MINERAL RESOURCES TASMANIA

REHABILITATION OF ABANDONED ALLUVIAL TIN MINES

Stage 1- Rehabilitation Concept Plans

Prepared By

SEMF

&

Southern Environmental Services

Project No: 13193
November 1997

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background

Following the establishment of the Rehabilitation of Mining Lands Trust Fund, Mineral Resources Tasmania (MRT) have reviewed a number of the states abandoned mine sites and developed a priority list of sites requiring rehabilitation.

The first of these sites to be addressed are located in north east Tasmania, where up until the early 1970's extensive alluvial tin mining operations were undertaken. Unfortunately a number of these operations did not undertake appropriate rehabilitation measures resulting in estimates of over 2,500 hectares of disturbed land across the north east.

In order to facilitate the fast, effective completion of rehabilitation activities MRT have engaged SEMF to prepare rehabilitation concept plans for degraded areas at Monarch, Endurance and Star Hill mines (Stage 1), prior to the development of formal rehabilitation designs (Stage 2) and the management of rehabilitation works (Stage 3).

This report is concerned with the completion of the first stage of site activities, and covers the following;

- preparation of site evaluation methodology,
- completion of detailed site inspections,
- initial consultation and discussions with key stakeholders,
- determine rehabilitation management programs, and
- provide recommendations on areas to be rehabilitated.

1.2 Stakeholder Consultation

Community participation is an integral component within this project because of the public safety issues involved, and the need to have some form of community ownership in the process. Success of the program including, the employment of local residents, approval of Council and involvement of interest groups, is essential if the rehabilitation program is to succeed.

From the onset of Stage 1 activities all works have been developed in close conjunction with the program managers, MRT and Environment Tasmania (ET) and the regional stakeholders.

Initial site inspections completed by SEMF staff (October 29-31) identified key community and social groups within the Gladstone region who utilising concerned mine areas. These groups including local tourist operators, four wheel drive groups, motorbike groups, recreational hunting groups and adjacent landowners.

In conjunction with additional site inspections, meetings will be held in the near future with the key stakeholders. These would include the Council and interest groups identified by the Council, MRT and ET. The meetings will aim to identify their concerns and priorities, identify recreational opportunities, and in the case of the Council, the approvals required.

2.0 SITE EVALUATION METHODOLOGY

A simple, qualitative site ranking methodology, based on that used by Singline (1985)[1] in north east Tasmania, was developed to assess the rehabilitation priorities across the sites. The comprehensive ranking proforma is provided in Appendix A. Each possible area for rehabilitation (including major areas within each site) was assessed against a set of criteria (Table 1); which included vegetative cover, erosion, sedimentation, safety and other variables such as acid drainage.

Table 1 Site Ranking Methodology

HAZARD RANK	HIGH	MEDIUM	LOW
VALUE	3	2	1
VEGETATIVE COVER	<10%	10-70%	>70%
EROSION	LARGE GULLY SEVERE RILL	SEVERE RILL SMALL GULLY	SOME RILL
SEDIMENTATION	IMPACT CREEKS DESTROYS VEGET.	MODERATE	MINOR
SAFETY	FACES/EXCAV > 5M; ADITS/PITS	FACES 2-5M, STEEP BANKS	FACES <2M SMALL GULLIES
ACID MINE DRAINAGE	LARGE FLOWS EXIT SCALDS ETC	MOD. FLOW MOD. IMPACT	SMALL SEEPS LTD AREA

Background considerations for assessment included;

- Health of vegetation and aggressiveness of colonisation,
- Presence of dam at lower end of catchment,
- Integrity of dam walls,
- Unstable landforms,
- Dangerous relics plant/equipment,
- Aeolian erosion,
- Size of catchment above feature,
- Weed invasion,
- Soil characteristics (sand/clay/gravel),
- Presence of topsoil mounds,
- Cost effectiveness of rehabilitation, &
- Visibility.

Each of these variables was given a value for the extensiveness or degree of impact and the importance of the impact, and ranked from 1 to 3 (3 representing the worst impact and 1 the least). These values were then added together to give a final score for each area (Table 2).

[1]Singline.R (1985): Rehabilitation Priorities for Mined Lands in North East Tasmania, Centre for Environmental Studies, September 1985.

Table 2 Site Assessment/Score (example)

HAZARD RANK	HIGH	MEDIUM	LOW
VALUE	3	2	1
VEGETATIVE COVER	3		
EROSION		2	
SEDIMENTATION		2	
SAFETY		2	
ACID MINE DRAINAGE			1
Within view of main roads			1

TOTAL SCORE 11

In total over 40 separate rehabilitation regions were determined and assessed across the three mine sites, utilising the above ranking methodology. The description of these areas and associated scores are detailed in section 3.0 below and are ranked in priority order for rehabilitation for each mine site.

3.0 SITE ASSESSMENTS

The three sites were inspected over a 4 day period and a variety of information recorded. This included an assessment of each site against the above criteria, the construction of preliminary rehabilitation maps, water /soil sample collection and the recording of individual zone information including; local botany, soil structure, soil stockpiles, acid drainage, historical features, risk areas (eg, high faces, tailings dams).

3.1 Monarch

The Monarch mine located on the Monarch Flats is approximately nine kilometres west of Gladstone. The impacted area covers approximately 50 hectares and has been subject to minor rehabilitation works. Current site uses are confined to camping activities conducted by the Scottsdale High School, at the southern fringe of the mine, miscellaneous 4 wheel drive and motorbike use across the northern flats and fire fighting access, (roads not required for the latter activity should be marked for rehabilitation).

An extensive field reconnaissance of the mine site ascertained that ten distinct rehabilitation zones existed. The area of each zone is shown in Figure 1 and a brief description and associated rehabilitation priority score is detailed below. (Note, site coding corresponds to Figure 1)

S1.1 Monarch

This extensive central gully is approximately 78 metres in length, 8-12m wide and at it's maximum 12 metres deep. The gully is considered extremely active with extensive recent

slips and movement at both ends of it's length. The area is considered highly dangerous given the nearby School Camp and motorbike activities. Further, the significant sedimentation created by this channelling activity is impacting downstream areas and habitats.

The most viable solution to alleviate the problems associated with the active system lies with the construction of a 3-4 metre gabion wall at the gully exit point, this combined with the placement of dolerite quarry rock (300-1200mm) along the gully base will allow sediment to settle out in the gully, slow the impact friction of inflow water and eventually lead to the ponding, sedimentation and stabilisation of the gully structure.

Rehabilitation Score 12 (high priority)

M3 Monarch
This area is characterised by flat plain gravels with 5-8% organic and 15-20% clay content. Upstream erosion and moderate gullying have resulted in significant sedimentation within the area. The control of the sediment is important as it impacts upon a well structured downstream wetland. The border to this gravel plain is covered by mullock mounds which are 60-80% vegetatively covered and slowly encroaching upon the study zone. The placement of a settling pond upstream of the wetlands would significantly aid in sediment control.

Rehabilitation Score 9 (moderate priority)

M4 Monarch
This distinctive depositional gravel plain is surrounded by eroding banks (5-15 metres in height) to the south and east. Flowing across the zone is a central stream depositing significant sediment as in meanders. The area is generally highly active with extensive upstream erosion and downstream depositional activities occurring.

Rehabilitation Score 9 (moderate priority)

S1 Monarch
This area is a meandering basin stream with gravel deposition along the banks. It has a significant abundance of new vegetative growth. At the time of inspection an extensive heath cover dominated the surface. Larger Casuarina's scattering this area have deposited extensive layers of soil binding nettles. *Gahnia grandis* is in abundant growth, preventing significant erosion and sedimentation from surrounding banks and gullies. If sedimentation from upstream "S1.1" can be prevented this area will form a stable creek system. At present any earthworks in this area could do more damage than good.

Rehabilitation Score 8 (moderate priority)

S2 Monarch

This area is classified as a depositional gravel plain with minor clay material. There is evidence of sheet erosion into area "S.1.1" occurring across the borders of this plain. Vegetative development across the area is very poor with Casuarina's representing the only significant species. Given the flat expanse of this area and nearby location of the School Camp, the plain would provide an ideal location for revegetation trials. These trials would assist in the prevention of water and sediment ingress into "S1.1" gully system, but would only be a success if motorbike use can be kept of this plain.

Rehabilitation Score 8 (moderate priority)

N2 Monarch

This flat plain of depositional gravel borders a well defined wetland system to the east and the area "N1" to the west. Vegetative growth across this zone is sparse with little or no mature species and very few seedlings. The coarse gravels are poorly consolidated and are virtually free from clays, sands and organic materials. Ripping and fertiliser application may alleviate these problems, however as the area is utilised extensively by motorbikes such rehabilitation would prove fruitless. There was no evidence of erosion or off site sedimentation coming from this area.

Rehabilitation Score 6 (low priority)

N3 Monarch

The area defined by "N3" is composed of undulating mullock heaps (1-4 metres height). These heaps are largely gravel but contain some binding clays which are assisting in site stability and vegetative growth. The basins of many mullock heaps contain minor wetland ponds and from these areas new vegetative growth is occurring. The "N3" area is bordered by invading, well established bushland.

This bushland contains seed-bearing Eucalypts. There is moderate active gullying in the region, but as sediment is being collected by the wetland system, and the gullies have minimal long term impact potential, the prospects for full revegetation are promising. Motor bike activity in the area was minor and a number a small mining relics were observed.

Rehabilitation Score 6 (low priority)

M1 Monarch

This area of gravel plains/fan is surrounded by dense vegetative stands. The area has minor 4 x 4 and motorbike activities that do not appear to impede the poor vegetative growth. Minor gullies exist in the upper levels of the fan, creating sediment depositions in the lower

reaches of the fans. This sedimentation is relatively stable and does not leave the site. No safety concerns or mining relics were associated with this area.

Rehabilitation Score 6 (low priority)

N1 Monarch
This gently sloping area of coarse depositional gravels is characterised by poor vegetative growth and minor wind blown erosion. Past revegetation attempts have proved largely unsuccessful. This is partly attributed to the lack of clay fines and organic material within the soil and the motorbike activities of the area. Any sediment eroding from this zone does not have a significant impact on regional waterways as it is collected downstream by a well functioning wetland system.

Rehabilitation Score 5 (low priority)

M2 Monarch
This area was classified as a very stable undulating gravel/clay region, with little off site or border impact. Casuarina stands in the order of 3-6 metres, cover the area and impede any 4 wheel drive or motorbike activities (none were noted). Evidence of rabbit browsing on new growth was observed and warrens appear in the moderate gullies that flow into area. Casuarina nettles were stabilising gravels across the site, providing much needed organic material to the underlying substrate. Abundant marsupial activity was noted across this site.

Rehabilitation Score 5 (low priority)

3.2 Endurance

The Endurance mine is located 5 kilometres south of Gladstone, adjacent to the west of Gladstone Road. The entire site is approximately 400 hectares in area and has been subject to considerable rehabilitation activities. A recent review by Environment Tasmania found that significant sections of the mine require further rehabilitation activities before they become self-sustaining. The area is currently utilised by local residents and tourists for 4 wheel drive activities, motorbiking, swimming, hunting, gem collection, camping site seeing and fire fighting access, (roads not required for the latter activity should be marked for rehabilitation).

An extensive field reconnaissance of the mine site ascertained that 19 distinct rehabilitation zones existed. The area of each zone is shown in Figures 2 & 3 and a brief description and associated rehabilitation priority score is detailed below. (Note site coding corresponds to Figures 2 and 3).

N2 Endurance (Fig. 2)
A distinct area of gullying characterised by two distinct ravine systems operating off a well revegetating escarpment. These fast moving gullies have similar upslope stratigraphy, with

a 120-340mm gravel top layer underlain by an extensive clay/kaolinite layer 2-8 metres in thickness. Due to the fast activity of gullying, little vegetation survives across this region and down slope sedimentation has led to an extensive depositional fan. The origins of this landform appear to lie in water movement over an elevated layer of gravel tailings. High flow water activity has resulted in the continual erosion of upslope clay subsoils. The area is extremely dangerous for both recreational activities and machine based revegetation attempts. As such alternative land stabilisation techniques should be utilised, which may include low shock blasting.

Rehabilitation Score 12 (high priority)

M3 Endurance (Fig 3)

The "M3" area represents the largest gully system across the three mine sites. This highly active central gully is located between a well established Eucalypt/Acacia forest to the east and the extensive revegetated area of "M4" to the west. Central to the gullies erosion and original formation, is a stream flowing along the gully floor southward from the South Endurance lake. Approximately 15 main spur gullies are moving laterally off the central channel westward into well established revegetation. Surface gravels in this area have approximately 20% clay content, once this binding matrix is breached a highly friable kaolinite layer is exposed. Vegetative development is minimal due to the fast eroding surface. Possible remediation activities may include water diversion at the lake entrance and active excavator works on the lateral gully systems.

Rehabilitation Score 12 (high priority)

S2.1 Endurance (Fig 3)

An expansive area of depositional coarse gravels (1-3 metres in depth) with little clay or organic material. Resultant vegetation is sparse and dominated by Acacia, Casuarina spp. and an unknown heath. This depositional area is bordered by native bushland and despite the ready supply of seeds natural revegetation is not occurring. A standard application of NPK is required to boost this area which is devoid of nutrients. The southern perimeter of the zone is bordered by a small creek, which receives surface and sub surface drainage from the zone. At strategic points across this creek evidence of acid drainage and resultant metal precipitation was observed.

A sample of this creek water was taken and analysed by the DELM laboratory for pH, metals and Sulphate, the results of this analysis are shown in Appendix D. Of immediate concern with regard to this sample is the presence of Aluminium in soluble form (pH 2.8) at a level 10,000 fold above the acceptable ANZECC limits for fresh water.

Rehabilitation Score 12 (high priority)

M2 Endurance (Fig 3)
This area is a riparian escarpment bordering the adjacent lake system. The dominant gravel surface appears to have received clay and organic particles from the surrounding "M1" or bush areas. As such the soils are richer and support a variety of mature vegetation including Acacia, Casuarina and Eucalypt species. Unfortunately high flow events off the southern plains and northern bushlands combined with the proximity of the escarpment have led to relatively recent perimeter erosion along the lake borders. Recent slips suggest this activity is increasing into established vegetation stands. As with a number of areas, once the gravel capping is breached the kaolinite based subsoils erode rapidly.
The area is utilised for water sports, recreational camping and contains a number of mining relics.

Rehabilitation Score 11 (high priority)

N6 Endurance (Fig 2)
This moderate east / west gully system has sparse vegetative cover across it's gravel and interspersed clay soils. Insipient gullying off the central system combines with extensive sheet erosion to create significant down slope sedimentation. The main vegetation is *Pinus radiata* and interspersed Acacia spp. The area lacks vital nutrients as evidenced by the slow vegetative growth and yellow appearance of tree leaves.

Rehabilitation Score 10 (moderate priority)

N5 Endurance (Fig 2)
This area is similar to N6, with regard to vegetation cover and sheet erosion, and consists of sloping ground to cliff edges at location N3. Vegetation consists of interspersed *Pinus radiata*, Acacia spp, Eucalypt spp, and Casuarina's. In general the area is unstable and prone to growing gully erosion. Considerable domestic garbage was noted across the site.

Rehabilitation Score 10 (moderate priority)

M5 Endurance (Fig 3)
This area is a gravel plain similar to M4 in it's topography, stratigraphy and landforms. However this area has not received the same attention as the latter with little NPK or vegetative input. As a result it is distinctively barren when compared to the latter area. Insipient gulling is occurring across the eastern fringe of this zone where it borders the extensive gully system of area M3. With little prospect for rapid vegetative development and with increasing gully activity the area requires earthwork intervention to stabilise eroding landforms.

Rehabilitation Score 10 (moderate priority)

M7 Endurance (Fig 3)
An extensive gravel (tailings) fan ranging in depth from 8-10 metres with little or no clay or organic material. Westward water migration via lake overflows has carved a linear channel over 105 metres in length. The unconsolidated sediments are in continual migration resulting in a plain devoid of vegetation, similar to coastal coarse dune systems. The area is subject to lateral gullying, however these are not impacting extensively upon revegetated areas.

Rehabilitation Score 10 (moderate priority)

M6 Endurance (Fig 3)
A characteristic depositional fan of gravel tailings with little or no clay or organic material. As a result the zone is largely clear of any significant vegetation. Moderate levels of erosion occur across the fan but appear localised to the escarpment. Extensive motorbike activity across the area appears to have little negative impact.

Rehabilitation Score 9 (moderate priority)

N3 Endurance (Fig 2)
A characteristic depositional plain of gravel tailings with little or no clay or organic material. As a result the zone is largely void of any significant vegetation. Moderate levels of erosion occur across the fan but appear localised to the "N1" escarpment. A small wetland system exists on the down slope assisting in the control of wind or water borne sediment migration.

Rehabilitation Score 9 (moderate priority)

N3.1 Endurance (Fig 2)
A depositional plain of gravel tailings with little organic material but some clay deposits. The zone is similar to that of N3 but with increased clay levels and associated vegetation. Moderate levels of erosion occur across the fan but appear localised to the "N1" escarpment. Additional NPK application and ripping should see this area continue to stabilise.

Rehabilitation Score 8 (moderate priority)

M1 Endurance (Fig 3)
A gently sloping gravel plain with 20-30% clay content. The northern border of the zone contains extensive small gullying as it moves onto the lake border escarpment. A low density of vegetation was observed, however what has developed (above 2m) appears healthy. Moderate 4 wheel drive and motorbike activities appear to impact upon new vegetative growth as does an extensive rabbit population.

Rehabilitation Score 8 (moderate priority)

N4 Endurance (Fig 2)
An expansive area characterised by gently undulating topography and gravel/clay soils. Most vegetation is under 4 metres in height and comprised of *Pinus radiata, Eucalyptus amagdalina, pulchella* and Acacia spp. The area contain a numbers mining relics of (1960-70) and considerable domestic waste including an illegal tip site. Erosion and associated sedimentation is moderate but confined. The level of vegetative development appears to be keeping pace with erosion and sedimentation activities. Some insipient gullying may require earthwork intervention to ensure the area remains stable.

Rehabilitation Score 7 (low priority)

M4.1 Endurance (Fig 3)
This small gravel/clay area sloping southward at 8 degrees, has been subject to extensive ripping and revegetation activities. Unfortunately revegetation attempts have been largely unsuccessful although ripping activities have assisted in land stabilisation. The area requires reseeding and NPK application to promote vegetative development.

Rehabilitation Score 7 (low priority)

S1 Endurance (Fig 3)
A localised area of coarse elevated gravels utilised extensively by motorbikes. This activity combined with poor water retention (coarse gravels), and with little or no organic or clay material has led to an area devoid of vegetation. Despite these negative attributes, bike activity at Endurance is confined largely to this zone, where makeshift tracks and jumps have been developed. These activities are actually creating gentle slopes, preventing gullying and off site sediment migration. Revegetation activities and associated earthworks are not recommended.

Rehabilitation Score 6 (low priority)

M4 Endurance (Fig 3)
An expansive flat gravel/clay plain with an average slope of 4 degrees, covers approximately 55% of the South Endurance mine area, predominantly across the central plateau. The area contains most of the sites mining relics. This area has been subjected to extensive ripping and revegetation (species include; *Acacia mucronata, verticillata, longifolia, Restio tetraphyluss, Gahnia grandis*, and various Leptospermum and Mellaleauca spp.). These activities combined with natural regeneration has created a stable landform with sustainable vegetative development and little erosion, sedimentation or gullying. Areas of denser vegetation located across this area provide a habitat for native fauna and a floral seed source.

Unfortunately lateral gully erosion from perimeter areas including "M5", "M7", "M3", "M1" and "M2" are jeopardising the viability of this landform. As this is the largest stable zone across the mine area priority should be placed on addressing the worst of these lateral gullies (As detailed in sections above).

Rehabilitation Score 6 (low priority)

S2 Endurance (Fig 3)

An area similar to "M4" in that it is a gently sloping landform that has received previous ripping and revegetation. Unlike area "M4" it has coarser gravels, no clays, and little organic material. Resultant vegetation is sparse and dominated by Acacia and Casuarinas spp. Bordered by bushland, *Gahnia grandis* and an unknown heath are progressively encroaching across denuded areas and providing a promising outlook for site stability. In general the area is a stable landform with low traffic volumes, a number of safe mining relics and relatively low rates of sedimentation and erosion.

Rehabilitation Score 5 (low priority)

N1 Endurance (Fig 2)

An area similar in landform to "M4" characterised by gravel/clays, undulating landforms, some moderate perimeter gullying and older well established vegetation. The gravels across this zone have been stabilised by clay and organic material, which in turn has led to a thickening of vegetative undergrowth of Acacia, Eucalypt and Casuarina species. Whilst moderate gullying is occurring, the density of vegetation is ensuring that landform stability is maintained. As their are a number of degraded roads across this site thought should be given to ascertaining which are used for fire fighting purposes and which can be closed and ripped for revegetation.

Rehabilitation Score 5 (low priority)

N1.1 Endurance (Fig 2)

A gravel based plateau with rich organic laced gravels and mature Banksia spp, Casuarina spp. and *Eucalyptus amagdalina*. The area is producing abundant seed and has no evident erosion or sedimentation. No further human input into this area is required at this point in time.

Rehabilitation Score 5 (low priority)

3.3 Star Hill

The Star Hill site to the east of Gladstone covers some 150 hectares of workings. The area is similar to other mine sites in the Gladstone area which were subject to extractive sluicing activities earlier this century. The site displays the typical range of eroded granite landscape features, gullying in water courses, often severe sheet erosion on the old mining

paddocks, and rilling of steep, exposed benches. In addition, there has been poor regeneration of native plant species associated with soils of very low nutrient status, either heavy leached gravelly clays or tailing gravels that hold no water.

The site is currently used for gem collection, camping, minor motor bike use and fire fighting access, (roads not required for the latter activity should be marked for rehabilitation). An extensive field reconnaissance of the mine site ascertained that 16 distinct rehabilitation zones existed. The area of each zone is shown in Figures 4 and 5 and a brief description and associated rehabilitation priority score is detailed below.

S1 Star Hill (Fig 4)

Area S1 forms the dominant extraction landform at Star Hill and is easily observed from aerial photographs. This area located on the pinnacle of Star Hill has been subject to extensive alluvial extraction activities leaving a resultant basin of highly friable sands. Significant wind and water based erosion has left a characteristic landscape of elevated vegetative islands, sand pans, iron pans, silt pans and silt lakes. The surrounding area and vegetated islands are dominated by *Eucalyptus amagdalina, Eucalyptus pulchella,* Casuarinas and Kunzea. The thickness of surrounding vegetation has prevented gully movement off this area and no "off site" active sediment deposition is occurring.

The landform can be considered to be stabilising itself into a shallow lake depression. Earthwork activities which lessen the steepness of perimeter banks and increase water retention will significantly assist the aesthetic and environmental benefits associated with the formation of such a structure.

Rehabilitation Score 13 (high priority)

M6.1 Star Hill (Fig 5)

A large active gully, created by sluicing activities dominates this zone. At a height of 15-18 metres and a width of 20-25 metres this gully presents significant safety problems. Left unaddressed this active gully will continue to scour, destroying native vegetation and creating further down slope sedimentation. Located down slope of the gully is a small lake which captures all eroding sediment. However, continual erosion will result in this lake filling and resultant off site sediment deposition.

Rehabilitation Score 11 (high priority)

S8 Star Hill (Fig 5)

An expansive gently sloping depositional fan of gravel based sediment located upslope of a significant wetland. This fan has poor water retention and little clay or organic material. As such vegetative development across the fan has been minimal and impaired by motorbike activities and 4 wheel drive use. Off site sedimentation is controlled by the wetland. The dam wall was inspected and noted to be in a poor state of repair. The dam wall requires

further investigation and the depositional fan needs slow release NPK input and deep contour ripping.

Rehabilitation Score 10 (moderate priority)

M7 Star Hill (Fig 5)

This area is categorised by a series on longitudinal sluiced gullies positioned across moderate sloping topography, comprising predominantly coarse gravels and clay outcrops. Active erosion along these gullies promotes significant sedimentation down slope into the depositional area "M8". Active revegetation (Kunzea, Casuarina and *Eucalyptus amagdalina*) occurs between these gullies, but their survival is under question as a result of continual erosion.

Rehabilitation Score 10 (moderate priority)

S6 Star Hill (Fig 4)

A scoured plain covered by gravel and minor clay sediments. The plain does not appear fertile with sparse vegetative development. The only active species is *Gahnia grandis* and Kunzea both of which are assisting in the prevention of perimeter gullying. Given the 15-20% clay content of the surface gravels, NPK input with contour ripping should be a cost effective method of assisting in revegetation.

Rehabilitation Score 9 (moderate priority)

S7 Star Hill (Fig 5)

An area of alluvial tailing deposition. These tails are a combination of sand and gravel material, with low clay and organic content. This matrix coupled with the high permeability of the surface cover has led to a landscape devoid of mature vegetative development. However, an abundance of Kunzea and Leptospermum seedlings have recently germinated, although it is not known whether the existing conditions can support these species as they mature.

Some iron hydroxide precipitation was noted in the seepage of water from this tailings area, no sample was taken.

Rehabilitation Score 9 (moderate priority)

M1 Star Hill (Fig 5)

A large area of alluvial gravel extraction that despite appearances is relative stable. The dominant sandy gravels have been left in a basin depression which in turn has formed a

series of minor lakes. This area is utilised because of it's shelter and beauty by a number of recreational campers. As with other sites the quality of the crystal blue waters is not known but should be quantified prior to any earthwork activities across this area. Historically this site contains the most relevant historical features of any reviewed area, with a large mechanised Trommel and sluicing channels.

Whilst a number of the perimeter edges of this basin are eroding and their are minor lateral gullies forming, the subsequent collapsed material is vegetating rapidly with Banksia's, Kunzea's, and Acacia seedlings.

Rehabilitation Score 9 (moderate priority)

M6 Star Hill (Fig 5)

This distinct open cut contains evidence of high grade tin deposits. Few relics remain, but those that exist include pipework a pumphouse and assorted metalliferous items. The dominant vegetation in this area is Pinus radiata, which is growing successfully in the stabilised gravel/clay soils. A number of Mathinna beds outcrop the area providing stability against gully erosion. Most of the open cut walls are stable, however the 6-8 metre high walls in a number of locations are considered very dangerous. No rehabilitation priorities are recommended as access is difficult and off site erosion/sedimentation impacts minimal.

Rehabilitation Score 9 (moderate priority)

M4 Star Hill (Fig 5)

This area is characterised by a two distinct active water races carved in a moderate sloping gravel/clay horizon. Whilst border revegetation is excellent the gully is growing via water ingress along the races and impacting downstream upon the sediment lakes of "M3". Removal of the races will alleviate the problem but may pose a heritage issue.

cut off drains?

Rehabilitation Score 9 (moderate priority)

S2 Star Hill (Fig 4)

This area comprises a large tailings outwash fan dominated by gravel and sand sediments. Despite this area being largely level, moderate sheet erosion and gullying are evident and little vegetation has established. Given the size and location of the area aerial seeding and fertiliser application are recommended.

Rehabilitation Score 9 (moderate priority)

S5 Star Hill (Fig 4)

A tailings outwash fan of coarse gravels with little or no clay, silt or organic material. The area contains minor relics and little vegetation. The bleached gravels only support

unhealthy *Pinus radiata* and minor Leptospermum and Kunzea seedlings. Erosion across the site consists of moderate rilling and down slope sedimentation is evident.

Rehabilitation Score 8 (moderate priority)

M8 Star Hill (Fig 5)
Alluvial tailing fans formed as a depositional feature from upstream sluicing. The sandy gravels are relatively stable but they do not support any significant vegetation. Despite this denuded landscape erosion is low and down slope sedimentation is collected via the lake network. Motor bike activities do not appear to be significantly affecting the sustainability of this landform.

Rehabilitation Score 7.5 (low priority)

M3 Star Hill (Fig 5)
A distinct sequence of water retaining terraces covers this zone of deposition. The design of these structures has probably been constructed to sequentially sluice fines from coarse gravels. A high level of clay material in this zone functions as a land stabiliser preventing erosion. Gravel depositional fans are subject to minor rilling towards the final dam. Vegetative development is poor but appears to be gradually encroaching from the surrounding bush.

The lower dam in this zone requires immediate attention before the next rain season. The face of the dam is significantly eroded and the spillway compromised by an extensive gully.

Rehabilitation Score 7.5 (moderate priority)

M5 Star Hill (Fig 5)
This area is an assortment of test pits and minor workings over gently sloping sandy gravels with clay and organic content. This substrate supports emerging revegetation by Casuarina, Eucalyptus and Kunzea species. This revegetation is sufficient in density to control the moderate levels of erosion and sedimentation.

Rehabilitation Score 7 (low priority)

M2 Star Hill (Fig 5)
An isolated pocket of depositional gravels displaced from the "M1" area. Whilst revegetation is occurring at a rapid rate by Kunzea and Casuarina species, water flow across the exposed gravels are pooling into an old water race. This race in turn is being

intercepted by minor lateral gullies. A simple solution lies in the dozing and levelling of the race and associated gullies.

Rehabilitation Score 7 (low priority)

S4 Star Hill (Fig 4)

A flat stable area with silt and clays, progressive vegetative development and moderate levels of erosion and sedimentation. A number of car bodies require removal and a full 205 litre hydrocarbon drum remains on site. The removal of these items will ensure that this area is one of low priority.

Rehabilitation Score 7 (low priority)

S3 Star Hill (Fig 4)

A linear tailings gully progressing across a historic water bed over approximately 550 metres. Whilst few mature seedlings exist, new growth is in abundance, species include Kunzea, Banksia, Casuarina and *Eucalyptus amagdalina* and *Euc. obliqua*. Unfortunately much of the regrowth has a purple colour indicating a lack of phosphorous. NPK input should be sufficient to ensure this area stabilises.

Rehabilitation Score 7 (low priority)

4.0 REHABILITATION METHODS

The three mine sites surveyed in the Gladstone area all show a variety of erosional and associated depositional processes and landforms, some of which can be categorised as extreme by any national standard. Fortunately they can be classified into a few discreet processes to which a range of well known treatments can be applied, and most areas have the capacity to be rehabilitated successfully. The previous revegetation projects carried out over the past ten-fifteen years have provided enough information on which to base a variety of rehabilitation programs.

The different methodologies employed will vary according to the type of erosion and the soil/substrate types currently found exposed on the areas. The sites can be simplistically categorised as:

a) higher crest zones of extraction, with numerous steep sided pits, remnant high faces, mullock heaps and enclosed dams which have been the source areas for
b) the sandy/gravelly tailings sluiced into the surrounding gullies or depressions.

The Granite country is composed of a mix of exposed, heavily leached sub-base clays, with gravels and sands in varying amounts (varying both within individual sites and between different areas). Generally the sluiced areas and open pits contain clays with some areas of sands and gravels. Nutrient status is very low (NPK – 20/0/30 ppm). The clays are thus infertile and relatively impermeable, with high dispersibility in some areas. The gravel tailings are often deep, highly permeable and also nutritionally poor. No extensive stockpiles of topsoil were noted, which are commonly black, highly organic sandy loams.

4.1 Areas Subject To Sheet Erosion

The unvegetated flatter areas on the crests and the bulk of the tailing deposits in the gullies are all subject to sheet erosion. In many cases the deposits are being slowly re-worked and moved down catchment, sometimes associated with minor gullying. At Endurance most of these sites have been treated in previous rehabilitation programs with more or less good success, but expansive areas exist at the other two sites. The flat clay sites in the pits should regenerate well, but the tailings gravels will be difficult. They are highly porous, will dry out quickly in summer, contain few nutrients and do not hold nutrients like the clays. They will require more regular fertiliser maintenance.

The treatment is basically one of deep ripping by bulldozer/chisel plough along the contour, seeding with suitable native species and broadscale fertilising. Ripping should be to at least 50cm deep and at 3m intervals while the surfaces are dry. Light harrowing between the rips will be required. Any pans should be broken.

Depending on catchment position, slope and size, some diversion banks/cutoff drains may be necessary. Any drains are to be parabolic in cross-section, , fertilised and sown with ryecorn at a rate of 10-15kg/ha. Brushing may also be appropriate. More significant drains should be lined with a geo-textile. The treatment of drains or gullies carrying larger flows will be described in section 4.2.

Seed mixes

Seed is to be sown at 3kg/ha from locally collected seed and should be undertaken in mid to late Autumn after the rains have started. Wattle and Kunzea seed should be heat treated and smoke treatment may also be beneficial for some species. The species are suitable for all types of eroded areas as detailed below under section 4.2, 4.3 and 4.4.

	Proportion by weight (%)
Coastal wattle	10
Cutting grass	5
Banksia	10
Black peppermint	10
Black She Oak	5
Kunzea	15
Lemon bottlebrush	5
Manuka	5
Narrow leaf wattle	15
Scented paperbark	5
Drooping She Oak	5
Sunshine wattle	10

Wetter areas may contain higher proportions of Small-leaved Paperbark, Woolly Tea Tree, Prickly Moses, Black gum, and especially Cutting grass.

Sandy areas will contain less wattles (except Boobyalla) and more Banksia, Allocasuarina spp. and especially Kunzea.

Fertiliser

Initially two annual applications of 200kg/ha 8:4:10+Mg plus 200 kg/ha blood and bone for tractor or hand spreading. Further applications may be required in future years after a maintenance inspection. Aerial spreading is probably warranted especially considering the large areas, and the blood and bone component should be replaced by a slow release granular type. The thickness of regeneration in some of the older plots would be damaged by tractor application. New and small accessible areas would be suited to tractor application, while small inaccessible sites may be hand fertilised.

4.2 Areas Subject To Minor Gullying And Sheet Erosion

These zones include flatter areas subject to minor gullying up to 2 metres deep and includes some of the side gullies which have been sluiced. The options for treatment are going to be more expensive than for the sheet eroded areas. These areas can generally be easily treated with bulldozers/excavators, filling in the gullies and ripping the hard surrounding areas. Cutoff drains or diversion banks will usually be required to keep surrounding run-off from entering the newly formed drainage channel.

Because some water will still flow through these areas special treatments are required. A variety of techniques are available depending on each individual situation, but basically the

new surface has to be temporarily armoured until the native seedlings are large enough to provide good root and surface protection. Possible techniques include;

- Geotextile (e.g. Jute) can be laid along the drainage line and the area fertilised and sown with a mix of ryecorn and native seedlings. Some of the plastic geotextiles can withstand velocities of 4m/sec but are expensive (e.g. "Tensar" mat). There are a wide variety of geotextile products.

- The areas can be hydroseeded with a mix containing a protective coating like latex, or hydro-mulching may be appropriate.

- Smaller, flatter areas may be treated with a thick layer of brushing, fertiliser, ryecorn and native seed.

- Steeper gullies with less cohesive "soils" and/or more flow may require a series of cross-channel "dykes" or trenches filled with rock.

- More problematic steep areas may require more expensive grade control, like small wooden silt traps or even gabion weirs.

For simplicity, seed mixes and fertiliser rates will be as stated in section 4.1.

4.3 Areas Subject To Severe Gullying

In some areas deep, steep sided gullies have developed with near vertical walls sometimes in excess of 20 metres. On the granite country some of the sub-clays are dispersible and they display several lateral gullies actively branching out from the main trench. The problem for these areas is that at Endurance they are threatening previously regenerating areas. Treatment will be expensive and more difficult than for the smaller gullies mentioned in 4.2.

Because the side walls are so large and steep, machinery alone will not fix them. Also, as these areas are subject to continuing, often larger flows on unconsolidated material, hard engineering solutions (concrete chutes) are not advised and a flexible solution should be sought. Rigid structures will be subject to continual attack as the water works to undermine them. Two treatments are suggested:

- The downstream outlet should be held by some form of grade control structure, either a gabion weir, or rock or timber weir. The entire gully system will need a perimeter cutoff drain. Steeper head walls can be reformed by hand and lined with geotextile or even a pipe chute.

- A more comprehensive treatment would be to blast the entire gully system with explosives and then use machinery (excavator) to finalise the battering to a gentler parabolic shape. Cutoff drains will be required. The new drainage line can be protected by geotextile/hydroseeding/brushing, while the downstream end may require a grade control structure.

These larger features will require individual detailed design, including survey drawings and perhaps an engineering plan for any contract work. Seed mixes and fertiliser treatments will be as already outlined, with ryecorn as an initial stabilising cover.

4.4 Areas With Remnant Steep Faces

Many of the sluiced pit areas are surrounded by remnant steep faces, sometimes over 20 metres in height but often covered on top with a good cover of vegetation. On the Mathinna beds these are relatively stable and, considering the cost of rehabilitation, may be left. At Endurance however these faces are gullying and starting to impact on older rehabilitated areas. Similar to 4.3 above, the only solution may be to blast the faces and batter the slopes by machine to less than 20 degrees for ease of revegetation.

Seed mixes and fertiliser treatment will remain the same as detailed above, although the newly formed batters may require brushing or hydroseeding for initial protection, including the use of ryecorn.

4.5 Dam Walls

Scattered throughout the three sites are several dams, some of which are quite large. While many are now partly filled by the extensive sedimentation processes a few still hold significant volumes of water. Three of the dams are in need of further inspection from an engineer in regard to their safety as the front walls have received little attention since operations were abandoned. These are the dam at the southern end of Monarch, the large dam on the northern side of Star Hill and the dam at the end of Hardens ravine, also at Star Hill.

The Monarch dam is in danger from a large gully which is working its way back towards the spillway zone, while at Star Hill and Hardens ravine the dam walls are rilling with some minor gullies developing on the faces. The spillway at the Harden's dam is also gullying. These features will probably require a surveyed drawing and engineering review to ensure safety and environmental risks are handled in an appropriate manner, but also for reference in any contractual works that may be undertaken. It is not considered the rehabilitation procedures so far outlined have much relevance to any works that may be proposed here, and certainly the tree cover on some of the dam walls may even be considered a hazard from an engineering perspective.

4.6 Timing of Works

The timing of works will of course depend very much on the particular season in any one year; rains can be delayed or come early, and decisions must be based on the appropriate field conditions at any one time. A schematic overview is depicted in the following table:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
EARTH WORKS										EARTH WORKS	
			DIRECT SEEDING								
							FERTILISING				
SEED COLLECTION											SEED

5.0 RECOMMENDED AREAS FOR REHABILITATION

The evaluation assessment for each of the main rehabilitation areas combined with the determined rehabilitation methods has led to the following recommended areas for future earthwork and revegetation activities. These recommendations have been based on initial community consultation, the existing budget and the prioritisation of areas that have the most significant environmental and public safety impacts. In total eight areas require immediate attention.

- Endurance Mine area "M3" - The extensive central gully with associated lateral intrusion is the single greatest threat to the extensive revegetation that has been undertaken at the Endurance site. It is estimated that approximately 1.8 hectares of established revegetation are being destroyed by this gully annually and that associated sedimentation is having a significant downstream impact. Prioritised earthwork activity combined with gully blasting may provide a landform of sufficient stability for revegetation. Further it is proposed to reinstate a diversion channel between the source lakes to prevent water ingress along this gully floor.

- Monarch Mine area "S1.1" - Of the mine sites studied the Monarch site was considered to be the most ecological and geomorphological stable. The only major area of concern was the central gully immediately below the southern lake. This huge gully presents significant safety, sedimentation and erosion hazards to human users and the surrounding environment. Given the close proximity of this gully to school camp activities and the fact that it is encroaching upon the dam borders, immediate attention is recommended. As detailed in Section 3.0, the construction of a gabion sediment trap with associated earthwork stabilisation should provide an effective solution to all issues associated with this landform.

- Monarch Mine area "S2" - This depositional area is a characteristic gravel plain with minor clay material and little organic matter. As such, vegetative development is poor and confined to Casuarina spp. This type of landform is considered representative with other mine sites in NE Tasmania with approximately 21% of Endurance site, 38% of the Star Hill site and 28% of the Monarch site having near identical depositional areas. Given the flat expanse of this area and nearby location of the School Camp, the plain would provide an ideal location for revegetation trials. These trials would assist in the prevention of water and sediment ingress into the "S1.1" gully system and confirm assumptions made in previous reports regarding the best rehabilitation methods. Further, such works will enable public viewing of a true revegetation trial upslope of a innovative gully management earthworks.

- Dam Assessment (Monarch, Endurance and Star Hill) - A preliminary review of dams at the concerned mine sites indicated that they were performing a vital function in the control of sediment and prevention of down slope gullying. This review also briefly assessed the structural integrity of retaining walls. It was noted that dam walls at Star Hill, Monarch and to a lesser extent Endurance require a full engineering review and associated structural report with recommendations. Two such walls at Star Hill are in

what would be considered to be a dangerous state of repair and if ruptured would lead to extensive downstream sedimentation, and regional flooding. Recommendations regarding suitable earthwork stabilisation cannot be made until a full engineering study has been completed.

- Endurance Mine area "N2" - This characteristic kaolinite area consists of four rapidly eroding gullies, within two distinct ravine systems cutting into a well vegetating escarpment. These fast moving gullies have similar upslope stratigraphy, with a 120-340mm gravel top layer underlain by an extensive clay/kaolinite layer 2-8 metres in thickness. Due to the fast activity of gullying little vegetation survives across this region and down slope sedimentation has led to an extensive depositional fan. The origins of this landform appear to lie in water movement over an elevated layer of gravel tailings. The area is extremely dangerous for both recreational activities and machine based revegetation attempts. As such alternative land stabilisation techniques should be utilised, these may include low shock blasting, followed by earthwork activities and revegetation via hydromulching.

- Star Hill Mine area "S1" - This area formed the dominant extraction landform at Star Hill. Located on the pinnacle of Star Hill the area has been subject to extensive alluvial extraction activities leaving a resultant basin of highly friable sands. The surrounding area and vegetated islands are dominated by *Eucalyptus amagdalina, Eucalyptus pulchella,* Casuarinas and Kunzea. The thickness of surrounding vegetation has prevented gully movement off this area and no "off site" active sediment deposition is occurring. The landform can be considered to be slowly stabilising itself into a shallow lake depression. As such it is recommended that earthwork activities which lessen the steepness of perimeter banks and increase water retention be implemented. Such activity will significantly assist the aesthetic and environmental benefits associated with the formation of such a structure, whilst leaving behind a remnant landscape of mining history.

- Star Hill Mine area "S2" - Potentially the largest tailings depositional plain devoid of vegetation across the three mine sites. Despite this area being largely level, moderate sheet erosion and gullying are evident and little vegetation has established. Initially the area received only a moderate rehabilitation score, however due to it's large size, close proximity to water courses and observed excessive down slope sedimentation during high rainfall events, is essential that the plain be revegetated. Given the size and location of the area, aerial seeding and fertiliser application are recommended as the most cost effective viable option.

- Water Quality Issues - As previously detailed a number of lakes and water impoundments across the study area are utilised by recreational campers and local residents. The sediment contained within the majority of these lakes is derived from depositional outwash tailings. Of particular concern are a number of lakes at Endurance and Star Hill located near Kaolinite outcrops. Kaolinite is not only a highly erodable silicate but is prone to the leaching of it's Aluminium component into surrounding waters. As such preliminary water sampling should be completed over all

accessible lakes to determine whether any harmful metal are present in soluble form and if so their concentrations. Whilst MRT does not promote the active use of these lakes, they are widely accepted as being suitable for human use.

Secondly acid drainage discharges occur across the three mine sites. A preliminary sample from one site at Endurance as detailed in section 3.2 area "S2.1" revealed extreme levels of Aluminium. As a component of this water quality study acid drainage discharges should be sampled and quantified.

It is proposed that these rehabilitation priorities be reviewed with local stakeholders, MRT and ET staff to determine which areas should be prioritised for rehabilitation. Based on these discussion Stage Two of the project will commence with the formal design and associated costings for selected areas.

LIMITATIONS STATEMENT

These Rehabilitation Concept Plans for three abandoned alluvial tin mines located in NE Tasmania, have been prepared in accordance with the scope of services set out in the letter of agreement between SEMF Holdings (SEMF) and Mineral Resources Tasmania ('the Client'). To the best of SEMF's knowledge, the proposal presented herein represents the Client's requirements at the time of printing of the Report. However, the passage of time, manifestation of latent conditions or impacts of future events may result in the actual project and its impact differing from that described in this Report. In preparing these Rehabilitation Concept Plans, SEMF has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations referenced herein. Except as otherwise stated in this Report, SEMF has not verified the accuracy or completeness of such data, surveys, analyses, designs, plans and other information.

APPENDIX A

SITE EVALUATION FORMS

MINERAL RESOURCES TASMANIA
SEMF - NE MINE SITE REHABILITATION

MINE SITE_____
LOCATION_____
DATE_____

A) SITE DESCRIPTION

B) SITE RANKING METHODOLOGY

HAZARD RANK	HIGH	MEDIUM	LOW
VALUE	3	2	1
VEGETATIVE COVER	<10%	10-70%	>70%
EROSION	LARGE GULLY +/- SEVERE RILL	SEVERE RILL +/- SMALL GULLY	SOME RILL
SEDIMENTATION	IMPACT CREEKS DESTROYS VEGET.	MODERATE	MINOR
SAFETY	FACES/EXCAV > 5M; ADITS/PITS	FACES 2-5M, STEEP BANKS	FACES <2M SMALL GULLIES
ACID MINE DRAINAGE	LARGE FLOWS EXT SCALDS ETC	MOD. FLOW MOD. IMPACT	SMALL SEEPS LTD AREA
*			

*** BACKGROUND CONSIDERATIONS FOR ASSESSMENT, THESE MAY INCLUDE; Health of veg/aggressive colonisation, Presence of dam at lower end of catchment, Integrity of dam walls, Unstable landforms, Dangerous relic plant/equip, Aeolian erosion, Size of catchment above feature, Weed invasion, Soil characteristics (sand clay gravel), Presence of topsoil mounds, Cost effectiveness of rehab, & Visibility.**

C) SITE ASSESSMENT/SCORE

HAZARD RANK	HIGH	MEDIUM	LOW
VALUE	3	2	1
VEGETATIVE COVER			
EROSION			
SEDIMENTATION			
SAFETY			
ACID MINE DRAINAGE			

TOTAL SCORE _____

APPENDIX B

BOTANICAL SPECIES

Botanical Names

Banksia	Banksia marginata
Black Gum	Eucalyptus ovata
Black Peppermint	Eucalyptus amygdalina
Black She Oak	Allocasuarina littoralis
Boobyalla	Acacia sophorae
Cutting grass	Ghania grandis
Drooping She Oak	Allocasuarina stricta
Kunzea	Kunzea ambigua
Manuka	Leptospermum scoparium
Narrow leaf wattle	Acacia mucronata
Prickly Moses	Acacia verticillata
Ryecorn	Secale cereale
Scented paperbark	Melaleuca squarrosa
Scruff wattle	Acacia stricta
Small leaved paperbark	Melaleuca gibbosa
Spreading wattle	Acacia genistifolia
Sunshine wattle	Acacia terminalis
Wirilda	Acacia retinoides
Woolly tea tree	Leptospermum lanigerum
Lemon bottlebrush	Callistemon pallidus

APPENDIX C

FIGURES 1-5

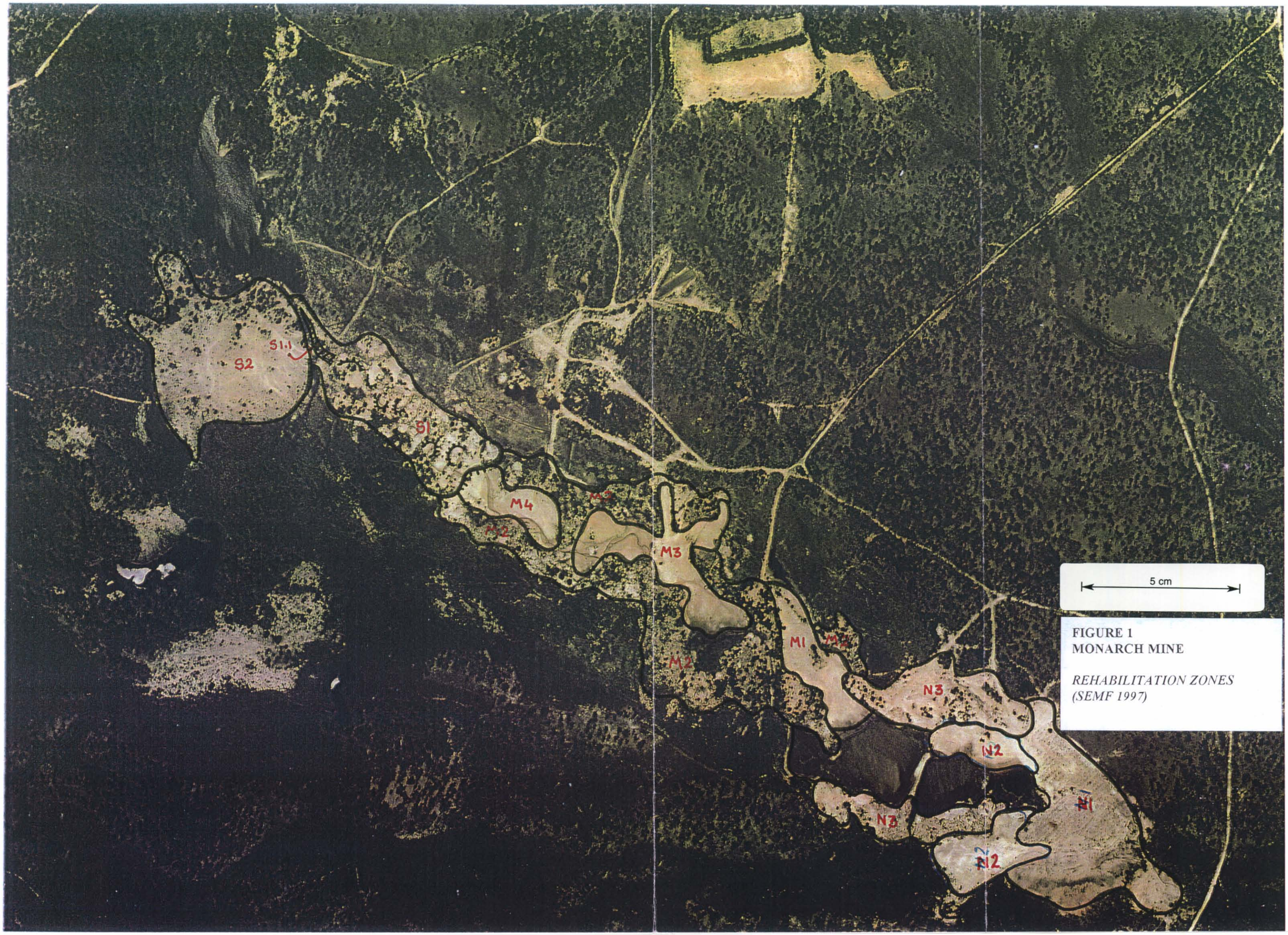

FIGURE 1
MONARCH MINE

REHABILITATION ZONES
(SEMF 1997)

FIGURE 2
ENDURANCE MINE *(NORTH)*

REHABILITATION ZONES
(SEMF 1997)

FIGURE 3
ENDURANCE MINE *(SOUTH)*

REHABILITATION ZONES
(SEMF 1997)

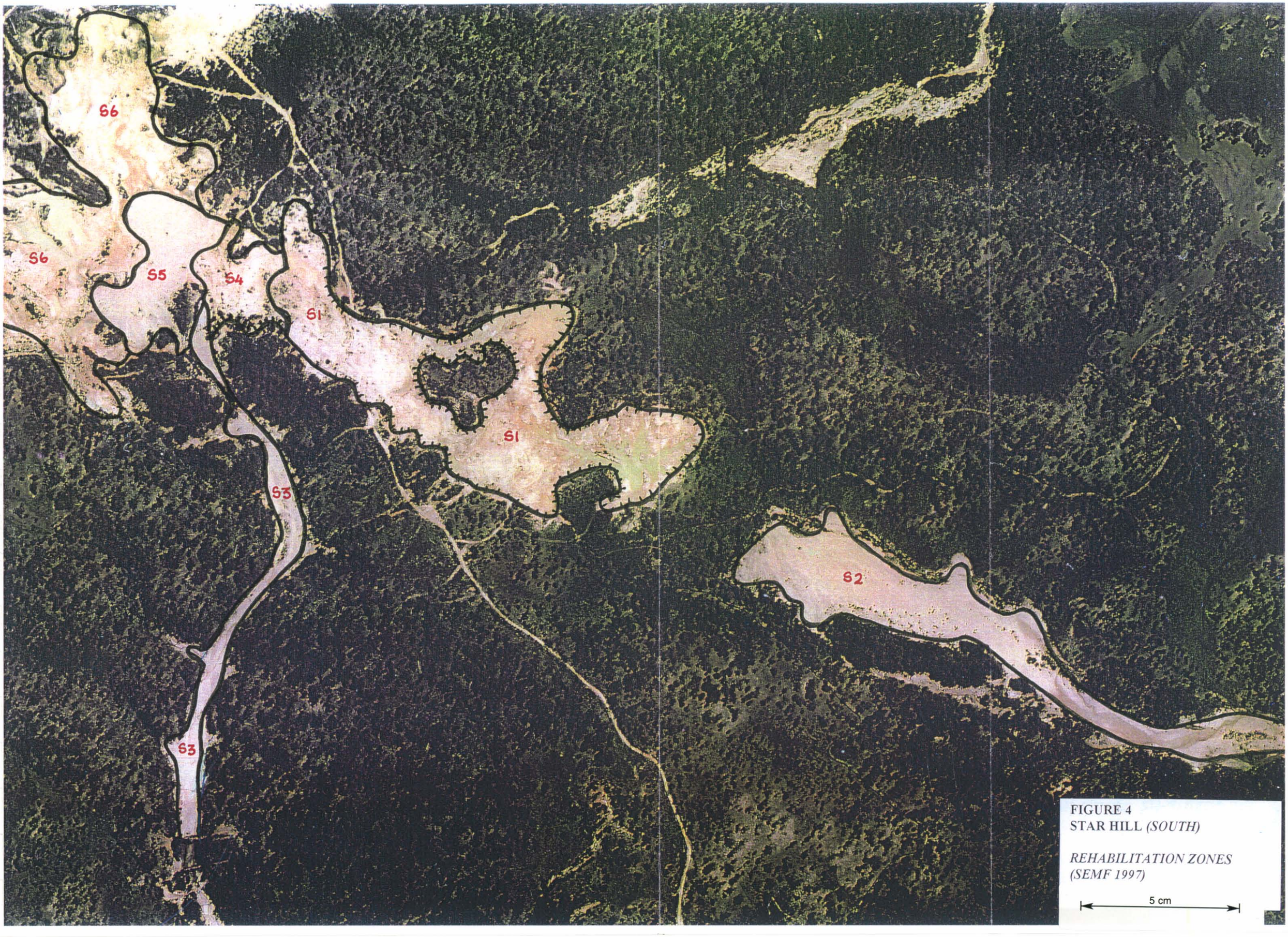

FIGURE 4
STAR HILL *(SOUTH)*

REHABILITATION ZONES
(SEMF 1997)

5 cm

FIGURE 5
STAR HILL *(NORTH)*

REHABILITATION ZONES
(SEMF 1997)

APPENDIX D

SAMPLE RESULTS

Department of Environment & Land Management
Environmental Chemistry Laboratory
C/- Chemistry Department, University of Tasmania
Box 252-75 GPO Hobart 7001, Hobart
Telephone (03) 6226 7175 Fax (03) 6226 7825

Report Number: 8515-2
Submitted By: S. Talbot
Reported To: S. Talbot
Test Method: APHA 3120

Lab. No: 976973&976981
Date Sampled: 30&31/10/97
Date Received: 3/11/97
Date Reported: 11/11/97

Stephenson EMF Consultants Water Samples

Lab. No.	Sample ID	pH	Sulphate mg/L	Al µg/L	Cd µg/L	Co µg/L	Cr µg/L	Cu µg/L	Fe µg/L	Mn µg/L	Ni µg/L	Pb µg/L	Zn µg/L
976973	S2.1	2.8	764	60 900	<1	16	11	3	56 000	102	15	13	69