MANAGEMENT AND REHABILITATION OF THE SILVERMINES AREA

PHASE II REPORT: MANAGEMENT OPTIONS

Prepared for:

DEPARTMENT OF MARINE AND NATURAL RESOURCES

Prepared by:

SRK Consulting
Windsor Court
1-3 Windsor Place
Cardiff
CF10 3BX

Tel: +44 (029) - 20348150
Fax: +44 (029) – 20348199
www.srk.co.uk

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SRK Consulting
Engineers and Scientists

SRK (UK) Ltd.
Windsor Court
1-3 Windsor Place
Cardiff
CF10 3BX, UK
E-mail: enquiries@srk.co.uk
URL: www.srk.co.uk
Tel: + 44 (0)29 2034 8150
Fax: + 44 (0)29 2034 8199

SUMMARY

MANAGEMENT & REHABILITATION OF THE SILVERMINES AREA
PHASE II REPORT: MANAGEMENT OPTIONS

This report covers the second phase of the study for the management and rehabilitation of the Silvermines area, and is concerned with the available management and rehabilitation options.

INTRODUCTION

The Silvermines area of County Tipperary has been mined for over a thousand years for lead, zinc, copper, silver, baryte and sulphur. The last mine, Magcobar, closed 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 dams, and the presence of derelict surface structures. Figure 1 is an annotated orthophoto showing the main features of the study area. The yellow outline represents the extent of the study area.

The waste products contain heavy metals, which are mobilised after heavy rain, entering the streams. 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, and there have been cattle deaths caused by lead poisoning. It is primarily these deaths and the dust blows which have alerted the authorities to the need to undertake closure and rehabilitation measures to reduce the risk to human and livestock health and safety, and to the environment. There are, however, other pollutants and other problems, such as mining subsidence associated with the Silvermines area, which require consideration. These have been included in the present investigation.

A number of studies have been carried out to investigate the problems and, in 2001, the Department of Marine and Natural Resources (DMNR) appointed SRK Consulting to prepare conceptual designs for the management and rehabilitation of the Silvermines region, over an area of about 2,300 ha. This design was to include five specific sites identified as requiring treatment:

- *Gortmore tailings management facility (TMF);*
- *Tailings at Shallee;*
- *Lagoon and settlement pond at Garryard;*
- *Ballygown area and ground to the south of Silvermines village; and*
- *Magcobar pit and waste dumps.*

The work was to include any other sites within the study area requiring remediation. Although particular problem areas were identified, the problems are linked and it was recognised by all concerned with the study that the Silvermines area must be dealt with as a whole. It was required to present separately 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.

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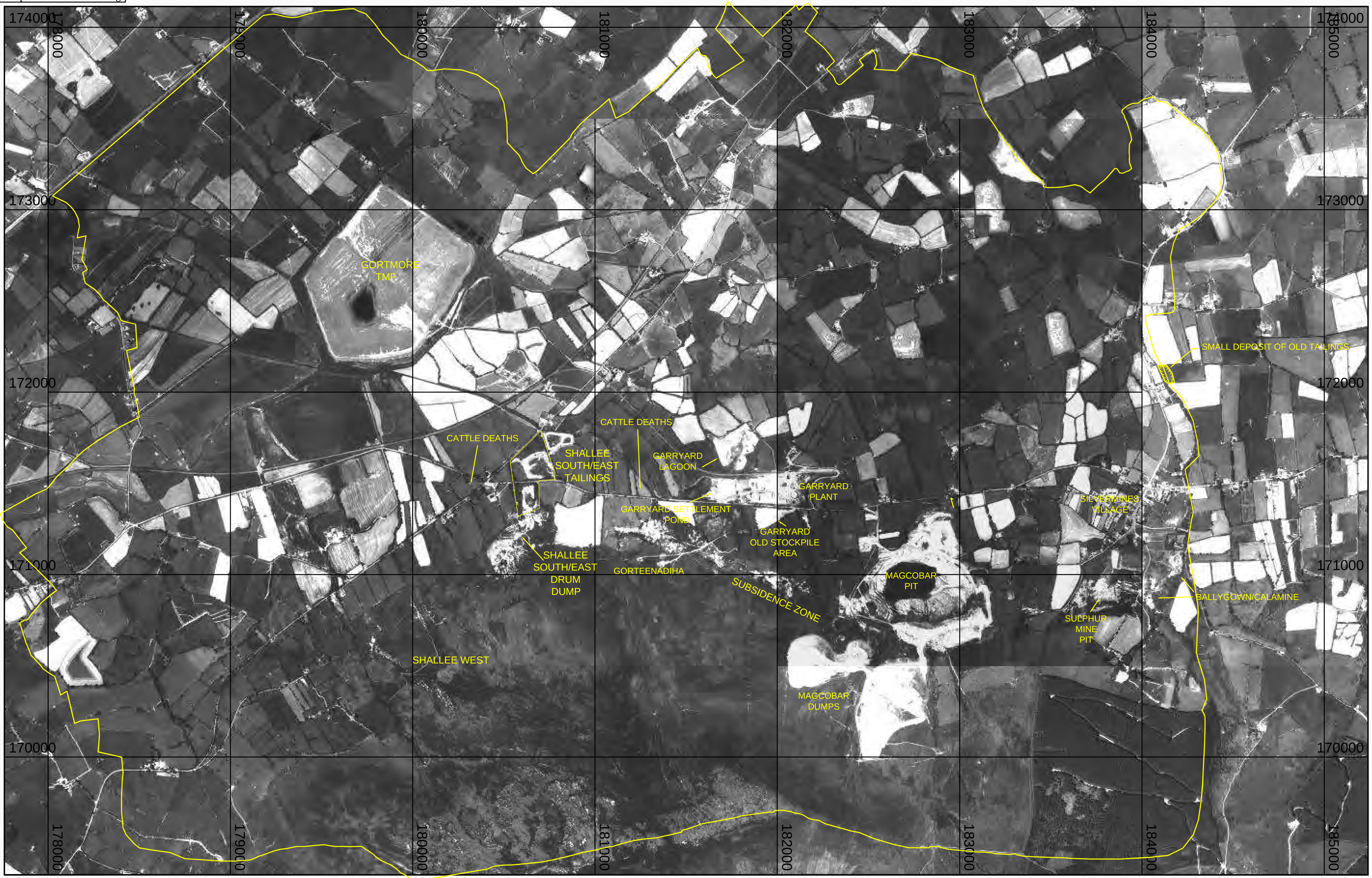


April 2001	PROJ. No: U1606	SILVERMINES	1:20,000
SRK Consulting Engineers and Scientists		THE STUDY AREA	Fig 1

THE STUDY

The study was to be carried out in three stages:

- *Phase I, review of available information,;*
- *Phase II, management options; and*
- *Phase III, conceptual design of selected options.*

The report on the Phase I study was concerned with the review of the large amount of documentary information, the identification of gaps in the data, the identification of potential remedial measures, and the definition of the work required for Phase II.

THE SITE WORK

The study was undertaken on the basis that the available information would be sufficient for the preparation of the conceptual design for management of the site. It was appreciated that the Phase I review of available information might identify minor gaps in the data, and the intention was that, during Phase II, these gaps would be filled.

During Phase I, the need for a limited amount of additional sampling and testing of water and soils was identified, and this was carried out during Phase II. It was also found that there was very little groundwater information and, as a result, DMNR authorised additional drilling and testing. In addition, Phase II included the completion of observational work on the site, comprising the photographic record, the surface inventory and the assessment of the mining heritage. This work was limited and delayed during Phase I by the foot and mouth restrictions.

The ecology of the area, both habitats and vegetation, was reviewed, with site inspections and the examination of the available data and publications. This information was used in the assessment of re-vegetation options and sustainability in Phase II.

As a result of the foot and mouth restrictions and the additional groundwater study, the programme was extended, with the reports to be submitted at the end of December 2001.

INDUSTRIAL HERITAGE

The Shallee Mine is considered to be a unique survival, worthy of preservation, conservation and utilisation. Major archaeological sites have also been identified at Ballygown, Gorteenadiha, and the old copper mining at Magcobar. These sites should be protected.

Detailed recording of structures on all these sites should be carried out, and public consultation should take place before finalising the programme for conservation and usage. This usage may include the establishment of a centre for Mining Heritage and a walking trail linking the sites.

RIVER AND STREAM CONTAMINATION

During the Phase II study, sampling of surface water and soils was carried out to supplement the data already available. The main purposes were to identify the significant sources of elevated metals in the 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.*

The results confirmed that surface water in all parts of the study area contains elevated metals. Most of this loading is particulate material. The metals include lead, barium, cadmium, zinc, iron and manganese.

GROUNDWATER

A drilling investigation was carried out to supplement the available information on geology, groundwater levels, groundwater aquifer properties and groundwater quality. Thirteen holes were drilled and sampled at Ballygown, Garryard, Shallee and Gortmore, to determine the effect of the mining works and waste deposits on the groundwater. Pump tests were carried out in two boreholes, and double piezometers were installed in four.

The results showed a low permeability in the limestone aquifer matrix, with higher permeabilities associated with fracture features. The overlying alluvial aquifers are more susceptible to potential contamination, but there is no evidence of significant effects of mining on groundwater levels or quality. No active remedial measures for groundwater are considered necessary.

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 levels in the groundwater are insignificant.

DUST

No dust investigation has been carried out in the Phase II 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. The remedial design for Gortmore TMF will include measures for the improvement and maintenance of the vegetation.

MINE STABILITY

The available plans and reports have been reviewed, and it has been concluded that future subsidence of the Mogul underground workings will be confined to the present subsidence zone with some possible expansion to the north.

WASTE DUMP STABILITY

The Magcobar dumps are granular and relatively free-draining. With continued maintenance of the surface water drainage system, these dumps will remain stable. No problems are anticipated with the Shallee South/East tailings dumps, or with the old tailings deposits at Ballygown.

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

HAZARD IDENTIFICATION

The list of key hazards is as follows:

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

There are numerous other minor problems requiring remediation, but the six items listed above are the most significant. All problems, both major and minor, are considered in the Phase II report.

DISPOSAL OF WASTE MATERIAL

The remediation of the study area will result in the disposal of quantities of contaminated soil and waste materials:

- *Ballygown – disposal of asbestos roofing and possible concrete;*
- *Ballygown – about 100m^3 of mine waste from vicinity of Silvermines Stream;*
- *Magcobar – about 200m^3 of sulphide waste from dump area;*
- *Magcobar – disposal of scrapped crushing plant and associated structures;*
- *Garryard – about 14,000m^3 of ore and process waste from Old Stockpile;*
- *Garryard – about 22,000m^3 of process waste from Tailings Lagoon;*
- *Garryard – disposal of general scrap and waste from the site and old hostel building;*
- *Dredging of stream sediments, annual or biennial, quantities unknown; and*
- *Shallee – segregation and disposal of ore, process waste and scrap metal, about 4,000m^3.*

These estimated quantities are not based on measurements and actual quantities must be confirmed during the detailed design.

This material will be disposed of at a remote site or at a suitable location within the study area, which could be the surface of the Gortmore TMF. The options are under review. The waste materials at Shallee include large quantities of metal drums, cables and other mine debris, and would require separate disposal off-site, probably at a designated site in Shannon.

REMEDIATION OPTIONS

A detailed risk assessment has been carried out for the study area and the remediation options have been considered. The main features of the preferred options are:

- *general upgrading and maintenance of surface water system;*
- *conservation of mining heritage features of Ballygown and Gorteenadiha;*

- *conservation of Shallee South/East as mining heritage site with visitor facilities;*
- *possible establishment of a heritage trail linking the mining features of the Silvermines area;*
- *removal of contaminated materials from areas as listed above, and deposition on a designated disposal site, which may be the Gortmore TMF;*
- *construction of temporary silt retention structures for discharges from Gorteenadiha area and Ballygown;*
- *segregation of drums and other waste from Shallee South/East and disposal on a designated licensed site outside the study area or on site;*
- *clearing of the Garryard tailings lagoon and redevelopment as a wetland treatment pond;*
- *establishment of a wetland treatment pond for water discharged from Shallee South/East;*
- *minor earthworks at the Gortmore TMF, upgrading of pool decant and retention ponds; and*
- *application of a growth medium to parts of the Gortmore TMF and re-establishment of vegetation.*

PHASE III

The Phase II report, giving the options and proposing preferred options, provides the information on which the Phase III Conceptual Design will be prepared and costed. A programme will be prepared for implementation.

8 DUST

Dust from the Gortmore TMF has been identified as a major issue in the past. There is also a lesser dust potential from the Shallee South/East tailings.

The effects of dust blows are stream contamination, soil contamination, collection on herbage, health and safety from inhalation and nuisance. Fortunately, there are few houses in the vicinity of the Gortmore TMF but during the 1980s, dry conditions and a sparcity of vegetation on the impoundment resulted in large dust blows extending for considerable distances and reportedly affecting numerous households.

8.1 Previous dust blows

Tailings deposition on the Gortmore TMF ceased in 1982, when Mogul Mine closed. The subsequent drying out of the upper surface resulted in dust blows. The most severe events took place in February 1985 (Boland, Mogul, 2000)[91], and there was evacuation of residents and condemnation of local organic produce. The owners embarked on a rehabilitation programme to establish grassland on the tailings. Dust monitoring was carried out in 1986/7, and a formal dust-monitoring programme was established in 1999 by the EPA, in response to local concerns. The monitoring results have been compared to the limits for lead, cadmium and thallium specified in the German T.A Luft Regulations, as there are no Irish specifications (the German limits have been recommended by the EPA in 1989). Most recorded readings have been well below the limits, but four results did exceed the allowable Pb value, two exceeded the allowable Cd value and one exceeded the allowable Tl value. These gauges were, however, within 20m of the toe of the Gortmore TMF. The EPA will continue with the monitoring programme.

Thallium was only identified at two sites in the SRK investigation, in surface water in the Garryard tailings lagoon and at Magcobar in the pit lake.

8.2 Present potential for dust blows

The vegetation, moss and algal cover on most of the tailings has prevented repeats of the serious blows of the early 1980s and monitoring has not revealed any significant dust emissions since 1999. The concern is whether deterioration of the vegetation cover on the Gortmore TMF will cause future problems to develop. Undoubtedly, exceptionally dry conditions or the frost conditions prevailing in February, coupled to poor vegetation growth on the Gortmore TMF would result in dust blows. The key to ensuring that there is no recurrence of such events is the continued programme for the establishment of vegetation on the impoundment.

The top surface of the Gortmore TMF was briefly used for grazing. The disturbance to the vegetation and the crust caused by livestock would increase the potential for dust generation, and it is important that there should be no access for livestock, unless under a closely managed situation to manage grass growth.

8.3 Dust Implications for Remediation

There is sufficient data available to assess the remediation requirements for the Gortmore TMF. The proposed remedial measures will include the placement of new growing medium on areas where the impoundment is bare of vegetation, and the establishment of suitable grasses, and shrubs. The maintenance of the vegetation will continue and the surface of the impoundment will be unsuitable for general grazing. The final land-use will depend on the nature and extent of the remedial works. The options are considered in Section 14. They range from a permanent multi-layer capping, incorporating a moisture barrier a capillary break and a growth medium, with a push-down of the outer slopes, to the placement of a growth medium directly on the surface of the impoundment. The choice will depend on cost, on the requirements for dust prevention and on the measures required to protect the groundwater.

At Shallee South/East, the outer slopes of the tailings are already heavily vegetated, and there is a relatively small area of exposed tailings. Some local stabilisation will be beneficial depending on the final end use for the Shallee site as a heritage site.

9 GEOTECHNICS

9.1 Stability of Underground Workings

The main underground workings are the Mogul workings at Garryard, with lesser workings at Shallee South/East, at Magcobar adjacent to the Magcobar pit, and at Ballygown. Figure 9.1 shows the locations of the workings. The qualitative assessment made in this report section is based on an examination of the available mine plans, geological plans and geotechnical reports, a knowledge of the subsidence which has occurred, and discussions with representatives of Mogul. Mr. Phelim Lally of the Geological Survey of Ireland provided an assessment, which has been incorporated.

9.1.1 Ballygown area underground workings

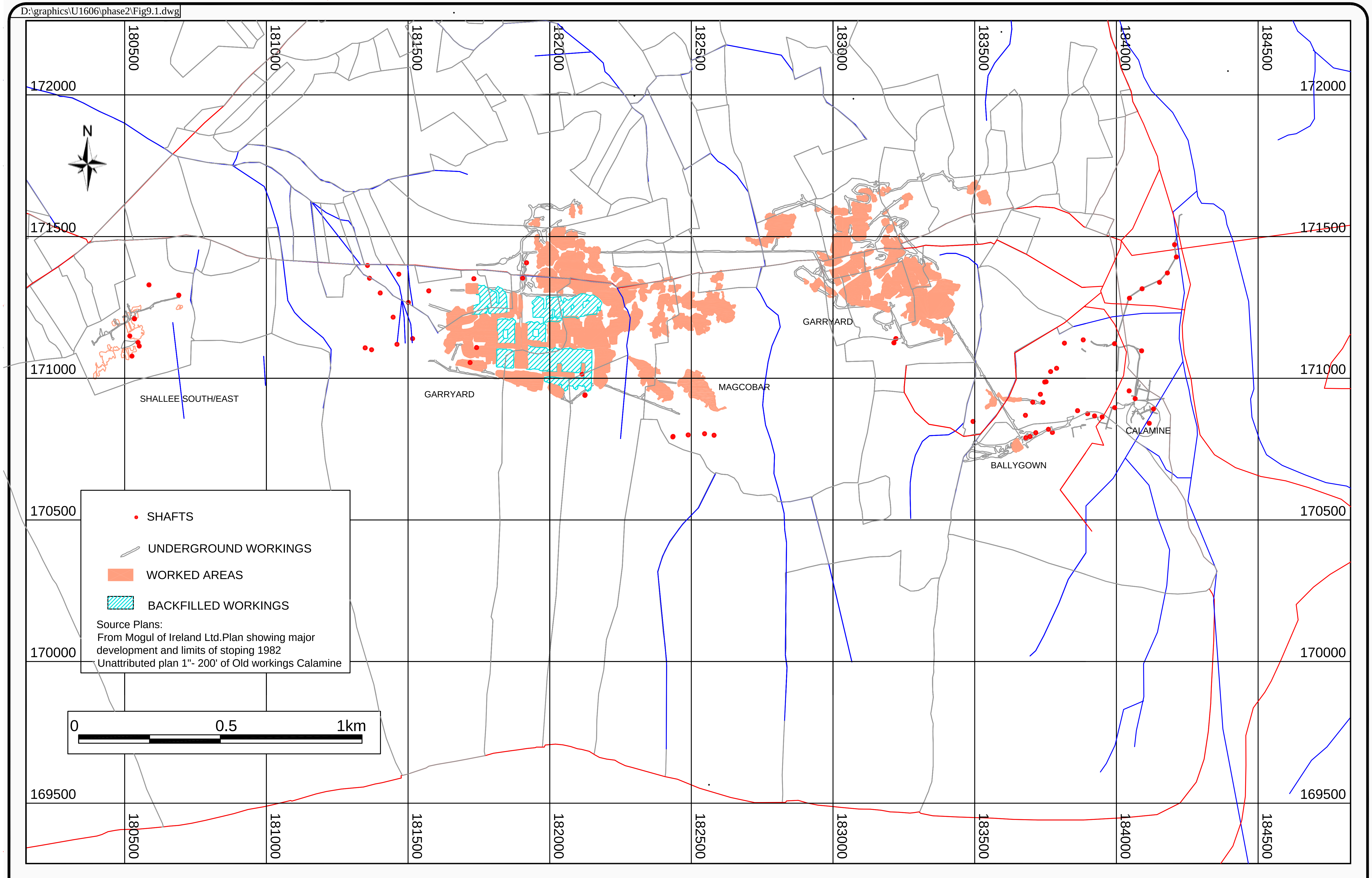
The workings in the Ballygown area consist of interconnected adits including a long drainage adit discharging into the Silvermines stream to the north of Silvermines Village (Figure 3.1). A further separate system at the Sulphur Mine is connected by a long adit to the Mogul Garryard workings. There are known to be approximately 20 shafts. A few are fenced, but most are no longer visible, and it is presumed that they are hidden by vegetation or backfilled.

It was not possible to enter the workings, and no reports are available on their nature and condition. There is little likelihood of large-scale subsidence over the workings due to the age, nature and depth of the workings, but future collapses of the adits may result in localised settlement. The workings mainly comprise development tunnels in the Calamine area and limited, multi-level workings at Sulphur Mine. There was no major extraction but presumably narrow vein stoping to pursue individual reefs and some exploration drives. If any subsidence was to occur, it would therefore have a very localised influence.

Collapse of workings usually occurs relatively shortly after mining and the older the workings the less likelihood of major collapse. It is not considered that action is required beyond the making safe of shafts and adit entrances. If construction were to be proposed over the undermined areas, an investigation would be necessary.

9.1.2 Mogul underground workings

The Mogul underground workings exploited a lead-zinc orebody to the north of the Silvermines Fault. The orebody is approximately 15m thick, thinning out to the north and lies between 25m and 100m below surface. The orebody dips gently towards the north, but adjacent to the Silvermines Fault which defines the southern limit of mineralisation, the orebody dips steeply to the north at an angle of approximately 60º. The immediate hangingwall of the orebody comprises strong, competent dolomites containing occasional thin bands of weak shale.



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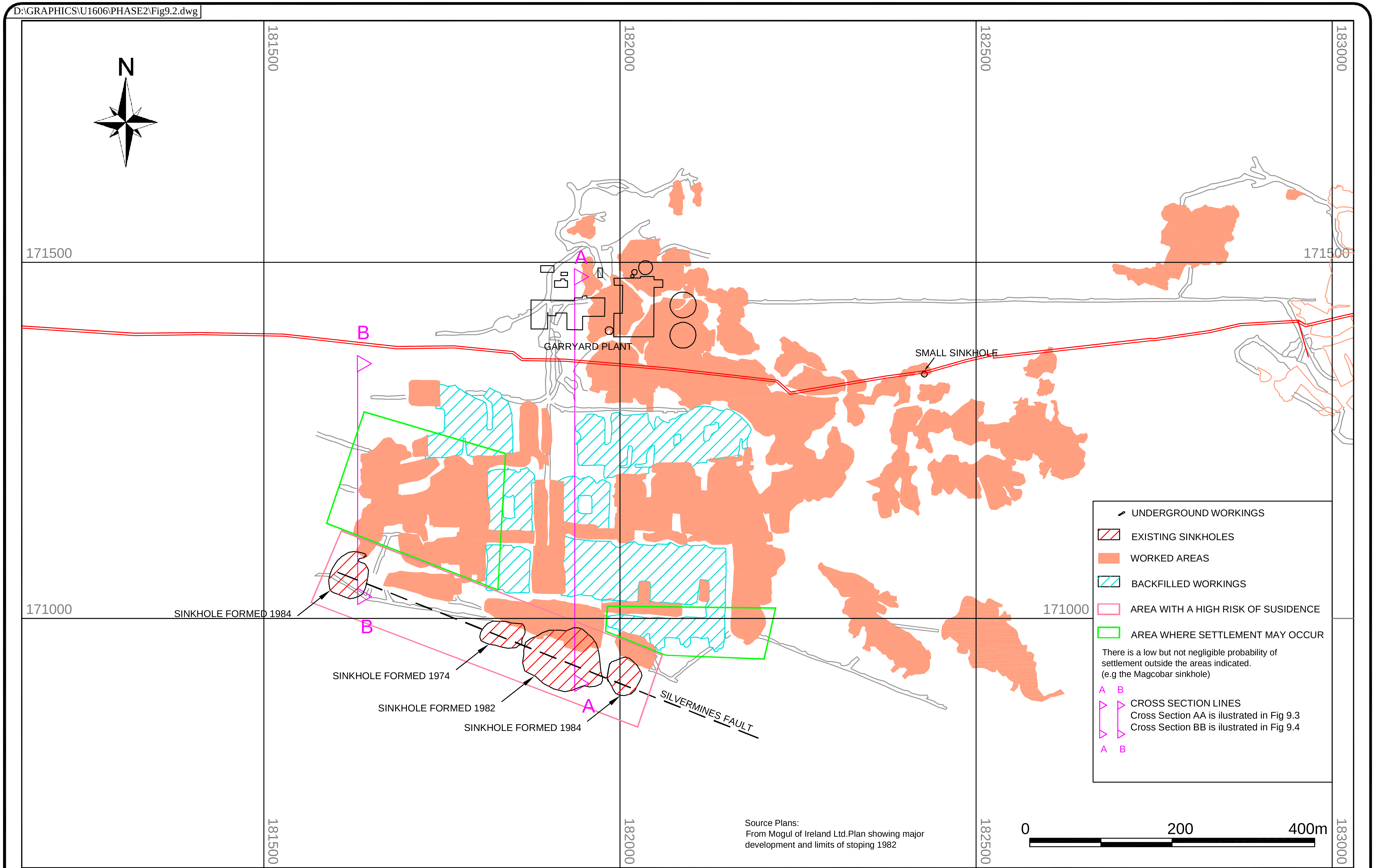
SRK Consulting Engineers and Scientists		UNDERGROUND WORKINGS	Fig 9.1

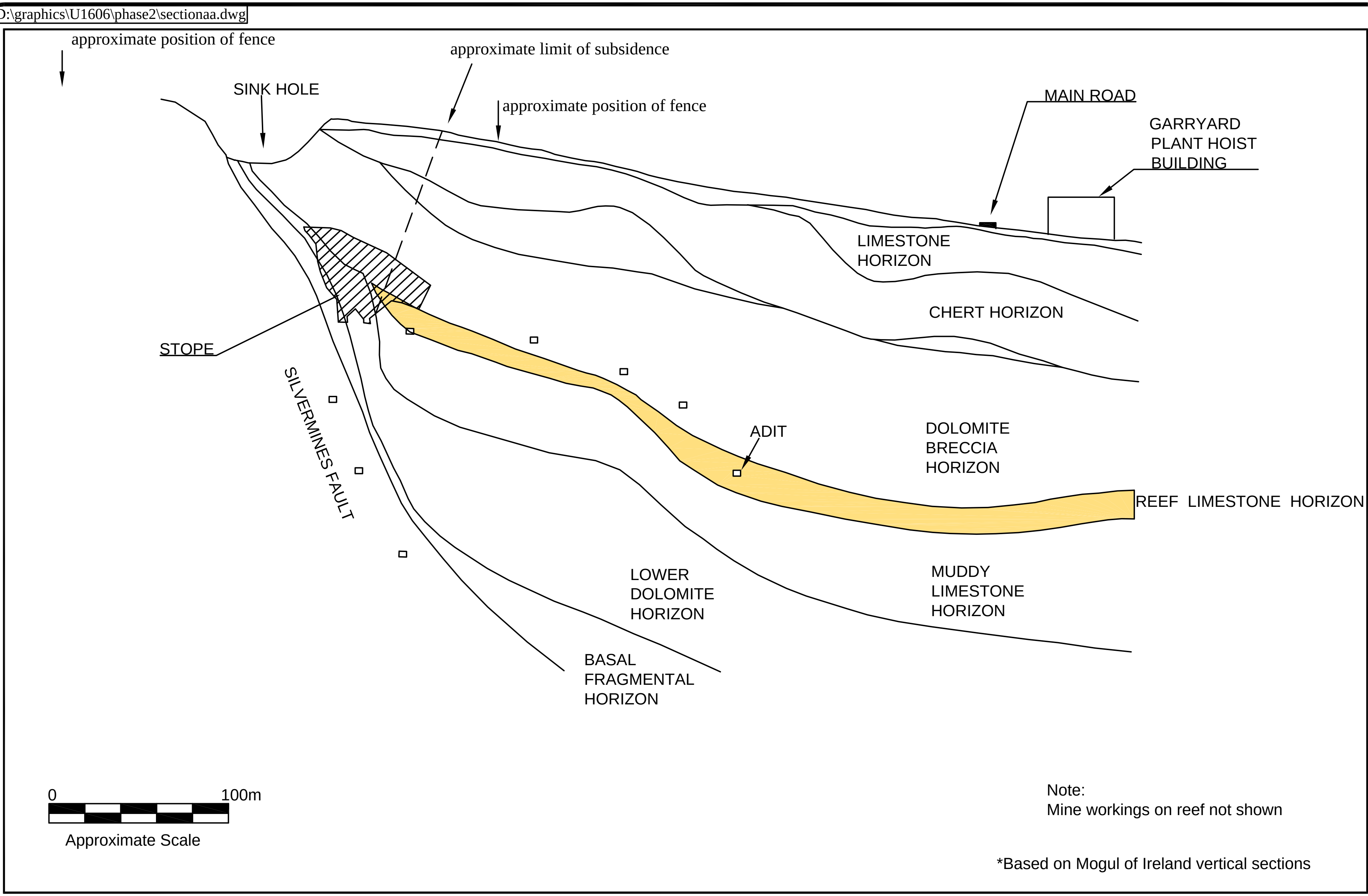
The mining method in the steeply dipping and flat, thick areas of the orebody is sub-level open stoping with dip and strike pillars being left in-situ. Average stope sizes are 30m (100 ft) along strike and 70m (230 ft) down dip. The dip and strike pillars are approximately 12 m (40 ft) thick. Primary extraction ratios are of the order of 60-65%. Cemented backfill has been used in some of the stopes to allow partial or full removal of pillars where secondary extraction ratios increase to 90%. The available mining plans show that between 40% and 50% of the stope voids in the G ore zone have been backfilled. The thinner orebody, at the northern limit of the mine below the plant area, has been extracted by room and pillar methods with a maximum extraction ratio of 90%. The stope, pillar sizes and extraction ratios were developed by Mogul, in conjunction with Golder Associates, to maximise ore recoveries whilst providing adequate stability of the mine elements. A number of reports are available on the design and monitoring of the underground workings.[20,24,30]

A surface subsidence feature developed in 1974 (Figure 9.2)[248], and the 1W6-S stope caved through to surface during April 1977. This stope mined a steep area of orebody adjacent to the Silvermines fault. It is believed that the large size of the stope, combined with the steeply dipping strata in the hangingwall and the poor ground conditions adjacent to the fault, caused collapse of the stope roof. The collapse propagated to surface resulting in the development of a 50 m long by 17m wide depression. A similar subsidence feature developed to the east in 1982[206], after mining of the adjacent 1E1-S stope had been completed. Failure of this stope resulted in the formation of a surface depression 75m long by 17m wide. The combined span of these stopes was in excess of 160 m. These subsidence features are still active. Figures 9.3 and 9.4 give schematic geological sections through the subsidence areas (see Figure 9.2 for section locations), showing the locations of the stopes. A number of stopes still remain open adjacent to the Silvermines Fault, albeit with spans somewhat smaller than the two stopes that had previously collapsed. It is probable that, with time, these stopes could also collapse, resulting in the development of surface subsidence. It is considered that the section of stoping along the Silvermines Fault between the existing sinkholes (Section 37300E to 38700E on the mine plans) has a high risk of the development of further subsidence. This area has already been fenced.

The previous collapses were probably aggravated by surface storage of water and future stream diversions will assist in limiting future collapse.



NOV 2001	PROJ. No: U1606	SILVERMINES	Scale 1:5000
SRK Consulting Engineers and Scientists		PLAN OF MOGUL EASTERN UNDERGROUND WORKINGS SHOWING AREAS OF SUBSIDENCE	Fig 9.2



NOVEMBER 2001	PROJ. No: U1606	SILVERMINES	N.T.S
SRK Consulting Engineers and Scientists		SCHEMATIC SECTION AA THROUGH SUBSIDENCE ZONE AND MOGUL WORKINGS (CROSS SECTION LINE ILLUSTRATED ON FIG 9.2)	Fig 9.3

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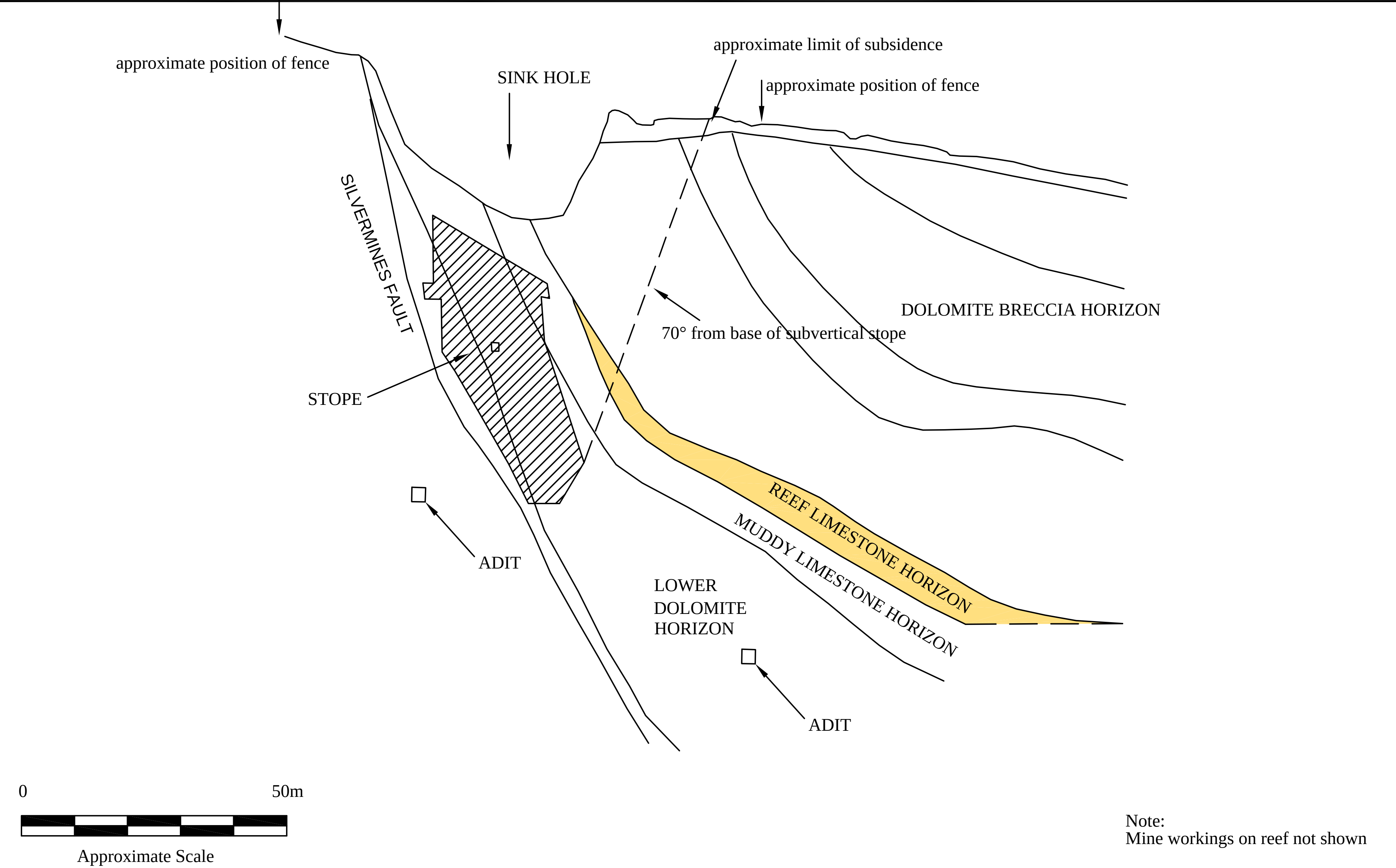


*Based on Mogul of Ireland vertical sections

NOV 2001	PROJ. No: U1606	SILVERMINES	Scale NTS
SRK Consulting Engineers and Scientists		SCHEMATIC SECTION BB THROUGH SUBSIDENCE ZONE AND MOGUL WORKINGS (CROSS SECTION LINE ILLUSTRATED ON FIG 9.2)	Fig 9.4

Historically, the stopes in the flat dipping areas of the orebody would appear to be stable. If subsidence were to develop over the backfilled areas, it is likely to manifest itself as a general lowering of the ground surface as a result of roof beam bending and consolidation of the backfill. Where the stopes remain open, north and west of the backfilled area, the pillars remaining should provide sufficient support to prevent large-scale collapse of the stope roofs. The room and pillar area at the north of the orebody was initially planned with a maximum extraction ratio of 75% because the mining area directly underlay the Mogul plant site. However, the actual extraction ratio exceeded 90%. Records show that levelling stations placed on structures around the plant site showed no signs of movement during the period of mining. There would have been detailed consideration of the risks of any subsidence below the plant site before increasing the abstraction. Furthermore, the height of abstraction and the depth, and the age of workings suggest that any failure of the roof has probably already occurred. Arching and bulking would tend to prevent any significant subsidence effects at surface.

Areas of possible settlement are over the stopes west of Mine Section 38000E on 2 and 3 Levels, where the pillar roof support is not large. The area above Stopes 1E4, 5 and 6 (backfilled) and 1E7 (not backfilled) may also be subject to movement because deep weathering has produced a mineralised mud and rubble zone in the upper strata. The areas where settlement may occur are indicated in Figure 9.2.

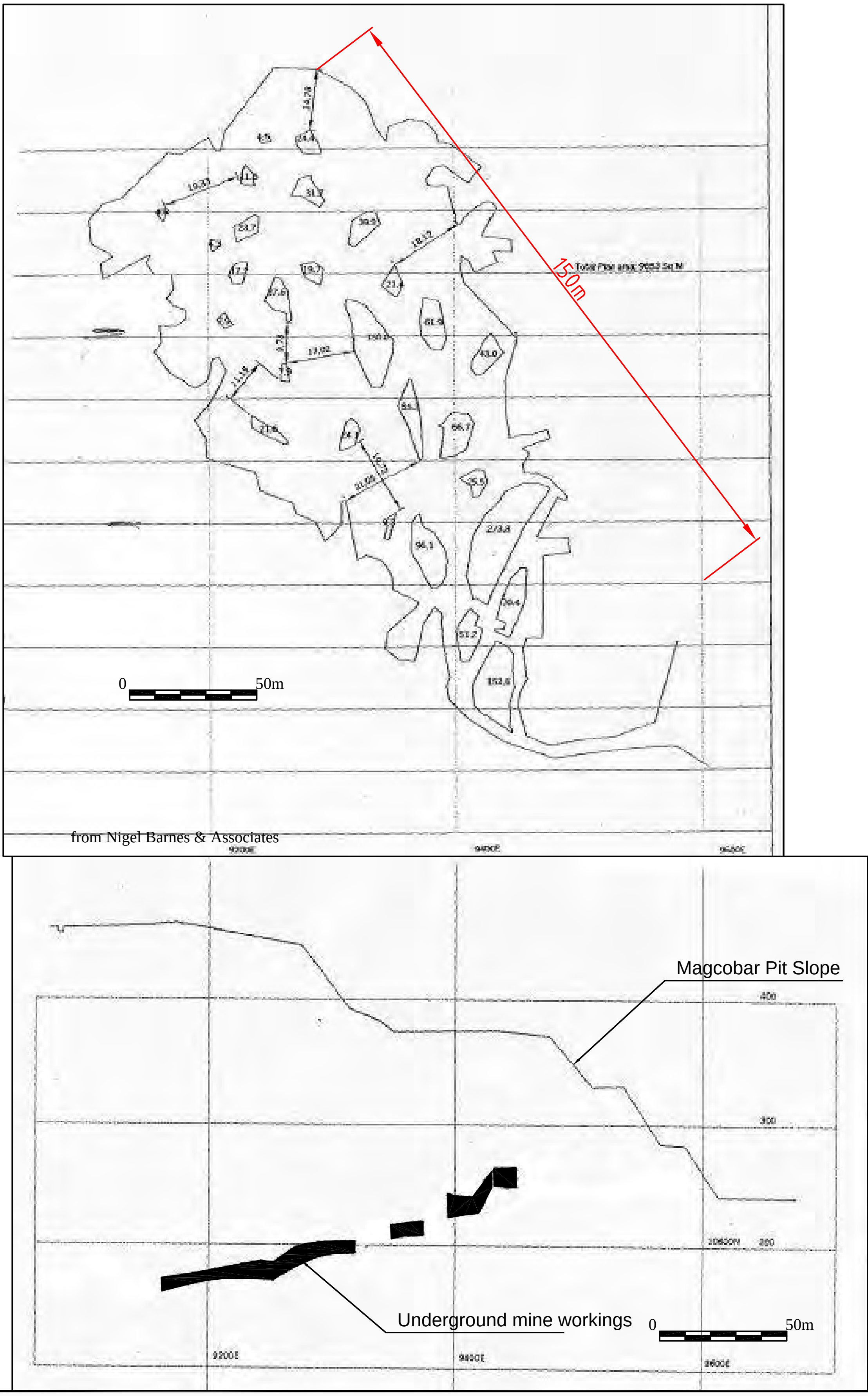
Apart from the subsidence zone adjacent to the fault the risk of large-scale subsidence (as opposed to the postulated settlement described above) occurring elsewhere is considered to be low, requiring no action. A small sinkhole has developed near the road (Figure 9.2). This was interpreted to be subsidence associated with a palaeokarst feature, probably due to dewatering of Mogul Mine. (The lowering of the water table in karst areas sometimes results in the collapse of soils into existing underground cavities.)

No other subsidence has been noted elsewhere at Garryard.

9.1.3 Magcobar underground workings

The Magcobar underground workings are an eastern extension to the Mogul workings. Little information was available for review, but Nigel Barnes and Associates had produced a plan and sections through the workings[257]. Figure 9.5 shows a plan of the workings and a typical section. The area of pillar support is small in relation to the area of extraction, and the stope width ranges from 15 to 26m. More than half the area of the workings is under the Magcobar pit slope, with the remainder beyond the crest. There has been no indication of mining subsidence.

Graphics\U1606\Phase2\Fig9.5.dwg



NOV 2001	PROJ. No: U1606	SILVERMINES	N.T.S
SRK Consulting Engineers and Scientists		Plan and Typical Section through the Magcobar Underground Workings	Fig 9.5

It is not possible, from the available information, to predict the risk of future subsidence over the workings. Although the pillar support is 15% of the total area overall and less than 10% over most of the workings, the total length and width of the workings are only 100 x 60m. It is concluded that there is a low risk of future subsidence over the workings and that no action is required.

9.1.4 Shallee South/East underground workings

The Shallee Mine exploited an Old Red Sandstone-hosted lead deposit, developed in the footwall of the Silvermines Fault (as opposed to the limestone-hosted Mogul deposit in the hanging-wall). The dominant structural feature is the bedding dipping at about 30^o to the north, and there are two sub-vertical joint sets. Mining at Shallee was first undertaken in two quarries, followed by underground mining from the base of each quarry, using a combination of room and pillar and open stope mining. Stopes are generally about 30m long, varying in width between 8 and 15m. The roof of each stope varies in height, from 5m, to more than 25m, because of the dip of the bedding. A raise mined at their southern extremities connects each stope to surface.

As part of the investigation for a proposed Irish National Mining Heritage Centre at Shallee Mine, a geotechnical review of the underground workings was carried out (SRK 1999[76]). It was concluded that the condition of the underground openings is generally good.

There have been a number of small rock falls. The roof of one stope appeared to be doming up through the overburden soil above the limestone. It was concluded that, in general, the underground openings should remain stable. Limited support was recommended for the area intended for visitor access, and continuing monitoring was proposed.

The results of the study indicate that significant underground collapse or surface subsidence is unlikely.

9.2 Stability of Pits and Other Surface Workings

The only significant opencast mine working, in terms of geotechnical stability, is the Magcobar barite pit. No dimensioned plans or sections of this pit were obtained, but the pit has a maximum depth of approximately 70m, and plan dimensions of 300m x 500m.

No information is available on the jointing and other rock mass properties. There have been minor slope failures on the upslope face, presumably during the mine operation, but there is no indication of any incipient large-scale failures.

At the end of pit development, mining continued underground, by room and pillar extraction from the base of the pit. These workings are beneath the pit slope. They are limited in extent, but the stopes are up to 26m wide, with limited pillar support.

On the crest of the upslope side of the pit there is a small waste dump.

In summary, the Magcobar pit slopes give no indication of incipient failure, but there is little information on the rock mass properties, part of the pit slope is undermined and there is a surcharge load of waste at the crest.

9.3 Stability of Waste Dumps and Tailings Impoundments

The significant waste dumps and tailings impoundments in terms of the potential for deep-seated instability are listed in Table 9.1.

Table 9.1: Significant Waste Dumps and Tailings Impoundments

DESCRIPTION	COMMENT
Old tailings North of Silvermines village	Vegetated old tailings
Magcobar waste dumps	Rockfill, free-draining
Shallee tailings impoundments	Fine sand, moderately free-draining
Gortmore TMF	Silt, saturated, with pool on upper surface, not free-draining

The waste dumps at Ballygown are not considered to be a stability risk.

9.3.1 Magcobar waste dumps

There are no available plans or sections of the Magcobar waste dumps, and the representation in Figure 3.2, Plan showing Magcobar pit, waste dumps and buildings, is based on observation and the air photographs. The material on the dumps has been deposited at its angle of repose, approximately 38^{o}, and not a large amount of vegetation has become established. The maximum slope height, on Dump B, is approximately 60m. The waste is considered to be relatively free-draining, and the surface water diversion structures constructed during the operational life of the mine are still effective in preventing most of the surface water from entering the dumps. At two places, the diverted streams pass under low sections of dumped waste, but there is no indication that this is affecting stability.

There is no knowledge of the nature of the soils on which the dumps are founded, but surface exposures of soil are granular and, if the dumps were founded on clayey soils, there would almost certainly have been deep-seated failures caused by slides on the clay. An undated investigation of the stability of the dumps included trial pits to 5m depth, and all the waste material proved to be a granular, cohesionless material.

At Dump A, material is being excavated from the toe for construction purposes elsewhere. This has two detrimental effects. First, it destroys the vegetation which has established on the outer slopes. Second, it results in steep outer slopes which will eventually ravel to a flatter slope angle.

An inspection of the dumps revealed no previous or incipient deep-seated failures, but several superficial failures were observed. These are ravelling failures extending about 1m below the outer surface of the slope, occurring during or after heavy rain, when a surface layer becomes completely saturated and slides. These failures are not dangerous and can probably be prevented by improvements in the control of surface water, to stop water from flowing over the crest of the dump or ponding on the upper surface.

The previous analyses of waste dump stability were carried out using different assumed water conditions, and the factor of safety against deep-seated failures was found to be adequate. It was concluded however that, if water levels within the slope rose to within 20m of the crest, a slip failure is probable. The authors noted that when mine pumping ceased, the general groundwater level would rise, and natural springs could reappear. They also warned of the danger of allowing water to pond behind the spoil heaps, but this appears unlikely due to the free drainage of the material and the existing drainage under the low sections of the dumps (Figure 7.6).

It is considered that, with maintenance of good surface water control, deep-seated failures of the dumps will not occur. The uncontrolled excavation at the toe of Dump A should cease, however, as the steep, excavated slope could fail after rain. Re-shaping of the excavated slope and controlled excavation could follow.

9.3.2 Shallee tailings impoundments

The Shallee tailings impoundments are in two areas to the north and south of the Silvermines road (Figure 3.4). The larger northern deposit has a maximum height estimated to be generally less than 3m, and no permanent water pool on the surface. (There is a small depression which collects rainfall from time to time.) Large parts of the surface and outer slopes are vegetated, there is no significant probability of a deep-seated failure of large-scale erosion, nor is a problem anticipated. The smaller southern deposit on the south side of the road has an outer slope adjacent to the road with a height of approximately 6m. Most of this slope and the upper surface is vegetated and, again, the present risk of a deep-seated failure or large-scale erosion is considered small. No action is required to protect the slopes against such failures.

9.3.3 Gortmore TMF

The Gortmore TMF covers an area of approximately 70 ha (Figure 3.5). It was used for the disposal of tailings from Mogul Mine until the closure of the mine in 1982. The tailings were deposited as a slurry on three ponds contained within outer embankments. On Pond 1, the tailings was initially deposited within clay starter embankments and, during those early stages, it is reported that sliding failures did occur. As a remedial action, waste rock was placed on the clay starter embankments, and on the surface of the tailings slope. In Ponds 2 and 3, clay starter embankments were not used.

The stability of the Gortmore TMF was investigated in 1977[32], while the impoundment was still in operation. An assumed maximum height of the outer slope of between 10m and 12m was used in the analyses, and factors of safety of 1.20 to 1.26 were obtained. (A factor of safety of less than 1.0 would indicate incipient failure.) The actual final slope height is estimated to be between 8m and 12m.

The results of the stability analyses carried out in 1977 were applicable to the impoundment at its final height, but it is necessary to consider any subsequent changes, which may have had a detrimental effect on stability. Since closure in 1982, the impoundment has been partially vegetated, and a small pool has been maintained on the upper surface. Some recent earthworks were carried out at the north corner, when an access ramp was built, but this ramp was later removed, and the slope profile at this position has been adequately restored. The existing decant ponds at the north-east edge of the impoundment are still functioning, and receiving run-off water from the pool on the upper surface of the impoundment. There have been some minor works relating to the decant structure on the upper surface, but these are not an influence on stability. The most important changes to the condition of the impoundment are likely to have been in the position of the phreatic surface within the impoundment, and in the degree of consolidation of the tailings. Since deposition ceased, it is likely that the phreatic surface has remained in the same position or has lowered. During the period since closure, the degree of consolidation of the tailings will have increased and excess pore water pressures, which are detrimental to stability, will have dissipated. Both these changes are advantageous, in that they enhance stability, implying that the Gortmore TMF is more stable now than during the period when the mine was still operating.

It is considered that the factor of safety against slope failure is likely to have increased since closure, and the risk of a deep-seated slope failure is low. No action to reduce the risk of a deep-seated slope failure is required. If any significant changes to the height or shape of the impoundment or to the water conditions are anticipated as part of the long-term management of the facility, it will be necessary to review the stability of the slopes.

9.4 Sources of Capping and Rehabilitation Materials

Imported spoil may be required for capping various waste deposits in the Silvermines area. No formal survey of sources of material was carried out as part of the present study, but the following readily available sources were noted.

- Natural soil was used for a cover over the Silvermines Primary School playing fields. This borrow is understood to have been obtained from a site approximately 15km to the east of Silvermines Village.
- The waste rock dumps at Magcobar are a potential source of granular limestone material for capping. The nearest operating quarries are Killough and Compien’s quarry, Lisduff, both about 50km by road.
- There are local sources of organic waste, including bone meal, meat waste and sewage sludge, available at low cost because their disposal is problematic. Their use would require specific risk assessments to be done.

9.5 Geotechnical Implications for Remediation

9.5.1 Ballygown

The adits and shafts at Ballygown are limited in extent, and will not be the cause of extensive surface subsidence. Local collapses and subsidence at adit entrances and shafts are possible, and it will be necessary to make these areas safe. There are no significant waste dumps or waste stability problems at Ballygown.

9.5.2 Mogul

The Mogul underground workings along the Silvermines Fault have collapsed, and there will be some limited extension of the collapsed areas. Stabilisation or backfilling will be costly, and the correct solution is to continue to prevent access to the subsidence areas by fencing and signs. Surface water should be diverted around the subsidence area, because water ingress to the soils over the workings can encourage subsidence.

9.5.3 Shallee South/East

The Shallee South/East underground workings are expected to remain stable, based on the results of a geotechnical evaluation carried out in 1999.

The Shallee tailings impoundment presents no stability problem, but measures are required to control surface run-off from the old plant area.

9.5.4 Magcobar

The Magcobar pit shows no signs of incipient slope failures, though there have been minor slips in the past, probably during mining. Some erosion ravelling in areas of weathered rock can be expected. No new measures are required.

The Magcobar dumps are of granular material. They have been subject to minor sloughing failures, but large deep-seated failures are not anticipated. The key to maintaining the stability of these dumps is the continued maintenance of the surface drainage system. The uncontrolled excavation from the toe of Dump A should cease and the slope should be flattened and vegetated.

The Magcobar underground workings are limited in extent and have not subsided. There is insufficient data to predict the long-term stability of these workings. It would not be difficult to extend the fencing around the Magcobar pit to include the undermined area, but this is not considered necessary.

9.5.5 Gortmore TMF

Based on an examination of stability analyses carried out by others, and on observations made during an inspection, it is considered that the Gortmore tailings impoundment is stable, but slope stability must be considered when contemplating changes to the outer slopes or the upper surface drainage. The proposed new works will not affect stability, but stability should be considered during the detailed design.

10 HAZARD IDENTIFICATION

A general discussion of potential hazards in the Silvermines study area has been included in the Phase I report. In the present section, the most significant hazards will be identified, based on the results of the previous work and the results of the site investigation presented in earlier sections.

10.1 Metals and Human Health

The following metals have been measured as exceeding the Irish Standards at certain points in the water courses of the study area. They are also present in sediments and surface deposits.

Arsenic (As)
Aluminium (Al)
Barium (Ba)
Cadmium (Cd)
Copper (Cu)
Iron (Fe)
Lead (Pb)
Manganese (Mn)
Mercury (Hg)
Nickel (Ni)
Zinc (Zn)

High sulphate levels have also been recorded.

The hazard from lead has been dealt with in detail in the IAG report of 2000, but the other metals listed above are also a potential hazard for human health. Appendix H contains a description of the occupational exposure limits, the manner in which absorption can occur, and the effects of exposure.

In the development of the proposed remedial options, the health risks have been a major consideration. The remedial measures proposed are considered to be in accordance with the recommendations of the IAG report and, although these recommendations are related to the health risk of lead, they are also appropriate for the other metal contaminants. Like lead, the elevated levels of other metals are generally present as particulate material, and the treatments required is similar – removal of sources, wetlands, etc.

10.2 Stream pollution

Figure 10.1 shows a summary of the concentration of selected metals (Pb, Zn and Ba) at the mouths of each of the sub catchments. The chemical data used is:

- total metal values;
- maximum values where more than one data set is available;
- 95th percentile value from the long term EPA monitoring data sets; or
- half the detection limit, where metals have not been detected.

At each point, the calculated average flow is also quoted. The data is the same as that used at the end of Section 7 for the calculation of metal loadings.

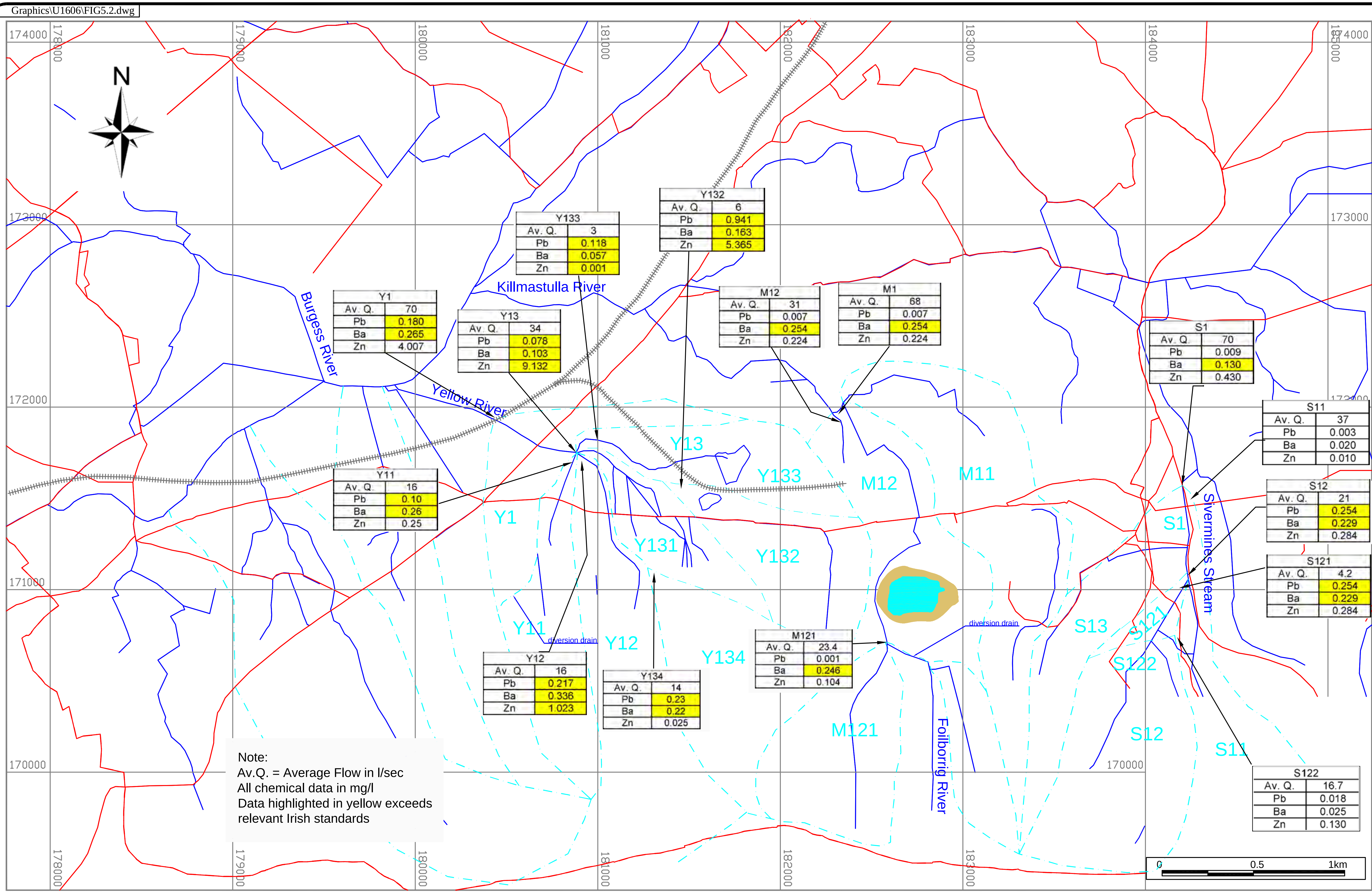
The Silvermines River carries Pb, Ba and Mn in concentrations exceeding the Irish Standards. The majority of this material is from the waste at Ballygown on the banks of the river. However, the contribution of metal load is small, relative to the total flow in the river and metal concentrations downstream of Silvermines Village are within limits.

The Yellow River catchment carries the highest metal loads within the study area containing elevated concentrations of Cu, Pb, Ba, Cd, Zn, Fe, Mn, As and Al. The Yellow River is the most polluted watercourse in the study area. The main sources of elevated metals have been identified as the Old Stockpile area at Garryard, and the Tailings Lagoon at Garryard.

Between the catchments of the Yellow River and the Silvermines River is the Foilborrig River, which has its source upslope of the Magcobar pit. Flowing downstream towards the Kilmastulla, it passes between the Magcobar waste dumps, is diverted in a concrete canal around the pit, and skirts beyond the east of the Garryard plant site before entering the Kilmastulla River. As a result of the barytes mineralisation within the Magcobar area, the river contains elevated levels of Ba, including upstream sources. The concentration and load of Ba transported is higher than that transported in the Silvermines river, but slightly lower than that in the Yellow River. Other metals found at elevated concentrations are Mn and Cd.

The principal sources of surface water metal contamination are the:

- waste rock dumps at Ballygown;
- old Stockpile area at Garryard;
- tailings lagoon at Garryard;
- the mineralisation at Magcobar; and
- parts of the Shallee tailings and Shallee Drum Dump.



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Engineers and Scientists

SURFACE WATER METAL CONCENTRATION

FIG 10.1

Within each catchment, metal mobility is governed by dispersion of particulate material greater than 0.45 μm.

The greatest risk posed by the elevated metal levels in surface water are ecological, livestock and human toxicity. In order to limit the risk of such exposure, remedial measures aimed at breaking the source-pathway-receptor pathways are required. As the source of elevated metals within surface water are elevated metals in sediment and waste rock, the remedial measures selected will also need to consider the separate hazards associated with the elevated metals in the sediment. This integrated approach will ensure that the most cost effective risk management remedial options are selected.

10.3 Groundwater Quality

Groundwater in karstic environments in North Tipperary will typically have an Electrical Conductivity (EC) of approximately 700 μS/cm. In the Silvermines area, EC values of around 500 μS/cm appear typical for the limestones. Close to the Gortmore TMF, EC increases to approximately 1700 μS/cm. The groundwater investigation for the Magcobar EIA showed elevated EC around the pit.

Regional surveys of domestic water by the Health Board have shown three domestic supplies with slightly elevated metals in the Shallee area, but the samples of water were taken from taps in the houses and the metal source cannot be specifically defined.

In summary, within close proximity to the areas impacted by mining, groundwater does contain slightly elevated metals, but the metal contents and TDS are within acceptable limits. Ongoing monitoring of groundwater should be carried out in particular near Garryard and Gortmore TMF.

10.4 Land Contamination

The main areas of contaminated land comprise areas of mine waste and of former processing activities, areas where flooding has deposited metal-bearing sediment, areas where dredged sediment has been placed, and areas affected by dust blow.

The identified areas of contaminated land are:

- the waste dumps at Ballygown;
- small deposits of sulphides on the Magcobar waste dumps;
- the Old Stockpile at Garryard;
- the tailings lagoon at Garryard;
- Drum Dump at Shallee;
- Shallee South/East tailings dam; and

- Gortmore TMF.

The Garryard Tailings Lagoon and the Garryard Old Stockpile are the most critical to the rivers, in terms of pollutant load.

10.5 Stream Sediments

Stream sediment sampling has identified very high levels of lead and other metals in all the stream channels draining from the mining areas, particularly in the Yellow River catchment down to the Kilmastulla River, and in the Kilmastulla River itself. Where dredging has taken place in the poorly-drained areas to the north of the mining area, there are stream sediment deposits in the fields next to the streams. Although the sediments were spread and have grassed over, they will contain elevated metals.

10.6 Dust

Dust has been produced from the Gortmore TMF and, to a lesser extent, from the Shallee South/East tailings dams. The worst occurrences were prior to 1990, and dust has been successfully controlled since that time by the establishment and maintenance of surface vegetation. Dust is a hazard which will be dealt with as part of the remedial re-vegetation works to be included in the conceptual remedial measures.

10.7 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.

The existing and potential ecological hazards will be assessed as part of the Environmental Impact Statement (EIS), and the detailed design of the remedial works will be carried out in accordance with the recommendations of the EIS.

10.8 Shafts, Mine Workings, Cavities and Surface Subsidence

The shafts, workings, cavities and surface subsidence have been plotted on the drawings of Section 3. The information was obtained from old maps and from observation. The approximate distribution of shafts is as follows:

Table 10.1: Distribution of Old Shafts

Mining Area	Number of Shafts
Ballygown/Sulphur mine	33
Magcobar	None identified, but submerged adit and former shafts in pit and adit in old copper mine
Garryard/Gorteenadiha	19 (including 6 Mogul shafts)
Shallee South/East	7
Shallee West	None

The shafts at Ballygown/Sulphur Mine are generally not visible, and collapsed, but several are still open and fenced. At Garryard, the main shaft at the plant is still open, but capped, and there are a number of vent shafts. There is one flooded shaft at Gorteenadiha. Shafts used by Mogul have been capped but most other shafts are no longer identifiable in the field. At Shallee South/East, one large vent shaft is open, and others are collapsed.

Open surface workings and accessible underground workings are the small pit at Ballygown and the Sulphur Mine, neither of which represent significant hazards, the Magcobar Pit, the Gorteenadiha surface workings, the Shallee South/East surface workings and adits, and the Shallee West surface workings.

Subsidence is limited to the severely affected zone along the Silvermines Fault, and the small sinkhole at Magcobar.

The significant hazards are considered to be the open shafts, the Magcobar pit, the Shallee workings and the unmapped Gorteenadiha workings.

Where pits and shafts are open and flooded, they present an additional hazard in terms of potential drowning.

10.9 Surface Structures

The existing buildings and other surface structures require to be made safe, but are not considered to be major hazards.

10.10 Waste Dump Slope Stability

The review of waste dump stability has indicated that there is no significant hazard at Magcobar, Shallee or Gortmore TMF, apart from the undercut Dump A at Magcobar.

10.11 Summary of Significant Hazards

The key hazards are listed in Table 10.2 below. There are numerous other items of concern, which are discussed in Section 14, but the list presents those hazards which require priority treatment or further investigation.

Table 10.2: Key Hazards

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

11 DISPOSAL OF WASTE MATERIALS

11.1 Sources of Waste Materials

The remedial works will involve the removal and disposal of quantities of toxic and other waste from various sites. Preliminary estimates (without measurement) of the amounts of contaminated soils involved with elevated metal contents at each site are:

- Ballygown – about 100m^3 of process work from vicinity of Silvermines Stream;
- Magcobar – about 200m^3 of sulphide waste from dump area (consolidate on site);
- Garryard – about 14,000m^3 of ore and process waste from Old Stockpile;
- Garryard – about 500m^3 of metal, pipes and other wastes from Old Stockpile;
- Garryard – about 22,000m^3 of process waste from Tailings Lagoon;
- Shallee South/East – about 4,000m^3 of process waste, metal drums, cables, etc;
- Dredging of stream sediments, initial and annual or biennial quantities quantities unknown but estimated at 2,000 m^3 for initial dredging.

The actual quantities can only be determined after detailed survey and the numbers are only given as an indication of the order of magnitude. These materials broadly comprise contaminated soils and rocks, and are suitable for co-disposal, but the waste materials at Shallee include large quantities of metal drums, cables and other mine debris which would require segregation of the process waste and ore and separate disposal of the metal and other waste on a licensed site, such as that at Shannon.

Other wastes for disposal include:

- Ballygown – Concrete and steel from demolition of Waeltz Plant Buildings;
- Ballygown – Asbestos roof sheeting from Waeltz plant Buildings; and
- Magcobar – Steel, bricks and sheeting from Magcobar crusher and buildings;

Other earthworks will involve the movement of inert materials, which will be used on site as fill material.

11.2 Disposal Method for Contaminated Soils and Rock

It would normally be necessary to provide a complete encapsulation in clay or a synthetic liner, or a multi-layer system, to ensure that water and air cannot enter the waste, and contaminated water cannot seep from it. These measures are required to ensure that there is no contamination of surface or groundwater. There are circumstances in which the full encapsulation measures may be relaxed. When mine waste is placed beneath a water cover, for example, oxidation is retarded, and it may be possible to show that there will be no contaminant migration. Similarly, when mine waste is placed in an area already containing material with similar properties, the new material may not increase the existing pollution potential and, if other measures are instituted at the same time to reduce seepage and run-off from the area, conditions may actually be improved. There are sites corresponding to both these conditions in the study area.

11.3 Potential Disposal Sites

In 1996, the Irish Government passed the Waste Management Act, which demanded new waste management plans from Councils. The aim was to ensure that Ireland meets its obligations under the current Landfill Directive. Some of the mine waste may be defined as toxic due to its potential to generate Acid Rock Drainage. The disposal of toxic waste will be governed by planning limitations and the regulations of the EPA and the Tipperary North County Council. The potential disposal options are as follows:

- **Encapsulation in its present location**
  This is an unattractive option, because it involves the additional cost of the establishment of several disposal facilities, and the potential loss of land in several different places.

- **Transport to a location outside the Silvermines area**
  This option appears attractive, but the cost of transportation and the charges levelled by the owner will be high. The closest site for disposal of contaminated soil is the Atlas Oils site at Portlaoise. The drums and metal waste would go to other designated sites.

- **Disposal in the Magcobar pit**
  Disposal in the Magcobar pit would be permissible if the analyses indicate that, at the base of the pit, under a considerable water cover, the waste will remain inert, and will not result in contamination of groundwater. This would also depend on no alternative use of the pit.

- **Disposal on the Gortmore TMF**
  The Gortmore TMF contains tailings waste with elevated metal contents. With an adequate design confirmed by seepage analyses, the facility would be a suitable disposal site from several viewpoints. It is not close to dwellings, there is a good access road, there is a very large upper surface area, and there will be no loss of farmland. It would be possible to place the waste to improve the geometry of the Gortmore TMF for drainage and final rehabilitation.

- **Encapsulation on farmland site within study area**
  It would be possible to encapsulate the waste on a suitable piece of level ground, which is not subject to flooding. The disadvantage of this solution is that it would require the purchase and loss of pasture land.

11.4 Preferred Option

The preferred option for disposal of waste depends on the factors mentioned above, but the Gortmore TMF will provide the best solution for disposal of ore and process waste from both a cost and an environmental viewpoint. There is a strong advantage in the establishment of a local disposal site (Gortmore TMF) for the annual or biennial disposal of dredged sediment. An alternative site will be required for the other wastes as defined below, which includes metal, drums, etc. The preferred disposal methods are shown in Table 11.1.

Table 11.1: Disposal of waste materials

Location	Material	Qty*	Potential Disposal
Ballygown mine waste from vicinity of Silvermines Stream	Process klinker	100m^3	Remove to disposal area established on Gortmore TMF and cover
Ballygown concrete and steel from demolition of Waeltz Plant Buildings	Building debris		Non-toxic, to Ballygown Opencast, and possibly Magcobar
Ballygown roof sheeting from Waeltz plant Buildings	Asbestos		Designated site in Belgium
Magcobar sulphide waste from dump area	Weathered rock	200m^3	Consolidate and cover at Magcobar
Magcobar demolition materials from crusher and buildings	Steel, brick, sheeting		Non-toxic, to scrap off-site
Garryard Old Stockpile	Ore and process waste Processed and **other wastes	14,000m^3 500m^3	Remove to disposal area established on Gortmore TMF and cover To designated site
Garryard Tailings Lagoon	Fine process discharges	22,000m^3	Remove to disposal area established on Gortmore TMF and cover
Shallee Drum Dump	Ore and Process waste ** other wastes	4,000 m^3	Remove to disposal area established on Gortmore TMF and cover Remove to designated site
Annual dredgings from streams	Sediment with elevated metals and organic debris	Initial 2,000m^3 Annual 200m^3	Remove to disposal area established on Gortmore TMF

* Estimated quantity to be moved. Actual quantities to be ascertained.

** Other waste includes scrap metal, drums, piping, cables etc which will require segregation and disposal to a suitable designated site.

11.5 Permitting

The excavation, the transportation and the disposal of toxic waste require the issue of permits for each activity, in accordance with the planning controls and regulations of the TNCC and the EPA (see Section 13.4). The encapsulation of toxic waste in-situ, without the excavation or movement of the waste, would not require such permits.

If toxic waste is to be removed from Garryard, Shallee and Ballygown to be deposited in such a way as to minimise the potential for contamination of surface water, groundwater and atmosphere, it will be necessary to submit applications for permits and licences. The applications will include the design for the entire process, from excavation to final deposition. Prior to the submission of the applications, it will be necessary to hold a meeting with TNCC and the EPA to determine the precise procedure and the time required for reviewing the application.

12 SURFACE WATER MANAGEMENT AND STREAM SEDIMENT

The study area is drained by a network of streams field drains and rivers feeding the Kilmastulla River. Many of these water courses pass through mining areas, but others drain the flat farming area to the north of the Silvermines Mountain.

12.1 Stream Management

The existing streams and man-made channels are coping with all but major storm events, but the protection of the farmland near the Yellow River and Kilmastulla river depends on periodic dredging of the rivers and streams.

The maintenance procedures will include periodic dredging of stream sediments and disposal of these sediments on a waste disposal site, as discussed in Section 11.

12.2 Stream Sediment Control

The water courses contain varying amounts of sediments washed from upstream. Much of this sediment is from the disturbed mining areas, and the remedial works to be carried out as part of the management plan for the area will remove the main sources of these sediments. There will remain the existing streambed sediments and future lesser quantities of sediment washed from upstream.

In previous years, the build-up of sediments in the rivers through the pastureland to the north of Silvermines Mountain has been removed by annual dredging of the rivers, streams and field drains. This work has not been carried out in 2001, in anticipation of the recommendations for the management plan.

If dredging is not recommenced, there will be seasonal flooding of the pasturelands, and their agricultural value will be severely reduced. The difficulty is that some of the sediments contain high levels of lead and other metals. In Section 11, the options for disposal of waste materials resulting from the remedial works were discussed, and it was proposed that a single disposal site be established for contaminated soil on the Gortmore TMF.

It is recommended that dredging be recommenced when the disposal site becomes available, subject to clearance concerning foot and mouth restrictions. It is anticipated that, when the main sources of sediment have been removed, the sediment load will be reduced, and it may not be necessary to dredge every year. It is difficult to estimate the quantities of sediment requiring removal to a designated site. For costing purposes it is assumed that 2,000m^3 of material will require removal followed by an annual average of 200m^3.

It can be assumed that sediment removed from the streams draining from the mining area to the Yellow River, down to the confluence with the Kilmastulla River, should be considered as contaminated.

12.3 Existing Sediment Deposits

The sediments from the annual dredging of rivers and streams have been deposited on the adjacent fields beside the water courses. Although it is intended that, in future, dredged sediment will be placed at Gortmore TMF, this existing sediment may represent a hazard where there is extended grazing in the same area, and where the sediment contains metals. The recommendation of the IAG report that this problem be dealt with by good farm management practices is endorsed. These practices will include fencing, and control of access for grazing, by means of local electric fencing as required. Removal of contaminated soils has been considered but this is likely to cause more environmental damage than leaving it in-situ.

13 ACCEPTANCE CRITERIA FOR REMEDIAL OPTIONS

13.1 Introduction

The acceptance criteria for the remedial options define the standards and requirements by which the success of a particular solution is judged. The criteria range from fixed quantitative technical limits for measurable parameters, such as the quality of water discharged to a natural stream, to general criteria on the end-use of a particular area.

The application of fixed concentration limits as acceptance criteria for discharges to the water, the soils and the atmosphere are not appropriate in every case. They may be applicable to a new mining development but, on a site such as Silvermines, where mining has occurred over hundreds of years, and where there are also instances of elevated metal levels in waters unaffected by mining (i.e. upstream of mining such as sample CAL 15 at Silvermines showing elevated Cu and Pb and MAG1 at Magcobar with elevated Cu), an attempt to achieve an arbitrary standard may be impractical. It is for such situations that the concept of BATNEEC (best available technology not entailing excessive cost) has been developed and applied internationally. It is proposed that this approach will be applied to the Silvermines area.

The acceptance criteria have been defined for each site individually. The following sub-sections summarise the key issues considered in developing those definitions.

13.2 International Industry Guidelines and Practice

The majority of guidelines for closure have been developed in the USA, although others are being developed in Europe. A frequently quoted reference is the Ontario guidelines (Rehabilitation of Mines – Guidelines for Proponents, Ontario Ministry of Northern development and Mines, 1995). A report on Guidelines for Closure of Mines was prepared by SRK on behalf of MIRO (Mineral Industries Research Organisation) in 1999. This report draws on North American experience, but is more applicable to European conditions.

13.3 Irish Standards

The EPA was established in 1992 and has published guidelines for aspects of mining activities which potentially impact on the environment (Integrated Pollution Control Licensing – BATNEEC Guidance Note for the Extraction of Minerals, Environmental Protection Agency, 1997). These guidelines are for existing or proposed operations.

The ideal for abandoned mines would be to achieve the guideline targets and methods, as far as possible. In the BATNEEC Guidance Note, reference is given to European Communities regulations which will be used as the target for compliance and modified where prudent and acceptable. (See Section 13.10 and Table 13.2).

The BATNEEC Guidance Note indicates that for an abandoned mining facility such as exist at Silvermines regard should be had to:

- the current state of technical knowledge;
- the nature, extent and effect of existing emissions;
- the requirements of environmental protection; and
- the application of measures for these purposes, which do not entail excessive costs, having regard to the risk of significant environmental pollution which, in the opinion of the Agency, exists.

The BATNEEC Guidance Note includes emission limit values, which are intended for application to *new* activities. In the case of *existing* activities or the effects of previous activities, the aim will be to progress towards attainment of similar emission limit values. The specific emission limit values and associated time frames will be identified on a site-specific basis. Additional and more stringent measures may be specified where considered necessary for environmental protection.

For specific aspects of the rehabilitation planning, the following legislation or guidelines have been applied:

13.3.1 Safety in Abandoned Mines

Irish legislation pertinent to disused mine workings includes the *Mines and Minerals Act 1931* - Section 52 Fencing of Abandoned Mines and the *Mines and Quarries Act 1965* – Section 106, Part VII Fencing of Abandoned and Disused Mines. Relevantly, these statutes provide for:

"… the top or entrance of every shaft or outlet used in connection with such workings to be kept surrounded by a structure of a permanent character sufficient to prevent accidents, and may enter on any land for the purpose of so doing" (Section 52); and

"It shall be the duty of the owner of every abandoned mine ………… to secure that the surface entrance to every shaft or outlet thereof is provided with an efficient enclosure, barrier, plug or other device so designed and constructed as to prevent such surface entrance from being dangerous to any person" (Section 106).

13.3.2 Safety of Mine Waste Dumps

The UK *Quarries Regulations 1999* Approved Code of Practice Appendix 3 provides guidance on appraising whether a tip *"would pose a significant danger if they failed.*"

The hazard is considered significant if such a failure would directly or indirectly be:

"(a) liable to endanger premises, roadways or other places where people are likely to be found off-site; or
(b) likely to kill or seriously injure anyone."

13.3.3 Landform Aesthetics

In relation to landform aesthetics, there appear to be no specific Irish guidelines or standards associated with mining. In a consultation paper on the *Minerals Planning Guidance Note 11: Controlling & Mitigating the Environmental Effects of Minerals Extraction in England*, the British Department of the Environment, Transport and Regions, in relation to visual intrusion/landscape effects, states:

"The effects of a mineral working can be to:

- *destroy some of the existing landscape, e.g. a hill, or distant view, or skyline; this may be addressed as part of a restoration plan;*
- *introduce a feature into landscape which may be alien to it and create a visual intrusion, e.g. a quarry face, an overburden mound, machinery, or screening fences and hedges;*
- *screen from view some of the landscape that is otherwise unaffected, e.g. by an overburden mound or plant/equipment.*

13.3.4 Asbestos

Relevant to the Waeltz Plant, the *European Communities (Asbestos Waste) Regulations 1994* state that:

"A person who carries on an activity, which gives rise to the production of asbestos waste shall take the measures necessary to ensure that the asbestos waste arisings are, as far as reasonably practicable, reduced at source or prevented."

13.3.5 Groundwater Standards

Discussions with the Irish EPA indicate that there are currently no Irish groundwater standards. The EPA are however, currently working on producing a set of standards for groundwater. In the interim, in areas prior to any anthropogenic influences, the EPA advise that reference is made to drinking water standards, SI No 81 of 1988, which will be revoked by SI No 439 of 2000 but not until 1st January 2004. These standards are presented in Table 13.6. For example, standards in drinking water for Pb are 0.05 mg/l, Zn 1 mg/l, Cd 0.005 mg/l and Fe 0.2 mg/l. However, the implications of the background levels of metals (*in situ* mineralogy) and the effects of mining need to be considered.

13.3.6 Sediments and Soils

There are no regulations in Ireland for sediment and soils. The EPA use the “New Dutch List” from the Dutch Ministry of Housing, Spatial Planning and the Environment. This is discussed in more detail in Section 13.10.4.

13.4 Waste Disposal and Permitting Requirements

Disposal and recovery of waste falls under Part V of the Waste Management Act, 1996, and the EPA are responsible for the waste licensing under the Waste Management (Licensing) Regulations, S.I. No 133 1997 and the Amendment Regulations S.I. No 162 of 1998.

Certain wastes may have to be classified as hazardous due to their potential to generate Acid Mine Drainage without in-situ neutralisation.

Ideally, certain target areas of waste should be consolidated to one formal disposal site in the mining area, and local movement of waste on individual sites to enhance remediation should be permitted.

The key issues will be:

- Collection of waste;
- Identification and separation of different wastes;
- Transport;
- Disposal;
- Monitoring;
- Long term maintenance and financial bonding; and
- Closure.

It will be necessary to have discussions with the EPA and Tipperary North County Council (TNCC) to evaluate the options prior to carrying out Environmental Impact Assessments (EIA), finalising conceptual designs and formalising the required planning application.

This process will have an impact on scheduling of the overall remediation project and these implications will have to be considered.

Another option is to cap the materials in-situ, which will overcome the problems of waste disposal licensing, but will not remove the environmental risk and is not a preferred option.

13.5 Public Acceptance

Public acceptance is an important consideration in developing closure criteria.

The initial consultation meetings have provided guidance on the perceptions and requirements of the local community, the regional and national agencies, and other interested groups.

It is important to recognise that individuals and groups will have different opinions on what is acceptable or not, depending on their own desires and requirements. These may often be in conflict with other groups or individuals. It will not be possible to satisfy all demands.

13.6 Health and Safety

A key issue is lead in water supplies, or potentially taken up by direct contact or in food. This has been extensively addressed in the IAG report, but other issues are dust, other heavy metals and the safety of shafts and workings.

Elevated levels of lead, copper, barium, cadmium, zinc, iron, manganese, mercury, arsenic and aluminium have been measured in water, soils and sediments. The specific recommendations of the IAG report will be implemented in the remedial design, and measures will be applied as appropriate for other contaminants, in accordance with Irish and International guidelines. In general, the measures proposed in the IAG report for lead will be similar to those required for other metals. The only difference would be if there are sites or streams which are not contaminated by lead, but which are contaminated by other metals. The BATNEEC principle will be applied, to minimise the risk to human health from the ingestion of contaminants.

13.7 Land Use

Land use within the Silvermines area is principally residential and farming, with some minor commercial activity.

Portions of land affected by mining activity have been purchased by private owners. These areas include the Gortmore TMF, the Garryard plant site, the Garryard Tailings Lagoon and Settlement Ponds and the Old Stockpile 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.

There are other areas not directly used for mining and processing activities, but which have issues affecting the options for land-use. One example is the fields on which dredged material from the rivers and streams, with elevated levels of lead, has been deposited.

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.

Some areas of land have no real value for restoration to any active use and expensive remediation cannot be justified. The term derelict land has been used to describe the final land use. It should be noted that the term ‘derelict’ used in this report means nothing other than land which has been affected by mining and for which the costs of restoration to alternative use outweigh the benefits. This land will not be utilised, but will be vegetated with a self-sustaining cover, with restricted access.

13.8 Mining Heritage

The Silvermines area includes the remains from a wide range of mining activities carried out over many centuries. These are important for future industrial archaeological research, and as part of Ireland’s mining heritage. Where appropriate, the remedial works and future management of the Silvermines area will be designed to conserve the mining heritage, and to make historic sites accessible for research workers and the public. Of particular historical interest are the remains at Ballygown, Magcobar, Gorteenadiha and Shallee South/East.

13.9 Aesthetics

The largest visual intrusion is the waste rock dumps at Magcobar, particularly where recent working of the dumps has exposed fresh waste rock, but this intrusion can be lessened without extensive work. The exposed outer slopes of the Gortmore TMF have a visual impact which can be lessened by the planting of a tree screen.

13.10 Technical Limits for Water, Soil and Air Quality

On abandoned mine sites there is usually a compromise between the technical possibilities, public requirements, the standards and the costs. The following sub-sections summarise the key technical issues and the proposed acceptance criteria.

13.10.1 Water discharges

Discharges of water from abandoned mines may have been occurring since before relevant legislation was promulgated. The following are key considerations:

- the standard which should be achieved;
- whether any improvement is necessary or acceptable, whether or not it achieves a standard;
- adoption of a water quality compliance point, whether the initial discharge itself, or some point in the receiving water-course; and
- background water quality in a mineralised environment where metal levels are naturally elevated.

Table 13.1 gives discharge standards for water, with the accompanying notes. These are taken from the BATNEEC Guidance Note (EPA 1997). It is proposed that they be used as targets for remediation.

Downstream of the Gortmore TMF, in the Kilmastulla river, the acceptance criteria may be based on Salmonid water. These requirements are given in Table 13.6.

Table 13.1: Limits for discharges of water to the natural stream*

Parameter	Limit Value	Notes
pH	6-9	4
BOD	90% removal or 25mg/l	1,4
Toxic units	5TU	2,4
Total Nitrogen (mg/l as N)**	>80% removal or 15 mg/l	4,5
Total Phosphorus (mg/l as P)**	>80% removal or 2 mg/l	4
Total Ammonia (mg/l as N)	5	4
Oils, fats and grease (mg/l)	25	4
Fish Tainting	No tainting	3,4
Mineral (Oil (interceptor) (mg/l)	100	4
Mineral Oil (effluent mg/l	1	4
Metals, Cyanides etc	As appropriate	6

Notes for Table 13.1

*All values refer to daily averages, except where otherwise stated to the contrary, and except for pH which refers to continuous values. Limits apply to effluent prior to dilution with uncontaminated streams, e.g. storm waters, cooling waters, etc.

**The emission limit values for nitrogen and phosphorus are only applicable to waters subject to eutrophication. One or both limits may apply depending on the sensitivity of the receiving waters.

1 – The daily raw waste load for BOD and Suspended Solids is defined as the average daily mass arising for treatment over any three month period. Calculations of the removal rates for BOD and Suspended Solids should be based on the differences between the waste loads arising for disposal and those discharges to the receiving waters. The amounts removed by treatment (physical, chemical, biological) may be included in the calculation.

2 – The toxicity of the effluent shall be determined by testing an appropriate aquatic species. The number of toxic units (Tu) = 100 / x hour EC/LC_{50} in percentage vol / vol so that higher Tu values reflect greater levels or toxicity. For test regimes where species death is not easily detected, immobilisation is considered equivalent to death.

3 – No substances shall be discharged in a manner which, or at a concentration which, following initial dilution causes tainting of fish or shellfish, interferes with normal patterns of fish migration or which accumulates in sediments or biological tissues to the detriment of the fish, wildlife or their predators.

4 – Consent conditions for these parameters to discharge to municipal treatment plants can be established with the Licensing Authority, and different values may apply.

5 – Reduction in relation to influent load. Total nitrogen means the sum total of Kjeldahl-nitrogen plus nitrate-nitrogen plus nitrite-nitrogen.

6 – Determination of limits at the time of licensing based on consideration of appropriate technologies and the requirement of the receiving environment. In this regard, particular attention should be paid to the maximum acceptable concentration standards (wherever relevant and applicable for the chemical parameters of:

a) S.I. 293 of 1988 – European Communities (Quality of Salmonid Waters) Regulations, 1988.
b) S.I.294 of 1989 – European Communities (Quality of Surface Water intended for the Abstraction of Drinking Water intended for Human Consumption) Regulations, 1989
c) S.I. 200 of 1994 – European Communities (Quality of Shellfish Waters) Regulations, 1994.

Relevant EC Directives on water quality are given in Table 13.2.

Table 13.2: Relevant European Community Directives On Water Quality

Directive	Title	Comments
75/440/EEC	Directive on the quality required of surface water intended for the abstraction of drinking water.	Gives water quality guidelines (guide values and mandatory) for a range of determinants.
76/464/EEC	Directive on pollution caused by certain dangerous substances discharged into waters. This Directive requires Member States to control all emissions of dangerous substances by an authorisation system. Introduces List 1 and List 2 substances.	Contains List 1 and List 2 substances, not water quality guidelines. 7 Daughter Directives give limit values and quality objectives for mercury and cadmium, among other List 1 substances
78/659/EEC	Directive on the quality of freshwaters needing protection or improvements in order to support fish life.	Gives water quality guidelines (guide values and mandatory values) for salmonid waters and cyprinid waters. Also specifies methods of analysis and minimum sampling and measuring frequency.
80/68/EEC	Directive on the protection of groundwater against pollution caused by certain dangerous substances. For certain substances and groups of substances, any discharge to groundwater is prohibited (List 1 substances), whilst List 2 substances must be subject to an elaborate authorisation process.	Does not give water quality guidelines.
80/778/EEC	Drinking Water Directive, relating to the quality of water for human consumption, designed to safeguard human health by establishing standards for the quality of drinking water.	Gives guide levels and maximum admissible concentrations for a range of determinants
84/156/EEC	Directive on limit values and quality objectives for mercury discharges by sectors other than the chlor-alkali electrolysis industry.	Sets limits for mercury discharges.
86/280/EEC 90/415/EEC	Directives on limit values and quality objectives for certain List 1 substances.	
79/923/EEC	Directive on the quality required of shell fish waters	Does not give quantitative water quality guidelines, but gives descriptive guide and mandatory guidelines – e.g. for metals "the concentration of each substance in the shellfish water or in the shellfish flesh must not exceed a level which gives rise to harmful effects on the shellfish and their larvae. The synergistic effects of these metals must be taken into consideration".
91/271/EEC	Urban Waste Water Directive, aims to protect surface inland waters and coastal waters by regulating collection and treatment of urban waste water and discharge of certain biodegradable industrial waste water.	
2000/60/EC	Water Framework Directive, incorporating 75/440/EEC, 78/659/EEC, 79/869/EEC, 80/68/EEC, 76/464/EEC and its seven Daughter Directives	

13.10.2 Discussion of technical acceptance criteria for water quality

The review of tests of water chemistry has shown that, in streams close to the mining area, the content of heavy metals sometimes exceeds the statutory limits. The extent to which this occurs during a year is not known, because it is likely that sediment loads during storm flows are much higher than during average flows.

It is proposed that the BATNEEC principle will be used at Silvermines, by identifying the prime sources of pollution and removing them, and by installing wetland treatment systems.

13.10.3 Atmospheric pollution

Potential atmospheric pollution issues in the area comprise dust blow, especially dust from the Gortmore TMF. This was discussed in the Phase I report. Following a major dust blow, remedial works were carried out, and dust monitoring was implemented. The results have indicated that the establishment of vegetation on the impoundment has reduced the dust emissions to within the BATNEEC emission limits given in Table 13.3. The relevant EC Directives are given in Table 13.4.

Table 13.3: Emission Limits

Emission	Limit Value
Particulates	1 mg/m^3
Metals	As per T.A. Luft[1]

[1] German limits

Table 13.4: European Community Directives on Air Quality

Directive	Air
96/62/EC	Air Quality Framework Directive, on ambient air quality assessment and management.
99/30/EC	Council Directive relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air

EC Directive 99/30/EC establishes limit values for particulates and lead in the ambient air (Table 13.5).

Table 13.5: Air Emission Limits from Directive 99/30/EC

Parameter	Limit	Implementation Date
Stage 1 Particulate matter (PM10)	50 µg/m3 (24 hours) 40 µg/m3 (calendar year)	1 January 2005 1 January 2005
Stage 2 (indicative[1]) Particulate matter (PM10)	50 µg/m3 (24 hours) 20 µg/m3 (calendar year)	1 January 2010 1 January 2010
Lead	0.5 µg/m3 (calendar year)	1 January 2005 or 1 January 2010 in vicinity of specified contaminated industrial sites)

[1] The Stage 2 PM_{10} limit values are not binding. They are indicative values to be reviewed at EU level by 2003 in the light of further information on health and environmental effects, technical feasibility and experience in the application of Stage 1 limit values.

The Directive sets temporary margins of tolerance (MOT) in relation to some of the limit values and their attainment dates. Margins of tolerance are pollutant levels set at a fixed percentage above the limit value and they decrease by a constant percentage year by year until the date of attainment of the limit value.

The situation with regard to air pollution at Silvermines is different to that for water pollution, in that air emissions are under control, and it will be possible to achieve the listed emission levels.

Table 13.6: Irish Water Quality Standards

Regulation Statutory Instrument No		**Drinking Water** **S.I. no 81 of 1988 I/MAC value**	**A1 I/MAC value**	**Surface Water** **S.I. No 294 of 1988 A2 I/MAC value**	**A3 I/MAC value**	**Salmonid Water Regulations S.I. No 293 of 1988 I/MAC value**
	Unit of Analysis					
Aluminium	Al mg/l	0.2				
Ionised ammonia	NH_4 mg/l	0.3	0.2	1.5	4	<1, subject to conforming with the standard for non-ionised ammonia
Un-ionised ammonia	NH_3 mg/l					≤0.02 (Standard may be exceeded in the form of minor peaks in daytime).
Antimony	Sb μg/l	10				
Arsenic	As μg/l	50	50	50	100	
Barium	Ba μg/l	500	100	1000	1000	
Beryllium	Be mg/l					
Boron	Bμg/l	2000	2000	2000	2000	
Cadmium	Cd μg/l	5	5	5	5	
Calcium	Ca mg/l	200				
Chloride	Cl/mg/l	250	250	250	250	
Chlorine residual	Cl mg/l					≤0.003 in 95% of samples over 12 months on sampling at least once per month
Chromium	Cr mg/l	50	50	50	50	
Cobalt	Co mg/l					
Conductivity	μS/cm @ 20°C	1500	1000	1000	1000	
Copper	Cu μg/l	500	50	100	1000	≤5@10mg/l$CaCO_3$, ≤22@50mg/l$CaCO_3$, ≤40@100mg/l$CaCO_3$, ≤112@300mg/l$CaCO_3$
Cyanide	CN μg/l	50	50	50	50	
Fluoride	F μg/l	1000	1000	1700	1700	
Hydrogen ion concentration	pH	6.0-9.0	5.5-8.5	5.9-9.0	5.5-9.0	≤6 and ≥9 in 95% of samples over 12 months, sampling at least once per month
Hydrocarbons dissolved and emulsified	μg/l	10	10	200	1000	Petroleum products must not form a visible film on surface or impart a detectable hydrocarbon taste to fish
Iron	Fe μg/l	200	200	2000	2000	
Lead	Pb μg/l	50	50	50	50	
Magnesium	Mg mg/l	50				

TABLE 13.6 : Irish water quality standards (continued)

Regulation Statutory Instrument No		**Drinking Water** **S.I. no 81 of 1988 I/MAC value**	**A1 I/MAC value**	**Surface Water** **S.I. No 294 of 1988 A2 I/MAC value**	**A3 I/MAC value**	**Salmonid Water Regulations S.I. No 293 of 1988 I/MAC value**
Manganese	Mn μg/l	50	50	300	1000	
Mercury	Hg μg/l	1	1	1	1	
Methylene blue – active substances	LAS μg/l	200	200	200	200	
Molybdenum	Mo mg/l					US NAS recommendation for irrigation water is 0.01mg/l
Nickel	Ni μg/l	50				
Nitrate	NO_3 mg/l	50	50	50	50	
Nitrite	NO_2 mg/l	0.1				≤0.05 in 95% of samples over 12 months, sampling at least once per month
Oxygen demand, biochemical	O_2 mg/l		5	5	7	
Oxygen, dissolved	O_2 mg/l % sat		>60%	>50%	>30%	1:50% ≥9 mg/l O_2
Pesticides	μg/l	0.5 (TOT):0.1(IND)	0.5	2.5	5.0	
Phenols	O_6H_5OH μg/l	0.5	0.5	5	100	Phenolic compounds must not be present in such quantities that they adversely affect fish flavour
Phosphates	P_2O_5 μg/l	5000	500	700	700	
Polynuclear Aromatic Hydrocarbons	μg/l	0.2	0.2	0.2	1.1	
Potassium	K mg/	12				
Selenium	Se mg/l	0.01	0.01	0.01	0.01	
Silver	Ag μg/l	10				
Sodium	Na mg/l	150				
Sulphate	SO_4 mg/l	250	200	200	200	
Tellurium	Te mg/l					
Thallium	TI mg/;					
Titanium	SN mg/l					
Tin	Ti mg/l					
Uranium	U mg/l					
Vanadium	V mg/l					
Zinc	ZN mg/l					≤0.03@10mg/l $CaCo_3$, ≤0.2@50mg/$CaCo_3$, ≤0.3@100mg/l$CaCo_3$, ≤0.5@500mg/l$CaCo_3$

TOT – Total; IND = Individual; % SAT = Percentage Saturation; LAS = Lauryl Sulphate; I/MAC – Mandatory maximum admissible concentration

13.10.4 Soils

The technical issues for soils include:

- distinction between soils with naturally elevated levels of metals and those affected by mining activity;
- the variation of potential contaminants due to the variation of material in the mine waste areas;
- the variation of leachability and mobility of different constituents;
- the leaching history of the materials in terms of vertical profile variation and subsurface contamination;
- the distribution of contaminants spread on farmland by stream overflow, dust blow, erosion or drain clearance; and
- the potential cover design requirements and objectives.

The approach in this investigation will be largely based on the assumptions that:

- sediment and water in the streams will reflect the quantity and nature of contaminants leaving the site;
- contaminated sites that would benefit from removal or covering can be clearly identified without the need for extensive sampling programmes (The sampling programmes proposed are based on field characterisation with limited laboratory testing); and
- pasture land with elevated metals due to natural conditions or due to deposition or precipitation by wind or water can be managed agriculturally to minimise any possible effects.

In order to assist assessment of soil contamination, the Dutch Ministry of Housing, Spatial Planning and the Environment list has been used. This is referred to as ‘The New Dutch List’ and is used within Ireland by the EPA to assess sediment quality. As geological conditions within the Netherlands are quite distinct, the application of the standards in other environments requires engineering judgement. Consequently, in the context of assessing the current data set, the standards are principally used to categorise sediment chemistry data. This approach is the same as that used by the EPA. The numerical values are summarised in Table 13.7.

It should be noted however, that the Dutch guidelines were developed for a country where groundwater and surface water are almost contiguous and very sensitive to contamination. Care should be taken, therefore, to avoid overstating the risk when using these guidelines.

The BATNEEC principle will be applied to soils and sediments. In some cases, the application of this principle may limit the final land-use of specific sites.

Table 13.7: New Dutch List Values

Parameter	Optimum	Action
	mg/kg	
As	5	29
Ba	200	625
Cd	0.8	12
Cr	100	380
Co	20	240
Cu	36	190
Pb	85	530
Mo	10	200
Ni	35	210
Hg	0.3	10
Zn	140	720

13.11 Ecology (Flora, Fauna and Habitats)

Legally protected habitats, under the EU Birds Directive, 1979, the Flora, Fauna and Habitats Directive, 1992, and the Wildlife Amendment Act, 2000, do not occur in the areas being remediated. However, bats (protected from disturbance under the Wildlife Act, 1976, and the Flora, Fauna, and Habitats Directive, 1992) may occur in the underground workings. Game birds, such as pheasant, and game fish, such as trout and salmon, also need consideration before remediation works commence.

Environmental Impact Statements (EIS) may be required for some of the remedial works, particularly where waste materials are being removed and placed elsewhere. Where they are not required, ecological impacts of remedial works must be considered as part of the design construction works.

The impact of metal uptake through various food chain pathways does not have any regulatory criteria at present, but requires consideration in any ecological risk assessment of remedial options.

Further discussion of the ecology is presented in Appendix G.

13.12 Self-Sustainability of Vegetation Covers

Sustainability will be based on sufficient nutrient cycling of plant production to support the vegetation cover perpetually, without the necessity for external nutrient inputs. On mine wastes, productivity and sustainability are often inversely related due to the costs to the plant of physiological adaptation to a metalliferous, saline or drought-prone substrate. Rate of decomposition is frequently low due to the absence of earthworms which are sensitive to soil acidity or metal concentrations in metallophyte herbage. An index of self-sustainability has been developed for Irish tailings grasslands, based on the ecological development of soil faunal communities other than earthworms (Good, 1996) [70]. Further discussion of options is in

Appendix G.

13.13 Summary of general acceptance criteria to be applied to Silvermines

The principles given in this section are summarised below.

1. GENERAL. The principle of BATNEEC (best available technology not entailing excessive costs) will be applied.
2. REMEDIAL STANDARDS. Irish and International Standard and Guidelines will be applied for the remedial works.
3. PUBLIC ACCEPTANCE. The concerns and requirements of Interested and Affected Parties will be given a high priority during the assessment of options for remediation and land usage.
4. HEALTH. Irish and International Standards will be applied to water, soil and atmospheric emission levels. The recommendations of the Inter-Agency Group concerning lead (Report of June 2000) will be applied.
5. LAND-USE. Where possible, land will be restored to agricultural, recreational, commercial or light industrial use, as appropriate. In cases where costs to restore the land to such use are prohibitive, usage and access will be controlled. Where there is no real value in restoring land or where it should be left as part of mining heritage, it is described as ‘derelict’ land.
6. MINING HERITAGE. Structures of significant historic value will be conserved.
7. AESTHETICS. Works will be carried out in such a way as to maintain or improve the present aesthetics of the area.
8. WATER DISCHARGES. The prime sources of water pollution will be removed by excavation and storage elsewhere. Wetland treatment systems will be installed as appropriate. The objective will be to settle and retain suspended metal solids, which are the main concern, and to reduce the dissolved solids to the limits of the EPA BATNEEC Guidance Note.
9. ATMOSPHERIC POLLUTION. The regulatory limits will be applied.
10. SOIL CONTAMINATION. Contaminated soils, defined in terms of the “New Dutch List” will be removed or covered as appropriate.
11. ECOLOGY. The existing ecology and habitats will be maintained and enhanced, including the plant communities which have adapted to the man-made conditions on the mine sites. Remedial works will be carried out in accordance with the recommendations of the Environmental Impact Statements.

14 REMEDIATION ASSESSMENT

14.1 General

In this Section, the specific problems at each of the areas - Ballygown, Magcobar, Garryard, Gorteenadiha, Shallee South/East, Shallee West and Gortmore TMF - are dealt with, updating the Phase I assessment using the additional information gathered during Phase II, and adding the risk assessment and proposal of the preferred remedial options. The detailed assessments are in Appendix I.

14.2 Definition of RISK

In the following section, each particular hazard is identified, then the ***probability of occurrence*** is estimated and the ***consequence*** of the occurrence is assessed. The ***risk*** is the product of the probability and the consequence:

RISK = (PROBABILITY OF OCCURRENCE) X (CONSEQUENCE OF OCCURRENCE)

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.

Three levels of probability and consequence have been used in the following analyses:

LEVEL OF PROBABILITY

L_P	Low probability of occurrence
M_P	Medium probability of occurrence
H_P	High probability of occurrence

LEVEL OF CONSEQUENCE

L_c	Low significance of consequence
M_c	Medium significance of consequence
H_c	High significance of consequence

The appropriate response depends on the product of probability and consequence. The intent is to reduce High and Medium risks to Low risks by remedial works and/or by control of access.

14.3 Action in Response to Assessed Risk

Table 14.1 summarises the general response to a particular risk, but the final remediation measures will depend on the nominated end land-use, and the Acceptance Criteria discussed in Section 13.

Table 14.1: Relationship of Risk to Required Action

RISK (Product of probability and consequence of occurrence)	SIGNIFICANCE OF RISK	ACTION REQUIRED
$L_P.L_c$	Low	None, or beneficial works as part of overall plan
$L_P.M_c$	Low	None, or beneficial works as part of overall plan
$L_p.H_c$	Medium	Limited beneficial works and/or restrictions on access to reduce risk to Low
$M_p.L_c$	Low	None, or beneficial works as part of overall plan
$M_p.M_c$	Medium	Limited remedial works and/or restrictions on access, to reduce risk to Low
$M_p.H_c$	High	Remedial measures to reduce risk to Low
$H_p.L_c$	Medium	Limited remedial works and/or restrictions on access, to reduce risk to Low
$H_p.M_c$	High	Remedial measures to reduce risk to Low
$H_p.H_c$	High	Remedial measures to reduce risk to Low

14.4 Risk/Remediation Tables

The risk/remediation tables 14.2, 14.3, 14.4, 14.5, 14.6 and 14.7 deal with the six areas Ballygown, Magcobar, Garryard, Gorteenadiha, Shallee and Gortmore respectively. The assessments are based on the detailed assessments in Appendix I.

Although each potential problem has been dealt with separately for each area in this remediation assessment, the remedial measures required cannot be treated in isolation, but will form part of the holistic overall planning for the management of the Silvermines area.

For all actions, detailed surveys will be required followed by detailed designs, specification, costs and schedules. This is not necessarily listed in the tables as it is common to all.

In the Tables, the remediation assessment for each potential problem is dealt with in the following sequence:

(a) Identification of hazard or issue
The hazard is the source of the potential impact, such as an area of contaminated soil or an open shaft.

(b) The pathway
The hazard has little significance if there is no way for it to affect people, animals or the environment. The "pathway" is the route by which the hazard reaches the receptors. An example might be the take-up of pollutants by

plants which are eaten by livestock. Groundwater and surface water would be pathways for spread of contaminants but they have also been defined as receptors (see (c) below).

(c) Receptors

The Receptors are the affected people, animals or environment. Where receptors are described as surface water or groundwater, they are included because they are subject to protection from contamination by legislation as well as being a host for aquatic life.

(d) Impact

The Impact is the effect which the Hazard has on the Receptor. For example, an open shaft has a potential impact on human health and safety.

(e) Risk

The Risk, as previously explained, is the product of the probability that a particular event will occur and the consequence of its occurrence.

(f) Potential remediation options

In some cases, there is only one realistic option. In others, the choice depends on whether it is justified to pay a premium for a favoured more costly option.

(g) Nominated end-use

There may be several end-uses which are acceptable in environmental, community and cost terms. This box gives the end-use which is considered to be appropriate, and on which the selection of remedial measures depends. Where the nominated end use is derelict land, this is defined in Section 10.6.

(h) Recommended actions

The actions are the recommended immediate actions, rather than the actual implementation works. This is because, in most cases, the next step is to gather information to be used in the design of the selected option.

Although each potential problem has been dealt with separately in this remediation assessment, the remedial measures required cannot be treated in isolation, but will form part of the holistic overall planning for the management of the Silvermines area. This overview will be discussed later in the report.

Table 14.2: Risk Assessment - Ballygown (See Figure 3.1)

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 and fence • Backfill shafts • Fence adits • Fence subsidence area	• 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 • Streambank 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	• School playing field	• 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 • Streambank 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 (Fig.3.2)

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 (Fig.3.3)

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 construct 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 (Fig.3.3)

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 allowed, but restricted.

Table 14.6: Risk Assessment - Shallee South/East and Shallee West (Fig.3.4)

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 I 5.3 + 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 (Fig.3.4)

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	• 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	• 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: Site : Risk Assessment - Gortmore TMF (Fig.3.5)

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

*** 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.**

15 CLAUSE K

The works for which Mogul Mine is responsible in terms of its State Mining Lease are listed in Table 15.1, and details are given in 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.

Table 15.1: Mogul Clause K Responsibilities

Description	Summary Table	Section of Appendix I
GARRYARD PLANT AREA:		
Garryard Settling Pond – Minor remedial works	14.4	I4.1
Garryard Tailings Lagoon – Remove process wastes to Gortmore TMF	14.4	I4.2
Garryard Tailings lagoon – Establish wetland to treat Mogul underground water	14.4	I4.2
Mogul underground subsidence area – Repair and extend fence	14.4	I4.3
Mogul underground water contamination – Construct water diversion structures	14.4	I4.4
Garryard Old Stockpile – Segregate wastes and remove contaminated soil and process waste to Gortmore TMF and other waste to designated site	14.4	I4.5
Garryard Plant Area - Profile and cover unsurfaced areas, carry out landscaping works	14.4	I4.6
MAGCOBAR:		
Backfill small sinkhole near entrance to site	14.3	I3.2
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	I5.1, I5.5
GORTMORE TMF		
Dust and erosion control – Place growth medium, plant vegetation and shrub windbreaks	14.7	I6.1
Leaching of metals and salts – Place growth medium, vegetate and improve toe wetlands	14.7	I6.3
Erosion of tailings by run-off – Repair toe paddocks and slope gulleys	14.7	I6.4
Visual impact – plant crest vegetation and toe tree screen	14.7	I6.2
Pool on surface of TMF – Construct new decant and decant pipeline	14.7	I6.6
Three retention ponds at TMF – Minor repairs to ponds and discharge system	14.7	I6.7
MOGUL VENT RAISES AND SHAFTS		
Fence or cap as required	14.4	I4.3
	14.5	I4.9
	14.2	I2.5

16 THE PHASE III STUDY

The present Phase II report presents the results of the assessment of remediation options for the Silvermines area, and proposes the preferred options.

The preferred options will be discussed and agreed with the DMNR. SRK will then proceed with the Phase III task, which comprises development of conceptual designs and testing. A preliminary schedule of remedial works will also be prepared.

The Phase III report will include recommendations for additional studies necessary for the presentation of detailed design of the remedial works.

For and on behalf of SRK (UK) Ltd

Dr Ian Brackley	**Richard Connelly**
Director	**Director**