliery Village lies just outside this zone and is thus not impacted by the colliery noise.

vii) Noise levels from traffic on Road A14 at the Kgaswe Primary School are slightly higher than desirable for an educational environment. The outdoor ambient noise level should not exceed 50dBA. Noise from vehicles passing over the rumble strips on the power station access road just to the west of the school is a significant noise nuisance factor.

viii) Noise from the colliery does not have a significant impact on the activities at the Kgaswe Primary School.

ix) The overall impact of the noise from the coal trains on noise sensitive sites in the area is not significant. There is a minor nuisance effect at the school from the warning horn sounding when the train approaches the level crossing with the power station access road.

Refer to Appendix B for more details.

4.3. Noise Standards/Impact Criteria (Planning Framework)

From these findings it was considered appropriate to determine the noise impact in Palapye on the basis of urban residential standards, namely the daytime period ambient noise level should not exceed 55dBA and that for the night-time period should not exceed 45dBA. The noise impact criteria for the Morupule Colliery Village and "Contractor's Village" at Kgaswe Primary School should be based on suburban residential standards, namely the daytime period ambient noise level should not exceed 50dBA and that for the night-time period should not exceed 40dBA. The noise impact criteria for any rural settlements (homesteads) should be based on rural residential standards, namely the daytime period ambient noise level should not exceed 45dBA and that for the night-time period should not exceed 35dBA. Noise levels at schools should not exceed 50dBA (outdoor condition).

4.4. Assessment of the Construction Phase

4.4.1. General

The potential noise climate was established in general for the construction during Phases 1 and 2 of the colliery expansion project, inclusive of appurtenant works such as the internal road and access road system and the coal conveyors. Construction activity will increase from a fairly low level during Phase 1 to a high intensity during Phase 2 of the expansion project. A large

construction camp will be established near to the construction site. Construction of the above mentioned activities will commence in 2010. Backfill construction material will be sourced from a local borrow pit. Construction activities will employ about 2000 people. These people will be accommodated in a temporary contractor's camp erected in the vicinity of Morupule Colliery. It is expected that the camp will be decommissioned after use.

Although not all of the details of the proposed expansion project and its infrastructure have been finalised, general concepts have been used in the noise impact evaluation and these are adequate to provide a sound basis for the analysis of typical noise conditions and impacts that are likely to prevail due to the project. Data related to construction have been sourced from various consultants and the experience that JKA has had working on similar sites.

4.4.2. Construction Noise Conditions

Construction will likely be carried out during the daytime only (07h00 to 18h00 or 20h00). It should however be noted that certain activities may occasionally extend into the late evening period, while others such as de-watering operations may need to take place over a 24-hour period. It is estimated that Phase 1 of the project will take place over a period of three years (2009 – 2012) and Phase 2 over three years (2012 – 2015).

4.4.2.1. Sources of Noise

The following are likely to be the main construction related sources of noise for the proposed power station and the related infrastructure:

i) Construction camp establishment. This will be for the site offices, workshops and the accommodation camp for the workers on site.
ii) Activities related to the relocation of services.
iii) Excavation of service trenches. Blasting may be required in places but in general pneumatic breakers will be used where rock is encountered.
iv) Shaft sinking excavations.
v) Piling operations.
vi) Excavation of the mine and ventilation shafts
vii) Temporary ventilation system for the shaft during excavation.
viii) Erection of shuttering for concrete works.
ix) Fixing of steel reinforcing.
x) Placing and vibration of concrete. Poker vibrators will be used.
xi) Stripping of shuttering after concrete pour.
xii) Erection of structural steelwork.
xiii) Installation of plant and equipment.

xiv) Finishing operations on buildings. Cladding, services installation, etc.

xv) General movement of heavy vehicles such as concrete delivery vehicles, mobile cranes, mechanical dumpers and water trucks (dust suppression) around the site.

xvi) De-watering pumps for storm-water and ground water in the excavations. A 24-hour operation may sometimes be necessary.

xvii) Road and railway line construction equipment. Scrapers, dozers, compactors, etc. (Construction of the internal road and rail system, and access roads).

xviii) Construction site fabrication workshops and plant maintenance workshops.

xix) Construction material and equipment delivery vehicles.

xx) Concrete batching plant and asphalt batching plant on site.

The level and character of the construction noise from the proposed expansion project will be highly variable as different activities with different plant/equipment take place at different times, over different periods, in different combinations, in different sequences and on different parts of the construction site. Typical noise levels generated by various types of construction equipment are given in Table 3A. These noise levels assume that the equipment is maintained in good order. Conservative attenuation conditions (related to intervening ground conditions and screening) have been applied. Using baseline data from typical construction sites, the ambient noise conditions at various offsets from the construction activities are likely to be as indicated in Table 3B. Once shaft sinking commences, the noise from the temporary ventilation system supplying fresh air down into the shaft will increase the noise generated from the shaft area. Noise levels are then likely to be more of the order of those indicated in Table 3C. As the shaft sinking operation will take place on a 24-hour, 7-days per week basis, the noise levels in the latter table represent the anticipated 24-hour condition.

TABLE 3A: TYPICAL NOISE LEVELS GENERATED BY CONSTRUCTION EQUIPMENT

Plant/Equipment	Typical Operational Noise Level at Given Offset (dBA)							
	5m	10m	25m	50m	100m	250m	500m	1000m
Air compressor	91	85	77	71	65	57	51	46
Compactor	92	86	78	72	66	58	52	46
Concrete mixer	95	89	81	75	69	61	55	49
Concrete vibrator	86	80	72	66	60	52	46	40
Conveyor belt (mobile)	77	71	63	57	51	43	37	32
Crusher (aggregate)	90	84	76	70	64	56	50	44
Crane (mobile)	93	87	79	73	67	59	53	47
Dozer	95	89	81	75	69	61	55	49
Loader	95	89	81	75	69	61	55	49
Mechanical shovel	98	92	84	78	72	64	58	52
Pile driver	110	104	97	91	85	77	71	65
Pump	86	80	72	66	60	52	46	40
Pneumatic breaker	98	92	84	78	72	64	58	52
Rock drill	108	102	94	88	82	74	68	62
Roller	84	78	70	64	58	50	44	38
Trucks	87	81	73	67	64	60	57	54

TABLE 3B: TYPICAL CONSTRUCTION NOISE LEVELS FOR THE COLLIERY EXPANSION PROJECT SITES

Equipment	Sound pressure level at given offset (dBA)										
	200 m	400 m	500 m	600 m	700 M	800 m	1000 m	1200 m	1500 m	2000 m	2500 m
Total construction operation	53.5	46.4	43.9	41.9	40.1	38.5	35.7	33.4	30.4	26.3	22.9

TABLE 3C: TYPICAL CONSTRUCTION NOISE LEVELS FOR SURFACE CONSTRUCTION AND SHAFT SINKING ACTIVITIES AT GIVEN OFFSETS FROM THE SHAFT COMPLEX AND INCLUDING NOISE FROM THE TEMPORARY SHAFT VENTILATION SYSTEM

Equipment	Sound pressure level at given offset (dBA)										
	200 m	400 m	500 m	600 m	700 m	800 m	1000 m	1200 m	1500 m	2000 m	2500 m
Total construction operation	65	58	56	54	53	51	48	47	44	41	38

4.4.2.2. Noise Impact

The nature of the noise impact from the construction sites is likely to be as follows:

i) Source noise levels from many of the construction activities will be high. Noise levels from all work areas will vary constantly and in many instances significantly over short periods during any day working period.

ii) Exact daytime period and night-time period continuous equivalent sound pressure levels are not possible to calculate with certainty at this stage as the final construction site layout, work programme for the various components, work *modus operandi* and type of equipment have not been finalised. Working on a worst case scenario basis, it is estimated that the ambient noise level from *general construction* should not exceed 35dBA at 1000m offset:

- Construction at the existing colliery (Phases 1 and 2): No noise sensitive receptors will be negatively affected.
- Construction at the additional ventilation shafts (Phase 1): Four homesteads will possibly be affected, but as these homesteads are close to Road A14 where there is already a degraded noise climate, noise impact is expected to be minimal.
- Construction at the new mine shaft complex (Shaft 2: Phase 2): Three homesteads could be slightly negatively affected at night if construction is allowed during night-time periods.
- The Kgaswe Primary School and the Morupule Colliery Village will not be negatively affected by the construction site noise from any of the three main construction site areas.
- Construction of new houses in the Morupule Colliery Village will have only a minor negative impact on the surrounding houses during the day. No night-time construction activities are anticipated.

iii) During the sinking of the Phase 1 ventilation shafts, temporary ventilation of the excavations will result in the noise levels being extremely high and an area of about 3000m surrounding the operation will be negatively affected.

iv) During the sinking of the Phase 2 mine shaft and the associated ventilation shafts, temporary ventilation of the excavations will result in the noise levels being extremely high and an area of about 3000m surrounding the operation will be negatively affected.

v) No Traffic Impact Assessment was undertaken for the project. It has been estimated that the construction activities at the site will on average generate no more than about 250 vehicle trips (two way trips) daily. The main percentage of the trips will be concentrated in the morning and evening peak periods. As the daily volume of

construction generated traffic will be relatively small in comparison with the existing daily traffic on the external main road system, the noise impact from this additional traffic on the surrounding areas will be insignificant. Ambient traffic noise levels on Road A14 due to the construction traffic will increase only marginally.

vi) For all construction work, the construction workers working with or in close proximity to equipment will be exposed to high levels of noise as can be seen from Table 2 (refer to the 5 metre offset noise levels).

It should be noted that for residential areas, higher ambient noise levels than recommended in SANS 10103 and WHO Guidelines for Community Noise are normally accepted as being reasonable during the construction period, provided that the very noisy construction activities are limited to the daytime and during the week, and that the contractor takes reasonable measures to limit noise from the work site. Note that it has been assumed that surface facility construction will generally take place from 07h00 to 18h00 with no activities (or at least no noisy construction activities) at night. From the details presently available, it appears that the construction noise impact is not likely to be a problem in the area.

4.5. Assessment of the Operational Phase: Phase 1

Phase 1 of the Morupule Colliery Expansion Project will increase the output to 4M tpa from the existing mining complex and infrastructure with minor upgrading. It will also require an additional intake and outtake ventilation shaft approximately 3,5km to the south-west of the existing mine shaft (Shaft 1).

The following predicted conditions in the study area and the following aspects were determined from the surveys, calculations of noise indicators and the predictive modelling undertaken for the assessment of the noise impact of Phase 1 of the project. This Section summarises the more detailed technical analysis, which is documented in Appendix C. The altered noise climate situation was evaluated on the basis of the noise impact from Phase 1 of the project, the noise impact from ancillary works and the noise impact from traffic generated by the Phase 1 Expansion.

4.5.1. Noise Sources

The main sources of noise in the area will be from:

i) Traffic on Road A1 North, Road A1 South and Road A14.

ii) Morupule Power Station.

iii) Morupule B Power Station (anticipated commissioning in 2012).

iv) Morupule Colliery (Phase 1 anticipated commissioning in 2012).

v) The colliery trains.

4.5.2. Noise Sensitive Areas

The main noise sensitive areas/sites/receivers in the study area are:

i) Palapye Village.

ii) Morupule Colliery Village (residential).

iii) Several homesteads scattered throughout the study area.

iv) “Contractor” village adjacent to the Kgaswe Primary School.

v) Kgaswe Primary School

4.5.3. Predicted Noise Generated by Phase 1 of the Morupule Colliery Expansion Project

Analysis of the existing Morupule Colliery and the Phase 1 requirements (ascertained from existing plant on site and similar types of collieries elsewhere) predicted the noise profile indicated in Tables 4 and 5 and in Figure 3:

TABLE 4: PHASE 1 - FUTURE AMBIENT NOISE CLIMATE GENERATED BY THE EXISTING (UPGRADED) MORUPULE COLLIERY COMPLEX (2010-2012)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	62.7	**1200**	45.4	**2000**	38.7
500	55.6	**1300**	44.3	**2100**	38.0
600	53.5	**1400**	43.4	**2200**	37.4
700	51.8	**1500**	42.5	**2300**	36.8
800	50.3	**1600**	41.6	**2400**	36.2
900	48.9	**1700**	40.9	**2500**	35.7
1000	47.6	**1800**	40.1	**3000**	33.1
1100	46.4	**1900**	39.4		

There is only a very small change (on average 0.3dBA) between the future noise climate (2012 upgrading) and the current noise climate (existing colliery).

The future noise profile (refer to Figure 3) of the planned ventilation shafts for the existing mining complex is predicted to be (see Table 5):

TABLE 5: PHASE 1 - FUTURE AMBIENT NOISE CLIMATE GENERATED BY THE NEW VENTILATION SHAFTS (2012)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	54.5	**1200**	38.0	**2000**	31.9
500	47.6	**1300**	37.1	**2100**	31.2
600	45.7	**1400**	36.2	**2200**	30.7
700	44.1	**1500**	35.4	**2300**	30.1
800	42.6	**1600**	34.6	**2400**	29.5
900	41.3	**1700**	33.9	**2500**	29.0
1000	40.1	**1800**	33.2	**3000**	26.6
1100	39.0	**1900**	32.5		

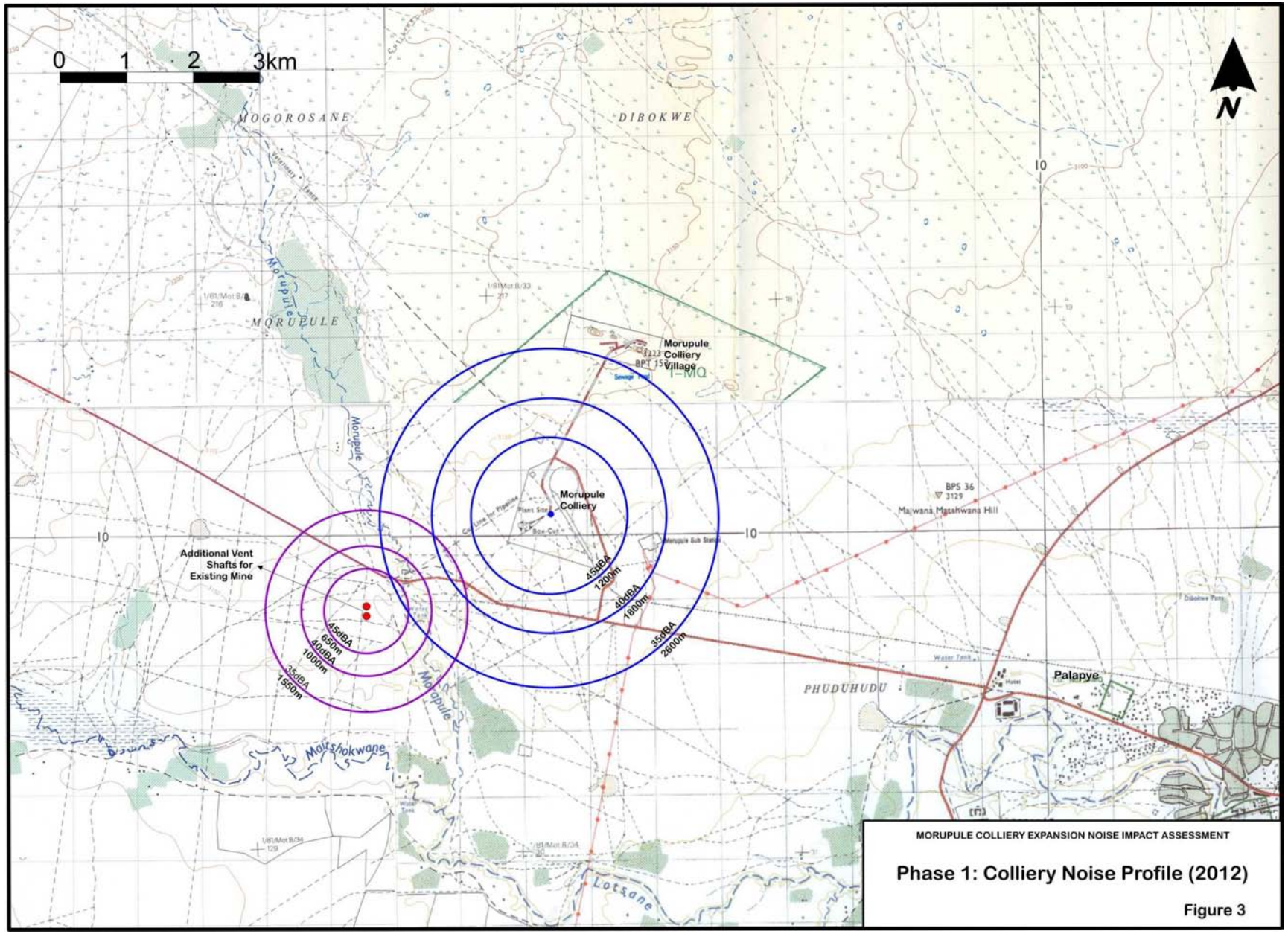
The noise levels given are the unmitigated values. A conservative approach has been taken in the estimate of the number of cooling fans and the rated sound power level of these fans. A conservative approach has also been taken for the propagation of the sound in that a hard intervening ground condition has been modelled. The thick vegetation in the area will however generally result in greater attenuation with distance than shown. There will also be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

4.5.3. Impact of Colliery Generated Traffic: Phase 1

Table C11 in Appendix C evaluates the influence of the Phase 1 expansion on the noise profile of the road traffic on Road A14 in 2012. The traffic generated by the colliery has been estimated to be as follows (two-way volume):

- Existing (2008): 115 vehicle trips per day (this is estimated to be approximately 5% of the total Average Daily Traffic (ADT) on Road A14).
- Phase 1 (2012): 220 vehicle trips per day (this is estimated to be approximately 7.3% of the total Average Daily Traffic (ADT) on Road A14).

The effect of colliery traffic in 2012 (Phase 1 expansion) will be to increase the road traffic noise by 0.3dBA (see Table C11 in Appendix C).


0 1 2 3km
N
MOGOROSANE
DIBOKWE
MORUPULE
Morupule
Morupule Colliery Village
Morupule Colliery
Additional Vent Shafts for Existing Mine
45dBA 1200m
40dBA 1800m
35dBA 2600m
45dBA 650m
40dBA 1000m
35dBA 1500m
BPS 36
3129
Malwana Matshwana Hill
PHUDUHUDU
Palapye
Motshokwane
Lotsane
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASSESSMENT
Phase 1: Colliery Noise Profile (2012)
Figure 3

4.5.4. Noise Climate Related to the Coal Train Traffic

The number of coal trains on the line from the Morupule Colliery to Palapye generally averages three trains per week and it is not anticipated that the number of trains will increase significantly in the next four years during Phase 1. The noise from the passing of a freight train (drawn by a diesel locomotive) travelling at 45km/h peaks in the vicinity of 92dBA at a 30 metre offset from the track. There are level crossings at the Colliery access road, the power station access road and Road A1 N (in Palapye) where it is mandatory that the trains sound a warning horn. Noise from these horn soundings can be as loud as 105dBA at 30 metres and 84dBA at 350 metres from the train. This can be extremely disruptive, especially at night.

4.5.5. Assessment of Impact: Operational Phase 1

It was established that:

i) Noise levels near to the main roads will remain high and will continue to increase as traffic volumes increase.

ii) The proposed Phase 1 upgrading required at the existing Shaft 1 complex will increase the area of influence from this source area only marginally.

iii) The additional ventilation shafts to the south-west of Shaft 1 will introduce a very loud source of noise to an area which is fairly quiet, but the impact from the traffic from Road A14 would still be significant. It should be noted that, during the night-time, when the traffic noise is intermittent, the noise from the ventilation shafts will be continuous.

iv) The situation in the study area is predicted to be as follows:

   a) The residences on the western edge of Palapye (*urban residential*) lie well outside the colliery's 45dBA+ impact zone and thus will not be negatively affected.

   b) The Colliery Village (*suburban residential*) lies well outside the colliery's 40dBA+ zone and thus will not be negatively affected.

   c) Some 11 homesteads (*rural residential*) fall within the area where the noise levels exceed 35dBA.

   d) The noise from the colliery will not significantly worsen the noise climate at the Kgaswe Primary School. The noise climate at the school is already significantly degraded from road traffic noise.

   e) Night-time noise levels in the "contractor's" village are already degraded from road traffic noise and the anticipated increase from the planned colliery expansion will be minor.

v) The volume of traffic generated by the operations by the Phase 1 expansion will only marginally increase the ambient noise levels along the road corridor between the colliery and Palapye.

vi) Colliery trains travelling at night have the potential to have a high impact in some areas.

4.6. Assessment of the Operational Phase: Phase 2

Phase 2 of the Morupule Colliery Expansion project will increase the output to 12M tpa and will require the development of a new mining area with a new shaft complex (Shaft 2) approximately 3,5km to the north-west of the existing shaft (Shaft 1).

The following predicted conditions in the study area and the following aspects were determined from the surveys, calculations of noise indicators and the predictive modelling undertaken for the assessment of the noise impact of Phase 2 of the project. This Section summarises the more detailed technical analysis, which is documented in Appendix C. The altered noise climate situation was evaluated on the basis of the noise impact from Phase 2 of the project, the noise impact from ancillary works and the noise impact from traffic generated by the Phase 2 Expansion.

4.6.1. Noise Sources

The main sources of noise in the area will be from:

vi) Traffic on Road A1 North, Road A1 South and Road A14.
vii) Morupule Power Station.
viii) Morupule B Power Station (anticipated commissioning in 2012).
ix) Morupule Colliery (Phase 1 anticipated commissioning in 2012).
x) The colliery trains.

4.6.2. Noise Sensitive Areas

The main noise sensitive areas/sites/receivers in the study area are:

vi) Palapye Village.
vii) Morupule Colliery Village (residential).
viii) Several homesteads scattered throughout the study area.
ix) “Contractor” village adjacent to the Kgaswe Primary School.
x) Kgaswe Primary School

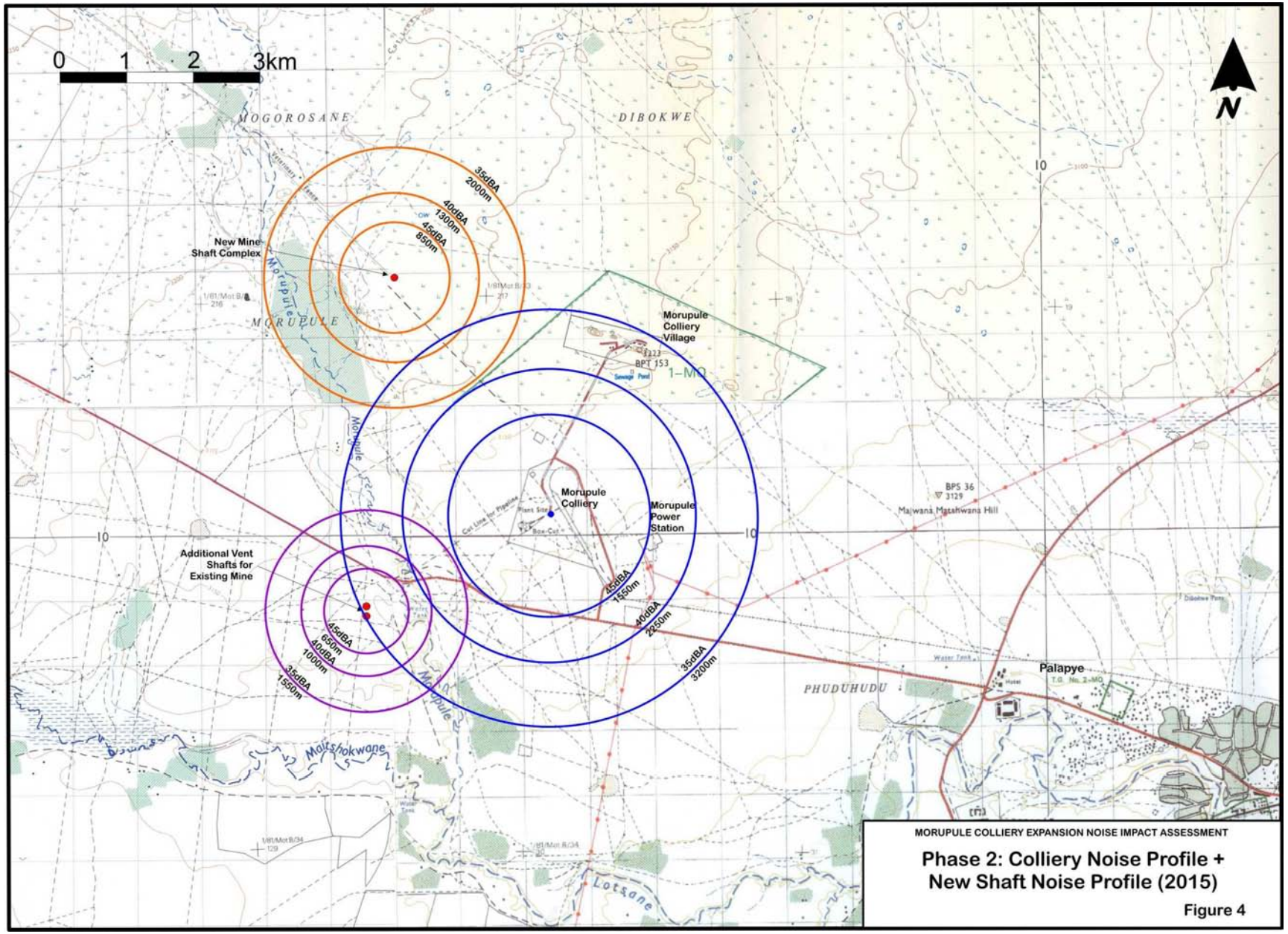
4.6.3. Predicted Noise Generated by Phase 2 of the Morupule Colliery Expansion Project

Analysis of the existing Morupule Colliery and the Phase 1 requirements (ascertained from existing plant on site and similar types of collieries elsewhere) predicted the noise profile indicated in Table 6 and in Figure 4:

TABLE 6: PHASE 2 - FUTURE AMBIENT NOISE CLIMATE GENERATED BY THE UPGRADED/EXPANDED EXISTING MORUPULE COLLIERY COMPLEX (2015)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	66.2	**1400**	46.5	**2400**	39.1
500	58.9	**1500**	45.5	**2500**	38.6
600	56.9	**1600**	44.7	**3000**	35.9
700	55.1	**1700**	43.9	**3100**	35.5
800	53.5	**1800**	43.1	**3200**	35.0
900	51.8	**1900**	42.4	**3300**	34.6
1000	50.8	**2000**	41.7	**3400**	34.1
1100	49.6	**2100**	41.0	**3500**	33.7
1200	48.5	**2200**	40.3		
1300	47.4	**2300**	39.7		

The noise levels given are the unmitigated values. A conservative approach has been taken in the estimate of the number of cooling fans and the rated sound power level of these fans. A conservative approach has also been taken for the propagation of the sound in that a hard intervening ground condition has been modelled. The thick vegetation in the area will however generally result in greater attenuation with distance than shown. There will also be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.


0 1 2 3km
N
MOGOROSANE
DIBOKWE
MORUPULE
New Mine Shaft Complex
35dBA 2000m
40dBA 1300m
45dBA 850m
Morupule Colliery Village
BPT 153
1-MO
Morupule Colliery
Morupule Power Station
Additional Vent Shafts for Existing Mine
45dBA 1550m
40dBA 2250m
35dBA 3200m
45dBA 650m
40dBA 1000m
35dBA 1550m
BPS 36
Malwana Matshwana Hill
Palapye
PHUDUHUDU
Motshokwane
Lotsane
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASSESSMENT
Phase 2: Colliery Noise Profile + New Shaft Noise Profile (2015)
Figure 4

4.6.4. General Noise Conditions Related to Conveyor System

Coal will be transported from the new shaft to the main crushers and coal washing plant at the existing shaft complex by means of a conveyor belt system. Noise will be generated by the conveyor belt drive houses and by the belt sections of the conveyor system. There will also be a number of additional conveyors in the area to the east of the existing shaft complex. The predicted noise profile ("footprint") around a drive house is as follows:

Offset Distance from Drive House	Sound Pressure Level (noise) (dBA)
250m	57.3
500m	50.3
1000m	42.6
2000m	33.8
3000m	28.2

The predicted noise profile ("footprint") at the indicated offsets from the belt sections is as follows.

Offset Distance from Conveyor	Sound Pressure Level (noise) (dBA)
100m	48.2
250m	39.6
500m	32.7
1000m	25.0

The details and the position of the conveyor system has not been finalised, but it can be assumed that it will be on the most direct route between the new and existing shaft complexes. The route between the new and the existing shaft complexes lies within a corridor which is located within a envelope of high noise levels and thus its noise impact should not be significant. No specific details have been given regarding the position of the coal conveyor to the planned Morupule B Power Station.

4.6.5. Impact of Colliery Generated Traffic: Phase 2

Table C12 in Appendix C evaluates the influence of the Phase 2 expansion on the noise profile of the road traffic on Road A14 in 2015. The traffic generated by the colliery has been estimated to be as follows (two-way volume):

- Existing (2008): 115 vehicle trips per day (this is estimated to be approximately 5% of the total Average Daily Traffic (ADT) on Road A14).
- Phase 1 (2012): 220 vehicle trips per day (this is estimated to be approximately 7.3% of the total Average Daily Traffic (ADT) on Road A14).

- Phase 2 (2015): 470 vehicle trips per day (this is estimated to be approximately 14.2% of the total Average Daily Traffic (ADT) on Road A14).

The effect of colliery traffic in 2015 (Phase 2 expansion) will be to increase the road traffic noise by 0.6dBA (see Table C12 in Appendix C).

4.6.6. Noise Climate Related to the Coal Train Traffic

The number of coal trains on the line from the Morupule Colliery to Palapye will increase significantly due to higher production levels during Phase 2. Estimates of the future volume of train traffic are not yet available from MCL. The noise from the passing of a freight train (drawn by a diesel locomotive) travelling at 45km/h peaks in the vicinity of 92dBA at a 30 metre offset from the track. There are level crossings at the Colliery access road, the power station access road and Road A1 N (in Palapye) where it is mandatory that the trains sound a warning horn. Noise from these horn soundings can be as loud as 105dBA at 30 metres and 84dBA at 350 metres from the train. This can be extremely disruptive, especially at night.

4.6.7. Assessment of Impact: Operational Phase 2

It was established that:

i) Noise levels near to the main roads will remain high and will continue to increase as traffic volumes increase.

ii) The proposed Phase 2 upgrading required at the existing Shaft 1 complex will increase the area of influence from this source area by a radius of about 600 metres.

iii) The additional ventilation shafts to the south-west of Shaft 1 will continue to be a very loud source of noise. It should be noted that, during the night-time, when the traffic noise is intermittent, the noise from the ventilation shafts will be continuous and will form the main component of the noise intrusion where relevant.

iv) The construction of the Shaft 2 complex will introduce a very loud noise source to an area which is very quiet.

v) The noise situation in the study area after the commissioning of the Phase 2 expansion, is predicted to be as follows:

   a) The residences on the western edge of Palapye (*urban residential*) lie well outside the colliery's 45dBA+ impact zone and thus will not be negatively affected.

   b) The Colliery Village (*suburban residential*) lies just outside the colliery's 40dBA+ zone and thus will not be negatively affected.

   c) Some 21 homesteads (*rural residential*) fall within the area where the noise levels exceed 35dBA. These noise sensitive receptors are shown in Figure 5. The noise

contours in Figure 5 are the cumulative noise values from all three elements of the Phase 2 Colliery Expansion Project.

d) The noise from the colliery will not significantly worsen the noise climate at the Kgaswe Primary School. The noise climate at the school is already significantly degraded from road traffic noise.

e) Night-time noise levels in the “contractor’s” village are already degraded from road traffic noise and the anticipated increase from the planned colliery expansion will be minor.

vi) Noise impact from ancillary works and equipment (such as the conveyor belts) will in general be low and localised. The drive houses for the conveyor belt system, however, will be sites of high noise levels.

vii) The volume of traffic generated by the operations by the Phase 2 expansion will only marginally increase the ambient noise levels along the road corridor between the colliery and Palapye.

viii) Colliery trains travelling at night have the potential to have a high impact in some areas.

4.7. Cumulative Effect of the Morupule Power Station and the Morupule B Power Station

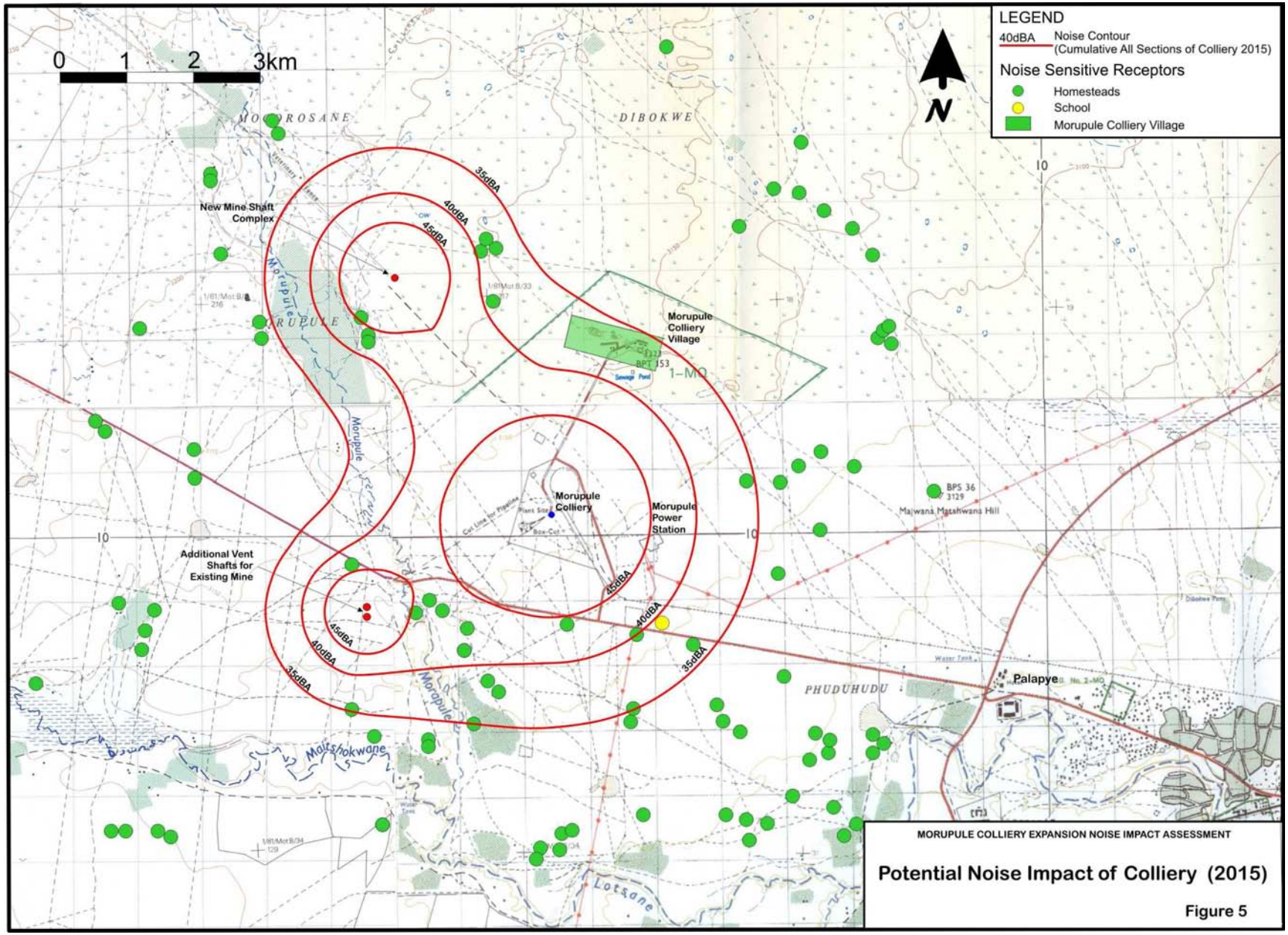
The proposed Morupule B Power Station will be constructed approximately 1500 metres to the south-east of the existing power station. The estimated commissioning date is 2012. There will thus be cumulative effects, that is, the noise from the individual power stations at any point within the area of influence of both power stations will be enhanced to some extent (refer to Figure 6). The maximum increase will be 3dBA. This noise enhancement will be experienced mainly in the area between the power stations. Morupule B Power Station will be the louder of the two, if unmitigated, and thus there will also be some enhancement to the west of the existing power station (Noise Impact Assessment of the Planned Morupule B Power station, Report prepared by Jongens Keet Associates for Botswana Power Corporation, 2007).

4.8. Cumulative Noise Climate (2015)

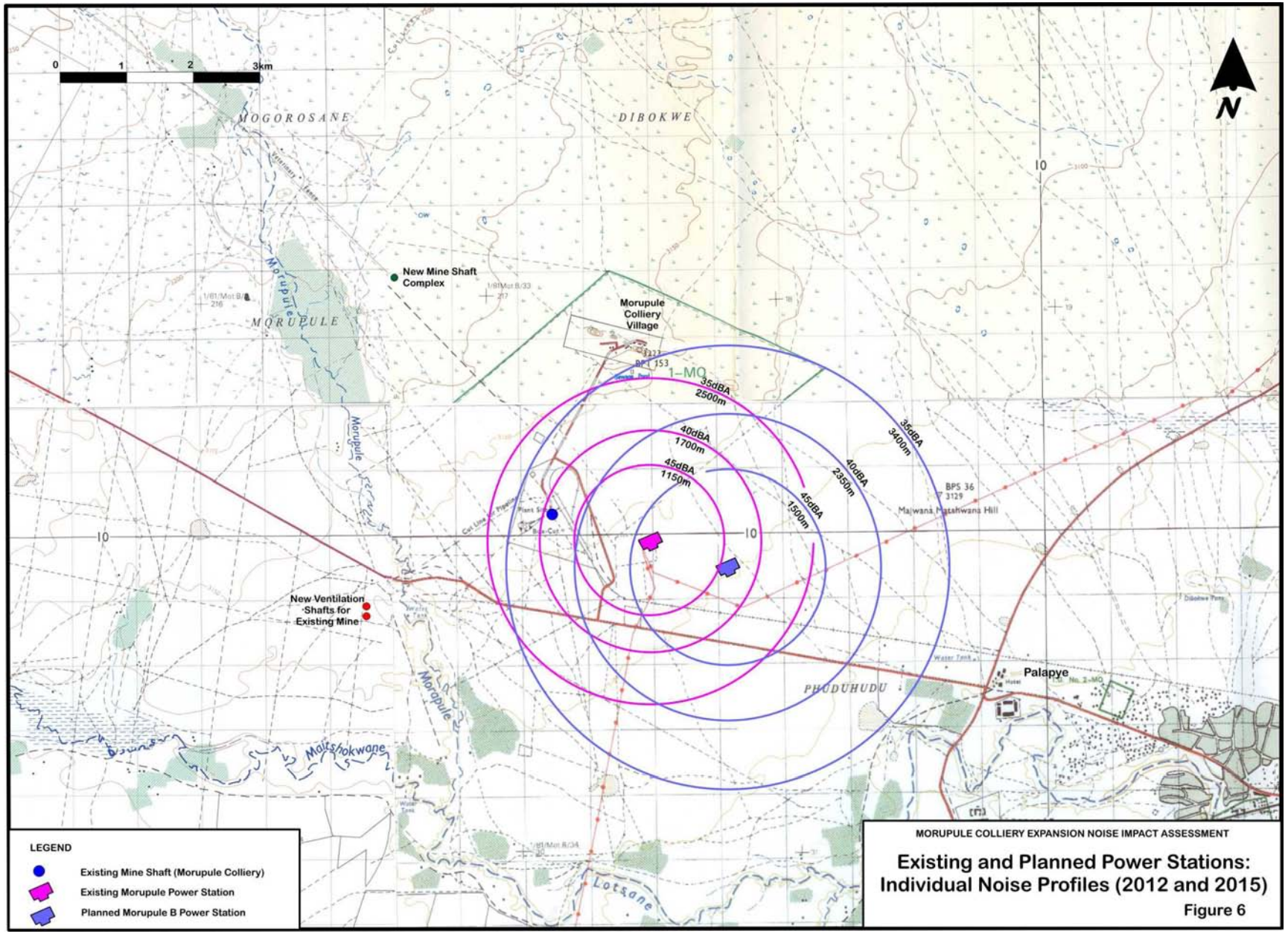
The predicted cumulative noise climate (including the colliery expansion and the two power stations, but excluding the road traffic component) are given in Figure 7. The noise sensitive receptors are also shown in Figure 7.

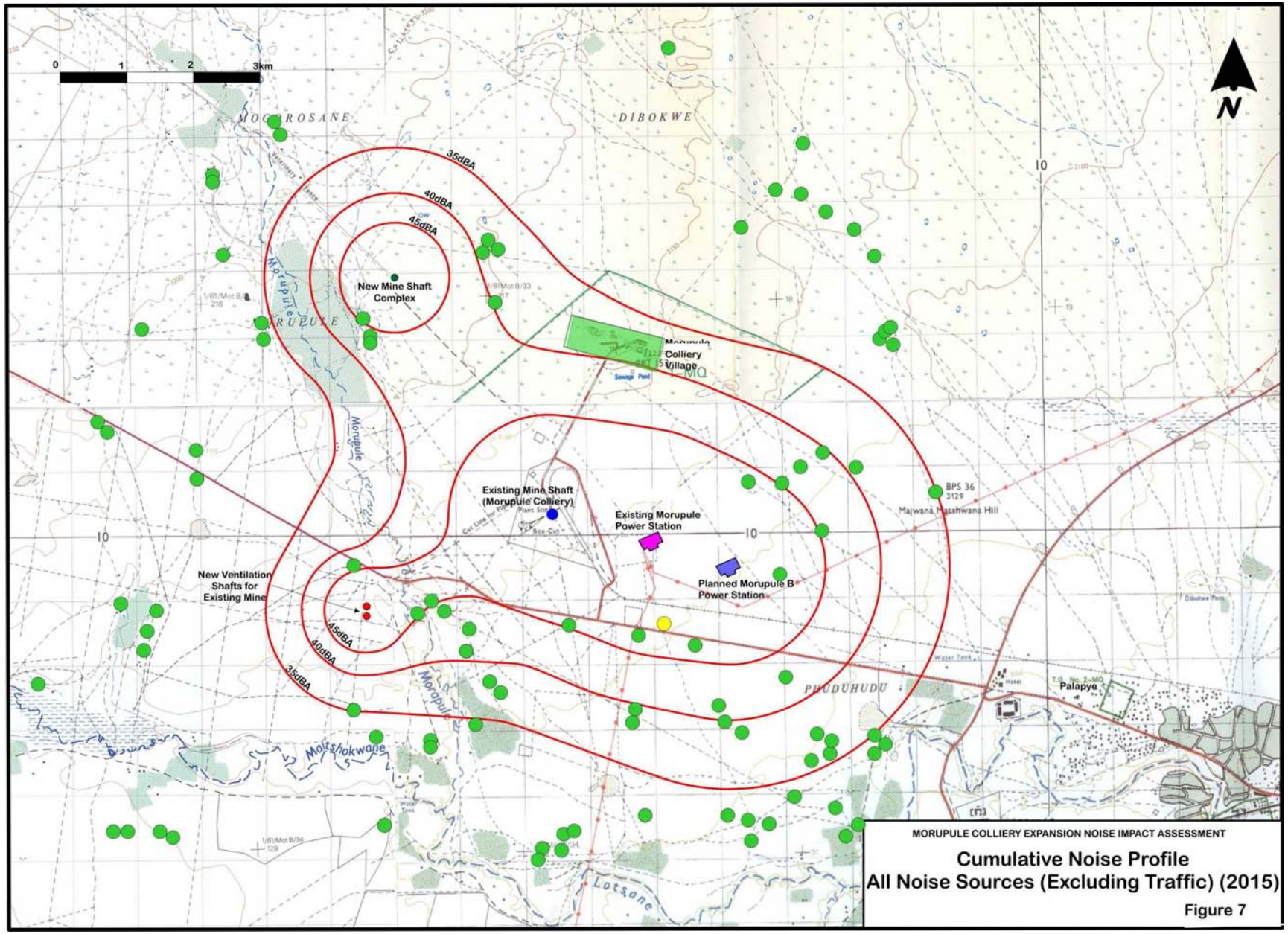
4.9. Assessment of Decommissioning Phase

No details of the decommissioning works are known at this time. Most of the noise impact elements of the decommissioning phase are similar to the noise impact elements of the construction phase.


0 1 2 3km
N
LEGEND
40dBA Noise Contour
(Cumulative All Sections of Colliery 2015)
Noise Sensitive Receptors
Homesteads
School
Morupule Colliery Village
New Mine Shaft Complex
Additional Vent Shafts for Existing Mine
Morupule Colliery
Morupule Power Station
Morupule Colliery Village
35dBA
40dBA
45dBA
MOROSANE
DIBOKWE
PHUDUHUDU
Palapye
Malwana Matshwana Hill
Motshokwane
Lotsane
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASSESSMENT
Potential Noise Impact of Colliery (2015)
Figure 5

f)


0
1
2
3km
N
MOGOROSANE
DIBOKWE
MORUPULE
New Mine Shaft Complex
Morupule Colliery Village
1-MO
35dBA 2500m
40dBA 1700m
45dBA 1150m
35dBA 3400m
40dBA 2350m
45dBA 1500m
BPS 36
Malwana Matshwana Hill
New Ventilation Shafts for Existing Mine
PHODUHUDU
Palapye
Morupule
Motshokwane
Lotsane
LEGEND
Existing Mine Shaft (Morupule Colliery)
Existing Morupule Power Station
Planned Morupule B Power Station
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASSESSMENT
Existing and Planned Power Stations: Individual Noise Profiles (2012 and 2015)
Figure 6


0
1
2
3km
N
MOGOROSANE
DIBOKWE
35dBA
40dBA
45dBA
New Mine Shaft Complex
MORUPULE
Morupule
Colliery Village
Existing Mine Shaft (Morupule Colliery)
Existing Morupule Power Station
Planned Morupule B Power Station
New Ventilation Shafts for Existing Mine
BPS 36
3129
Malwana Matshiwana Hill
PHUDUHUDU
Palapye
Motshokwane
Lotsane
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASSESSMENT
Cumulative Noise Profile
All Noise Sources (Excluding Traffic) (2015)
Figure 7

4.10. Significance Rating of Impact

The following procedure for the *rating of impact* was provided by Ecosurv (Pty) Ltd. The tables relate to the operational phase of the project.

4.10.1. Phase 1

Prediction of Impact

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Probability*	*Confidence*
Noise	-	Low	Local	Long-term	Highly Probable	High
With Mitigation	-	Low	Local	Long-Term	Highly Probable	High

Consequence Rating

Impact	*Nature*	*Consequence*	*Probability*	*Confidence*
Noise	-	Low	Probable	High
With Mitigation	-	Low	Probable	High

Significance Rating

Impact	*Consequence*	*Probability*	*Significance*	*Confidence*
Noise	Low	Probable	LOW	High
With Mitigation	Low	Probable	LOW	High

4.10.2. Phase 2

Prediction of Impact

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Probability*	*Confidence*
Noise	-	Low	Local	Long-term	Highly Probable	High
With Mitigation	-	Low	Local	Long-Term	Highly Probable	High

Consequence Rating

Impact	*Nature*	*Consequence*	*Probability*	*Confidence*
Noise	-	Low	Probable	High
With Mitigation	-	Low	Probable	High

Significance Rating

Impact	*Consequence*	*Probability*	*Significance*	*Confidence*
Noise	Low	Probable	LOW	High
With Mitigation	Low	Probable	LOW	High

5. MITIGATING MEASURES

Potential noise mitigating measures for the project were assessed.

5.1. Construction Phase

The noise mitigating measures to be considered during the construction phase are as follows:

i) Construction site yards, concrete batching plants, asphalt batching plants, construction worker camps (accommodation) and other noisy fixed facilities should be located well away from noise sensitive areas adjacent to the development site.

ii) All construction vehicles and equipment are to be kept in good repair.

iii) Construction activities, and particularly the noisy ones, are to be contained to reasonable hours during the day and early evening.

iv) The temporary ventilation system for construction of the new mine shaft and the various ventilation shafts should incorporate all the applicable noise mitigating measures, such as enclosure within a berm area.

v) With regard to unavoidable very noisy construction activities in the vicinity of noise sensitive areas, the contractor should liaise with local residents on how best to minimise impact.

vi) In general operations should meet the noise standard requirements of the relevant occupational health and safety legislation.

vii) Construction staff working in areas where the 8-hour ambient noise levels exceed 75dBA should wear ear protection equipment.

5.2. Operational Phase

The following noise mitigating measures, which will need to be considered where appropriate, are preliminary indicators that may assist further in the design of the Phase 1 and Phase 2 elements of the Morupule Colliery Expansion Project:

i) The design of the proposed expansion elements is to incorporate all the necessary acoustic design aspects required in order that the overall generated noise level from the new installation does not exceed a maximum equivalent continuous day/night rating level (L_{Rdn}), namely a noise level of 70dBA (just inside the *property projection plane*, namely the property boundary of the colliery) as specified for industrial districts in SANS 10103. Refer to Appendix A. Notwithstanding this provision, the design is also to take into account the maximum allowable equivalent continuous day/night rating level of the potentially impacted noise sensitive receptors outside the colliery property. Where the L_{Rdn} for the external site is presently lower than the maximum allowed, the maximum shall not be exceeded. Where the L_{Rdn} for the external site is presently at or exceeds the

maximum level allowed, the existing level shall not be increased by more than indicated as acceptable in SANS 10103 (refer to Table A3 in Appendix A).

ii) The latest technology incorporating maximum noise mitigating measures for the colliery expansion project components should be designed into the syste.0m. (The contract specifications for the proposed elements should indicate that the contractor shall achieve, wherever possible, a sound pressure level of 85dBA at a 1 metre offset from all plant and equipment in order to meet the noise exposure standards of the Occupational Health and Safety Act.)

iii) The design process is to consider, *inter alia*, the following aspects:
   a) The position and orientation of buildings on the site.
   b) The design of the buildings is to minimise the transmission of noise from the inside to the outdoors.
   c) The insulation of particularly noisy new plant and equipment. (The contract specifications for the proposed expansion project should indicate that the contractor shall achieve a sound pressure level of 85dBA at a 1 metre offset from all plant and equipment.).
   d) The alignment of the coal conveyor systems and in particular the positioning of the drive houses.

iv) The ventilation fans at Shaft 2 should be placed within the box cut.

It should be noted that any measures taken at the development site will limit the impacts in the specific areas designed for, and will not necessarily contribute to improving the degraded noise climates in adjacent areas where there is already a problem.

5.3. Decommissioning Phase

The noise management (mitigating) measures to be considered during the decommissioning phase are similar to the construction phase:

i) Contractor site yards, workshops, worker camps (accommodation) and other noisy fixed facilities should be located well away from noise sensitive areas adjacent to the development site.

ii) All vehicles and equipment are to be kept in good repair.

iii) Demolition and any construction activities, and particularly the noisy ones, are to be contained to reasonable hours during the day and early evening.

iv) With regard to unavoidable very noisy demolition activities in the vicinity of noise sensitive areas, the contractor should liaise with local residents on how best to minimise impact.

6. CONCLUSIONS

The following conclusions may be drawn from the foregoing analysis:

i) Although not all of the final baseline noise design data was available for the analysis, the assumptions made are considered adequate to give a meaningful analysis of the noise impact situation, taking into account the fact that the proposed expansion project was modelled on the data from measurements at the existing Morupule Colliery and at other similar operational collieries, and that a conservative (worst case scenario) approach was used.

ii) Road traffic noise will continue to have a major negative impact in the areas immediately adjacent to the main roads.

iii) Although the existing general noise climate of much of the study area is still fairly representative of a quiet rural/farming district, ambient noise levels in the corridor between Palapye and Morupule Colliery are already severely degraded near to the colliery as well as at power station and near to the main roads.

iv) The commissioning of the Morupule B Power Station will introduce a very loud new source of noise into the eastern sector of the study area.

v) The predicted noise from the colliery expansion project has to potential to negatively affect several homesteads in the area, particularly at night. At the commissioning of Phase 1 some 11 homesteads could be impacted. At the commissioning of Phase 2, the number of homesteads impacted will increase to about 21.

vi) Noise mitigating measures intended for the proposed expansion project will further reduce its area of potential negative impact.

7. RECOMMENDATIONS

The following are recommended:

i) The WHO Guidelines for Community Noise, the South African National Noise Control Regulations, and SANS 10103 should be used as the main guidelines for addressing the potential noise impact on this project. These guidelines are as stringent as the World Bank Group Guidelines for mines and provide additional guidance to that provided by the World Bank Group.

ii) Once the final design details of the planned expansion project are known, the parameters which directly affect the calculations made in this noise impact study are to be checked and validated. If necessary, the calculations are to be redone and the noise impact checked.

iii) Various measures to reduce the potential noise impact from the planned expansion elements are possible, and the mitigating measures indicated in Section 5, *inter alia*, need to be considered.

iv) The noise mitigating measures will need to be designed and/or checked by an acoustical engineer in order to optimise the design parameters and ensure that the cost/benefit of the measure is optimised.

v) At commissioning of Phase 2, the noise footprint of the planned expansion project should be established by measurement in accordance with the relevant standards, namely SANS ISO 8297:1994 and SANS 10103. The character of the noise (qualitative aspect) should also be checked to ascertain whether there is any nuisance factor associated with the operation.

8. REFERENCES

1. Jongens Keet Associates (2007). *Noise Impact Assessment of the Planned Morupule B Power Station*, Report prepared by Jongens Keet Associates for Botswana Power Corporation.
2. South African National Standard SANS 10103:2004, *The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and to Speech Communication*.
3. South African National Standard SANS 10210 (SABS 0210), *Calculating and Predicting Road Traffic Noise*.
4. South African Bureau of Standards Code of Practice SANS 10328 (SABS 0328), *Methods for Environmental Noise Impact Assessments*.
5. South African National Standard SANS 10357 (SABS 0357), *The Calculation of Sound Propagation by the Concawe Method*.
6. South African National Noise Control Regulations.
7. South Africa. (1993). *Occupational Health and Safety Act* (Act 85 of 1993).
8. World Bank Environment, Health and Safety Guidelines. (1995). *Mining and Milling – Open Pit.*
9. World Health Organization (WHO) (1999). *Guidelines for Community Noise*. Birgitta Berglund, Thomas Lindvall & Dietrich H Schwela (Eds.)

APPENDIX A

GLOSSARY OF TERMS AND NOISE IMPACT CRITERIA

APPENDIX A: GLOSSARY OF TERMS AND NOISE IMPACT CRITERIA

A1. GLOSSARY OF TERMS

In order to ensure that there is a clear interpretation of this report the following meanings should be applied to the acoustic terminology:

- **Ambient sound level** or **ambient noise** means the totally encompassing sound in a given situation at a given time, and usually composed of sound from many sources, both near and far. Note that ambient noise includes the noise from the noise source under investigation. The use of the word *ambient* should however always be clearly defined (compare with *residual noise*).
- **A-weighted sound pressure, in Pascals**: The root-mean-square sound pressure determined by use of frequency-weighting network A.
- **A-weighted sound pressure level (SPL) (noise level) (L_{pA}), in decibels**: The sound pressure level of A-weighted sound pressure is given by the equation:

  $L_{pA} = 10 \log (p_A/p_o)^2$ where:

  p_A is the A-weighted sound pressure, in Pascals; and

  p_o is the reference sound pressure (p_o = 20 micro Pascals (μPa))

  Note: The internationally accepted symbol for sound pressure level, dB(A), is used.
- **Controlled areas** as specified by the SA National Noise Control Regulations are areas where certain noise criteria are exceeded and actions to mitigate the noise are required to be taken. Controlled areas as related to roads, airports and factory areas are defined. These Regulations presently exclude the creation of *controlled areas* in relation to railway noise.
- **dB(A)** means the value of the sound pressure level in decibels, determined using a frequency weighting network A. (The "A"-weighted noise levels/ranges of noise levels that can be expected in some typical environments are given in Table A2 at the end of this appendix).
- **Disturbing noise** means a noise level that exceeds the outdoor equivalent continuous rating level for the time period and neighbourhood as given in Table 2 of SANS 10103:2004. For convenience, the latter table is reproduced in this appendix as Table A1.
- **Equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$)** means the value of the A-weighted sound pressure level of a continuous, steady sound that, within a specified time interval, has the same mean-square sound pressure as a sound under consideration whose level varies with time.

- **Equivalent continuous rating level ($L_{Req,T}$)** means the equivalent continuous A-weighted sound pressure level during a specified time interval, plus specified adjustments for tonal character and impulsiveness of the sound and the time of day.
- **Equivalent continuous day/night rating level ($L_{R,dn}$)** means the equivalent continuous A-weighted sound pressure level during a reference time interval of 24-hours, plus specified adjustments for tonal character and impulsiveness of the sound and the time of day. (An adjustment of +10dB is added to the night-time rating level).
- **Integrating sound level meter** means a device that integrates a function of the root mean square value of sound pressure over a period of time and indicates the result in dBA.
- **Noise** means any acoustic phenomenon producing any aural sensation perceived as disagreeable or disturbing by an individual or group. Noise may therefore be defined as any *unwanted* sound or sound that is *loud, unpleasant or unexpected*.
- **Noise climate** is a term used to describe the general character of the environment with regard to sound. As well as the ambient noise level (quantitative aspect), it includes the qualitative aspect and the character of the fluctuating noise component.
- **Noise Control Regulations** means the regulations as promulgated by the SA National Department of Environmental Affairs and the World Health Organisation.
- **Noise impact criteria** means the standards applied for assessing noise impact.
- **Noise level** means the reading on an integrating impulse sound level meter taken at a measuring point in the presence of any alleged disturbing noise at the end of a total period of at least 10 minutes after such meter was put into operation, and, if the alleged disturbing noise has a discernible pitch, for example, a whistle, buzz, drone or music, to which 5dBA has been added. (The "A"-weighted noise levels/ranges of noise levels that can be expected in some typical environments are given in Table A2 at the end of this appendix).
- **Noise nuisance** means any sound which disturbs or impairs or may disturb or impair the convenience or peace of any reasonable person considering the location and time of day. This applies to a disturbance which is not quantitatively measurable such as barking dogs, etc. (compared with disturbing noise which is measurable).
- **Residual sound level** means the ambient noise that remains at a position in a given situation when one or more specific noises are suppressed (compare with *ambient noise*).
- **Sound** means the aural sensation caused by rapid, but very small, pressure variations in the air. In quantifying the subjective aural sensation, "loudness", the letters dBA after a numeral denote two separate phenomena:
    - "dB", short for *decibel*, is related to the human's subjective response to the change in amplitude (or largeness) of the pressure variations.

- The "A" denotes the ear's different sensitivity to sounds at different frequencies. The ear is very much less sensitive to low (bass) frequency pressure variations compared to mid-frequencies.

The level of environmental sound usually varies continuously with time. A human's subjective response to varying sounds is primarily governed by the total sound energy received. The total sound energy is the average level of the fluctuating sound, occurring during a period of time, multiplied by the total time period. In order to compare the effects of different fluctuating sounds, one compares the average sound level over the time period with the constant level of a steady, non-varying sound that will produce the same energy during the same time period. The average energy of sound varying in amplitude is thus equivalent to the continuous, non-varying sound. The two energies are equivalent.

- **Sound exposure level or SEL** means the level of sound accumulated over a given time interval or event. Technically the sound exposure level is the level of the time-integrated mean square A-weighted sound for stated time or event, with a reference time of one second.
- **Sound (pressure) level** means the reading on a sound level meter taken at a measuring point.
- **SANS 10103** means the latest edition of the South African National Standard SANS 10103 titled *The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and to Speech Communication*.
- **SANS 10210** means the latest edition of the South African National Standard SANS 10210 titled *Calculating and Predicting Road Traffic Noise*.
- **SANS 10328** means the latest edition of the South African National Standard SANS 10328 titled *Methods for Environmental Noise Impact Assessments*.
- **SANS 10357** means the latest edition of the South African National Standard SANS 10357 titled *The Calculation of Sound Propagation by the Concawe Method*.

Refer also to the various South African National Standards referenced above, the World Health Organisation Guidelines for Community Noise and the SA National Noise Control Regulations for additional and, in some instances, more detailed definitions.

TABLE A1: TYPICAL NOISE RATING LEVELS FOR AMBIENT NOISE IN DISTRICTS (NOISE ZONES) SANS 10103

Type of District	Equivalent Continuous Rating Level for Noise ($L_{Req,T}$) (dBA)					
	Outdoors			Indoors with open windows		
	Day-night ($L_{R,dn}$)	Daytime ($L_{Req,d}$)	Night-time ($L_{Req,n}$)	Day-night ($L_{R,dn}$)	Daytime ($L_{Req,d}$)	Night-time ($L_{Req,n}$)
RESIDENTIAL DISTRICTS						
a) Rural districts	45	45	35	35	35	25
b) Suburban districts (little road traffic)	50	50	40	40	40	30
c) Urban districts	55	55	45	45	45	35
NON RESIDENTIAL DISTRICTS						
d) Urban districts (some workshops, business premises and main roads)	60	60	50	50	50	40
e) Central business districts	65	65	55	55	55	45
f) Industrial districts	70	70	60	60	60	50

TABLE A2: NOISE LEVELS/RANGES OF NOISE LEVELS THAT MAY BE EXPECTED IN SOME TYPICAL ENVIRONMENTS

Noise Level dB(A)	Typical Environment	Subjective Description
140	30m from jet aircraft during take-off	
130	Pneumatic chipping and riveting (operator's position)	Unbearable
>120	Hearing damage possible even for short exposure	
120	Large diesel power generator	
105-120	Low level military aircraft flight	
110-120	100 m from jet aircraft during take-off	
110	Metal workshop (grinding work), circular saw	
105-110	High speed train at 300 km/h (peak pass-by level at 7,5m)	
90-100	Printing press room	Very noisy
95-100	Passenger train at 200km/h (peak pass-by level at 7,5m).	Very noisy
95-100	Freight train at 100 km/h (peak pass-by level at 7,5 m)	Very noisy
90-100	Discotheque (indoors)	
75-100	7,5 m from passing motorcycle (50 km/h)	
75-80	10 m from edge of busy freeway (traffic travelling at 120 km/h)	
80-95	7,5 m from passing truck (50 km/h)	
80	Kerbside of busy street	
70	Blaring radio	Noisy
70	3 m from vacuum cleaner	Noisy
60-80	7,5 m from passing passenger car (50 km/h)	
65	Normal conversation	
65	Large busy office	
60	Supermarket/small office	
50	Average suburban home (day conditions)	Quiet
40	Library	
40-45	Average suburban home (night-time)	
30-35	Average rural home (night-time)	
25-30	Slight rustling of leaves	
20	Background in professional recording studio	Very quite
20	Forest (no wind)	
0-20	Experienced as complete quietness	
0	Threshold of hearing at 1000 Hz	

A2. NOISE IMPACT CRITERIA

The international tendency is to express noise exposure guidelines in terms of absolute noise levels. These guidelines imply that in order to ascertain an acceptable living environment, ambient noise in a given type of environment should not exceed a specified absolute level. This is the approach provided by the environmental guidelines of the World Health Organisation and the World Bank, which specify 55dBA during the day (06:00 to 22:00) and 45dBA during the night (22:00 to 06:00) for residential purposes, determined over any hour.

TABLE A3: WORLD HEALTH ORGANISATION (WHO) GUIDELINES FOR AMBIENT SOUND LEVELS

Environments	Ambient Sound Level L_{Aeq} dB			
	Daytime		Night-time	
	Indoor Space	Outdoor Space	Indoor Space	Outdoor Space
Dwellings	50	55	-	-
Bedrooms	-	-	30	45
Schools	35	55	-	-
Hospitals				
- general	35	-	35	45
- ward rooms	30	-	30	40

TABLE A4: WORLD BANK GUIDELINES FOR AMBIENT SOUND LEVELS

Receptor	Maximum Allowable Ambient Noise Levels 1-hour L_{eq} (dBA)	
	Daytime 07:00 – 22:00	Night-time 22:00 – 07:00
Residential, institutional, educational	55	45
Industrial, commercial	70	70
Note: No interior L_{Aeq} values nor values for rural areas are stipulated.		

SANS 10103 conforms to the described international tendency but makes recommendations for urban, suburban and rural districts. The recommended standards to be applied are summarised in Table A1.

A3. COMMUNITY RESPONSE TO NOISE

Communities generally respond to a change in the ambient noise levels in their environment, and the guidelines set out in SANS 10103 provide a good indication for estimating their response to given increases in noise. The suggested severity criteria for the noise impacts are summarised in terms of the above guidelines in Table A5.

TABLE A5: CATEGORIES OF COMMUNITY/GROUP RESPONSE (CRITERIA FOR THE ASSESSMENT OF THE SEVERITY OF NOISE IMPACT)

Increase in Ambient Noise Level (dBA)	Estimated Community/Group Response	
	Category	Description
0 – 10	Little	Sporadic complaints
5 – 15	Medium	Widespread complaints
10 - 20	Strong	Threats of community/group action
Greater than 15dBA	Very strong	Vigorous community/group action

Changes in noise level are perceived as follows:

- *3dBA:* For a person with average hearing acuity, an increase in the general ambient noise level of 3dBA will be just detectable.
- *5dBA:* For a person with average hearing acuity an increase of 5dBA in the general ambient noise level will be significant, that is he or she will be able to identify the source of the intruding noise. According to SANS 10103 the community response for an increase of less than 5dBA will be 'little' with 'sporadic complaints'. For an increase of equal or more than 5dBA the response changes to 'medium' with 'widespread complaints'.
- *10dBA:* A person with average hearing will subjectively judge an increase of 10dBA as a doubling in the loudness of the noise. According to SANS 10103 the estimated community reaction will change from 'medium' with 'widespread complaints' to 'strong' with 'threats of community action'.

APPENDIX B:

DETAILS OF THE NOISE MEASUREMENT SURVEY AND EXISTING NOISE CLIMATE CONDITION ASSESSMENT

APPENDIX B: DETAILS OF THE NOISE MEASUREMENT SURVEY AND EXISTING NOISE CLIMATE CONDITION ASSESSMENT

B1. GENERAL

The technical details of the noise measurement survey and general *noise climate* investigation related to the potential noise impact of the proposed Morupule Colliery Expansion Project which is to be constructed in the area to the west of Palapye in Botswana are dealt with in this Appendix.

Botswana in general applies the World Health Organisation (WHO) and World Bank (WB) environmental standards and procedures. There are South African National Standards (SANS) codes of practice and procedures which have been developed based on the requirements of the WHO and WB as well as those of the International Standards Organisation (ISO). As the South African documents are more detailed, more prescriptive and often apply more stringent standards it is recommended that the South African as well as the international standards be applied on this project. The noise impact assessment was undertaken in accordance with the requirements of the South African National Standard SANS 10328 (SABS 0328) *Methods for Environmental Noise Impact Assessments*. Daytime and evening period noise measurements were taken at seventeen main monitoring sites at appropriate locations in the study area in order to establish the residual (existing) *noise climate*.

B2. STANDARDS AND MEASUREMENT EQUIPMENT

The sound pressure level (SPL) (noise) measurements were taken in accordance with the requirements of the South African National Standard SANS 10103:2004, *The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and Speech Communication*. A Type 1 Integrating Sound Level Meter, a Rion NA-28, was used for the noise measurements. The meter was calibrated at an accredited acoustical laboratory within the last 12 months. The calibration status of the meter was also checked before and after completion of the total measurement period of the day. A calibrated signal with a sound pressure level of 94,0dB at 1 kHz was applied to the meter. A Rion Sound Calibrator NC-74 was used.

For all measurements taken to establish the ambient noise levels, the equivalent noise level (L_{Aeq}), the maximum sound pressure level (L_{Amax}) and the minimum sound pressure level (L_{Amin}) during that measurement period were recorded. The frequency weighting setting was set on “A” and the time weighting setting of the meters were set on *Impulse* (I). Measurement periods of a minimum of 10 minutes were used. In addition, the variation in instantaneous sound pressure level (SPL) over a short period was also measured at some of the Sites. For these latter

measurements the time weighting setting of the meter was also set on *Impulse* (I). At all the measurement sites, the meters were set up with the microphone height at 1,3 metres above ground level and well clear of any reflecting surfaces (a minimum of 3 metres clearance). For all measurements, a standard windshield cover (as supplied by the manufacturers) was placed on the microphone of each meter.

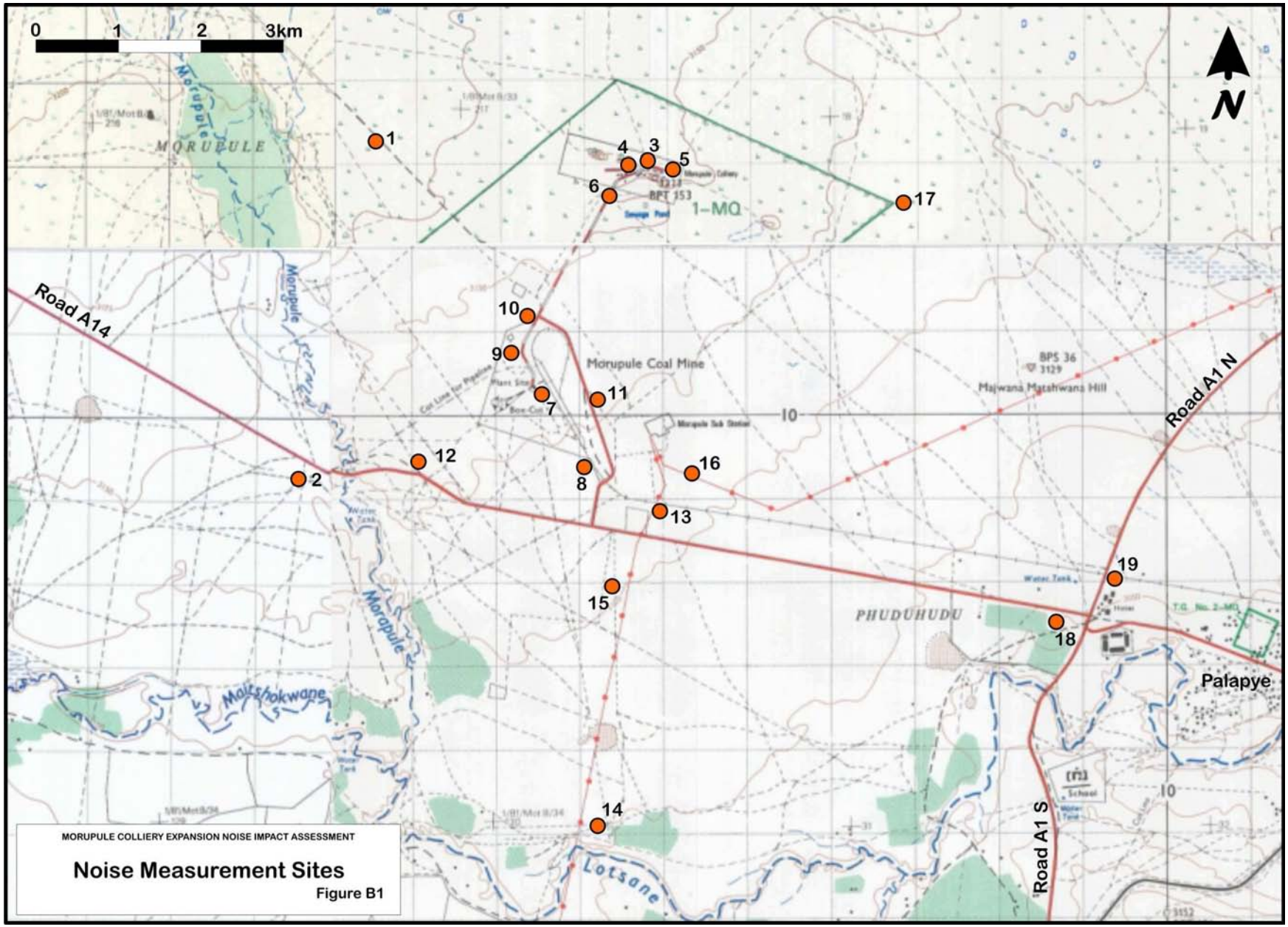
At the same time as each individual measurement was being taken, the qualitative nature of the *noise climate* in the area of the measurement site was assessed and recorded. This comprised an appraisal of the general prevailing acoustic conditions based on the subjective response to the sounds as perceived by the listener (i.e. *auditory observation* by the surveyor), as well as identifying those noise incidents, which influenced the noise meter readings during that measurement period. This procedure is essential in order to ensure that that there is a *human* correlation between the noise as perceived by the human ear and the noise, which is measured by the meter, as well as to establish any anomalies in the general ambient noise conditions.

B3. MEASUREMENT SITES

B3.1. Sites to Establish the Residual Noise Climate

Noise measurements to establish the residual (current ambient) noise conditions were taken at nineteen (19) main sites in the study area. Refer to Figure B1. These are:

Site No	Location Description	GPS Co-ordinates
1	At location of proposed Shaft 2 (June 2008)	S22°29.379' E27°00.300'
2	At location of proposed ventilation shaft (June 2008)	S22°31.802' E26°59.790'
3	In Morupule Mine Village outside No. 29 (June 2008)	S22°29.532' E27°02.100'
4	In Morupule Mine Village in Mokowe Crescent (Assembly Point 4) (September 2007)	S22°29.564' E27°02.088'
5	In Morupule Mine Village outside Guesthouse (2 Monyane Close) (June 2008)	S22°29.580' E27°02.298'
6	At entrance gate to Morupule Mine Village on eastern side of access road (September 2007 and June 2008)	S22°29.684' E27°01.910'
7	Coal wash plant to the south-west of the power station at 63m (June 2008)	S22°31.012' E27°01.506'
8	On road to coal washing plant, 1024m from washing plant, directly opposite the power station (June 2008)	S22°31.453' E27°01.805'
9	Just outside the main colliery offices (on mine shaft side) 336m from crusher (June 2008)	S22°31.012' E27°01.506'
10	On road to and north of colliery site, at junction to village at 787m from crusher (June 2008)	S22°30.515' E27°01.451'
11	At coal conveyor crossing over the Colliery access road (June 2008)	S22°31.134' E27°01.835'
12	Opposite stonedust silo on main road (Road A14) at 1708m from crusher (June 2008)	S22°31.548' E27°00.680'
13	On the western boundary of Kgaswe Primary School, at approximately 30m from centre line of access road to the Morupule Power Station (September 2007)	S22°31.841' E27°02.312'
14	At remote settlement ("Molapu Wapitsi") just north of the Lotsane River. (Approximately 3500m south of Road A14) (September 2007)	S22°33.777' E27°01.927'
15	On road to settlement (Site 14) at approximately 750m south of Road A14 (September 2007)	S22°32.310' E27°01.990'
16	At the entrance gate to the Morupule Golf Course to the southeast of the Morupule Power Station (September 2007)	S22°31.485' E27°02.409'
17	At the north-east corner of the game fence of the Morupule Colliery Game Park, approximately 4865m north-east of Shaft 1 at the Colliery (September 2007)	S22°29.809' E27°03.660'
18	On the south side of the road to Serowe (Road A14) just west of Palapye. The site is at the north-west boundary of the Palapye Development Trust houses. The site is approximately 30m from the centre-line of Road A1 (September 2007)	S22°32.427' E27°05.067'
19	In residential area of Palapye to east of Road A1. The site is at the north of the Desert Sands Motel and is approximately 100m east of the centre-line of Road A1 (September 2007	S22°32.282' E27°05.432'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BPT 353
Road A14
Morupule Coal Mine
Majwana Matshwana Hill
BPS 36
3129
Road A1 N
Road A1 S
PHUDUHUDU
Palapye
Motshokwane
Lotsane
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASSESSMENT
Noise Measurement Sites
Figure B1

B4. MEASUREMENT DATES/TIMES

General observation of the noise conditions in the study area as well as the site specific sound pressure level (noise) measurements and observations were taken on Thursday 20 September 2007 during the daytime from 09h00 to 18h00 and in the evening/night from 19h30 to 23h00. Further measurements to establish the residual noise climate related to the colliery project were taken on Monday 23 June 2008 during the daytime from 11h30 to 17h00 and during the evening/night from 20h00 to 21h30. The more specific measurements of plant and equipment at the colliery were taken on the morning of Monday 23 June 2008.

B5. NOISE MEASUREMENT DETAILS

B5.1. Residual Sound Pressure Level Measurements

The results of the residual noise condition measurement survey are summarised in Table B1. The equivalent sound pressure (noise) level (L_{Aeq}), the maximum sound pressure level (L_{Amax}) and the minimum sound pressure level (L_{Amin}) are indicated. Note that the equivalent sound pressure (noise) level may, in layman's terms, be taken to be the average noise level over the given period. This "average" is also referred to as the residual noise level (excluding the impacting noise under investigation) or the ambient noise level (if the impacting noise under investigation is included).

TABLE B1: MEASURED CURRENT NOISE LEVELS IN THE MORUPULE COLLIERY STUDY AREA (YEAR 2007 AND 2008)

Measurement Site	Survey Date	Measured Sound Pressure Level (Noise) (dBA)					
		Daytime Period			Evening Period		
		L_{Aeq}	L_{max}	L_{min}	L_{Aeq}	L_{max}	L_{min}
Site 1	June 2008	28.6	45.0	19.3	n	n	n
Site 2	June 2008	39.5	51.3	25.9	n	n	n
Site 3	June 2008	45.8	71.8	27.4	41.5	54.9	36.3
Site 4	Sept 2007	47.5	68.0	32.3	39.2	52.0	23.0
Site 5	June 2008	33.8	46.8	22.5	31.5	42.8	22.3
Site 6	Sept 2007	39.8	52.8	27.1	28.8	45.1	21.1
	June 2008	39.6	52.2	25.6	39.4	55.2	29.2
Site 7	June 2008	68.8	70.5	67.3	n	n	n
Site 8	June 2008	54.8	65.1	45.5	n	n	n
Site 9	June 2008	56.1	61.1	51.8	n	n	n
Site 10	June 2008	46.0	56.6	37.8	n	n	n
Site 11	June 2008	51.0	58.2	46.0	n	n	n
Site 12	June 2008	*	*	*	42.9	58.5	37.6
Site 13	Sept 2007	57.9	76.6	38.8	49.8	54.6	44.8
Site 14	Sept 2007	45.4	58.3	29.5	30.8	38.5	28.2
Site 15	Sept 2007	43.5	57.6	33.0	n	n	n
Site 16	Sept 2007	46.6	54.4	39.9	n	n	n
Site 17	Sept 2007	35.2	50.1	30.5	n	n	n
Site 18	Sept 2007	62.4	79.0	43.6	46.2	52.0	41.3
Site 19	Sept 2007	56.8	76.0	43.9	51.0	58.7	39.6

Notes: n indicates that no night-time measurements were taken at the site

* no daytime measurements were taken due to interference of traffic noise

The weather conditions on the survey days were such that the measurements to establish the ambient noise levels were not adversely affected and no specific corrective adjustments needed to be made.

B5.2. Noise Climate generated by the Existing Colliery Operations

An attempt was made to isolate the noise levels from operations directly associated with the colliery from other major noise sources in the area. The noise measurements at Sites 7, 8, 9, 10 and 12 (see Table B2) provide an indication of the noise levels generated by the existing colliery operations at varying distances from the mine itself. The reference offset distances are from the

crusher plant. The more detailed calculation of the generated noise profile of the colliery is given in Appendix C.

TABLE B2: MEASURED ISOLATED NOISE LEVELS FROM THE MORUPULE COLLIERY STUDY AREA (YEAR 2008)

Site	Offset distance from crushers at mine (metres)	Ambient noise level generated by the mine (dBA)	
		Daytime	Night-time
7	63	68.8	n
8	1024	54.8	n
9	336	56.1	n
10	787	46.0	n
12	1708	*	42.9

Notes: n indicates that no night-time measurements were taken at the site

* no daytime measurements were taken due to interference of traffic noise

B5.3. Noise Climate Related to the 24 hour Road Traffic

In order to complement the short-term noise measurements, the existing 24-hour residual noise levels related to the average daily traffic (ADT) flows on Road A1 South (south of Palapye), Road A1 North (north of Palapye) and Road A14 (Palapye to Serowe) were also calculated. These data provide an accurate base for the SANS 10103 descriptors. The noise levels generated from the traffic on these roads were calculated using the South African National Standard SANS 10210 (SABS 0210), *Calculating and Predicting Road Traffic Noise*. Typical situations were used for the calculation site. The Year 2007 traffic data were used as the baseline for the calculations. The traffic data were obtained from the Botswana Department of Transport.

The noise levels at various offsets from the relevant road centrelines were established and are summarised in Table B3. The noise descriptors used are those prescribed in SANS 10103:2004, namely:

i) Daytime equivalent continuous rating (noise) level ($L_{Req,d}$) (L_d used in Table), namely for the period from 06h00 to 22h00).

ii) Night-time equivalent continuous rating (noise) level ($L_{Req,n}$) (L_n used in Table), namely for the period from 22h00 to 06h00).

iii) Day-night equivalent continuous rating (noise) level ($L_{R,dn}$) (L_{dn} used in Table), namely for the 24 hour period from 06h00 to 06h00).

The noise levels given are for generalised and the unmitigated conditions. There will be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

It should be noted that the noise contours calculated for Road A1 are those within the urban area of Palapye where average traffic speed is 70km/h. Outside the urban area where traffic speeds increase to between 110km/h and 120 km/h, the noise level values shown in Table B3 for Road A1 North and Road A1 South will increase by approximately 3dBA.

TABLE B3: EXISTING NOISE CLIMATE ADJACENT TO THE MAIN ROADS IN THE MORUPULE COLLIERY STUDY AREA (YEAR 2008 TRAFFIC)

Offset	Noise climate alongside main roads (dBA) (SANS 10103 Descriptor)								
	Road A1 N			Road A1 S			Road A14		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
25m	60.3	54.3	62.1	60.8	54.8	62.6	60.4	54.4	62.2
50m	57.3	51.3	59.1	57.8	51.8	59.6	57.4	51.4	59.2
100m	54.3	48.3	56.1	54.8	48.8	56.6	54.4	48.4	56.2
250m	50.3	44.3	52.1	50.8	44.8	52.6	50.4	44.4	52.2
500m	47.3	41.3	49.1	47.8	41.8	49.6	47.4	41.4	49.2
1000m	44.3	38.3	46.1	44.8	38.8	46.6	44.4	38.4	46.2
1500m	42.5	36.5	44.3	43.0	37.0	44.8	42.6	36.6	44.4
2000m	41.3	35.3	43.1	41.8	35.8	43.6	41.4	35.4	43.2
2500m	40.3	34.3	42.1	40.8	34.8	42.6	40.4	34.4	42.2
3000m	39.5	33.5	41.3	40.0	34.0	41.8	39.6	33.6	41.4
4000m	38.3	32.3	40.1	38.8	32.8	40.6	38.4	32.4	40.2

B5.4. Noise Climate Related to the Coal Train Traffic

The number of coal trains on the line from the Morupule Colliery to Palapye varies and generally does not exceed more than one train per day. The noise from the passing of a freight train (drawn by a diesel locomotive) travelling at 45km/h peaks in the vicinity of 92dBA at a 30 metre offset from the track. There are level crossings at the Colliery access road, the power station access road and Road A1 N where it is mandatory that the trains sound a warning horn. Noise from these horn soundings can be as loud as 105dBA at 30 metres and 84dBA at 350 metres from the train.

B5.5. Existing Noise Climate

In overview, the existing situation with respect to the existing *noise climate* in the study area was found to be as follows:

i) The main sources of noise in the area are from:

   a) Traffic on Road A1 North, Road A1 South and Road A14.

   b) Morupule Power Station.

c) Morupule Colliery.

d) Colliery railway line.

ii) The main noise sensitive areas/sites/receptors in the study area are (refer also to Figure C1 in Appendix C):

a) Palapye Village.

b) Morupule Colliery Village (residential).

c) Scattered homesteads in the study area, including the settlement ("Molapu Wapitsi") just north of the Lotsane River.

d) Contractor village adjacent to the Kgaswe Primary School.

e) Kgaswe Primary School

iii) Noise levels in Palapye Village are high and are typical of an urban complex. The existing *noise climate* alongside the main roads in Palapye is degraded with regard to acceptable urban residential living standards (SANS 10103 noise impact criteria), that is noise exceeds acceptable levels particularly at night. Residences in some areas are negatively impacted from traffic noise (night-time standard) for up to 220 metres from the main roads. In general the daytime conditions are acceptable (SANS 10103).

iv) The areas outside Palapye and remote from the main roads and the power station/colliery are very quiet and reflect a rural character.

v) The existing *noise climate* alongside Road A14 outside Palapye Village is degraded with regard to acceptable rural residential living standards (SANS 10103 noise impact criteria). Any residences within 2000 metres of the road are negatively impacted from traffic noise (particularly at night).

vi) The impact of the Morupule colliery on noise sensitive sites in the surrounding area is relatively minor. Noise levels from the colliery exceed 35dBA (the maximum allowable night-time level for rural residential use) up to a distance of about 2600 metres from the facility. Seven homesteads lie within this area of influence. The Colliery Village lies just outside this zone and is thus not impacted by the colliery noise.

vii) Noise levels from traffic on Road A14 at the Kgaswe Primary School are slightly higher than desirable for an educational environment. The outdoor ambient noise level should not exceed 50dBA. Noise from vehicles passing over the rumble strips on the power station access road just to the west of the school is a significant noise nuisance factor.

viii) Noise from the colliery does not have a significant impact on the activities at the Kgaswe Primary School.

ix) The overall impact of the noise from the coal trains on noise sensitive sites in the area is not significant. There is a minor nuisance effect at the school from the warning horn sounding when the train approaches the level crossing with the power station access road.

APPENDIX C

ASSESSMENT OF NOISE IMPACT

APPENDIX C: ASSESSMENT OF NOISE IMPACT

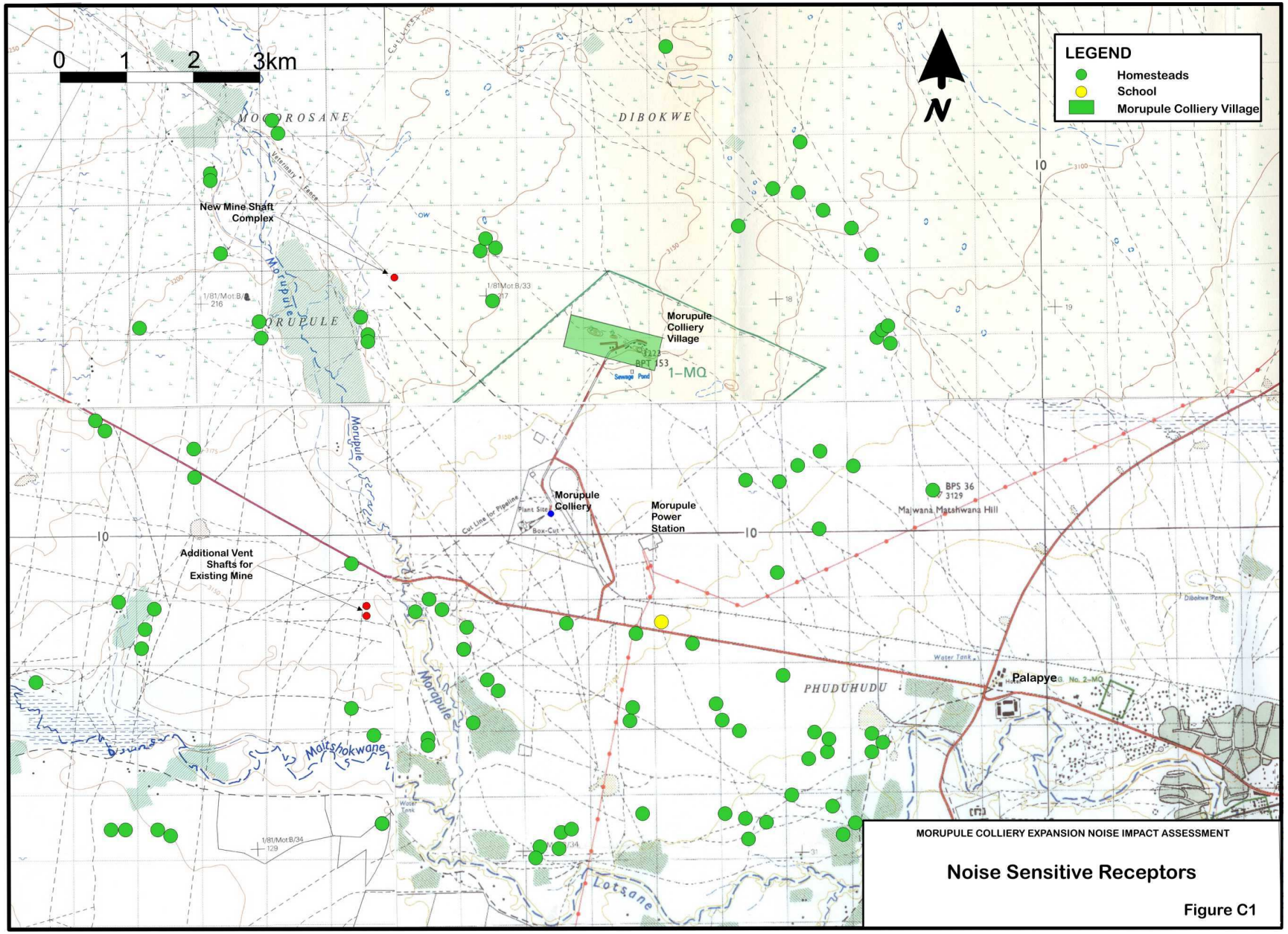
C1. GENERAL

An expansion of the Morupule Colliery is planned, which is to be developed at a site approximately 9 kilometres west of Palapye Village. The planned expansion of the colliery will allow a production level of approximately 12 million tons per annum (tpa), from the current 1 million tons per annum level. This expansion will take place in two phases: an initial expansion to approximately 4M tpa (Phase 1) and a subsequent expansion to 12M tpa (Phase 2). The expansion of mining capacity to 4M tpa can be accommodated by the existing mine and related infrastructure with minor upgrading. Phase 2 will require the development of a new shaft complex and mining operation approximately 3,5km to the north-west of the existing shaft and the construction of additional crushing and coal washing facilities in the vicinity of the existing shaft.

The assessment of the noise impact was guided by the requirements of the South African National Standard SANS 10328 (SABS 0328) titled *Methods for Environmental Noise Impact Assessments*, the World Health Organisation (WHO) Noise Standards and relevant Noise Control Regulations and Guidelines including those of the World Bank Group for thermal power plants. A comprehensive assessment using the appropriate noise impact descriptors (standards) has been undertaken. The noise impact criteria used in this investigation specifically take into account those as specified in the South African National Standard SANS 10103:2004, *The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and Speech Communication,* as well as those in the National Noise Control Regulations. Sections of these Regulations and SANS 10103:2004 are provided in Appendix A.

A plan indicating the noise sensitive receptors in the area that are potentially affected by the planned expanded operations at the Morupule Colliery was provided by the team undertaking the social impact assessment (refer to Figure C1). These were sources from Figure 11 in "Scoping Report and ToR for the Morupule Colliery Expansion Project", April 2008). Some of these were confirmed on the ground during the site inspection by the acoustician and from satellite photography (Google™ Earth). The following 1:50 000 topographical cadastral maps were also used in the analysis of the area:

- REPUBLIC OF BOTSWANA 1:50 000, Sheet 2226 B4, Edition 3-DSL 1983.
- REPUBLIC OF BOTSWANA 1:50 000, Sheet 2226 D2, Edition 3-DSL 1983.
- REPUBLIC OF BOTSWANA 1:50 000, Sheet 2227 A3, Edition 3-DSL 1983.
- REPUBLIC OF BOTSWANA 1:50 000, Sheet 2227 C1, Edition 3-DSL 1983.


0 1 2 3km
N
LEGEND
Homesteads
School
Morupule Colliery Village
MOGOROSANE
DIBOKWE
MORUPULE
New Mine Shaft Complex
Morupule Colliery Village
1-MQ
Morupule Colliery
Morupule Power Station
Cut Line for Pipeline
Plant Site
Box-Cut
Additional Vent Shafts for Existing Mine
BPS 36
3129
Majwana Matshwana Hill
PHUDUHUDU
Palapye
No. 2-MQ
Water Tank
Sewage Pond
Dibokwe Pans
Motsholokwane
Lotsane
Morupule
1/81/Mot.B/33
1/81/Mot.B/34
MORUPULE COLLIERY EXPANSION NOISE IMPACT ASSESSMENT
Noise Sensitive Receptors
Figure C1

C2. ASSESSMENT OF THE OPERATIONAL PHASE

C2.1. General

The planned expansion of the Morupule Colliery was evaluated on the following basis:

i) Noise impact from Morupule Colliery:
   a. Existing Morupule Colliery operations.
   b. Colliery expansion project and ancillary works.
      - Phase 1
      - Phase 2

ii) Noise impact from Morupule Power Station and the planned Morupule B Power Station:
   a. Existing Morupule Power Station operations.
   b. Planned Morupule B Power Station operations.

iii) Noise impact from traffic:
   a. Current traffic (2008).
   b. Future traffic (2015).

iv) Noise impact from conveyor system.

v) Features of acoustical significance.

vi) Cumulative effects of all main noise sources during operational phase.

C2.2. General Noise Conditions Related to the Existing and the Planned Expansion of the Morupule Colliery

C2.2.1. Existing Morupule Colliery Operations

The main sources of noise from the existing colliery operations are the

- Coal crusher/screening plant (two off).
- Coal washing plant.
- Ventilation shaft (two off in the box cut adjacent to the mine shaft).
- Conveyor drive house

The noise profile of the existing Morupule Colliery (refer to Figure 2) was determined from measurement and calculation. The parameters for the calculation were determined from a baseline noise measurement of the various plant and equipment at the colliery and these in turn were used as input to an appropriate noise propagation calculation model, namely SANS 10357:2000, *The Calculation of Sound Propagation by the Concawe Method*. The noise profile of the colliery was found to be (see Table C1):

TABLE C1: EXSITING AMBIENT NOISE CLIMATE GENERATED BY THE MORUPULE COLLIERY (2008)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	62.2	**1200**	45.0	**2000**	38.4
500	55.1	**1300**	44.0	**2100**	37.8
600	53.1	**1400**	43.0	**2200**	37.1
700	51.4	**1500**	42.1	**2300**	36.5
800	49.9	**1600**	41.3	**2400**	35.9
900	48.5	**1700**	40.6	**2500**	35.4
1000	47.2	**1800**	39.8	**3000**	32.8
1100	46.0	**1900**	39.1		

The noise levels given are the unmitigated values. A conservative approach has been taken in that a hard intervening ground condition has been modelled. The thick vegetation in the area will however generally result in greater attenuation with distance than shown. There will also be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

C2.2.2. Colliery Expansion Project and Ancillary Works

The expansion of the colliery will take place in two phases:

- Phase 1 (2010 – 2012) will increase the output to 4M tpa from the existing mining complex and can be accommodated by the existing infrastructure with minor upgrading.
- Phase 2 (2012 – 2015) will increase the output to 12M tpa and will require a new mining area with a new shaft complex approximately 3,5km to the north west of the existing shaft.

C2.2.2.1. Phase 1

In order to increase production to 4M tpa from the existing mining complex, some minor upgrading are required:

- The existing screening plant and crushers will be replaced with new equipment housed in new buildings.
- The ventilation of the existing shaft will need to be improved and this will require the construction of two new ventilation shafts approximately 3km to the south-west of the portal of the existing decline shaft.

The noise profile of the existing Morupule Colliery was determined from measurement and calculation. The parameters for the calculation were determined from a baseline noise measurement of the various plant and equipment at the colliery and these in turn were used as input to an appropriate noise propagation calculation model, namely SANS 10357:2000, *The*

Calculation of Sound Propagation by the Concawe Method. The future noise profile (refer to Figure 3) of the existing colliery (excluding the new ventilation shafts) at the 4M tpa production stage is predicted to be (see Table C2):

TABLE C2: PHASE 1 - FUTURE AMBIENT NOISE CLIMATE GENERATED BY THE EXISTING (UPGRADED) MORUPULE COLLIERY COMPLEX (2010-2012)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	62.7	**1200**	45.4	**2000**	38.7
500	55.6	**1300**	44.3	**2100**	38.0
600	53.5	**1400**	43.4	**2200**	37.4
700	51.8	**1500**	42.5	**2300**	36.8
800	50.3	**1600**	41.6	**2400**	36.2
900	48.9	**1700**	40.9	**2500**	35.7
1000	47.6	**1800**	40.1	**3000**	33.1
1100	46.4	**1900**	39.4		

There is only a very small change (on average 0.3dBA) between the future noise climate (2012 upgrading) and the current noise climate (existing colliery).

The future noise profile (refer to Figure 3) of the planned ventilation shafts for the existing mining complex is predicted to be (see Table C3):

TABLE C3: PHASE 1 - FUTURE AMBIENT NOISE CLIMATE GENERATED BY THE NEW VENTILATION SHAFTS (2010-2012)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	54.5	**1200**	38.0	**2000**	31.9
500	47.6	**1300**	37.1	**2100**	31.2
600	45.7	**1400**	36.2	**2200**	30.7
700	44.1	**1500**	35.4	**2300**	30.1
800	42.6	**1600**	34.6	**2400**	29.5
900	41.3	**1700**	33.9	**2500**	29.0
1000	40.1	**1800**	33.2	**3000**	26.6
1100	39.0	**1900**	32.5		

The noise levels given are the unmitigated values. A conservative approach has been taken in that a hard intervening ground condition has been modelled. The thick vegetation in the area will however generally result in greater attenuation with distance than shown. There will also be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

C2.2.2.2. Phase 2

In order to increase production from 4M tpa to 12M tpa, a new shaft complex is planned to be developed 3,5km to the north-west of the existing shaft and the infrastructure will have to be upgraded significantly.

At the new complex the following is planned for construction:

- An incline shaft.
- Ventilation fans at the shaft entrance.
- An open-circuit crusher.
- Conveyor system from the new shaft complex to the existing shaft complex.
- New or expanded workshops, change-rooms, dining facilities, lamp-room, stores, offices, laboratory facilities, weighbridge and access control systems.

The noise profile of the planned new shaft complex of the Morupule Colliery was determined from measurement and calculation. The parameters for the calculation were determined from a baseline noise measurement of the various plant and equipment at the colliery and these in turn were used as input to an appropriate noise propagation calculation model, namely SANS 10357:2000, *The Calculation of Sound Propagation by the Concawe Method*. The future noise profile (refer to Figure 4) of the new shaft complex at the 12M tpa production stage is predicted to be (see Table C4):

TABLE C4: PHASE 2 - FUTURE AMBIENT NOISE CLIMATE GENERATED BY THE NEW SHAFT COMPLEX (2015)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	58.4	**1200**	41.3	**2000**	34.8
500	51.3	**1300**	40.3	**2100**	34.1
600	49.3	**1400**	39.4	**2200**	33.9
700	47.6	**1500**	38.5	**2300**	33.0
800	46.1	**1600**	37.7	**2400**	32.3
900	44.7	**1700**	36.9	**2500**	31.8
1000	43.5	**1800**	36.2	**3000**	29.3
1100	42.3	**1900**	35.5		

In addition to the new shaft complex to the north-west, the required expansion of the mine to production capacity of 12M tpa will require upgrading/expansion at the existing shaft complex:

- New screening plants.
- Additional crushers.
- New coal washing plant.

- New complex of conveyors.

The noise profile of the upgraded/expanded Morupule Colliery complex at the existing site in 2015 was determined from measurement and calculation. The parameters for the calculation were determined from a baseline noise measurement of the various plant and equipment at the colliery and these in turn were used as input to an appropriate noise propagation calculation model, namely SANS 10357:2000, *The Calculation of Sound Propagation by the Concawe Method*. The future noise profile (refer to Figure 4) of the existing colliery complex at the 12M tpa production stage is predicted to be (see Table C5):

TABLE C5: PHASE 2: FUTURE AMBIENT NOISE CLIMATE GENERATED BY THE UPGRADED/EXPANDED EXISTING MORUPULE COLLIERY COMPLEX (2015)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	66.2	**1400**	46.5	**2400**	39.1
500	58.9	**1500**	45.5	**2500**	38.6
600	56.9	**1600**	44.7	**3000**	35.9
700	55.1	**1700**	43.9	**3100**	35.5
800	53.5	**1800**	43.1	**3200**	35.0
900	51.8	**1900**	42.4	**3300**	34.6
1000	50.8	**2000**	41.7	**3400**	34.1
1100	49.6	**2100**	41.0	**3500**	33.7
1200	48.5	**2200**	40.3		
1300	47.4	**2300**	39.7		

The noise levels given are the unmitigated values. A conservative approach has been taken in that a hard intervening ground condition has been modelled. The thick vegetation in the area will however generally result in greater attenuation with distance than shown. There will also be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

C2.3. General Noise Conditions Related to the Existing and the Planned Power Stations

C2.3.1. Existing Morupule Power Station Operations

In an earlier, separate, study the noise profile of the existing Morupule Power Station was determined from measurement and calculation. The parameters for the calculation were determined from a baseline noise measurement of the various plant and equipment at the power station and these in turn were used as input to an appropriate noise propagation calculation model, namely SANS 10357:2000, *The Calculation of Sound Propagation by the Concawe Method*. The dominant source of noise from the power station in the far field (exceeding 300 metres) was found to be that from the cooling fans. The noise profile of the power station was found to be (see Table C6):

TABLE C6: EXISTING MORUPULE POWER STATION NOISE PROFILE (2008)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	61.0	**1400**	42.7	**2400**	35.7
500	54.2	**1500**	41.9	**2500**	35.2
600	52.3	**1600**	41.1	**3000**	32.6
700	50.6	**1700**	40.3	**3100**	32.2
800	49.2	**1800**	39.6	**3200**	31.7
900	47.6	**1900**	38.9	**3300**	31.2
1000	46.7	**2000**	39.2	**3400**	30.8
1100	45.6	**2100**	37.5	**3500**	30.4
1200	44.6	**2200**	36.9		
1300	43.6	**2300**	36.3		

The noise levels given are the unmitigated values. A conservative approach has been taken in that a hard intervening ground condition has been modelled. The thick vegetation in the area will however generally result in greater attenuation with distance than shown. There will also be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

C2.3.2. Planned Morupule B Power Station Operations

In an earlier, separate, study the noise profile of the existing Morupule Power Station was determined from measurement and calculation. The parameters for the calculation were determined from a baseline noise measurement of the various plant and equipment at the power station and these in turn were used as input to an appropriate noise propagation calculation model, namely SANS 10357:2000, *The Calculation of Sound Propagation by the Concawe Method*. The dominant source of noise from the power station in the far field (exceeding 300 metres) was found to be that from the cooling fans. The noise profile of the power station was found to be (see Table C7):

TABLE C7: PLANNED MORUPULE B POWER STATION NOISE PROFILE (2012)

Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)	Offset Distance from Colliery (metres)	Sound Pressure Level (noise) (dBA)
250	64.0	**1400**	46.2	**2400**	39.6
500	57.3	**1500**	45.4	**2500**	39.1
600	55.4	**1600**	44.7	**3000**	36.7
700	53.8	**1700**	43.9	**3100**	36.3
800	52.4	**1800**	43.2	**3200**	35.8
900	51.2	**1900**	42.6	**3300**	35.4
1000	50.0	**2000**	41.9	**3400**	35.0
1100	49.0	**2100**	41.3	**3500**	34.6
1200	48.0	**2200**	40.7		
1300	47.1	**2300**	40.2		

The noise levels given are the unmitigated values. A conservative approach has been taken in that a hard intervening ground condition has been modelled. The thick vegetation in the area will however generally result in greater attenuation with distance than shown. There will also be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

C2.4. Noise Impact from Traffic

In order to complement the short-term noise measurements, the existing 24-hour residual noise levels related to the average daily traffic (ADT) flows on Road A1 South (south of Palapye), Road A1 North (north of Palapye) and Road A14 (Palapye to Serowe) were also calculated. These data provide an accurate base for the SANS 10103 descriptors. The noise levels generated from the traffic on these roads were calculated using the South African National Standard SANS 10210 (SABS 0210), *Calculating and Predicting Road Traffic Noise*. Typical situations were used for the calculation site. The Year 2007 traffic data were used as the baseline for the calculations. The traffic data were obtained from the Botswana Department of Transport.

The noise levels at various offsets from the relevant road centrelines were established for the years 2008, 2012 and 2015 and are summarised in Tables C8 – C12 below. The noise descriptors used are those prescribed in SANS 10103:2004, namely:

i) Daytime equivalent continuous rating (noise) level ($L_{Req,d}$) (L_d used in Table), namely for the period from 06h00 to 22h00).

ii) Night-time equivalent continuous rating (noise) level ($L_{Req,n}$) (L_n used in Table), namely for the period from 22h00 to 06h00).

iii) Day-night equivalent continuous rating (noise) level ($L_{R,dn}$) (L_{dn} used in Table), namely for the 24 hour period from 06h00 to 06h00).

The noise levels given are for generalised and the unmitigated conditions. There will be greater attenuation than shown with distance where there are houses, other buildings and terrain restraints in the intervening ground between the source and the receiver point.

It should be noted that the noise contours calculated for Road A1 are those within the urban area of Palapye where average traffic speed is 70km/h. Outside the urban area where traffic speeds increase to between 110km/h and 120 km/h, the noise level values shown in Table B3 for Road A1 North and Road A1 South will increase by approximately 3dBA.

C2.4.1. Current Traffic

The existing traffic noise profile is summarized in Table C8. The traffic volumes used to calculate these data include the traffic to the existing Morupule Colliery and the existing Morupule Power Station. (Table C8 below contains the same information as Table B3 in Appendix B).

TABLE C8: EXISTING NOISE CLIMATE ADJACENT TO THE MAIN ROADS IN THE MORUPULE COLLIERY STUDY AREA (YEAR 2008 TRAFFIC)

Offset	Noise climate alongside main roads (dBA) (SANS 10103 Descriptor)								
	Road A1 N			Road A1 S			Road A14		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
25m	60.3	54.3	62.1	60.8	54.8	62.6	60.4	54.4	62.2
50m	57.3	51.3	59.1	57.8	51.8	59.6	57.4	51.4	59.2
100m	54.3	48.3	56.1	54.8	48.8	56.6	54.4	48.4	56.2
250m	50.3	44.3	52.1	50.8	44.8	52.6	50.4	44.4	52.2
500m	47.3	41.3	49.1	47.8	41.8	49.6	47.4	41.4	49.2
1000m	44.3	38.3	46.1	44.8	38.8	46.6	44.4	38.4	46.2
1500m	42.5	36.5	44.3	43.0	37.0	44.8	42.6	36.6	44.4
2000m	41.3	35.3	43.1	41.8	35.8	43.6	41.4	35.4	43.2
2500m	40.3	34.3	42.1	40.8	34.8	42.6	40.4	34.4	42.2
3000m	39.5	33.5	41.3	40.0	34.0	41.8	39.6	33.6	41.4
4000m	38.3	32.3	40.1	38.8	32.8	40.6	38.4	32.4	40.2

C2.4.2. Future Traffic

Traffic growth rates were based on data provided by the Botswana Department of Transport. Annual growth of background traffic has been estimated at about 3,5% per annum up to 2015. The predicted volumes of traffic for the years 2012 and 2015 were used to calculate the relevant noise profiles along the main roads of the area.

Table C9 summarises the traffic noise situation in 2012 and Table C10 summarises the traffic noise situation in 2015. For Roads A1 (North and South) the data in Tables C9 and C10 represent the noise climate generated only by the natural growth of the background traffic, while the data for Road A14 include both natural growth and the traffic predicted to be generated by the planned Morupule B Power station.

Note that the data in Tables C9 and C10 *exclude* the noise from traffic that will be generated by Phase 1 (2012) and Phase 2 (2015) of the expansion of the Morupule Colliery. The traffic noise data related to the Colliery expansion project are summarised in Tables C11 and C12.

TABLE C9: FUTURE NOISE CLIMATE ADJACENT TO THE MAIN ROADS IN THE MORUPULE COLLIERY STUDY AREA (YEAR 2012 TRAFFIC)

Offset	Noise climate alongside main roads (dBA) (SANS 10103 Descriptor)								
	Road A1 N			Road A1 S			Road A14		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
25m	60.9	54.9	62.7	61.5	55.4	63.2	61.6	55.6	63.4
50m	57.9	51.9	59.7	58.5	52.4	60.2	58.6	52.6	60.4
100m	54.9	48.9	56.7	55.5	49.4	57.2	55.6	49.6	57.4
250m	50.9	44.9	52.7	51.5	45.4	53.2	51.6	45.6	53.4
500m	47.9	41.9	49.7	48.5	42.4	50.2	48.6	42.6	50.4
1000m	44.9	38.9	46.7	45.5	39.4	47.2	45.6	39.6	47.4
1500m	43.1	37.1	44.9	43.7	37.6	45.4	43.8	37.8	45.6
2000m	41.9	35.9	43.7	42.5	36.4	44.2	42.6	36.6	44.4
2500m	40.9	34.9	42.7	41.5	35.4	43.2	41.6	35.6	43.4
3000m	40.1	34.1	41.9	40.7	34.6	42.4	40.8	34.8	42.6
4000m	38.9	32.9	40.7	39.5	33.4	41.2	39.6	33.6	41.4

TABLE C10: FUTURE NOISE CLIMATE ADJACENT TO THE MAIN ROADS IN THE MORUPULE COLLIERY STUDY AREA (YEAR 2015 TRAFFIC)

Offset	Noise climate alongside main roads (dBA) (SANS 10103 Descriptor)								
	Road A1 N			Road A1 S			Road A14		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
25m	61.4	55.4	63.1	61.9	55.9	63.6	62.0	56.0	63.8
50m	58.4	52.4	60.1	58.9	52.9	60.6	59.0	53.0	60.8
100m	55.4	49.4	57.1	55.9	49.9	57.6	56.0	50.0	57.8
250m	51.4	45.4	53.1	51.9	45.9	53.6	52.0	46.0	53.8
500m	48.4	42.4	50.1	48.9	42.9	50.6	49.0	43.0	50.8
1000m	45.4	39.4	47.1	45.9	39.9	47.6	46.0	40.0	47.8
1500m	43.6	37.6	45.3	44.1	38.1	45.8	44.2	38.2	46.0
2000m	42.4	36.4	44.1	42.9	36.9	44.6	43.0	37.0	44.8
2500m	41.4	35.4	43.1	41.9	35.9	43.6	42.0	36.0	43.8
3000m	40.6	34.6	42.3	41.1	35.1	42.8	41.2	35.2	43.0
4000m	39.4	33.4	41.1	39.9	33.9	41.6	40.0	34.0	41.8

Table C11 evaluates the influence of the Phase 1 expansion on the noise profile of the road traffic on Road A14 in 2012 and Table C12 evaluates the influence of the Phase 2 expansion on the noise profile of the road traffic on Road A14 in 2015. The traffic generated by the colliery has been estimated to be as follows (two-way volume):

- Existing (2008): 115 vehicle trips per day.
- Phase 1 (2012): 220 vehicle trips per day.
- Phase 2 (2015): 470 vehicle trips per day.

The effect of colliery traffic in 2012 (Phase 1 expansion) will be to increase the road traffic noise by 0.3dBA (see Table C11).

TABLE C11: COMPARISON OF THE FUTURE NOISE CLIMATE ADJACENT TO THE MAIN ROADS IN THE MORUPULE COLLIERY STUDY AREA WITH AND WITHOUT ADDITIONAL COLLIERY TRAFFIC (YEAR 2012 TRAFFIC)

Offset	Noise climate alongside main roads (dBA) (SANS 10103 Descriptor)					
	Road A14 without Colliery Traffic			Road A14 with Colliery Traffic		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
25m	61.6	55.6	63.4	61.9	55.9	63.7
50m	58.6	52.6	60.4	58.9	52.9	60.7
100m	55.6	49.6	57.4	55.9	49.9	57.7
250m	51.6	45.6	53.4	51.9	45.9	53.7
500m	48.6	42.6	50.4	48.9	42.9	50.7
1000m	45.6	39.6	47.4	45.9	39.9	47.7
1500m	43.8	37.8	45.6	44.1	38.1	45.9
2000m	42.6	36.6	44.4	42.9	36.9	44.7
2500m	41.6	35.6	43.4	41.9	35.9	43.7
3000m	40.8	34.8	42.6	41.1	35.1	42.9
4000m	39.6	33.6	41.4	39.9	33.9	41.7

The effect of colliery traffic in 2015 (Phase 2 expansion) will be to increase the road traffic noise by 0.6dBA (see Table C12).

TABLE C12: COMPARISON OF THE FUTURE NOISE CLIMATE ADJACENT TO THE MAIN ROADS IN THE MORUPULE COLLIERY STUDY AREA WITH AND WITHOUT ADDITIONAL COLLIERY TRAFFIC (YEAR 2015 TRAFFIC)

Offset	Noise climate alongside main roads (dBA) (SANS 10103 Descriptor)					
	Road A14 without Colliery Traffic			Road A14 with Colliery Traffic		
	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
25m	62.0	56.0	63.8	62.6	56.6	64.4
50m	59.0	53.0	60.8	59.6	53.6	61.4
100m	56.0	50.0	57.8	56.6	50.6	58.4
250m	52.0	46.0	53.8	52.6	46.6	54.4
500m	49.0	43.0	50.8	49.6	43.6	51.4
1000m	46.0	40.0	47.8	46.6	40.6	48.4
1500m	44.2	38.2	46.0	44.8	38.8	46.6
2000m	43.0	37.0	44.8	43.6	37.6	45.4
2500m	42.0	36.0	43.8	42.6	36.6	44.4
3000m	41.2	35.2	43.0	41.8	35.8	43.6
4000m	40.0	34.0	41.8	40.6	34.6	42.4

C2.5. General Noise Conditions Related to Conveyor System

Coal will be transported from the new shaft to the main crushers and coal washing plant at the existing shaft complex by means of a conveyor belt system. Noise will be generated by the conveyor belt drive houses and by the belt sections of the conveyor system. There will also be a number of additional conveyors in the area to the east of the existing shaft complex. The predicted noise profile ("footprint") around a drive house is as follows:

Offset Distance from Drive House	Sound Pressure Level (noise) (dBA)
250m	57.3
500m	50.3
1000m	42.6
2000m	33.8
3000m	28.2

The predicted noise profile ("footprint") at the indicated offsets from the belt sections is as follows.

Offset Distance from Conveyor	Sound Pressure Level (noise) (dBA)
100m	48.2
250m	39.6
500m	32.7
1000m	25.0

The final details and the position of the conveyor system has not been finalised, but it can be assumed that it will be on the most direct route between the new and existing shaft complexes. The route between the new and the existing shaft complexes lies within a corridor which is located within a envelope of high noise levels and thus its noise impact should not be significant. No specific details have been given regarding the position of the coal conveyor to the planned Morupule B Power Station.

C2.6. Features of Acoustical Significance

C2.6.1. ***Wind***

Analysis of the wind records for the area indicates that overall (day and night average) the main prevailing winds blow from a north and a north-easterly direction. Under windy conditions there will thus be a sight enhancement of noise levels to the south-west of the study area, namely in the area of the Kgaswe Primary School.

C2.6.2. ***Topography***

The terrain in the study area is relatively flat with a gentle fall to the south-east. There are no real features in the area that will influence the propagation and attenuation of sound.

C2.6.3. ***Vegetation***

The vegetation in the area is thick bush and trees that will result in some attenuation of the power station noise with increasing distance from the source.

C2.7. ANALYSIS OF THE CUMULATIVE NOISE IMPACT EFFECTS

The predicted cumulative effects of the three main sectors of the Morupule Colliery that will be operational in 2015 (namely from the upgraded works at the existing mine shaft, from the additional ventilation shafts and from the new mine shaft complex) are given in Figure 5. This excludes the noise from road traffic and the noise from the existing Morupule Power Station and the planned Morupule B Power Station. The noise sensitive receptors that are potentially impacted by the colliery noise are also indicated in this figure. Due to the close proximity of the excising and planned power stations to the Morupule Colliery complex, the cumulative effects of the colliery operations with the two power station operations has also been assessed. The noise profiles of the two individual power stations are shown in Figure 6 and the cumulative effects of the noise from the power stations together with the colliery expansion is shown in Figure 7. Here again, the influence of traffic noise has not been included.

APPENDIX 3: HYDROLOGY / HYDROGEOLOGY IMPACT ASSESSMENT

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EIA FOR MORUPULE COLLIERY EXPANSION PROJECT

Final Hydrogeology Report

September 2008

Prepared by

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LIST OF ACRONONYMS AND ABBREVIATIONS

AIA	Archaeological Impact Assessment
ALD	Acid Leachate Drainage
AMD	Acid Mine Drainage
BPC	Botswana Power Corporation
DEA	Department of Environmental Affairs
DWM&PC	Department of Waste Management and Pollution Control
DWNP	Department of Wildlife and National Parks
EIA	Environmental Impact Assessment

EMP	Environmental Management Plan
GIS	Geographic Information System
GoB	Government of Botswana
GPS	Geographic Positioning System
km	Kilometre
kV	Kilovolt
mamsl	Meters above mean sea level
mbgl	Meters below ground level
MCL	Morupule Colliery Limited
MW	Megawatts
NSC	North South Carrier
PEIA	Preliminary Environmental Impact Assessment
ToR	Terms of Reference
tpa	Tones per annum
UB	University of Botswana

1 INTRODUCTION

This Hydrogeological EIA 'specialist' report outlines the surface and groundwater findings (and likely impacts associated with) the proposed expansion of the Morupule Colliery. The report assesses both potential impacts and changes in water resources (quantity) (changes in run off, changes in regional groundwater resources) as well as possible impacts on water quality. A location plan for the Colliery is shown as Figure 1.

1.1 Project Background

The Morupule Colliery Limited (MCL), a subsidiary of Debswana Diamond Company (Pty) Ltd has been operating the coal mine since 1973 and is currently producing 1 million tonnes of coal per year. The coalfield within the mining lease area is immense and contains good quality coal, with the estimated overall coal presence exceeding 5 billion tonnes. Production has increased steadily over the years from 145 000 tonnes per year in 1973 to a total of 985 000 tonnes of coal mined and 964 000 tonnes sold in 2005.

The Botswana Power Corporation (BPC), which operates a coal-fired power station nearby has been the main consumer of the MCL coal.

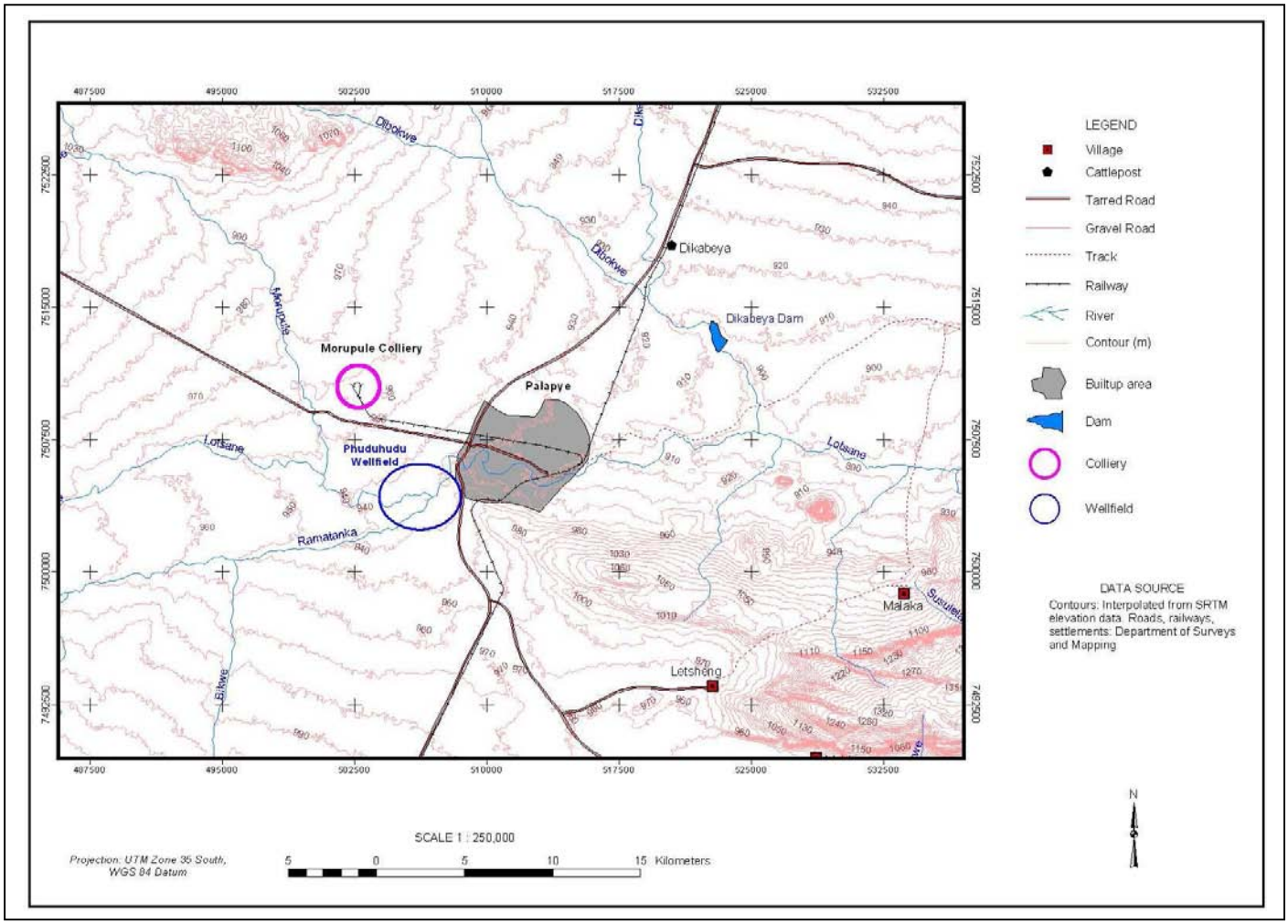
Other major industries supplied by the MCL mine include the BCL copper mine at Phikwe, Botswana Ash Plant in Sowa Pan, Botswana Meat Commission, Botswana Breweries, Foods Botswana, Makoro Bricks, and two retail coal distributors. In addition, the mine also supplies graded coal to Zimbabwe, Zambia and the Democratic Republic of Congo.

The colliery now proposes to expand its coal production from 1 million tonnes per year to 12 million tonnes per year (from two shafts which will be opened between 2009 and 2013). The purpose of this expansion is to:

- Cater for an increase in power generating capacity at the Botswana Power Corporation (coal-fired) power station site at Morupule. BPC recognised that they will not be able to meet future power demand for the country specifically after 2007 when Eskom, the main exporter of power to BPC, is expected to run out of surplus power to export. The power increase is expected to be 600 MW for phase 1, and 600 MW for phase 2, together with the current 132 MW of generating capacity.
- Produce beneficiated coal that has been processed through washing plants, for the local coal market and for export.
- Produce unbeneficiated coal of power station grade coal to existing and new customers.

The colliery has been given the authority by the BPC board to proceed with the planning and preparations aimed at ensuring adequate supply of coal to generate 600 MW for the phase 1expansion of the power station and the current 132 MW. Confirmation from BPC for the second phase is still pending.

Figure 1: Project Location



1.2 Purpose and Objective of the Study

MCL is currently undertaking different studies associated with these expansion works that will provide sufficient coal to cater for the BPC upgrade. This Hydrogeological/Hydrological component of the EIA study is amongst these with the main objectives being to:

- Ascertain and evaluate the environmental, hydrogeological and hydrological impacts, which will be caused by the project.
- Identify any key parties who exist in the area and how they will potentially be impacted
- Identify and describe procedures and measures that will mitigate any predicted adverse impacts of the development proposals and introduce means to enhance the beneficial effects of the proposed activities.
- Review drainage impacts
- Assess locations and construction of new material lay down areas;
- Develop an ongoing environmental audit and environmental management plan to ensure mitigation measures can be implement during construction/development;
- Assess all impacts apart from occupational, health and safety.

The specific objective is to ensure that the impacts of the mining development will not influence the regional ground and surface water regime in a manner that is detrimental to either the current or future users or the environment as a whole. The key issues (and associated impacts) of the expansion relate to:

- Impacts on water resources, in particular with groundwater
- Impacts pm water quality
- Potential soil and sub soil contamination
- Potential acid leachate run off and acid mine drainage
- Impacts on surface water/mining systems due to storm runoff
- Cumulative impacts as the mine area increases including possible subsidence.

Clearly some issues will only be temporary occurring only during the construction phase (ie: movement and storage of chemicals, fuels etc required for the construction works which if spilt or leaked onto the ground could cause impacts particularly if transported off site by either surface or subsurface (groundwater) flow). Thus the types of material to be used in the construction phase (and their storage location) require them to be environmentally well placed at a position with the least possible likely impact if there were to be spillages or leakages.

However permanent storage sites for the new mine including the coal piles, which will be considerably larger than present, are more important especially with regard to drainage (and

the potential for acid leachate runoff/drainage) and the benefits for incorporating a completely self sealed drainage system are discussed.

Although it is understood that the new coal washing facilities will release very little liquid into the environment, the potential for some inevitable residues from the washing to cause environment damage has also been assessed. The waste water stream from the various processes and from the new laboratory likely to be routed to the Palapye treatment works have been briefly reviewed although the pipeline route for this is not yet available. The likely effluent produced both solid and liquid waste disposal and where this material is stored, transported or disposed of needs to be evaluated to reduce or eliminate environmental impact.

Larger numbers of staff employed at the site will necessarily mean more waste - both as sewage and solid waste. The methods by which these increases will be processed needs to be evaluated and current effluent treatment plant requirements (upgrading) to deal with this is reviewed and both positive and negative impacts noted.

Storm water run off which may be likely to overcome the present drainage requirements is assessed to ensure that pollutants are not 'picked up' unnecessarily in heavy storms thus preventing a release of unchecked contaminants out into the environment. A separate flood risk report is attached as an Appendix II.

There is already an awareness on the part of the Colliery management for the need to have action plans in place to prevent any impacts spreading off or below site particularly from unexpected incidents. These are also reviewed.

However the main specific objective is to balance negative impact with appropriate and effective mitigation and to improve and increase positive impacts.

From a hydrogeological/hydrological view point the study has shown that very little base data gathering has ever taken place or is currently taking place at the mine. As such the project is entering largely uncharted territory where the baseline information required will need to be obtained as a result or consequence of the EIA study. No comparison of how the current operations have impacted the water environment mine prior to its opening in the 1980's has been possible as not available data on what the conditions were at that time exists. One area where the Colliery is positively recording impact is the network of subsidence monitors that have been set up. This is seen as potentially a very major issue for the future expansion although no reporting of subsidence to date has been made.

2 BACKGROUND

2.1 Topography, Soils and Climate

Morupule Colliery lies about around 7 kilometres west of the village of Palapye within the Lotsane River catchment area (see Figure 1 - previous). The Colliery surface lies at a ground elevation of between 950 - 960 mamsl. The topographic gradient is southeast sloping towards Palapye. The ephemeral Lotsane River is the major river in the area and drains from west to east, rising at the Serowe escarpment some 30 km west of the Power Plant. The Morupule River, a tributary of the Lotsane River, drains from north to south and is located about a kilometre west of Colliery site. The relatively deeply incised nature of the Lotsane River suggests little contribution to flow from the surrounding area. The main flow is a result of drainage from the Serowe escarpment.

The soils in the study area mainly comprise of aeolian sands, derived from the weathering of the Ntane Sandstone Formation. (The Ntane Sandstone outcrops along the escarpment slope west of Serowe village 30 kilometres to the west of the Colliery). The soils are mainly orange coloured, fine-grained sandy silty loams. The dominant soil types within the area of the colliery are Ferralic Arenosols and Arenic Ferric Luvisols (<3% clay), although southwards along the axis of the Lotsane River Calcaric Cambisols and Orthic Luvisols predominate. The geotechnical report by Schwartz Tromp and Associates (2007) for the development of the new Morupule B Power Station just to the east of the Colliery site records the soil as "Dry, orange brown blotched off white, loose to medium dense, porous, fine sand. The aeolian sands becoming more medium grained with depth to about 4 metres, generally underlain by a calcrete/ferricrete layer". The soils are well to very well drained, and consequently do not retain any significant moisture. As a result there do not seem to be any associated lines of drainage around the Colliery or the surrounding areas other than the more deeply incised Lotsane and Morupule Rivers. Additionally as the soils do not contain any significant clayey material (or organic material) they are unlikely to prevent the downward migration of contaminants. Thus great care must be taken to ensure that where such potential contaminants exist on the surface (either as a waste stream or as a storage facility) they are well protected.

It is thus concluded that the soils on site do represent a potentially high-risk vulnerability in terms of environmental protection as they do not afford any barrier to contaminants and allow easy access from surface to shallow groundwater.

In terms of rainfall and consequent surface water, the most useful indicators are rainfall intensities (rather than total rainfall during a year) as intense rainfall is likely to be the event that causes an issue such as localised flooding or large scale run off. These intensities are available from the National Water Master Plan Review. Table 1 below presents rainfall intensities from the closest available site - Palapye.

Table 1 - Rainfall Intensities at Palapye - Source BNWMPR 2005

Palapye												
		Rainfall for respective duration and return period										
Duration (minutes/hours)		Minutes						Hours				
		5	10	15	30	45	60	2	4	6	12	24
	In hours:	0.08	0.17	0.25	0.5	0.75	1	2	4	6	12	24
Return Period (Years)	24-hour max rainfall (mm)											
2	54.4	52.2	45.7	43.5	32.6	26.1	21.8	16.3	10.9	8.2	4.4	2.3
5	76.6	73.5	64.3	61.3	45.9	36.8	30.6	23.0	15.3	11.5	6.2	3.2
10	91.3	87.6	76.7	73.0	54.8	43.8	36.5	27.4	18.3	13.7	7.4	3.8
20	105.3	101.1	88.5	84.2	63.2	50.5	42.1	31.6	21.1	15.8	8.5	4.4
50	123.6	118.7	103.8	98.9	74.2	59.3	49.4	37.1	24.7	18.5	10.0	5.2
100	137.2	131.7	115.2	109.8	82.3	65.9	54.9	41.2	27.4	20.6	11.1	5.7

Gaugings are not taken on the Morupule River and only flows on the Lotsane River are available and these are far downstream at Maunatlala towards the eastern end of the Tswapong Hills. Table 2 shows available flow data on the Lotsane River. In general (in comparison with other rivers in Botswana) the flows are not particularly significant apart from a few odd record years.

Table 2 - Mean Daily Mean Flows on the Lotsane at Maunatlala - Source BNWMPR 2005

Department of Water Affairs
Mean Monthly flows (MCM)

Station Number : 3321
Station Name : Lotsane River at Maunatlala (3321)

Latitude : 22:35: 0 S Longitude : 27:38: 0 E Elevation : 0.0 metres Area : 6385.0 sq km

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
1979/80	0	0	0.341	0.743	1.647	0	0	0	0	0	0	0	
1980/81	0	0.028	1.506	5.821	4.931	0	0	0	0	0	0	0	
1981/82	0	0	0.09	0.106	0.162	0.479	0	0	0	0	0	0	
1982/83	0.7	0.011	0.002	0.425	0.233	1.712	0.192	0	0	0	0	0	
1983/84	0	2.378	0.704	0	1.357	16.716	0.028	0	0	0	0	0	
1984/85	0.01	2.263	4.078	3.46	2.989	0.314	0	0.054	0	0	0	0	
1985/86	0.03	1.496	4.622	0.973	5.125	1.725	8.139	0.003	0	0	0	0	
1986/87	1.197	2.412	9.33	1.044	0.945	0.287	0.227	0	0	0	0	0	
1987/88	0	0.001	69.979	41.359	198.329	63.98	1.747	0.014	0	0	0	0	
1988/89	0.036	0	0	0.434	2.515	0.097	0	0	0	0	0	0	
1989/90	0	1.37	1.53	0	0.083	0.245	0.004	0	0	0	0	0	
1990/91	0	0.409	4.582	3.988	9.257	6.93	0.026	0	0.195	0	0	0	
1991/92	0	0	4.264	0.371	0.018	0	0	0	0	0	0	0	
1992/93	0	0.117	5.74	0.314	0.316	0	0.003	0	0	0	0	0	
1993/94	0	0.067	2.74	3.347	4.073	0	0	0	0	0	0	0	
1994/95	0	0	0	0	0	0	0	0	0	0	0	0	
1995/96	0	1.517	0.05	21.5	47.107	1.398	0.081	0	0	0	0	0	
1996/97	0	0.461	0	0.017	0.156	0.62	0.031	0	0	0	0	0	
1997/98	0	0	0	23.46	0	0	4.13	0	0	0	0	0	
1998/99	0	0.098	1.174	2.293	0	0	0	0	0	0	0	0	
1999/000	0	2.31	5.42	-	-	-	-	-	-	-	-	-	
2000/01	-	-	-	-	-	-	-	-	-	-	-	-	
2001/02	-	-	-	-	-	-	-	-	-	-	-	-	
2002/03	-	-	-	-	-	-	-	-	-	-	-	-	
2003/04	-	-	-	-	-	-	-	-	-	-	-	-	
2004/05	-	-	-	-	-	-	-	-	-	-	-	-	

Storm drainage from the site will be likely to be caused by short duration flows and be as a result of the development of more infrastructure on the surface and more storage of materials on site. Also potential for flooding within the site and in particular the shafts may be an issue. On a positive impact side, greater emphasis on rain water harvesting and storm water capture for re use on site should be a high priority for the Colliery to provide positive impacts from the development. A full flood risk assessment has been carried out, which makes use of the rainfall intensity data and estimates potential surface water flows, and this is included as Appendix II of this report.

2.2 Geology

Table 1 shows the stratigraphic sequence using accepted terminology after Smith (1984), Ermanovics, Key & Jones, 1978.

Table 1 - Stratigraphy in the Palapye/Serowe Area

AGE	SUPERGROUP	GROUP	FORMATION	LITHOLOGICAL DESCRIPTION
CAINOZOIC		Kalahari	Kalahari Beds	soil, sand, calcrete, silcrete and clay
			Tuli Dyke Swarm	Dolerite dyke and sill intrusive event
MESOZOIC	KAROO	Stormberg Lava	Serwe Pan	Massive amygdaloidal flood basalt extrusion
		Lebung	Ntane Sandstone	Aeolian sandstone. Medium to fine grain with minor mudstone intercalations becoming fluvial to base
			Mosolotsane	Fluvial red beds. Siltstones and fine grained sandstone
		Beaufort	Tlhabala	Non-carbonaceous mudstones and siltstones with minor sandstones
		Ecca	Serowe	Siltstones, mudstones with minor sandstones, limestones and vitrinite coal seams
			Morupule	Carbonaceous shales and dull coal seams with minor sandstones
			Kamokata	Coarse clastic fluvio-deltaic sediments
			Makoro	Post glacial lacustrine argillaceous mudstones and siltstones
		Dwyka	Dukwi	Base of Karoo sequence tillites, shales, varved siltstones and mudstones
PROTEROZOIC	WATERBERG			Dolerite dyke and sill intrusions
		Palapye	Shoshong	Conglomerate and sandstone with banded ironstones, dolomite and quartzite
			Lotsane	Variegated shales and mudstones
			Tswapong	Massive to flaggy purple quartzites
			Moeng	Argillites pink shales and micaceous siltstones with minor limestone
			Selika	Volcanic tuffs and coarse grained sandstones/quartzites
ARCHAEAN	BASEMENT	Limpopo Mobile Belt		Granite gneiss and amphibolite

The area to the north and west of the current Morupule Colliery essentially represents the eastern margin of the South East Central Kalahari Karoo Sub Basin (DGS 1984 Smith), where shales,

sandstones, mudstones and siltstones of the Karoo Supergroup sediments unconformably overlie the Lotsane Mudstones of the Palapye Group.

These Karoo Supergroup rocks are a succession of conglomerates, shales and sandstones occurring to around 300m in thickness. Within these sequences lie the coal seams that are currently mined at the Colliery.

The Karoo Supergroup rocks unconformably overlie the Palapye Group sediments with its base being represented by sediments of the Dwyka Group, which were deposited on an irregular basement land surface and comprise shales, tillites, varved siltstones and mudstones of the Dukwi Formation. Their distribution is irregular by virtue of variations in the basement topography or as a result of post depositional erosion by glacial meltwater. Few intersections are recorded in diamond drill cored coal exploration boreholes. The Dukwi Formation comprises a basal tillite (rounded pebbles of Palapye Group quartzite and shale together with granite gneiss and dolerite set in a grey-green coloured muddy to coarse grained sandy matrix). This basal tillite can be seen as outcrop (together with elements of the Tswapong Formation - part of the Palapye Group) just along the Lotsane River to the south of the Colliery close to the Colliery Phuduhudu wellfield area and indicates the south eastern edge of the basin. Overlying the tillite is a sandstone unit (~25m in thickness) comprising a medium to coarse grained sandstone becoming stratified, calcareous and fining towards the top. The uppermost unit are varved mudstones (banded or laminated grey green siltstones). The argillites are commonly slumped or disrupted and contain scattered dropstones.

Ecca Group sediments overlie the Dukwi Formation strata. Within the regional area four formations have been identified by Smith, 1984 comprising the Makoro; Kamokata; Morupule and Serowe Formations. The basal Makoro Formation is represented by argillaceous mudstones and siltstones, fine grained sediments deposited in broad lakes which developed after the final retreat of the Dwyka ice sheet. High energy deltaic sand bodies of the Kamokata Formation were laid down over the lacustrine Mokoro Formation sediments. The deltas formed from rivers draining the crystalline highlands in the east. The development of temperate marsh lands in adjacent low energy areas of the deltas resulted in the formation of minor coal horizons within the sandstone units. Along the basin edge the arkosic sandstones commonly oversteps onto pre Karoo basement. Generally the sandstones show a fining up sequence from pebbly at the base grading to fines. The lower Ecca Group arenaceous sediments generally form the main aquifer horizon although at the Colliery the strata was found to be dry when intercepted.

The Morupule and Serowe Formations represent the main carbonaceous and coal bearing strata lying above the main fluviatile dominated deltaic sequence. The heavy dull coal seams occur within the Morupule Formation when deposition of organic and argillaceous material occurred in large low-lying tundra swamp areas. The carbonaceous shales contain channel sandstones, which were locally introduced as a result of subsidence. The overlying Serowe Formation is distinguished by its characteristic light grey siltstone member which overlie the black carbonaceous shales. The Formation comprises siltstones and mudstones with minor sandstones and limestones. Smaller coal seams with vitrinite occur within the carbonaceous horizons.

Overlying the Ecca Group are Beaufort Group sediments represented by the Tlhabala Formation which comprise a thick suite of non-carbonaceous grey silty mudstones which were laid down following widespread inundation of the peat swamps and the formation of an open lake.

Dolerite dyke and sill intrusions occur throughout the project area. The dykes are post Karoo and form pronounced aeromagnetic and photographic features with a west-north-west trend The dykes range from less than a metre to as much as 50m wide, have medium to coarse grain sizes, and develop large feldspar phenocrysts in the thicker bodies. The sills appear to intrude a specific stratigraphic horizon often being at the contact between the Tlhabala and Serowe Formations.

The results of core holes drilled by MCL have been assessed. Typically in the development area there is 20 to 30 metres of Kalahari Sediments overlying 20 to 30 m of Shales and Siltstones containing a few thin coal seams which in turn overlie the first main Coal seam.

The Palapye Group rocks to the east of Colliery lie unconformably upon gneissic Basement Complex rocks and are sub-divided into five conformable formations. For the purpose of this study only the Tswapong and Lotsane Formations are relevant and are the only rocks described in detail. The age of the Palapye Group is thought to be Middle Precambrian (i.e. +/- 2000 Ma) and the group forms a subset of the Waterberg Supergroup. The rocks are primarily clastic and are thought to originate from the weathering of the adjacent crystalline basement rocks, deposited in a shallow water environment.

The Archaean basement rocks comprise granite gneiss and amphibolites which represent a westward extension of the Southern Marginal Straightening Zone of the Limpopo Mobile Belt. The Proterozoic sediments comprise clastic sedimentary rocks with minor volcanic beds of the Palapye Group. The Tswapong Formation sediments comprise five members as described in Table 2.

Table 2 - Tswapong Formation Members

Member (approx. thickness in m)	Brief Lithological Description
Grit Member (400m)	Massive, coarse grained ferruginous quartzitic sandstone, intercalated with siltstone towards the top.
Flag Member (140m)	Interlayered pisolitic ironstones and ferruginous quartzitic sandstones, with brown purple coloured shales.
Upper Quartzite Member (140m)	Flaggy, medium to coarse grained ferruginous quartzitic sandstone.
Pisolite Member (150m)	Flaggy ferruginous quartzitic sandstone with harmatite pisolites (35% haematite).
Lower Quartzite Member (140m)	Brown to purple coloured, massive and flaggy, medium grained, ferruginous quartzitic sandstone.

The Lotsane Formation sediments comprise flagstones, siltstones and sandy shales. The Lotsane Formation forms the confining layer to the underlying Tswapong Formation, which forms the main aquifer in the area and provides the water in the Palapye Wellfield east of the village.

The Palapye Group sediments were also intruded by dolerite sheets, representing transgressive bodies of magma which rose along faults displacing the Palapye Group. Dykes composed of identical rock types cross-cut the sills and the host rock along north-west and east-north-east trends.

2.3 Hydrogeology

The major aquifer units in the area are the quartzitic members of the Tswapong Formation from which the Palapye wellfield boreholes (east of the village) abstract. Essentially, the aquifer displays a secondary porosity nature due to intense small-scale and large-scale fracturing. Primary porosity is regarded to be minimal due to the considerable age of the rocks and their history of cementation and recrystallisation. Larger scale fracture and fault zones provide areas of enhanced but highly directional transmissivity through which regional flow occurs. Storage coefficients of such zones are low. Aquifer conditions are largely confined to the north of the Tswapong Hills by the thick sequence of Lotsane shales. The piezometric surface for the Tswapong formation is frequently only a few metres below ground level in the Lotsane shales and in some instances flowing or artesian conditions have been recorded in some boreholes near to the river. Unconfined aquifer conditions occur in the Tswapong Hills where the aquifer outcrops. This is the main recharge zone to the aquifer whilst the confined area in the valley bottom appears to be a groundwater discharge zone where the head in the aquifer is often greater than the head in the overlying Lotsane formation.

The Lotsane formation is a low yielding aquifer with groundwater occurrence being restricted to limited fracturing. A good number of old boreholes in the area tapped this source. Today the groundwater in this aquifer around Palapye village is highly contaminated with nitrate and chloride and is unfit for public supply. Further to the north and west, towards the Colliery area, the Tswapong aquifer becomes deeply confined below the Lotsane Formation and Karoo Supergroup and yields reduce, probably as a result of a decrease in fractures at depth.

The area along the Lotsane River indicates the contact zone between the Tswapong and the Karoo. Although the Karoo sequence, particularly the Ntane and Ecca Sandstones, are considered the most valuable and important aquifers in Botswana, at the location of the colliery the Ntane is not present and the Ecca sequence does not contain the most productive sandstone formations available elsewhere in Botswana. The mine operates a small wellfield to the south of the mine on the margins of the Lotsane River. The wellfield area (the Phuduhudu Wellfield) taps the contact zone between the Tswapong and Dwyka Formations. Although the Tswapong Formation in the Palapye Wellfield area (east of the village) does provide quite reasonable (albeit very variable) yields ranging from almost nothing to 30+ m^3/hr, the thickness of this unit close to the colliery is not large (a few tens of metres), is unconfined and is away from the obvious recharge area in the Tswapong Hills.

Groundwater within the mine lease area has also historically been used for supply to the Morupule Mine 'Village' area. The hydrogeological 'target' at the village area appears to be the contact zone with the deeper basement rocks (Gneissic Basement Complex) as the boreholes there all penetrate to around 300mbgl.

Thus the setting of all three of the sites - the Colliery, the Wellfield and the 'Village' area - cannot be considered to be located on major or particularly productive aquifers and their vulnerability is therefore assessed as being not of great significance. The only major groundwater usage is from the east of Palapye village some 30 kms from the site.

Existing Borehole Data

Archive data for boreholes in the area was collected from the National Borehole Archive. The data is, in general, skewed towards the Palapye Village and Wellfield area. Unfortunately the National Archive has not been updated for over 10 years and as a result only contains rather 'old' boreholes. Very few of these 'older' boreholes unfortunately provided any meaningful information. The results of the few existing available boreholes with some information, close to the Colliery site, are presented in Table 3. The results indicate that the sandstones/shales are low yielding. The borehole completion certificates generally indicate the groundwater quality is marginal in terms of drinking water supply (TDS values 1000-2000mg/l).

Table 3 - Summary of Boreholes close to the Colliery

Bh No	Depth (mbgl)	Water Strike (mbgl)	Water Rest Level (mbgl)	Yield (m^3/hr)	Geology
412	410	113	41	2.2	Sandstone
1050	103	31	25	1.4	Sandstone/shale
1051	103	53.5	8.8	1.5	Shale/sandstone
3828	80	-	-	dry	Sandstone
3830	10	-	-	dry	Sandstone
3831	378	41 + 156	22	7.4	Sandstone/shale

It should also be noted that the locations of boreholes in the "National Borehole Archive" is notoriously inaccurate particularly boreholes drilled before the advent of GPS.

2.5 Water Reconnaissance Results

A groundwater survey has been carried out around the Colliery and Expansion Area. The results of the groundwater survey are given in Tables 4, 5 and 6 - summaries of the wellfield boreholes, the village boreholes and other private boreholes.

Table 4 - Summary of Existing Wellfield Boreholes from the Groundwater Reconnaissance Survey

BH no / Site no	Coordinates		Elevation	Depth	SWL	Yield	BH status
	x	y	(m)	(m)	(m)	(m3/h)	
BH 5A/ Possibly BH1691	507294	7504350	947.56	113	16.45	2	in use
BH 5B	507765	7504680	943.27	78, collapsed	18.00		abandoned
BH 5C1/ (BH4775 OBS)	507755	7505072	941.75	145	18.85	8	in use
BH 5C2/ BH4775	507761	7505064	940.22	85	19.00	5	in use

Table 5 - Summary of Existing Village Boreholes from the Groundwater Reconnaissance Survey

BH no. / ID no	Coordinates	Elevation	Depth	SWL	Yield	BH status

	x	y	(m)	(m)	(m)	(m3/h)	
BH 1	504080	7512402	971.86	330	45	5	Not in use
BH 2	503266	7512787	973.94	260	25		Blocked with equipment
BH 3	503976	7512396	973.41			Dry	
BH 4	504020	7512364	972.16			Dry	
BH 5	503933	7512501	977.24			Dry	
BH 6	503344	7512681	974.78	400	31.7		
BH 7	503318	7512773	974.02	380	30.5	2	Not in use
BH 8	503280	7512740	973.61	380		Dry	
BH 9	503101	7512705	974.13	300		Dry	
Sewage pond 2	503598	7512331	972.21				
Sewage pond 3	503365	7512840	974.47				

Table 6 - Summary of Existing Private Boreholes from the Groundwater Reconnaissance Survey

BH no. / ID no.	Coordinates		Elevation	Depth	SWL	Water	Yield	BH status
	x	y	(m)	(m)	(m)	Quality	(m3/h)	
Masakeng	493218	7512859	995.87					in use
Elijah Shashane	494265	7514159						in use
Albert Paki	495712	7512837				salty		in use
Ketumile Monnaesi	495417	7511826	984.58			salty	2.9	in use
Old Morupule 3 (shell cool)	495368	7511805	985.42					abandoned
Kikia Khesa	494674	7512739	988.16			1.40 ppt		in use
Atlasaone Maliehe	494537	7510408	981.85	200		very salty		in use
Matshampane	496962	7510625	978.42	200		very salty		in use
Malwela	496134	7507524	967.23			very salty		in use
Monyena (Dikoko)	497705	7510231	977.07					in use
Old Morupule 1 (nxt to rd)	499764	7509192	967.32					abandoned
Old Morupule 2	499599	7509885	971.07					abandoned
Sebetela	499562	7511392	981.00			salty	5	in use
David Tsedie (oranges)	499966	7505531	958.43					in use
Tswelelo Shashane	505886	7507046	953.82			salty	2	in use
Gothatamang C. Motswagole	504540	7503423	948.29	196		sweet	5	in use

From this survey (Figure 2) it is clear that there are quite a few current active boreholes to the west of the mine in the area where the coal seams are to be mined and which potentially could be impacted by dewatering.

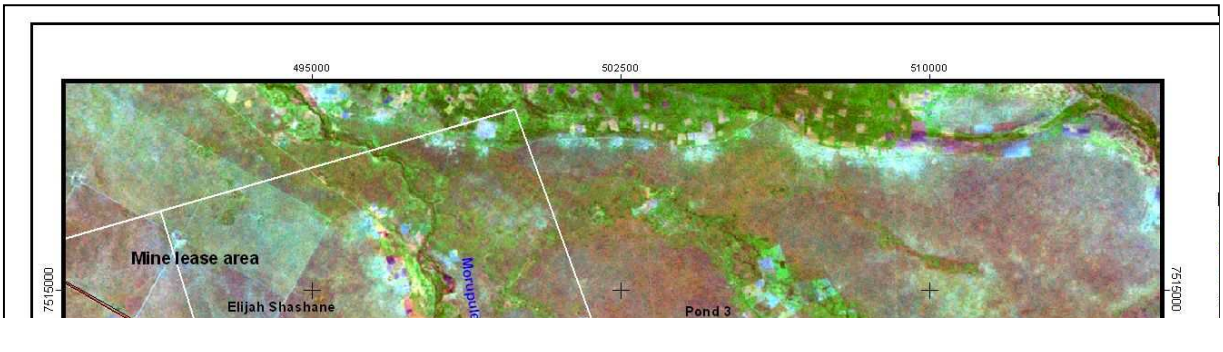


Figure 2 - Distribution of Boreholes from Survey around the Colliery Area

The private wells are shown as white dots, whilst the Colliery's own boreholes, drilled to determine coal thicknesses, are shown as yellow dots. The red dots indicate the Colliery's wellfield and the blue dots show the boreholes local to the Colliery's residential areas which were used for local water supply.

2.6 Groundwater Head Distribution

A piezometric contour map of the Palapye area including the Colliery has been produced from field data and historical evidence and is shown as Figure 3. Regionally groundwater flow direction follows the major rivers in the area - the Lotsane River flow direction eastward and more locally to the Colliery, the contours also flow from the north following the Morupule River. In the Palapye area, the groundwater flow direction is controlled from the recharge area (the Tswapong Hills) located to the south of the area and is northwards down towards the Lotsane River. The roughly E-W axis of the Tswapong/Moeng Hills forms a groundwater divide between northerly and southerly flowing groundwater systems. The piezometric map appears to show a small groundwater high at the confluence of the Lotsane and Morupule Rivers. This perhaps represents the cumulative effects of groundwater impacts as a result of occasional flow in the two rivers at that point. Towards the Colliery Wellfield area the 920 mamsl groundwater contour

seems to have been pulled south possibly indicative of the impacts of the drawdown cone of depression produced by the wellfield.

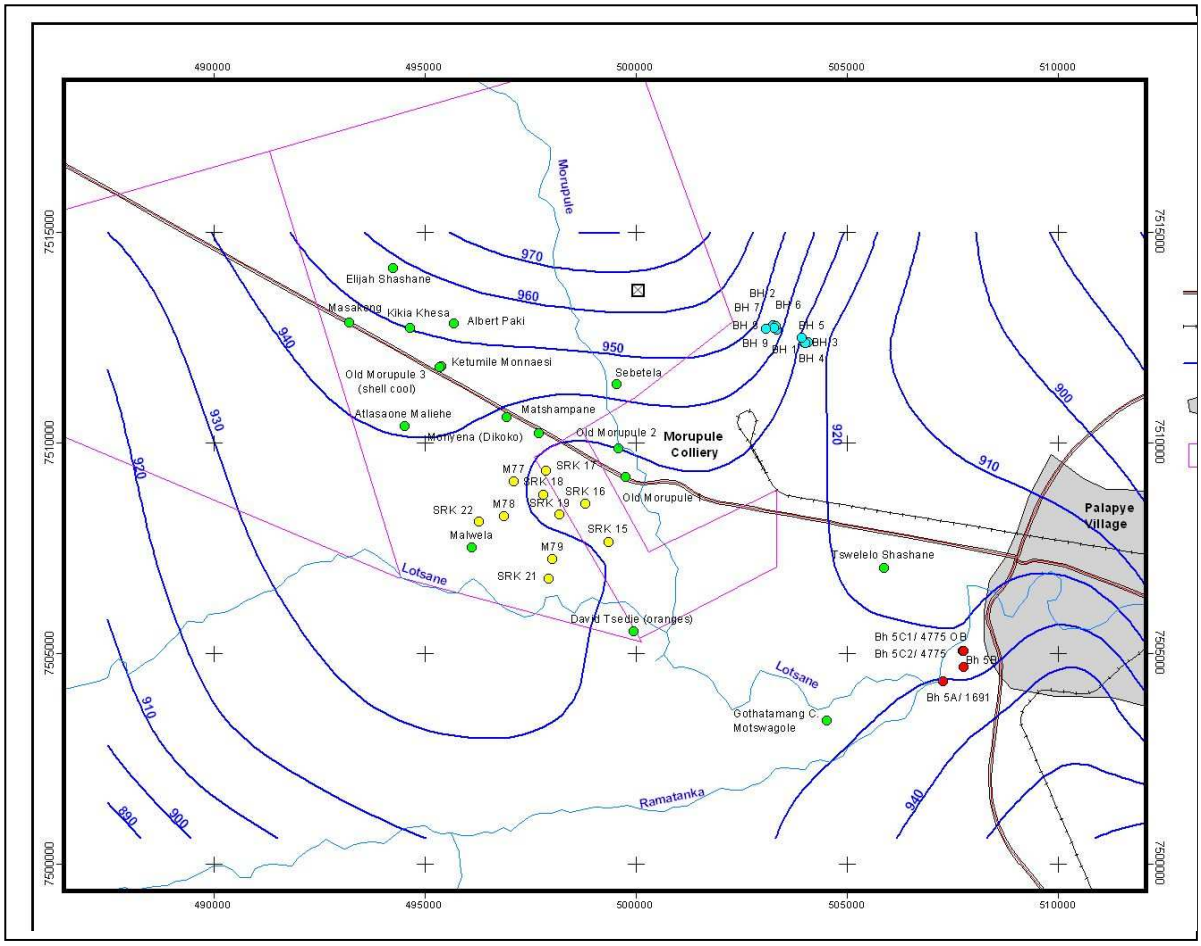


Figure 3 - Piezometric Contours around the Colliery

Additionally a schematic of the groundwater conditions within the Expansion Area has been produced in a geological cross section through the area. This is not strictly to scale as the intention is to highlight key issues and as a result not all the data available was incorporated. This is shown as Figure 4.

What is clear from this is however is that the major coal seams are below groundwater level. The present mining is reported to be at a depth of ~80 - 90 mbgl, and hence working is currently below the regional groundwater level, however few seepage problems are recorded by the mine. However as the mine expands there would appear to be an increase in potential for groundwater to enter new adits via seepages. This is shown in the schematic Figure 4.

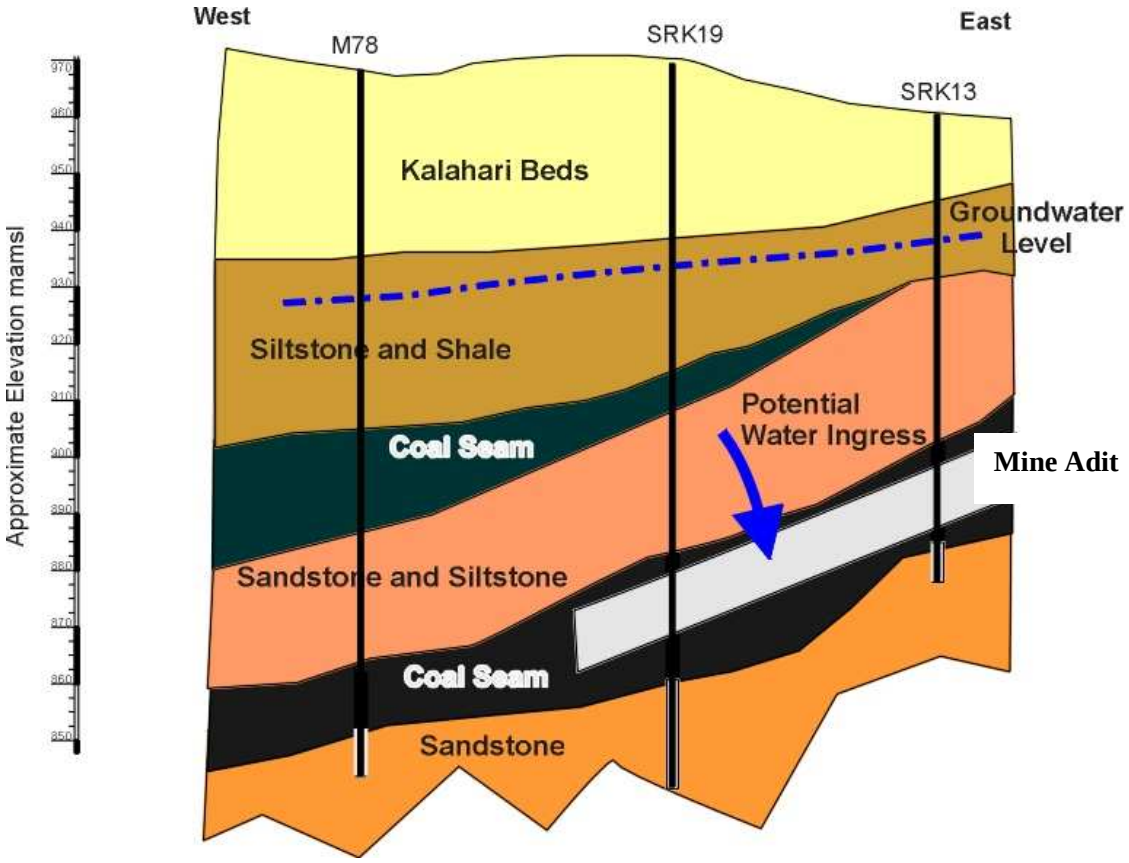


Figure 4 - Schematic of Geology/Hydrogeology through Expansion Area (Corehole Data)

2.7 Water Quality of Aquifers

DWA archive records for the wellfield and older Palapye water supply boreholes located within the village environs indicate a long term degradation in water quality, particularly with respect to NO_3 levels which are undoubtedly induced by human pollution. The high NO_3 indicates that the fractured aquifers of the Palapye Group are highly vulnerable to pollution. Little water quality data was available for boreholes around the Colliery. However what has been established is that the boreholes are compromised by faecal contamination. The water contains significant amounts of Coliforms which are indicators of animal and human waste products. Potentially this is a result of inflow from sewage works and maturation ponds. A large pond, which exists updip from the Colliery Wellfield at the Lotsane Senior Secondary School, may be a potential source of contamination.

2.8 Water Supply and Infrastructure

At present water demand is in the order of 150 - 200 m^3/day. It is understood that this water demand will soon rise to around 480 m^3/day, and then nearly double that (880 m^3/day) in 2010

and to reach a maximum of around 1300 m^3/d in 2015 and thereafter as a result of the expansion development. Thus water will become a scarce and valuable commodity.

At present the resources available to the Colliery are: - a borehole in the village area site, which used to supply the residents and houses in the Village at Morupule, a small wellfield at the Colliery Phuduhudu Wellfield area, at present owned by the Council, dewatering and surface water drainage collection from the mine area and a 'top up' facility from Paje Wellfield provided by BPC. Expansion of these supplies must take place to source any extra water demand. Additionally the infrastructure to deal with increased water supply (and storage) will need to be reassessed.

Current and historic average water supply figures suggest the following:

- ~400 - 500 m^3/month available from on site borehole in the village (BH1) to supply the village although this source is currently off line as a result of potential contamination issues.
- ~3000 - 4000 m^3/month from the Phuduhudu Wellfield (3 boreholes BH5C1, BH5C2 and BH5a)
- ~500 - 1000 m^3/month from the Raw Water top up from BPC (Paje Wellfield) although this figure has been 2,000 + m^3/month, presumably when other sources were down
- Mine drainage and rain water collection (unspecified and irregular)

The total is in the order of 150 m^3/day.

As has been stated the Colliery and associated infrastructure is located on a marginal aquifer (in terms of water yield). Thus any methods by which water resources can be gathered or water demand reduced can only benefit the Colliery as it seeks to find new (and probably costly) water resource areas.

The expansion of the Morupule Colliery to the north and west will require additional shafts and adits. This development will undoubtedly be below the current piezometric level. As such there will likely be an impact on the current groundwater levels. Greater amounts of seepage into the shafts and adits can be expected, as the surface area of rock face open to the adits and shafts in the mine will increase. Although potentially this could cause piezometric drawdowns over the area, it does represent an opportunity for increased water supply to the surface. Clearly the effects of this will need to be monitored very carefully especially with other groundwater users in the area in mind. Clearly there is potential for even the mines own boreholes to be impacted by the development as well as private boreholes off-site within the new mining lease area to be derogated by reductions of groundwater levels as a result of the new mining. Where there is detrimental impact, fair mitigation measures must be enacted to ensure that other users are not disadvantaged. The mechanism for compensation this is discussed further in the mitigation sections below.

2.9 Aquifer Vulnerability

Although the Karoo sequence, particularly the Ntane and Ecca Sandstones, are considered the most valuable and important aquifers in Botswana, at the location of the colliery the Ntane is not present and the Ecca sequence does not contain the most productive sandstone formations available else where in Botswana. Thus the setting cannot be considered a major or particularly valuable aquifer. The vulnerability of an aquifer is therefore considered only medium to low vulnerability. However clearly groundwater is present and this requires evaluation and protection.

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The soil setting (soils of the study area are mainly aeolian, derived from the weathering of the Ntane Sandstone Formation) means that these are moderately to high vulnerability and additionally they do not contain any significant clayey material (or organic material) likely to prevent the downward migration of contaminants particularly biodegradable pollutants. However the depth of Kalahari Beds ~ 20 - 30 m acts as a reasonable protective unsaturated layer to combat pollution migration.

3 POTENTIAL IMPACTS

3.1 Pollution

Pollution is an emotive word and causes a range of reactions. However without leakage, spillage or bad house keeping of any materials on site, there is no potential pollution source material available to migrate from site. So before discussion of potential pollution impacts it is necessary to consider firstly what, if any, potential pollutant sources may result from this type of development or be involved during the process.

Secondly for a pollutant to leave site there must be a pathway along which it can travel. Therefore removing the pathway or route for any contamination to leave the site eliminates the potential risk. Conversely operations or developments, which can open up new pathways, have considerable risk potential.

Pollution Control on site is therefore a key area of importance.

The immediately and apparent pollutant risks on site would appear to be the coal stockpiles, fuel and other chemicals storage, sewage and waste water systems and the general waste stream and resulting waste products on site.

From the Scoping Study the following issues were highlighted as being a potential concern:

- Uncontrolled drainage from the site thus opening up a route for contaminants to leave site in an uncontrolled manner. There is a need to avoid pollution from the site being transported to the Morupule and Lotsane Rivers as well as being lost to groundwater.
- Containment of potentially polluting substances;
- Reuse of treated water/storm run off for processing;
- Potential impact on groundwater from activities at site (stock piling of material causing Acid Leachate Drainage, site drainage, storage of chemicals and fuels, etc).
- Impact on groundwater environment as a result of any both solid and liquid waste streams - these being the sewage systems, the coal wash effluent, and all waste material on site..
- (Note this may have a knock on effect for the need to increase the size or capability of the waste water treatment facility in Palapye).
- Potential impacts during construction works for new buildings, processing etc.
- Potential impacts caused by accidents/spillages on site including chemicals from the new laboratory facilities (planned)..
- Disturbance of soils/unsaturated zone during construction and the possible loss of material through erosion (thus altering the vulnerability setting of the site and possibly the drainage characteristics).
- Impact on existing private boreholes within the lease area and the need to limit any new borehole developments;

Pollution Potential

Any losses occurring from the storage tanks and supply pipe lines are generally not obvious particularly if the tanks are below ground, unless they are so large that discrepancies are noted in stock control. Usually, small differences are put down to evaporation or changes in volume due to temperature differences. Breaks in the supply lines due to passage of heavy vehicles and uneven settlement of the soil will constitute a hazard as will spills occurring when the tanks/planes etc are being refilled.

Thus fuel storage tanks and storage of other materials and chemicals and associated cleaning areas may also pose a risk.

It is uncertain what environmental impacts the mine has already caused since its opening in the 1970's, however the expansion and development will likely increase the size of any impacts already felt and increase the possibility for new impacts.

Protection is the key and this will need to be the case for the new development. At the same time the new development presents an opportunity for improvements in the existing infrastructure and a chance to rethink some of the previously installed pollution prevention measures.

3.2 Fuel/Chemical Storage

In line with the Colliery's own SHE documentation - Fuel and Oil Handling Procedures Document - all tanks containing liquids whose spillage could be harmful to the environment should be bunded.

Bunds should in general:

- be impermeable and resistant to the stored materials
- have no outlet (that is, no drains or taps) and drain to a blind collection point
- have pipework routed within bunded areas with no penetration of contained surfaces
- be designed to catch leaks from tanks or fittings
- have a capacity greater than 110 percent of the largest tank or 25 percent of the total tankage
- be subject to regular visual inspection
- have fill points within the bund where possible or otherwise provide adequate containment

Safety, security, access and maintenance needs must be considered when storing fuels and other chemicals. Clearly it is necessary to minimise the risk of damage caused by accidental impact.

Secondary containment will prevent oil escaping to the environment in the event of leakage from the tank or ancillary equipment. Therefore it is necessary to situate all tanks and their ancillary equipment within an oil tight secondary containment system such as a bund. It is necessary to

consider the potential escape of fuel/chemicals/hydrocarbons beyond the bund area in the event of the tank developing a hole (where a jet of liquid can rise above the bund.) The risk of this can be minimised by:

• keeping the primary container as low as possible;

• increasing the height of the bund wall;

• leaving sufficient space between the tank and bund walls;

• not siting one tank above another;

For steel tanks in open bunds, a minimum distance of 750 mm between the tank and the bund wall and 600 mm between the tank and the base is recommended to allow access for external inspection.

The secondary containment system should be impermeable to oil and water, and there should be no direct outlet.

Ideally, pipework should not pass through the bund wall.

Capacity of Storage

The secondary containment system must provide storage of at least 110% of the tank's maximum capacity. If more than one container is stored, the system must be capable of storing 110% of the biggest container's capacity or 25% of the total tank capacity within the bund, whichever is the greater.

When calculating bund capacity, take account of any volume taken up by tank supports within the bund and consider the volume of any of the primary tank, pipework or pumps.

The 10% margin is intended to take into account a range of factors, including:

• loss of the total contents, for example due to vandalism or an accident;

• sudden tank failure or leaks;

• overfilling;

• containment of fire-fighting agents;

• an allowance for rainwater in the bund.

NB: Research by the Construction Industry Research and Information Association (CIRIA) involving tanks of 25 m^3 or less suggests that, in some circumstances, the 10% safety margin is inadequate to provide protection from loss of oil due to the above factors.

• Storage areas should be located away from sensitive boundaries, for example, adjacent to areas of public use, and should be protected against vandalism.

• Storage areas should be clearly marked and signed plus containers should be clearly labelled.

• The maximum storage capacity of individual tanks should be clearly marked and the contents indicated. Maximum storage should be stated and not exceeded. The maximum storage period for containers should also be specified.

Good Management Practice

An effective system of management is a good technique for ensuring that all appropriate pollution prevention and control techniques are delivered reliably and on an integrated basis. These management policies appear to exist within the Colliery Management Structure. The question is really how strictly these policies are applied and how rigorous is the penalization for non-conformance.

The maintenance system should include auditing of performance against requirements arising from the above and reporting the result of these audits to top management. It is recommended that formal quarterly inspections be carried out at the colliery. The reports should be formally delivered to senior management who would sign for acceptance of it and act upon its findings.

Accidents/incidents

The Colliery's own Fuel and Oil Handling Procedure Document is clear about appropriate actions to take place should there be an accident, spillage or leakage detected.

This states that there should be immediate availability of absorbent material to soak up liquid, although this needs to be enforced and staff made aware. Mobile bunds and booms to help stop surface flow of material over impermeable surfaces or along drains and ditches should also be available. Absorbent socks should be available to place across drainage/storm outlets if the spillages occurs during rainfall. Not withstanding all drainage off site should be channeled through oil separators/inceptors as a matter of routine.

3.3 Stockpiling

It has been reported that new and enlarged stockpile areas for coal will be developed. In the MCL Expansion EIA Support Document – Description of Planned Expansion - it is reported that the new stockpiles will be located on concreted and compacted areas.

These coal stockpiles must have some potential (albeit perhaps limited) to create Acid Leachate Drainage (ALD) (as has been well documented in Europe and America in terms of strategic coal store drainage). Rain water can leach acidic material in the coal which can then mobilise heavy metals present within the rock. Whether there is actually sufficient rainfall in Botswana for this to occur is not certain and the ALD leachability potential of this with regard to the new expansion area is not yet know. However increasing the size of the coal stocks as a result of the development would be likely to amplify any risks posed as a result of ALD.

If, as has been suggested (in the Colliery's own management strategy), the new stockpile areas are to be concreted, then as a consequence the drainage from these must be contained on site probably flowing to a collection sump rather than being allowed to flow off site. This water can then either go through the upgraded treatment works or, if of appropriate quality, be used in the

processing areas where there is reportedly no final effluent produced - all effluent being finally evaporated as a result of the process.

Additionally as a result of the development should larger than presently recorded groundwater seepages be experienced in the mine adits and associated shaft and tunnel network, this water should be tested to see whether Acid Mine Drainage (ie leaching of in situ metals from the mine walls) is occurring so that the appropriate disposal or reuse options can be put in place.

Any seepage drainage can be collected for reuse as process water on the site. This water can be used for coal washing and if, as is stated in the above document quote "The washing plant generates no discard products, and all water (bar surface moisture) is recovered and re-used within the plant – there is no slime or effluent stream" there is no effluent stream from this process to be dealt with. Ideally all 'dirty' water (appropriately treated and fit for purpose) should be recycled as far as possible back into the coal cleaning stream.

Drainage from less contaminating areas of the site should also be contained and stored for reuse, as water will increasingly become a scarce commodity. However this will require the development of large holding areas for surface water run off. Areas like fuelling areas, parking areas for large machinery should have drainage channeled through oil interceptors/separators before being either reused or sent for treatment.

Waste water is currently routed to one main sewage treatment plant at the Colliery area and two smaller maturation ponds at the residential village area. It is reported in the Department of Water Affairs (DWA) Water Quality and Conservation Division Report July 2008 that the main facility is undergoing a P1.7 Million upgrade. If this is the case and there is extra treated effluent available as a result this must be incorporated back into the process water system. The driving force for obtaining a good quality effluent must be that it is of sufficiently good quality for reuse.

The two maturation ponds at the village do not appear to be performing a particularly robust service as it is reported that there are groundwater contamination problems at the village borehole (BH1) which is now out of commission as a result of faecal contamination. Consideration of how the waste stream to these might possibly be integrated into the new upgraded waste water system should be made to potentially produce a larger effluent stream for recycle/reuse.

POTENTIAL IMPACTS

3.4 Physical

Rainwater Harvesting

The Colliery management is to be applauded for the production of the Water Saving Procedure Document. This document details ways that water demand can be reduced, and how water can be collected and reused/recycled. Even the use of 'grey water' is proposed albeit only for landscaping and irrigation. This document must be integrated in the Environmental Management Plan for the Colliery, must be widely dissimilated so that all staff and residents understand it and be rigorously enforced as far as possible. Any new developments offer a great positive environmental impact to be made but these must be well managed and coordinated.

The document refers to Jojos being fitted to new guttering and roof top collection areas. However these tanks must be positioned and plumbed appropriately so that the water can be used and not allowed to merely overspill once full.

Monthly inspections of all rain water and surface water collection and containment facilities must be carried out with the results transmitted to the appropriate high level management.

3.5 Subsidence

As the mining area increases and the number of shafts, tunnels and adits expands, there is greater potential for physical effects to be felt on a regional scale. One of these is subsidence. The Colliery is clearly aware of the potential and currently has subsidence monitoring points which recorded any events.

Although the existing mining area already just extends beneath the Morupule River, the expanded area clearly contains a larger percentage of the river. It is thought likely that the Kalahari and alluvial material within the river feature will be more weathered and probably more porous as a result of surface and groundwater movement along and through it when this ephemeral river is in flow. As a result the material is likely to allow greater groundwater flow. How deep this weathered zone extends downwards is not known. But mining below this weathered zone could potentially open up groundwater flow lines more easily than at the less disturbed areas away from the river corridor. This has two potential impacts. One could be greater subsidence along the line of the river, and two the possibility for greater groundwater seepages in the mine adits. What the impacts of subsidence in the river itself would be is unclear. It is thought likely that any ground disturbance would be countered by sediment transport during the next river flow event. Any hollows produced would probably be quickly filled in and the riverbed levelled back to its original form. Surface water ingress would perhaps be initially higher but the finer, more silty particles in the sediment would fairly quickly help to reseal the surface. It is just a possibility that there could be some enhanced impacts along the line of the river as a result of the mining.

Should significant subsidence be noted in the river, it is suggested that it should be remediated as this subsidence would potentially allow greater water ingress into the shallow groundwater (from surface flows) which would in turn potentially impact the amount of water seeping into the mine workings.

3.6 Regional Groundwater Impacts

Another regional impact of the expanded mining activities is the possibility of causing changes in the regional groundwater level. Several private borehole users are currently within or close to the expansion area. It is possible that changes in water levels will impact on these users. It is recommended that the mine oppose the drilling of new private boreholes in the mine area where possible to restrict the number of potential impact points. Not only will drawdowns in regional levels result in the shallower boreholes not being able to abstract, but these boreholes may intercept coal seams which could be mined out, but also may result in the release of coal bed methane which could be explosive at surface.

4 FINDINGS - IDENTIFIED IMPACTS WITH POTENTIAL MITIGATIONS

The first major conclusion from the study is that the mine is and will be operating in the expansion area below the water table. Several private boreholes exist in and close to the expansion area. Therefore there is the possibility that water levels in these borehole may be impacted by the works below ground level. This may result in derogation of existing users rights of water abstraction. Furthermore there may be implications for regional groundwater levels and this may also lead to potential inflows of water into the mine shaft and adits and possible subsidence issues. These are considered of high significance although they are by no means certain.

Additionally there is potential for the Morupule River to be impacted by subsidence. As it is probable that the alluvial fill in the river is more porous and weathered than the surrounding area, as a result of surface and subsurface flow on the occasions the river has water in it, it does beg the question whether geological disturbance caused by mining below the river will open up pathways for surface water ingress into the mine.

However it is not known what possible mitigation measures can be put in place to reduce this. The only option in the first instance is to monitor the situation so that any changes can be recorded. Since no water level monitoring data is available from the Colliery records, it is recommended that this monitoring start with immediate effect. It is suggested that coreholes already in the ownership of the Colliery should be used as regional groundwater level monitoring boreholes.

The mine already operates a series of subsidence measurement recorders westwards from the site. These do not appear to have detected any significant disturbance as a result of the current mining and these will continue to be monitored and assessed. However it is recommended that the network be expanded particularly along the line of the Morupule River especially when mining starts to take place below the river.

Should any subsidence impacts be noted from the monitoring then repairs to any damage caused must be made. This might include damage to roads, bridges and buildings within the expanded mining area. Severe subsidence along the river might require earthworks to replace and rebuild the bed to its original levels. While this would mitigate any surface damage, it might also reduce potential surface water impacts from the river entering the groundwater and subsequently the mining network and so alleviate future seepage problems below ground.

Table 7 below outlines impacts and potential mitigations with regard to mining below ground level and possible outcomes - both dewatering of the aquifer, seepage into the mine and subsidence issues.

Table 7 - Prediction of Impacts - Mining below Groundwater Level

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Probability*	*Confidence*
Groundwater						
Mining Below Groundwater Levels						
Reduction in Regional Groundwater Levels Impacting Existing Water Users	Negative	Medium	Local	Long Term	Possible	Medium
If impacts detected, other groundwater users rights may be impaired and require compensation						
Impacts for Mine through seepages in workings, etc	Generally Negative - requires pumping	Medium	Local	Long Term	Possible	Medium to Low
Seepage Water in the mine workings can be used for process water	Positive as water resources in the area are scarce	Medium	Regional	Long Term	Possible	Medium
Note - seepage water should be tested for Acid Mine Drainage						
Mitigation Measures Suggested						
Regional Groundwater Monitoring using Colliery's coreholes as piezometers	Potentially Positive if no groundwater impacts detected	High	Regional	Long Term	Necessary	High
Expansion of subsidence network into the expanded mine area (particularly along the Morupule River)	Potentially Positive if none detected	High	Regional	Long Term	Necessary	High
Earthworks in river bed if substantial subsidence noted	Will mitigate any impacts	Medium to Low	Local	Long Term	Possible	Low
Repairs to damage caused by subsidence - reducing surface to groundwater ingress	Potentially positive - reduce groundwater seepage impacts in mine	Medium to Low	Local	Long Term	Possible	Low

It should be noted that there is limited potential for actually monitoring individual private boreholes, as they were not constructed with this requirement in mind (ie there is no dipper access). Therefore only the regional situation can be monitored and the results of that extrapolated to cover the areas of concern.

It should also be noted that many of these concerns are uncertain and have not be detected to date. Increased monitoring of the situation (groundwater levels, subsidence impacts, etc) will decide whether these issues are a cause for concern.

4.1 Waste Water/Contaminated Drainage

The current sewage system is reported to be soon undergoing a major overhaul (P1.7 Million as reported in the DWA Water Quality and Conservation Division Report July 2008). At present the system is unlined and there are assumed to be discharges to groundwater occurring although no monitoring of the groundwater situation local to the ponds is currently carried out. The improved upgraded sewage system would be likely to have greater surface discharge (as the facility will no longer be allowed to discharge to ground) and this effluent, if adequately treated within the upgraded system, is seen as a valuable resource which could be used for processing or other industrial purposes - dust suppression etc.

The impacts on the shallow groundwater resulting from the sewage works should be measured. It is recommended that a monitoring borehole be established down the hydraulic gradient so that any adverse changes in water quality can be detected.

Additionally there are two other maturation ponds, which deal with sewage/waste water from the 'Village' (residential) area. Again the final effluent water is not used and is allowed to evaporate/infiltrate into the ground. This is seen as further wastage of scarce resources. The boreholes which supply this residential area are known to be contaminated with microbiological contaminants and these ponds are potentially the source.

It is felt that during the upgrade of the sewage treatment works at the Colliery consideration be given to improvements of the sewage treatment ponds at the village.

Reference is made to the Colliery's own Water Saving Procedure Document produced by the mine's SHE manager. Where rainwater harvesting or surface drainage can be collected then this water must be made available for processing or dust suppression etc. The necessary infrastructure for the collection and delivery of this captured water must be put in place and properly maintained.

4.2 Contaminated Drainage/Drainage from Stockpiles

At present some areas of the site are designed to capture surface water runoff from rainfall events. However there is little effort made in collecting or controlling drainage from the stockpile areas at present. As discussed in Section 3 these coal stockpiles are likely to have some (possibly limited) potential to create Acid Leachate Drainage (ALD). Whether there is sufficient rainfall in Botswana for this to occur is not certain and the ALD leachability potential of this with regard to the new expansion area is not yet know. However increasing the size of the coal stocks as a result of the development would be likely to amplify any risks posed as a result of ALD.

As a first stage, leachability testing of the new coal reserves could be carried out. If the leachability potential is low or zero, less emphasis can be placed on mitigation measures to combat this risk. However if the tests prove positive, then serious consideration must be placed on the drainage from these areas, far more than is currently carried out.

Although it is not necessarily recommended that the stockpile areas be constructed with an impermeable base (as has been suggested by the Colliery Management), it is suggested that as a minimum a monitoring borehole be drilled down-gradient of the stockpile area into the Kalahari Beds to monitor the quality of any shallow groundwater and thus provide a baseline for groundwater quality. If this borehole can then be monitored and sampled on a regular (quarterly) basis, any changes in groundwater quality or levels as a result of the stockpile area can be recorded and action can be taken accordingly at the appropriate time and at the appropriate level.

However if (as has been suggested in the Colliery's own management strategy) the new stockpile areas are to be concreted, then the drainage from these must be maintained on site and not released in an uncontrolled manner. This water can then either go through the upgraded treatment works or, if of appropriate quality, be used in the processing areas where there is reportedly no final effluent produced - all effluent being finally evaporated as a result of the process.

Additionally should larger groundwater seepages be recorded in the mine network as a result of the expansion, this water should be tested to see whether Acid Mine Drainage is occurring so that the appropriate disposal or reuse options can be put in place.

Table 8 is a summary of impacts from drainage, waste, stockpiles and acid leachate issues.

Table 8 - Summary of Impacts from Drainage/Waste Water

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Probability*	*Confidence*
Groundwater						
Stockpile Areas						
Water Quality Changes due to Acid Leachate Drainage Impacting Existing Water Quality	Negative	Medium	Local	Long Term	Possible	Medium
Can be avoided if stockpile areas are made impermeable	Positive as water can be captured for reuse	Medium	Local	Long Term	High	High
(This will require collection system to be constructed)	If drainage collected and reused - positive					
Can be mitigated by Monitoring using a groundwater monitoring borehole to determine whether there are any impacts	Potentially Positive as Lack of Detection of Impact means this issue is not significant	Medium	Local	Long Term	Necessary	High
Leachability Testing on new coal resources	This will provide the evidence as to whether ALD is an issue					
Waste Water - Impacts on both Surface and Groundwater						
Existing Waste Water Treatment	Negative Allows discharge to groundwater	Medium	Local/ Regional	Long Term	High	High
Upgrading Sewage Treatment - it is reported that this facility is planned for an upgrade	Positive Impact if effluent quality is improved	High	Local	Long Term	High	High
Reuse / Recycling of treated effluent	Further positive impacts if the effluent can be reused					
Rain Water Harvesting and Surface Water Run off						

Collection						
If not controlled - potential for contaminants to be released, soil erosion etc	Potentially slightly Negative	Medium	Local to Medium	Long Term	High	Medium
If controlled, contained and reused	Positive	Medium	Local	Long Term	High	High
If this includes reuse of 'grey water'	Very Positive	High	Local	Long Term	High	High

Water supply for the mine is seen as a critical issue. Every effort must be taken to reuse and recycle as much as possible. This is in line with the Colliery's own policies but must be enforced to a high degree (See Colliery's Water Saving Procedures Document). All new hard standing areas and roofs have potential to collect water. However there will need to be considerable infrastructure put in place to ensure all this water can be used.

Chemical and Fuel Storage

All Chemical and Fuel stores during both temporary (during construction of the new phase of development) and permanent should be subject to the rigorous SHE policies already in place at the mine (Colliery's own Fuel and Oil Handling Procedures Document). Materials, which are capable of absorbing spillages, which can then flow into drains, must be made easily available in case of accident. Additionally oil interceptors/separators should be in place at all discharges of surface water within the drainage system. These interceptors will require regular maintenance otherwise they will cease to operate effectively.

Table 9 is a summary of the impact possible from poor material/fuel storage.

Table 9 - Summary of Impacts from Tanks, Fuels, Oils and Chemical Stores

Impact	*Nature*	*Intensity*	*Extent*	*Duration*	*Probability*	*Confidence*
Groundwater and Surface Water						
Tanks: Fuels, Oils, Chemicals etc						
If spills, leaks, etc occur and are not managed	Negative	Medium	Probably Local	Long Term	Possible	High
With Mitigation: Proper Pollution Prevention Measures - Bunds around Tanks, Accident Equipment and Materials Availability - ie SHE measures enforced	Neutral with Mitigation	Medium	Local	Long Term	Probable	High
Discharge of oily wastes from fuelling areas or chemical stores	Negative if not mitigated	Medium	Local/Regional Could get into the river system which would then be transported larger distances	Long Term	Possible	Medium
Oil Interceptor/Separators on all discharges to surface - where fuels, oils, chemicals are loaded, processed etc. Waste waters to be channeled to new water treatment plant.	Mitigation	Medium	Local	Long Term	Possible	Medium

As a matter of course any flows off site and those to the treatment works must first pass through an oil interceptor/separator. Oily residues on the surface of the treatment works will render the effluent treatment process there far less satisfactory.

5 SUMMARY OF OVERALL FINDINGS

Keys findings are that:

- The aquifer potential in the area is small
- The aquifer although sitting below a relatively high vulnerability soil matrix is in itself not a major resource and only of medium to low vulnerability
- Changes in groundwater levels/heads made be produced due to presence of new shafts and adits.
- There is potential impact on piezometric surface as a result of the development
- This may impact existing private boreholes within and close to the expanded lease area and there is need for the Colliery to limit any new private borehole developments if possible, to ensure that no new compensation claims can be made;
- There is potential impact on groundwater quality from activities at site (stock piling of material, site drainage, storage of chemicals and fuels, etc).
- This needs to be monitored by the use of shallow groundwater monitoring wells.
- Drainage from the site must be well managed and there is a need for containment of potentially polluting substances;
- There is a requirement to contain potential ALD from stockpile areas and if these areas are to concreted provision for drainage collection and reuse on site needs to be made
- There are potential positive impacts during construction works for new buildings, processing etc where additional rain water harvesting of 'clean' water for subsequent use can be introduced
- Water is a scarce commodity at the Colliery and all efforts must be made to reuse, recycle, reduce;
- There is potential for reuse of treated water for processing from the upgraded water treatment works;
- There is a probable need for new/expanded water supply and implications from expanded abstraction at the site and the need for improved water infrastructure. Also protection of those resources currently abstracted on or near site.
- There needs to be provision made for all new site drainage and water collection from expansion of the infrastructure to be interlinked within the water supply system.
- There is the possibility of subsidence, an issue which is already known to the mine. However expansion of the lease area, particularly under the Morupule River may cause greater than expected subsidence. The monitoring network of the Colliery with regard to subsidence must be expanded to match the expansion in the mined area.
- Regional groundwater levels are not currently monitored and may be impacted as a result of this development.
- None of the private boreholes have dipper access for monitoring
- Some exploration coreholes (which have been left open) are actively venting methane gas

- The gas is bubbling through the water thereby providing further evidence that the water is above the methane source (ie the coal).
- Some of these coreholes should be used for monitoring purposes.

6 CONCLUSIONS OF IMPACT STUDY

It appears that there are potentially some significant impacts resulting to ground and surface water as a result of this mine expansion, but the certainty of the extent to which these will occur is not clear. Thus the situation requires carefully monitoring (far more than is currently going on) to assess whether impacts are recorded in future. At this stage mitigation measures can be implemented.

6.1 Mining below groundwater level

The mining below groundwater level, and the possible regional impacts of this, is one main impact, which could negatively affect other groundwater users or the mine itself through leakage/seepage into the mine adits. By monitoring groundwater levels regionally this impact can be assessed. It is uncertain whether the problem can be mitigated as such, as if the mining causes an impact, then it is only the level of impact which can be managed rather than the cause. Should individual users of groundwater have their resource removed by the mining process, then adequate measures will need to be taken to compensate.

Note:

Under the Tribal Land Act (32:02) and Compensation Guidelines for Tribal Areas (2001), where impacts are made on individuals on tribal land in Botswana, such land is governed by land boards under the Tribal Land Act of 1968 (as amended). The Act empowers Landboards to grant rights of use of such land. When Government or a statutory body undertakes a project which is of national or public importance and the only land suitable for that project is already occupied, the President shall determine in accordance with Section 32 of the Act that it is in the public interest that the land be acquired for the project (Tshosha, 1994). When such land or other resource is taken, Section 33 of the Tribal Land Act notes that the Landboard shall grant under the provisions of Part III the occupier of such land a right to use land elsewhere of equivalent value to the land so granted or leased to the State. If the occupier is not granted another piece of land, subsection 2 of Section 33 requires that the occupier shall be entitled to compensation from the State for:

- the value of any standing crops taken over by the state
- the value of any improvements effected to such land (ie the drilling and use of a borehole) the benefits of which enure to the State including the value of any clearing or preparation of land for agricultural or other purposes

For purpose of compensation of persons affected by developmental projects on tribal land, the Department of Lands formulated Compensation Guidelines for Tribal Areas (Department of Lands, 2001). The Guidelines state that the acquiring body shall inform the relevant Land Board of its intention at least six months prior to commencement of the project, both of which shall consult the affected parties. In the event of compensation of land owners/occupiers, the

Guidelines require that the Secretary of the Land Board sets up a Compensation Assessment Committee composed of the following:

- Member of the Land Board (other than Land Board Chairman) – who will chair the committee.
- Land Board Secretary – Secretary
- Acquiring Authority
- Land Officer (Land Use) – Member
- District Agricultural Officer – Member
- Sub Land Board Chairman of the relevant area – Member
- Clerk of the relevant Sub Land Board – Member
- Council Chief Technical Officer – Member
- Land Board Technical Officer – Member
- Land Valuer

The Assessment Committee then carries out a physical inspection of the land recording all the details of all improvements to the land and any other fixed assets affected within the zoned area. The owners/occupiers of the affected land should be present during the inspection or be represented.

6.2 Subsidence

The second main issue is the issue of subsidence, which, like the regional impacts on groundwater, is very uncertain,. It is thought that this is possibly more likely when the mining occurs below the Morupule River as the ground conditions here are likely to be more weathered and disturbed. A consequence of this may be increased subsidence along the river and it is recommended that the subsidence monitoring network is increased close to the river. An additional problem here may be that subsidence will increase the ingress of water from the surface particularly during periods of flow which might then have a knock on effect underground with potential for increased groundwater seepage in the mine adits.

The mitigation suggested would be to monitor this carefully and have material available to rework the river bed if necessary which could then act as a seal to avoid the potential for surface water ingress. However if serious subsidence does take place, then there could be regional impacts on roads, bridges or buildings within or close to the expansion area. These might require either repair or financial compensation if serious.

6.3 Contaminant Transport

The other main issues relate to potential pollution aspects and the movement of potential contaminants and other materials off site together the positive potential impact created by the reuse/recycling of effluent/drainage/collected rainfall etc.

Positive impacts can be made if waste water or mine seepage can be used to reduce reliance on other local water resources for use as processing water and if water reductions can be made by awareness campaigns (and the use of the existing SHE Policies Water Awareness Procedure Document) then further positive gains for the environment can be obtained.

Drainage from the coal stockpiles could potentially result in ALD. This could increase the risk of increased concentrations of heavy metals and other cations being released and must be avoided. There must be no release of uncontrolled drainage from the stockpile areas.

This can be approached in two was. Either the ground and surface water must be monitored (by the use of monitoring boreholes) to assess whether an impact is being caused, or the drainage must be completely contained on site - ie having an impermeable surface - which is the approach proposed by the Colliery in their outline document on managing the coal resources. The advantage of this second method is that increased collection of scarce water resources can take place and this water (if of appropriate quality) can be then used as process water in the coal washing plant from which there is no final effluent to dispose of (the moisture having been removed ultimately by evaporation). If water is not of suitable quality then it must be channeled into the new upgraded effluent treatment plant being proposed.

6.4 Water Reuse/Recycling

Water is scarce in the local area. The aquifer is low yielding and BPC (at the Morupule Power Station next door to the Colliery) have to pump water for their turbines from a wellfield over 50 kilometres away. Therefore even greater emphasis must be placed on reducing water demand and recycling and reusing water.

This is in line with the Colliery's own thinking and they have produced a Water Saving Procedure Document. This should be rigorously enforced. However also there are options available from the site which can help the situation. Some of these are even mitigation measures against other potential issues.

The upgrading of the sewage treatment works should ensure that there is firstly no continued discharge to groundwater through the base of the currently unlined ponds, and secondly should ensure that the treated effluent is suitable for use on the site as process water.

However as far as possible all site drainage should be considered for reuse. Some of this will come from areas which have potential to contaminate - fueling areas, fuel, oil and chemical stores, stockpile areas, etc. All this drainage should be passed through the effluent treatment plant as far as possible to ensure that the final recycled water is as clean as possible. Furthermore

potentially oily drainage should pass through oil separators/interceptors to remove surface oils and hydrocarbons.

Table 10 outlines the consequences and significance of all impacts identified both with and without mitigation.

Table 10 - Consequences and Significance of Impacts

Impact	*Consequence*	*Probability*	*Significance*	*Confidence*
Reduction in Groundwater Levels as a result of mining	Medium	Possible	Medium	Medium
Mitigation: **Groundwater Levels to be monitored to ensure other users do not lose their existing resource (Note: Not possible to monitor other users directly as boreholes not accessible for dipping)**	**This will give a high confidence in whether impacts are occurring.**			
Mitigation **If groundwater levels are reduced, other users may have their water resource removed**	**There will need to be compensation agreed**			
Increased Seepages into Mine Adits and Shafts	Small to Medium	Possible	Medium	Medium
Mitigation: **Monitoring and the installation of pumping equipment**	**(Positive impact if the waste water can be used on site)**			
Water quality may be poor	**Water will need to be tested to see if acid mine drainage is occurring**			
Drainage off site of contaminants - Stockpile area. Potential Groundwater Contamination due to acid leachate drainage	Medium	Probable	Medium	Medium
Mitigation: - Concrete Surface and collect drainage for reuse in the plant	**Positive Gain if water can be reused/recycled**			
Alternatively monitor groundwater for any impacts on groundwater quality	**Not a true mitigation but gives a scale of any problem which then allows the appropriate clean up required**			
Groundwater Pollution due to spillage, leakage from oil/fuel tanks etc	Medium	Possible	Low	Medium
With Mitigation - correct surfacing and bunding - in line with the Colliery's own Fuel and Oils Handling Documentation	**Low**	**Improbable**	**Low**	**High**
New Sewage Treatment Works	High and Positive	Probable	High	High

If the new treatment works produce good quality effluent then this can be reused and results in less potential contaminant moving off site.				
All site drainage from 'dirty' areas to be channeled through treatment plant. Additionally if possible sewage from village area also treated				
Necessary Mitigation - monitoring borehole to measure any improvement	**Medium**	**Possible**	**Low**	**High**
All other drainage needs controls on discharge - ie oil inceptors and absorbent material to be available to deal with problems, spills, leaks, accidents etc.				
Water Resource issues for the Colliery There is likely to be a lack of available water resources for the Colliery in the future	High	Certain	High	High
All surface run off and roof drainage to be collected and contained for reuse at mine for processing **This is in line with the Colliery's own long term objectives and their Water Saving Documentation**	**High Positive**	**Certain**	**High**	**High**
Use of waste water from sewage treatment (maturation ponds) for Processing	High - Positive	Possible	High	Medium
Reduction of Water Use as per Water Saving Policy	Medium Positive	Possible	Medium	Low
Needs a great deal of effort and education to make Staff aware of the need to save water				

7 ENVIRONMENTAL MANAGEMENT PLAN

7.1 Construction Phase

Impact	Objective/ Target	Management Principle	Performance Indicator	Responsibility	Resources (Personnel)	Resources (Equipt & Materials)	Estimated Costs	Timing/ Deadline
Regional Groundwater Levels	Measure changes and impacts in groundwater levels	• This is to mitigate against claims made by private borehole owners that they have been derogated by the mining activity	Change in depth (downwards) in the long term.	Mine staff	H/Geologist	Groundwater level Dipper	P3000 for equipment and a visit each month	Immediate and Ongoing (monthly)
Spills - Oils, Fuels, etc	Mitigate by Bunding Areas Self contained drainage - not off site	• This is ensure fuel and oil loading areas during construction do not leak or spill in to the environment	Inspection of facilities and oil inceptors	Mine staff	Technician	Visual check		Ongoing Monthly checks
Waste Water treatment upgrade	Groundwater monitoring of quality impacts	• To ensure that the new upgraded effluent treatment plant has a positive improvement on groundwater	Change in water quality	Mine staff	H/Geologist	Sampling and analysis of water samples	Quarterly samples - P400 each	Once borehole has been drilled.

It is recommended that the groundwater monitoring borehole(s) to monitor the success or otherwise of the upgrade of the sewage treatment works be drilled as soon as possible to provide background information on water quality. It is further recommended that baseline regional groundwater level recording (monthly) should start as soon as possible when suitable coreholes are identified.

7.2 Operation Phase

Impact	Objective/ Target	Management Principle	Performance Indicator	Responsibility	Resources (Personnel)	Resources (Equipt & Materials)	Estimated Costs	Deadline
Regional Groundwater Levels	Measure changes and impacts in groundwater levels	• This is to mitigate against claims made by private borehole owners that they have been derogated by the mining activity	Change downwards in the long term.	Mine staff	H/Geologist	Groundwater level Dipper	P3000 for equipment and a visit each month	Immediate and Ongoing (montlhly)
Subsidence	Expand subsidence monitoring network	• This is to mitigate against claims for damage caused by subsidence and also safeguard the mine from potential collapses and groundwater ingress into the mine as a result of geological disturbance	Any subsidence impacts however small	Mine staff	Mine management	Subsidence monitoring equipment	Mine already have a network of monitoring points. These just need to be expanded	As soon as mining goes into the new area, these must be in place
New Stockpile area - if not having impermeable cover	Monitor quality of groundwater if no site drainage system is constructed	• To ensure that potential impacts from ALD do not compromise groundwater quality Drilling groundwater monitoring point(s) to be able to sample to see if any impacts as a result of the stockpiles	Water quality monitoring of borehole drilled down gradient of stockpile	Mine staff	H/Geologist	Sampling and analysis of water samples	Quarterly samples - P400 each	Once borehole has been drilled. (monthly)
New Stockpile area - if impermeable cover	Ensure that all drainage is self contained - with positive recycling/ reuse of water	• Water Conservation and pollution prevention. -	No surface water discharge from contained area Ensure that drainage collected is returned for reuse. -	Mine Staff	Technician	Visual check	A visit once a week	Weekly - once construction phase is completed
Waste Water treatment	Groundwater monitoring of	• To ensure that the new upgraded effluent treatment plant has a positive	Change in water quality	Mine staff	H/Geologist	Sampling and analysis	Quarterly samples -	Once borehole has

Impact	Objective/ Target	Management Principle	Performance Indicator	Responsibility	Resources (Personnel)	Resources (Equipt & Materials)	Estimated Costs	Deadline
upgrade	quality impacts	improvement on groundwater				of water samples	P400 each	been drilled.
Fuels Oils etc	No uncontrolled drainage off site -	• Oil Interceptor/Separators on all drainage from Fuel, Oil stores	Oil Separators to be managed on regular basis. If oil smear observed trouble shot problem back	Mine Staff	Technician	Visual check		Weekly
Rainwater harvesting and surface run off collection	Reduce water supply needs by capturing all available surface water and roof water	• See - Colliery's own Water Saving Documentation Reduce reliance on outside water sources	Weekly inspection during rainy season.	Mine staff	Technician	Visual check with written report to senior management		Weekly

It is recommended that if the new stockpile area is not going to be built with an impermeable base the groundwater monitoring borehole(s) to monitor water quality be drilled as soon as possible. The borehole for monitoring success of the upgrade of the sewage treatment works should continue to be assessed for water quality changes. The baseline regional groundwater level recording should continue (monthly). If the stockpile area drainage is contained then there must not be release to surface water. This water must be collected in a sump and returned to the plant for treatment/reuse. This can be checked by a technician on a weekly basis. Similarly all new water collection and rain water harvesting measures require checks to ensure that resources are being used and not allowed to overspill. This could be carried out by a technician on a weekly basis but should result in a (paper?) report to higher management.

7.3 Decommissioning and Closure

Impact	Objective/ Target	Management Principle	Performance Indicator	Responsibility	Resources (Personnel)	Resources (Equipt & Materials)	Estimated Costs	Deadline
Regional Groundwater Levels	Measure changes and impacts in groundwater levels	• This is to mitigate against claims made by private borehole owners that they have been derogated by the mining activity	Any change downwards in the long term.	Mine staff	H/Geologist!	Groundwater level Dipper		6 monthly
Groundwater monitoring - water quality	Measure long term impacts of water quality around site	• After all waste streams (any waste water effluent) or stockpiles have ceased usage, monitoring should continue on a less frequent basis for five years at which time if all trends are neutral or positive they can discontinue.	Any upward trend in water quality	Mine Staff	Mine staff	Water sampling and analysis		6 monthly
Subsidence	Expand subsidence monitoring network to cover entire lease area	• This is to mitigate against claims for damage caused by subsidence and also safeguard the mine from potential collapses and groundwater ingress into the mine as a result of geological disturbance	Any subsidence impacts however small	Mine staff	Mine management	Subsidence monitoring equipment		6 monthly

Long term levels of monitoring need to continue after closure of the mine until a stable situation is achieved.

Long term evaluation of groundwater levels, groundwater quality and subsidence effects will need to continue after closure until stability and equilibrium is achieved. This monitoring is recommended to continue for five years after closure but need not be done so frequently. It is recommended that all records are carried out on a six monthly basis. If at the end of the five year period no significant impacts have been noted since closure, then monitoring can cease.

8 APPENDIX II: FLOOD RISK REPORT

1 INTRODUCTION

Under the Strategic Groundwater Partnership (SGTP) Contract Number HO-SCM-C002312 Revised, Debswana Mining Company (Jwaneng Mine) commissioned Water Surveys Botswana Pty Ltd to undertake a surface water flood risk study around the Morupule Colliery site near Palapye as part of the ongoing rehabilitation project. A site location plan is presented as Figure 1.

2 PROJECT OBJECTIVES

The objective of the study was to review rainfall and, assess the potential for surface flow and hence flood risks for the mine site and in particular for the shaft. To achieve this goal the following work was undertaken:

- Satellite imagery was used to assess the wider catchment area
- The site plan made available from Debswana was integrated into the satellite imagery data (Shuttle Radar Topography Mission)
- Ground contours were evaluated
- Soils were assessed
- Interpretation of slopes and catchments
- Evaluation/quantification of surface water run off
- Reporting.

3 BACKGROUND

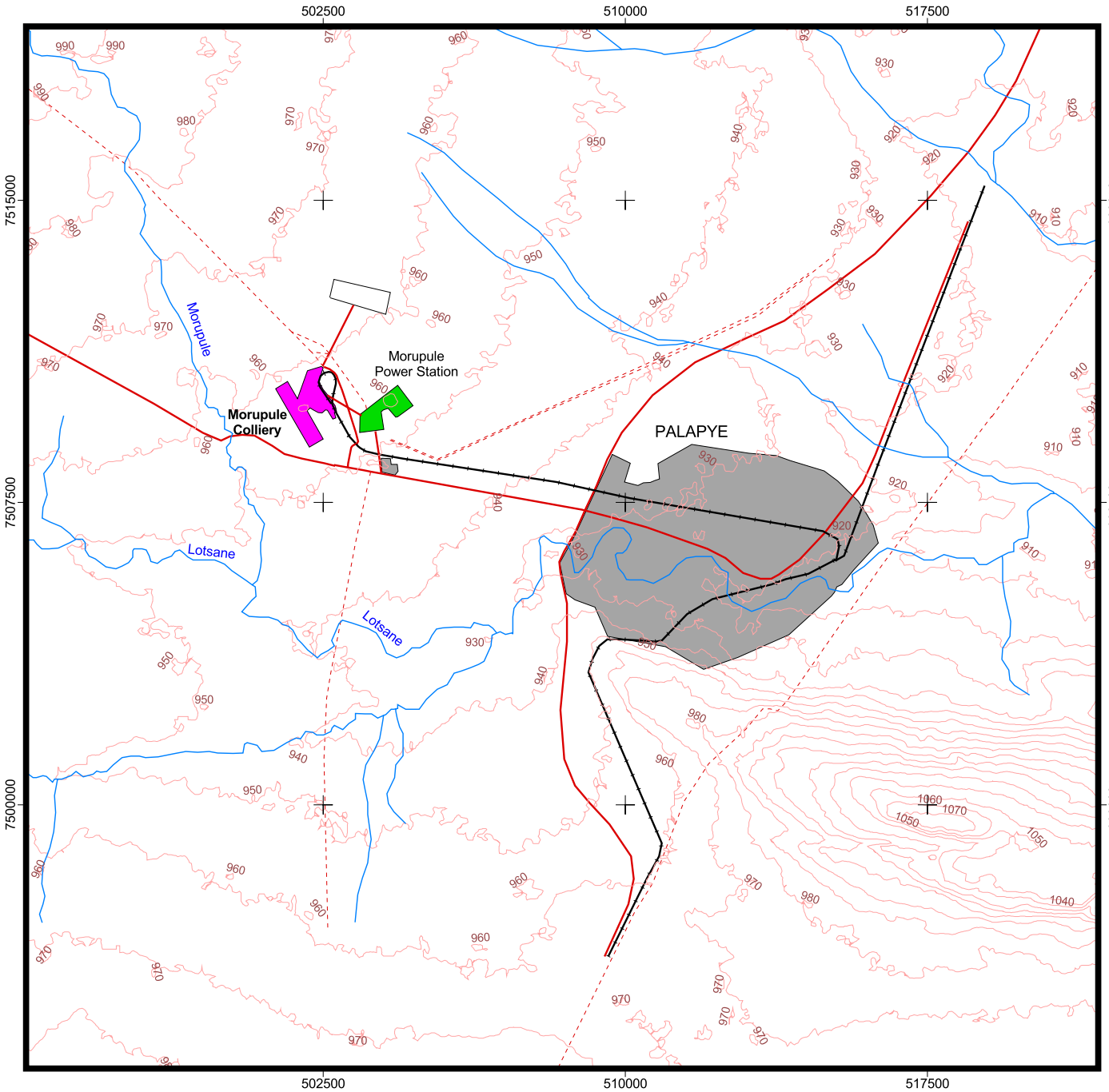
Morupule colliery lies within the Lotsane River catchment area (Figure 1), which is characterised by very gently rolling flat plains. The colliery surface lies at a ground elevation of between 950 - 960 mamsl. The topographic gradient is southeast sloping towards Palapye, which is approximately 5 kilometres from the Power Station. The ephemeral Lotsane River (incised 2 - 3 m below the surrounding land) is the major river in the area and drains from west to east, rising at the Serowe escarpment some 30 km west of the Power Plant. The Morupule River, a tributary of the Lotsane River, drains from north to south and is located some three kilometres west of the power plant and colliery site. The relatively deeply incised nature of the Lotsane suggests little contribution to flow from the surrounding area. The main flow is a result of drainage from the Serowe escarpment.

The soils in the study area mainly comprise of aeolian sands, derived from the weathering of the Ntane Sandstone Formation. The Ntane Sandstone outcrop forms the majority of the escarpment slope west of Serowe village 30 kilometres to the west of the Power Station. They are mainly orange coloured, fine-grained sandy silty loams (1990 Ministry of Agriculture FAO/BOT/85/011). The dominant soil types within the area of the colliery are Ferralic Arenosols and Arenic Ferric Luvisols (<3% clay), whereas southwards along the axis of the Lotsane River Calcaric Cambisols and Orthic Luvisols predominate.

A geotechnical report by Schwartz Tromp and Associates (2007) for the development of the new Morupule B Power Station confirms the soil as "Dry, orange brown blotched off white, loose to medium dense, porous, fine sand. The aeolian sands become more medium grained with depth to about 4 metres, generally underlain by a calcrete/ferricrete layer". The soils are well to very well drained, and consequently do not retain any significant moisture. As a result there do not seem to be any associated lines of drainage around the colliery or the surrounding areas other than the more deeply incised Lotsane and Morupule Rivers.

Having visited the Lotsane River it is hard to imagine any flood risk posed by flow in the river as its elevation is so below the elevation of the surrounding areas.

LOCATION MAP OF MORUPULE COLLIERY



Scale 1 : 150,000

5 0 5 Kilometers

N

Projection: UTM Zone 35 S, WGS 84 Datum

Data Source

Roads, rivers, built-up areas: Digitised from 1998 Landsat ETM Satellite Image. Contours: Interpolated from SRTM elevation data.

LEGEND

- Road
- Railway
- Track
- River
- 1000 Contour (meter)
- Morupule Colliery
- Morupule Power Station
- Built-up area

DEBSWANA

FIGURE : 1

Water Surveys Botswana

AERIAL IMAGE OF MORUPULE COLLIERY

NOTE

This image was obtained from Google Earth and georeferenced. On the Image, Morupule Colliery and Morupule Power Station are clearly visible and their related infrastructure such as roads and the railway. From this image, the area of the mine likely to contribute to surface water runoff was estimated.

DEBSWANA

FIGURE : 2

Water Surveys Botswana (Pty) Ltd

Projection: UTM Zone 35 South
WGS 84 Datum

Scale 1 : 15,000

500 0 500 Meters

N

4 METHODOLOGY

The CAD drawing provided by Debswana was assessed and is presented in Figure 3. It contained raster images of contours but only few spot heights that could be extracted. Interestingly the values of the spot heights did not seem to correlate very well with the calculated contours. However the national elevation data set (the SRTM (Shuttle Radar Topography Mission) data from NASA) was used to assess a larger area around the site. The contours from the site plan were useful in tying in the SRTM. Figure 4 shows the overlay of the STRM and the site plan.

From this figure it was possible to estimate the likely catchment area which potentially could provide flow to the mine. Although this task was somewhat subjective it did at least allow a 'quantifiable' estimate to be made. The resulting potential catchment is shown in Figure 4 along with potential overland flow lines that were made to help estimate this area. It was assumed that the area down gradient of the mineshaft entrance could not contribute to flow. As alluded to above the cut off distance from the mine might be considered rather arbitrary but bearing in mind the very sandy nature of the soils, and its flatness, it has been considered to probably represent a worst case.

Flood Prediction Methods

The rational method for calculating surface water runoff was then used. Mulvaney, Kuichling and Lloyd - Davis are credited with the empirical formula which is generally recognised as slightly overestimating peak flow runoff, but without previous flood records and flow events is the only feasible method. The basic formula used was:

$$Q = 0.278\ C\ I\ A$$

(Where:

Q = flow m^3/s

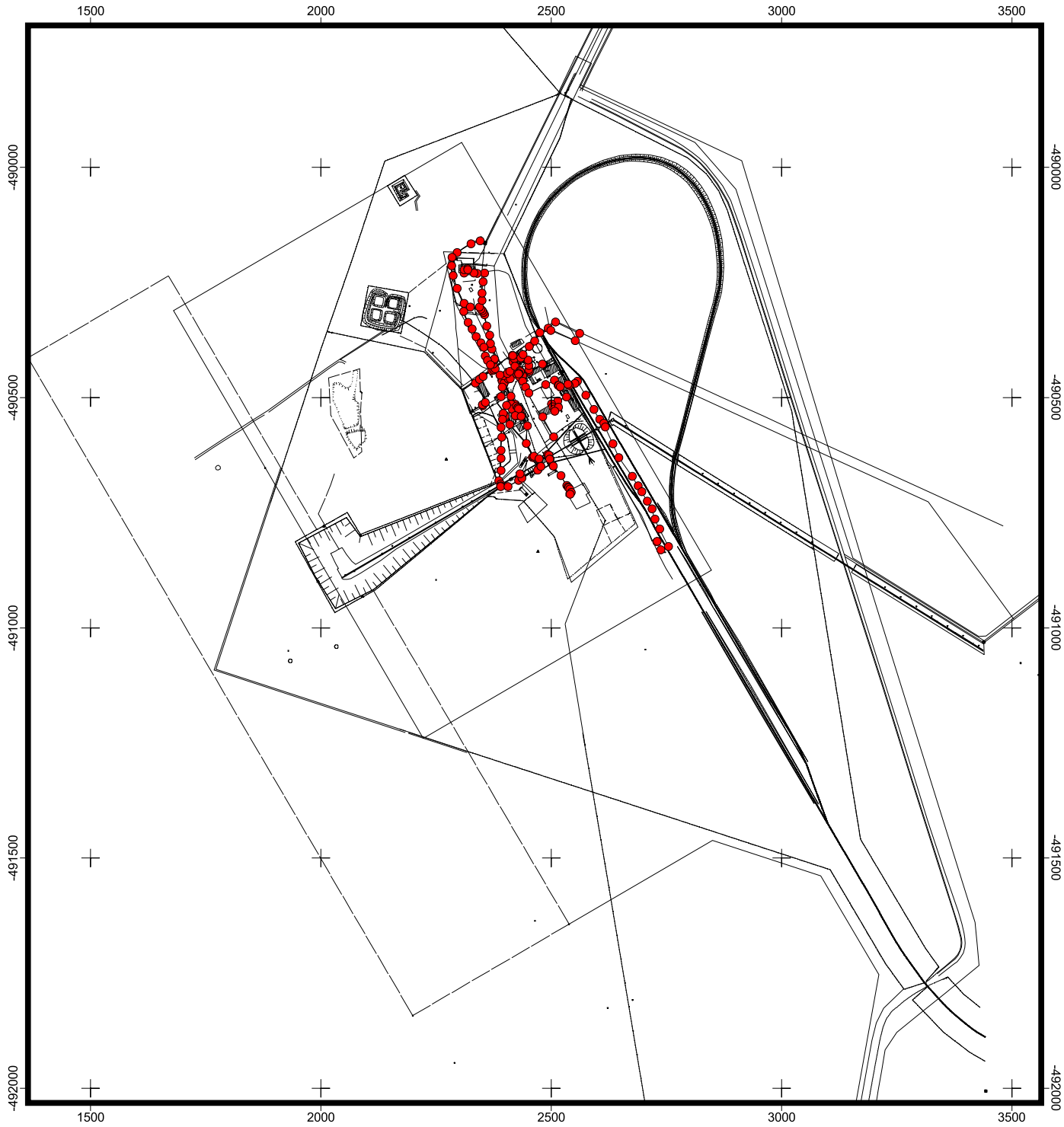
C (volumetric run off coefficient) = 0.05 sand to 0.95 urban

I = rainfall intensity mm/hr

A = area in km^2)

It was calculated that the maximum total area of catchment that could flow towards the shaft area was in the order of 2 km^2. Using rainfall intensity figures for Palapye (See Figure 6 below), taken from the BNWMPR 2005, which indicate a one hour 42 mm/hr intensity rainfall with a 20 year return period (representing a realistic return period of storm to protect against), the resulting peak runoff from this catchment was calculated as being in the order of 1 - 2 m^3/s. This assumes that the run off coefficient is in the order of 0.05 - 0.1 as indicated in Table 1. (Ref: LMNO Engineering).

MORUPULE COLLIERY LAYOUT



Scale 1 : 12,500

500 0 500 Meters

N

Co-ordinate System: LO 27

Data Source

Morupule Colliery layout: Debswana

LEGEND

Spotheight

Colliery layout

DEBSWANA

FIGURE : 3

Water Surveys Botswana

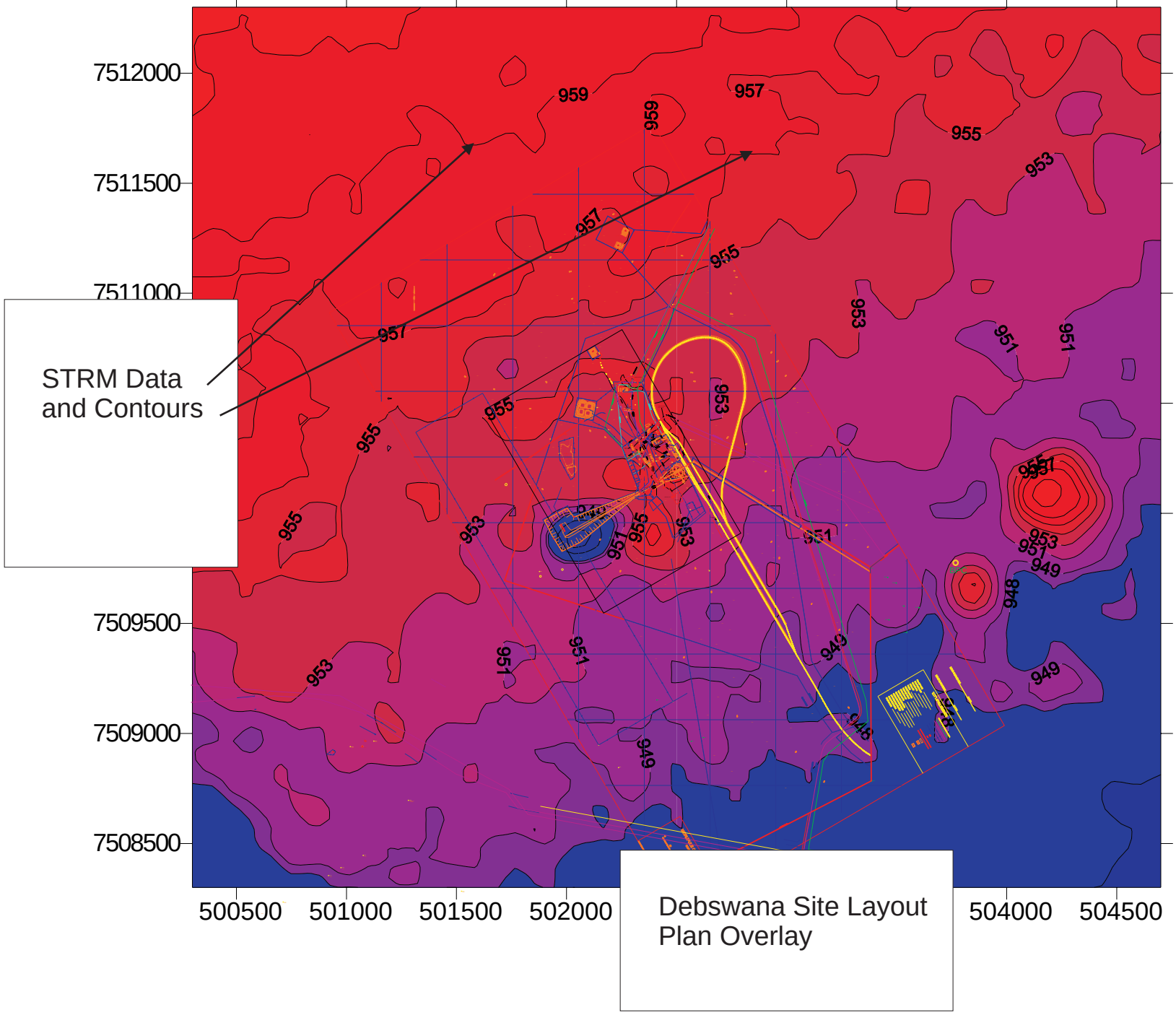


Figure 4 - Shuttle Radar Topographic Mission Data with Site Plan Overlay

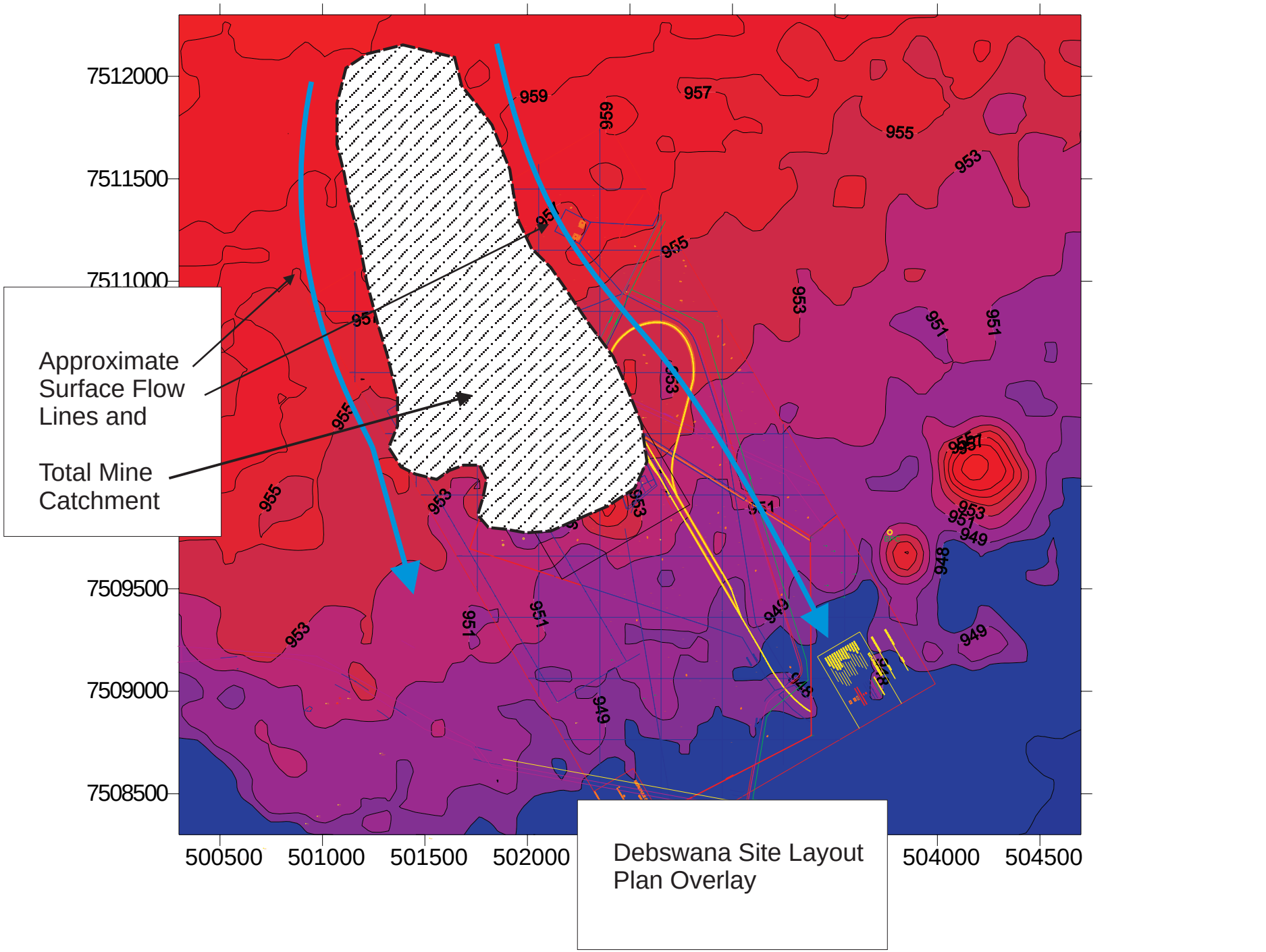


Figure 5 - Shuttle Radar Topography with Mine Catchment

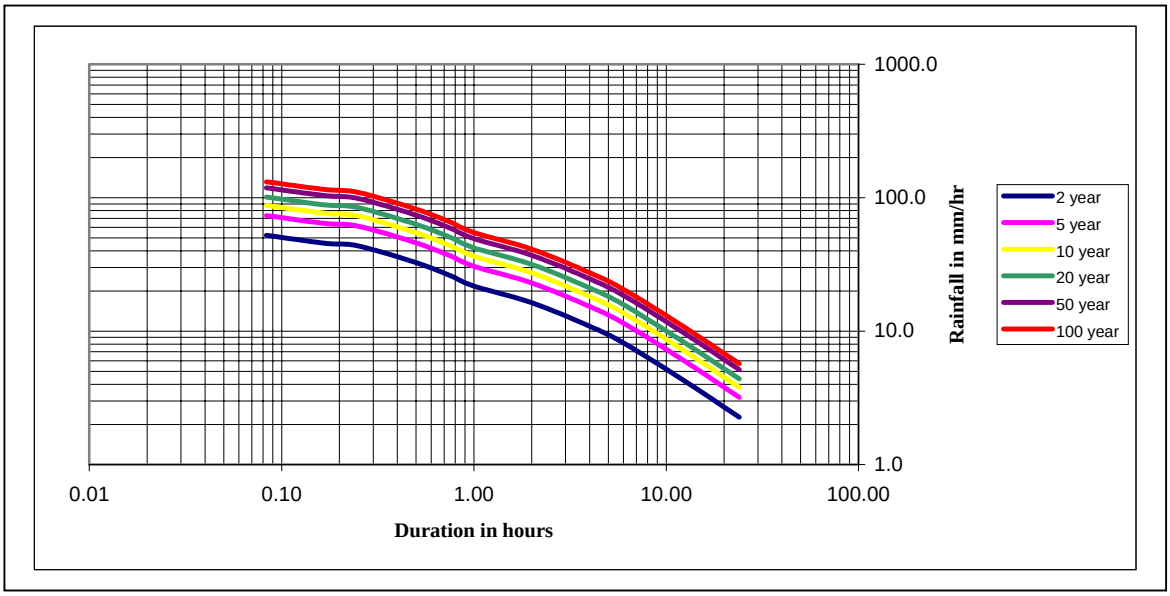


Figure 6 - Rainfall Intensity for Palapye - *Source - Volume 3 Surface Water - BNWMPR 2006*

Table 1 - Simplified Table of Rational Method Runoff Coefficients

Ground Cover	**Runoff Coefficient, c**
Sand	0.05 - 0.1
Lawn	0.05 - 0.35
Forest	0.05 - 0.25
Cultivated land	0.08-0.41
Meadow	0.1 - 0.5
Unimproved areas	0.1 - 0.3
Pasture	0.12 - 0.62
Residential areas	0.3 - 0.75
Business areas	0.5 - 0.95
Industrial areas	0.5 - 0.9
Asphalt streets	0.7 - 0.95
Brick streets	0.7 - 0.85
Roofs	0.75 - 0.95
Concrete streets	0.7 - 0.95

Source: www.lmnoeng.com/Hydrology/rational.htm

For the actual mine area, which had been estimated to be 0.2 km^2 in area, the likely run off coefficient will be much higher as there is much more hard standing, asphalt roadways etc. The value used here was 0.75. Thus the same storm would cause flows of around 2 m^3/s just from this area. Thus a worst-case estimate would be total flows in the order of 3 - 4 m^3/s in total. Although the entrance to the mineshaft is bunded to prevent surface water ingress, a 'bleak' worst case assessment might be that half of this flow water could potentially be diverted into towards the roadway into the mine. An estimate from the site plan gives the width of the roadway slope into the shaft as ~85 m, thus assuming a slope into the shaft of between 1:10 and 1:100, this flow would result in a depth of flow of between 3 and 7 cm (Mannings Number taken as 0.02).

(Mannings Equation Q (Flow) = 1/Mannings Number (n) x Wetted Area $^{5/3}$ /Wetted Perimeter $^{2/3}$ x Slope $^{1/2}$)

The half hour 1 in 50 return year period storm has an intensity of 99 mm/hr (for half an hour). Using this figure the flows above increase to around 6 - 8 m^3/s.

From a regional perspective, the natural slope in the area is in the order of 0.003 (10 m in 3 km), this would provide a surge depth of around 5 - 10 cm for a 1 in 20 year storm. Taking a far worse case - 1 in 50 year half hour storm (rainfall intensity 99 mm/hr), falling on the mine area results in a flow depth of ~20 cm.

The area of the inward sloping shaft zone is estimated as 0.03 km^2. Rainfall into this area will flow directly towards the shaft. Taking a run off coefficient of between 0.5 - 0.75 for the area (quite high to simulate very worse case), and the 1 in 50 year half hour storm, the surge flow is in the order of 0.4 - 0.6 m^3/s. For the one in 20 year storm the flow is 0.2 - 0.25 m^3/s. Thus the dewatering pumps should in the short term be able to pump some where in the order of these quantities to ensure complete protection. However these are very much worst-case scenarios of very short term storm events and provided some short term sump storage is available, it is probable that smaller pumps would be able to deal with these events.

5 CONCLUSIONS

The total regional surface water run off flow expected from a 1 in 20 year return period calculated using the 'rational method' is in the order of 2 to 4 m^3/s. To ensure that flow does not enter the shaft then drainage away from the area must be able to accommodate this.

To fully protect the mine in the case of a one in fifty year 1 hour flood, there would need to be a continuous bund around the shaft entrance to delay a surge of around 20 cm of flood water and the drainage culverts should be capable of removing around 4 - 6 m^3/s. The dewatering pumps in the mine shaft should be capable of pumping around 0.2 m^3/s to ensure complete protection against a one in twenty year return storm.

APPENDIX 4: ARCHAEOLOGICAL IMPACT ASSESSMENT

Prepared by

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(ARMS)

ARCHAEOLOGICAL IMPACT ASSESSMENT FOR THE MORUPULE COLLIERY EXPANSION PROJECT

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June 2008

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APPENDICES

1.0. Introduction

This is an Archaeological Impact Assessment (AIA) report prepared by Archaeological Resources Management Services (ARMS) as part of an Environmental Impact Assessment (EIA) prepared by Ecosurv Environmental Consultants. This is in connection with the proposed expansion of the Morupule colliery lease area.

The primary objective of the Archaeological Impact study was to identify all possible project activities that will have impact on cultural and historical resources. The study was undertaken through an intensive field survey of the proposed project area. Existing literature in and around the proposed project area was also consulted and or reviewed as a way of finding whether there are any archaeological or historical sites recorded within the proposed project area.

2.0. Legal Framework (EIA and AIA legislations)

Archaeological and historical constituents have continuously played a fundamental role in addressing many questions in our contemporary societies and such constituents have helped to investigate and divulge the full extent of the human past. Therefore it is imperative to protect and conserve the archaeological and historical resources that we have while on the other hand guided by the environmental legal entities whose mandate relate to the general preservation and sustainable use of natural resources. These legal entities include the following:

2.1. Environmental Impact Assessment Act of 2005

The mandate of the above is to foster national development planning principles and emphasis on the role of natural resources. It is in this regard that all developmental interventions are required by the Act to carry out an Environmental Impact Assessment to assess the potential effects of “planned developmental activities; to determine and to provide mitigation measures for impacts of such activities as may have a significant adverse impact on the environment; to put in place a monitoring process and evaluation of the environmental impacts of implemented activities; and to provide for matters incidental to the foregoing.”(EIA Act, 2005)

2.2. Monuments and Relics Act 2001 (As amended)

This act endeavours to continually preserve and ensure a sustained use of Historical, cultural and Archaeological resources, the Government of Botswana through the Botswana National Museum has established some legal compulsions to be met prior to any developmental intervention that will affect the natural setting. This is as laid out in the Monument and Relics Act, (2001, as amended) of the laws of Botswana, of which Section 18 of the Act prohibits any

alteration, damage or removal from original site of any national monument, relic or recent artefact.

In realising the fact that it may not be possible to save all archaeological remains amidst the ever-rising needs of developments in contemporary societies, the same Act, in section 19 provides for salvage work. Of note is the fact that mitigation and salvage work can only be carried out by an individual of recognized credentials. It is therefore in the interest of the Act to rally round developments to take the right cultural context in all the proposed areas. The objective of archaeological impact assessment must lie in the identification of sites and this must inform a generation of mitigation strategies, which should zero in the care of archaeological and other heritage resources. Where archaeological sites are encountered within the proposed areas of development, mitigation will be recommended in consonance with the National Museum guidelines, which are as follows:

1= Preserve at all costs
2= Preserve if possible, otherwise extensive salvage work
3= Test excavation to determine whether further work is required
4= Systematic representative sampling
5= No further archaeological work

3.0. Literature Review

Existing documents containing information relevant to the project areas were consulted for background overview of the areas concerned. Such background information entails historical and archaeological overview of the project areas and its surroundings.

3.1. Brief historical background

The Ngwato tribe is the most dominant tribe in Central District of Botswana. They were probably an ancient section of the Kwena, a tribe that was well known for their skills in mining, smelting and refining of metal ore. Ngwato is credited to have found the clan in 1500's and the clan remained a section of the Kgabo- Kwena (Kwena Sechele) chiefdom until the late 1700's when the Lesele- Khurutshe led the Ngwato to the Shoshong hills. The Khurutshe were the first Kwena cluster to dominate part of the Central District. The first independent Ngwato Kgosi was Mathiba, followed by his two sons who caused the group to split due to disputes on inheritance of chieftainship. Kgama won and Tawana and his followers retired to Boteti and finally Ngamiland, where he founded the Tawana chiefdom. Mathiba followed his favourite son Tawana, but was spurned and returned to the Shoshong hills. After being rejected also by Kgama, he committed suicide in 1795 (Parsons 1973; Schapera 1953, 1970; Tlou & Campbell 2003).

In the 18th Century during the Defacane wars, the Ngwato community was small and weak and was mostly seen in highly mobile clans in a large poor territory. Khama fled to Selolwane and Meojaneng north of Serowe. In 1817 Khama died and his son Kgari inherited a reconsolidated Ngwato clan (Parsons 1973; Schapera 1970). Kgari integrated smaller groups into his clan and reigned until 1828.

During the other series of the Defacane wars the Ngwato were dispersed by the Kololo and Ndebele. Kgari's son Sekgoma I regrouped the tribe, he conquered and expelled the Kaa from Shoshong in 1849. This is where the sovereign Ngwato state started. Sekgoma ruled from 1835 and in 1899 he gave to his son Khama II. The Ngwato by then had covered the entire present Central District. (Parsons 1973, Schapera, 1970).

The Ngwato decided to abscond Shoshong for Phalatswe north to the side of Tswapong hills due to depletion of the land in the area, this is when they were under the reign of Khama III (Parsons 1998). Phalatswe was Khama's favorable place particularly that it became his alliance together with the British movement, against the Amandebele (Parsons, 1998).

3.2. Archaeological background

The cultural environment in Southern Africa is divided into the Stone Age, the Iron Age and the historical period. This particular rough and temporal division associates in the following order; Stone Age followed by the Iron Age and then the historical period. The division is based primarily on the technologies used. The Stone Age which characterizes the hunter-gatherer lifestyle is identified in the archaeological record through stone; being the primary raw material used to make tools. During the Iron Age period, people used their skills to work with iron and other metals and their lifestyle is represented in the archaeological record as agricultural practitioners; that is both animal husbandry and crop production. Also, the lifestyle of the Iron Age people is associated with kinships and civilization, which are indicative of complex social hierarchy. Moreover, the historical period is marked by the advent of writing; in particular the first European travelers brought these. (Mitchell, 2002)

On a larger scale, intensive archaeological work has been conducted mostly in the eastern margin of Botswana. Stone Age studies have been conducted in southern and eastern Botswana where there is high quality of stones. For example, Bosutswe prehistoric people exploited chert, as it was indigenous to their area. Cooke 1979 argues that the first stone tools in Botswana were recorded in 1930, while systematic collections were initiated by Wayland in 1943. Weedman (1992) analyzed African localities including Bosutswe and Mmadipodi. He argues that lithics in Botswana are multifaceted in technology and that the lithic demonstrate trade and exchange across Kalahari Desert.

Many researches that have been conducted in the Palapye locality have yielded some historic and cultural sites including Toutswemogala, old Palapye, Moremi gorge conservation area and other many Bosutswe type-sites. Toutswemogala lies about 30km North West of Palapye near Topisi. It is one of the large settlements, which were built on hilltops in Botswana. The site has undergone excavations and various cultural materials were found. The Toutswe tradition is associated with the domination of livestock and evidence of large cattle herds (Lane, 1998).

Moremi gorge conservation area is about 32 km east of Palapye along the Northern edge of the Tswapong Hills. This area might have been occupied by the Bapedi who might have arrived in the Tswapong area just before the Matebele incursions around 1830 (White 2001). The spiritual ancestors are believed to be living in the Manonnye gorge. Some other sites in the vicinity of Palapye include Majojo, some royal cemeteries in Serowe, Lotsane ruins, Malaka waterfalls and old Palapye. Old Palapye was the capital of Bamangwato from 1889-1902. Settlement patterns at this site have demonstrated division between the Africans and Europeans. Scholars collected artifacts and demonstrated that settlements around the towns were clustered into ward structures (Lane 1998, Mathibidi 1996).

There are about 400 Toutswe type-sites that were identified by Denbow and these sites are associated with the Toutswe tradition. Toutswe fits into the prehistoric socio political phases of southern Africa. It has been occupied for over ten centuries and has the longest sequence of periods thus ranging from Early Stone Age (ESA) to Late Iron Age (LIA). Bosutswe site was occupied from 700AD-1700AD with a continuous settlement sequence in terms of stratigraphy, probably having been occupied by the same people.

Denbow (1993) argues that occupation of Bosutswe from AD 700-1700 has ideological and economic implications about cattle farming. Evidence of vitrified cow dung due to high cattle farming demonstrates social differentiation from AD 700-1100.The name Galesupjwe or Bosutswe define the symbolic and cosmological meaning of the site. Thebe (2004) is of the view that the site is important as it represents the voice of the under class or minority in prehistory and how they have contributed to development of the country. He adds that this is because there is evidence of san and Kalanga heritage at the site. The good archaeological evidence at most of Bosutswe sites are in forms of animal kraals and burials.

A number of Archeological Impact Assessments have been conducted in the Palapye locality. These were in relation to developments including those for borrow pit at Majwanaadiphiri, expansion of the Morupule Colliery, Palapye Serule road rehabilitation, proposed University of Science and technology, proposed airport, Morupule Power Station expansion and proposed borrow pit for Palapye internal roads. The study of these archival materials has shown that

the study area is rich in archaeological materials though the deep sands tend to cover most of the archaeological materials.

4.0. Project description

The Morupule Colliery site is located in the Central District of Botswana approximately 300 km north of the capital city, Gaborone and some eight kilometres north-west of Palapye towards Serowe. The Morupule Colliery Limited (MCL), a subsidiary of Debswana Diamond Company (Pty) Ltd has been operating a coal mine since 1973 and is currently producing 1 million tonnes of coal per annum. The coalfield is immense and contains good quality coal, with the estimated overall coal resources exceeding 12 billion tonnes. Production has increased steadily over the years from 145 000 tonnes per annum in 1973 to a total of 985 000 tonnes of coal mined and 964 000 tonnes sold in 2005.

The Botswana Power Corporation (BPC), which operates a coal-fired power station nearby has been the main consumer of the MCL coal, consuming about 66 % of the MCL annual production. Other major industries supplied by the MCL mine include a copper mine in Selebi Phikwe, Botswana Ash Plant in Sowa Pan, Botswana Meat Commission, Botswana Breweries, Foods Botswana, Makoro Bricks, and two retail coal distributors. In addition, the mine also supplies graded coal to Zimbabwe, Zambia and the Democratic Republic of Congo.

The colliery now proposes to expand its coal production from 1 million tonnes per annum to 12 million tonnes per annum. The purpose of this expansion is to

- Cater for an increase in power generating capacity at the Botswana Power Corporation (coal-fired) power station site at Morupule. BPC recognised that they will not be able to meet future power demand for the country specifically after 2007 when Eskom, the main exporter of power to BPC, is expected to run out of surplus power to export. The power increase is expected to be 600 MW for phase 1, and 600 MW for phase 2, together with the current 132 MW of generating capacity. The coal required to meet these requirements has been established as 5.8 million tons per annum.
- Produce beneficiated coal that has been processed through washing plants, for the local coal market and for export (2.7m tons of beneficiated coal).
- Produce unbeneficiated coal of power station grade coal to existing and new customers (3.5 million tons per annum).

The colliery has been given the authority by the BPC board to proceed with the planning and preparations aimed at ensuring adequate supply of coal to generate 600 MW for the phase 1 and the current 132 MW. Confirmation from BPC for the second phase is still pending.

Activities planned for the proposed expansion project and which are covered under the environmental impact assessment include;

- Development of the existing shaft production capability from one continuous miner section to four, i.e. upgrading from 1 million tonne to 4 million tonnes.
- Construction of another incline shaft with twelve continuous miner sections some 4.5 km to the North of the existing shaft.
- Replacement of the surface screening and crushing facilities at the existing location
- Addition of a coal wash plant
- Construction of new workshops and offices
- Construction of new housing units at Morupule Village

Figure 1: Location of the Project

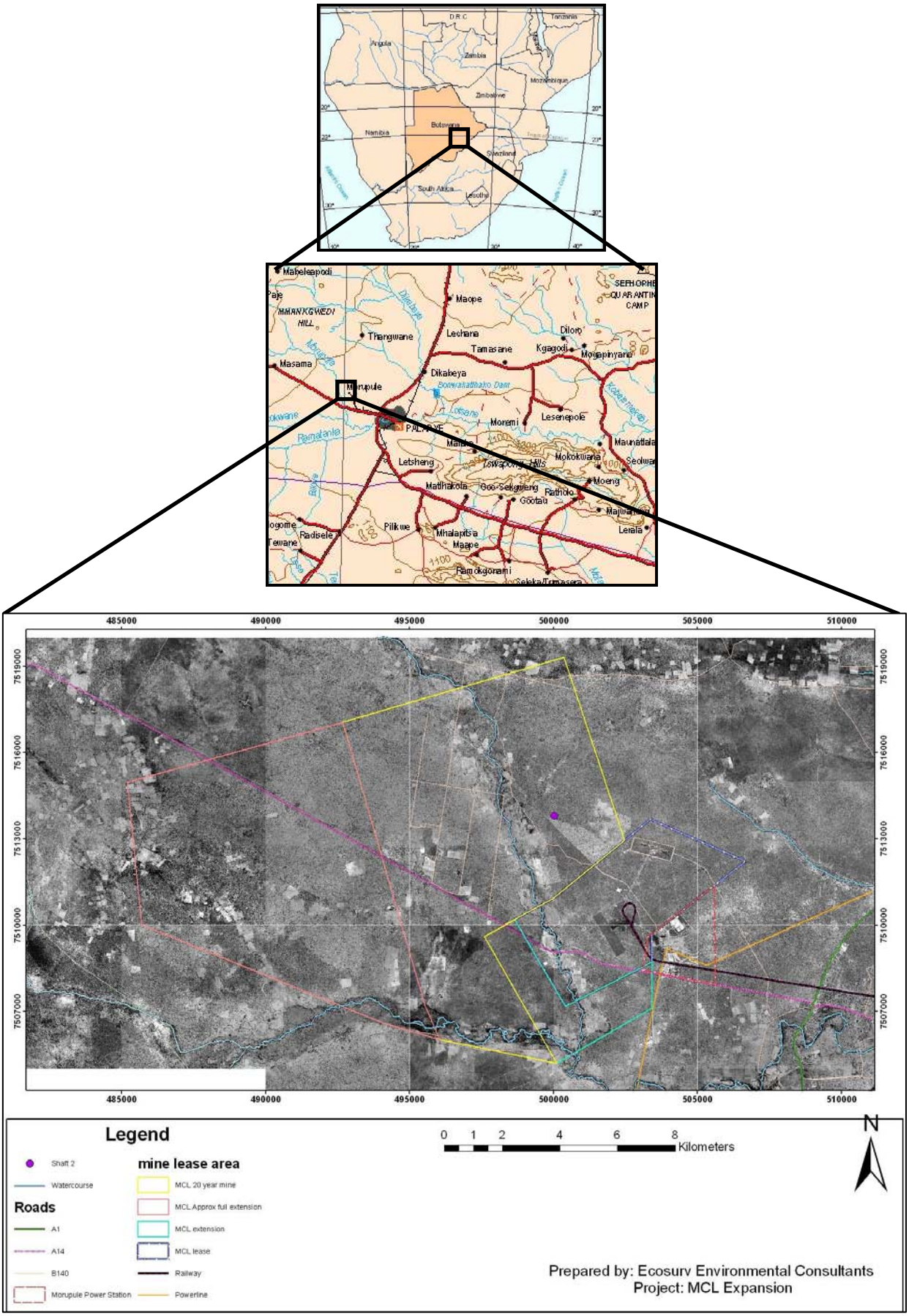
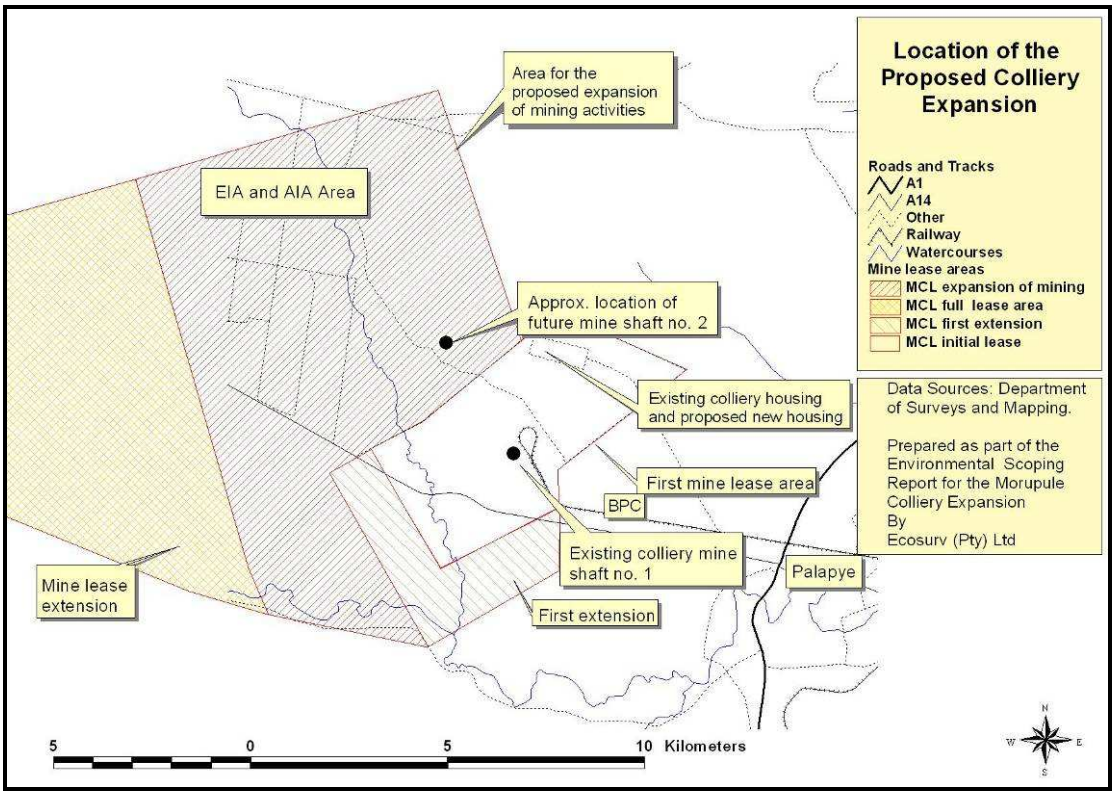


Figure 2: Showing location of lease areas and some developments relating to the expansion



The mining surface plant, infrastructure and housing are at pre-feasibility stage. If the project goes ahead, construction of the mine will begin in the year 2009-2013 and the mine will be operated for twenty years. The proposed activities will be decommissioned in the year 2050.

5.0. Survey methodology

An intensive desktop study was conducted through the use of various information sources pertaining to the proposed project area to establish the historical, cultural and archaeological background of the area. Publications consulted covered the biophysical environment, topography, and vegetation. Amongst the various sources consulted, the National Museum library, National Museum Site database (old and new) and the National archives and records substantiated the study. Previous Archaeological Impact Assessment reports were also consulted as some developments around the area have been subjected to Archaeological Impact Assessments.

Table 1: Archaeological sites in the vicinity of the project area as outlined in the National Museum Sites database

Site No.	Type	Location	Name
27-C1-1	Toutswe	194 E 070 N	Naboom Hill
27-C1-2	Toutswe	245 E 056 N	N\A
27-C1-3	Toutswe	103 E 030 N	N\A
27-C1-4	Stone Age\ Toutswe	185 E 926 N	Ikotwe Hill
27-C1-5	Middle Stone Age	020 E 709 N	Ramherwane Hill
27-C1-6	Middle Stone Age	016 E 509 N	N\A
27-C1-7	Iron Age\ Toutswe	101 E 539 N	Khurumela Hill
27-C1-8	Historic	Palapye	Postal tree
27-C1-9	Toutswe	019 E 879 N	Ramherwane Hill
27-C1-10	19th Century	2233 83.4S\2708 83.6E	Malekakopu Hill
27-C1-11	19th Century	224323.9S\270115.9E	N\A
27-C1-12	Iron Age	749 2700E\524600N	East of Lecheng
27-C1-13	Iron Age	0525300E\7493300N	Lecheng South East
27-C1-14	Iron Age	0525500E\7493400N	N\A
27-C1-15	Iron Age	052400E\7493100N	West of Lecheng
27-C1-16	Early Stone Age	0508937E\7505076N	Palapye
27-C1-17	Early Stone Age	0511051E\7506125N	Palapye

Foot surveys were conducted by a team of 4 people in an approximate 100m transects covering the assessed area in an east-west and north-south directions. Site locations were recorded with a Garmin e-Trex Venture GPS (datum -UTM WGS84) instrument. Topographic maps were used to locate and record sites. Interviews aiming at soliciting information on the location of archaeological and historical sites and public views on the issue of loss of historic heritage were also conducted. Field investigations were concentrated in the area designated for the expansion of the mine lease area and its associated activities.

These are as follows:

- **Mining:** shaft 2 which will be located 4.5 km to the North of the existing shaft where Coal will be mined using the underground mining (bord and pillar) methods
- **Screening and Crushing Facilities:** The existing facilities will be replaced
- **Coal Wash Plant:** An additional coal wash plant will be constructed which will be 4 times the existing one (in terms of capacity). This will be located near the existing plant.
- **Housing:** A number of houses will be constructed at the village to accommodate senior personnel involved in the operation of the proposed mine.
- **Other Support Infrastructure:** Other necessary infrastructure include;
    - New workshops and offices within the plant. The plant area covers an area of 34 ha;
    - Administration office block to be erected in the vicinity of the existing administration offices;
    - Various 11 kV distribution power lines to distribute power from the substation to plant areas where power is required;
    - Internal water pipelines;
    - Storm water capture systems;
    - New access roads;
    - Expansion of the existing railway link to allow increased levels of coal transport from the mine to the main railway line; and
    - Fully equipped laboratory to perform washability tests on the products of the washing plants.
    - Conveyors

Table 2: List of interviewed informants

Names	Date of Birth	Knowledge of any Cultural/Archaeological areas
G. S. Nyangane	1940	Burials within his farm
Mr K. Olebogeng	1920	None
G.Kukama	-	Burials
T. Oabile	-	Burials
B.M. Marumo	1952	Burials
M.Setshogo	1940	None
S. Makgaritha	1963	None
G.O. Tanyala	-	Burials
T.Tau	1939	None
P. Maphosa	1945	None
T. Moeng	1957	Burials
S. Moalodi	1940	None
O. Molaodi	1948	None
S.Ramaphane	1936	None
G.Ogopotse	1945	None
G. Olebeng	1952	None
S.Dintwa	1951	None

6.0. Survey Results and Discussion

It is essential to outline and discuss the findings of this archaeological investigation. The focus of the archaeological investigation was mainly within the major areas earmarked for the Morupule Mine expansion project. As mentioned earlier, the proposed project areas were systematically walked to assess the probability of archaeological, cultural and/or historical heritage sites. However, it should be noted that not much was encountered within and around the project areas.

The field assessment results were accustomed to the Botswana National Museum's standardized system of grading archaeological sites with regard to their level of importance in relation to the likely development impacts.

The following details describe sites grading system as espoused by the Botswana National Museum:

1 = Preserve at all costs

2 = Preserve if possible, otherwise extensive salvage work,

3 = Test excavation to determine whether further work is necessary,

4 = Systematic representative sampling sufficient

5 = No further archaeological work required

In this regard, the system is used to evaluate archaeological sites encountered within the proposed development area. On that note, some possible archaeological sites were encountered within the Morupule Mine extension areas.

The Morupule mine lease area is largely occupied by agriculturalists practicing both pastoral and arable farming systems. Nonetheless, some archaeological sites were encountered within the lease area during the archaeological investigations. The following sites were encountered during the survey.

MCL 1

Location GPS: 500116S 7509941E

Artefacts: Pottery fragments. Animals burrow stratigraphy and undecorated ceramics were identified. The artefacts were brought to the surface by burrowing animals and are inferred to originate from a sub surface level which may exceed below to the depth, about a metre in relation to the present day surface.

Period: Iron Age

Level of importance: 3

Recommendation: Given the level of importance of the site, it is recommended that there be some test excavation to assess the stratigraphical assemblages of the sites. The stratigraphy gave an impression that the anthropic layer may be expected at approximately 20-50 cm below the present day surface. Two (2) man days are allocated for the test excavations at this site.

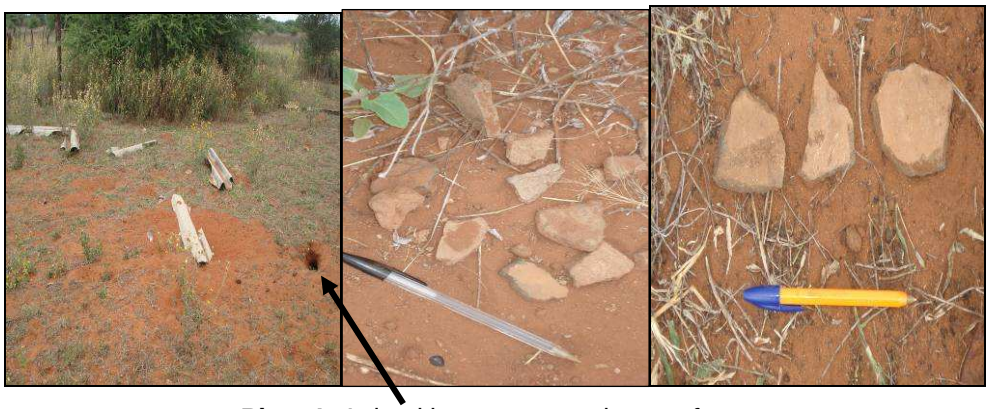


Plate 1: Animal burrows exposing artefacts

MCL 2

GPS Location: 500516S 7506548E

Artefacts: Decorated and undecorated pottery, faunal remains (bones)

Period: Iron Age

Level of importance: 3

Associated midden deposits characterized by burrowing animal activities that have exposed mostly a concentration of undecorated ceramic fragments. Of particular note at this site was a beaker or bowl shaped sherd and some few decorated fragments of pottery.

The decorations for the pottery are mainly confined to the neck of the vessel and the rim. The potsherds are decorated with surface decorations, especially the use of incisions.

Also visible in this site were bones, some stones that might have been used for burnishing during pot making or for house floor burnishing stones. Other residential remains are expected beyond the midden area and towards the outer perimeter of the site. The site is rated 3 and test excavation should be carried out to see if further work is needed. This work is allotted two (2) man days.

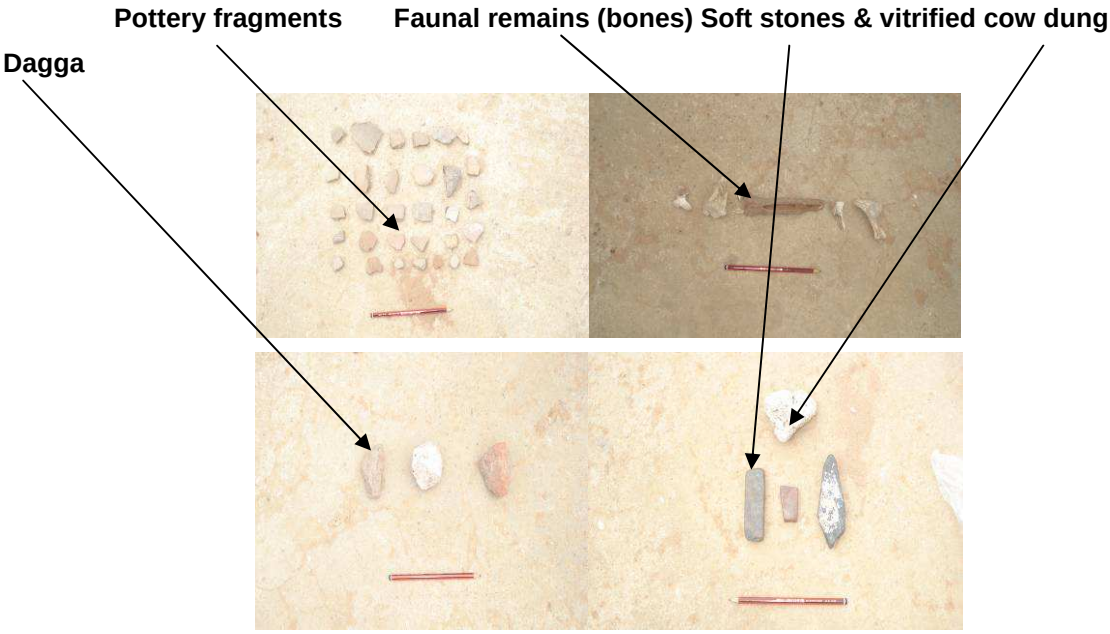


Plate 2: Artefacts found at MCL 2

MCL 3

GPS Location: 485449S 7515092E

Artefacts: Flakes of different sizes were encountered in an area along the stream. These flakes could have been brought by running water as the area is eroded.

Period: Middle Stone Age

Level of importance: 4

Recommendations: None, except monitoring as the main project activities are going to be underground.

Plate 3: Flakes at site

MCL 4

GPS Location: 500227S 7215583E

Artefacts: Ceramic sherds

Period: Iron Age

Level of importance: 3

Recommendations: Site characterized by an approximate 50m in diameter clearing in the natural vegetation. A high density of ceramic sherds were identified primarily representative of Tswana/Ngwato occupation. Looking through the stratigraphy exposed by burrowing animals, more remains may be expected underground. This is also due to the deep soils found within the area. The site is rated 3 and test excavations should be carried out to see if further work is needed. Further work is allotted 2 man days at this site.

Plate 4: Animal burrows exposing artefacts

MCL_5

GPS Location: 485439S 7515533E

Artefacts: Situated along the stream or a non perennial river was a site characterised by general feature consisting of Stone Age tools from various materials, probably the materials is indigenous to the area. The feature gives an expression that secures an expected Middle and late Stone Age presence in the palaeolandscape. Some bits of pottery were also visible within this locality. The direct association of the artefacts with a vital life source in the landscape (find's proximity to water source) may be of relevance; however the finds might have been brought by agents of erosion to the area.

Period: Middle Stone Age, Late Stone Age and Iron Age

Level of importance: 5

Recommendations: The artefacts suggest the presence of stone tool usage and a possible post occupation of the Iron Age people in the general area. The site is assigned rate number 5; no archaeological work required as the samples collected are representative enough.

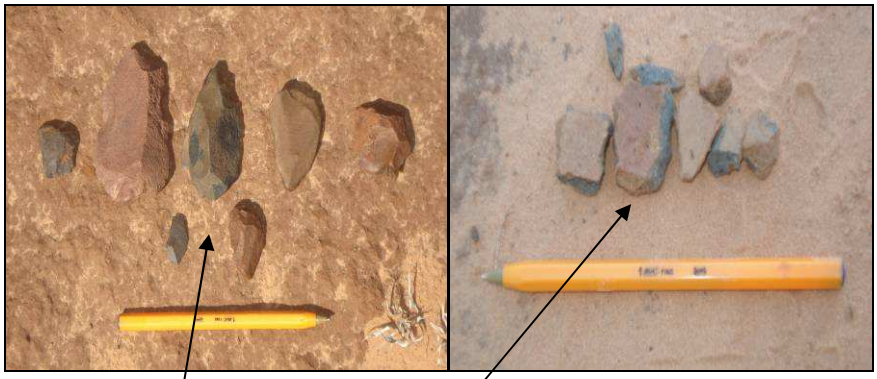


Plate 5: Stone Age artefacts and Iron Age artefacts occurring in the same locality

MCL-6

GPS Location: 501070S 7508521E, 500871S 7508425E

Archaeological/Cultural finds: Some burials were mentioned to be within the project area. Ms Boitumelo Marumo gave information regarding these burials. She was aware of some graves associated with the area though she only pointed to a general location. About 9 people whose names were not provided were buried. These are within an agricultural land allocated to Ms Sennye Makgaritlha. Some two infant burials were also identified together with other two burials that were identified in an agricultural land. The informant was not very sure when these were buried however it was inferred to the 1970's. The burials are for Rratsatsi and Mmatsatsi.

Period: Historical

Level of importance: 1

Recommendations: The burials should be preserved by any means possible. Monitoring during any development associated with the mine developments towards these burials is highly recommended.

The site is rated 1. Fencing may be necessary otherwise an arrangement for reburial may be made if impacts cannot be avoidable.

Plate 6: Ms. Boitumelo Marumo pointing at one of the burial locations

MCL-7

GPS Location: 500907S 7508556E

Archaeological finds: Burials

Another infant burial was also spotted closely towards the river (indicated by the yellow paper).The child might have been buried within a hut as the hut floor was still visible. This burial is located within the first mine lease area but on the southern part of the road from Palapye to Serowe.

Period: Historical

Level of importance: 1

Recommendations: This burial site should be preserved where possible. Monitoring during any development associated with the mine developments towards these burials is recommended. The site is rated 1 and fencing may be necessary otherwise an arrangement for reburial if impacts on these burials cannot be avoided.

Plate 7: Location of one of the burials

MCL-8

GPS Location: 496829S 7507078E

Archaeological/Cultural finds: Burials

Some other burials spotted around the area were those for Maria, Kukama and Makhurutshe. These burials fall within the twenty years mine lease area and may be impacted by the mine activities. These are located within the land for Mosamarea Seporogane. As per the information given by Goitsemang Kukama, these were probably buried towards the end of year 1975.

Period: Historical

Level of importance: 1

Recommendations: On the basis that burials play a very significant spiritual role in human culture, it is recommended herein that the site be preserved by any means possible. Monitoring during any development associated with the mine developments towards these burials is needed. The site is rated 1; fencing may be necessary otherwise extensive salvage work may be engaged if impacts on these burial sites cannot be avoided.

Plate 8: Informant showing the general area for the burials

MCL-9

GPS Location: 486263S 7509135E

Artefacts: Ceramics

Period: Iron Age

Level of importance: 5

Recommendations: The site is approximately 50m in diameter. Relatively low density of archaeological deposits especially ceramics were found, these were probably overlain by modern cattle herding evidence, house floors were also visible adjacent to the kraal. The site is rated 5. No further archaeological work is necessary.

Plate 9: Pottery fragments at site MCL9

Table 3: Summary of archaeological sites and further work required

Site No.	Archaeological Findings	Type	GPS location	Museum Ranking	Further work required	Mitigation Duration
MCL1	undecorated ceramics	Iron Age	500116S 7509941E	3	Test excavation to determine whether further work is required	3 man days
MCL2	undecorated pottery, few decorated pottery, house daga, burnishing stones, bones	Iron Age	500516S 7506548E	3	Test excavation to determine whether further work is required	3 man days
MCL3	Flakes	Middle Stone Age	485449S 7515092E	4	None, except monitoring if any activities are going to take place directly on site.	None
MCL4	Ceramic sherds, granary stand poles	Iron Age	500227S 7215583E	3	Test excavation to determine whether further work is required	3 man days
MCL5	Pottery and Stone tools	Iron Age/ Stone Age	485439S 7515533E	5	No further Archaeological work required	None
MCL6	Burials	Historical	501070S 7508521E	1	Fencing, avoiding or reburial	3 man days
	Infant burial	Historical	500871S 7508425E	1	Avoiding, Fencing or reburial	2 man days
MCL 7	Infant burial	Historical	500907S 7508556E	1	Preserve if possible, otherwise extensive salvage work	2 man days
MCL 8	Burials	Historical	496829S 7507078E	1	Avoid, Fencing, avoiding, or reburial	3 man days
MCL9	Pottery	Iron Age	486263S 7509135E	5	No further Archaeological work required	None

7.0. Summary and recommendations

The results of the archaeological investigation testify the prehistoric human occupancy remains within the Morupule Mine Lease area. This is evidenced by the historic finds such as the pottery, which are visible on the landscape. Interaction with other communities can also be inferred. The cultural materials resembling other traditions mark this, for instance the decorated pottery.

It should be noted that the archaeological materials occur within the twenty year mine lease extension as well as the other part of the mine extension lease area. These archaeological materials may be impacted especially if the method of mining changes, that is if they decide to go open pit (opening the whole area instead of operating underground). Those within the twenty-year mine lease extension as well as those within the first mine area may be impacted by the developments scheduled for the period. There is indication that burials occur within the lease area, this may mean that more unknown burials may also be present within the area; therefore the developer should be prepared for chance discoveries. It should also be noted that all burial sites are rated 1=preserve at all costs as per the National Museum sites' ranking system. As such, they should be avoided by all means possible and/or fenced. Reburial arrangements may only be implemented if the impacts on the burial sites are unavoidable.

It is therefore very important that before any development takes place all sites recommended for further archaeological investigation be mitigated. In areas where archaeological sites were not reported, development may proceed but there will be a need for frequent monitoring by an archaeologist so as to safeguard whatever artefacts may be exposed during such development phases.

Should anything of archaeological significance be unearthed during the clearing, excavation, construction phases or any associated development of the mine expansion, the consulting archaeologist and the National Museum should be notified with immediate effect. It is also very imperative that those who engage in the construction process are inducted on the importance of reporting archaeological materials to the Botswana National Museum or relevant authorities.

All these would be done to meet the requirements of the Monuments and Relics Act (as amended, 2001) of the laws of Botswana. This act protects all archaeological and or historic monuments and sites in the country whether they are recorded in the National Museum site register or not. The act also recommends that upon encountering archaeological material, relevant authorities should be informed. Section 18 prohibits any alteration, damage or removal from original site any national monument, relic or recent artefact. The act also recognizes the fact that the alteration, damage or removal of monuments and relics may be occasioned through authentic developments. Section 19, therefore, provides for predevelopment archaeological impact assessment and mitigation where planned developments are likely to disturb the earth's surface.

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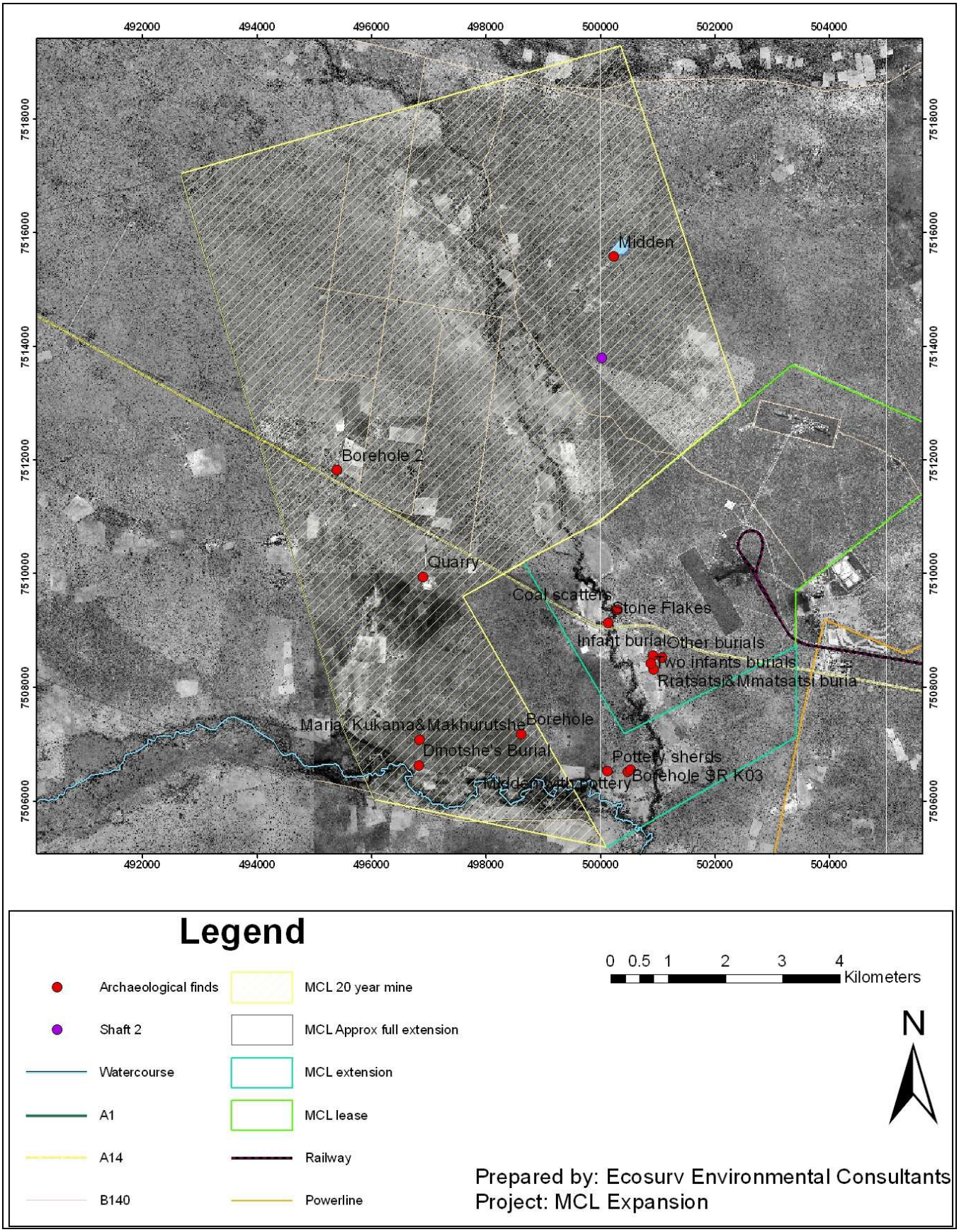
Appendix 1: Map showing encountered archaeological sites in relation to the project area



APPENDIX 5: BOTANICAL IMPACT ASSESSMENT

Prepared by

M. Muzila

Executive summary

A botanical assessment of an area that has been proposed for the expansion of Morupule colliery was done. The overall objective of the analysis was determine the impact that the project may have on the vegetation of the area, and the specific objectives included the following: (1) To determine plant species that populate the area that has been proposed for expansion of the mine colliery, (2) To determine if there are any plants in the area that are part of Botswana's protected plants, (3) To search for species that have been listed in the IUCN red data list. The area was surveyed as according to Dallimeir (1992)'s method of vegetation assessment. Two invasive species (*Dichrostachys cineria* and *Argemone Mexicana*) were identified and one rare species of *Stapelia*. Hence, upon bush clearing – during the construction phase - the *Stapelia* species should be rescued and deposited at the National Botanic Garden for *ex-situ* conservation. Upon rescuing the plant, the soil in which it grows should be collected as well. In that regard, it would be good if the plant is transplanted (i.e. carried while still alive). After rescuing the *Stapelia* species, then the Radical Bush Control procedure should used to clear the bush. For this method, heavy plant machinery - e. g. bulldozers - must be used. If the invasive species reoccur during the operation and decommissioning phases, Selective Bush Control procedures should be used. Under these procedures, Electric saws and pair of secateurs shall be suitable to control the *Dichrostachys cineria*, while conventional tools for weed control such as spades and hoes will be suitable for controlling the *Argemone mexicana*.

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Botanical Impact Assessment at the site proposed for expansion of Morupule Colliery

1.0 Introduction

A botanical survey at the site proposed for expansion of Morupule Colliery was performed. The overall objective of the survey was to fulfill Botswana's Environmental Impact Assessment Act No.6 of 2005, which can be stated as;

An Act to provide for environmental impact assessment to be used to assess the potential effects of planned developmental activities; to determine and to provide mitigation measures for effects of such activities as may have a significant adverse impact on the environment; to put in place a monitoring process and evaluation of the impacts of implemented activities; and to provide for matters incidental to the foregoing.

In the botanical context, adverse impacts refer to events that can lead to plant extinction. Infrastructural developments may lead to plant extinction if there is insufficient data about plant populations in an area or if such information is ignored. An example can be the destruction of protected species through uncontrolled felling and veld fires. Hence, the specific objectives of this survey were as follows:

1. To determine plant species that populate the area that has been proposed for expansion of the mine colliery.
2. To determine if there are any plants in the area that are part of Botswana's protected plants
3. To search for species that have been listed in the IUCN red data list.

2.0 Methodology

Historic data

Prior to the field survey, plants species that occur within the area that has been proposed for morupule colliery expansion and those that occur in the surrounding villages were determined. That was done through the help of a data base known as PRECIS. The information was used to

check for the likelihood of finding red-listed plants and protected plants during the field survey. The program also gives a rough idea of what to expect during the field survey.

Field survey

Areas to be sampled were predetermined on qualitative basis. Hence, both the terrestrial and riparian vegetation types, within the proposed site, were sampled.

Plot construction

Within the selected area, a one Ha plot (100m X 100m) was demarcated. All representative species within the plot were recorded or collected. The plot was surveyed by maintaining an 'S' direction, starting from the bottom left corner, and ending in the bottom right corner of each 1Ha block (Dallemeir 1992).

Plant Identification

Material that was easy to identify was recorded during the survey. And difficult material was identified through text books and verified at PSUB and UCBG herbaria.

3.0 Baseline/Existing situation

According to the historical data (Table 1) and field survey data (Table 2), the following plant species occur within or in the periphery of the site that has been proposed for expansion of the mine.

Table 1. Historic data for plant species that occur within and around the area of the proposed area of development.

Sum of Species count			
Family	Species name	GridRef	Total
ACANTHACEAE	Barleria spinulosa	2227BB	1
	Barleria spinulosa Total		1
	Blepharis bainesii	2227AA	1
	Blepharis bainesii Total		1
	Blepharis serrulata	2227BB	1
	Blepharis serrulata Total		1
	Crabbea velutina	2227BB	1
	Crabbea velutina Total		1

	Justicia protracta rhodesiana	2227BB	1
	Justicia protracta rhodesiana Total		1
ACANTHACEAE Total			**5**
AMARANTHACEAE	Hermbstaedtia odorata odorata	2227BB	1
	Hermbstaedtia odorata odorata Total		1
	Kyphocarpa angustifolia	2227BB	1
	Kyphocarpa angustifolia Total		1
AMARANTHACEAE Total			**2**
AMARYLLIDACEAE	Ammocharis coranica	2226DD	1
	Ammocharis coranica Total		1
	Crinum buphanoides	2226DD	1
	Crinum buphanoides Total		1
AMARYLLIDACEAE Total			**2**
ANACARDIACEAE	Lannea schweinfurthii schweinfurthii	2227BB	2
	Lannea schweinfurthii schweinfurthii Total		2
	Lannea schweinfurthii stuhlmannii	2227AA 2227BB	1 1
	Lannea schweinfurthii stuhlmannii Total		2
	Ozoroa paniculosa paniculosa	2226DD	1
	Ozoroa paniculosa paniculosa Total		1
	Rhus tenuinervis tenuinervis	2227AD	1
	Rhus tenuinervis tenuinervis Total		1
	Sclerocarya birrea caffra	2227BB	1
	Sclerocarya birrea caffra Total		1
ANACARDIACEAE Total			**7**
ANNONACEAE	Annona senegalensis senegalensis	2227BB	1
	Annona senegalensis senegalensis Total		1
ANNONACEAE Total			**1**
APIACEAE	Heteromorpha arborescens abyssinica	2226DB	1
	Heteromorpha arborescens abyssinica Total		1
	Steganotaenia araliacea araliacea	2227BB	1
	Steganotaenia araliacea araliacea Total		1
APIACEAE Total			**2**
ASPARAGACEAE	Asparagus cooperi	2226DD	1
	Asparagus cooperi Total		1
	Asparagus exuvialis	2227BB	1
	Asparagus exuvialis Total		1
	Asparagus virgatus	2226DA	1
	Asparagus virgatus Total		1
ASPARAGACEAE Total			**3**
ASTERACEAE	Acanthospermum hispidum	2226DA	2
	Acanthospermum hispidum Total		2
	Felicia clavipilosa clavipilosa	2227BB	1
	Felicia clavipilosa clavipilosa Total		1
	Geigeria burkei fruticulosa	2227BB	1
	Geigeria burkei fruticulosa Total		1
ASTERACEAE Total			**4**
BIGNONIACEAE	Markhamia zanzibarica	2227AB	1

		2227BB	1
	Markhamia zanzibarica Total		2
BIGNONIACEAE Total			**2**
BORAGINACEAE	Ehretia obtusifolia	2227AC	1
	Ehretia obtusifolia Total		1
	Ehretia rigida rigida	2226CB	1
	Ehretia rigida rigida Total		1
	Heliotropium steudneri	2226CB	1
	Heliotropium steudneri Total		1
BORAGINACEAE Total			**3**
BURSERACEAE	Commiphora glandulosa	2227AB	1
		2227BB	2
	Commiphora glandulosa Total		3
	Commiphora marlothii	2227AB	2
		2227BB	1
	Commiphora marlothii Total		3
	Commiphora mollis	2227AB	2
		2227BB	2
	Commiphora mollis Total		4
	Commiphora pyracanthoides	2227BB	1
	Commiphora pyracanthoides Total		1
BURSERACEAE Total			**11**
CAPPARACEAE	Boscia foetida rehmanniana	2226CB	1
	Boscia foetida rehmanniana Total		1
	Cadaba aphylla	2227BB	1
	Cadaba aphylla Total		1
	Cadaba termitaria	2226CB	1
	Cadaba termitaria Total		1
	Cleome oxyphylla oxyphylla	2227BB	1
	Cleome oxyphylla oxyphylla Total		1
	Maerua angolensis angolensis	2226CB	1
		2227BB	1
	Maerua angolensis angolensis Total		2
	Maerua parvifolia	2227BB	1
	Maerua parvifolia Total		1
CAPPARACEAE Total			**7**
COMBRETACEAE	Combretum apiculatum apiculatum	2227BB	1
	Combretum apiculatum apiculatum Total		1
	Combretum mossambicense	2227BB	2
	Combretum mossambicense Total		2
	Terminalia prunioides	2227BB	2
	Terminalia prunioides Total		2
COMBRETACEAE Total			**5**
CONVOLVULACEAE	Evolvulus alsinoides	2227BB	1
	Evolvulus alsinoides Total		1
	Ipomoea bolusiana	2227BB	1
	Ipomoea bolusiana Total		1
	Ipomoea magnusiana	2227BB	2

	Ipomoea magnusiana Total		2
	Ipomoea obscura obscura	2227BB	1
	Ipomoea obscura obscura Total		1
	Merremia kentrocaulos	2227BB	2
	Merremia kentrocaulos Total		2
	Seddera suffruticosa	2227BB	2
	Seddera suffruticosa Total		2
CONVOLVULACEAE Total			**9**
CUCURBITACEAE	Coccinia rehmannii	2226CB	1
	Coccinia rehmannii Total		1
	Coccinia sessilifolia	2226CD	1
	Coccinia sessilifolia Total		1
	Momordica cardiospermoides	2226CD	1
	Momordica cardiospermoides Total		1
	Momordica repens	2226CB	1
		2226DD	1
	Momordica repens Total		2
CUCURBITACEAE Total			**5**
CYPERACEAE	Cyperus indecorus decurvatus	2227BB	1
	Cyperus indecorus decurvatus Total		1
	Cyperus rupestris rupestris	2227BB	1
	Cyperus rupestris rupestris Total		1
CYPERACEAE Total			**2**
ERIOSPERMACEAE	Eriospermum porphyrium	2226CB	1
	Eriospermum porphyrium Total		1
ERIOSPERMACEAE Total			**1**
EUPHORBIACEAE	Flueggea virosa virosa	2227BB	3
	Flueggea virosa virosa Total		3
	Jatropha erythropoda	2227BB	1
	Jatropha erythropoda Total		1
	Jatropha zeyheri	2227BB	1
	Jatropha zeyheri Total		1
	Securinega virosa	2227AC	1
	Securinega virosa Total		1
	Spirostachys africana	2226CB	1
	Spirostachys africana Total		1
	Tragia okanyua	2227BB	1
	Tragia okanyua Total		1
EUPHORBIACEAE Total			**8**
FABACEAE	Acacia arenaria	2227BC	1
	Acacia arenaria Total		1
	Acacia erioloba	2226DA	1
	Acacia erioloba Total		1
	Acacia erubescens	2227AA	1
		2227BB	2
		2227BC	1
	Acacia erubescens Total		4
	Acacia galpinii	2227BB	1

		2227BC	1
		2227BD	1
	Acacia galpinii Total		3
	Acacia gerrardii gerrardii gerrardii	2227BB	1
		2227BC	1
	Acacia gerrardii gerrardii gerrardii Total		2
	Acacia karroo	2227BB	1
	Acacia karroo Total		1
	Acacia nilotica kraussiana	2227BD	1
	Acacia nilotica kraussiana Total		1
	Acacia tortilis heteracantha	2227BB	2
		2227BC	1
	Acacia tortilis heteracantha Total		3
	Albizia brevifolia	2226CB	2
	Albizia brevifolia Total		2
	Albizia harveyi	2226DD	1
		2227BB	1
	Albizia harveyi Total		2
	Cassia abbreviata beareana	2227BB	1
	Cassia abbreviata beareana Total		1
	Colophospermum mopane	2227AD	1
	Colophospermum mopane Total		1
	Dolichos junodii	2227BB	1
	Dolichos junodii Total		1
	Elephantorrhiza goetzei goetzei	2227BB	1
	Elephantorrhiza goetzei goetzei Total		1
	Indigastrum costatum macrum	2227BB	1
	Indigastrum costatum macrum Total		1
	Lonchocarpus capassa	2227BB	1
	Lonchocarpus capassa Total		1
	Lotononis curtii	2227BB	1
	Lotononis curtii Total		1
	Philenoptera violacea	2227BB	2
	Philenoptera violacea Total		2
	Rhynchosia densiflora chrysadenia	2227BB	1
	Rhynchosia densiflora chrysadenia Total		1
	Rhynchosia totta totta	2227BB	1
	Rhynchosia totta totta Total		1
	Senna italica arachoides	2227BB	2
	Senna italica arachoides Total		2
	Tephrosia purpurea leptostachya leptostachya	2227BB	1
	Tephrosia purpurea leptostachya leptostachya Total		1
	Vigna unguiculata dekindtiana dekindtiana	2226DB	1
	Vigna unguiculata dekindtiana dekindtiana Total		1
FABACEAE Total			**35**
HYACINTHACEAE	Dipcadi sp.	2226CB	1
	Dipcadi sp. Total		1
	Ledebouria revoluta	2227BB	1

	Ledebouria revoluta Total		1
	Ornithogalum seineri	2227BB	1
	Ornithogalum seineri Total		1
HYACINTHACEAE Total			**3**
IRIDACEAE	Lapeirousia sandersonii	2227BB	1
	Lapeirousia sandersonii Total		1
IRIDACEAE Total			**1**
LAMIACEAE	Aeollanthus sp.	2227BB	1
	Aeollanthus sp. Total		1
	Becium filamentosum	2227BB	1
	Becium filamentosum Total		1
	Clerodendrum sp.	2227BB	1
	Clerodendrum sp. Total		1
	Endostemon tenuiflorus	2227BD	1
	Endostemon tenuiflorus Total		1
	Endostemon tereticaulis	2227BB	1
	Endostemon tereticaulis Total		1
	Hemizygia elliottii	2227BB	1
	Hemizygia elliottii Total		1
LAMIACEAE Total			**6**
LORANTHACEAE	Erianthemum ngamicum	2227BB	1
	Erianthemum ngamicum Total		1
LORANTHACEAE Total			**1**
MALVACEAE	Abutilon pycnodon	2227BB	1
	Abutilon pycnodon Total		1
	Azanza garckeana	2227BB	1
	Azanza garckeana Total		1
	Hibiscus caesius caesius	2227BB	1
	Hibiscus caesius caesius Total		1
	Hibiscus engleri	2227BB	1
	Hibiscus engleri Total		1
	Hibiscus micranthus micranthus	2227BB	1
	Hibiscus micranthus micranthus Total		1
	Hibiscus sidiformis	2227BB	1
	Hibiscus sidiformis Total		1
	Pavonia burchellii	2227BB	2
	Pavonia burchellii Total		2
	Sida sp.	2227BB	2
	Sida sp. Total		2
MALVACEAE Total			**10**
MELIACEAE	Turraea obtusifolia	2227BB	1
	Turraea obtusifolia Total		1
MELIACEAE Total			**1**
MOLLUGINACEAE	Corbichonia decumbens	2227BB	1
	Corbichonia decumbens Total		1
	Limeum fenestratum fenestratum	2227BB	1
	Limeum fenestratum fenestratum Total		1
MOLLUGINACEAE Total			**2**

MORACEAE	Ficus tettensis	2227AB	1
		2227BB	1
	Ficus tettensis Total		2
MORACEAE Total			**2**
NYCTAGINACEAE	Commicarpus pilosus	2227BB	1
	Commicarpus pilosus Total		1
NYCTAGINACEAE Total			**1**
OCHNACEAE	Ochna glauca	2227BB	1
	Ochna glauca Total		1
	Ochna pulchra	2226CD	1
	Ochna pulchra Total		1
OCHNACEAE Total			**2**
OLEACEAE	Jasminum stenolobum	2227BB	3
	Jasminum stenolobum Total		3
OLEACEAE Total			**3**
PASSIFLORACEAE	Adenia repanda	2227AD	1
	Adenia repanda Total		1
PASSIFLORACEAE Total			**1**
PEDALIACEAE	Pterodiscus speciosus	2226DD	1
	Pterodiscus speciosus Total		1
PEDALIACEAE Total			**1**
POACEAE	Aristida canescens canescens	2226DD	1
	Aristida canescens canescens Total		1
	Aristida congesta congesta	2227BB	1
	Aristida congesta congesta Total		1
	Aristida scabrivalvis scabrivalvis	2226DD	1
	Aristida scabrivalvis scabrivalvis Total		1
	Aristida stipitata robusta	2226CA	1
	Aristida stipitata robusta Total		1
	Brachiaria deflexa	2226DD	1
	Brachiaria deflexa Total		1
	Brachiaria nigropedata	2226DD	1
	Brachiaria nigropedata Total		1
	Brachiaria serrata	2226DD	1
	Brachiaria serrata Total		1
	Chloris virgata	2226DD	1
	Chloris virgata Total		1
	Digitaria sp.	2226DD	1
	Digitaria sp. Total		1
	Eragrostis cylindriflora	2227BB	1
	Eragrostis cylindriflora Total		1
	Eragrostis pallens	2226CA	1
	Eragrostis pallens Total		1
	Eragrostis rigidior	2226DD	2
	Eragrostis rigidior Total		2
	Eragrostis sp.	2227BB	1
	Eragrostis sp. Total		1
	Hyparrhenia filipendula pilosa	2226DD	1

	Hyparrhenia filipendula pilosa Total		1
	Panicum maximum	2226DD	1
	Panicum maximum Total		1
	Panicum sp.	2226DD	1
	Panicum sp. Total		1
	Pogonarthria squarrosa	2226DD	1
	Pogonarthria squarrosa Total		1
	Schizachyrium sp.	2226DD	1
	Schizachyrium sp. Total		1
	Schmidtia pappophoroides	2226DD	1
	Schmidtia pappophoroides Total		1
	Sporobolus consimilis	2227AA	1
	Sporobolus consimilis Total		1
	Stipagrostis uniplumis uniplumis	2226CA	1
	Stipagrostis uniplumis uniplumis Total		1
	Tricholaena monachne	2226DD	1
	Tricholaena monachne Total		1
	Urochloa oligotricha	2226DD	1
	Urochloa oligotricha Total		1
POACEAE Total			**24**
POLYGALACEAE	Polygala sphenoptera sphenoptera	2227BB	1
	Polygala sphenoptera sphenoptera Total		1
POLYGALACEAE Total			**1**
RHAMNACEAE	Helinus integrifolius	2227BB	2
	Helinus integrifolius Total		2
	Ziziphus mucronata mucronata	2227BB	1
	Ziziphus mucronata mucronata Total		1
RHAMNACEAE Total			**3**
RUBIACEAE	Pavetta eylesii	2227BB	1
	Pavetta eylesii Total		1
	Pavetta gardeniifolia subtomentosa	2227AB 2227BB	1 1
	Pavetta gardeniifolia subtomentosa Total		2
RUBIACEAE Total			**3**
SAPINDACEAE	Cardiospermum corindum	2227BB	1
	Cardiospermum corindum Total		1
	Pappea capensis	2227BB	1
	Pappea capensis Total		1
SAPINDACEAE Total			**2**
SCROPHULARIACEAE	Antherothamnus pearsonii	2227BB	1
	Antherothamnus pearsonii Total		1
SCROPHULARIACEAE Total			**1**
SOLANACEAE	Lycium cinereum	2227BB	1
	Lycium cinereum Total		1
SOLANACEAE Total			**1**
STERCULIACEAE	Melhania acuminata acuminata	2227BB	2
	Melhania acuminata acuminata Total		2
	Melhania rehmannii	2227BB	1

	Melhania rehmannii Total		1
	Sterculia rogersii	2227AB	1
		2227BB	1
	Sterculia rogersii Total		2
	Waltheria indica	2227BB	1
	Waltheria indica Total		1
STERCULIACEAE Total			**6**
STRYCHNACEAE	Strychnos pungens	2226DC	1
	Strychnos pungens Total		1
STRYCHNACEAE Total			**1**
TILIACEAE	Corchorus asplenifolius	2227BB	3
	Corchorus asplenifolius Total		3
	Corchorus longipedunculatus	2227BB	1
	Corchorus longipedunculatus Total		1
	Grewia bicolor	2227AC	1
		2227BB	2
	Grewia bicolor Total		3
	Grewia flavescens	2227BB	1
	Grewia flavescens Total		1
	Grewia monticola	2227BB	1
	Grewia monticola Total		1
	Grewia retinervis	2227BB	1
	Grewia retinervis Total		1
	Grewia subspathulata	2227AA	1
	Grewia subspathulata Total		1
TILIACEAE Total			**11**
TURNERACEAE	Tricliceras glanduliferum	2227BB	1
	Tricliceras glanduliferum Total		1
	Tricliceras schinzii schinzii juttae	2227AC	1
	Tricliceras schinzii schinzii juttae Total		1
TURNERACEAE Total			**2**
VELLOZIACEAE	Xerophyta humilis	2227BB	1
	Xerophyta humilis Total		1
VELLOZIACEAE Total			**1**
VERBENACEAE	Chascanum incisum	2227BB	1
	Chascanum incisum Total		1
	Lantana rugosa	2227BB	2
	Lantana rugosa Total		2
VERBENACEAE Total			**3**
VITACEAE	Cissus cornifolia	2227AB	2
		2227BB	1
	Cissus cornifolia Total		3
	Cyphostemma hereroense	2226CB	1
	Cyphostemma hereroense Total		1
VITACEAE Total			**4**

Table 2 Plant species recorded during the field survey and the location in which they were recorded.

ACANTHACEAE
- Barleria eranthemoides
  - 22o30'.179S 26o59'.555E
- Barleria lancifolia
  - 22o30'.179S 26o59'.555E
- Blepharis bainesii
  - 22o30'.179S 26o59'.555E
- Blepharis transvaalensis
  - 22o30'.179S 26o59'.555E

AMARANTHACEAE
- Aerva leucura
  - 22o30'.179S 26o59'.606E
- Alternantha pungens
  - 22o30'.179S 26o59'.555E
- Amaranthus hybridus
  - 22o30'.179S 26o59'.606E
- Cyathula orthacantha
  - 22o30'.179S 26o59'.555E
- Kyphocarpa angustifolia
  - 22o30'.179S 26o59'.555E

ANACARDIACEAE
- Ozoroa paniculosa
  - 22o29'.407S 27o00'.320E
- Rhus tenuinervis
  - 22o29'.407S 27o00'.320E
  - 22o30'.179S 26o59'.606E
  - 22o30'.249S 26o59'.729E

ASCLEPIDACEAE
- Asclepias fruticosa
  - 22o29'.407S 27o00'.320E
- Stapelia sp
  - 22o29'.407S 27o00'.320E

ASPARAGACEAE
- Asparagus bechuanicus
  - 22o29'.407S 27o00'.320E

22o30’.179S 26o59’.606E
Asparagus cooperii
22o30’.179S 26o59’.555E
Asparagus nelsii
22o29’.407S 27o00’.320E
22o30’.179S 26o59’.606E
22o30’.249S 26o59’.729E

ASTERACEAE

Abutilon austro-africanum
22o30’.179S 26o59’.555E
22o30’.179S 26o59’.606E
Abutilon austro-africanum
22o30’.249S 26o59’.729E
Acanthospermum hispidum
22o30’.249S 26o59’.729E
Achryranthes aspera
22o30’.179S 26o59’.606E
Bidens pilosa
22o30’.179S 26o59’.606E
Helichrysum argyrosphaerum
22o30’.249S 26o59’.729E
Osteopermum muricatum
22o30’.179S 26o59’.555E
Schkuhria pinnata
22o30’.179S 26o59’.606E
Tarchonanthus camphoratus
22o30’.179S 26o59’.555E
Targetes minuta
22o30’.179S 26o59’.555E
22o30’.179S 26o59’.606E
Verbesina encelioides
22o30’.249S 26o59’.729E
Vernonia poskeana
22o29’.407S 27o00’.320E
Xanthium strumarium
22o30’.179S 26o59’.555E
22o30’.179S 26o59’.606E

BORAGINACEAE

Ehretia rigida
22o29’.407S 27o00’.320E
22o30’.179S 26o59’.555E
22o30’.179S 26o59’.606E

BURSERACEAE
Commiphora sp
22o29’.407S 27o00’.320E
CAESALPINIACEAE
Burkea africana
22o29’.407S 27o00’.320E
CAPPARACEAE
Boscia albitrunca
22o29’.407S 27o00’.320E
22o30’.249S 26o59’.729E
Boscia angustifolia
22o30’.249S 26o59’.729E
Cadaba aphylla
22o30’.249S 26o59’.729E
CELASTERACEAE
Eleaodendron transvaalensis
22o29’.407S 27o00’.320E
Maytenus senegalensis
22o29’.407S 27o00’.320E
22o30’.179S 26o59’.606E
22o30’.249S 26o59’.729E
COMBRETACEAE
Combretum hereroense
22o30’.179S 26o59’.555E
22o30’.249S 26o59’.729E
Combretum imberbe
22o30’.179S 26o59’.555E
22o30’.179S 26o59’.606E
Terminalia sericea
22o29’.407S 27o00’.320E
22o30’.249S 26o59’.729E
COMMELINACEAE
Commelina sp
22o30’.249S 26o59’.729E
CONVOLVULACEAE
Evolvulus alsinoides
22o29’.407S 27o00’.320E
Merremia tridentata
22o29’.407S 27o00’.320E
CUCURBITACEAE
Acanthosicyos naudiniana
22o29’.407S 27o00’.320E

DRACAENACEAE
Sansevieria aethiopica
22o30'.249S 26o59'.729E
EBANACEAE
Diospyros lycoides
22o30'.179S 26o59'.606E
Euclea divonorum
22o30'.179S 26o59'.555E
EUPHORBIACEAE
Phyllanthus angolensis
22o29'.407S 27o00'.320E
Tragia okanyua
22o29'.407S 27o00'.320E
FABACEAE
Acacia tortilis
22o30'.179S 26o59'.606E
22o30'.249S 26o59'.729E
Acacia erioloba
22o29'.407S 27o00'.320E
22o30'.249S 26o59'.729E
Acacia erubescens
22o30'.179S 26o59'.606E
Acacia fleckii
22o29'.407S 27o00'.320E
22o30'.179S 26o59'.555E
22o30'.249S 26o59'.729E
Acacia mellifera
22o30'.249S 26o59'.729E
Acacia nilotica
22o30'.179S 26o59'.606E
Bauhunia c.f. petersiana
22o29'.407S 27o00'.320E
Bauhunia c.f.petersiana
22o30'.249S 26o59'.729E
Chamaecrista comosa var capricona
22o29'.407S 27o00'.320E
Colophospermum mopane
22o30'.249S 26o59'.729E
Dichrostachys cineria
22o30'.179S 26o59'.555E
22o30'.249S 26o59'.729E
Dichrostachys cineria subsp africana

22o29’.407S 27o00’.320E
Indigofera daleoides
22o29’.407S 27o00’.320E
22o30’.249S 26o59’.729E
Indigofera tinctus
22o29’.407S 27o00’.320E
Peltophorum africanum
22o29’.407S 27o00’.320E
22o30’.249S 26o59’.729E
Rhynchosia sp
22o30’.179S 26o59’.555E
Rhynchosia totta
22o29’.407S 27o00’.320E
Tephrosia purpurea
22o30’.179S 26o59’.555E

LAMIACEAE

Acrotome inflata
22o29’.407S 27o00’.320E
22o30’.179S 26o59’.555E
22o30’.179S 26o59’.606E
22o30’.249S 26o59’.729E
Leonotis neptifolia
22o30’.179S 26o59’.606E

LOGANIACEAE

Strychnos sp
22o29’.407S 27o00’.320E

MALVACEAE

Pavonia senegalensis
22o29’.407S 27o00’.320E
22o30’.249S 26o59’.729E
Sida cordifolia
22o30’.179S 26o59’.555E
22o30’.249S 26o59’.729E
Sida dregii
22o29’.407S 27o00’.320E
22o30’.179S 26o59’.606E

OLACACEAE

Ximenia americana
22o30’.179S 26o59’.555E
Ximenia caffra
22o29’.407S 27o00’.320E
22o30’.179S 26o59’.555E

PAPAVERACEAE
Argemone mexicana
22o30’.249S 26o59’.729E
POACEAE
Aristida congesta
22o29’.407S 27o00’.320E
Dactyloctenium giganteum
22o30’.249S 26o59’.729E
Eleusine coracana
22o30’.179S 26o59’.606E
Eragrostis curvula
22o29’.407S 27o00’.320E
Perotis patens
22o29’.407S 27o00’.320E
Pogonarthria squarrosa
22o29’.407S 27o00’.320E
Sporobolus coromandelianus
22o30’.249S 26o59’.729E
Urochloa trichophus
22o29’.407S 27o00’.320E
22o30’.179S 26o59’.555E
Urochloa trichopus
22o30’.249S 26o59’.729E
RHAMNACEAE
Ziziphus mucronata
22o29’.407S 27o00’.320E
22o30’.179S 26o59’.606E
22o30’.249S 26o59’.729E
SOLANACEAE
Lycium cinereum
22o30’.179S 26o59’.555E
Solanum panduriforme
22o29’.407S 27o00’.320E
22o30’.249S 26o59’.729E
STERCULIACEAE
Hermania burchellii
22o30’.179S 26o59’.555E
Hermania tomentosa
22o30’.179S 26o59’.555E
Melhania acuminata
22o30’.179S 26o59’.555E
Waltheria indica

22o29’.407S 27o00’.320E

TILIACEAE

Grewia flava

22o29’.407S 27o00’.320E

22o30’.249S 26o59’.729E

Grewia retinervis

22o30’.249S 26o59’.729E

4. 0. Planning framework

According to Setshogo and Hargreaves (2002) thirteen plant species in Botswana are vulnerable or endangered (Table 3).

Table 3: IUCN listed species (excluding those of Least Concern) occurring in Botswana (Source: Setshogo & Hargreaves 2002).

Species name	Common Name	Red-list	
Adenium boehmianum	Step palm	EN	
Adenium oleifolium	Bitterkambro	VU B1B2ce	
Ansellia africana	Leopard orchid	VU Al ad	
Hoodia lugardi	Ghaap, Bitter Ghaap	VU A1de	
Huernia levyi	Camellia	VU D2	
Orbea tapscottii	Unknown	EN A 1ac	
Orbeopsis knobelii	Unknown	VU D1D2	
Euphorbia venteri	Unknown	EN C2a	
Nesaea minima	Unknown	VU D2	
Eulophia angolensis	Yellow S. Orchid	VU A1ad	
Eulophia latilabris	Jewel Orchid	VU A1ad	
Anacampseros rhodesiaca	Unknown	VU A1ad	
Erythrophysa transvaalensis	Bosveld saffraan , Monomane	VU D1D2	

And according to chapter 38:03 of the laws of Botswana, the following are protected trees and destruction of the trees is prohibited (Table 4):

Table 4. Protected trees in Botswana.

Botanical name	Common name
Afzelia quanzensis	Pod mahogany
Burkea plurijuga	Rhodesian teak
Brachystegia sp	Mowombo
Guibourtia colosperma	Rhodesian copal wood
Pterocarpus angolensis	Blood wood
Entandrophragma caudatum	Brown mahogany
Spirostachys africana	Tamboti
Adansonia digitata	Baobab
Berchemia discolor	Motsintsila
Diospyros mespiliformis	African ebony

In addition to that, Morupule Colliery has a vegetation clearing standard procedure - MCL/ENV/101-, which "details the method by which all MCL employees and any other contractors doing work for MCL on the lease area shall follow when preparing site for project or carrying out works which require site clearance".

5.0 Findings

Protected and red listed species

None of the red listed species (Table 3) or the protected species (Table 4) occur within the area that has been proposed for expansion of the Morupule colliery mine.

Invasive species

The following invasive species were identified:

Argemone Mexicana
22°30'.249S 26°59'.729E

Figure 1. *Argemone mexicana*

Dichrostachys cineria
22°30'.179S 26°59'.555E, 22°30'.249S 26°59'.729E

Figure 2. *Dichrostachys cineria*

Rare species

A rare species of *Stapelia* (Figure 3) was identified at location 22°29'.407S 27°00'.320E (Figure 4).

Figure 3. *Stapelia* species at the proposed project site in Morupule, Palapye.

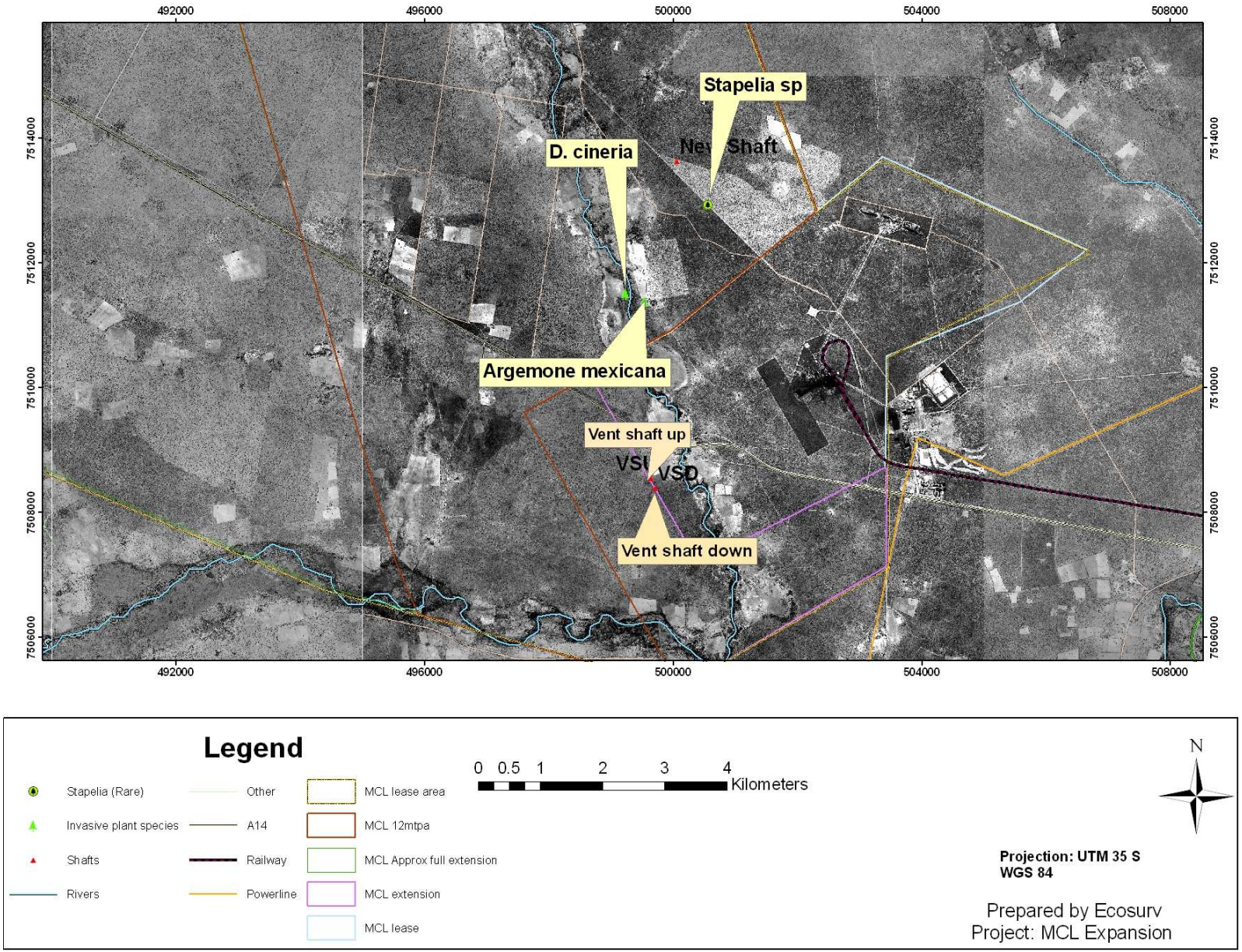

Figure 4: Location of *Argemone Mexicana*, *Dichrostachys cinerea and Stapelia* species

6.0 Identified Impacts, Assessment and Mitigations

The project may lead to the destruction of one *Stapelia* species located at $22^{o}29'.407S$ $27^{o}00'.320E$. It would therefore be best for the species to be rescued by transplanting it to the National Botanic Garden for ex- situ conservation.

7.0 Environmental management plan, monitoring and Auditing

The proposed project site is infested with *Dichrostachys cineria* and *Argemone Mexicana*, which are invasive species. Therefore, during the construction phase, Radical Bush Control procedure should used to clear the bush. For this method, heavy plant machinery - e. g. bulldozers - must be used. If the invasive species reoccur during the operation and decommissioning phases, Selective Bush Control procedures should be used. Under these procedures, Electric saws and pair of secateurs shall be suitable to control the *Dichrostachys cineria*, while conventional tools for weed control such as spades and hoes will be suitable for controlling the *Argemone mexicana*.

8.0 Conclusions and recommendations

There are no threats to clearing of the vegetation at the proposed project site, except for the destruction of the *Stapelia* species listed at section 6. 0 above. But since rescue measures have been provided as to how the species can be saved, the vegetation clearing at the proposed site will not be of any threat to the vegetation of Botswana.

9.0 Reference

DALLMEIER, F. 1992. Long-term monitoring of biological diversity in tropical forest areas.

Methods for establishment and inventory of permanent plots. **MAB DIGEST** Series, 11

SETSHOGO, M. P and HARGREAVES, B. 2002. Botswana. In: Janice Golding (editor) Southern African plant red data lists. Southern African Botanical diversity Network Report No.14

APPENDIX 6: CLOSURE COSTS

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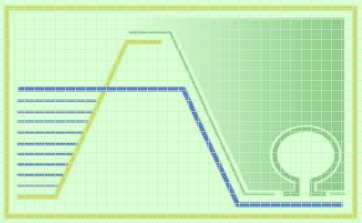

MORUPULE COLLIERY EXPANSION FINANCIAL PROVISION FOR CLOSURE

Prepared For

Ecosurv (Pty) Ltd

PROJECT NUMBER E009-02

REPORT NO.1 Final

September 2008

Morupule Colliery Expansion Financial Provision for Closure

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MORUPULE COLLIERY EXPANSION FINANCIAL PROVISION FOR CLOSURE

1. INTRODUCTION

Mining operations are required by legislation (The Mines and Minerals Act, 1999) to make adequate and ongoing financial provision for environmental rehabilitation and closure. This report outlines and follows the South African Department of Minerals and Energy (DME) procedure for the determination of the quantum for financial provision for closure (DME, 2005). The financial provision provided in this report is for the 4Mtpa expansion and for those buildings and infrastructure excluded from the previous closure cost estimate provided by Geoflux (2006). The financial provision provided in this report therefore excludes the closure cost estimate for the then existing buildings, structures and infrastructure as provided in Geoflux (2006).

The preliminary mine closure plan is documented in Part 3 of Geoflux (2006) and describes, among others, the:

- closure objectives,
- legal requirements,
- final land use,
- preliminary closure plan, and
- closure management plan for the Morupule Colliery.

The Geoflux (2006) report further recommends that the preliminary closure plan be revised every five years with a final closure plan drafted five years before mine closure.

2. TERMS OF REFERENCE

The terms of reference of this determination of financial provision for closure are contained in the inception report sent to the client on 03 July 2008.

3. INFORMATION PROVIDED

The following information was made available:

- The current Morupule Colliery Preliminary Closure Plan (Part 3 of Geoflux (2006)) provided by Ecosurv (Pty) Ltd;
- The Morupule Colliery site layout (DRA drawing C2824-L101) including the proposed 4Mtpa expansion provided by Dowding, Reynard and Associates (DRA) on 26 August 2008;
- Confirmation and information supplied by the mine following queries by Metago during the calculation of the financial provision.

4. INPUT TO THE FINANCIAL PROVISION CALCULATION

4.1. STEP 1: PRIMARY MINERAL AND SALEABLE MINERAL BY-PRODUCTS

DME require that the type of mineral mined or processed, and the saleable mineral by-products (not trace elements) be identified.

Mine/Process type	Underground Coal Mine
Saleable Mineral By-Product	N / A

4.2. STEP 2: RISK CLASS

The risk ranking class is determined using Table B.12 of DME (2005) and is used later to determine the multiplication factors applied to the master rate (see Step 4.3). The risk ranking class for the Morupule Colliery Expansion is shown in Table 4-1.

TABLE 4-1: DETERMINATION OF RISK CLASS

Primary Risk Ranking	Class A* - High Risk (coal mine)
Revised Risk Ranking	Class A* – High Risk

**** Class A – High Risk: A high probability of the occurrence of the impact with a severe consequence***

4.3. STEP 3: AREA SENSITIVITY

The area sensitivity is established based on the most critical of three criteria, these being:

- Biophysical.
- Social.
- Economic.

Table B.4 from DME (2005), as presented in Table 4-2, is used in ascertaining the Area Sensitivity.

Based on the descriptions provided in Table 4-2:

- The area has a medium biophysical sensitivity.
- The area has a low social sensitivity.
- The area has a medium economic sensitivity.

Based on DME (2005), which requires that the highest sensitivity value be adopted, the above yields a **medium** area sensitivity. The area sensitivity ranking is used later to determine the multiplication factors applied to the master rate (see Step 4.3).

TABLE 4-2: CRITERIA TO BE USED FOR AREA SENSITIVITY (TABLE B.4 OF DME, 2005)

Sensitivity	Sensitivity Criteria		
	Biophysical	**Social**	**Economic**
Low	Largely disturbed from natural state. Limited natural fauna and flora remains. Exotic plant species evident. Unplanned development. Water resources disturbed and impaired.	The local communities are not within sighting distance of the mining operation. Lightly inhabited area (rural).	The area is insensitive to development. The area is not a major source of income to the local communities.
Medium	Mix of natural and exotic fauna and flora. Development in is a mix of disturbed and undisturbed areas, within an overall planned network. Water resources are well controlled.	The local communities are in the proximity of the mining operation (within sighting distance). Peri-urban area with density aligned with a development framework. Area developed with an established infrastructure.	The area has a balanced economic development where a degree of income for the local communities is derived from the area. The economic activity could be influenced by indiscriminate development.
High	Largely in a natural state. Vibrant fauna and flora, with species diversity and abundance matching the nature of the area. Well-planned development. Area forms part of an overall ecological regime of conservation value. Water resources emulate their original state.	The local communities are in close proximity of the mining operation (on the boundary of the mine). Densely inhabited area (urban/dense settlements). Developed and well-established communities.	The local communities derive the bulk of their income directly from the area. The area is sensitive to development that could compromise the existing economic activity.

4.4. STEP 4: CLOSURE COSTS

4.4.1. STEP 4.1: DETERMINE THE LEVEL OF INFORMATION

As per the DME (2005) definitions, limited information is available which requires that the 'rule-based' approach be adopted as described below.

4.4.2. STEP 4.2: DETERMINE THE CLOSURE COMPONENTS

The applicable DME closure components relevant to the Morupule Colliery Expansion Project are presented in Table 4-3.

TABLE 4-3: CLOSURE COMPONENTS

Component No.	Main Description	Applicability of Closure Components	
		Yes	No
1	Dismantling of processing plant and related structures (including overland conveyors and power-lines)	✓	
2 (A)	Demolition of steel buildings and structures	✓	
2 (B)	Demolition of reinforced concrete buildings and structures	✓	
3	Rehabilitation of access roads	✓	
4 (A)	Demolition and rehabilitation of electrified railway lines		✗
4 (B)	Demolition and rehabilitation of non-electrified railway lines		✗
5	Demolition of housing and facilities	✓	
6	Opencast rehabilitation including final voids and ramps		✗
7	Sealing of shafts, adits and inclines	✓	
8 (A)	Rehabilitation of overburden and spoils		✗
8 (B)	Rehabilitation of processing waste deposits and evaporation ponds (basic, salt producing)		✗
8 (C)	Rehabilitation of processing waste deposits and evaporation ponds (acidic, metal rich)	✓	
9	Rehabilitation of subsidence areas		✗
10	General surface rehabilitation, including grassing of all denuded areas	✓	
11	River diversions		✗
12	Fencing		✗
13	Water management (separating clean and dirty water, managing polluted water and managing the impact on groundwater, including treatment, when required)		✗
14	2 to 3 years of maintenance and aftercare	✓	

It is noted that the financial provision calculation is based on the following buildings and infrastructure being constructed:

- Existing Access road from southeast;
- Existing middlings conveyor;
- Existing washing plant and associated structures, bins, conveyors and stockpiles;
- Expansion to the administration office area;

- Expansion to the clinic and training area;
- Expansion to the survey, change house and workshop area;
- New BPC feed conveyor, sample tower, surge bin etc. northeast of railway line;
- New Secondary screening and crushing and associated conveyors;
- New DMS plant and associated bins, screens and conveyors;
- New adit conveyor;
- New primary screening and crushing and associated conveyors, bins and stockpiles;
- New stacker feed, reclaimer and transfer conveyors and stockpile areas.

4.4.3. STEP 4.3: IDENTIFY UNIT RATES FOR CLOSURE COMPONENTS

The unit or master rate for each closure component as provided by DME (2005) is based on generally accepted closure methods and are considered to be in line with the closure objectives and criteria provided in Geoflux (2006).

The unit or master rates for each closure component has been taken from DME (2005) as at January 2005 and inflated or escalated using the annual CPIX indices (as prescribed by the DME procedure) by 27% (Jan 2006: 4.3% y/y, Jan 2007: 5.3% y/y, Jan 2008: 8.8% y/y, Jul 2008: 13.0% y/y, from Statistics South Africa) to account for escalation from January 2005 to August 2008. Metago is however of the opinion that escalation of the master rates using CPIX will result in an underestimation of inflation with particular reference to the mining and construction industry in Southern Africa. Metago rather recommends that the PPI indices be used which results in an escalation of the master rates of 36% (Jan 2006: 5.5% y/y, Jan 2007: 9.8% y/y, Jan 2008: 10.4% y/y, May 2008: 16.4% y/y, from the monthly Investec South Africa Economic Research updates) between January 2005 and August 2008. In addition the currency of the master rates was converted from ZAR to BWP. The BWP / ZAR exchange rate as at 28 August 2008 at 06:32:03 UTC was 1 BWP = 1.16635 ZAR. A

comparison of the escalated and converted master rates using both the CPIX and PPI indices are provided in Table 4-4.

As prescribed in DME (2005), a multiplication factor was applied to each escalated master rate depending on the risk ranking and the area sensitivity of the mine. The multiplication factors for each closure component are presented in Table 4-4.

TABLE 4-4: MULTIPLICATION FACTORS AND MASTER RATES

Component No.	Main Description	Unit	Multiplication Factor	Escalated Master Rate (using CPIX)	Escalated Master Rate (using PPI)
1	Dismantling of processing plant and related structures (including overland conveyors and power-lines)	m^3	1.00	BWP 7.43	BWP 7.95
2 (A)	Demolition of steel buildings and structures	m^2	1.00	BWP 103.44	BWP 110.77
2 (B)	Demolition of reinforced concrete buildings and structures	m^2	1.00	BWP 152.44	BWP 163.24
3	Rehabilitation of access roads	m^2	1.00	BWP 18.51	BWP 19.82
5	Demolition of housing and facilities	m^2	1.00	BWP 206.88	BWP 221.55
7	Sealing of shafts, adits and inclines	m^3	1.00	BWP 55.53	BWP 59.47
8 (C)	Rehabilitation of processing waste deposits and evaporation ponds (acidic, metal rich)	ha	0.80	BWP 261,545.85	BWP 280,080.59
10	General surface rehabilitation, including grassing of all denuded areas	Ha	1.00	BWP 57,274.40	BWP 61,333.22
14	2 to 3 years of maintenance and aftercare	ha	1.00	BWP 7,622.07	BWP 8,162.22

4.4.4. STEP 4.4: APPLY THE WEIGHTING FACTORS

Two weighting factors are applied to the closure costs:

- Weighting Factor 1 (applied to all closure components):
  The nature of the terrain in which the mine is located; options being:
  - **Flat** **(factor = 1.00)**
  - Undulating (factor = 1.10)
  - Rugged (factor = 1.20)

- Weighting Factor 2 (applied to preliminary and general item only):
  The proximity of the mine to an urban area where goods and services are supplied; options being:
  - Urban - Located in an urban area (factor = 1.00)
  - **Peri-urban - Less than 150 km from a developed urban area** **(factor = 1.05)**
  - Remote - Greater than 150 km from a developed urban area (factor = 1.10)

Based on the above the weighting factors are:

- **Weighting factor 1: 1.00**
- **Weighting factor 2: 1.05**

4.4.5. STEP 4.5: IDENTIFY AREAS OF DISTURBANCE

The proposed Morupule Colliery Expansion site layout provided by DRA is shown in Figure 4-1. The specific areas of disturbance (for the expansion only) were listed in Section 4.4.2.

FIGURE 4-1: MORUPULE COLLIERY EXPANSION – SITE LAYOUT PROVIDED BY DRA

4.4.6. STEP 4.6: CLOSURE COSTS FOR SPECIALIST STUDIES

The risk ranking identifies what type of specialist studies should be carried out to ensure successful closure of the mine and/or process operation as shown in Table 4-5.

TABLE 4-5: SPECIALIST STUDIES THAT SHOULD BE REQUESTED (DME, 2005)

Risk Ranking	Specialist Studies
Class A (High risk)	Water pollution potential studies Overall quantified risk assessment
Class B (Medium risk)	Screening level risk assessment
Class C (Low risk)	

An allowance for each of the required specialist studies shown in Table 4-5 have been made as part of the calculation of financial provision for closure.

5. CALCULATION OF THE FINANCIAL PROVISION FOR CLOSURE

5.1. STEP 4.7: CALCULATE THE CLOSURE COSTS

The following is noted with regards to the calculation of the financial provision for closure provided in this report:

- The DME (2005) master rates have been escalated using both South African CPIX and PPI figures to the base date of August 2008. Therefore the costs quoted are in August 2008 money terms and is not the cost at the end of life of mine;

- All rates and costs quoted are in BWP and excludes any taxes (e.g. VAT). Note the master rates were converted from ZAR to BWP as it is not expected that rates will vary significantly between Botswana and South Africa;

- The financial provision for closure is an estimate only (< +25%; > -15%) and will require review on an ongoing basis (at least every 5 years as recommended by Geoflux (2006)). In addition it is recommended that, in order to increase the

confidence level of the determination, a site specific and thorough 'bill of quantities' method be used 5 years prior to closure in accordance with the closure objectives and targets of the final mine closure plan;

- The possible salvage value of mine infrastructure at closure were not considered

The total financial provision for closure of the Morupule Colliery Expansion only (and those buildings and infrastructure previously excluded from the Geoflux (2006) closure cost calculation) has been calculated as follows using the DME (2005) method:

- BWP 3,290,050.90 using CPIX to escalate the master rates to August 2008 (refer Appendix 1 for calculation sheet);
- BWP 3,505,078.52 using PPI to escalate the master rates to August 2008 (refer Appendix 1 for calculation sheet).

Metago is of the opinion that escalation of the master rates using CPIX will result in an underestimation of inflation with particular reference to the mining and construction industry. Metago therefore recommends that the PPI indices rather be used to escalate the master rates to August 2008 money terms. Therefore the recommended financial provision for closure of the Morupule Colliery Expansion only is **BWP 3,505,078.52**.

5.2. ESTIMATION OF CLOSURE COSTS FOR EXISTING BUILDINGS AND INFRASTRUCTURE (FROM GEOFLUX, 2006)

The preliminary mine closure plan documented in Part 3 of Geoflux (2006) included a closure cost estimate for the then existing mine buildings and infrastructure of BWP 32,963,080.50. This cost was in November 2005 money terms and several qualifications were made e.g. P&Gs and contingency were excluded.

In order to calculate the total financial provision for closure of the Morupule Colliery including the 4Mtpa expansion, the Metago estimate for the expansion of some BWP 3.5million needs to be added to the Geoflux (2006) estimate escalated to August 2008 terms with an allowance added for P&Gs and contingency (Metago

recommends an additional 25%). Therefore the total financial provision for closure of the Morupule Colliery including the 4Mtpa expansion is in the region of some BWP 58million (to be confirmed by the mine).

Francois van Heerden	Stephen van Niekerk (PrEng)
Author	**Reviewer**

REFERENCES:

DME, 2005, “Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine”, January 2005, Department of Minerals and Energy, Republic of South Africa.

Geoflux, 2006, “Environmental Situation Analysis, EMP and Closure Plan for Morupule Colliery”, March 2006

APPENDIX 1: FINANCIAL PROVISION FOR CLOSURE COST ESTIMATE USING THE DME (2005) 'RULES-BASED' APPROACH

MORUPULE COLLIERY 4Mtpa EXPANSION
FINAL ESTIMATE OF CLOSURE COST - 2SEP2008
CALCULATION OF CLOSURE QUANTUM

Template for "rules-based" approach of the quantum for financial provision

CALCULATION OF THE QUANTUM (USING RSA CPIX TO ESCALATE MASTER RATES AND CONVERTED TO BWP)

Mine: **Morupule Colliery 4Mtpa Expansion**

No.	Description:	Unit:	A Quantity	B Master rate	C Multiplication factor	D Weighting factor 1	E=A*B*C*D Amount (BWP)
			Step 4.5	Step 4.3	Step 4.3	Step 4.4	
1	Dismantling of processing plant & related structures (incl. overland conveyors & power lines)	m^3	14,021	BWP 7.43	1	1	BWP 104,120.97
2 (A)	Demolition of steel buildings & structures	m^2	2,239	BWP 103.44	1	1	BWP 231,607.45
2 (B)	Demolition of reinforced concrete buildings & structures	m^2	294	BWP 152.44	1	1	BWP 44,817.76
3	Rehabilitation of access roads	m^2	16,630	BWP 18.51	1	1	BWP 307,833.58
4 (A)	Demolition & rehabilitation of electrified railway lines	m	0	BWP 179.66	1	1	BWP 0.00
4 (B)	Demolition & rehabilitation of non electrified railway lines	m	0	BWP 98.00	1	1	BWP 0.00
5	Demolition of housing and/or administration facilities	m^2	4,126	BWP 206.88	1	1	BWP 853,606.38
6	Opencast rehabilitation including final voids & ramps	ha	0	BWP 105,293.44	0.52	1	BWP 0.00
7	Sealing of shafts, adits & inclines	m^3	5,655	BWP 55.53	1	1	BWP 314,034.68
8 (A)	Rehabilitation of overburden & spoils	ha	0	BWP 72,300.77	1	1	BWP 0.00
8 (B)	Rehabilitation of processing waste deposits & evaporation ponds (basic, salt producing waste)	ha	0	BWP 90,049.30	1	1	BWP 0.00
8 (C)	Rehabilitation of processing waste deposits & evaporation ponds (acidic, metal-rich waste)	ha	1	BWP 261,545.85	0.8	1	BWP 228,988.62
9	Rehabilitation of subsidised areas	ha	0	BWP 60,541.00	1	1	BWP 0.00
10	General surface rehabilitation	ha	2	BWP 57,274.40	1	1	BWP 114,548.81
11	River diversions	ha	0	BWP 57,274.40	1	1	BWP 0.00
12	Fencing	m	0	BWP 65.33	1	1	BWP 0.00
13	Water management	ha	0	BWP 21,777.34	0.67	1	BWP 0.00
14	2 to 3 years of maintenance & aftercare	ha	5	BWP 7,622.07	1	1	BWP 38,110.34
15 (A)	Specialist study (overall quantified risk assessment)	SUM	1	BWP 85,737.56	1	1	BWP 85,737.56
15 (B)	Specialist study (water pollution potential study)	SUM	1	BWP 102,885.07	1	1	BWP 102,885.07
						Sub Total 1 (Sum of items 1 to 15 Above)	BWP 2,426,291.22

1	Preliminary and general	12% of Subtotal 1	**Weighting factor 2 (step 4.4)**	1.05	BWP 305,712.69
2	Administration & supervision costs	6.0% of Subtotal 1			BWP 145,577.47
3	Engineering drawings & specifications	2.0% of Subtotal 1			BWP 48,525.82
4	Engineering & procurement of specialist work	2.5% of Subtotal 1			BWP 60,657.28
5	Development of a closure plan				
6	Final groundwater modeling	2.5% of Subtotal 1			BWP 60,657.28
				Sub Total 2 (Subtotal 1 plus sum of management & administrative items, 1 to 6 above)	BWP 3,047,421.78
7	Contingency	10.0% of Subtotal 1			BWP 242,629.12
				GRAND TOTAL (Subtotal 2 plus contingency - excluding all taxes e.g. VAT)	**BWP 3,290,050.90**

Template for "rules-based" approach of the quantum for financial provision

CALCULATION OF THE QUANTUM (USING RSA PPI TO ESCALATE MASTER RATES AND CONVERTED TO BWP)

Mine: **Morupule Colliery 4Mtpa Expansion**

No.	Description:	Unit:	A Quantity	B Master rate	C Multiplication factor	D Weighting factor 1	E=A*B*C*D Amount (BWP)
			Step 4.5	Step 4.3	Step 4.3	Step 4.4	
1	Dismantling of processing plant & related structures (incl. overland conveyors & power lines)	m^3	14,021	BWP 7.95	1	1	BWP 111,499.62
2 (A)	Demolition of steel buildings & structures	m^2	2,239	BWP 110.77	1	1	BWP 248,020.58
2 (B)	Demolition of reinforced concrete buildings & structures	m^2	294	BWP 163.24	1	1	BWP 47,993.83
3	Rehabilitation of access roads	m^2	16,630	BWP 19.82	1	1	BWP 329,648.56
4 (A)	Demolition & rehabilitation of electrified railway lines	m	0	BWP 192.40	1	1	BWP 0.00
4 (B)	Demolition & rehabilitation of non electrified railway lines	m	0	BWP 104.94	1	1	BWP 0.00
5	Demolition of housing and/or administration facilities	m^2	4,126	BWP 221.55	1	1	BWP 914,098.17
6	Opencast rehabilitation including final voids & ramps	ha	0	BWP 112,755.18	0.52	1	BWP 0.00
7	Sealing of shafts, adits & inclines	m^3	5,655	BWP 59.47	1	1	BWP 336,289.11
8 (A)	Rehabilitation of overburden & spoils	ha	0	BWP 77,424.44	1	1	BWP 0.00
8 (B)	Rehabilitation of processing waste deposits & evaporation ponds (basic, salt producing waste)	ha	0	BWP 96,430.75	1	1	BWP 0.00
8 (C)	Rehabilitation of processing waste deposits & evaporation ponds (acidic, metal-rich waste)	ha	1	BWP 280,080.59	0.8	1	BWP 245,216.16
9	Rehabilitation of subsidised areas	ha	0	BWP 64,831.31	1	1	BWP 0.00
10	General surface rehabilitation	ha	2	BWP 61,333.22	1	1	BWP 122,666.44
11	River diversions	ha	0	BWP 61,333.22	1	1	BWP 0.00
12	Fencing	m	0	BWP 69.96	1	1	BWP 0.00
13	Water management	ha	0	BWP 23,320.62	0.67	1	BWP 0.00
14	2 to 3 years of maintenance & aftercare	ha	5	BWP 8,162.22	1	1	BWP 40,811.08
15 (A)	Specialist study (overall quantified risk assessment)	SUM	1	BWP 85,737.56	1	1	BWP 85,737.56
15 (B)	Specialist study (water pollution potential study)	SUM	1	BWP 102,885.07	1	1	BWP 102,885.07
						Sub Total 1 (Sum of items 1 to 15 Above)	BWP 2,584,866.16

1	Preliminary and general	12% of Subtotal 1	**Weighting factor 2 (step 4.4)**	1.05	BWP 325,693.14
2	Administration & supervision costs	6.0% of Subtotal 1			BWP 155,091.97
3	Engineering drawings & specifications	2.0% of Subtotal 1			BWP 51,697.32
4	Engineering & procurement of specialist work	2.5% of Subtotal 1			BWP 64,621.65
5	Development of a closure plan				
6	Final groundwater modeling	2.5% of Subtotal 1			BWP 64,621.65
				Sub Total 2 (Subtotal 1 plus sum of management & administrative items, 1 to 6 above)	BWP 3,246,591.90
7	Contingency	10.0% of Subtotal 1			BWP 258,486.62
				GRAND TOTAL (Subtotal 2 plus contingency - excluding all taxes e.g. VAT)	**BWP 3,505,078.52**

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MORUPULE COLLIERY LTD
GENERAL SURFACE PLAN
PLANT AREA

SURVEY SYSTEM
PROJECTION : GAUSS CONFORM (LO SYSTEM)
ELLIPSOID : CLARKE 1880 MODIFIED
LO 27° EAST

LEGEND

- NEW / PROPOSED INFRASTRUCTURE
- RAILWAY LINE
- TELEPHONE LINE
- POWER LINE
- PIPE LINE
- FENCE
- ELECTRIC FENCE
- FIRE ASS. POINT
- FIRE HYDRANT
- TARRED ROAD
- GRAVEL ROAD/TRACKS
- BUILDINGS/STRUCTURES
- EXPLOSIVES MAGAZINE
- WATER BOREHOLE
- DAMS/SUMPS

0 50 100 200 300 METRES

DRAWING NO.	DESCRIPTION	DRAWING NO.	DESCRIPTION
REFERENCE DRAWINGS		REFERENCE DRAWINGS	

REV.	BY	DATE	REVISIONS	CHK.	DATE	S.L.	DATE
B	MdT	25.08.08	DRG No CHANGED FROM E2742-L101 TO C2824-L101				
A	MdT	28/07/08	ISSUED FOR INFORMATION ONLY				

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APPROVAL	SIGNATURE	DATE	

DRA MINERAL PROJECTS (Pty) Ltd.
BOX 3567 RIVONIA 2128
REPUBLIC OF SOUTH AFRICA
TEL No (011) 202 8600
FAX No (011) 202 8807/8

TITLE DEBSWANA DIAMOND COMPANY (PTY) LTD
MORUPULE COLLIERY EXPANSION PROJECT
FEASIBILITY STUDY – OPTION 2. RECOST
CONCEPTUAL BLOCKPLAN – LONGITUDINAL S/PILE

SIZE	DWG NO.	REVISION	SCALE
A0	C2824-L101		1:1000 U.O.S.