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# Draft Remediation Strategy Abandoned Mines in Zeehan

Prepared for

Mineral Resources Tasmania

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	<b>Name</b>	<b>Signature</b>	<b>Date</b>
<b>Authorised by:</b>	<b>Jim Lockley</b>		<b>27 June 2005</b>

# 1. Introduction

Mineral Resources Tasmania (MRT) commissioned Pitt & Sherry on 29 April 2005 to provide a draft remediation strategy for the abandoned mines in the Zeehan area.

There are many abandoned mines in the Zeehan area, some of which present a risk to public safety and the quality of receiving waters.

A number of remediation programs and investigations have been undertaken in the Zeehan area over many years with varying degrees of success and sustainability.

Some of the works have been documented and recorded for future reference. Other works have been incidental and opportunistic.

MRT requested a review of the available remediation information and a draft remediation strategy update, to refocus and prioritise potential future projects for the Zeehan area.

## 1.1 Objectives

The objectives of this report are to:

- Review the available information regarding abandoned mines in the Zeehan area.
- Provide a draft remediation strategy with prioritised future actions.

## 1.2 Methodology

- Undertake a summary review of the documents supplied by MRT.
- Inspect specific abandoned mining areas in the Zeehan.
- Develop a draft remediation strategy.
- Supply a report.

## 1.3 Limitations

The following limitations exist for developing the draft strategy:

- Restricted to the documents supplied by MRT.
- The outlined scope of work.

- The limited time available to review and assess all the Zeehan abandoned mining areas.
- The limited access to many areas.

## 1.4 Reference Documents

The reference documents supplied by MRT are:

- 1) 'Acid Mine Drainage in the Zeehan District, Timothy Parr, November 1997'. An Honours Thesis, Geology Department, University of Tasmania.
- 2) 'Recommendations for an Acid Drainage Remediation Program in the Zeehan District', by Timothy Parr 1998. (Further to the above mentioned thesis)
- 3) 'Rehabilitation of Abandoned Mine Sites in the Zeehan Area', Naomi Oosting, July 1998, School of Geography and Environmental Studies, University of Tasmania.
- 4) 'An Archaeological Survey of the Historic Zeehan Queen Hill Mine Workings', Parry Kostoglou, undated.
- 5) 'Remediation Investigations & Pilot Works in the Zeehan Mineral Field', Earth Systems, September 1999.

## 2. Site Inspection

An inspection of specific areas at Zeehan was undertaken 9 May 2005.

Mr Robin Halfacre of MRT was present for the field inspection. Mr David Lane of the Zeehan Landcare Group attended intermittently.

A summary of the site inspection and the field measurements taken during the site inspections are contained in Appendix A.

The site inspection was restricted to the Storms Down and Oonah areas.

The Zeehan Landcare Group does not appear to have any remediation plans in the inspected areas. Apparently their programs are targeting the Nike Creek and Austral Creek head waters.

The findings of the field inspection are discussed below.

## 2.1 Findings

### 2.1.1 Silver Lead Creek

The Storms Down area on the northern western side of Queen Hill is rehabilitating slowly following rehabilitation works undertaken in 1999 to 2000.

A new section of the Trial Harbour Road has been constructed in this area and has impacted on previous rehabilitation works.

The main areas impacted are:

- The primary treatment wetlands for the Storms Down surface water runoff have been used as a disposal area for the road works. The storage has also interfered with the drainage of the wetlands to an adjacent secondary wetlands treatment area on the other side of the Storms Down access road. The under road culvert drain should be reinstated to prevent wash out by the existing drainage system.
- The new Trial Harbour roadside drains has resulted in deep excavations into the historic waste material in the area and has resulted in drainage of the secondary treatment wetlands. The secondary treatment wetlands should be reinstated.
- The Queen 4 shaft has been affected by the road works. A concrete pier has been removed and relocated beside the road along with other rubble from the earth works. See photographs in Appendix B.
- Road construction waste material has also been disposed of to a previously remediated area opposite the Queen No. 4 shaft. Ponding of run off water behind the new stockpiles is likely and should be rectified.
- The roadside drain on the northern side of the new road has been excavated and the iron precipitate material has been thrown back onto dry ground and exposed to the air and erosion back into the drain.

The Silver Lead Creek downstream of the Queen No. 4 shaft is highly polluted with acid mine drainage (AMD). Silver lead Creek upstream of the Queen No. 4 shaft is relatively clean.

A roadside adit east of the Queen No. 4 shaft is still discharging AMD to the roadside drain.

Reinstatement of the previous works is considered a priority to prevent ongoing damage and loss of the previous works.

Access to most areas of the Storms Down works on the side of Queen Hill and to the top of Queen Hill appears still reasonable. Diversion of surface waters

away from adits and shafts on top of the Queen Hill should reduce AMD discharges at the Trial Harbour Road lower levels.

Installing safety grates over the many Queen Hill shafts and adits should also be a priority.

Future works should consider the diversion of the Queen No. 4 shaft water to the wetlands on the northern side of the Trial Harbour Road.

### **2.1.2 Peas Soup Creek**

Pea Soup Creek drainage reports to an existing natural wetland area adjacent to the northern side of the Trail Harbour Road.

The Bradshaw area drains into Pea Soup Creek upstream of the wetland area.

The Bradshaw area could not be investigated due to the overgrown access tracks and the limited time to fully inspect the area.

Any future rehabilitation of the Bradshaw area would be restricted by the existing access limitations to the area.

Pea Soup creek is highly polluted with AMD and the Bradshaw area is likely to contribute significantly to the AMD emissions down Pea Soup Creek.

The existing Pea Soup Creek wetlands has been affected and drained by the large open roadside drains on the northern side of the new road works.

Reinstatement and enhancement of the wetlands in this area is considered a priority. However a proper survey is required of the area to ensure water levels are appropriate and separable from the new road works.

### **2.1.3 Oonah Creek**

The Oonah Creek abandoned mining area is far more extensive than it appears from the roadways.

The revegetation of the area appears to be quite slow due to the poor soil conditions in the area and the bare waste rock dumps.

Following are the field observations for the Oonah area:

- No capping of waste rock dumps, proper covering of shafts and adits or surface water diversions appear to have been undertaken as part of the CRA Exploration, Oonah Hill Rehabilitation Plan, August 1991.
- The whole area contains:
  - Potentially dangerous locations.

- Actively mobile landforms.
- Diffuse and point source acid mine drainage.
- Oonah Creek appears highly polluted by AMD and its flow path has been altered over time by the placement of waste rock dumps, and the location of mine shafts and adits.
- Active erosion of waste rock dumps in the area was evident and the eroded material appears to be migrating downstream into flat wetland areas and then settling.
- Surface water flows were difficult to delineate due to sub surface flows in several drainage lines.
- Public safety may be an urgent issue for the area. Mine subsidence has been reported in a specific area. (McKenzie pers. com. to Robin Halfacre)

The potential exists to divert surface waters away from waste rock dumps and shafts, however good access and a survey of the area will be required.

As the existing access to the upper Oonah areas is poor, this may need to be addressed if any works in the upper reaches is to be considered.

### **3. Document Review**

A short summary review of the reference documents is outlined below in the order of the document numbers in section 1.4.

#### **3.1 Tim Parr's Thesis.**

- The drainage waters around Zeehan have a pH between 2.2 in clastic sedimentary rocks to 7.6 in carbonates.
- The worst contamination of surface waters in the Zeehan district occurs around Queen Hill, the Smelter and the Old Spray.
- The Zeehan Queen area emissions had the highest concentrations of iron and acid. The Zeehan West emissions had the highest lead.
- 'Svens' swamp area adjacent to the Trial Harbour Road was naturally mitigating some of the acid and iron loads from the Pea Soup Creek and Oonah Creek catchment.
- Calculated mass loads of contaminants have shown that AMD from the mine sites around Queen Hill have a significant effect on stream contamination in the area.

- Metal speciation calculations have shown that most metals are transported as bare ions in the Zeehan drainage waters.
- Goethite was the prime secondary precipitate in the streams.
- Remediation options include:
  - Enhancement of naturally occurring wetlands. (Eg 'Sven's swamp).
  - Remediation using anoxic limestone drains.
  - Reducing high metal and acid flows by adit plugging with concrete.
  - Recontouring and covering waste rock dumps.

### **3.2 Tim Parr's Recommendations (extra to the thesis)**

- Of eight major water contamination sources north west of Zeehan, five are the major sources of contamination.
- They are Queen No.4 shaft, Queen No.4 workings, Storms Down workings, adits besides the Trial Harbour Road and one adit at the south Oonah workings.
- The Bradshaw area and the Oonah areas were deemed to be of lower AMD priority.
- Remediation options outlined were:
  - Recontouring and compaction of waste rock dumps.
  - Removal or flooding of lower waste rock dumps.
  - Surface water diversions.
  - SAPS.
  - Enhancement of the naturally occurring 'Svens' Swamp.

### **3.3 Naomi Oosting's Study**

- The study developed a ranking table to categorise, prioritise impact values and give an overall ranking.
- The categories were:
  - AMD.

- Safety.
  - Erosion.
  - Vegetation.
  - Visibility.
  - Heritage.
- The top four ranked areas overall were:
- Austral Smelter
  - Montana
  - Queen No. 4
  - Storms Down

The Oonah works came in at number 8.

Of particular interest was:

- The top four were also the top four for safety hazards
- Three of the sites (Montana, Queen No. 4 and Storms Down) were in the top five for AMD.
- Two of the sites (Montana and Queen No. 4) were in the top four for visibility. All top four sites were in the top seven for visibility.
- The Austral Smelter site had the overall highest ranking due to the AMD, safety hazards, visibility and heritage rankings.

The Oosting study brings into focus other important aspects to be considered when reviewing the strategic rehabilitation plan for the Zeehan area.

Public safety especially is an important consideration in prioritising any works program.

The current Zeehan demographics has not been researched, but it is highly likely that new residents are coming to Zeehan attracted by the new employment opportunities at the new Allegiance Mine on the Trial Harbour Road and the new operations at the Renison Mine.

New residents may not be as aware of the inherent safety hazards that exist virtually around the town peripheries.

The protection of the public, especially young children and even their pets should be the highest priority in the strategic plan.

Appropriate warning signage and the capping with light gauge galvanised iron grates, rocks, or concrete, of all identified and readily accessible shafts and adits in close proximity to the town and roadways should be investigated.

A safety audit of the open shafts and adits in the Zeehan area should be undertaken by MRT with a view to quantifying and prioritising the safety works program.

### **3.4 Heritage Survey**

An undated heritage survey was undertaken for the Queen Hill mine workings.

The survey identified many items in the Queen Hill district of medium to high values with recommendations to protect.

Any remediation works will need to take into account the identified heritage values of areas or specific items at risk of disturbance.

### **3.5 Earth System's Investigation**

The Earth System investigation collated the information from the previously mentioned reports and identified and addressed many of the technical data gaps.

Regardless of the limitations, the Earth Systems investigation is likely to remain the primary reference document for the Zeehan area for quite some time.

The investigation quantified, with limitations, the main contaminant mass loads for AMD discharges in the area.

The findings relevant to the strategic remediation planning in the area are summarised below:

- Oonah Creek is the main source of acidity and metals loads into Pea Soup Creek.
- Nike Creek is the next significant source of metals and acidity.
- Pea Soup Creek and the lower Silver Lead Creek inputs are also sources of acid and metals into the Zeehan Rivulet, but mainly iron and acidity.
- Key metal contaminants of aquatic ecological concern from the Zeehan mining field were:
  - Zinc.
  - Lead.

- Aluminium.
- Copper.
- Cadmium.
- Iron.

It was interesting to note that most of the metals were present in the water samples as the 'soluble' <0.45 microns fraction, while the iron content had a considerable fraction as the 'insoluble' or >0.45 microns.

- Alkalinity addition was identified as a remediation option.
- A HALT mill trial demonstrated that alkalinity addition using limestone was able to significantly reduce the metal and acidity content of the surface water.
- However, a staged remediation plan was developed that required significant infrastructure and capital cost, beyond the scope of the funding capacity.
- The Zeehan Rivulet at the Zeehan Highway Bridge does not meet the ANZECC water quality guidelines for the protection of 95% of aquatic ecosystems.
- The Little Henty River water quality at the Strahan Road Bridge does not meet the ANZECC water quality guidelines for the protection of 95% of aquatic ecosystems.
- Pollutant loads appear to be significantly greater when associated with flushing events.

Based on the analytical results in the Earth Systems investigation, removal of most of the metals and acidity from Zeehan Rivulet would result in only marginal water quality improvements in the Little Henty River, as measured at the Strahan Road Bridge. The indicative reductions are outlined below:

- Zinc 28%
- Lead 55%
- Iron 22%
- Acidity 11%.

It appears from the data that Zeehan is not the major source of pollutants into the Little Henty River at the Strahan Road Bridge. The most likely sources are the Dundas mining field including the Comet and Razorback areas discharging into the Dundas River.

## 4. Protected Environmental Values

The protected environmental values (PEV) for surface waters in the Zeehan area have been established by the West Coast Council and DPIWE in accordance with the *State Policy on Water Quality Management 1997*.

The PEVs have been specifically outlined for Pea Soup Creek, Silver Lead Creek, Nike Creek and Zeehan Rivulet. Austral Creek was not specified so the PEVs for this creek will be determined by defaulting to the land tenure classification.

The PEVs for the Zeehan area are not high and reflect the currently degraded state of local waterways. This is not, however, an excuse to do nothing as part of the strategic planning.

The PEVs are summarised as follows:

### 4.1 Pea Soup Creek

A: Protection of Aquatic Ecosystems

- (i) Protection of modified (not pristine) ecosystem
- (b) from which edible fish are not harvested

B: Recreational Water Quality & Aesthetics

- (iii) Aesthetic water quality

### 4.2 Silver Lead Creek, Nike Creek and Zeehan Rivulet

A: Protection of Aquatic Ecosystems

- (i) Protection of modified (not pristine) ecosystem
- (b) from which edible fish are not harvested

B: Recreational Water Quality & Aesthetics

- (ii) Secondary contact water quality
- (iii) Aesthetic water quality

### 4.3 Water Quality Objectives

The ANZECC guidelines have recreational limits for general chemicals. The key chemical limits are summarised below.

As – 50 µg/L; Cd – 5 µg/L; Cr – 50 µg/L; Pb – 50 µg/L; Ni – 100 µg/L; Al – 200 µg/L; Cu – 1,000 µg/L; Fe – 300 µg/L; Mn – 100 µg/L; pH – 6.5-8.5; SO<sub>4</sub> – 400,000 µg/L; Zn – 5,000 µg/L.

The Zeehan Rivulet at the Zeehan highway exceeded the recreational values for pH, Al, Fe, Mn and Pb.

The ANZECC guidelines have trigger value limits for 95% ecosystem protection level. The key chemical limits are summarised below.

As – 24 µg/L; Cd – 0.2 µg/L; Cr – 1.0 µg/L; Pb – 3.4 µg/L; Ni – 11 µg/L; Al – 55 µg/L; Cu – 1.4 µg/L; Mn – 1,900 µg/L; Zn – 8.0 µg/L.

The Little Henty River at the Strahan Road Bridge exceeded the guidelines for Pb, Al, Cu and Zn.

The Zeehan Rivulet at the Zeehan Highway exceeded the guidelines for Cd, Pb, Ni, Al, Cu and Zn.

## 5. Draft Remediation Strategy

The aim of the draft remediation strategy for abandoned mines in the Zeehan area is to set in place the basis to maintain and where possible improve the existing risks and impacts over time.

Due to budgetary and resource limitations and the potential scale of the Zeehan works, the likely timeframe for the implementation of action plans associated with the draft remediation strategy may be 5 years or longer.

Should further information became available during implementation of the remediation strategy, the remediation strategy and timeframe may need to be reviewed in line with the new information.

### 5.1 Priorities

Base on the review of the reference documents and the site investigation, the priorities of the draft remediation strategic for abandoned mines on Crown Land in the Zeehan area are as follows:

1. Safety.
2. Strategic access.
3. Strategic surveys.
4. Enhance existing wetland.
5. Passive alkalinity treatment.

## 5.2 Safety

It is proposed to make safe the many readily accessible exposed shafts and adits in and around the Zeehan township.

A hazard assessment and audit of these known shafts and adits should be undertaken to prioritise and form the basis for actions to be undertaken over a specific period.

It is estimated that approximately 40 adits and shafts should be audited, regardless of whether they are located on Crown Land or private land.

The approximate locations of the shafts and adits are summarised as follows:

- Approximately 7 adjacent to the eastern side of the highway heading north out of Zeehan.
- Approximately 7 adjacent to and above the Trial Harbour Road to the NW of Zeehan.
- Approximately 9 in the Zeehan Rivulet catchment to the north of the township.
- Approximately 5 to the south of Zeehan near the recreation area at the Strahan turnoff.
- Approximately 12 in the Nike Creek catchment to the west of the township.

Further to the above, Oosting prioritised the Austral Smelter, Montana, Zeehan Queen No. 4 area and Storms Down areas.

A Mr McKenzie has reported a safety issue at the Oonah Mine and this should also be investigated further as a priority.

It is estimated that only a small proportion of the shafts and adits to be audited will require remediation works. Some may have already undergone remediation also.

It is estimated that 2 to 3 shafts may require upgrading of the existing capping or fill or require new capping or new grating per year for approximately 5 years. This will be decided following the hazard audit.

It is recommended that auditing and documentation of the hazards in the Zeehan area should be undertaken at least once every five years.

Refer to Appendix 5 of the Earth Systems' Investigation Report for the location of many of the old mine sites and potential hazardous shafts and adits in and around the Zeehan township and those readily accessible from local roadways.

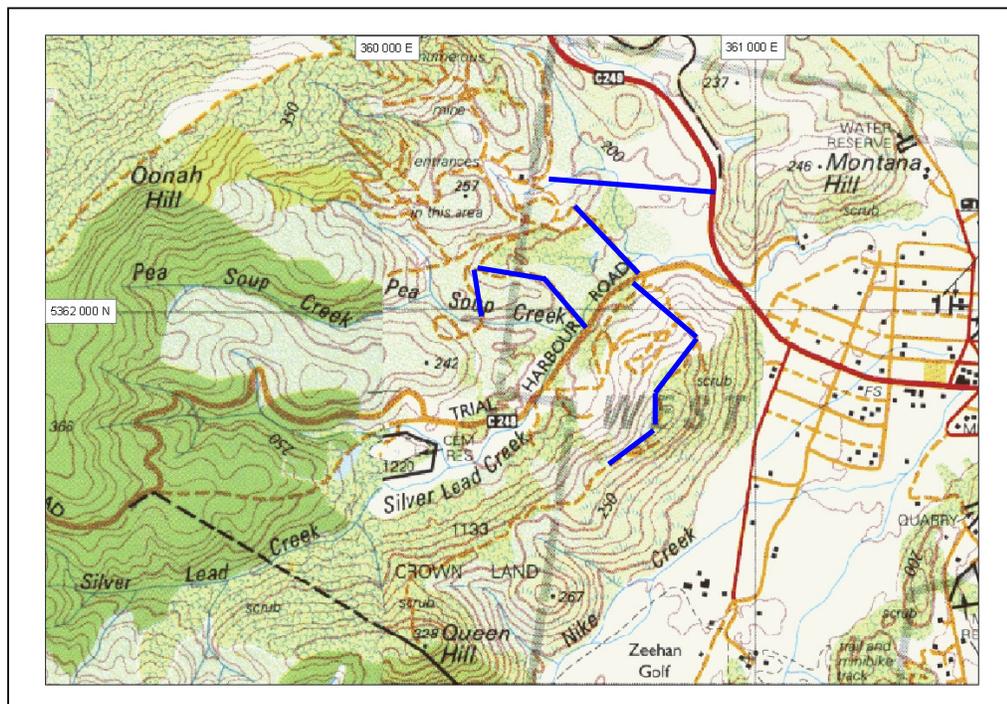
## 5.3 Strategic Access

It is important that safe reliable access to strategic areas for future investigation is maintained. Initially it is envisaged the following main access tracks are maintained with appropriate signage and security with a view to future extension if and when required.

- Access to the top of the Storms Down workings at Queen Hill. This will ensure access for water diversion works and shaft and adit management.
- Access to the Oonah workings from the highway turnoff north of the Trial Harbour Road turnoff. This will ensure access to future surveying, water diversion works, shaft and adit management and potential passive water treatment.
- Access into the Pea Soup Creek wetlands areas. This should include an upgrade of the existing tramway 'formation' and the old roadway to Queen No. 5 workings through the 'Svens' swamp area.

Safe access and security gates to the above mentioned areas should be implemented and maintained over the 5 years timeframe. It may be possible to use benign waste rock from the Comstock and Allegiance mines in the area for the civil engineering works required.

The strategic access tracks and the tramway access are outlined below in blue in Figure 1.



**Figure 1. Strategic Access Tracks.**

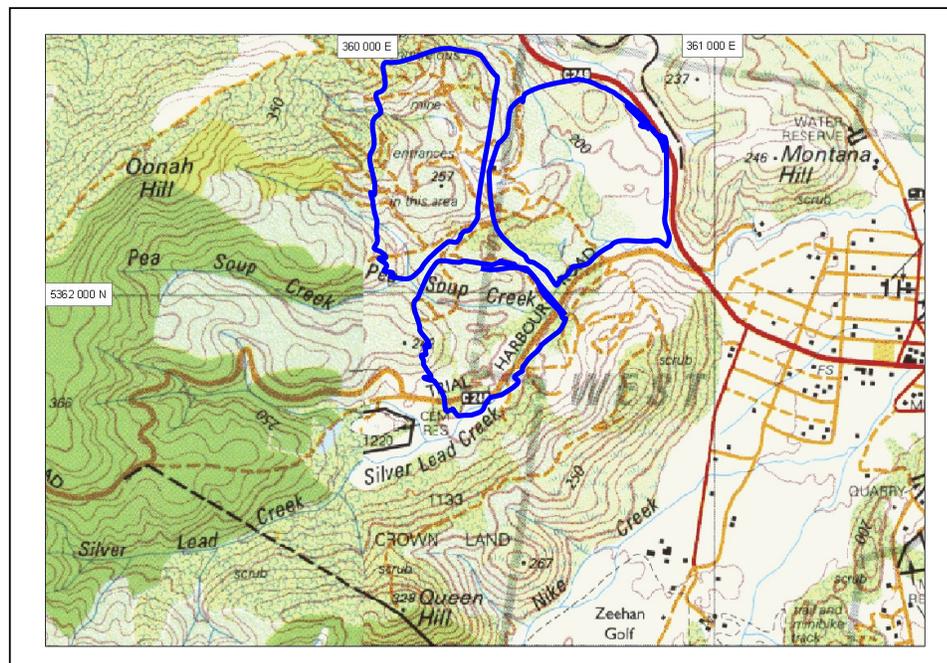
## 5.4 Strategic Surveys

Ground level surveys should be undertaken in the Pea Soup Creek and Oonah Creek catchment areas for future reference.

The scope of the surveys can be spread out over the first two years of the strategy but the information needs to be available when considering the following:

- Enhancement of Pea Soup Creek wetlands. Establishing correct water levels and the extent of civil works will not be possible without proper surveys.
- Storm water diversions. Future storm water diversion may be implemented along the Trial Harbour Road, in the Pea Soup Creek catchment and the Oonah workings. Establishing correct water levels and the amount of civil works will not be possible without a reasonably accurate survey of the areas.
- Montana and Austral Smelter works. It may be necessary to survey these two areas also for the enhancement of wetland treatment for the reasons outlined above.

The locations of the areas that may require more accurate surveys are outlined below in blue in Figure 2.



**Figure 2. Areas that may require more accurate survey.**

## 5.5 Enhancing Existing Wetlands

It is proposed to enhance the performance of existing wetlands areas wherever possible.

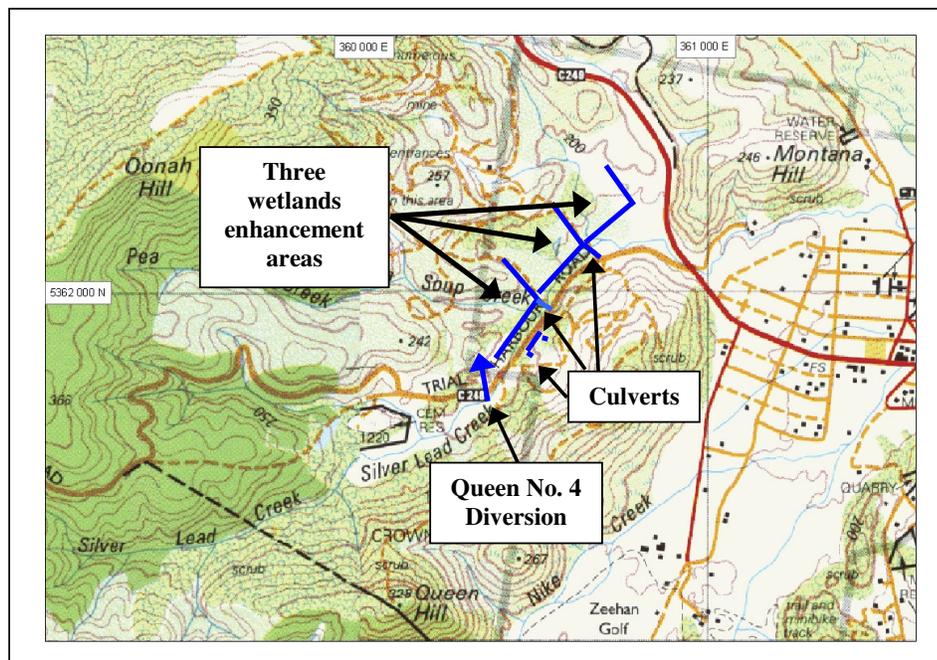
The main wetlands areas along the Trial Harbour Road are considered the highest priority at this time.

Water levels may need to be slightly raised to improve performance. The level increase is initially considered to be in the order of 0.5 m. The proposed upgraded access track and tramway from the Trial Harbour Road northwards into the old Oonah and Pea Soup creek workings would form part of the enhancement infrastructure.

Benign waste rock from historic or currently operating mines in the area could be used for wetland enhancement. Although the constructed enhancement walls may not be impermeable to water, if compacted they should have a sufficiently low hydraulic permeability for the purposes of the enhancement. (I.e. Sufficient retention time to allow neutralisation, oxidation and some settlement.

The wetlands enhancement design will ensure physically separation from and no impact upon the new road works and associated drainage.

The locations for potential wetlands enhancement are outlined below in blue in Figure 3.



**Figure 3. Potential wetland enhancement areas.**

Over time, the wetland can be readily maintained, altered or added to as required, due to the safe access infrastructure which will form an integral part of the wetlands enhancement infrastructure.

The enhancement of an upper wetland area at the top of the old tramway formation (not shown in the above figure) is also possible in future if required.

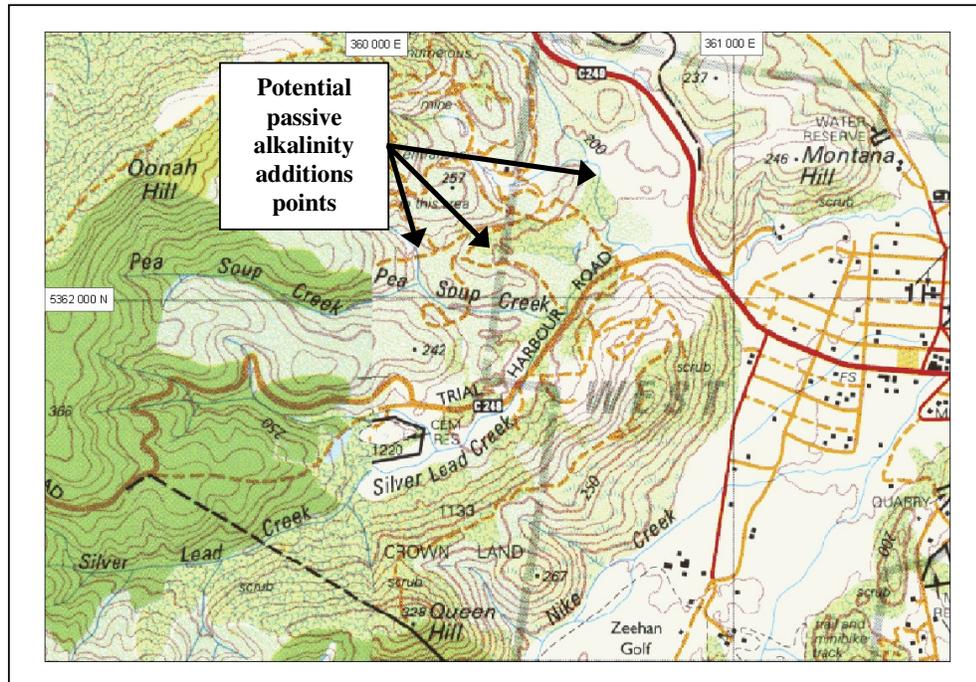
The existing wall of this wetland requires maintenance to reduce short-circuiting and re-establish the washed away spillway.

## 5.6 Passive Alkalinity Treatment

The low pH of the waters in Pea Soup Creek, Bradshaws Creek and the Oonah catchment makes them readily amenable to passive alkalinity addition. Alkalinity additions to surface waters require a more intrusive approach above a pH of 5.5 to 6.0.

Coupled with the wetlands enhancement, alkalinity addition has the potential to reduce the heavy metal content of waters discharging from the wetlands (due to adsorption of heavy metals onto iron and aluminium precipitates).

The locations of potential passive alkalinity additions are outlined below in Figure 4. Note the alkalinity addition points need to be above the wetlands water level and in a flowing section of the watercourse.



**Figure 4. Potential passive alkalinity additions points.**

## 5.7 Monitoring

A localised monitoring program should be included in the strategy so that improvements or otherwise can be measured and adjustments made to any ongoing strategic remediation as required.

## 5.8 Dundas River

It is evident from the Earth Systems investigation report that the Dundas River has a much higher pollutant input into the Little Henty River than the Zeehan Rivulet.

However, the Zeehan Rivulet is considered a higher priority than the Dundas River at this time, due to the proximity to the township and the higher profile of the Zeehan waterways.

From an ecological point of view, the Dundas River catchment should be studied in future to confirm the apparent 70% pollutant input to the Little Henty River. A similar strategic remediation plan update should be developed for the Dundas areas similar to the Zeehan district.

## 5.9 Austral Smelter and Montana workings

The Oosting report prioritised several safety and environmental issues surrounding the Austral Smelter and the Montana works sites.

The issues associated with the Austral Smelter area are mainly the slag dump stability, exposed workings and the AMD emissions from the sulphide dump.

It is understood that the area is under a retention licence (RL), so the site may not be strictly speaking an abandoned mine on Crown Land.

It is assumed that although the RL owner has some responsibilities, MRT are responsible for the site safety hazards and environmental impacts until a Mining Lease is taken out on the site.

Due to the potential administrative issues associated with the management and regulation of the Austral Smelter retention licence, the action plan for this area has been kept separate from the remediation strategic plan.

MRT in consultation with the RL owner should develop a separate plan as follows:

- Recontour and stabilise relevant areas of the slag dump.
- Facilitate sale of the sulphide dump to a mineral processor so that the mineral values of the dump can be realised instead of being lost to the Little Henty River.

- In lieu of point above, relocate or encapsulate the sulphide dump.
- Enhance the wetlands for the slag dump leachate and consider passive alkalinity additions in the area.

It should be noted that the current chemical degradation of the sulphide dump at the Austral Smelter might be sterilising the mineral resource of the dump from future mineral processing.

The issues associated with the Montana site are mainly safety and these should be assessed and addressed under section 5.2 of this remediation strategy.

## 5.10 Others

It appears that the Zeehan Landcare Group is pursuing funding for remediation works in the area of the Nike Creek and the Austral Creek headwaters.

The draft remediation strategy will not interfere or impact on the landcare group's proposals.

## 6. Remediation Action Plan

A remediation action plan reflecting the minimum 5-year life of the remediation strategy is summarised below in Table 1.

Priority	Year 1	Year 2	Year 3	Year 4	Year 5
<b>Safety</b>	Adits at top of Queen Hill	Audit. Then 3 other adits	3 other adits	3 other adits	3 other adits
<b>SW Diversion</b>	Adits at top of Queen Hill. Storms Down wetlands	Queen No. 4. Shaft	Investigate Oonah diversions		
<b>Access</b>	Pea Soup creek	South Oonah	Upper Oonah		
<b>Survey</b>	Trial Harbour Road area	Pea Soup Creek area	Svens/Oonah area		
<b>Enhance Wetlands</b>		Storms Down area	Pea Soup Creek area	Svens/Oonah area	
<b>Passive treatment</b>				Add alkalinity	Add alkalinity
<b>Monitor</b>					Localised plan

**Table 1. Indicative Action Plan**

## 7. Indicative Budget Estimate

An indicative budget estimate has been included in the remediation strategy and is summarised below in Table 2.

The estimates are only indicative at this time and based on a conceptual design.

Further site assessment and detailed design will be undertaken if the strategy is adopted and implemented. Some costs are dependant on the availability of local waste rock and local contractors.

<b>Priority</b>	<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>	<b>Total</b>
<b>Safety</b>	\$5,000	\$5,000	\$5,000	\$5,000	\$5,000	<b>\$25,000</b>
<b>SW Diversion</b>	\$10,000	\$10,000	\$10,000			<b>\$30,000</b>
<b>Access</b>	\$20,000	\$20,000				<b>\$40,000</b>
<b>Survey</b>	\$20,000	\$20,000	\$10,000			<b>\$50,000</b>
<b>Enhance Wetlands</b>	\$10,000	\$20,000	\$20,000	\$20,000		<b>\$70,000</b>
<b>Passive treatment</b>				\$10,000	\$10,000	<b>\$20,000</b>
<b>Monitor/Report</b>					\$10,000	<b>\$10,000</b>
<b>Project Design and Management</b>	\$12,000	\$15,000	\$8,000	\$7,000	\$3,000	<b>\$45,000</b>
<b>Total</b>	<b>\$77,000</b>	<b>\$90,000</b>	<b>\$53,000</b>	<b>\$42,000</b>	<b>\$28,000</b>	<b>\$290,000</b>

**Table 2. Indicative Budget Estimate**

**APPENDIX A  
FIELD SUMMARY**

## Zeehan Field Investigation 09/05/05

Present: Shorty Halfacre, David Lane (temporary) and Jim Lockley.

Following is a preliminary data summary of the site investigation for your preliminary information. The site locations are numbered at this stage from bottom to top as shown on the map, until I can give them their proper historic titles.

Site	1	2	3	4	5	6
<b>Description</b>	Queen No. 4 adit	Queen Open Cut Treatment	Lower Trial Road Culvert	Lower Pea Soup Creek	Top of Tramway Formation	Other side of Wall above iron terrace
<b>AGD 66</b>	E0360419 N5361738	E0360504 N5361779	E0360484 N5361846	E0360418 N5360970	E0360372 N5362112	E0360379 N5362144

Site	7	8	9	10	11
<b>Description</b>	Adit above iron terrace	Little adit beside a waste rock dump	Lower Oonah Creek	Top of Oonah WRD	Creek running into adit towards top of workings
<b>AGD 66</b>	E0360363 N5361166	E0360282 N5361189	E0360642 N5362364	E0360295 N5362374	E0360277 N5362451

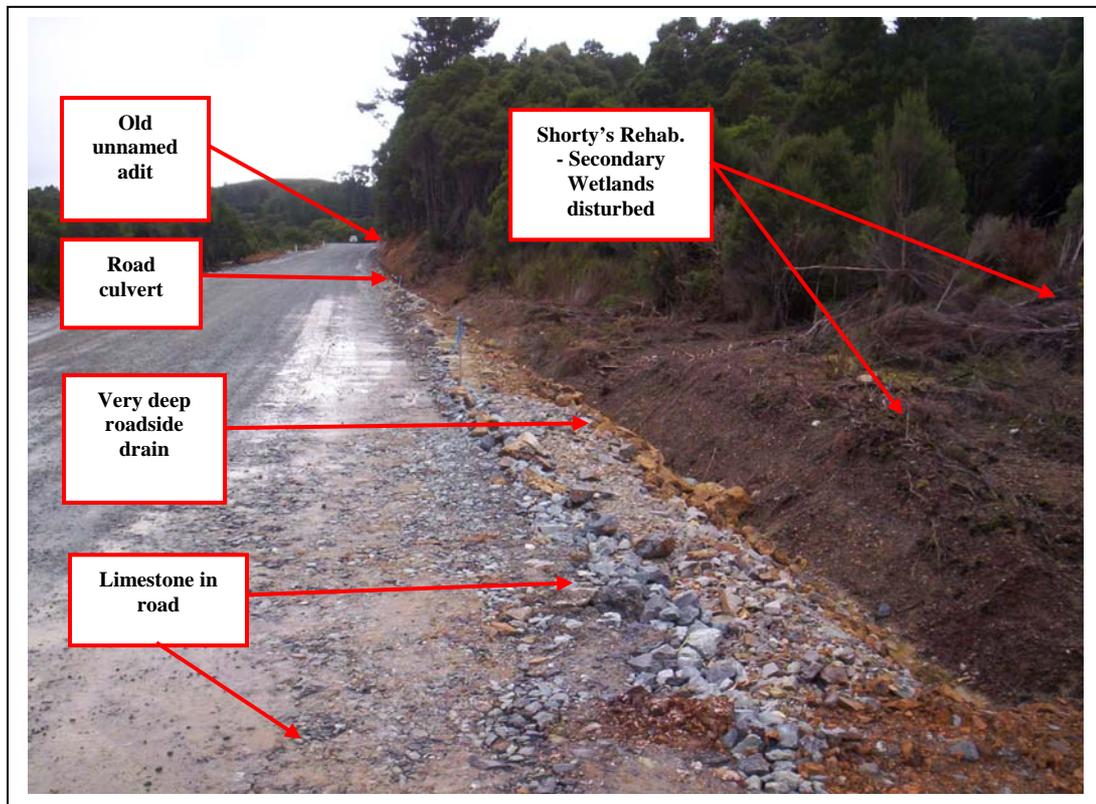
<b>Water quality Site</b>	<b>pH</b>	<b>Conductivity μS/cm</b>	<b>Temperature °C</b>	<b>DO %</b>
<b>1</b>	3.44	1240	11.5	47
<b>2</b>	2.96	1534	10.6	55
<b>3</b>	3.25	980	11.3	58
<b>4</b>	3.5	403	10	120
<b>5</b>	3.36	588	10.1	110
<b>6</b>	Not measured	Not measured	Not measured	Not measured
<b>7</b>	4.7	571	10.9	7.5
<b>8</b>	3.3	547	11.4	85
<b>9</b>	3.55	459	12.3	70
<b>10</b>	3.15	614	10.6	50
<b>11</b>	Not measured	Not measured	Not measured	Not measured
<b>Silver Lead Creek above Queen 4</b>	7.6	107	10	102
<b>Silver lead Creek Upper Culvert opposite site 1</b>	5.5	185	10.2	92



Appendix B

**PHOTOGRAPHS**

## Photographs



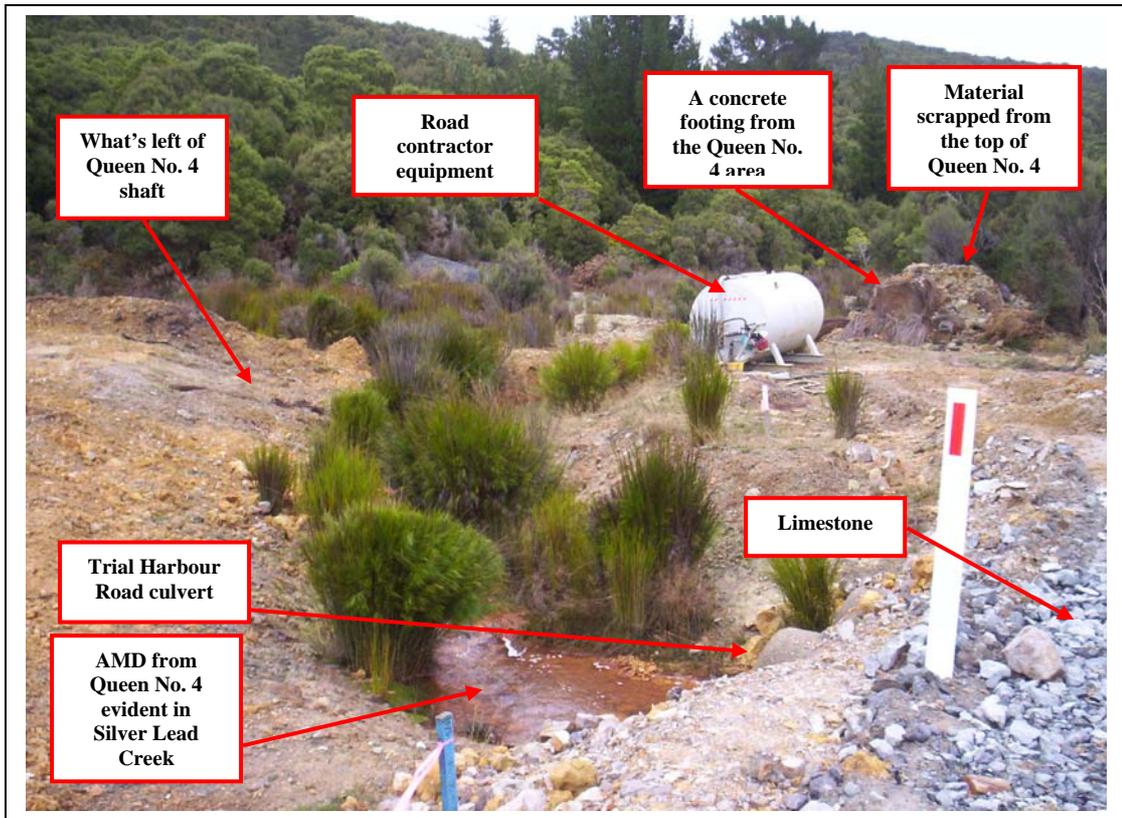
**Photograph 1.**

**Trial Harbour Road looking east from access road to the Storm Downs workings. New road drain is very deep and draining the secondary wetlands, which was treating the Storm Downs runoff. It is likely the secondary wetland vegetation will die off if bund walling along the top of the drain is not reinstated to hold back the AMD. One good point is the amount of limestone that can be seen in the road upgrade. Should give some neutralisation of the AMD seeping through it.**



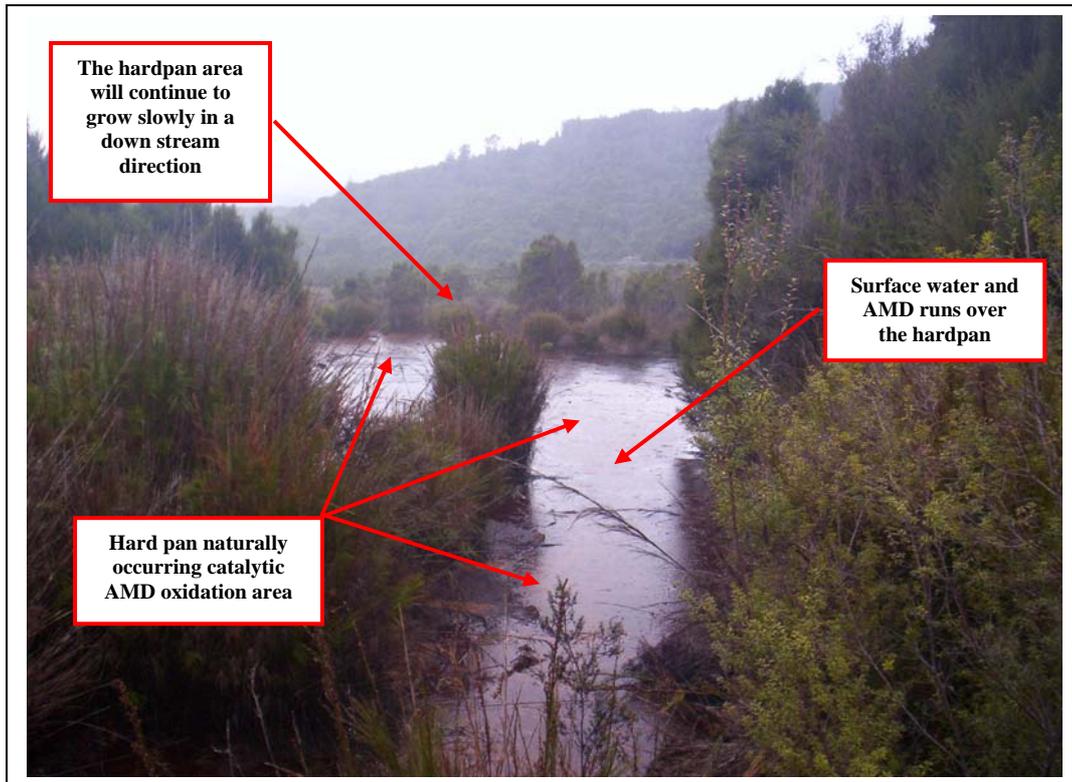
**Photograph 2.**

**Storm Downs access road looking south east. The road has been disturbed and the primary wetlands covered with road works rubble. The culvert from the primary wetlands to the secondary wetlands has been buried also. There is now no definitive surface water flow through the culvert and in winter the surface water will overtop the primary wetlands area and erode a new surface water pathway to the Trial Harbour Road.**



**Photograph 3.**

**The old Queen No. 4 shaft area looking southwest.**



**Photograph 4.**

**Natural remediation area at the top of the old tramway formation, off the Trial Harbour Road, looking southeast. Hard panning of ferric and other metal hydroxide precipitates are apparent, as well as possibly some gypsum formation, and this forms a relatively stable crust. This natural remediation and crusting occurrence is also evident at Mt Bischoff No. 9 adit. The 'Pyrimid' study outlines ways to emulate this natural treatment process and when artificially created it is describes as a 'SCOOFI' treatment. This stands for 'surface catalysed oxidation of ferrous iron'.**