December 2009

MATLA COAL LIMITED

Matla Colliery Mine 2: Development of Rehabilitation Measures for Panels 6, 7 and 8

Submitted to:
Matla Coal Limited
Private Bag X5006
Kriel
2271

REPORT

Report Number: 11978-9326-1

Distribution:Distribution:

2 x Matla Coal Limited
1 x Golder Associates Africa (Pty) Ltd Library
1 x Golder Associates Africa (Pty) Ltd Project File

A world of capabilities delivered locally

Golder Associates

Executive Summary

Matla Colliery Mine 2 (Matla 2) is conducting short-wall underground mining of three local coal seams near Ogies, and approximately one year ago, mining of the bottom, final seam commenced. In the area where all three seams have been mined, final goaf (surface depression) settlement has now occurred, with the result that the process of rehabilitation of the area can commence.

During 2007, African EPA (Pty) Ltd (AEPA) conducted a rehabilitation feasibility investigation for the goaf area (areas 1 to 8) at Matla 2 (AEPA has since merged with Golder Associates Africa (Pty) Ltd). A basic framework for rehabilitation of standing water was determined and described in the feasibility design submitted to Matla. At present, the mine would like to proceed with implementation of the first phase of the suggested rehabilitation as soon as possible, and received approval of funding from Eskom to implement the work.

As mining along the entire Mine 2 area will be undertaken over planned life-of-mine (approximately another 30 years), the rehabilitation planning and design along the remainder of the area will be conducted as mining progresses and more information becomes available. The areas under consideration in this report are panels 6, 7 and 8 and the objective of this study is to devise rehabilitation measures to achieve the most appropriate/effective post-mining land use for the three goaf panels already mined and reshaped.

Due to the complex and unique nature of the problem it was decided to follow a hierarchical decision making process to integrate knowledge of expertise from different fields and achieve the most effective solution to the problem. From this interaction aims, drivers and rehabilitation options were developed.

The main aims and sub-aims for rehabilitation of the area are to:

- Prevent continued oxygen and water ingress into the underground workings through surface cracks and in so doing prevent
  - Underground fires.
  - Acid mine drainage by exposure to pyrite in mined-out areas.
- Ensure on-site soil stabilisation.
  - Ensure erosion stabilisation of soil.
  - Reinstate the land capability according to commitments.
- Prevent off-site effects due to on-site soil disturbance.
  - Prevent wetland sedimentation.
  - Maintain wetland ecology.
  - Prevent negative effects on downstream water quality.

After clearly establishing the aims for rehabilitation the drivers for the problem were identified and listed. The drivers causing continued oxygen ingress into the underground workings were determined to be:

- Continued settlement of the goaf area causing further cracking and widening of existing cracks;
- Occurrence of voids below backfill material pushed into cracks. Backfill material collapses or is washed into voids as backfill material settles and further cracking occurs; and
- Runoff from pillar portions collects in slight depressions caused by the crack resulting in the soil to becoming less consistent and then being washed into cracks.

The drivers for continued erosion are:

- Poor vegetative cover of the area;
- Steep and long side slopes;
- Mixed top and subsoil profiles resulting in poor physical properties with increased erosion potential;
- Long central drainage lines causing ephemeral gullies (concentrated flow erosion or Megarill erosion);
- Nick point along pillar area causing concentrated water follows; and
- Shallow soil depth on pillar area acting as a collection area for additional water causing increased erosion on side slopes.

The loss of land capability is driven by:

- Mixed top and subsoil profiles resulting in poor sub-soil material being mixed with high potential soils resulting in lower fertility and poor physical structure (crusting and compaction results);
- Land capability is limited due to the steepness of some slopes;
- Erosion reduces land capability;
- Soil loss due to crack filling and erosion limits the quantity of soil available to improve land capability; and
- Pillar areas have little or no soil to act as growth medium.

From these drivers the main rehabilitation actions required were determined to be:

- Filling side cracks;
- Preventing rill and gully erosion; and
- Reinstate the land capability according to commitments.

Alternatives for each of these were suggested and their appropriateness for implementation must now be determined together with the rehabilitation team of Matla. Ongoing monitoring of rehabilitation will be a further requirement.

The first step requiring urgent attention is to address the oxygen and water ingress into the underground workings. Once this has been addressed the on-site stabilisation of the soil can be addressed by aggressively vegetating the area. Vegetation of the area can not commence until any major soil disturbance to address the crack formation has been stopped. Together with the stabilisation of the site the land capability will be protected and managed.

Table of Contents

TABLES

No table of figures entries found.

FIGURES

APPENDICES

1.0 INTRODUCTION

Matla Colliery Mine 2 (Matla 2) is conducting short-wall underground mining of three local coal seams near Ogies, and approximately one year ago, mining of the bottom, final seam commenced. In the area where all three seams have been mined, final goaf (surface depression) settlement has now occurred, with the result that the process of rehabilitation of the area can commence.

During 2007, African EPA (Pty) Ltd (AEPA) conducted a rehabilitation feasibility investigation for the goaf area (areas 1 to 8) at Matla 2 (AEPA has since merged with Golder Associates Africa (Pty) Ltd) (Appendix A). A basic framework for rehabilitation of standing water was determined and described in the feasibility design submitted to Matla. At present, the mine would like to proceed with implementation of the first phase of the suggested rehabilitation as soon as possible, and received approval of funding from Eskom to implement the work.

As mining along the entire Mine 2 area will be undertaken over planned life-of-mine (approximately another 30 years), the rehabilitation planning and design along the remainder of the area will be conducted as mining progresses and more information becomes available. The areas under consideration in this report are panels 6, 7 and 8 and the objective of this study is to devise rehabilitation measures to achieve the most appropriate/effective post-mining land use for the three goaf panels already mined and reshaped.

2.0 DEVELOPMENT OF REHABILITATION MEASURES

Due to the complex and unique nature of the problem it was decided to follow a hierarchical decision making process to integrate knowledge of expertise from different fields and achieve the most effective solution to the problem. The process follows the following stepwise approach:

- Collect background information;
- Conduct a workshop to develop a clear understanding of the problem, its drivers and potential solutions;
- Develop a site conceptual model presenting a clear understanding of the problem;
- Develop a list of potential remediation solutions;
- Establish criteria for effectiveness of remediation solutions; and
- Rate options according to its potential to achieve set criteria.

2.1 Workshop methodology

A workshop was held with the mine personnel and the other members of the project team to discuss the different aspects that need to be considered for the most effective rehabilitation measures for the rehabilitation of panels 6, 7 and 8 at Matla Colliery Mine 2.

The members present at the workshop:

Present	Representing	Contact Details
Carl Steyn (CS), Chairman	Golder Associates	csteyn@golder.co.za
Andre Cronje (AC)	Matla Colliery	AndreF.Cronje@exxaro.com
Danie Otto (DO)	Golder Associates Golder Associates	dotto@golder.co.za
Albert van Zyl (AvZ)	Golder Associates	avanzyl@golder.co.za
Brian Dawson	Reveg BLD	brian.dawson@iafrica.com

Present	Representing	Contact Details
Tanya Kemp (TK),	Golder Associates	tkemp@golder.co.za

A hierarchical decision making process was used during the workshop. This type of process is useful for teams of experts from different fields working on complex problems, with limited available information about the potential success of particular alternative solutions. The first step is to model the problem as a hierarchy. In doing this the aspects of the problem are explored from general to detail. As the group work to build the hierarchy, the understanding of the problem, its context, and each others views are increased.

A discussion and field trip was conducted to develop a common understanding to the background of the problem. Detail gained from this and other sources is presented in the background section above. Following this the three main questions addressed during the work shop were Why, What and How.

- Why the project is required? To establish clear aims for rehabilitation work required,
- What causes the problem? Develops a common understanding of the causes or main drivers of the problem, and
- How to address the problem? Generate alternative solutions to the problem taking into account the drivers and objectives to be achieved.

Following the workshop a clear understanding of the problem and alternatives was obtained. Brian Dawson presented a written report which has been incorporated into this document. Evaluation and selection of alternatives are then explored further in this report.

The overall process for this workshop is as follows:

- Establish clear rehabilitation aims.
- Determine the main drivers of problem.
- List rehabilitation options.

Results are recorded and this document then builds on the workshop to establish a number of alternative rehabilitation options. Results of this workshop are presented in a hierarch of aims, sub-aims and drivers for rehabilitation.

3.0 ENVIRONMENTAL BASELINE SITUATION

3.1 Mineral Deposit and Mining Method

The Matla Colliery mineral deposit forms part of the Highveld Coal Field. The coal seams are found within the Vryheid Formation of the Karoo Supergroup and are numbered from the bottom upwards. The stratigraphic sequence within the Matla area includes five coal seams that are numbered from the bottom upwards from 1 to 5. Economic reserves are found in the 2 seam, 4 seam (lower) and the 5 seam. The seam depths vary but are on average 35-50 m, 75-85 m and 100-120 m below surface for the 5 seam, 4 seam and 2 seam respectively. For panel 6, 7 and 8 only 2 and 4 seem is mined using the Total Extraction and board and pillar method. The total extraction results in the collapse of the land surface by between 5 and 8 meters as the roof supports are withdrawn, within a panel approximately 120 meters wide. A continuous pillar is left intact between adjacent mining panels approximately 60 meters wide which is mined by bord and pillar method.

3.2 Geology

The Karoo Supergroup in the Matla area comprises the Ecca Group and the Dwyka Formation. The Ecca sediments consist predominantly of sandstone, siltstone, shale and coal. Combinations of these rock types are often found in the form of interbedded siltstone, mudstone and coarse-grained sandstone. The Ecca sediments overlie the Dwyka Formation. The latter consists of a proper Tillite, sandstone and sometimes a thin shale development. The upper portion of the Dwyka sediments may have been reworked, in which case carbonaceous shale and even inclusion of coal may be found. The Dwyka sediments are underlain by felsitic rocks of the Bushveld Complex. The surface geology for panel 6, 7, and 8 is considered to be sandstone of the Ecca sediments with dolerite intrusions.

3.3 Climate

Matla Colliery is located in an area that is characterised by warm to hot summers and cool winters. Temperatures in the vicinity of the mine vary from 26˚C in the summer to 15˚C in the winter.

Most precipitation occurs over the period November to January with an average of approximately ninety rain days per annum. Rainfall over the period May to September is generally low or absent, with a noticeable increase in the months of October to April. Rainfall events in the region occur mainly in the form of thunderstorms and heavy showers. Annual rainfall values range from 550 mm-800 mm with an average of approximately 754 mm per annum.

3.4 Topography

The surface elevations within the Matla Colliery mining area lies between 1 565 to 1650 mamsl, and the area consists of gently rolling hills and valleys draining toward the north. The slope of the area varies between three to eight percent (3% - 8%) and between zero to three percent (0%-3%). The slope length varies from 500 meters to 1000 meters. The slope shape varies from convex to concave. In various areas, the topography has been altered due to surface subsidence of undermined areas. Surface subsidence has resulted in uneven topography, which in some places has resulted in the formation of ponds and wetlands.

In the panel 6, 7 and 8 area two water sheds and two low lying drainage areas are found as indicated in Appendix A. New contour maps are unavailable at present but goaf areas run across the main drainage lines resulting in a series of high points and valleys running perpendicular to the main drainage patterns.

3.5 Soils

The major soil forms encountered in the area include those of the orthic phase, Hutton, Clovelly, Griffin, Glenrosa, and Man-Made Soils along with the hydromorphic forms, including the Pinedene, Avalon, Bonheim, Bloemdal, Westleigh, Rensburg and Kroonstad. The overall soil types defining the area are of sandy-clay to loam and sandy-clay to clay nature. The soils derived from the sediments (Ecca Group) are of a sandy loam to sandy clay loam nature.

On average, the Hutton and Clovelly Soil Forms return rooting depths between 200 mm and greater than 1000 mm, while the Pinedene, Avalon and Bloemdal returned depths of between 200 mm and 800 mm. The hydro-morphic soils forms return shallower rooting depths of between 100 mm and 400 mm.

On panel 6, 7 and 8 there are upland areas and low lying areas. In the low lying areas vertic type soils are found and the upland areas have deep red soils probably of the Hutton form.

3.6 Land Capability

The land capability within the Matla Colliery area is predominantly of a grazing and agricultural capacity. Wetlands along the Rietspruit occur, and small pans, as a result of previous subsidence events also occur within the mining right area. Small wilderness areas do also occur.

According to the EMPR, June 2006 the land capability objective is: “To keep the area to be disturbed to a minimum and to restore disturbed land to its pre-disturbance potential.”

3.7 Land Use

The predominant land uses in the area are framing activities, mining infra-structure, Eskom Power Stations and wetland/ watercourses. The farming activities in the area are predominantly grazing and crop lands (predominantly maize farming). Selected industrial activities, including mining (Matla and Kriel Collieries) and power/electricity supply via the power stations, also occur. The riparian zone of the watercourse and some pans in the area can be described as wetlands.

Land cover for the area in which Matla Colliery occurs includes temporary cultivated commercial dry-land and unimproved grassland. Mining areas occur to the east and north east of Matla Colliery. Some wetland areas occur within the Matla Colliery mining right area.

According to the EMPR, June 2006 the land use objective is: “To minimize the disturbance of grazing and agricultural land and to restore the disturbed areas to grazing land.”

The original land use of area 6, 7 and 8 is largely arable land with some portions indicated as grazing land.

3.8 Natural vegetation

The vegetation falls within the Eastern Highveld Grassland vegetation types and is slightly to moderately undulating plains, including some low hills and pan depressions. The vegetation is short dense grassland dominated by the usual highveld grassland composition with small scattered rocky outcrops with wiry, sour grasses and some woody species. Also Veld Types 61, Bankenveld and 52, Themeda Veld or 35, Rocky Highveld Grassland and 38, Sandy Highveld Grassland. This is a broad classification of the vegetation of the area within which the wetlands mostly associated with drainage lines, from an integral part but which differ in plant species characteristics and composition, due mostly to differing edaphic and soil moisture conditions.

Although the fields on the crests and upper slopes tend to be on sandy soils, turf clay generally occurs along the drainage lines, forming a catena along the slopes. The vegetation exhibits a narrow to broad ecotone between the fields and the wetlands according to this catena, but the boundaries are mostly obscured by years of grazing and trampling, making delineation of the wetland difficult.

According to Mucina and Rutherford et al. (2006) this vegetation type is endangered and only a small fraction is conserved in statutory reserves. Endangered vegetation types have lost up to 40% of their original extent and are exposed to partial loss of ecosystem function. Planting indigenous vegetation on the areas to be rehabilitated and considering biodiversity establishment in the rehabilitation plan, will add value the effective ecosystem functioning on site as well as off-site.

3.9 Rehabilitation actions to date

As mentioned previously the mining method results in a continuous “pillar” being left intact between adjacent mining panels. As the mined panel collapses, a crack develops along the headwall of the panel when the initial surface collapse occurs or is initiated. Thereafter, a longitudinal crack develops on either side of the panel where the undermined parting and overburden shears away from the in situ “pillar” strata. As the collapse front moves away from the headwall, a series of cross-cracks parallel with the headwall occurs across the breadth of the panel as the panel progressively collapses behind the mining advance.

These cracks, and in particular the headwall and longitudinal cracks, allow the ingress of oxygen to the subsurface coal seams in the pillar areas, and spontaneous combustion can and does occur. The cross-cracks tend to close themselves up, as there is no height differential once successive portions have collapsed, and both sides of the crack consist of fractured ground. The cracks are most pronounced along the interface between fractured and intact material.

The mine has addressed the issue of the cracking in Panels 6, 7 and 8, in order to try to prevent or limit spontaneous combustion, by:

- Stripping the soils from the panel surface prior to mining and collapse, and stockpiling the soil in windrows on top of the longitudinal pillar areas;
- Allowing the initial subsidence to occur post-mining;

- Using the stockpiled soil to backfill the cracks, while at the same time shaping down the edges of the pillars (longitudinal high-walls) to provide a continual gradient between the landscape crests (highest point above the centre of the pillar) and the landscape troughs (lowest point generally running along the centre of each panel, though the use of large bulldozers;
- Pushing the remaining soil back across the collapsed panel surfaces.

However, as the mined areas continue to settle, the cracks re-open in places, due to the backfill soil collapsing through or washing through into deeper recesses. When this happens, more soil from the adjacent panel surface or from the crest area is pushed in to close up the cracks. This process could potentially continue indefinitely.

This results in:

- The soil cover over the surface of the collapsed panels is highly disturbed due to the stripping and replacement, and the subsequent borrowing for re-filling of cracks after they re-open;
- The effective overall depth of soil cover is reduced due to the volume of material that is used to backfill the cracks, and is effectively “lost” as soil;
- The agricultural potential of the panel areas (and the relatively narrow crests) has been significantly reduced overall, in that previously arable areas will no longer be able to support agricultural activity due to massive soil disturbance. The best possible new land-use post-rehabilitation will be grazing, which represents a down-grading of land-use on those areas which were previously arable;
- Sub-surface sandstone bands are exposed, and the soil layers above the sandstone are significantly reduced through the shaping down of the longitudinal highwall edges, so that successful vegetation establishment on those areas will be extremely difficult.

The manner in which these areas (Panels 6, 7 and 8) have been treated has resulted in a highly disturbed land surface where there is presently very little vegetation cover due to the repeated disturbance, and where rehabilitation is urgently required in order to conserve what remains of the topsoil, and to restore the area to some form of ecosystem and agricultural functionality.

4.0 REHABILITATION AIMS FOR PANELS 6, 7 AND 8

The first step in the decision making process is to set clear aims and sub-aims that the rehabilitation should achieve. Appendix B presents the hierarchy. The main aims and sub-aims for rehabilitation of the area are to:

- Prevent continued oxygen and water ingress into the underground workings through surface cracks and in so doing prevent underground fires
- Ensure on-site soil stabilisation.
  - Ensure erosion stabilisation of soil.
  - Reinstate the land capability according to commitments.
- Prevent off-site effects due to on-site soil disturbance.
  - Prevent wetland sedimentation.
  - Maintain wetland ecology.
  - Prevent negative effects on downstream water quality.

5.0 THE MAIN DRIVERS AND CRITICAL ISSUES OF THE PROBLEM

After clearly establishing the aims for rehabilitation the drivers for the problem were explored (Appendix B). The aim to prevent off-site effects is driven by the on-site stabilisation of soil and is therefore will be achieved if on-site drivers are addressed. This aim is therefore not explored further.

5.1 Drivers for continued oxygen and water ingress into underground workings

The drivers causing continued oxygen ingress into the underground workings were determined to be:

- Continued settlement of the goaf area causing further cracking;
- Occurrence of voids below backfill material pushed into cracks. Backfill material collapses or is washed into voids as backfill material settles and further cracking occurs; and
- Runoff from pillar portions collect in slight depressions caused by the crack resulting in the soil to becoming less consistent and then being washed into cracks.

These drivers are presented in a conceptual model in Figure 1. Figure 2 presents a photograph of a crack where fill material has fallen into the void as a result of continued settling and lack of support below the fill material. Figure 3 presents a photograph of where the crack has opened as a result of water ingress into the crack. Figure 4 shows the pooling of water in the slight depression of the crack which in time will wash the fill material down the crack and opening it. Figure 5 shows an aerial view of cracks that have been washed open. Lateral cracks in the geological material also occur but these have been successfully covered through the movement of soil.

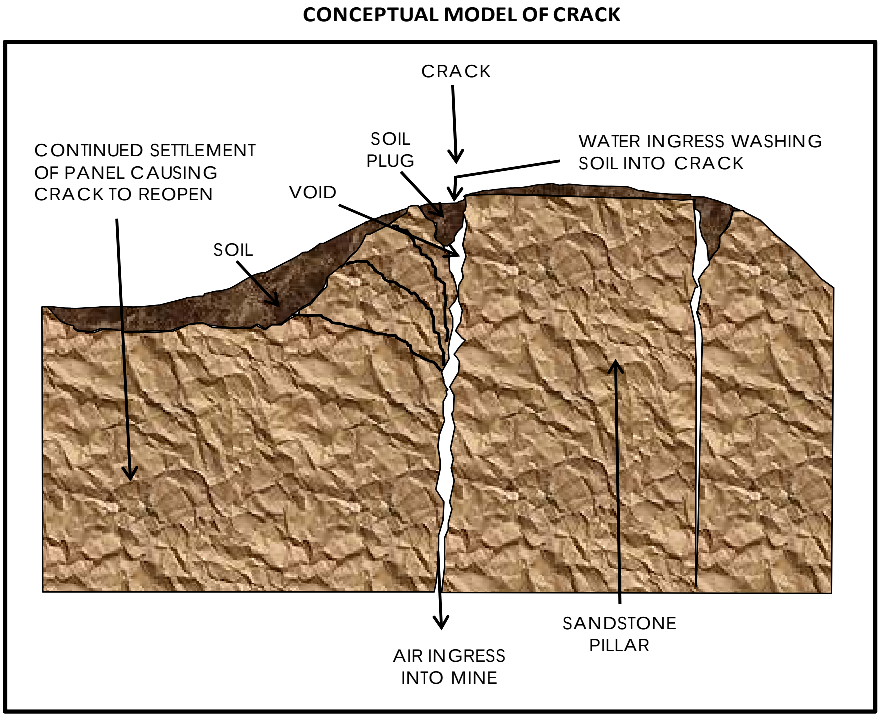


Figure 1: Conceptual model presenting drivers for continued crack formation

Figure 2: Crack where fill material has fallen into the void

Figure 3: Crack where fill material was washed into the void

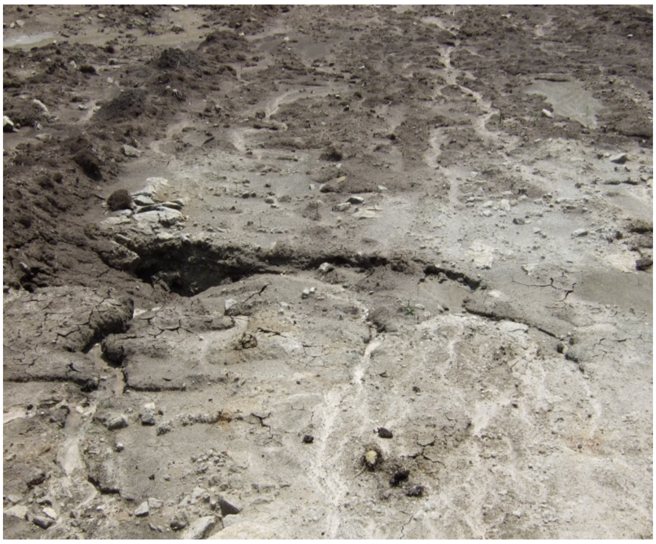


Figure 4: Slight collection of water which will result in soil material being washed into the void

Figure 5: Aerial view of continued crack formation

5.2 Drivers for soil erosion

Rill and gully erosion are the two main types of erosion on the goaf areas (Figure 6 and 7).

Figure 6: Rill erosion on side slopes

Figure 7: Gully erosion on main drainage lines

This erosion is driven by:

- Poor vegetative cover of the area;
- Steep and long side slopes;
- Mixed top and subsoil profiles resulting in poor physical properties with increased erosion potential;
- Long central drainage lines causing ephemeral gullies (Concentrated flow erosion, Megarill erosion or erosion occurring in the main channels in a field);
- Nick point (point where a sharp change in base level for erosion occurs) along pillar area causing concentrated water follows; and
- Shallow soil depth on pillar area acting as a collection area for additional water causing increased erosion on side slopes.

5.3 Drivers for loss in land capability

The loss of land capability is driven by:

- Mixed top and subsoil profiles resulting in poor sub-soil material being mixed with high potential soils resulting in lower fertility and poor physical structure (crusting and compaction results);
- Land capability is limited due to the steepness of some slopes;
- Erosion reduces land capability;
- Soil loss due to crack filling and erosion limits the quantity of soil available to improve land capability; and
- Pillar areas have little or no soil to act as growth medium.

Figure 8 shows the mixing that occurred during soil movement and Figure 9 the effect of this mixing of soil on weed growth.

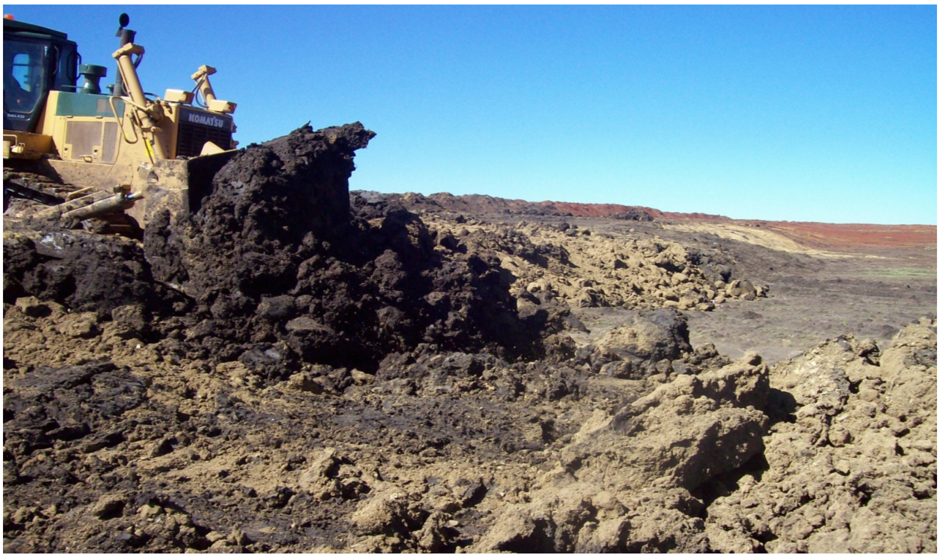


Figure 8: Soil mixing during soil movement

Figure 9: Poor vegetation establishment on areas were subsoil has been placed on surface

6.0 REHABILITATION OPTIONS

The main rehabilitation actions required are:

- Filling side cracks;
- Preventing rill and gully erosion; and
- Reinstate the land capability according to commitments.

A good land capability can not be established until the erosion is curbed and the erosion will continue if the soil is continually disturbed to fill the ongoing cracking. The crack rehabilitation has therefore become the critical rehabilitation process to complete first although originally erosion was considered the main rehabilitation focus.

6.1 Rehabilitation of side cracks

The first step to rehabilitation of the area is to fill and stabilise cracks to prevent oxygen and water ingress into the mine. To be successful the rehabilitation measures for crack filling should as a minimum achieve:

- Sufficient closure of the cracks to preventing oxygen or water entering the mine; and
- Prevent the crack continually opening.

Some alternatives rehabilitation measures discussed for the side cracks are:

- Continue filling the cracks as is currently the case.
- Use clay material to fill cracks while compacting the clay, as is being practiced in the wetland area.
- Excavate the crack areas that have opened with an excavator. Insert a bidim geotextile material into the void. Slowly fill with soil / clay material while carefully compacting the material held up by the bidim material.
- Chip rock material from the nick point of the sandstone into the cracks shaping the edge down. Then fill with graded gravel material. Place the bidim layer on this and fill with gravel which may or may not have a drain in. Place soil to act as a growth medium on top.
- Place a small bund wall to keep water from running into the cracks on the pillar area. Ponding of water on the top should however be prevented. This can be combined with any of the above methods of rehabilitation.

Crack backfilling needs to take place against a limiting boundary of sorts, so that some degree of compaction of the backfill can be achieved, and the backfill material is prevented from falling through into deeper recesses. Currently there is no clear understanding of the crack geometry as only surface assessments have been conducted. Designing a sustainable fill method is therefore difficult and at this stage only preliminary ideas are presented. More information on shape and depth of the crack is required to design the best possible methodology. This design would include a soil assessment, geotechnical material assessment and materials balance to obtain the most appropriate design and materials required.

While the crack design is being completed treatment of further cracking in the areas already treated should be conducted using an excavator (such as a TLB) in order to limit the area of future surface disturbance (this is already the mine's plan and intention). The effort and disturbance should thus be concentrated along the crack lines, with treatment of those areas where crack development occurs (areas of instability). Areas where the cracks have already been effectively closed up using the dozing method can be left, unless they start to show signs of collapse, in which case they can be treated on a localized basis. Regular inspection of the crack-lines will be required, particularly after rains, so that areas where crack-development is starting can be identified and treated at an early stage.

6.2 Rehabilitation of side slope rill erosion

From the Matla Colliery EMPR Amendment dated June 2006 stats that to ensure the prevention of erosion, control measures are required on all slopes exceeding 2% and engineered erosion control measures are required on all slopes exceeding 15%.

The main driver for the rill erosion that can be prevented is poor soil cover and continued soil disturbance. The main focus of rehabilitation measures is to address the soil cover and some alternatives discussed are:

- Continued soil disturbance must cease for all alternatives;
- Natural revegetation with no active seeding;

- Establish a quick-growing pasture grass cover. Till on contour to provide a rough surface. On steeper areas silt fences may be required to provide additional surface stabilization. Normal agricultural equipment can be used for this;
- Use the hydroseeding method;
- Use bunds on the pillars to prevent water running onto the side slopes but should be drained along the pillars. This option can be used together with any of the above option.

The topsoil (organically rich A soil horizon) was not stripped and stockpiled separately from the sub-soil, and as a result the replaced soil is a mixture of top- and sub-soil, and also appears to be a mosaic of different soil types (oxidized ferralitic soils [red] and dark bottomland soils). In order to reduce the loss of soil through erosion, it is necessary to actively establish vegetation, to speed up the establishment process. This will best be achieved through the use of agricultural equipment and the establishment of a quick-growing pasture grass cover. The establishment of contours will not be feasible due to poor contour precision and differential settlement of the subsidence. Contours will then result in pooling and subsequent erosion. Increasing the surface roughness should be sufficient to control the slope length.

Virtually all the site appears to be accessible and workable using a large four-wheel drive tractor. There may be a few localized areas where the slopes are too steep for tractor access (?>1:3 slope), and handseeding can be undertaken on these limited sections. Access will be a serious limitation should hydroseeding be considered as the rehabilitation method, as the unconsolidated soils of the panel surfaces will not be suitable for traditional truck-mounted hydroseeder access.

The soil-covered areas need to be tilled on contour using a large tractor and cultivator / tiller, in order to provide a rough rilled surface. It will be necessary to establish soil fertility requirements through soil-testing, but it is anticipated that a moderate lime application (5 tons per hectare?) and a general balanced fertilizer application (2:3:2[22] or 3:2:1[25] at 500 kg/ha?) will be required. Soil testing should identify if there are any soil nutrient deficiencies, or if any particular elements need to be supplemented. Local experience with rehabilitation or local agricultural practices can also be used to guide soil amendment and fertilization requirements.

Required lime and fertilizers can be applied by broadcasting with agricultural spreaders, and a suitable grass seed mixture sown also by broadcasting. On steeper slopes where tractor access might be prohibited, the rilling can be done by hand, as well as the lime and fertilizer application and seeding. On these steeper areas, the use of silt fences may be required to provide additional surface stabilization.

Once grazing has been established good grazing and fire management should be put in place to ensure continued good soil cover.

6.3 Rehabilitation of erosion on central gullies

- Aggressively vegetate the area as for the side slopes;
- Develop a series of small ponds along the drainage line to serve as sediment traps, to reduce the speed of run-off flow, and allow the establishment of wetland vegetation which will have a filtering and cleaning effect on water quality. Rock rip-rap (medium to large boulders) should be used in the water courses on the more steeply graded areas where scour and erosion occurs, to stabilize the floor of the channel and reduce the flow rate of the water in these areas. The rip-rap will also provide a suitable environment for the establishment of vegetation which will also serve to stabilize the watercourse and improve run-off water quality.
- Use rock rip-rap or other material for the entire drainage line which will safely channel water down the slope into the free draining areas constructed at the valley bottoms.
- Redirect the flow path in the central drainage line through barriers to reduce the speed of run-off flow. Revegetate the area as for the side slopes.

Run-off water will drain to the bottom of the slopes (which is generally along the centre line of the panels), and then drain along the panels in the downslope direction. Concentration of the water in the drainage lines could result in development of erosion gullies.

Although it is a general requirement that rehabilitated areas should be left free-draining, it is recommended that a series of small ponds be left along the drainage lines to serve as sediment traps, to reduce the speed of run-off flow, and allow the establishment of wetland vegetation such as *Typha capensis* (bulrushes) and sedges which will have a filtering and cleaning effect on water quality.

Rock rip-rap (medium to large boulders) should be used in the water courses on the more steeply graded areas where scour and erosion occurs, to stabilize the floor of the channel and reduce the flow rate of the water in these areas. The rip-rap will also provide a suitable environment for the establishment of vegetation which will also serve to stabilize the watercourse and improve run-off water quality.

6.4 Improve land capability

The land capability is mostly affected by the continued erosion on the site. This should be stabilised as a priority before any specific land use is considered. Some alternatives that were considered are:

- Liming and fertilisation of the area. This can be applied separately or together with other alternatives.
- Leave the panel area with limited soil as is presently the case.
- Rework slopes to apply more soil on the crest areas.

Other more productive land uses can be considered such as plantations (e.g. fruit or olive plantations) but this should be done once the initial stabilization of the soil cover has been achieved through the development of a basic grass cover. It must further be recognized that permits will be required for any major land use transformation.

Practically only limited soil can be placed on the crest areas and land capability will remain limited. However, the area between the crests can be utilised successfully for grazing purposes. The slope areas should be covered and stabilised more aggressively to prevent continued degradation and decrease in land capability.

7.0 ONGOING MONITORING

Monitoring is essential but often-neglected components of good practice rehabilitation. The principal purposes of monitoring is to confirm that rehabilitation operations have been carried out according to agreed procedures, to provide data in support of continuous improvement, to evaluate whether objectives are being met and to assess long-term sustainability of rehabilitated areas. Good rehabilitation monitoring programs have four components:

- Baseline and ongoing monitoring of unmined reference areas established during pre-mining mapping and surveys, to define the values that need to be protected or replaced;
- Documentation of the rehabilitation procedures carried out – details of topsoil sources and handling methods, seed mix composition, rates and application methods, densities of species planted and so on – which are all critical for interpreting the findings of later rehabilitation monitoring results;
- Initial establishment monitoring, which serves as a quality control step – this is carried out soon after rehabilitation establishment operations have been completed and records whether they have been carried out as required and whether initial establishment has succeeded – followed by establishment targets and standards that, if not met, require that specified corrective actions be undertaken; and
- Long-term monitoring, which commences usually two to three years later and which evaluates the progress of rehabilitation towards fulfilling long-term land use objectives as well as providing the information needed to determine whether the rehabilitated ecosystem would be sustainable over the long term.

The rehabilitation plan provisions should be time-bound and should take into account opportunities for progressive rehabilitation and closure. From a biodiversity conservation and re-establishment perspective, it is particularly important that the extent of disturbed areas is minimized at any point in time. Rehabilitation plans should be reviewed periodically as further information on site conditions becomes available and as new rehabilitation procedures are developed.

8.0 DISCUSSION ON THE WAY FORWARD

The aims, drivers and rehabilitation actions required were determined and alternatives for rehabilitation discussed. The first step requiring urgent attention is to address the oxygen and water ingress into the underground workings. Once this has been addressed the on-site stabilisation of the soil can be addressed by aggressive vegetation the area. Vegetation of the area can not commence until any major soil disturbance to address the crack formation has been stopped. Together with the stabilisation of the site the land capability will be protected and managed.

9.0 REFERENCES

- Authors unknown (2006): Good Practice Guidance for Mining and Biodiversity, International Council on Mining and Metals.
- Mucina, L. & Rutherford, M. (2006): The Vegetation of South Africa, Lesotho and Swaziland. p.400 - p.401 and p.730- p.731. SANBI, Pretoria.
- GCS (Pty) Ltd. (June 2006): Environmental Management Plan Programme Report Amendment, Volume 1. 2004.01.06

CE Steyn Rehabilitation Scientist	C van Renssen Reviewer

CES/CvR/CES

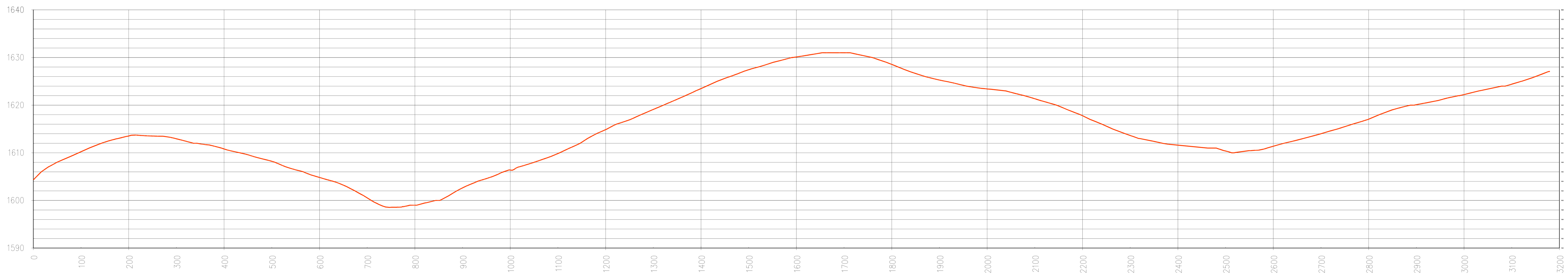
Reg. No. 2002/007104/07

Directors: FR Sutherland, AM van Niekerk, SAP Brown, L Greyling, SM Manyaka

p:\projects\11978 - matla ii mine rehabilitation master plan\reports\11978 matla coal mine ii development of rehabilitation measures for panels 6 7 and 8 draft 2009-12-04.docx

APPENDIX A

Profile map of Matla 2 panels 6, 7 and 8



REVISION	DESCRIPTION	CHECKED INITS	CHECKED DATE	APPROVED INITS	APPROVED DATE
T01	GUAF 6,7 & 8 TEXT MOVED TO NEW POSITION	JVDW	09/12/4		

REFERENCES

REF. No.	DESCRIPTION
	LIST OF DRAWINGS

VERIFY SCALES

BAR IS 20mm ON ORIGINAL DRAWING

0 —— 20mm

IF NOT 20mm ON THIS SHEET, ADJUST SCALES ACCORDINGLY

Golder Associates Africa (Pty) Ltd
MIDRAND OFFICE
Thandanani Park, Matuka Close, Midrand
P O Box 6001, Halfway House, 1685
South Africa
Tel: +(27)(0)11 254-4800
Fax:+(27)(0)11 315-0317
http://www.golder.co.za

CLIENT: EXXARO – MATLA COAL

DRAWN	DATE	DRAWING MANAGER	DATE
JVDW	06/2008	ADV	06/2008
DESIGN ENGINEER: CVR			06/2008
REVIEW ENGINEER: JJ	06/2008	PR. ENG. No.	
PROJECT MANAGER: CVR	06/2008	SCALE: 1:7500	

PROJECT: MATLA GOAF REHAB PH1

DRAWING TITLE: GENERAL ARRANGEMENT PLAN

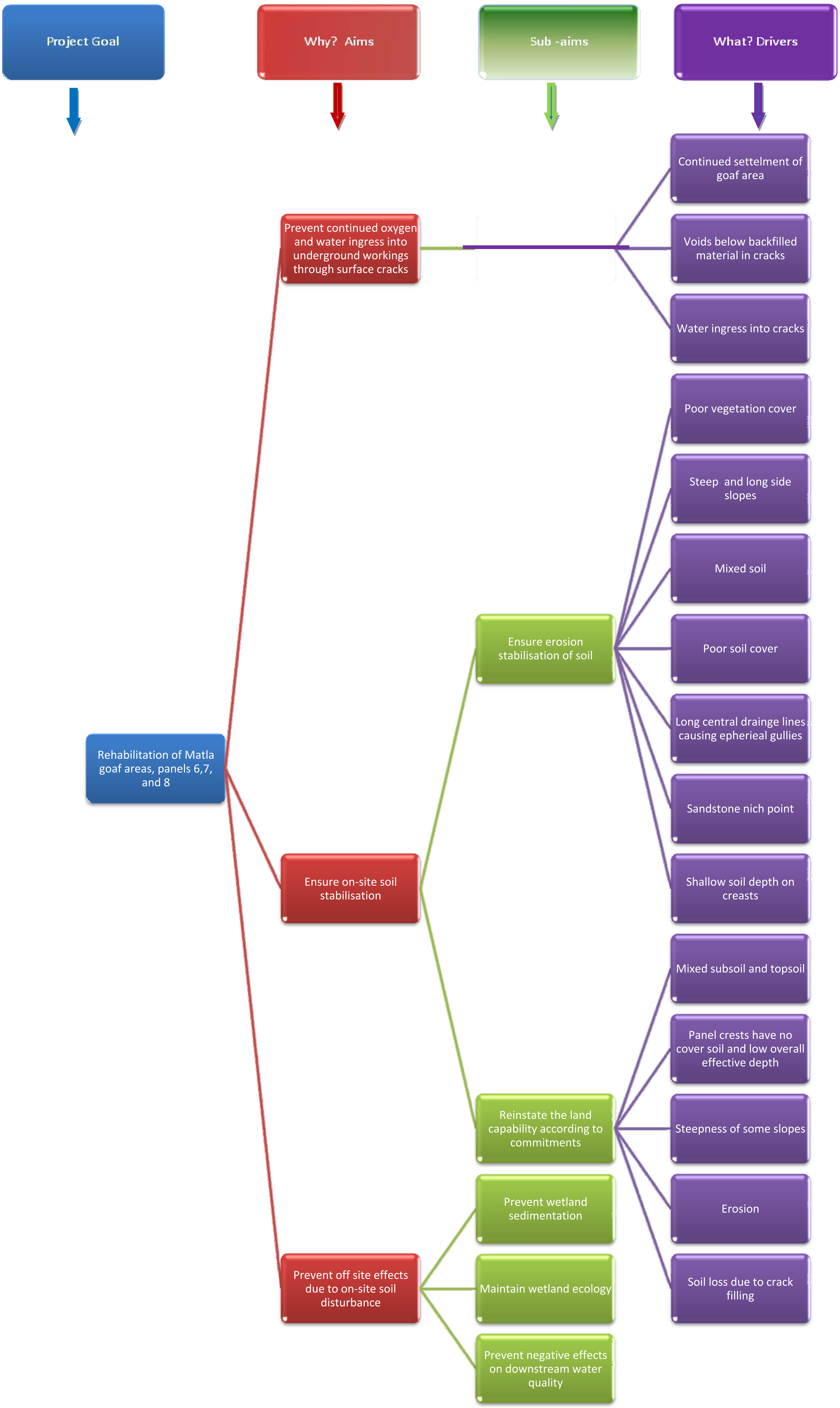
PROJECT No	DRAWING No	REVISION
11593	11593-200-10-L07	T01

A0

P:\Projects\11978 – Matla II Mine rehabilitation master plan\Info Received\11593-200-10-L07.dwg Dec 04, 2009 – 9:13am

APPENDIX B

Hierarchy of decision making for Matla 2 panels 6, 7 and 8



Project Goal
Why? Aims
Sub -aims
What? Drivers
Continued settlement of goaf area
Prevent continued oxygen and water ingress into underground workings through surface cracks
Voids below backfilled material in cracks
Water ingress into cracks
Poor vegetation cover
Steep and long side slopes
Mixed soil
Ensure erosion stabilisation of soil
Poor soil cover
Long central drainge lines causing epherieal gullies
Rehabilitation of Matla goaf areas, panels 6,7, and 8
Sandstone nich point
Ensure on-site soil stabilisation
Shallow soil depth on creasts
Mixed subsoil and topsoil
Panel crests have no cover soil and low overall effective depth
Reinstate the land capability according to commitments
Steepness of some slopes
Prevent wetland sedimentation
Erosion
Prevent off site effects due to on-site soil disturbance
Maintain wetland ecology
Soil loss due to crack filling
Prevent negative effects on downstream water quality

APPENDIX C

Document Limitations

DOCUMENT LIMITATIONS

This Document has been provided by Golder Associates Africa Pty Ltd ("Golder") subject to the following limitations:

i) This Document has been prepared for the particular purpose outlined in Golder's proposal and no responsibility is accepted for the use of this Document, in whole or in part, in other contexts or for any other purpose.

ii) The scope and the period of Golder's Services are as described in Golder's proposal, and are subject to restrictions and limitations. Golder did not perform a complete assessment of all possible conditions or circumstances that may exist at the site referenced in the Document. If a service is not expressly indicated, do not assume it has been provided. If a matter is not addressed, do not assume that any determination has been made by Golder in regards to it.

iii) Conditions may exist which were undetectable given the limited nature of the enquiry Golder was retained to undertake with respect to the site. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the site which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.

iv) In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. Golder's opinions are based upon information that existed at the time of the production of the Document. It is understood that the Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

v) Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either express or implied, that the actual conditions will conform exactly to the assessments contained in this Document.

vi) Where data supplied by the client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated. No responsibility is accepted by Golder for incomplete or inaccurate data supplied by others.

vii) The Client acknowledges that Golder may have retained sub-consultants affiliated with Golder to provide Services for the benefit of Golder. Golder will be fully responsible to the Client for the Services and work done by all of its sub-consultants and subcontractors. The Client agrees that it will only assert claims against and seek to recover losses, damages or other liabilities from Golder and not Golder's affiliated companies. To the maximum extent allowed by law, the Client acknowledges and agrees it will not have any legal recourse, and waives any expense, loss, claim, demand, or cause of action, against Golder's affiliated companies, and their employees, officers and directors.

viii) This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Golder accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

GOLDER ASSOCIATES AFRICA (PTY) LTD

At Golder Associates we strive to be the most respected global group of companies specialising in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organisational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Africa (Pty) Ltd
PO Box 13776, Hatfield, 0028
Ditsela Place
1204 Park Street
Hatfield, Pretoria
Gauteng
South Africa
T: [+27] (12) 366 0100

Golder Associates