MANAGEMENT AND REHABILITATION OF THE SILVERMINES AREA

SUMMARY REPORT:

Prepared for:

DEPARTMENT OF MARINE AND NATURAL RESOURCES

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GLOSSARY OF TERMS

Acceptable limit / acceptance criteria	The maximum concentration of a contaminant (in soil, water etc) which equates to a degree of risk which is considered acceptable within the context of a risk assessment.
Acid mine drainage (AMD)	Water draining from mine workings or mine dumps, which has become acidic usually as a result of the oxidation of sulphide minerals in the mine. The acidity can dissolve heavy metals and can result in deposits of iron ochre in stream and lake beds, etc.
Adit	A (near) horizontal passage driven from the surface for the working or drainage of a mine.
Aesthetics	The visual impact of a feature or landscape.
Alluvial	Applied to the environments, actions and products of rivers and streams. Alluvial sediments (alluvium) are deposited by a river in its flood plain.
Aquifer	A body of permeable rock or sediment that is capable of storing significant quantities of groundwater is usually underlain by impermeable material, and through which groundwater moves. May be a source of water supply.
Backfilled	A disused mine or excavation may have been filled or partially filled with material. The material may be natural soils and rocks, mine waste or other waste. It is highly variable and not placed in an engineered manner. It may be unstable.
Baseline data	A collection of (usually environmental) data which describes some pre-existing, or background, conditions. The data can be used as a benchmark to measure change which occurs following some action, such as the clean up of a contaminated area.
Capping and sealing	Covering of a contaminated area with engineered layers of natural rock, soil or man-made products to prevent direct contact with the contaminants, to prevent upward migration of contaminants and/or to prevent downward leaching of the contaminants by infiltrating water.
Catch paddock	An area of low-lying ground, usually enclosed by an embankment, designed to contain spillages and seepages of contaminated liquids or sediments.
Contaminant / contamination	In a risk-based context, a contaminant is a substance which occurs at a concentration (in soil, water etc.) that poses an unacceptable threat to human health, livestock health and/or the environment. Contaminants may be solids, liquids, gases/vapours, sludges, be diluted within the surrounding medium or concentrated in heaps or tanks.

Decant	A system of works and pipes designed to remove surplus water from a pond or lagoon where suspended solids are allowed to settle out.
Decline	A passage driven at an angle down from the surface for the working of a mine.
Derelict land	Land which will not be utilised, but which will be vegetated with a self-sustaining cover, and for which access will be allowable, but restricted.
Dilution in the environment	The reduction in concentration of a contaminant as it spreads through the environment and gets further from its source. Can be used in a controlled manner as part of a risk management scheme.
Drift	Unconsolidated sediments existing above the solid bedrock but excluding agricultural soils. Strictly used for sediments derived from glacial ice but the term is sometimes used to include all superficial sediments, such as those derived from rivers or lakes. A drift in mining parlance is an adit.
Ecology	Study of the relationships among organisms and the relationship between them and their physical environment.
Elevated metal	A shorthand term for elevated metal concentration, meaning that the concentration of the particular metal in the soil or water is greater than the normally expected background concentration. This may be a result of the natural existence of metal-bearing minerals or as a result of deposition by man of substances containing the metal in question. It does not necessarily mean the area is contaminated.
Environmental impact assessment	A multi-disciplinary study which evaluates the effect on the environment of large construction or development projects.
Environmental standards or targets	Published concentrations of contaminants which are maximum values designed to protect the environment or human health to an acceptable level of risk. (For example, the maximum concentration of a substance which is allowed in drinking water.) "Standards" are legally enforceable limits, "targets" or "guideline values" are advisory.
Gabion	A metal cage which is filled with rocks and fixed with others to form structures such as retaining walls and river bank protection.
Geochemical system	The inter-related chemical reactions and equilibria which take place in the environment, involving natural rocks, soils, water and air and any substances such as contaminants, waste rock or tailings introduced by man.
Groundwater	All the water contained in the void space within rocks and soil. Generally taken to exclude the vadose water, i.e., water travelling between the surface and the water table.

Hazard	Something with the potential to cause harm.
Heavy metals	An imprecise term for metals such as lead, cadmium, zinc etc. which have a moderate to high atomic number and inhibit plant growth.
Impact	An effect on some part of the environment caused by a certain action or change.
Ions	Atoms of elements or combinations of elements with a net electric charge, making them susceptible to reactions with other ions having an opposite electric charge.
Lagoon	An artificial pond used for the storage of water or silt/sludge.
Leach	The washing of a substance out of the rock or soil by the action of water passing through it.
Leachate	Liquid containing substances which are washed out of the rock or soil by the action of percolating water.
Licensed disposal facility	A landfill site which has a licence to operate, issued by the regulatory authorities. The terms of the licence dictate the type of waste that can be disposed in the landfill.
Mine opening	The entrance to a mine, be it a shaft, adit, decline, etc.
Mining residue	Waste materials left over from the mining and processing of minerals.
Mobilised	Substances, such as heavy metals, can become more mobile in the environment when subject to chemical changes. This is chemical mobilisation. For example, certain metals will dissolve in water to a greater extent if the water is more acidic. Physical mobilisation can also occur, when materials are eroded by flows of water or air, as suspended particulate solids, in streams or in the atmosphere.
Natural attenuation	The effect of naturally occurring physical, chemical and biological processes to reduce the amount, concentration, mobility or toxicity of contaminating substances (usually in groundwater). For natural attenuation to be effective as a remedial action, the rate at which those processes occur must be sufficient to prevent contaminating substances from entering receptors and to minimise movement within existing contaminated receptors.
Open-pit / opencast working	Mineral working from an open excavation or pit.

Orebody	A continuous, well-defined mass of material of sufficient ore content to make extraction economically feasible.
Outcrop	Part of a solid rock formation which is exposed at the Earth's surface.
Outcrop workings	Open pit and shallow underground workings where the orebody is exposed in the outcrop. Usually the oldest workings and subject to instability when abandoned. Often contiguous along the length of the outcrop of the orebody.
Pathway	The route (direct or indirect) in the environment by which the contaminant(s) may be transferred to the receptor(s) of concern.
Permeability	A general term to describe the ease with which water can flow through a porous medium such as rock or soil. Strictly speaking the term "intrinsic permeability" defines the pervious properties of the medium only and the term "hydraulic conductivity" describes the ability of the medium to transmit water.
Preferred options	A remedial strategy for risk management considers a wide range of possible measures. The preferred options are those which are deemed to be the most suitable to undertake in the light of all the factors.
Processing wastes	Waste rock which has been processed to remove the mineral being mined. This may include crushing and grinding to a fine powder and treatment with various chemicals to extract the desired product. May also include smelting wastes if that process was undertaken on site.
Receptor	The point at which damage may occur if a contaminant is present at a level sufficient to cause harm. This may be a person, animal, property or the environment
Rehabilitation	Reclaiming and re-developing land and buildings which have been abandoned, bringing them back into beneficial use.
Remedial options	The techniques available for remediation of physical and chemical dereliction of land and water. Remedial options for contaminated land are traditionally divided into civil engineering based options (excavation, containment and hydraulic control) and process based options (thermal, physical, chemical, biological and stabilization/solidification). Civil engineering based options are appropriate for the physical remediation of abandoned mine workings.
Remediation	Often synonymous with rehabilitation but strictly refers to the techniques used to remedy the effects of derelict and contaminated land, including the water environment.

Remediation plan or strategy	The strategy of risk control measures, which has been derived as part of the risk management process for a contaminated or derelict site.
Risk	The likelihood of a receptor being harmed.
Risk assessment	The systematic process of identifying and analysing the risks inherent in a system or situation and their significance in an appropriate context. It is a process which allows judgements about the nature of potential adverse effects and the chance that they are realised. The judgement may be expressed in a qualitative or quantitative manner.
Risk control	Actions designed to control or reduce risks to an acceptable level. Can include remedial actions such as removal, containment or treatment of contaminated material.
Risk management	The combination of risk assessment and risk control, used to manage risks to an acceptable level.
Settlement	The downwards movement of a structure resulting from subsidence of the ground on which it is founded, such as by mining subsidence. Settlement of structures can also be caused by consolidation of the foundation material.
Settlement pond	A (usually) artificial pond created to allow suspended sediment to settle out of water before the water is allowed to be discharged to the environment. For example, water draining from a mine or water used in the processing of minerals.
Shaft	A near-vertical mine entry of limited area constructed to access underground workings or to provide ventilation.
Shallow mine workings	Underground mine workings which are sufficiently close to the ground surface such that collapse of the workings will have a significant and local effect on the ground surface.
Sinkhole	Subsidence where the ground surface drops, leaving a deep depression with vertical sides. The cause is the collapse of surface soils into an underground cavity, which may be a natural cavern in limestone or an underground mine working.
Source	See contamination source.
Source-pathway-receptor linkage	The basic concept of risk assessment whereby linkages are established between potential contaminant sources (with the capacity to cause harm) and receptors (things which can be harmed) via pathways (routes of contact or uptake). Sources are sometimes called hazards and receptors are sometimes called targets.

Stockpile	A heap of economically valuable materials, such as ore, in temporary storage before being moved on to the next process.
Subsidence	Lowering of the ground surface caused by the collapse of underground mine workings.
Sulphide ore	Ore rich in sulphide minerals. It is prone to oxidation on exposure to the air, releasing sulphuric acid and initiating acid mine drainage (AMD).
Surface water	That part of the water environment which exists on the Earth's surface and includes all rivers, streams, lakes and the sea.
Sustainability	The concept of leaving natural resources undamaged and the environment in good order for future generations.
Tailings	The refuse material resulting from the washing, concentration or treatment of milled ore. Usually produced as a slurry of fine powder and water.
Tailings Management Facility (TMF) / tailings impoundment	An impoundment such as a dam which allows slurried tailings to be deposited, usually as the final disposal method. The solid matter settles out and the water which accumulates on top is removed during the life of the mine. Once stable, the tailings impoundment can be rehabilitated.
Target	See receptor.
Topographic survey	A survey plan showing physical features of the land and buildings together with ground elevation contours or spot heights.
Toxicity	The degree to which a substance is poisonous or harmful.
Underground workings	Mine workings which take place below the ground surface.
Undermining	Underground mining which takes place beneath some site. For example, a house might be subject to undermining, with the resulting risk of settlement from subsidence.
Vent raise	A mine shaft constructed to allow ventilation of the mine.
Void	The open spaces created by mining, either underground or in open pits.
Wall rock	The rock comprising the walls of the mine.
Waste	Any substance or object which the holder discards or intends to, or is required to, discard.
Waste dump	The deposit of waste materials on the selected disposal site.

Waste rock	Rock which is not ore but is brought to the surface by mining activities and has no economic value. Traditionally disposed of on the surface but some may be used to backfill old workings or as construction materials on the mine site.
Water balance	The auditing of water input, water usage, water losses and water discharges, analogous to financial book-keeping. The water balance is calculated to ensure good control of water usage and minimum wastage in an industrial process.
Water table	The upper surface of groundwater, below which an aquifer is fully saturated.
Wetland	An area of land which is covered with water for most of the time and contains water-loving plants (such as a marsh). Man-made wetlands can be engineered to be part of a remedial option for treating mine drainage, or other contaminated water.

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April 2002

MANAGEMENT AND REHABILITATION OF THE SILVERMINES AREA: SUMMARY REPORT

1 INTRODUCTION

1.1 Background

The Silvermines area of County Tipperary has been mined for over a thousand years for lead, zinc, copper, baryte, silver and sulphur. The last mine, Magcobar, ceased production in September 1992. The mining has resulted in undermining and surface subsidence, the excavation of open-pits, the construction of large waste dumps and tailings facilities, and the presence of derelict surface structures. Figure 1 is an air photograph showing the main features of the area. The yellow outline represents the extent of the study area.

The mining waste products contain heavy metals, which are mobilised into the streams after heavy rain. In the past, the tailings impoundments have also produced dust blows, with the wind-blown particles containing heavy metals. The metal of most concern has been lead which has caused cattle deaths. The concerns about cattle deaths and dust blows alerted the authorities, and an Inter-Agency Group (IAG) was formed to oversee an investigation of the presence and influence of lead in the Silvermines area. A *Report of the Investigation into the Presence and Influence of Lead in the Silvermines area of County Tipperary* was issued in June 2000. An Implementation Group was set up to apply the recommendations of the report, which included the preparation of management and rehabilitation plans for the Silvermines area. There are, however, other contaminants and other safety and environmental issues, such as mining subsidence associated with the Silvermines area, which require consideration. The results of a number of previous studies, including the proposal for a Heritage Centre at Shallee, also needed to be included in the overall plan. On behalf of the Implementation Group, the Department of Marine and Natural Resources (DMNR) undertook to commission an evaluation of all issues and the preparation of a management and rehabilitation plan to minimise the risks.

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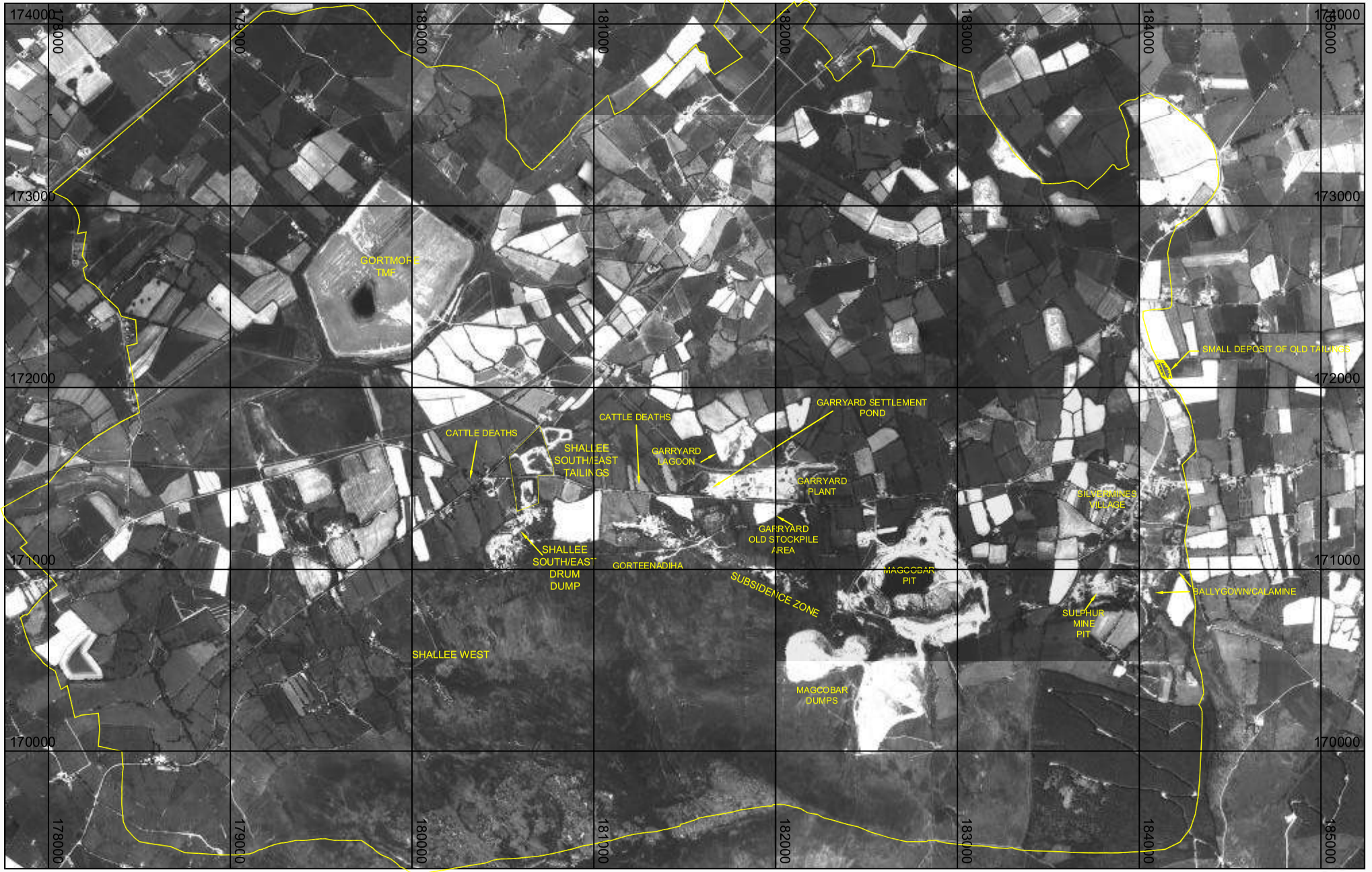


April 2002	PROJ. No: U1606	SILVERMINES	Not to scale
SRK Consulting Engineers and Scientists		THE STUDY AREA	Fig 1

In March 2001, the DMNR appointed SRK (UK) Ltd (SRK) to carry out the study and prepare conceptual designs for the management and rehabilitation of the Silvermines region, an area of about 2,300 ha. This design was to include the following five specific sites identified as requiring treatment together with any other aspects identified during the study:

- Gortmore tailings management facility (TMF);
- Shallee Mine and tailings;
- Garryard plant site, including lagoon and settlement ponds;
- Ballygown area and ground to the south of Silvermines village; and
- Magcobar pit and waste dumps.

The area of investigation and the key sites are indicated on Figure 1.

Although particular problem areas were identified, it was recognised by all concerned with the study that the whole Silvermines area must be evaluated as an integrated system and the work was to include any other sites within the study area which required remediation. This should ensure that the best possible value will be obtained from the applied resources. The subset of those work plans which correspond to works which Mogul of Ireland might be asked to carry out under Clause K of their State Mining Lease was required to be presented separately.

Photo 1: General view of Silvermines village across Ballygown

1.2 Purpose of the Project

The primary objective of the study was to develop rehabilitation and management plans for the various mining sites in the area, with conceptual designs and costs for the proposed remedial works. The Mogul mine closed in 1982 and, in terms of the State Mining Lease, the mine owner is responsible for closure of the mine in an environmentally acceptable manner under Clause K of the mining lease. The DMNR requested that rehabilitation work and costs resulting from the activities of the Mogul mine should be identified separately. The remediation work under clause K would be the responsibility of the Mogul company.

Other aspects to be carried out in the study included:

- provision of cost and time-scale for implementing the remediation plans;
- consultation with the public and agencies as part of the study and preparation of plans; and,
- assistance and advice to the DMNR in presenting such plans to the agencies and owners responsible for carrying out and supervising the plans, and to the local population.

As well as the specific health and safety concerns mentioned above, the study was to address any aspect where the residual effects of mining could impact on health and safety or the environment. These other aspects included:

- mine openings, vent raises, shafts and declines;
- mine buildings;
- tailings;
- stream sediments enriched in heavy metals;
- waste rock, tailings and other mining residues;
- scrapped equipment, metals, containers or chemicals used in former mining operations;
- subsidence, whether mining or natural; and
- the groundwater system.

1.3 The Study Team

The study was carried out by SRK (UK) Ltd, based in Cardiff and part of the international group of SRK companies. The SRK group is an independent consultancy specialising in all aspects of mining including mine closure and rehabilitation.

The study team for this project was composed of experts in the relevant disciplines, with internal and external reviewers who ensured that the work was carried out to international standards, and who are specialists with an international reputation in their fields of expertise.

Members of the project team were appointed on the basis of their specific technical expertise as well as experience in mine closure. Many of the team members have extensive experience of mining work in Ireland, and local expertise was used to assist for specific tasks.

A large amount of detailed knowledge of the Silvermines area rests with other individuals and organisations in Ireland, and an important part of the study was the consultation with others, to ensure that previous and local knowledge was included.

2 APPROACH TO THE PROJECT

The study was carried out in three phases to ensure that the work was developed in a progressive manner, with interim reviews by the DMNR.

Phase I comprised a review of the very extensive available information and consultation with Interested and Affected Parties (IAP). The work commenced in March 2001, but the Foot and Mouth crisis significantly changed the programme and the planned field survey. Meetings with local groups and detailed survey of the potential hazards in the field were planned for April, but carried out over a period of time, as access conditions permitted. This task was not completed until August 2001. At the end of this phase, the various potential hazards were identified and possible rehabilitation options were considered.

Phase II comprised the main technical assessment in which all the available information was presented and evaluated. Phase I identified that there was very little information on groundwater and that more comprehensive sampling and chemical analysis of water was required. Testing of water and soils was carried out to supplement and confirm the available information.

Thirteen boreholes were drilled at Ballygown, Garryard, Shallee and Gortmore TMF to allow a preliminary characterisation of the groundwater conditions and to assess the impacts mining may be having on the groundwater. Surface water and groundwater chemistry, ecology, and mining heritage were assessed. In addition, a photographic record and inventory of surface structures was completed.

The various hazards and key issues identified in phase I and the possible impacts on health, safety, environment and heritage, were assessed using a risk-based approach. Management and rehabilitation options were considered, preliminary costs assessed and recommendations given for the preferred options.

The draft report was completed at the end of December 2001, but underwent various reviews and updates for new information. It was finalised in March 2002.

Phase III presented the conceptual designs and costs for the selected rehabilitation options.

The present **Summary Report** was designed to summarise the key information, activities and remedial options. The reader should refer to the main technical reports for detail.

The study was undertaken on the basis that the available information would be sufficient for the preparation of the conceptual designs for management of the site. Although some additional data collection was required, as discussed above, the available information provided a sufficient basis for preparing conceptual designs.

3 SOURCES OF INFORMATION

The available information is extensive, but there were two recent studies which were of very direct relevance:

In 2000, Natural Resource Consultants of Sligo were appointed by DMNR to carry out an Initial Characterisation Study of the Silvermines area, and the report was issued in May 2000.

The Department of Agriculture, Food & Rural Development (DAFRD) *"Report of the Investigation into the Presence and Influence of Lead in the Silvermines area of County Tipperary"* (the IAG Report) was published in June 2000. It was based on work carried out under the guidance of an Inter-Agency Group (IAG) in response to local concerns about cattle deaths from lead poisoning and about dust blows from the Gortmore Tailings Management Facility (TMF).

The characterisation study provided invaluable background information, and the IAG Report contains the processed results of extensive sampling and testing, as well as guidance for future studies.

The Geological Survey of Ireland (GSI) assisted DMNR and SRK in collecting and collating numerous records and old mining plans of Mogul of Ireland and other mines in the area. Other key reports were the Environmental Impact Statement (EIS) for the proposed landfill at Magcobar and the Shallee Heritage proposals by Shannon Development. Research reports from the University of Limerick and the Institute of Technology, Sligo and Mogul were also reviewed. Considerable assistance was given by the local residents, interest groups, various departments of Tipperary North County Council (TNCC), the Mid-Western Health Board, Teagasc, Department of Agriculture, Food and Rural Development and the Environmental Protection Agency (EPA). Ongoing monitoring data collected by various organisations including the GSI, EPA and the IAG must be incorporated into the final design process.

4 KEY SITES

Various names have been applied to different mining areas around Silvermines. There are different features within the study area and, to avoid confusion, Table 1 gives the sites and the names which have been used in the reports, generally working from East to West.

Table 1: Site Identification

Area name used in the reports	Sites and features included
BALLYGOWN	Ballygown, Calamine, Sulphur, and Knockanroe mines south of Silvermines village, drainage adit, old tailings deposit
MAGCOBAR	Magcobar pit, dumps, lagoons and surface structures, archaeological remains
GARRYARD	Garryard Settlement Ponds and Tailings Lagoon, Mogul plant, Mogul underground workings, Old Stockpile
GORTEENADIHA	Gorteenadiha mine including waste dumps between Magcobar and Shallee, archaeological remains
SHALLEE SOUTH/EAST	Shallee South and East mines, surface structures, Drum Dump and tailings impoundment
SHALLEE WEST	The shallow opencast workings at Shallee West
GORTMORE TMF	The Gortmore tailings impoundment (TMF) and ponds

Rivers, streams, soils and isolated waste deposits will be considered outside these key areas, and identified separately. The sites can be seen on Figure 1.

5 ASSESSMENT OF RISK AND REMEDIATION REQUIREMENTS

5.1 Risk Assessment

In order to evaluate the need for remedial works and the nature of those works, it was necessary to understand what likely risk each particular hazard posed for people, animals and the environment. The procedure was based on assessing the risk of exposure to a particular hazard, combined with the nature of the hazard and the sensitivity of the people, animals or environment to the hazard.

As a simple example, we may consider the risk that a rock will fall down from the roof of Shallee underground workings. The risk of injury to a person depends not only on the likelihood that the rock will fall, but also on the likelihood that someone will be walking underneath the rock at that time. The probability that the rock will fall may be high but, if it is in an inaccessible or unvisited area, the consequence is negligible.

The analysis was, necessarily, on a qualitative basis using experience and the available data. There was sufficient information available to give the consultants confidence that all key issues have been identified and all potential hazards and risks assessed.

The intent of the remedial options chosen was to reduce High and Medium risks to Low risks by remedial works and/or by control of access.

The following summarises the key elements of the risk assessment:

Identification of hazard or issue
The *hazard* is the source of the potential impact, such as an area of unstable rock in the roof of Shallee mine.

The Pathway
The *pathway* is the route by which the hazard can affect the receptors. An example would be a rock in the roof (the hazard), falling out (the pathway) and hitting someone (the receptor).

Receptors
The *receptors* are the affected people, animals or environment.

5.2 Impact and Remediation

The Impact is the effect which the Hazard has on the Receptor. For example, an open shaft would be a hazard and the impact would be the consequences of someone or an animal falling into the shaft.

Depending on the potential impact and the risk of such impact occurring, decisions can be made on the approach to remediation. Decisions are based on many factors including environmental concerns and a realistic assessment of final land use. For instance, if an area contains mine waste which has revegetated over the years and is causing no significant contamination, the best decision is not to disturb it.

5.3 Acceptance Criteria

Remedial measures were selected where possible to meet legislated environmental standards or targets. Irish and European legislation has been applied where possible. The BATNEEC (best available technology not entailing excessive cost) approach has been used to select remedial measures to achieve those standards or targets, based on the Irish EPA guidelines and SRK's extensive experience of international guidelines and practice for mine closure.

It is not appropriate in every case to apply fixed concentration limits as acceptance criteria for discharges to the water, the soils and the atmosphere. While they may be applicable to a new mining development, they cannot as readily be applied on a site such as Silvermines, where mining has occurred over hundreds of years, and where waters unaffected by mining have instances of elevated metal levels. An attempt to achieve an arbitrary standard may be impractical. It is for such situations that the concept of BATNEEC has been developed and applied internationally. At Silvermines, a risk-based assessment coupled to the BATNEEC approach has been used to select the optimum solution.

6 KEY FEATURES AND HAZARD IDENTIFICATION

In developing the proposed environmental management and remediation programme, it is necessary to consider both the hazards which must be dealt with and the characteristics of the site which must be conserved or enhanced. In this particular case, the mining heritage is of great importance, and will influence the nature of most of the proposed works.

6.1 Mining Heritage

The series of mines at the foot of the Silvermines Mountain is a unique example of mining methods of different types, of the exploitation of different minerals, of the extraction of these minerals by a range of processes, and of mining activities spanning more than one thousand years. Individually, many of the remains are of great interest both to archaeologists and tourists, but together they provide a partial history of mining in Ireland, worth much more than the sum of the parts. One main aim of the proposed management plan must be the conservation of the mining heritage of the area and the implementation of works to make the mining remains accessible to the public. Remedial works which could damage mining structures, including mine dumps, must be avoided, and the impact of all proposed activities must be assessed in terms of the mining heritage.

All mining features and structures have been recorded and photographed. The Shallee Mine, comprising opencast and underground workings, surface structures including an old engine house and tailings dumps, is considered to be a unique survival, worthy of preservation, conservation and utilisation. Major archaeological sites have been identified at Ballygown, where there is a complex mixture of mining from different eras and for different minerals, Gorteenadiha, with an old ore washing area, and Magcobar, where there are remains of previous copper mining amongst the more recent waste dumps. These sites should be protected and investigated.

The vulnerable sites should be fenced, detailed recording of structures on all these sites should be carried out, archaeological surveys must be undertaken, and public consultation sought before the finalisation of the programme for conservation and usage. This usage may include the establishment of a Centre for Mining Heritage at Shallee and a walking trail linking the sites and commencing at Silvermines Village, which is also a part of the mining history.

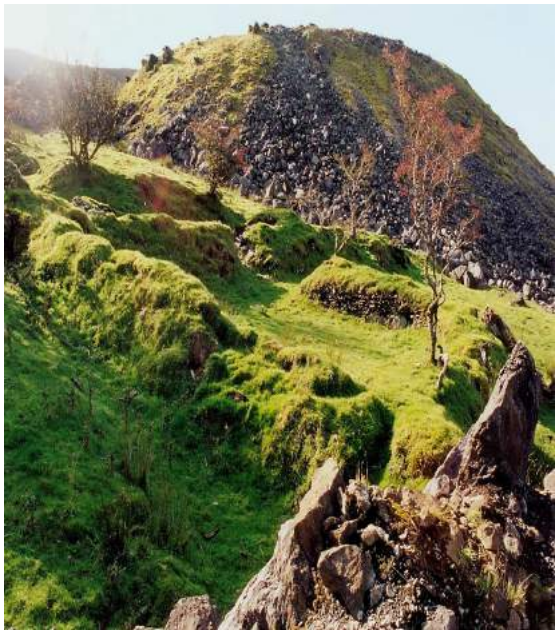


Photo 2: 19th century Mine structures, Magcobar

Photo 3: Engine House, Ballygown

6.2 Surface Water and Stream Sediment Contamination

Erosion and leaching of metals from mine waste sources has resulted in contamination of streams and stream sediment.

Dissolved metals in stream water

The results confirmed that surface water and stream sediments in the study area contain elevated metals (that is, concentrations higher than the standards). However, the levels of dissolved metal in the water are only slightly above acceptable levels and dilution in the Kilmastulla River brings these to within acceptable limits. The metals include lead, barium, cadmium, zinc, copper, aluminium, thallium, mercury, iron and manganese. The highest levels of contamination are in the streams close to the main waste dumps. These drain into the contaminated Yellow River which is sourced from the various mining sites. The Silvermines Stream also receives contaminated water from Ballygown process wastes on the stream bank.

The IAG study also showed slightly elevated lead levels in various parts of the Kilmastulla River well away from the mining sources, but within the study area. The most likely reason is precipitation and settlement of lead-bearing sediment over many years, especially after high stream flows and particularly during the period of mining activity.

Metal particles in sediments

Stream sediments and those stream bed dredgings placed on the river banks of the Kilmastulla River, the Yellow River and tributaries can contain high metal levels, where river flow conditions have allowed suspended sediment to accumulate in the past.

These sediments will have accumulated over many years in specific areas according to the stream flow conditions. The remedial works will reduce erosion of contaminated sediments into the streams thereby reducing the quantity of contaminated sediment accumulating in the streams. This will reduce the need to dredge and dispose of contaminated sediment in the future.

Sources of stream contamination

The key sources of the elevated metals are the Old Stockpile at Garryard, the Tailings Lagoon at Garryard and the Drum Dump at Shallee. Contaminated sediment is also eroded by stormwater run-off from the waste materials at Ballygown, waste materials at Gorteenadiha and the tailings at Shallee and Gortmore TMF. This observation is based on measurements of elevated metals in the water and sediments close to each facility.

Available information and additional sampling results were used to identify the sources of elevated metals in the various water courses, and to quantify the elevated metals from each sub-catchment. This information has been used in the design of the remedial measures to reduce the heavy metal content of the water courses, and as baseline data for the monitoring of the results of the remedial works.

6.3 Groundwater

The results of the drilling investigation showed a low permeability in the limestone aquifer, with higher permeabilities associated with fracture features. The overlying drift and alluvial aquifers are more susceptible to potential contamination, but there is no evidence of major residual effects of mining on groundwater levels or quality. No active remedial measures for groundwater are considered necessary, although groundwater should not be used for domestic drinking water supply in the areas close to mining activities. Local impacts will be partially remediated by proposed surface water control measures, which will reduce the mobilisation of metals.

Mercury was detected in two boreholes near the Gortmore TMF and one at Garryard in November 2001. Further sampling and analyses in January 2002 revealed levels of mercury below the detection limit, confirming that mercury pollution of the groundwater is insignificant.

6.4 Dust

In the 1980s, dust blows from the Gortmore TMF were a major issue, and local concerns about dust continue to be expressed. Remedial works were carried out by Mogul and their successors, after which no major dust blows have been reported.

No dust investigation has been carried out in this study, but the available monitoring information has been reviewed. There have been no significant dust blows from Gortmore TMF since the dust blows of the 1980s, because of the vegetation cover on the impoundment, but failure of grass seeding because of acidity has created large, bare areas. The remedial design for Gortmore will include measures for the improvement and maintenance of the vegetation to ensure a sustainable cover for the future, and for the prevention of dust generation from the outer slopes.

Photo 4: Gortmore TMF

6.5 Mine Stability and Safety

The available plans and reports have been reviewed for all the mines to assess the likelihood of future settlement or subsidence. Large subsidences have occurred at Gorteenadiha due to the underground workings close to the outcrop. The area has been fenced by Mogul to prevent access. Additional subsidence is possible on the north side (to be monitored during routine inspections) but no further subsidence will occur to the south where there are no workings.

Photo 5: Calamine open pit, Ballygown

In areas around Ballygown and Gorteenadiha in particular, there are numerous shafts and some small open-pits, which constitute a hazard. Many of the old shafts have been backfilled and are not deep, but some do remain open. There is a series of shallow ventilation shafts on a drainage adit passing on the east side of Silvermines village (not part of the Mogul workings, but from an earlier phase of mining). This adit remains an important drainage feature.

The Magcobar Pit and the Magcobar underground workings are stable at present, and no significant movement is predicted. They will be monitored and, if necessary, the existing fence will be extended. There is a small sinkhole near to the entrance to Magcobar, considered to be a result of Mogul mine dewatering. This will be backfilled.

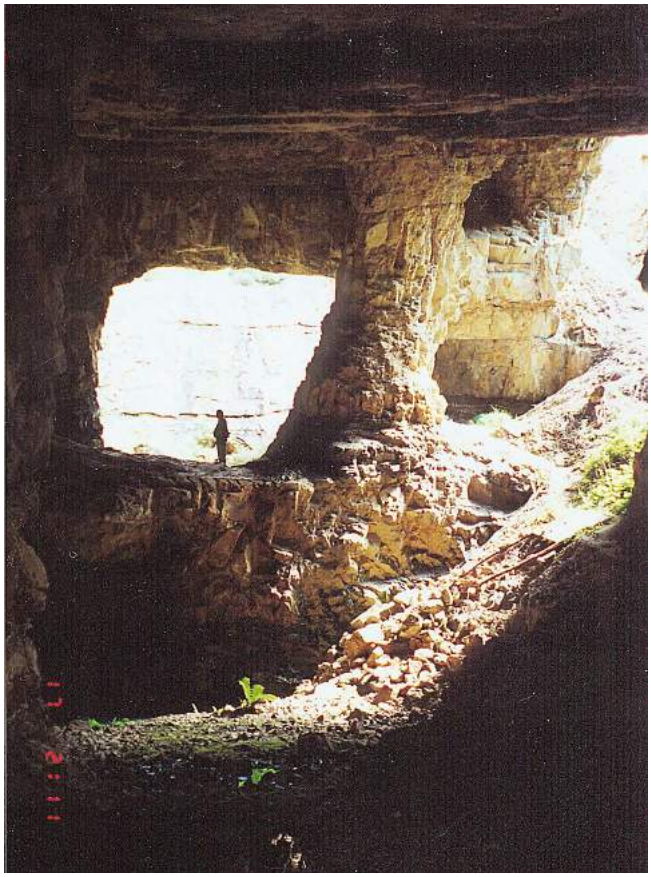


Photo 6: Shallee mine underground

Although some of the mine workings at Ballygown and Sulphur Mine are shallow, subsidence is not an issue, due to the age and limited extent of the workings. There is a low risk of subsidence over the deeper Mogul underground workings.

The open pits and underground working at Shallee do constitute a danger primarily due to people and animals falling into pits and underground holes. These features are addressed in the detailed risk assessment and proposed remedial works.

6.6 Waste Dump Stability

The Magcobar dumps are granular and relatively free-draining. With continued maintenance of the surface water drainage system, they will remain stable. Some material has been removed from the toe of one of the dumps and this can create some local steepening and instability around the excavated area. Re-shaping of this dump will be carried out to ensure stability.

No problems are anticipated with the Shallee South/East tailings dumps.

The Gortmore TMF contains silt-sized waste, which is not free-draining and, as a result, the TMF has a high water table. However, there has been no deposition on the

TMF for many years so the tailings have consolidated and are, therefore, more stable than they were during the operating life of the mine. No stability problems will occur under present conditions, and the proposed works including the waste disposal facility on the upper surface will not cause instability. The stability should be confirmed during the detailed design and if there is any future change in geometry or water management.

6.7 Summary of Key Hazards

The key hazards are summarised in Table 2.

Table 2: List of Key Hazards

HAZARD	KEY SOURCE
Stream water contamination and sediment loads	Garryard Old Stockpile
	Garryard Tailings Lagoon
	Shallee South/East Drum Dump
	Ballygown waste dumps
Dust potential	Gortmore TMF poorly-vegetated sections
Risk to human life	Open shafts and surface workings at Sulphur mine, Gorteenadiha and Shallee.

The items listed above are the most significant and remediation of the sources will result in significant improvement to the general conditions. There are many other sources of potential hazard for which remedial works will result in local improvements. All problems, both major and minor, have been considered. Appendix A includes the risk assessment tables from the Phase II Report.

Photo 7: Gorteenadiha Subsidence

Photo 8: Shallee Drum Dump

Photo 9: Garryard Tailings Lagoon

7 POTENTIAL IMPACTS

7.1 Human Health

The potential effects on human health are from particulate dust, from metals and chemicals which are inhaled, ingested or absorbed through the skin, and from the physical hazards posed by ponds, open workings, shafts and adits.

Elevated levels of lead, copper, barium, cadmium, zinc, iron, manganese, mercury, thallium, arsenic and aluminium have been measured in water, soils and sediments. The concentrations of lead in the soils and sediments around Silvermines are much higher, however, than those of other metals, relative to the international standards. The remedial and management measures proposed in the IAG report for lead are appropriate for the other metals.

The IAG report concluded that there is no human health problem in the area related to lead, because blood lead concentrations are within current international standards. However, appropriate precautionary or protective measures should be taken, and these measures are specified in the IAG report.

Water supply

A key issue is lead in water supplies. This has been extensively addressed in the IAG report. Water supplies in the Silvermines area come from local authority water supplies and there is no health risk. The Shallee Ground Water Scheme is supplied from a borehole which is monitored.

Streams

The metal levels in the streams and rivers are not sufficiently elevated above water quality standards to be of concern for human health, although the water is not suitable for drinking or swimming in the study area.

Fruit and vegetables

Investigations of fruit and vegetables for the IAG report showed metal concentrations within statutory limits and it was concluded that no specific remedial measures were required, apart from careful washing of fruit and vegetables and some further monitoring.

Soils

Metal concentrations in soils have been found to be very high in some areas, with lead above accepted limits, and ongoing monitoring is continuing. Lead is not efficiently absorbed through the skin. Consequently, this route does not contribute considerably to the total body lead burden.

Where metal concentrations are high in the soil *and* there is a high potential for skin contact, the placement of a protective capping is appropriate. This has been recommended for the Village Field, for instance.

Dust

Dust from the tailings impoundments, particularly the Gortmore TMF, is a source of particulate material with potential damage to the respiratory system by inhalation, and of metals which could affect health. The generation of dust from Gortmore TMF will be prevented by the maintenance of a good vegetative cover.

Ponds, mine workings, adits and shafts

The ponds, mine workings, adits and shafts that are a potential danger to humans, will all be dealt with by backfilling, capping or fencing to prevent access.

7.2 Land Use and Animal Health

The concentrations at which inorganic chemical constituents may render a water undesirable for use for livestock is subject to a number of variables. These include animal age, sex, species, and physiological state, water intake, diet and its composition, the chemical form of the inorganic element of concern, and the temperature of the environment. Naturally, if livestock feed and water both contain a potentially toxic substance, this must be taken into account. Both short- and long-term effects and interactions with other ions or chemical compounds must also be considered.

Available literature data, combined with an appropriate margin of safety for livestock that drink the waters and to humans who consume the livestock or their products, were reviewed in order to obtain guideline levels of toxic substances in drinking water for livestock.

In terms of toxicity of metals in water, only lead levels have been found to be above the recommended level (0.1mg/l), but recent research (see Appendix H of Phase II report) has indicated that levels of lead of up to 0.5mg/l in drinking water of livestock is safe. Nevertheless, 0.1mg/l is the accepted limit.

Portions of land affected by mining activity have been purchased by private owners. These areas include the Gortmore TMF, the Mogul plant site, the Mogul sediment and settlement ponds and the Mogul waste dump south of the plant site.

The ownership of mining sites south of the main road, comprising the actual mined areas and the waste dumps, is not clear at present, but is under investigation by the

DMNR. Many of the sites are accessed by cattle and sheep, although the value of the land for grazing is very low and the cost of upgrading to suitable grazing is likely to be high.

The options for final land-use depend on the present state of the land, the requirements of owners, regulators and interested parties, and the economic viability of the implied remedial measures and final use.

Areas of existing farmland have been affected by heavy metals as stated in the IAG report, but there is no general problem of lead toxicity in animals. There have been reported cattle deaths on two farms close to known sources of metals, and a more recent one in April 2001, just north of Silvermines village. Remedial works will be implemented to prevent release of metals from specific sites of source material but farm management methods as recommended in the IAG report should be implemented in the affected areas.

Certain areas of land have no real value for restoration to any active use and the cost of restoration could not be justified. Examples include the area around Sulphur Mine and the surface of Gortmore TMF. The term derelict land has been used to describe the final land use of such areas. It should be noted that the term 'derelict' used in the reports means nothing other than land which will not be utilised, but which will be vegetated with a self-sustaining cover, and for which access will be allowable, but restricted.

The health implications of lead have been covered extensively in the IAG report, and the proposed remedial works proposed by SRK would complement the actions proposed by the IAG. In terms of other metals, there are none that are sufficiently elevated to be a concern over and above the management recommendations based on lead.

7.3 Ecology and Sustainability

No designated areas or special habitats for plants, animals or birds have been identified in the area, but metal-tolerant vegetation has naturally colonised the mine spoil and old tailings areas. These plant colonies are of interest from a scientific and educational viewpoint, as well as providing possible species for use in rehabilitation. The ecology of the old mine areas is an integral component of the mining heritage, and will be protected and conserved as part of that mining heritage.

Wild fallow deer use the area and have access to the contaminated streams. Unidentified species of bats are reported to be using the underground workings at Shallee. Before shafts and adits are sealed, it will be necessary to demonstrate that there is no use of the workings by bats, or grills should be installed to provide access.

The biological quality of the Kilmastulla River has improved since the closure of the mines, and the river provides valuable spawning and nursery habitat for both salmon and brown trout. The Shallee River tributary is also valuable for trout, and salmon have returned to the Silvermines River. However, the Yellow River, draining both the Garryard and Shallee sites, has reduced biological quality.

Remediation will ensure that the existing ecology is maintained or enhanced. This particularly applies to the tailings deposits, to ensure long-term sustainability.

Revegetation programmes will be established as follows:

- long-term revegetation of Gortmore TMF;
- conservation of vegetation colonies associated with the mine sites; and
- revegetation of remediated mine areas and dumps.

7.4 Aesthetics

Photo 10: Gortmore TMF

The largest visual intrusions are the Gortmore TMF and the waste rock dumps at Magcobar. The main visual impact from the Gortmore TMF is the view of the bare outer slopes. This will be reduced by the planting of a tree screen, and some earthworks and planting around the upper slopes of the TMF. Gravel and soil-forming material will be placed at the crest and seeded with a grass/clover mix, and the existing planting of gorse will be extended. The slopes will not be covered or seeded, because this would require a push-down to produce flatter slopes, which would have detrimental effects on the existing system. Natural revegetation has occurred on the Magcobar dumps over the years, which has softened the profile of the dumps. Recent working of the dumps in some limited areas, has exposed fresh waste rock, but this intrusion can be lessened without extensive work.

8 REMEDIATION OPTIONS

8.1 Potential Remediation Options

For all sites, a number of possible remedial measures were considered from which preferred options were selected. In some cases, there is only one realistic preferred option. In others, the choice depends on whether it is justified to pay a premium for a favoured more costly option.

In the majority of cases a number of remedial actions are required for each site and each particular hazard.

8.2 Features of the Preferred Options

The main features of the preferred options are:

- enhancing vegetation cover on the Gortmore TMF;
- general upgrading and maintenance of surface water system;
- installation of wetland systems to treat flows from mine areas;
- removal of contaminated soil from the key areas (Garryard Old Stockpile, Garryard Tailings Lagoon, Shallee South/East Drum Dump, Ballygown waste dumps) and deposition on a designated disposal site on Gortmore TMF;
- construction of silt retention structures for discharges from Gorteenadiha area and Ballygown;
- minimisation of disturbance of well vegetated or stable areas;
- provision of protection around potentially unsafe areas; and
- conservation of mining heritage features.

8.3 Justification for the selected options

The risk assessment tables, from the Phase II report, are included in Appendix A of this report. These tables include the various options, the assessed qualitative risks and present the preferred option.

The key features of the preferred options are summarised in Section 8.2. The reader is referred to the Phase II report for complete detail and the following sections describe the key factors for each type of hazard.

8.3.1 Mining heritage

The whole Silvermines area is an interesting mix of mining history. The SRK approach has been to conserve as much of the mining landscape as possible. This includes waste dumps, processing wastes, infrastructure features and buildings.

Once made safe, there is good opportunity to create a walkway through the whole mining area with limited access for interest and educational purposes. An archaeological assessment will be made at design stage for all remedial works, to ensure that no valuable remains are damaged or lost. This assessment will include the associated plant colonies, which may have importance from a scientific and heritage viewpoint, as well as offering potential species for rehabilitation works.

8.3.2 Streams, lakes and ponds

Remediation of surface water often requires separation of clean and contaminated water. Such options are not considered necessary for the tributaries of the Kilmastulla River and it is the intention to maintain the present system of natural water courses and man-made channels, but to remove the major sources of contamination.

The largest lake is in the Magcobar pit, and no change is proposed to the drainage or water level of this lake. The existing small lagoon to the north of the pit at Magcobar which overflows into the stream will be fenced and maintained as a sediment trap. The small lagoon on the northern Dump E will be backfilled and vegetated. At Garryard, the Settlement Ponds will be maintained, and the Tailings Lagoon area developed as an artificial wetland after removal of the tailings.

8.3.3 Waste materials

The early miners scattered process and mining waste over wide areas. This material contains heavy metals but otherwise is stable and vegetated. The approach to remediation has been to minimise the amount of sediment that can erode to local water courses, by modifying surface drainage and creating silt traps where necessary.

8.3.4 Waste rock dumps at Magcobar

The major dumps of waste rock from mining are at Magcobar. The key issues are visibility from a distance and stability, although the dumps are presently stable. The older dumps have vegetated, and the approach is to ensure ongoing stability by drainage, to encourage vegetation to 'soften' the dump profile, and to carry out minor re-profiling. The option of replacing the rock back into the pit was considered to be unjustified in terms of the cost and the assessed risk.

Some of the limestone at Magcobar should be used for the remedial works subject to the owner’s approval and permitting. This will be drawn from existing crushed rock piles or a mobile crusher would be used to crush additional requirements. The stone would be drawn from areas to help in the re-profiling of the rock dumps where necessary and rehabilitated as part of the remedial works.

8.3.5 Dumps containing sulphide ore, tailings and process waste materials

This refers to the dumps containing sulphide ore and waste materials at Garryard Old Stockpile, Garryard Tailings Lagoon, Shallee Drum Dump and Ballygown. They are classified as toxic under the Hazardous Waste list, 2002, as used by the EPA because they can produce Acid Mine Drainage (AMD) or will contain heavy metals.

It is clear that these have been, and will continue to be, a significant source of metal contamination to the water environment if not remediated, and will have been a major contributor to toxicological problems to livestock in the area. Removal from their present site and formal disposal will be the preferred option for the wastes from Garryard Old Stockpile, Garryard Tailings Lagoon, and Shallee Drum Dump. The disposal is discussed under item 8.4. The Ballygown process wastes on the bank of the Silvermines Stream will be protected by gabion structures, but it is anticipated that small quantities will be removed for disposal. The small quantities of sulphide waste at Magcobar will not be removed, but will be consolidated and covered at Magcobar.

The option of covering the hazardous waste at the Old Stockpile, the Tailings Lagoon, and Shallee was considered. This would have the disadvantage of creating several hazardous waste dumps requiring long-term maintenance and an ongoing risk of contaminated discharge. Table 3 provides a simple comparison of the two options.

Table 3: Comparison of Hazardous Waste Options for Tailings Lagoon, Old Stockpile and Drum Dump

OPTION	ADVANTAGE	DISADVANTAGE
Cover in-situ	No excavation or transportation of waste	Importation and transport of cover material; Three separate hazardous waste sites requiring long-term management; Land lost to future use; No underliner to contain possible seepage.
Remove to disposal site on Gortmore TMF	Allows: Establishment of single disposal facility on existing hazardous waste site, to be rehabilitated as part of Gortmore TMF rehabilitation; Placement of an underliner to prevent seepage; Restoration of Tailings Lagoon area as artificial wetland; Restoration of Old Stockpile to pasture: Restoration of Shallee Drum Dump area within heritage site	Period of transportation of tailings to Gortmore using road transport

8.3.6 Tailings at Shallee and Gortmore

The areas of tailings are Gortmore TMF, Shallee tailings north and south, Garryard Tailings Lagoon and a small area of old tailings north of Silvermines village adjacent to the Silvermines river. The latter comprises a small area of semi-formal disposal in paddocks, and is well vegetated. In the vicinity of these tailings, it was reported that one calf died and one was blinded due to lead poisoning in April 2001. Sampling of soil and herbage by Teagasc showed levels of lead above the acceptable limits in soils in a number of fields both upstream and downstream of the tailings. The tailings field must be fenced to restrict access.

Shallee tailings are well-drained and well-vegetated. The key potential hazards are contamination of water and air through erosion and dust blow respectively. Although the tailings will contain high levels of metal, the surface layers will have been considerably leached and, provided the vegetation cover is maintained, the best remediation approach is to minimise disturbance. The present situation is sustainable for the future, subject to minor revegetation by seeding.

The Gortmore TMF is a large conventional tailings disposal facility. It was designed in a manner consistent with the practice at the time, with a rock outer wall and controlled outer slope angles. Since cessation of mining, the tailings has consolidated, becoming more stable than during the operating period. There is metal and sulphate contaminated water, but monitoring in the river indicates that natural attenuation and dilution in the environment results in metals within the acceptable levels.

Proposed key items of maintenance are the existing reedbeds and catch paddocks which naturally 'treat' the seepage water around the edges, and improvement to the drainage and surface vegetation cover to limit the infiltration of water. This will reduce the effects of acidification due to oxidation of sulphides on the surface of the facility by reducing the flow of seepage water to the groundwater.

The top surface of the TMF has been successfully vegetated with grass and moss, but areas of sparse vegetation have developed. It is proposed that soil or soil-forming material be added to these areas over a layer of crushed limestone and that they be reseeded. A major cause of dust generation on tailings impoundments are the wind eddies occurring at the crest of the outer slopes. This effect will be removed by the protection of the crest and the establishment of vegetation over the crest such as gorse. A tree barrier will be planted at the bottom of the outer slopes, to reduce dust generation and provide a visual screen. There will be no formal planting on the outer slopes themselves, because this would require them to be pushed down to a flatter angle, requiring considerable earthworks and destroying the vegetation and paddocks at the bottom of the slopes.

It is anticipated that monitoring and management of the TMF will continue for the foreseeable future, but that this will not include regular applications of fertilizer. A natural succession will develop with time, possibly including the spread of gorse and the establishment of trees such as ash, and this succession will require management. If further patches of degradation of the grass and moss cover occur, it may be necessary to apply crushed lime and additional organic matter.

It is not practical, cost effective or necessary to consider complete capping and sealing of the facility, but this does mean that the use of the surface for grazing will have to be avoided or limited subject to detailed management of the grass sward.

SRK consider that part of the TMF, where there is acid generating material, would be a preferred option for developing a sealed site for disposal of the toxic wastes from the Silvermines area on a one off basis. This area would then be covered and engineered to prevent water ingress and would limit the potential for the underlying material to generate metal bearing leachate. This would, therefore, reduce the overall ability of the TMF to produce leachate. An access road of crushed limestone would be built on the TMF surface to the selected disposal area. This would facilitate placement of soil cover for revegetation of the TMF. The activities of the revegetation would be integrated with the mine waste disposal.

8.3.7 Open pits

The approach to remediation of the Magcobar open pit is to ensure that it is fundamentally safe but to fence off access. The backfilling of the pit could not be justified in terms of cost and risk. The pits at Shallee would be considered as potentially dangerous but their value for heritage purposes means that they should not be backfilled but managed by fencing and information signs.

The pits at Sulphur Mine and Ballygown are shallow. The Ballygown pit is small and contains water at the bottom. The most practical solution is to backfill and recontour to make safe. The Sulphur mine pit is an interesting feature and part of the heritage. It is relatively easy to make it safe without backfilling. There is an area of subsidence on the floor of the pit at the site of one of the shafts, and this will be fenced.

8.3.8 Underground works

The main concern with underground mining is the possibility for surface subsidence. Additional concerns would be the potential contribution to groundwater contamination. Remedial action is not required in all cases because the mined areas are sufficiently deep or the open expanse of workings is limited such that the effects of collapse of workings will not migrate to surface. The exception is close to the outcrop of the Mogul worked seams on Gorteenadiha where the orebodies were very steep and the wall rocks have collapsed into the underlying voids. This effect is limited in extent. It is not practical or cost effective to backfill the area and the only remedy is to fence off and provide information signs, which has already been done.

There is a small sinkhole at the entrance to Magcobar which is considered to be the result of subsidence into a natural cavity following dewatering of the Mogul mine, and this will be backfilled. The small area of Magcobar underground workings is stable.

The old workings at Ballygown and Sulphur Mine are very shallow but they are limited in the extent of the underground openings, and the risk of subsidence is low.

8.4 Disposal of Waste Material

The remediation of the study area will result in the movement or disposal of quantities of contaminated soil from all sites on a once off basis. The majority of the material will come from the Garryard Old Stockpile, the Garryard Tailings Lagoon and the Shallee Drum Dump. This waste will be classified as hazardous due to its mineral content and will require a licensed facility for disposal.

Initial dredgings from streams and drains containing elevated metals must also be disposed of in a suitable facility. Future dredgings from those drains affected by elevated metals may have to be disposed of in a suitable facility until acceptable levels of metals are achieved. The volumes of contaminated dredgings will reduce because the remedial works will prevent further discharge of contaminated sediments to the streams.

The options for waste disposal are capping in situ, deposition at an existing disposal facility, or disposal on Gortmore TMF (see Section 8.3.5). In situ capping has been considered but dismissed as not being sustainable without a complete cover seal, significant earthworks and ongoing maintenance. It is also understood that Ireland does not have licensed toxic waste facilities and no site that could accept the quantities involved.

Development of an engineered facility on Gortmore TMF, to tie in with the other remedial works, was considered to be the most cost effective and best technical option. Firstly, the waste would be consolidated with the existing waste at the TMF and secondly, it would remove the wastes from various other sites to remove the contamination source and recover the land for alternative use.

It is expected that the stream dredgings will contain organic material and sufficiently low levels of metal to be used as part of the cover on top of the TMF where additional grass growth is required. The dredgings will provide a cover to aid growth, in combination with a soil or soil-forming material. The low levels of metal sulphide will not generate acid.

All options would be subject to licensing or permitting from the EPA and the TNCC.

8.5 Sustainability and Long-Term Maintenance

Sustainability and minimum maintenance of the remedial work in the long-term was an important consideration. Monitoring has been proposed for a four year period, consisting of inspections, monitoring of water quality, air quality, erosion and vegetation. Certain maintenance work will continue, but should reduce as a result of the implementation of the remedial measures. This reduction can only be confirmed by monitoring.

Long-term maintenance, which will continue indefinitely subject to periodic review, will comprise routine inspections, monitoring of water quality and vegetation, clearing of silt traps and wetlands, albeit at decreasing frequencies, fence and signage repairs, and management of vegetation, mainly at Gortmore TMF. This management will include cutting of grass, thinning or removal of particular plant and tree species and remedial re-seeding of grass. The material removed at intervals from the silt traps and the wetlands will be disposed of at suitable sites according to the metal content.

9 PREFERRED REMEDIAL WORKS

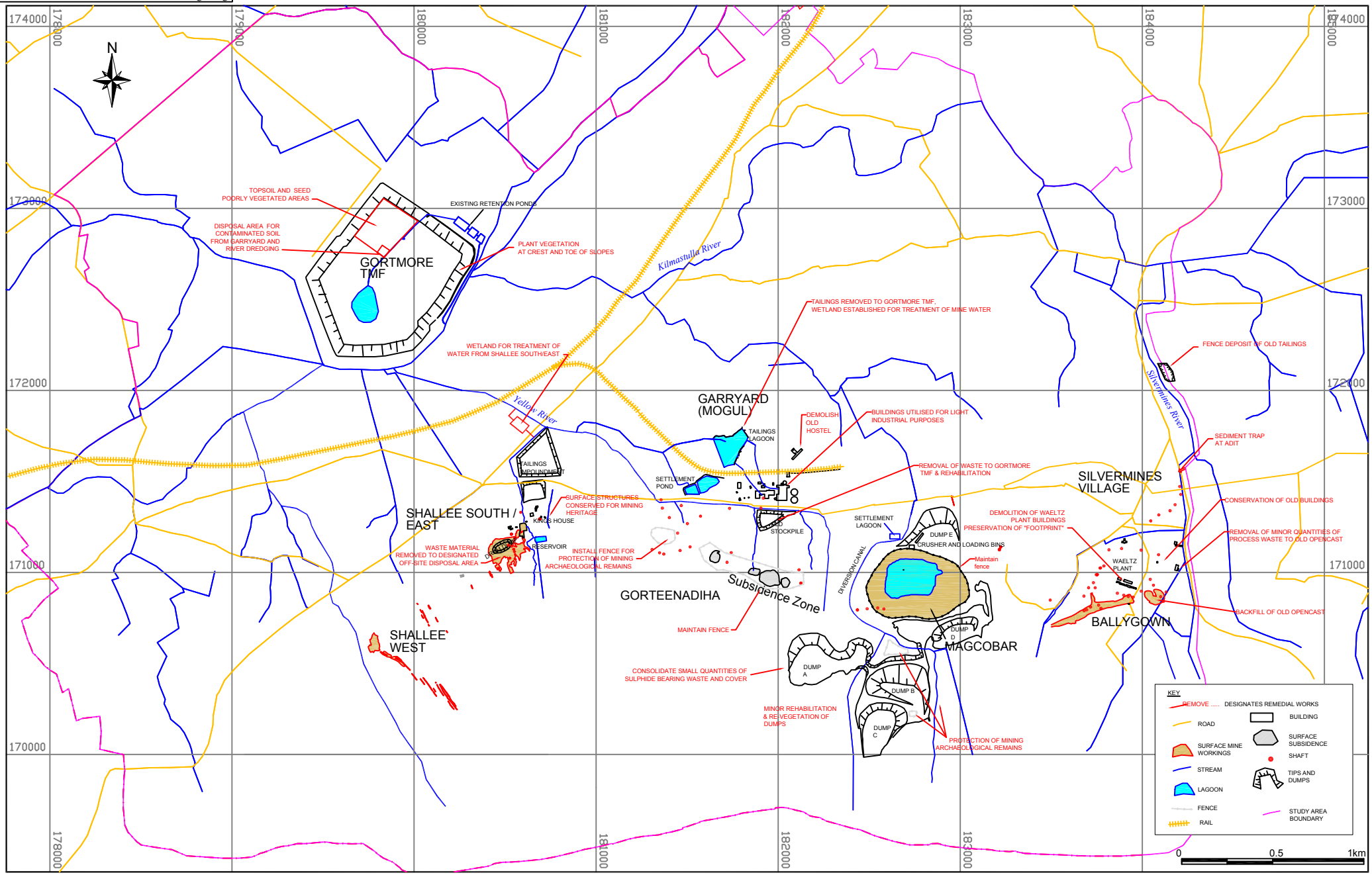
The preferred options selected for conceptual design are listed in Table 4 and indicated on the regional plan Figure 2.

Table 4: Main Elements of the Preferred Remedial Options

SITE	ITEM	REMEDIAL WORKS
BALLYGOWN	**General**	**Minor earthworks, re-vegetation, significant demolition, heritage conservation**
	Village Field	Capping and re-vegetation
	Opencast area	Partial backfill and re-vegetation
	Shafts, adits and wells	Backfill or fence, pressure relief holes.
	Mine water discharges	Clearing of adit and installation of sediment trap
	Waste materials area	Install streambank protection, remove small quantities of waste to Gortmore TMF, re-vegetate
	Old Engine House	Conservation measures
	Old Furnace Building	Conservation measures
	Waeltz Plant Buildings	Partial demolition, conservation to window or footprint level
	Old tailings to north of Silvermines Village	Install fence
MAGCOBAR	**General**	**Minor earthworks, re-vegetation, demolition**
	Mine pit	Maintain fencing and investigate pit water geochemistry
	Sediment lagoons north of pit	Fence and maintain
	Archaeological sites	Install protective fences
	Rock dumps	Minor re-shaping, topsoil and re-vegetation
	Surface drainage channels	Repair and maintain
	Small deposits of sulphide waste	Consolidate and cap
	Maintenance workshop	Possible alternative use
	Other buildings and crusher	Remove buildings and backfill lagoon on top of Dump E
	Small sinkhole near entrance	Backfill
GARRYARD	**General**	**Wetland development, removal of mine waste**
	Tailings Lagoon	Removal of process wastes, conversion to artificial wetland
	Settlement Ponds	Maintain as retention pond
	Knight Shaft	No change, but maintain discharge system
	Mogul shafts and vent raises in other areas	Protection as appropriate
	Sulphide and oxidation products - underground mine water	Discharged to new Tailings Lagoon wetland
	Old Stockpile	Removal of mine waste, rehabilitation to pasture
	Existing drainage channels	Repairs and improvements
	Subsidence area	Repair and maintain fences, install diversion drains
	Plant site	Remove waste and landscape
GORTEENADIHA	**General**	**Minor drainage works & gabion retention dam**
	Mining heritage	Protected by fence pending archaeological study
	Shafts, underground workings, adits and open pits	Identification, backfilling and fencing as appropriate
	Waste dumps	Install trench drains
	Surface run-off	Small gabion retention dam for sediment control
SHALLEE SOUTH/EAST	**General**	**Conservation of buildings and mine as heritage site, Disposal of process waste, wetland development**
	Mining heritage	Preparation of conservation schedule and execution of conservation measures.
	Open pits and Underground	Make safe by fencing
(Table continued next page)	Shafts and adits	Improvement of grill on Whim Shaft, fencing of Field Shaft, all other adits and shafts to be treated as appropriate for mining heritage conservation.

SITE	ITEM	REMEDIAL WORKS
SHALLEE SOUTH/EAST (Continued)	Scrap and waste, Drum Dump and other smaller deposits in-pit and elsewhere	Remove to designated off-site licensed dump
	Water discharges	Improvement of surface drainage system and establishment of downstream wetland
	Tailings dam run-off	To same wetland
	Tailings dam vegetation	Maintain
	Old Engine House	Conservation
	King's House	Conservation
	Plant foundations and other buildings	Conservation
SHALLEE WEST	**General**	**Minor backfilling**
	Trenches and mine waste	Backfilling of trenches with mine waste and fencing of trenches where appropriate.
GORTMORE	**General**	**Selective topsoiling and re-vegetation, establishment of vegetation screen, minor remedial earthworks**
	Top surface	Monitor existing vegetation and develop maintenance programme
	Top surface	Placing of limestone gravel and topsoil on approximately 25% of top surface, re-vegetation
	Top surface	Establishment of disposal area for contaminated soil waste from other parts of the study area
	Pool on top surface	New decant and pipeline
	Un-vegetated outer slopes	Selective topsoiling and re-vegetation at crest, planting of tree screen at toe.
	Retention ponds	Determination of water balance, detailed survey and minor works to improve retention time.

PROJECTS\U1606\REPS\SUMMARY REP\Fig2.dwg



DEC 2001	PROJ. No: U1606	SILVERMINES	Scale 1:27,500

SRK Consulting
Engineers and Scientists

SILVERMINES AREA - MAIN REMEDIAL WORKS

Fig 2

10 DESIGN AND MANAGEMENT OF THE REMEDIAL WORKS

The present study has been a conceptual design, and the subsequent detailed design will include certain additional investigations. The application for the necessary permits and licenses is also considered to be part of the next phase because the requirements of the authorities may influence the design.

10.1 Additional Investigations

The additional investigations required for the design are:

- detailed topographic survey to provide accurate maps on which the designs will be based;
- flow monitoring of streams for design of wetlands and engineering structures;
- additional drilling for groundwater management;
- archaeological investigation at all sites;
- investigation of chemistry of Magcobar pit; and
- identification of sources of fill and growth medium.

10.2 Detailed Design

The detailed design will comprise:

- appropriate additional investigations;
- initiation of a monitoring programme for surface and groundwater;
- preparation of Environmental Impact Statements;
- detailed design analyses;
- preparation of construction drawings and specifications;
- updated estimate of costs;
- programming of the works; and
- preparation of tender documentation including contract environmental management procedures.

10.3 Planning and Permitting

All proposed remedial works will require some form of planning permission from the TNCC. Permitting activities will include the application for permits for the excavation, transportation and disposal of contaminated waste. These will also include the submission of the Environmental Impact Statement for approval. It is anticipated that the permitting activities could be critical in terms of the timing of the programme.

10.4 Management of Works

It is anticipated that a government department will undertake the administration of the project, involving representatives of other statutory bodies and technical experts as necessary. The function of this department will be to administer funding, to appoint consultants and contractors, to supervise the works, to liaise with interested and affected parties, and to carry out monitoring. The on-site project management, coordination and liaison will be delegated to a full-time project manager based in Silvermines.

The duties of the project manager will include:

- supervision of the Contractors as Resident Engineer;
- overall Environmental Management, with enforcement of the environmental protocols;
- management and coordination of the input by technical specialist consultants;
- community liaison; and
- reporting to his supervisor at the Government Department

The activities on site will involve various levels of expertise, and it is anticipated that the project manager will coordinate the involvement of specialists in the control of the works. These specialists will be engineers and scientists from appropriately qualified companies.

10.5 Environmental Management During Remedial Works

The period of implementation of the remedial works will require environmental management procedures to be in place, since the works themselves will have high potential impacts. During the earthworks and prior to successful re-vegetation, for example, there will be an enhanced potential for the erosion of soil and ecological damage, and it will be necessary to construct temporary silt traps, or to construct intended permanent retention structures at the beginning of the works. Vehicles transporting waste materials will have covers to prevent spillage and will be cleaned prior to moving onto public roads, to prevent contaminated soil from being spread. The special measures required to ensure good environmental practices during implementation will form part of the Contract Specification for the Contractor, and particular requirements will apply to each site.

It is proposed that the environmental protocols for the sites will be applied by the contractors and enforced by the Project Manager.

10.6 Long-term Monitoring and Maintenance

After the completion of the Contractor's maintenance period and acceptance of the works, it will be necessary to continue the programme of monitoring and maintenance, including:

1 Water and atmospheric monitoring.
2 Monitoring of erosion and silt transportation.
3 Monitoring of vegetation and carrying out of revegetation as necessary.
4 Inspections of structures and fences and minor maintenance and repair.
5 Periodic clearing of silt traps and wetlands.
6 Dredging of contaminated streams and drains (for a limited period).

It is envisaged that, at the time of acceptance of the works, the supervising Government Department will hand over responsibility for long-term maintenance to another body, probably the TNCC. The responsibility for monitoring activities may remain with a body such as the EPA, which has the necessary expertise and laboratory facilities.

11 ESTIMATED COSTS

The estimated total costs of the preferred options are given in Table 5.

Table 5: Summary of Estimated Costs of Remedial Works

AREA/ACTIVITY	ESTIMATED COSTS
Project management (including EIS and permitting)	€700,000
Ballygown	€320,000
Magcobar	€209,000
Garryard	€1,233,000
Gorteenadiha	€97,000
Shallee South/East/West	€1,278,000
Gortmore	€1,331,000
TOTAL	**€5,168,000**
Long-term monitoring and maintenance	€68,480 per year

The totals include costs for monitoring, inspections and maintenance during the period of the works of four years, and for archaeological investigations.

Long-term maintenance after the period of the works has been estimated to cost €68,480 per year, and will continue indefinitely, subject to periodic review. The long-term monitoring will comprise routine inspections, monitoring of water quality and vegetation, clearing of silt traps and wetlands, albeit at decreasing frequencies, and occasional remedial revegetation works, mainly at Gortmore TMF.

The following additional contingencies are proposed:

Special contingency for hazardous waste disposal from Garryard	€354,000
Special contingency for water diversion at Gorteenadiha	€24,150
Special contingency for groundwater investigations and monitoring	€50,000

The Garryard contingency is considered necessary at the present conceptual stage because of lack of reliable information about total volumes and disposal areas.

The Gorteenadiha contingency is for the possible future diversion of water from Gorteenadiha to the Settlement Ponds, involving a new culvert. At present, the design includes a silt trap at Gorteenadiha. This would hold sediments but metals in solution would pass through the silt trap to the Yellow River. The purpose of the possible diversion would be to pass water from Gorteenadiha though the Settlement Ponds wetland treatment system, although the need for such measures will only be known after monitoring of the system.

12 POTENTIAL FUNDING BY THE EUROPEAN UNION

Shannon Development have an Irish Government allocation of over €1.5 million for the development of a heritage centre at Shallee.

Funding to promote sustainable development and care for the environment is potentially available from a range of sources within the EU:

- **The Structural Funds** promote more balanced socio-economic development across the Member States, assisting the poorer regions of the Union. Funds are increasingly used for environmental projects such as cleaning up coasts, harbours and rivers, and rehabilitating decayed industrial and urban areas.

  Ireland has received significant funds since the 1980s. The Silvermines district is in the Mid-West region which is classified as a transitional Objective 1 region, eligible for Structural Funds until 2005. The National Development Plan will be implemented by five programmes, including the Southern and Eastern Regional Programme (which covers the Silvermines area). Priority 3 of the Programme covers agriculture and rural development, to ensure that primary agriculture becomes more competitive, to diversify activities of farmers, to foster environmentally sustainable systems of production and to promote rural development.

- **The Cohesion Fund** finances projects to improve the environment and develop transport infrastructure. The current budget is for 2000-2006 and Ireland is one of four countries meeting the criteria for eligibility. The maximum rate of aid granted is between 80-85% of expenditure.

  The objectives for environmental projects are preserving, protecting and improving the quality of the environment; protecting human health; and assuring prudent and rational use of natural resources. The Fund gives priority to drinking water supply, treatment of waste water and disposal of solid waste. Re-afforestation, erosion control and nature conservation measures are also eligible.

- **The LEADER+ Community Initiative** is for rural development and promotes integrated schemes conceived and implemented by active partnerships operating at the local level. The objectives are to encourage and support rural actors in thinking about the longer-term potential of their area and encourage the implementation of integrated, high-quality, original strategies for sustainable development which experiment with new ways of:

(a) Enhancing the natural and cultural heritage.
(b) Reinforcing the economic environment in order to contribute to job creation.
(c) Improving the organisational abilities of their community.

Priority themes of Action 1 and of LEADER+ include improving the quality of life in rural areas and making best use of natural and cultural resources.

- **The LIFE Programme** was set up in 1992 and its third phase runs until 2004. It is devoted entirely to developing EU environmental policy and has three strands: LIFE-Nature, LIFE-Environment and LIFE-Third Countries. The Union co-finances projects to safeguard the environment in all Member States and half the budget is devoted to nature protection**.**

  LIFE-Environment funds are for demonstration projects contributing to the development of integrated and innovative techniques and methods to the more advanced development of Community policy relating to aspects of the environment. These aspects include the fields of physical planning and land use, the prevention of the impact of economic activities on the environment, the prevention, recycling and management of waste flows, and the reduction of the impact of products on the environment, by means of an integrated approach.

  The development and implementation of a coherent management plan to protect and preserve Lough Gill's (Co. Sligo) landscape, wildlife and water quality for future generations has been funded by LIFE-Environment.

- **The European Investment Bank** (EIB) provides long-term loans for projects designated to safeguard the environment, covering up to 50% of investment costs. Typical projects have included water management, waste treatment and urban renewal schemes.

- **Sustainable Development and Policy Support -** A general call for proposals in the field of environmental protection (2002) is currently out. This is to identify projects which might be eligible for financial support from DG ENV, by way of co-funding. Theme Ref ENV.A.1.1 concerns restoring environmental damage, especially restoring bio-diversity. There is only a small sum available, a maximum of two projects will be financed and the closing date is 30 April 2002. However, it is indicative of further funding which might be available in subsequent years.

13 CLAUSE K REQUIREMENTS

The works for which Mogul Mine is responsible in terms of its State Mining Lease are listed in Table 6. Details are given in the Phase II report, Appendix J. On anecdotal evidence, the drums and other mine waste deposited at Shallee South/East Mine are included in the table, as it is understood that this waste comes from Mogul's Garryard Plant. The costs associated with Clause K are approximately 51% of the total estimated costs of the remedial works.

The scheduling of the works for activities associated with Clause K is included in Figure 3. As the different activities are inter-related, it is important that the Clause K activities are carried out in accordance with the programme though, as previously noted, the programme is only indicative at this stage.

In addition to the capital costs, there will be costs for the investigation, design and monitoring of the remedial option. For the options described, this amounts to €579,000 for a four year period. A contingency of €354,000 has been allowed for disposal of hazardous waste from Garryard at an alternative site to Gortmore.

Table 6: Mogul Clause K Responsibilities

Description	Summary Table	Section of Appendix I (phase II)	Estimated Cost
GARRYARD PLANT AREA: Garryard Settlement Ponds – Minor remedial works to pond and decant	14.4	I 4.1	€5,880
Garryard Tailings Lagoon – Remove tailings to Gortmore TMF	14.4	I 4.2	€460,400
Garryard Tailings Lagoon – Establish wetland to treat Mogul underground water	14.4	I 4.2	€215,710
Mogul underground subsidence area – Repair and maintain existing fence, install diversion trench	14.4	I 4.3	€16,180
Mogul underground water contamination – Divert surface water	14.4	I 4.4	Note 1
Garryard Old Stockpile – Segregate wastes and remove contaminated soil and process waste to Gortmore TMF and other waste to designated site	14.4	I 4.5	€212,060
Garryard Plant Area – Remove waste materials, remove hostel building, profile and cover unsurfaced areas, carry out minor landscaping	14.4	I 4.6	€52,580
MAGCOBAR: Backfill small sinkhole near entrance to site	14.3	I 3.2	€740
SHALLEE SOUTH/EAST: Drum Dump and other process waste deposits – Remove drums and other mine waste and scrap to off-site licensed disposal site.	14.6	I 5.1, I 5.5	€50,000[4]
GORTMORE TMF Dust and erosion control – Place growth medium, plant vegetation and shrub windbreaks	14.7	I 6.1	€622,270[2]
Leaching of metals and salts – Place growth medium, vegetate and improve toe wetlands	14.7	I 6.3	Note 3
Erosion of tailings by run-off – Repair toe paddocks and slope gulleys	14.7	I 6.4	€9,390
Visual impact – Plant crest growth medium, vegetation and toe tree screen	14.7	I 6.2	€89,520
Pool on surface of TMF – Construct new decant and decant pipeline	14.7	I 6.6	€31,500
Three retention ponds at TMF – Minor repairs to ponds and discharge system	14.7	I 6.7	€3,220
Establish site for waste disposal on top surface, including access road	14.7		€282,765
MOGUL VENT RAISES AND SHAFTS Signage	14.7	I 6.1	€1,600
MOGUL VENT RAISES AND SHAFTS Fence or cap as required	14.4 14.5 14.2	I 4.3 I 4.9 I 2.5	0[5]
TOTAL			€2,053,815

Note: 1 – Included in subsidence works I4.3

2 – Crest vegetation and tree screen included in I6.2

3 – Included in I6.1, I6.4, I6.7

4 – Nominal sum only

5 – No sum allocated

Task Name	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7
GENERAL							
Produce topographical plans for mining areas with one metre contours							
Permitting, planning, land acquisition and EIS							
WORK AT BALLYGOWN							
Investigation, design and tender letting							
Cap and re-vegetate village field							
Demolish Waeltz Plant, deposit inert waste in Opencast							
Reshape and revegetate Opencast Area							
Install gabions as streambank protection							
Conservation of old structures							
Fence old tailings to north of village							
WORK AT MAGCOBAR							
Investigation, design and tender letting							
Fence archaeological sites							
Backfill small sinkhole							
Minor reshaping of rock dumps							
Consolidate and cap sulphide waste							
Demolish buildings and backfill Lagoon on Dump E							
Upgrade and maintain drainage							
WORK AT GARRYARD AND GORTEENADIHA							
Investigation, design and tender letting							
Fence Gorteenadiha archaeological site and carry out archaeological assessment							
Establish waste disposal area on Gortmore TMF							
Remove waste from Old Stockpile Garryard to Gortmore TMF, topsoil and vegetate Old Stockpile							
Remove waste from Tailings Lagoon Garryard to Gortmore TMF							
Establish wetland at Tailings Lagoon Garryard							
WORK AT SHALLEE SOUTH/EAST							
Determination of nature of heritage development and funding							
Investigation, design and tender letting							
Remove scrap to off-site designated dump							
Remove process waste to Gortmore TMF							
Install fences							
Conservation of buildings and structures							
Improvements to surface drainage & development of wetland							
WORKS AT GORTMORE TMF							
Investigation, design and tender letting							
Establish waste disposal area on Gortmore TMF							
Place growth medium on bare areas & vegetate							
Plant shrubs and trees at crest and toe							
Deposit Garryard waste on Gortmore TMF							
Carry out minor earthworks and drainage works							
Place soil capping on Garryard waste at Gortmore TMF							
Vegetate capping							
ONGOING MONITORING AND MAINTENANCE							

Figure 3: Indicative Time Schedule for Main Remedial Works

Note: Programme indicative only. Activities cannot commence until permits are in place.

14 SCHEDULE FOR REMEDIAL WORKS

The proposed programme (Fig.3) has been designed to fulfil the following criteria:

- Prioritise works, which are considered urgent. (These include the remedial works to the upper surface of the Gortmore TMF, and the removal of the waste deposits at the Garryard Old Stockpile, drum dump and the Tailings Lagoon).
- Provide a sequential programme, which will allow an assessment of the effectiveness of the implemented measures before the execution of the next stage. This will optimise expenditure and ensure that no unnecessary works are carried out. As a good example, the removal of the contaminated material from the Garryard Old Stockpile and tailings from the Tailings Lagoon will reduce the stream sediment load. The magnitude of this reduction will affect the design and the cost of the proposed wetlands on the site of the Tailings Lagoon.
- Spread the costs as evenly as possible over the project period, to improve cashflow. There are different potential sources of funding for certain of the remedial works, and this has been taken into account.

An entire year has been allowed for the arrangement of land access, funding, the planning and the detailed design for the first works to be carried out. This is considered to be realistic, and a carefully planned programme will give considerable benefit in both efficiency and cost. The establishment of a robust monitoring programme is an integral part of the management and remediation of the Silvermines area.

The programme given in Figure 3 is indicative only. It is possible that the initial activities, such as clarification of land access, the preparation of the EIS and the permitting process will cause delays, with work at Garryard and Shallee being postponed until the following year.

15 CONCLUDING REMARKS

The investigation has provided the opportunity to collect and collate information from a wide range of sources including the local population. Sufficient information was obtained to assess the risks and to define the best remedial options. A range of possible remedial options were considered for each potential hazard on the various mine sites, on the basis of an assessment of the risk to people, animals and the environment. The preferred options were selected after consideration of practicality, effectiveness and costs.

The conceptual designs and costs presented in the Phase III report were based on the preferred options. The preferred options are not final and will require verification and acceptance from others. The detailed design cannot be carried out until detailed topographic survey information is available. Some additional detailed work will be necessary for each site as part of the final design work.

A most important aspect of the project is the integration of works on all sites and the need for disposal of certain mine wastes in a licensed facility. The planning and environmental impact assessments for the whole project need to be carried out as a priority and the detailed work programme including potential funding will depend on that outcome. The planning and preparation could take up to a year before site work could take place, though the installation of fencing and other preparatory works can be carried out.

The Silvermines area, sitting against the side of the Silvermines Mountain, is a fascinating amalgam of historic mining sites, the Silvermines Village and attractive farmland. The proposed remedial works will largely remove the unpleasant side-effects of the old mining, whilst retaining the interest and heritage aspects. Remediation work, development of heritage sites and a possible heritage trail would restore the site to local people and to tourists and institutions interested in the mining history of the area.

For and on behalf of Steffen, Robertson & Kirsten (UK) Ltd

Dr Ian Brackley, C Eng
Director

Richard Connelly, C Eng
Director

APPENDIX A

SUMMARY REMEDIATION ASSESSMENT TABLES
(TAKEN FROM PHASE II REPORT)

Table 14.2: Risk Assessment - Ballygown

Source	School playing field (I2.1)	Village field* (I2.2)	Opencast area (two pits) (I2.3)	Sulphur mine pit (I2.4)	Shafts (I2.5)	Underground mine (I2.6)	Mine water discharge (I2.7)	Waste materials (I2.8)	Old tailings (I2.8)	Mine buildings/plant site (I2.9)
Hazard/issue	• Contaminated soil	• Contaminated soil *(Village field is club field above school, not school playing field)	• Stability • Leaching of metals • Depth of water	• Open shafts/adits • Footwall cliff • Subsidence	• Open shafts/adits • Collapse of backfill • Discharge of mine water	• Mine workings	• Sulfides/ oxidation products	• Sulfides/oxidation products • Erosion of contaminants	• Old tailings deposit to north-east of Village.	• Historic stone structures (Engine House and Furnace Building) • Concrete buildings at Waeltz Plant with asbestos roof
Pathway	• Human ingestion/exposure • Erosion and seepage	• Human ingestion/exposure • Erosion and seepage	• Leaching of metals • Seepage to surface & groundwater • Ingestion by animals • Instability of excavations • Access	• Access to shafts/adits • Access to cliff • Access to base of pit	• Access to shaft • Flooding or discharge to surface water through shafts • Proximity of buildings (two instances)	• Subsidence	• Seepage to groundwater/ surface water	• ARD/ metal leaching • Seepage to groundwater/ surface water	• ARD/ metal leaching • Seepage to groundwater/ surface water	• Collapse • Toxic dust
Receptors	• Human • Streams	• Human • Streams	• Surface water • Groundwater • Human & livestock safety	• Humans and livestock	• Human & livestock safety • Proximity of buildings	• Livestock • Human	• Surface water • Groundwater	• Surface water (local stream in village) • Groundwater	• Surface water (local stream in village) • Groundwater	• Human • Livestock
Impact	• Toxicity • Stream quality	• Toxicity • Stream quality	• Human & Livestock safety & health, herbage toxicity • Unstable slopes	• Human and livestock safety	• Building/road damage • Human and livestock safety • Flooding and shaft erosion	• Loss of land use • Livestock & human safety	• Human health • Livestock & herbage	• Human health • Livestock & herbage • Transport of contaminants	• Human health • Livestock & herbage • Transport of contaminants	• Human & Livestock safety & health
Risk	• LOW	• MEDIUM (both)	• LOW (stability danger) • LOW (toxicity danger) • MEDIUM (drowning)	• HIGH (shaft/adit danger to humans and livestock) • LOW (cliff danger to humans and livestock)	• HIGH (damage to structures) • HIGH (danger to humans & livestock • MEDIUM (water discharge)	• LOW (land-use) • LOW (property) • LOW (danger to humans & livestock)	• LOW (humans) • MEDIUM (livestock)	• MEDIUM (humans) • LOW (livestock) • MEDIUM (transportation of contaminants)	• LOW (humans) • MEDIUM (livestock) • LOW (transportation of contaminants)	• LOW (danger to humans of stone and concrete structures) • MEDIUM (human toxicity from asbestos) • LOW (livestock toxicity from asbestos)
Potential end use	• School playing field	• Recreational area • * Derelict land	• Fenced pit lagoon • Backfill to derelict land	• * Derelict land	• Grazing • Controlled public use • * Derelict land	• Rough grazing • * Derelict land	• Drain for underground workings	• * Derelict land	• Grazing	• Heritage Site • Continued farm usage at Waeltz Plant
Potential Remediation Options	• Completed (one metre of inert cover soil and gravel placed)	• Requires cover and improved drainage for recreational use • Information signs	• Partial re-shaping • Control of public access • Partial backfilling • Re-vegetation	• Cap shafts • Backfill shafts and fence • Fence adits and shafts • Fence subsidence area at shaft A	• Backfill shafts • Water pressure release • Information signs • Capping shafts	• No action • Information signs	• Sediment trap and clearance at adit entrance • Removal of sediment from Silvermines River • None	• Remove and dispose contaminated material • Remove contaminated sediment from stream • Partial removal from stream bank • Stream bank gabion protection • Cover waste rock to minimise leaching • Reprofile • Intercept run-off • Re-vegetate • Information signs	• Remove and dispose of contaminated material • Leave undisturbed and vegetated (no action). • Install fence	• Possible use of some of Waeltz Plant buildings for farm purposes • Conservation of Waeltz Plant buildings for future heritage restoration with removal of roofs • Reduce Waeltz plant buildings to window cell height and conserve • Conservation of Old Engine House and Furnace Building
Preferred option	• Completed	• Cover for recreational area	• Partial backfilling and re-vegetation	• * Derelict land	• As appropriate for individual shafts (details in Section I2.5)	• No action	• Sediment trap and clear adit entrance.	• Remove minor quantities from stream bank and re-profile • Intercept run-off	• Install fence	• Demolish Waeltz Plant, retain footprint • Conserve Old Engine House and Furnace Building
Actions	• None	• Design and cost works • Install cover layer, vegetate and improve drainage • Monitor stream quality as part of regional system	• Backfilling and re-shaping • Establishment of vegetation • Ownership and access to be determined	• Grill over east adit entrance • Fence round west adit and subsidence area • Backfill and re-vegetate open shafts and fence • Information signs	• Survey all shafts and adits • Geophysical survey to locate drainage tunnel below road • Backfill shafts, fence shafts which serve drainage function • Drill pressure release boreholes (2 number) and construct overflow drainage pipeline to river (I2.7) • Drill holes to confirm tunnel location/condition (integrate with I2.7)	• None • Information signs	• Sediment trap and clear adit entrance. (Integrate with I2.5). • Monitor discharge, and maintain integrity of drainage (Sediment removed from River as part of regional plan).	• Detailed survey • Stream bank gabion protection • Monitor stream water quality • Install signs • Construct run-off interception and silt trap	• Install fence	• Conservation and development as Heritage Site • Conservation of old engine house and furnace building structures • Demolition and removal of Waeltz Plant structures, retaining footprint • Specialist removal and disposal of asbestos on designated site

*** Note: Derelict land – Land which will not be utilised, but which will be vegetated with a self-sustaining cover, and for which access will be allowable, but restricted.**

Table 14.3: Risk Assessment - Magcobar

Source	Open pit & adjacent limited underground workings				Archaeological sites	Rock dumps			Mine buildings/plant site	Settlement Lagoons North of Pit
Hazard/issue	• Slope stability (I3.1)	• Subsidence of underground workings (I3.2) • Existing small sinkhole	• Deep water (I3.3)	• Contaminated water (I3.3)	• Destruction of old lead and copper mine remains (I3.4)	• Visual (I3.5)	• Stability (I3.6)	• Sulphides/oxidation products (I3.7)	• Safety (I3.8)	• Safety (I3.9)
Pathway	• Contact	• Contact	• Contact	• Seepage to groundwater • Leaching from sidewalls • Ingestion by animals & birds	• Remedial works	• Visible from a distance	• Slope failure	• ARD/ metal leaching • Seepage to groundwater/ surface water	• Access	• Access
Receptors	• Humans and livestock	• Humans and livestock	• Livestock & human	• Groundwater • Livestock & human	• Historic mine remains	• Human	• Humans and livestock	• Surface water • Groundwater	• Humans and livestock	• Humans and livestock
Impact	• Injury and death • Ravelling back outside present boundary	• Injury and death • Subsidence affecting pit stability	• Human & Livestock safety & health	• Groundwater contamination • Human & Livestock safety & health	• Loss of mining heritage	• Visual	• Injury • Exposure of fresh material	• Contamination of water • Human health • Livestock toxicity	• Human and livestock safety	• Humans and livestock safety
Risk	• MEDIUM (danger to humans and livestock) • MEDIUM (waste dump stability at crest	• LOW (danger to humans and livestock) • LOW (pit stability)	• HIGH (danger to humans and livestock)	• MEDIUM (human toxicity) • LOW (livestock toxicity) • LOW (groundwater contamination)	• HIGH	• LOW	• MEDIUM (human and livestock safety Dump A) • LOW (human and livestock safety (other dumps)	• MEDIUM (human & livestock toxicity) • MEDIUM (acid drainage to streams)	• LOW (risk to humans and livestock)	LOW (Risk to humans and livestock)
Potential end use	• Landfill • None	• Rough pasture.	• Pit lake or landfill	• Pit lake or landfill,	• Heritage site • Archaeological investigation, then derelict land	• * Derelict land	• * Derelict land • Source of aggregate for fill	• * Derelict land	• Possible alternative commercial use for workshop • Demolition and removal of other buildings	• *Derelict land • Backfill and re-vegetate
Potential Remediation Options	• Prevent access by fencing (There is an existing fence) • Partial backfill • Remove waste rock pile from pit edge • Backfill (Landfill)	• Do nothing • Extend boundary fence over undermined area • Backfill small sinkhole	• Prevent access to pit by fence (existing, but requiring improvement)	• Pump and treat • Increase alkalinity • Limit surface run-off • Prevent access	• Protective fence and signs • Archaeological investigation	• Re-profile to blend with natural topography • Prevent uncontrolled removal of stone from toe of dump • Promote vegetation	• Prevent uncontrolled removal of stone from toe of slopes, Dump A • Flatten slopes • Maintain drainage channels around and under dumps • Use as aggregate/fill source • Institutional controls (signage)	• Intercept and treat seepage • Cover waste rock to minimise leaching • Consolidate and cover acid generating material • Divert upstream flows	• Remove crusher plant • Remove oil tanks • Remove office • Consider alternative use for workshops • Backfill lagoon on top of Dump E and re-vegetate	• Backfill and re-vegetate • Fence to restrict access and maintain integrity
Preferred option	• Fencing to prevent access and leave as pit lake	• Backfill small sinkhole	• Fencing to prevent access and leave as pit lake	• Fencing to prevent access and leave as pit lake	• Protective fence and signs for future archaeological investigation	• Minor re-shaping and re-vegetation	• Prevent uncontrolled removal of stone at Dump A, carry out minor re-shaping and re-vegetate • Use as fill source • Institutional controls (signage)	• Consolidate and cover • Divert upstream flows	• Removal or re-use of buildings • Backfill lagoon	• Fence and maintain • Backfill Dump E lagoon
Actions	• Improve and maintain fences to prevent public access	• Backfill small sinkhole	• Improve and maintain fences to prevent public access	• Improve and maintain fences to prevent public access • Monitor water quality (depth profile of quality) • Evaluate pit lake chemistry	• Install protective fence and information signs	• Carry out minor reshaping • Establish new vegetation	• Prevent uncontrolled removal of material • Assess and use dump material as fill where required for remediation • Maintain drainage channels • Carry out minor reshaping	• Consolidate and cover • Place cover on selected areas of crest • Maintain and improve surface drainage to divert upstream flows	• Evaluate existing structures • Schedule removal or new usage • Backfill lagoon	• Fence • Backfill Dump E

*** Note: Derelict land – Land which will not be utilised, but which will be vegetated with a self-sustaining cover, and for which access will be allowable, but restricted.**

Table 14.4: Risk Assessment – Garryard (Mogul), including subsidence zone

Source	Settlement pond (I4.1)	Tailings Lagoon (I4.2)	Main Garryard Shaft (I4.3)	Mogul underground mine (I4.4)	(I4.4)	Garryard Old Stockpile (I4.5)	Garryard Mine Buildings at the Plant Site (I4.6)
Hazard/issue	• Contaminated water	• Contaminated water • Contaminated sediment	• Open shaft • Water discharge	• Subsidence	• Sulfides/oxidation products in underground water	• Sulfides/oxidation products • Mill concentrate spillage	• Buildings • Contaminated land
Pathway	• Seepage to surface & groundwater • Ingestion by animals	• Leaching of metals from sludge in pond • Seepage to surface & groundwater • Ingestion by animals	• Cap damage • Water head in workings	• Access	• Seepage to groundwater • Discharge to surface due to blocking shaft discharge	• ARD/ metal leaching • Seepage to groundwater/ surface water • Erosion to drains • Livestock access	• Access • Leaching of chemicals from contaminated land
Receptors	• Surface water • Groundwater • Livestock	• Surface water • Groundwater • Livestock	• Human • Surface water	• Surface dwellings, livestock, human health	• Groundwater • surface water	• Surface water • Groundwater	• Livestock, • Human • Streams
Impact	• Contamination of local water • Human health • Livestock	• Contamination of local water • Human health • Livestock & herbage toxicity	• Human • Contamination of local water	• Loss of land use, • Property damage • Livestock & human safety	• Contamination of groundwater and surface water	• Contamination of local water • Human health • Livestock & herbage toxicity	• Human and livestock safety (buildings) • Livestock health & safety • Human and livestock health (contaminated land)
Risk	• MEDIUM (metals and TDS in sediment and streams) • MEDIUM (human toxicity of ponds) • HIGH (livestock toxicity of ponds)	• HIGH (metals and TDS in sediment and streams) • MEDIUM (human toxicity) • HIGH (livestock toxicity)	• LOW (damage) • HIGH (discharge of contaminated water)	• HIGH (loss of land-use, but only in specified area) • LOW (surface dwellings) • HIGH (safety)	• LOW	• HIGH (contamination of streams) • MEDIUM (human toxicity) • HIGH (livestock toxicity)	• LOW (danger to humans and livestock) • MEDIUM (human and livestock toxicity)
Potential end use	• Run-off pond and wetland	• Redevelop as wetland for mine water treatment	• Light industrial	• Farmland, but *derelict land with prohibited fenced access where subsidence risk high	• None	• Pasture	• Light industrial use for plant area and infrastructure • * Derelict land
Potential Remediation Options	• Remove contaminated material • Place cover • Encourage wetland development • Water treatment plant • Drain to constructed wetland	• Engineered Cover • Intercept and treat seepage and ponded water • Divert clean water • Remove contaminated sediment to Gortmore TMF • Constructed wetland	• Monitor shaft flows • Backfill shaft • Information sign • Drain shaft flows to wetland • Treatment plant.	• Fence off high risk areas • Backfill subsidence with rock • Divert surface water	• Divert surface water • Maintain drainage of Knight Shaft water	• Intercept and treat seepage • Profile and engineer cover & restore to pasture • Remove waste to engineered containment	• Removal and site restoration • Preserve old farm cottages • Utilise buildings • Profile and cover unsurfaced areas to prevent infiltration • Landscaping around old plant area • Manage drainage
Preferred option	• Encourage wetland	• Remove sediment, construct wetland	• No change • Information sign	• Fence off and divert surface water • Divert surface water	• Divert surface water • Maintain shaft drainage	• Remove waste, cover and restore to pasture	• Light industrial use and manage drainage • Remove hostel
Actions	• Monitor inflows • Works for natural wetland development, Pond A, no works required, Pond B • Prevent further extension of existing hard standing	• Remove contaminated sediments • Dispose of sediments on Gortmore TMF • Design wetland • Re-establish diversion canals	• Monitor shaft flows and cap condition • Establish explanatory sign • Drain to tailings lagoon wetland.	• Carry out geotechnical assessment of potential subsidence • Review existing and required fencing • Topographic survey and design drainage	• Divert surface water • Maintain shaft drainage to tailings lagoon • Monitor	• Intercept and treat surface run-off and seepage • Separate soil and metal waste • Remove soil waste materials to Gortmore TMF and metal waste to designated off-site dump • Place capping layer and re-vegetate	• Prepare schedule of remedial works • Prepare specification for permissible usage • Preserve old farm cottages • Remove hostel • Profile and cover unsurfaced areas • Carry out landscaping works

*** Note: Derelict land – Land which will not be utilised, but which will be vegetated with a self-sustaining cover, and for which access will be allowable, but restricted.**

Table 14.5: Risk Assessment - Gorteenadiha

Source	Gorteenadiha mining heritage (I4.7)	Gorteenadiha waste dumps (I4.8)	Gorteenadiha underground and surface workings (I4.9)
Hazard/issue	• Loss of heritage structures	• Contaminated ground • Discharge of contaminated water	• Subsidence • Open shafts and pits
Pathway	• Remedial works, agricultural works, etc.	• Access and contact • Seepage to groundwater/surface water • Water courses from site	• Access
Receptors	• Heritage structures	• Human • Livestock • Surface water to Yellow River • Groundwater	• Human • Livestock
Impact	• Destruction or damage to mining remains, including hand washing structures	• Human and livestock safety and toxicity • Contamination of water courses and groundwater	• Human and livestock safety
Risk	• HIGH	• MEDIUM (human toxicity) • MEDIUM (livestock toxicity) • MEDIUM (contamination of surface water)	• MEDIUM (subsidence) • HIGH (danger to humans and livestock)
Potential end use	• Heritage site • * Derelict land	• Heritage Site • * Derelict land	• Heritage site • * Derelict land
Potential Remediation Options	• Fence and erect information signs • Carry out archaeological investigation and conserve (to be done before remedial works carried out)	• Placement of cover layer and vegetate • Control of access • Surface drainage works • Water diversion and treatment • Gabion retention structure to hold sediments • Information signs • Conservation and heritage	• Fence • Backfill shafts • Surface drainage works • Water diversion and treatment • Information signs • Conservation and heritage
Preferred option	• Protect for future archaeological investigation	• Protect and conserve, install run-off controls	• Protect and conserve
Actions	• Erect fences and information signs • Archaeological survey	• Design and construct system for drainage control • Construct small gabion dam to retain silt during and after execution of remedial works • Erect fencing and signage	• Map shafts and adits and backfill any open areas • Design and construct system for drainage control • Erect fencing and signage

*** Note: Derelict land – Land which will not be utilised, but which will be vegetated with a self-sustaining cover, and for which access will be allowable, but restricted.**

Table 14.6: Risk Assessment – Shallee South/East and Shallee West (Continued on next page)

Source	Opencast areas (pits and trenches) (i5.1)			Shafts (I5.2)	Underground mine (I5.3)		
Hazard/ issue	• Toxicity of ponded water in opencast areas	• Scrap and waste in opencast	• Safety (ponds and rock faces)	• Open shaft • Shaft collapse	• Subsidence/ collapse/rock falls	• Safety (drowning, falls)	• Sulfides/oxidation products • Surface contamination
Pathway	• Seepage to surface & groundwater • Ingestion by animals • Access	• Visual • Toxicity	• Access	• Access	• Access	• Access	• Seepage to groundwater/ surface water
Receptors	• Human • Livestock • Groundwater • Surface stream	• Human • Livestock • Groundwater • Surface stream	• Human • Livestock	• Human • Livestock	• Human • Livestock	• Human	• Surface water • Groundwater
Impact	• Human toxicity • Livestock toxicity • Surface water quality • Groundwater quality	• Human toxicity • Livestock toxicity • Surface water quality • Groundwater quality • Visual	• Injury and death	• Injury and death	• Injury and death	• Injury and death	• Contamination
Risk	• LOW (human toxicity) • LOW (livestock toxicity) • LOW (water quality)	• LOW (visual) • MEDIUM (toxicity)	• MEDIUM (human and livestock)	• MEDIUM (safety) • LOW (collapse)	• MEDIUM	• MEDIUM	• MEDIUM
Potential End-use	• Heritage site, with controlled public access • *Derelict land	• None	• Heritage site, with controlled public access • *Derelict land	• Heritage structures • None	• Heritage site with controlled public access to Cathedral cavern and beyond • *Derelict land	• Heritage site with controlled public access • *Derelict land	• Heritage site with controlled public access • * Derelict land
Potential Remediation Options	• None required	• Remove scrap and waste	• Backfill or re-profile • Clear vegetation to expose trenches • Fence off	• Fence off • Engineered cap • Safety grill for observation and bats	• Collapse or backfill underground workings • Restrict access to designated routes by fencing • Install rock support	• Restrict access to designated routes • Rock support/barring	• Intercept and treat seepage (wetland) • Divert surface water
Preferred option	• None	• Remove scrap and waste	• Safety fence • Notices	• Safety grill (Vent Shaft) • Field shaft to be fenced, but allowed to discharge water • As appropriate (other shafts)	• Restrict access by fencing	• Restrict access by fencing	• Surface water diversion • Wetland
Actions	• None	• Remove scrap and waste • Identify disposal site • Assess quantities • Segregate and remove (integrate with I 5.5)	• Survey fence requirements • Erect fencing • Notices (integrate with I5.3 + I 5.7)	• Locate and assess shafts and adits, treat as appropriate • Safety grill on vent shaft • Fence field shaft and others as appropriate	• Fencing, clearing and control access as part of development of heritage area (integrate with I 5.1 and I 5.7)	• Fencing and control access as part of development of heritage area (integrate with I 5.1 and I 5.7)	• Survey • Surface water diversion, clean and extend • Site water to wetland (with I 5.4)

*** Note: Derelict land – Land which will not be utilised, but which will be vegetated with a self-sustaining cover, and for which access will be allowable, but restricted.**

Table 14.6(Continued): Risk Assessment – Shallee South/East and Shallee West

Source	Tailings (I5.4)			Waste dumps (I5.5)		Mine buildings/plant site (I5.6)	Water reservoir (I5.7)	Shallee West (I5.8)Open Pit	Shallee West (I5.9)Waste Dumps
Hazard/ issue	• Dust	• Stability	• Leaching of metals from tailings • Erosion of tailings	• Mine waste (rock spoil)	• Scrap and process wastes (Drum Dump, etc.)	• Buildings and mine area	• Flooding from reservoir • Safety	• Safety	• Mine waste (rock spoil)
Pathway	• Aerial dispersion	• Slope failure and possible flow	• Seepage to surface & groundwater • Erosion from embankments	• Instability and contamination	• ARD/ metal leaching • Seepage to groundwater/ surface water • Erosion to drains • Livestock access	• Access	• Surface flow after wall breach • Access	• Access	• Contamination
Receptors	• Local soil & herbage, • Livestock, • Local residents • Streams	• Deposition on surrounding land • Flow into river	• Surface water • Groundwater • Ingestion by animals	• Seepage to groundwater and surface water • Human safety	• Surface water • Groundwater • Visual • Health and safety	• Safety • Visual	• Humans and structures	• Humans • Livestock	• Seepage to groundwater and surface water • Livestock Safety
Impact	• Stream quality • Dust nuisance • Loss of land use due to toxicity in herbage	• Contamination of land and water	• Contamination of surface water and groundwater • Livestock toxicity	• Contamination to surface water and groundwater • Slope failure and slides	• Contamination of surface water and groundwater	• Injury	• Injury and property damage • Drowning	• Drowning • Injury and Death	• Contamination to surface water and groundwater • Livestock toxicity
Risk	• LOW (streams) • LOW (dust) • LOW (herbage)	• LOW (risk of failure)	• LOW (contamination) • LOW (livestock)	• MEDIUM (contamination) • LOW (instability)	• HIGH (stream contamination) • MEDIUM (human toxicity) • HIGH (livestock toxicity) • HIGH (aesthetics)	• LOW (injury)	• MEDIUM (drowning)	• MEDIUM (safety)	• LOW (contamination) • MEDIUM (toxicity)
Potential End-use	• Heritage site with controlled public access • * Derelict land	• Heritage site with controlled public access • * Derelict land	• Heritage site with controlled public access • * Derelict land	• Heritage Site with controlled public access • * Derelict land	• Heritage Site with controlled public access • *Derelict land	• Heritage site with controlled public access • * Derelict land	• Heritage site with controlled public access • Drained *derelict land	• * Derelict land • Heritage site	• * Derelict land
Potential Remediation Options	• Prevent surface disturbance by control of access • Improve surface vegetation cover by addition of organic layer and reprofile where necessary	• None required	• Cover tailings to reduce leaching/erosion • Re-profile and cover • Intercept and treat seepage water in wetland • Construct sediment traps	• No action • Remove waste dumps	• Intercept and treat seepage • Profile and engineer cover • Remove waste to engineered containment • Divert surface water	• Removal of buildings and site restoration • Re-profile waste and building areas and cover • Conservation of buildings and all remnant structures • Landscaping in accordance with heritage requirements • None	• Maintenance of reservoir and utilisation of water • Draining of reservoir and diversion of feeder channels • Fencing	• Backfill • Draining • Fencing	• No action • Remove waste dumps
Preferred option	• Control access and improve vegetation	• No action	• Restrict access and maintain vegetation • Improve and maintain surface drainage system • Run-off to pass into wetland	• No action • Integrate with I 5.3	• Remove waste	• Conservation of all buildings and structures for heritage: King's House Engine House Core shed Laboratory Office Plant foundations, etc	• Maintain as reservoir • Install fence	• Install fence	• Push into open slot and cover with soil for growth medium
Actions	• Prevent livestock access (maintain fences) • Control public access (signage) • Re-establish vegetation and monitor	• No action	• Establish monitoring • Improve and maintain surface drainage system • Maintain dump profile and vegetation • Integrate with wetland for I5.3	• No action • Integrate with I5.3	• Remove waste to containment, off-site or on-site, re-vegetate and stabilise area	• Prepare schedule of conservation of all surface structures and restoration needs • Carry out conservation, landscaping and restoration measures	• Carry out safety inspection • Install fence • Monitor (integrate with I 5.3 and I 5.1)	• Survey • Install fence	• Survey quantity • Implement preferred option above

*** Note: Derelict land – Land which will not be utilised, but which will be vegetated with a self-sustaining cover, and for which access will be allowable, but restricted.**

Table 14.7: Risk Assessment - Gortmore TMF

Source	Tailings (dust I6.1)	Tailings (Visual I6.2)	Tailings (Leach I6.3)	Tailings (Erosion I6.4)	Tailings (Instability I6.5)	The tailings pool (I6.6)	The three retention ponds (I6.7)	Delivery pipe line (I6.8)
Hazard/issue	• Metals in dust from wind erosion	• Un-vegetated outer slopes	• Leaching of metal from tailings	• Erosion of tailings by water run-off	• Deep-seated slope instability	• Contaminated water	• Contaminated water	• Sediment from pipe breaks during mine operation
Pathway	• Aerial dispersion	• View	• Seepage to surface and groundwater	• Erosion from crest and embankments	• Slope failure and possible flow	• Seepage to groundwater • Flow to retention ponds along discharge channel	• Seepage to groundwater • Flow to river	• Access
Receptors	• Local soil & herbage, • Kilmastulla river, • Livestock, • Farmhouses and residents	• Local community	• Surface water • Groundwater	• Deposition on surrounding land • Flow into river	• Deposition on surrounding land • Mass flow into river	• Groundwater • Kilmastulla River	• Groundwater • Kilmastulla river	• Local soil & herbage, • Humans, Livestock
Impact	• Elevated metals in soils • Pollution of the Kilmastulla River, Yellow River and drains around the TMF by metals in dust • Animal & human toxicity • Dust nuisance	• Appearance of exposed rock slopes in rural setting	• Elevated metals in surface water • Elevated metals in groundwater • Human toxicity • Livestock toxicity	• Contaminates agricultural land • Metal sediments in river • Human toxicity • Livestock and herbage toxicity	• Contaminates agricultural land • Metal sediments in river • Human toxicity • Livestock & herbage toxicity	• Contamination of groundwater • Contamination of Kilmastulla River • Human toxicity • Livestock, bird and herbage toxicity	• Contamination of groundwater • Contamination of Kilmastulla river • Human toxicity • Livestock, bird & herbage toxicity	• Human health, • Livestock & herbage toxicity
Risk	• LOW (all, in present mitigated conditions) • HIGH (all, in future, without further maintenance and mitigation measures)	• MEDIUM	• MEDIUM (surface water) • MEDIUM (groundwater) • LOW (human) • LOW (livestock)	• LOW (land) • LOW (river) • LOW (human) • LOW (livestock & herbage)	• LOW (land) • LOW (river) • LOW (human) • LOW (livestock & herbage)	• MEDIUM (groundwater) • LOW (river) • LOW (human) • MEDIUM (livestock, bird, herbage)	• MEDIUM (groundwater) • LOW (river) • LOW (human) • MEDIUM (livestock, bird, herbage)	• LOW
Potential End-use	• * Derelict land • Wildlife sanctuary with limited public access, no livestock access • Pasture	• *Derelict land • Wildlife sanctuary with limited public access, no livestock access • Pasture	• * Derelict land • Wildlife sanctuary • Limited public access, no livestock access • Pasture	• * Derelict land • Wildlife sanctuary • Limited public access, no livestock access • Pasture	• * Derelict land • Wildlife sanctuary • Limited public access, no livestock access • Pasture	• Maintain pool as wildlife resource • Drain and backfill as derelict land • Backfill and cover for pasture	• Maintain ponds for water retention • Drain and backfill as derelict land • Backfill and cover for pasture	• Pipe previously removed
Potential Remediation Options	• Prevent surface disturbance by exclusion for general access and grazing • Improve surface vegetation cover by addition of organic layer growth medium • Construct engineered cover with low-permeability layer, capillary break and growth medium – for grazing end-use • Push-down and re-vegetate outer slopes	• Re-vegetate crest of slope, plant crest windbreaks, • Plant trees at toe to hide slope	• Construct engineered cover with low-permeability layer & capillary break, to reduce leaching • Improve surface vegetation cover by addition of organic layer growth medium • Water treatment plant • Collect toe seepage into toe wetlands	• Prevent surface disturbance by exclusion for general access and grazing • Improve surface vegetation cover by addition of organic layer growth medium • Improve sediment traps and vegetate • Push-down and re-vegetate outer slope • Repair erosion gulleys	• Push-down outer slopes • Repair eroded gulleys • Maintain surface water drainage system • Minor repairs to slope at decant pipe exit	• Treat decant water • Drain pool, backfill and vegetate • Upgrade pond decant system with buried pipeline • Construct engineered cover with low-permeability layer, capillary break and growth medium – for grazing end-use • Maintain in present state • Prevent access for livestock	• Treat pond water before discharge • Cover over pond area to restore site • Improve wetland system • Repair embankment crest • Information signs	• None
Preferred option	• * Derelict land, restrict access, place growth medium selectively and improve vegetation	• Vegetation screen to hide view of bare slope and plant trees at toe.	• * Derelict land, place growth medium selectively and improve toe wetlands	• * Derelict land, restrict access, place growth medium selectively and improve sediment traps	• * Derelict land, maintain drainage	• Maintain pool in present state, but upgrade decant system	• Improve and maintain wetland system and discharge structures (retention time to be maximised)	• None
Actions	• Detailed survey of quantities and prepare specs, schedule, design, costs • Re-vegetation of selected areas • Restricted access; prevent surface disturbance by exclusion for general access and grazing • Improve surface vegetation cover by addition of organic layer growth medium • Plant vegetation wind breaks (some already established) • Establish vegetation monitoring programme and maintenance schedule • Establish dust monitoring programme and contingency response (integrate with EPA programme) • Signage	• Detailed survey of quantities and prepare specs, schedule, design, costs • Survey for quantities prepare schedule and specs • Place soil layer and re-vegetate crest of slope • Plant crest windbreaks • Plant trees at toe to hide slope	• Detailed survey of quantities and prepare specs, schedule, design, costs • Restricted access; prevent surface disturbance by exclusion for general access and grazing • Monitor surface and groundwater quality • Information signs • Improvement works to existing wetlands (integrate with I.6.4)	• Detailed survey of quantities and prepare specs, schedule, design, costs • Re-vegetation of selected areas • Restricted access; prevent surface disturbance by exclusion for general access and grazing • Improve surface vegetation cover by addition of organic layer growth medium • Establish vegetation monitoring programme and maintenance schedule • Improve sediment traps around the toe (integrate with I.6.3) • Repair erosion gulleys	• Routine inspections • Integrate drainage with I6.1 and 6.6	• Detailed survey of quantities and prepare specs, schedule, design, costs • Upgrade decant and penstock system by installation of a penstock at the pool and a buried decant pipeline to retention ponds. • Maintain pool at precise minimum size by operation of the decant system	• Detailed survey of quantities and prepare specs, schedule, design, costs • Carry out detailed survey and water balance calculations • Optimise wetland operation • Carry out repairs to ponds and discharge system as required	• None

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