DEPARTMENT OF MINED AND ENERGY
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Golden Grove Extractive Industry Area Management Plan - A Discussion Paper

GEOLOGICAL SURVEY

by

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GOLDEN GROVE EXTRACTIVE INDUSTRY AREA MANAGEMENT PLAN - A DISCUSSION PAPER

ABSTRACT

The Golden Grove Extractive Industry Area is the centre of the State's brick industry and is the most important source of construction sand for the northern Metropolitan area.

This paper presents an overview of one option for a development strategy, and is intended as a basis for discussions between SADME, mining operators, Tea Tree Gully Council, South Australian Urban Land Trust and Department of Environment and Planning to achieve an agreed management plan.

Considerations paramount in the preparation of the strategy were:

. Yield of construction materials to be maximised.
. SAULT land south of Greenwith Road to be mined.
. Existing company development plans currently approved under the Mines and Works Inspection Act to be incorporated in the strategy.
. Tailings dams, as far as possible, to be restricted to one area.
. Disposal of tailings in deep dams to be avoided on SAULT land.

Mining is expected to continue in the Extractive Industry Zone for at least a further 50 years. Upon cessation of mining and dewatering, there will be a period of groundwater recovery resulting in the formation of a lake in the deeper part of the worked out area.

INTRODUCTION

Since mining began at Golden Grove in 1947, the area has become the most important source of construction sand, plastic clay and brick shale for northern Metropolitan Adelaide. Golden Grove is also the centre of the State's brick industry with plants operated by Hallett and PGH.

Importance of the sand resource at Golden Grove has been highlighted by the failure of drilling programmes to locate alternative sand supplies to the north of Adelaide in Tertiary sediments near Freeling and Tanunda (Scott, 1989).

The area east of Golden Grove Road to the Hills Face Zone was zoned for Extractive Industry in August 1985. An amendment to the Development Plan for part of the area of the City of Tea Tree Gully recognized the need for a management plan for the Golden Grove Extractive Industry Area, and proposed that;

> "the Department of Mines and Energy in consultation with the Department of Environment and Planning, the Tea Tree Gully Council and the mining companies will prepare a comprehensive management plan for the Golden Grove area that provides a framework for future mining operations, the co-ordinated reclamation of individual workings and the establishment of appropriate after-uses as a basis for developmental plans for individual pits under the Mines and Works Inspection Act".

Because knowledge of the basin configuration and contained mineral resources was insufficient to draft a management plan, Government and Industry jointly funded a programme of 69 reverse circulation holes. These were drilled between February and August 1986, and in March/April 1987. This discussion paper should be read in conjunction with a report prepared by McCallum (1988), which includes the results of the drilling programme.

In this report, no attempt is made to resolve all issues or to address all details which will be necessary in the preparation of a management plan. The report presents a broad overview of one possible development strategy, and is intended to provide a starting point for discussions involving:

- South Australian Department of Mines and Energy (SADME)
- Department of Environment and Planning (DEP)
- SA Urban Lands Trust (SAULT)

and the following operators:

- Amatek Limited (successor to Monier Ltd and hereinafter referred to as Amatek)
- Hallett Brick Industries Ltd (a member of the Nubrik Hallett Group; hereinafter refereed to as Hallett).
- Christies Sands Pty Ltd (also a member of the Nubrik Hallett Group; hereinafter referred to as Christies).
- PGH Industries Pty Ltd (hereinafter referred to as PGH).
- Clay and Mineral Sales Pty Ltd (a sister company to Mineral Holdings Pty Ltd, hereinafter referred to as CMS).

The Tertiary basin areas north and south of Greenwith Road which contain construction sand and plastic clay deposits are discussed separately from the 'Shelf Area' to the east which is underlain by brick shale deposits.

In devising the current overview, the basic strategy was to assume company development plans currently approved under the Mines and Works Inspection Act will be followed to their logical conclusion, and that recovery of resources will be optimised.

Prediction of the life of operations at Golden Grove is difficult. If the assumption is made that population will increase at about 0.5 to 1% per annum, and that production growth will parallel population growth, reserves of sand will be sufficient for 70-75 years and brick clay reserves in the eastern shelf area will be adequate for about 50 years. However, the depletion of sand reserves east of Gawler will shorten this life span somewhat, so the dates shown on the accompanying plans are probably best regarded as an informed guess.

Discussions with interested parties will provide sufficient information to draft a Management Plan conforming to the guidelines from the amendment to zoning in August 1985, outlined below:

Golden Grove Management Plan

The nature of the sand and clay deposits is such that on completion of extraction to the baseline of deposits, there will be a deep central area which may fill with water and a peripheral shelf zone with considerable redevelopment potential.

A management plan for the Extractive Industry Zone and adjoining worked out areas at Golden Grove is proposed to ensure that individual operators do not develop their properties in isolation. The possibility of individual operators completing reclamation works which are incompatible or inconsistent with their neighbours must be avoided.

The management plan is to be concerned with the following matters:

a) defining the boundaries of the central basin and shelf areas;
b) identifying the range of after-uses that are practical options for each area. Matters to be considered here will include:

   i) final landform;
   ii) drainage of surface waters;
   iii) groundwater recharge;
   iv) pollution of surface and underground waters;
   v) preferred staging of land available for reclamation and after-use, particularly with regard to the impact on existing and proposed residential areas surrounding the site; and

vi) visual impact of land, particulary abutting the public roads and the escarpment of the hills;

c) specifying final pit slope angles and surface treatment to ensure safety and stability;
d) the best means of final disposal of fine tailings from sand washing operations;
e) determining a preferred programme of working so that sites can be rehabilitated progressively and after-uses established as soon as possible;
f) rationalising trucking routes for materials from the workings and adjacent brickworks;
g) determining the most appropriate screening measures; and
h) determining the most effective means of minimising noise and other nuisance to surrounding residential and rural living areas.

NORTHERN BASIN AREA

Current Operations and Development Plans

Three operators currently work in this area. All have development plans which have been approved under the Mines and Works Inspection Act.

1. Christies mine sand, shale and plastic clay from section 5459, on Private Mine 32. The main area of sand extraction at present is in the southwestern corner of the section; sand, shale and plastic clay are mined from the eastern part and fine tailings are disposed of in a worked out pit area in the northwestern corner. The central part of the Private Mine is covered by shallow disused tailings dams which will be removed to gain access to underlying deposits of sand.

2. CMS operates two sand pits in section 5662, on Private Mines 81 and 118. These will expand westerly towards the boundaries with Christies and Amatek. No sand washing is carried out on site.

3. Amatek mines and washes sand from a pit in sections 5465 and 5460, on Private Mine 76. The current main operating face is orientated north-south and advancing easterly. Tailings are disposed of in deep ponds in worked out pit areas. The current tailings dam in the northern part of section 5465, flanking Ross Road, is in excess of 20 m deep. An abandoned dam with a maximum depth of 16 m, lies near the western boundary of the property. Current plans are to continue advancing the present face easterly and southeasterly, and to dispose of tailings in deep dams in worked out pit areas.

Amatek also owns a worked out rehabilitated area to the north: Private Mine 152 on section 5458.

Future Development and Rehabilitation

Current development plans can be readily incorporated into an overall management plan provided existing operators can negotiate agreements with their neighbours to mine and share material along their mutual boundaries. Consideration should be given to including such agreements in development plans submitted under the Mines and Works Inspection Act.

1. CMS/Christies Boundary

Christies mining operations have reached the northern part of the boundary; and CMS are very close to it. CMS will not be able to fully exploit the 40 m deep sand deposits along the southern part of the boundary without negotiating an agreement with Christies.

2. CMS/ Amatek Boundary

Neither operator has working faces near this boundary to date; Amatek will probably not reach this boundary for at least 15 years. However sand deposits along this boundary exceed 40 m in depth and an agreement will be necessary to enable the operators to fully exploit the resource.

3. PGH/Amatek Boundary

Construction sand and plastic clay deposits occur at depth beneath the boundary, and within PGH property. However, they are overlain by up to 30 m of fine sand suitable only for fill. It would be uneconomic for PGH to attempt recovery of these materials at present, but when Amatek's operating face reaches the boundary it will obviously be in the interest of both parties to continue the face southeasterly enabling PGH access to plastic clay and Amatek access to construction sand. This will probably be 20-30 years into the future, and an agreement will be necessary.

4. Ross Road

Ross Road separates the Christies and Amatek properties for a length of about 1 km. Closure of Ross Road is one of the most important pre-requisites for maximizing the yield of construction materials from this part of the basin, and ensuring a final landform of greatest versatility. Large reserves of sand to depths of more than 40 m would be sterilized in the road and in batters along either side if it were to be retained. 'Boundary agreements' between Christies, CMS and Amatek will need

to be considered in the context of closing this road. Because the road is currently the main CMS access route to sand pits in section 5662, an alternative trucking route will need to be negotiated.

Christies are currently mining adjacent to Ross Road near its western end. Closure of Ross Road would allow the current operating faces to advance southerly across the road and possibly, by negotiation with Amatek for some distance into the Amatek property. This would maximize the size of this pit for future tailings disposal, probably by both parties. It would also ensure recovery of sand which would otherwise be sterilized. Because this is an area of current operations, closure of Ross Road should be negotiated as soon as possible.

5. Fine Tailings

Because of constraints on available area, the Amatek and Christies sand washing operations are committed to disposal of tailings in deep dams in worked out pit areas (more than 16 m deep in Amatek's old dam at the west of the property). The dams in the central part of Christies property are relatively shallow (less than 8m deep) and will be removed to enable access to underlying construction sand. However, it seems unlikely that the Amatek dams and future Christies dams will ever be removed because of handling problems and the relatively small amount of sand which would be recovered from dam walls and floor in the process. The most likely outcome is that they will eventually dry out sufficiently to be covered by overburden and used for open space or recreation purposes. The time required for drying of deep dams is not known but is probably many decades. One of the few practical methods of accelerated dewatering of

these dams is by planting of suitable vegetation. It is recommended that the Extractive Areas Rehabilitation Fund sponsor a research program using a dam such as Amatek's western dam to determine the effectiveness of vegetative dewatering. Species such as River Red Gums (E. Camaldulensis) which have extensive root systems and transpire large amounts of water should be planted around the margins of the dam, and other suitable species in the centre. Drilling of the dam at 5-10 year intervals and surveying of the surface R.L. would provide indications of time required to dry dams sufficiently for them to be reclaimed for open space uses.

Because reclaimed tailings dams are probably suitable only for open space, there are some planning advantages in having dams restricted as far as possible to one area. Christies current sand pit at the southwestern corner of the property is adjacent to two deep dams in the Monier property. This is the logical area for development of a future tailings dam, the capacity of which can be maximized by mining the sand beneath Ross Road.

6. Heavy Minerals

Concentrations of heavy minerals (ilmenite, leucoxene, rutile and zircon) occur within a fine sand unit along the eastern flank of the basin in Amatek and PGH properties between Ross Road and Greenwith Road. If these materials are recovered it is likely to be during the course of sand and clay mining operations. However, if it becomes economic to extract these materials separately, no development should be permitted which

would prejudice the ultimate recovery of construction materials. In particular, pits should not be backfilled with tailings from a heavy minerals operation in a manner which would sterilize underlying sand and clay.

SOUTHERN BASIN AREA

Current Operations and Development Plans

Two operators currently have pits in this area.

1. Hallett Brick Industries Ltd

This company mines plastic clay and shale for brickmaking from a pit in section 5470 (Private Mine 56). The north-south face is advancing easterly and overburden is used to progressively reclaim worked out areas to the west flanking Hancock Road. Future development will continue this method of operation.

2. Amatek Limited

Amatek have a sand pit in section 5467 (Private Mine 71). About 16 m of sand and gravel lie beneath the pit floor but there is little scope for major development since the PM is less than 200 m wide and faces have reached or are close to the property boundaries on all four sides. The pit is currently worked intermittently.

Future Development and Rehabilitation

The key to future development of this area lies with the largest landholder, the S.A. Urban Land Trust (SAULT) which owns two separate areas of land:

- Most of section 5466 (22.08 ha)
- The southern part of section 5467 and the northern part of section 5468 (33.97 ha).

These areas contain, beneath 2.2 m tonnes of waste and overburden, the following resources:

- 10.3 m tonnes of coarse construction sand
- 3.2 m tonnes of fine construction sand
- 6.7 m tonnes of filling sand
- 3.9 m tonnes of clay

plus some shale suitable for brickmaking.

It is considered that reserves of sand within SAULT land should be mined. The practice of disposing of sand washing tailings in deep pits should be avoided in this area because:

- This method of tailings disposal usually involves sterilization of some of the resource in dam walls and beneath the floors.
- Deep tailings dams take a considerable time to dry out and areas containing tailings dams have a limited range of after-uses (open space or recreation).
- The total area of Urban Land Trust land is 56.05 ha which is sufficient to adopt the practice currently used by Readymix at Pedlar Creek, where tailings are spread to shallow depth in prepared dams, solar dried over a period of several months, picked up by front-end loader and used in rehabilitation programmes.

SAULT land should be worked by a single operator; this might be a consortium of two or more companies formed for the purpose of mining the deposit. If two separate mining operations are permitted in this area, the operators will experience similar problems with regard to lack of space for tailings disposal as are now experienced by Amatek and Christies.

The deposit should be opened in the western part of section 5466 and worked by north-south faces advancing in an easterly direction. Advantages of working in this manner are that:

- Overburden is relatively thin in the area of initial workings, but there is sufficient to form a bund wall along Hancock Road to shield the operations from view from residential land to the west.
- Operating method will parallel that of the Hallett pit to the south and it should be possible to co-ordinate rehabilitation programmes.
- There is currently some housing to the west of Hancock Road, but a large area to the west of Golden Grove road is zoned "Golden Grove Residential" and has yet to be developed for housing. Mining in an easterly direction, dumping overburden in worked out areas, and progressive rehabilitation will result in retreat of the operating face away from residential areas. This will create a widening buffer zone between the mining operations and the residential area.
- Depth to basement is shallower in section 5466 than further east in sections 5467 and 5468. After cessation of mining, water levels will rise in the deeper parts of the basin, and will ultimately cover much of sections 5467 & 5468. Dumping of overburden from these areas in section 5466 will maximize reclamation of ground above water level.

Two properties in private ownership present obstacles to working the SAULT land in the manner described, i.e. by a single sweep easterly from section 5466 to sections 5467 and 5468. These properties are:

1. "Carrail Property"; 1.2 ha with house and outbuildings near the corner of Hancock and Golden Grove Roads. This should ideally be acquired by SAULT or the operator of the SAULT land.
2. "Harpain Property". This is a strip of land approximately 100 m wide along the eastern margin of section 5466; an area of 6.5 ha with a refrigeration factory on the northern half and a houseboat factory on the southern half. Depth to basement along the southern boundary is approximately 38 m. It would not be feasible to mine the property separately. Ideally all of the property should be mined in conjunction with the SAULT land; however, mining would still be feasible if only the southern half were available. SAULT should commence negotiations with the owners of the Harpain property to acquire at least the southern half, or to negotiate an agreement whereby the owners would make the land available for mining in conjunction with the SAULT land. Assistance could be offered with relocation of the factory elsewhere, eg. on SAULT land, either outside the district, or possibly in the northwestern corner of section 5466 outside the proposed mining area.

As mining progresses, 'Boundary Agreements' similar to those already discussed for the northern area will be necessary between the operator of the SAULT land and Hallett to the south within PM56, and Monier to the north within PM71. Construction sand and plastic clay deposits occur at depth beneath Hamilton Road, and the Hallett property, including the brick kilns on section 5462 to the east. However, these reserves are overlain by a considerable thickness of fine sand suitable only for fill. It would be uneconomic to attempt recovery of those materials at present, but when the SAULT operating face reaches Hamilton Road, it will probably be in

the interests of both Hallett and SAULT operator to continue the face for some distance into the Hallett property. This will probably be 50 years or so into the future, but it should be recognized that Hamilton Road will ultimately require closure. This should not present a problem because the road is little used and no landowners will be disadvantaged by its closure.

If Greenwith Road is ultimately closed, it may be necessary to develop an alternative trucking route from the brickworks along the southern boundary of the SAULT land, to avoid increasing the volume of heavy traffic along Yatala Vale Road.

SAULT land should remain in SAULT ownership and be worked by an operator under an agreement. Advantages of this are:

- retention of the land by SAULT will give Government maximum control over ultimate use of the land, including ability to re-sell reclaimed land for specific purposes in accord with the overall management plan.
- An operation paying SAULT a negotiated royalty per tonne of product, with a specified minimum annual figure would ensure SAULT a cashflow for many years.

Hence SAULT should:

- Obtain mining leases over the land currently owned.
- Either acquire the Harpain and Carrail properties, or obtain agreements with the owners that they will make land available for mining in conjunction with the SAULT land.

. Seek submissions from interested mining operators with proposals for mining and rehabilitation of the land, and accept one which complies with the overall management plan and offers the most economically favourable terms to SAULT. SADME can provide assistance in preparing guidelines for prospective tenderers.

EASTERN SHELF AREA

Weathered shale deposits are exploited for brickmaking along the eastern flank of the Tertiary basin. There are currently three operators in this area.

. CMS in Private Mines 81 and 118
. PGH in Private Mines 206 and 215
. Hallett in PM 79.

The base of the deposits are defined by the transition from weathered to relatively fresh shale. Upon completion of mining an undulating surface will result, with relief comparable to the pre-mining surface.

Mining operators currently plan to expand shale pits to the boundaries of their properties within the zone of weathered shale.

Because the shale deposits are much thinner than the sand and plastic clay deposits within the Tertiary basin, potential for conflict at boundaries is much less than in the basin, and much more readily overcome.

GREENWITH ROAD

Sand and clay beneath Greenwith Road and the properties between the road and Amatek's PM 71 should be mined because:

- Reserves of approximately 5.6 million tonnes of construction sand, 1.4 mt of filling sand and 0.9 mt of plastic clay are contained within this area and the flanking batters.
- Deepest parts of the basin on either side of Greenwith Road will (after cessation of mining activities), fill with water. Removal of Greenwith Road will allow formation of a single, arcuate body of water approximately 2 km long with considerably greater value from recreational and aesthetic viewpoints reasons than two smaller separate bodies.
- Some bank treatment will be necessary for long term stability of the banks of the lake; possibly battering down or emplacement of spalls. Removal of Greenwith Road will save the expense of approximately 1 km of bank treatment.

Greenwith Road area should be mined <u>last</u>, because:

- Greenwith Road is a convenient trucking route for heavy vehicles to and from the brickworks. For most of its length the road passes through open space and extractive operations, and is a considerable distance from residential areas except for a few houses along the western part of the route.
- This is a well built road in good repair, with potential for a long life; maintenance would be discontinued prior to ultimate removal.
- No immediate capital expenditure is required to acquire the small holdings along the southern side of Greenwith Road.

- Political difficulties created by early compulsory acquisition, and the resultant delays in preparation of a management plan would be avoided.
- Sufficient time will be available for Council to establish policies which will ensure ultimate extraction of this area. This should include refusal of permission to build any new structures while existing structures will depreciate making acquisition for mining more feasible.

BRICKWORKS AREA

The ultimate fate of land currently occupied by the brickworks is difficult to predict so far into the future.

By the time the sand and plastic clay have been mined out from the Tertiary basin, shale deposits of the 'Eastern shelf' area will be exhausted, although there will be some supplies from the base of the sand pits in the deeper parts of the basin. Whether the brick plants continue to operate in this area, bringing in supplies of raw material from outside, or whether they close down and set up new plants in areas closer to raw materials is difficult to predict.

Plans produced for this report assume continued operation of the brickworks. However, were they to be dismantled, additional sand and clay would be available from beneath them. Most of this is fine sand suitable only for fill and would probably be used in rehabilitation programs within the Extractive Industry area.

GROUNDWATER RECOVERY

Computer modelling of groundwater recovery has been undertaken by Mr. D. Armstrong.

It is predicted that following cessation of mining and dewatering, water levels in the pit floor will rise. There are considerable technical difficulties in predicting the exact level to which water will rise, and the time required for full recovery. These parameters will not be accurately known until mining and dewatering have ceased and monitoring of groundwater recovery has been undertaken for possibly 5-10 years. Because recovery time will exceed 50 years there is merit in accelerating the rate of water recovery after cessation of mining by diverting as much as possible of the surface runoff from the east into the pit area. Such diversion would have greatest impact in the early stages of recovery; it is estimated that water levels would rise to a depth of 2-5 metres over a period of 8-10 years. Because the floor of the central part of the basin is flat, a body of water of sufficient depth for recreation purposes will form relatively quickly over a large area and 70-80% of the area ultimately covered by water will be inundated within about 10 years.

Ultimate water level will not exceed an R.L. of 175-180m AHD, and it will be possible to stop water rising above any desired level below this by installing a spillway or syphon to drain excess water via Cobbler's Creek.

Thus, studies to date have been sufficient to predict -

- Relatively rapid inundation by water of most of the central part of the basin when mining ceases.
- Prolonged recovery of water level, ultimately to R.L.170-180 m.

CONCLUSIONS

1. Golden Grove Extractive Industry area is the centre of the South Australian brick industry and the most important source of construction sand for the northern parts of Metropolitan Adelaide. It will continue to be an important source of construction sand, plastic clay and brick shale into the second half of the 21st Century.

2. A management plan is required which will:
   - Provide a framework for future mining operations;
   - Maximise yield of materials from the area;
   - Assist with co-ordinated reclamation of individual workings;
   - Identify the range of after-uses that may be considered practical options.

3. Overview of future development of the Extractive Industry Area presented in this report is to be used as a starting point for discussions between SADME, Council, DEP, SAULT and the Mining companies. A management plan should be prepared as an outcome of these discussions.

4. Two matters require urgent attention:
   - Negotiations regarding closure of Ross Road;
   - Prohibitiion of further building on the privately owned properties (including the Harpain property) along Greenwith Road.

RECOMMENDATIONS

1. A management plan should have maximum recovery of construction materials as a principal objective.

2. Development plans for individual pits currently approved under the Mines and Works Inspection Act be incorporated into the proposed Management Plan.

3. Agreements should be negotiated between neighbours to mine and share material along their mutual boundaries and such agreements should be included in development plans under the Mines and Works Inspection Act.

4. Ross Road should be closed and underlying resources be made available for mining.

5. Fine tailings dams should be restricted to the northeastern part of the sand mining areas.

6. Vegetative dewatering of Amatek's abandoned western dam should be monitored by drilling and sampling to demonstrate and quantify the effectiveness of this method.

7. No mining of heavy mineral deposits along the eastern part of the basin should take place in a manner that might prejudice ultimate recovery of construction materials.

8. SAULT land south of Greenwith road should be made available for mining:
   . By a single operator;

- Working from west to east, with progressive rehabilitation of worked out areas;
- Progressive drying of tailings in shallow dams;
- Working through the southern half of the 'Hairpain' land.
- The land should remain in SAULT ownership.

9. Material beneath Greenwith Road should be mined but this should take place at a later stage.

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REFERENCES

McCallum, W.S., 1988. Geology of the Golden Grove Extractive Industry Area. South Australian Department of Mines and Energy report 88/46 (unpublished).

APPENDIX A

GOLDEN GROVE PIT RECOVERY, GROUNDWATER MODEL

Results by D. Armstrong, Chief Geologist, Groundwater and Engineering.

GOLDEN GROVE, PIT RECOVERY, GROUNDWATER MODEL RESULTS

1. A conceptual model, using the USGS finite difference model package MODFLOW was developed to investigate the possible rate of recovery of the water level in a pit which was completely dewatered at the conclusion of mining.

   Initially, two basic scenarios were modelled:-

   1) Pit 1 km x 1 km representing the northern part of the Golden Grove deposit.
   2) Pit 2 km x 1 km representing complete extraction of Tertiary sediments.

   Three model runs were made for each scenario:-

   a) Steady State simulation of pre-mining water levels.
   b) Steady State simulation with 25 m drawdown within the pit which gives an indication of the discharge required to maintain 25 m of drawdown.
   c) Transient simulation of recovery of water levels on cessation of mining.

   Input of water to the model was via constant head cells along the eastern boundary (the hills) plus distributed recharge at the rate of 30 mm/year over the entire model. Discharge was via constant head cells along the southern and western boundaries in run a) with the addition of a constant head cell at the pit for run b).

Fig A-1

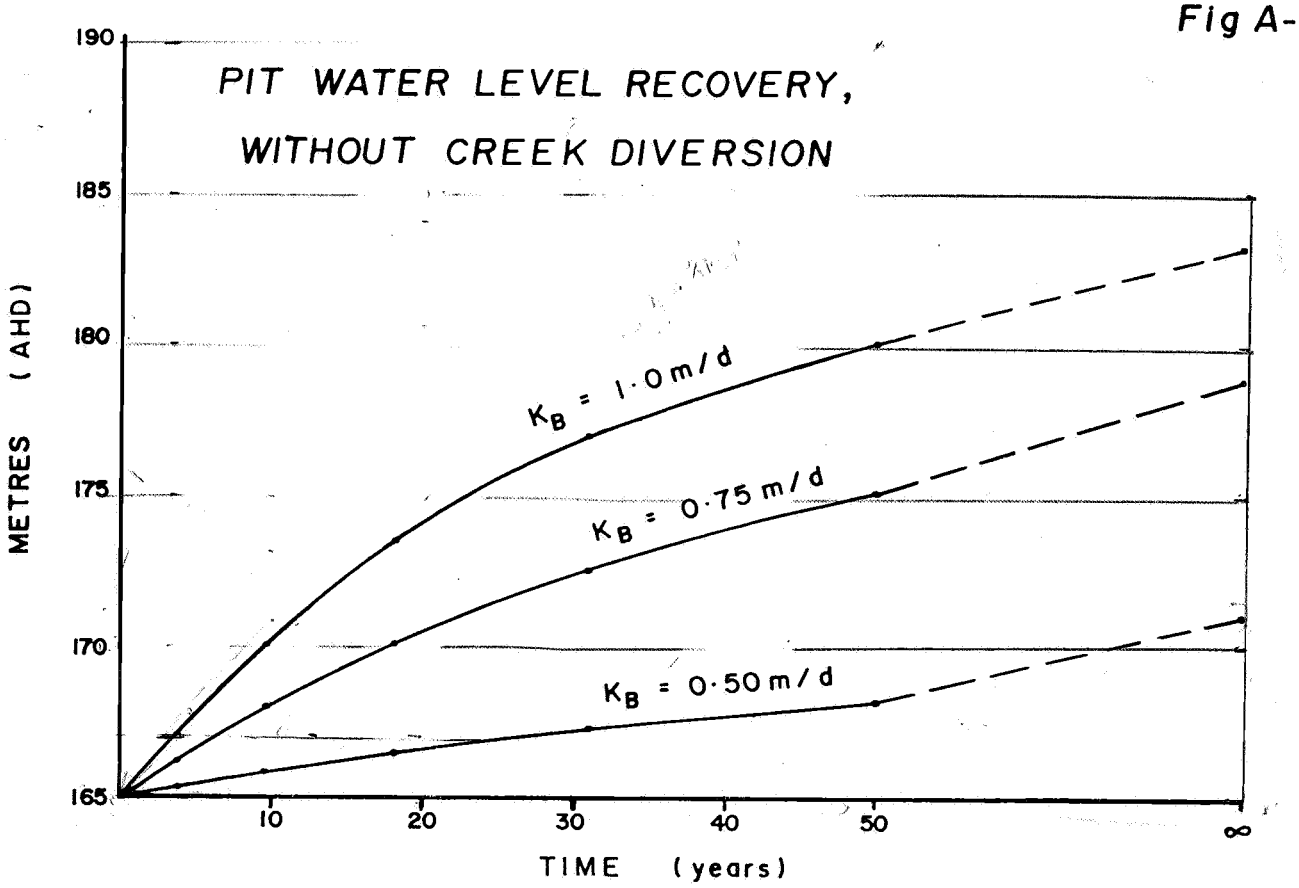
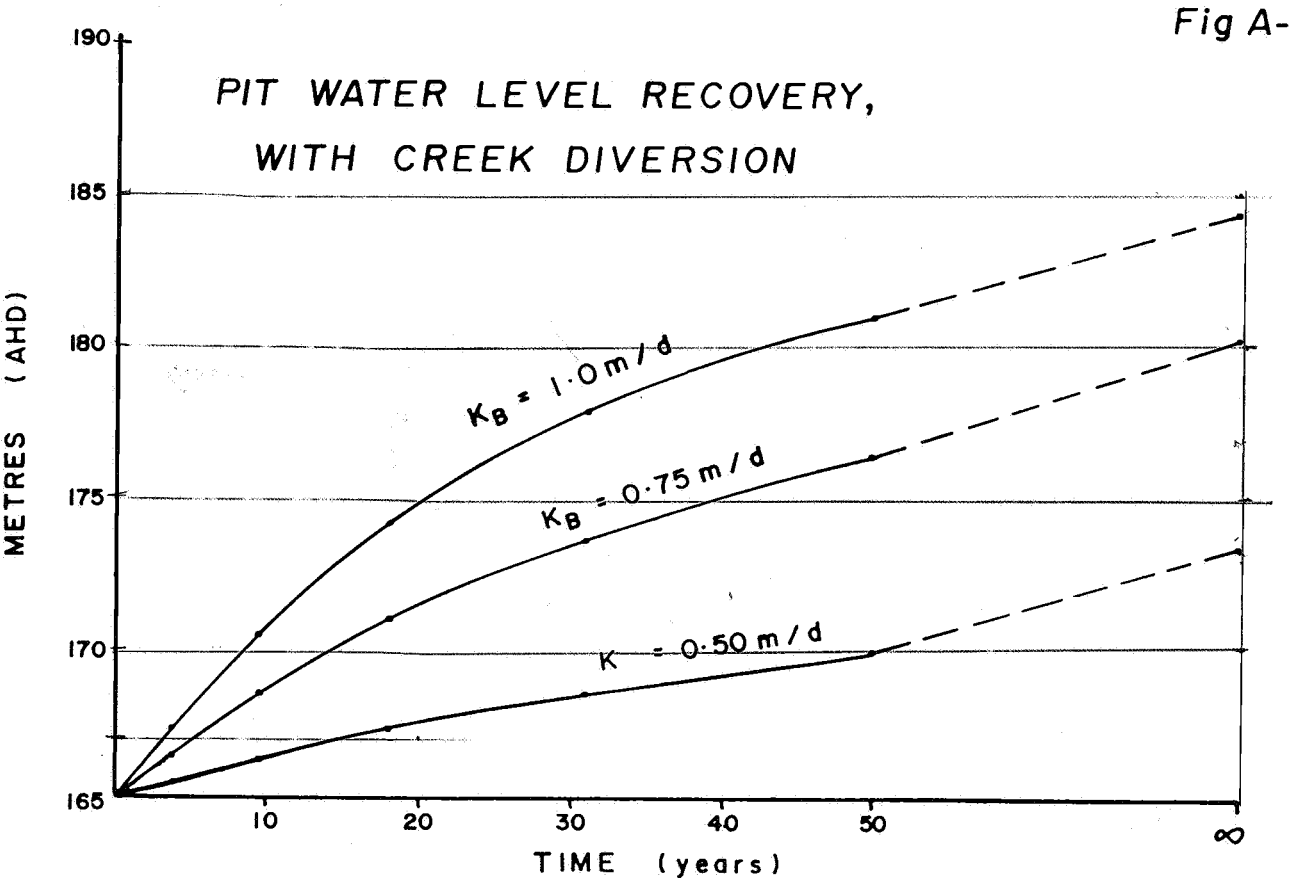


Fig A-2



GOLDEN GROVE : WATER LEVEL RECOVERY
FOR A 1·6 km² PIT (2·3 by 0·7 km)

The constant head at the pit was removed for run c) and the porosity at the pit cell was made equal to unity in order to simulate the filling of a void.

Steady State pit discharges were obtained from run b) for various values of basement rock hydraulic conductivity (KB).

In the transient recovery runs allowance was made for the evaporative loss from the free water surface in the pit.

The evaporative loss was estimated by taking 70% of the pan evaporation observed at Hope Valley (1600 mm/year) and subtracting the estimated 650 mm annual rainfall: (1600 x 0.7)-650 = 470 mm/year nett evaporative loss.

This figure, on a daily basis, was applied to the model as a negative recharge at the pit site.

The strong influence of evaporation and pit area was seen from the much slower recovery rates associated with the 2 km^2 pit, compared with the 1 km^2 pit.

2. Subsequently the model was run for a 2.3 km by 0.7 km (1.6 km^2) pit, as proposed in this management plan.

In the hydrological regime operating at Golden Grove, discharge from the pit comes from water stored in the Tertiary sediments and inflow from the surrounding basement rocks. With complete extraction of the Tertiary sediments the groundwater inflow to the pit, which partly governs the recovery rate, is controlled by the hydraulic

properties of the basement rocks (KB). The other major controlling factors are the evaporation and direct rainfall at the pit site.

In order to examine the sensitivity to KB, transient runs were made over 50 years with KB = 0.5; 0.75; 1.0 m/day and direct rainfall to the pit as the only non-groundwater input. Water level recovery curves are shown in Figure A-1. Recovery can be seen to be slow and strongly dependant upon the assumed value of KB.

Such recovery rates make the planning of rehabilitation a difficult exercise since stability of water levels takes more than 50 years to achieve and uncertainty regarding the hydraulic parameters leads to uncertainty in the level at which post-mining equilibrium will be established.

If the field value of hydraulic conductivity is equal to or less than the values used in the model there is clearly a serious problem with regard to rehabilitation of the pits unless KB is so small that evaporation can cope with all inflow, (REID, DME RB 134/80 estimates that the value of KB lies in the range 2×10^{-3} to 2×10^{-1} m/day).

The best current estimate of KB in the vicinity of the pit, based on evaporative losses and well discharges, places it in the range 0.1 to 1.0 m/day which is unfortunately the range of values over which the recovery is most sensitive to KB.

3. A possible strategy for increasing the rate of recovery involves the diversion of surface drainage into the pit.

A small hills catchment on the headwaters of one branch of Cobbler's Creek lies to the east of the pit area. The approximate area of this catchment is 750 000 m^2 and run-off is estimated to be equivalent to 76 mm/year giving an additional 57 mm/year of water over the 1 km^2 pit area. Rainfall over the pit was revised from 650 to 670 mm and, taking this into account, the effects of creek diversion were to reduce nett pit loss to 393 mm/year.

Model runs for various KB values with creek diversion are presented in Figure A-2, which shows only very minor improvements in recovery rates for early years and increased equilibrium water levels, especially in the case of KB = 0.5 m/day.

4. A second strategy for increasing the recovery rate involved the assumption that the pit could be filled with clean solids (giving a porosity of 0.2) at roughly the same rate that the pit was filling with water.

Evaporative losses would be the same as in the previous runs since free water would be covering the pit bottom.

Equilibrium is attained at 50 years and the system is approaching equilibrium after about 20 years.

This strategy calls for the unreasonably large volume of 2 to 4 million m^3 of fill per year in the early years.

5. A final strategy which was modelled utilised imported water from an outside source such as the River Murray in an attempt to accelerate recovery to the appropriate equilibrium level in the pit with solid fill. By pumping imported water at 11 000 m^3/day continuously, the equilibrium level for KB = 0.5 m/day can be attained after about 4.6 years of pumping.

Although this is a desirable result from the rehabilitation point of view, it is extremely unlikely owing to the lack of nearby water sources or pipelines and the high pumping costs unless the pit could be used as a water storage by EWS. The value of the pit as a water storage is negligible because of the very small catchment draining into it.

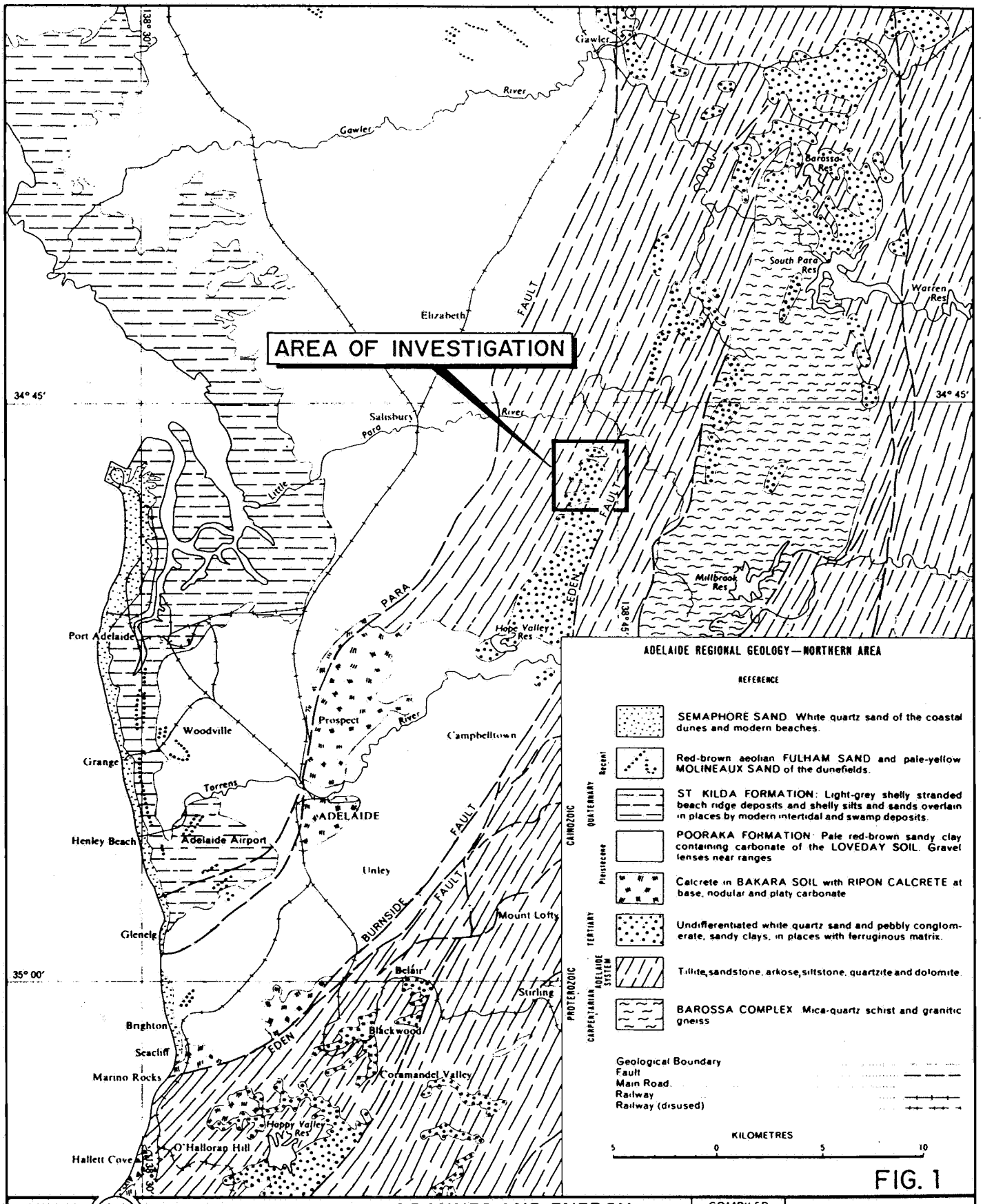


FIG. 1

DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	COMPILED W. McC.	CDO 13.6.89 DATE
	DRAWN A.F.	SCALE 1:250000
GOLDEN GROVE MANAGEMENT PLAN	DATE April '89	PLAN NUMBER
LOCALITY PLAN	CHECKED	S 20760

4796

PF No S9992 GH

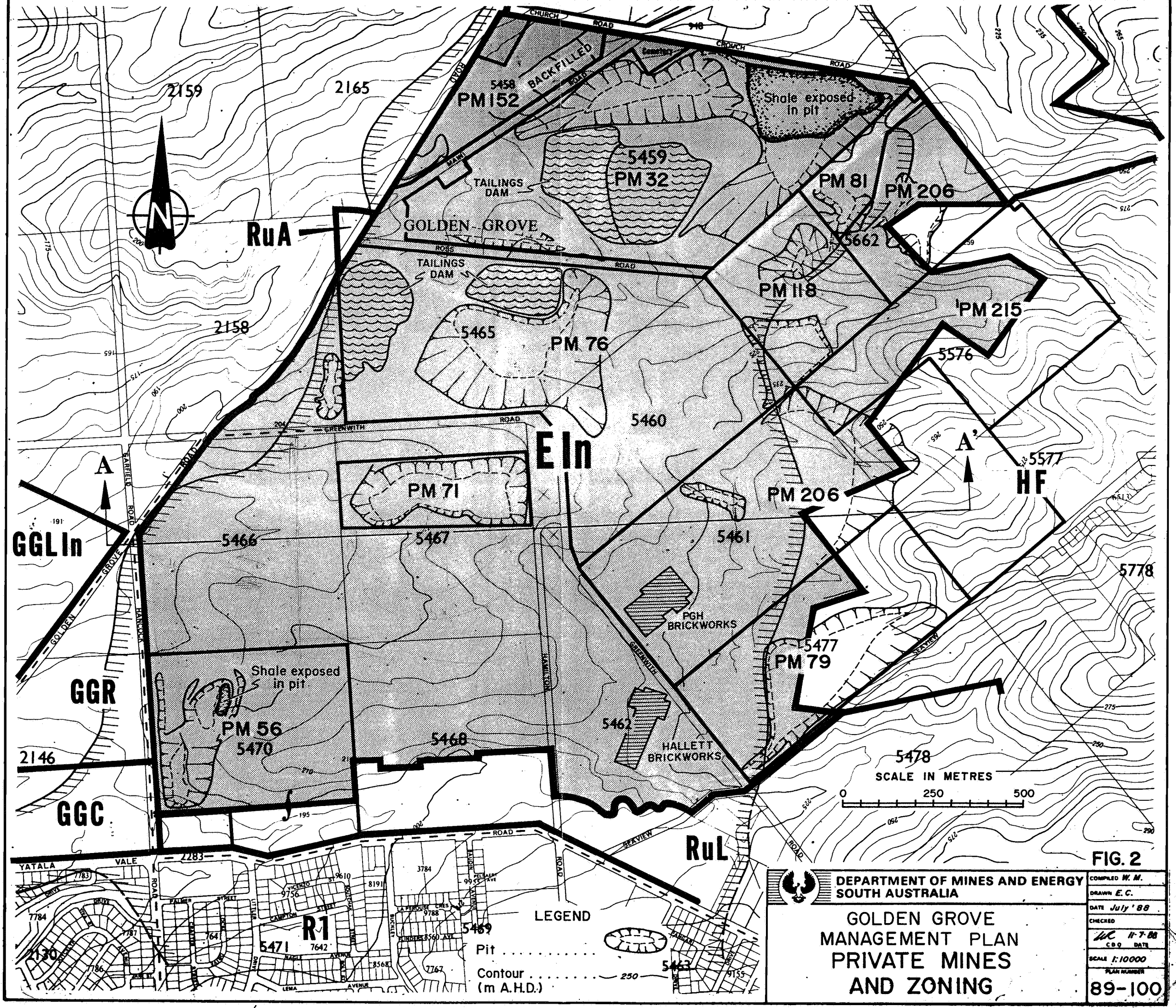


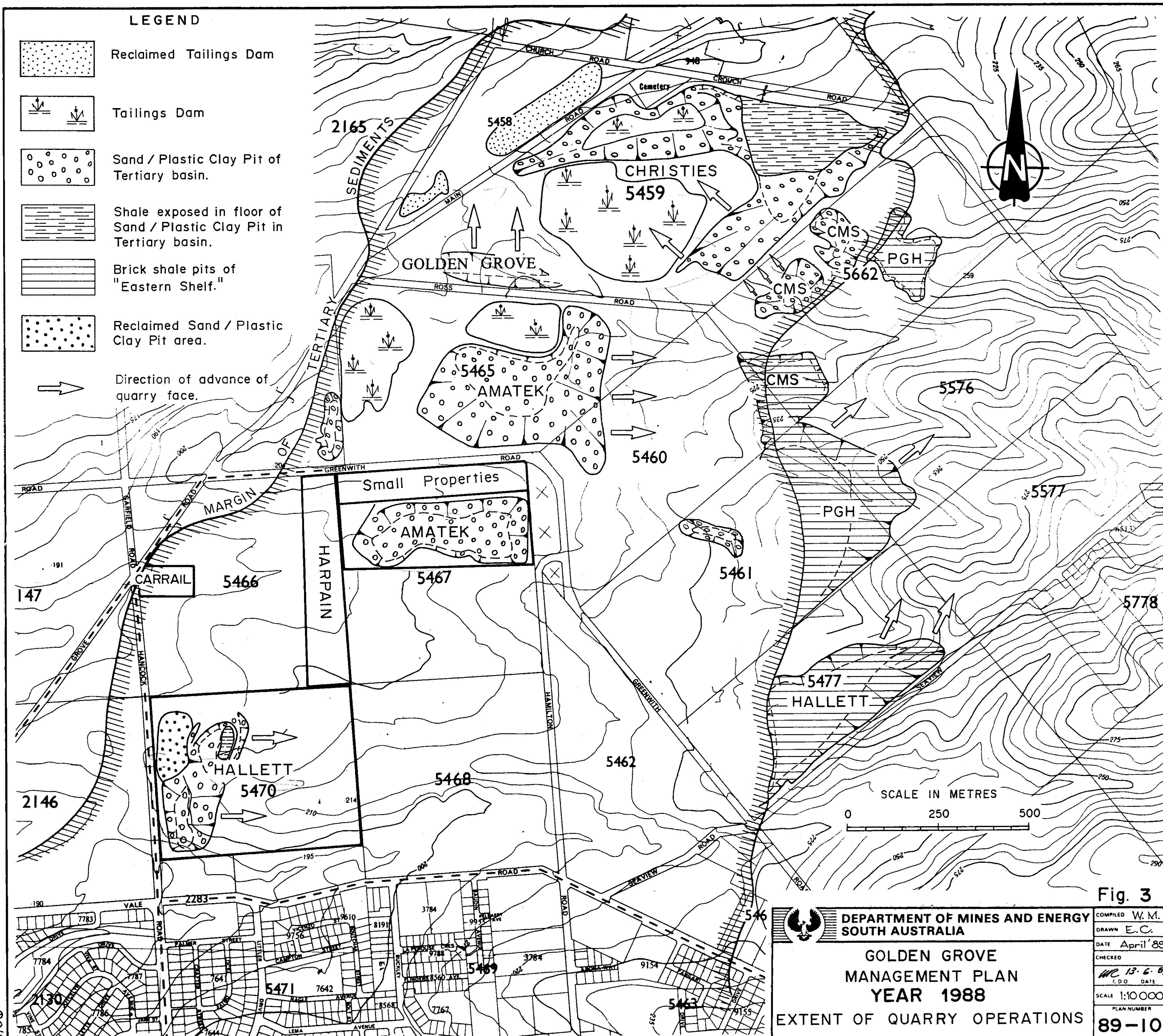
FIG. 2

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GOLDEN GROVE MANAGEMENT PLAN
PRIVATE MINES AND ZONING

COMPILED	W. M.
DRAWN	E. C.
DATE	July '88
CHECKED	
CDQ DATE	11-7-88
SCALE	1:10000
PLAN NUMBER	89-100

4796


LEGEND
Reclaimed Tailings Dam
Tailings Dam
Sand / Plastic Clay Pit of Tertiary basin.
Shale exposed in floor of Sand / Plastic Clay Pit in Tertiary basin.
Brick shale pits of "Eastern Shelf."
Reclaimed Sand / Plastic Clay Pit area.
Direction of advance of quarry face.
CHRISTIES
5459
5458
2165
SEDIMENTS
TERTIARY
OF
MARGIN
GOLDEN GROVE
CHURCH ROAD
CROUCH ROAD
Cemetery
MAIN ROAD
ROSS ROAD
CMS
PGH
5662
5465
AMATEK
5460
5576
5577
5778
5461
5477
HALLETT
Small Properties
AMATEK
5467
HARPAIN
CARRAIL
5466
147
2146
HALLETT
5470
5468
5462
GREENWITH ROAD
GARFIELD ROAD
GROVE ROAD
HANCOCK ROAD
HAMILTON ROAD
GREENWITH
SEAVIEW ROAD
VALE ROAD
2283
5471
5469
5463
2130
SCALE IN METRES
0 250 500
Fig. 3
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA
GOLDEN GROVE
MANAGEMENT PLAN
YEAR 1988
EXTENT OF QUARRY OPERATIONS
COMPILED W. M.
DRAWN E. C.
DATE April '89
CHECKED
C.D.O. DATE 13 · 6 · 89
SCALE 1:10 000
PLAN NUMBER
89–101
479G

LEGEND

- Reclaimed Tailings Dam
- Tailings Dam
- Shale exposed in floor of Sand / Plastic Clay Pit in Tertiary basin.
- Brick shale pits of "Eastern Shelf"
- Reclaimed Sand / Plastic Clay Pit area.

SCALE IN METRES

0 250 500

Fig. 4

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GOLDEN GROVE
MANAGEMENT PLAN
YEAR 2005
EXTENT OF QUARRY OPERATIONS

COMPILED	W.M.
DRAWN	E.C.
DATE	April '89
CHECKED	
	13-6-89
	CDO DATE
SCALE	1:10000
PLAN NUMBER	89-102

4796

LEGEND

- Reclaimed Tailings Dam
- Tailings Dam
- Shale exposed in floor of Sand / Plastic Clay Pit in Tertiary Basin
- Brick Shale Pits of "Eastern Shelf"
- Reclaimed Sand / Plastic Clay Pit area

SEDIMENTS OF TERTIARY MARGIN

GOLDEN GROVE

CHURCH ROAD
CROUCH ROAD
MAIN ROAD
ROSS ROAD
GREENWITH ROAD
HANCOCK ROAD
GARFIELD ROAD
VALE ROAD
SEAVIEW ROAD
HAMILTON ROAD
GROVE DRIVE
Cemetery

2165 5458 5459 5662 5576 5577 5778
2158 5465 5460 5461 5477
147 5466 5467 5462 5468 5470
2146 5471 5469 5463 546
2130

SCALE IN METRES
0 250 500

Fig. 5

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GOLDEN GROVE MANAGEMENT PLAN
YEAR 2045
EXTENT OF QUARRY OPERATIONS

COMPILED	W. M.
DRAWN	E.C.
DATE	April '89
CHECKED	
	13.6.89
SCALE	1:10000
PLAN NUMBER	89-103

4796

LEGEND

- Reclaimed Tailings Dam
- Tailings Dam
- Shale exposed in floor of Sand/ Plastic Clay Pit in Tertiary basin.
- Brick shale pits of 'Eastern Shelf' undergoing rehabilitation
- Reclaimed Sand/ Plastic Clay Pit area.

GOLDEN GROVE

SCALE IN METRES
0 250 500

Fig. 6

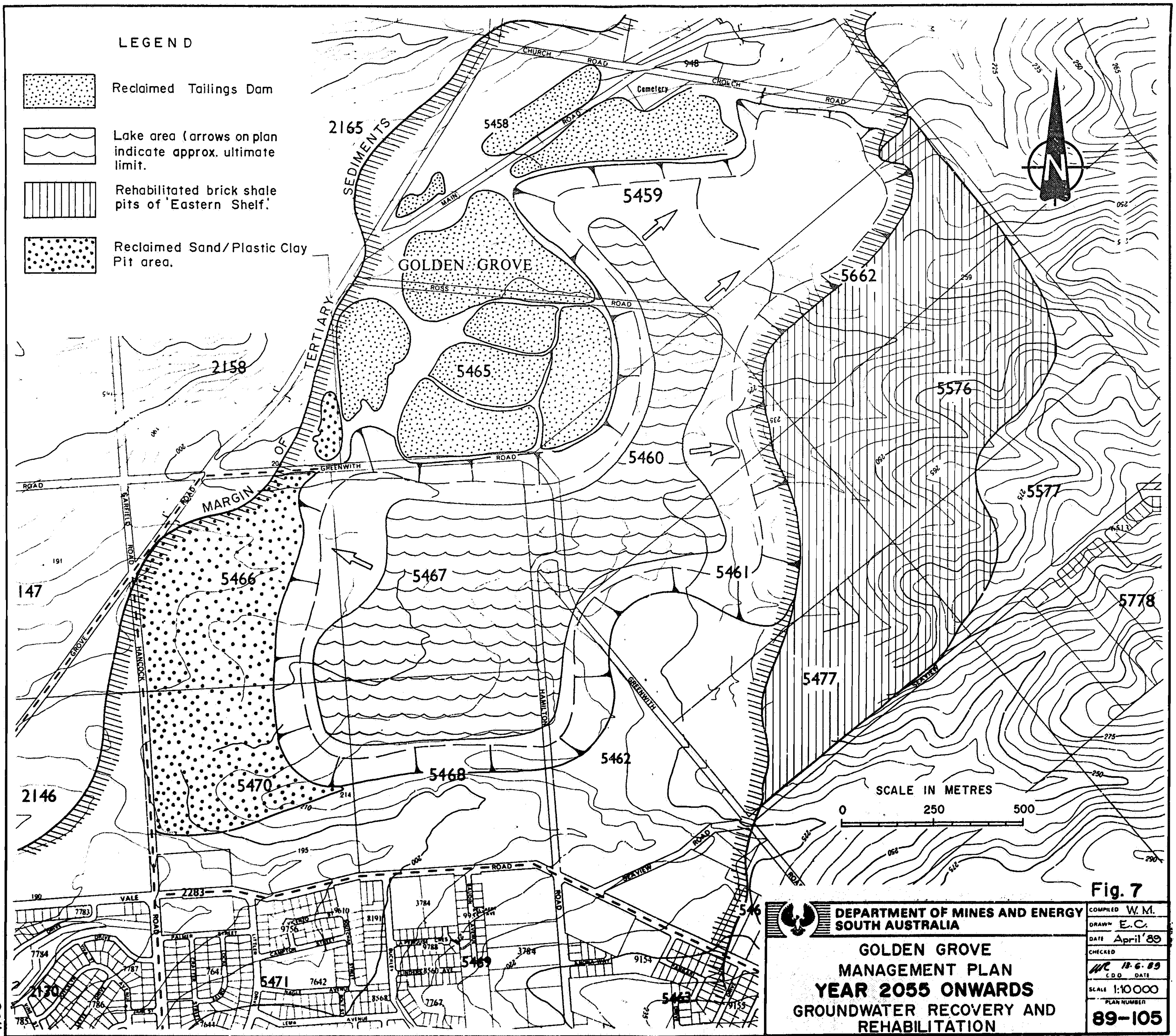
DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GOLDEN GROVE MANAGEMENT PLAN
YEAR 2050
EXTENT OF QUARRY OPERATIONS

COMPILED	W.M.
DRAWN	E.C.
DATE	April '89
CHECKED	
CDO	13-6-89
DATE	
SCALE	1:10000
PLAN NUMBER	89-104

479G

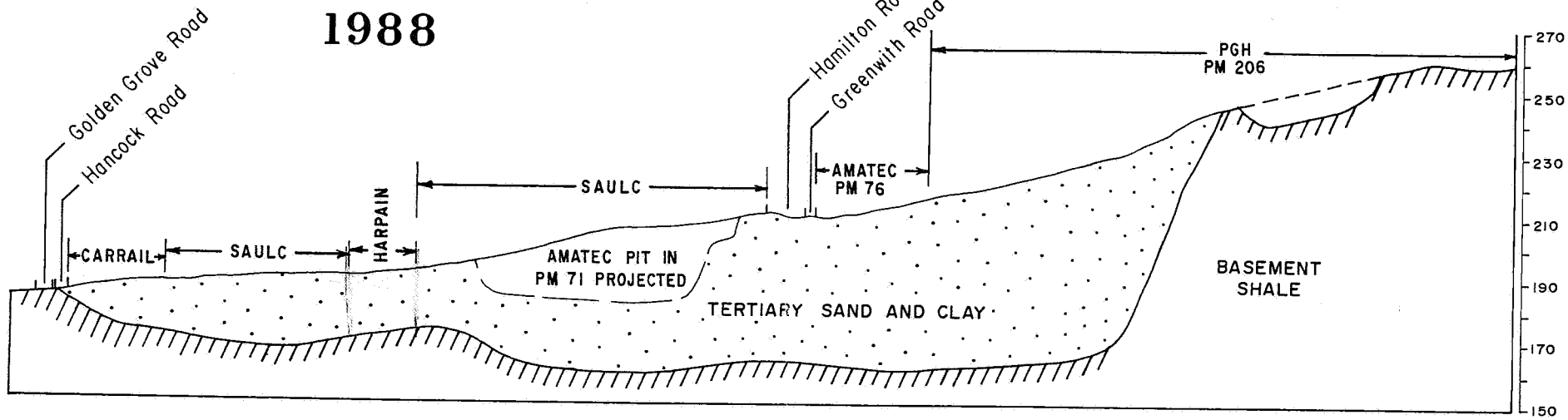
STAEDTLER | MARS 561 70-13 Made in England BS1347


LEGEND
Reclaimed Tailings Dam
Lake area (arrows on plan indicate approx. ultimate limit.
Rehabilitated brick shale pits of 'Eastern Shelf.'
Reclaimed Sand/Plastic Clay Pit area.
GOLDEN GROVE
MARGIN OF TERTIARY SEDIMENTS
CHURCH ROAD
CROUCH ROAD
Cemetery
MAIN ROAD
ROSS ROAD
GREENWITH ROAD
GARFIELD ROAD
GROVE ROAD
HANCOCK ROAD
HAMILTON ROAD
SEAVIEW ROAD
VALE ROAD
2165
5458
948
5459
5662
5465
2158
5460
5576
5577
5466
5467
5461
147
5778
5477
5462
5468
5470
2146
2283
5471
5469
5463
546
2130
SCALE IN METRES
0
250
500
Fig. 7
DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA
GOLDEN GROVE
MANAGEMENT PLAN
YEAR 2055 ONWARDS
GROUNDWATER RECOVERY AND REHABILITATION
COMPILED W. M.
DRAWN E.C.
DATE April '89
CHECKED
CDO DATE 18.6.89
SCALE 1:10000
PLAN NUMBER
89-105
479G

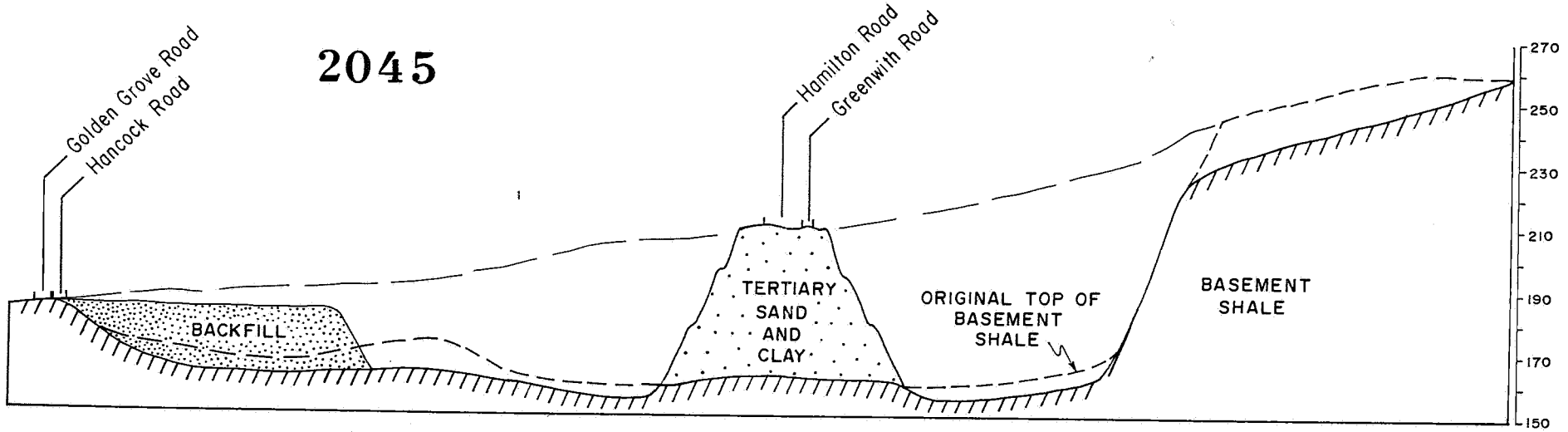
A

A'

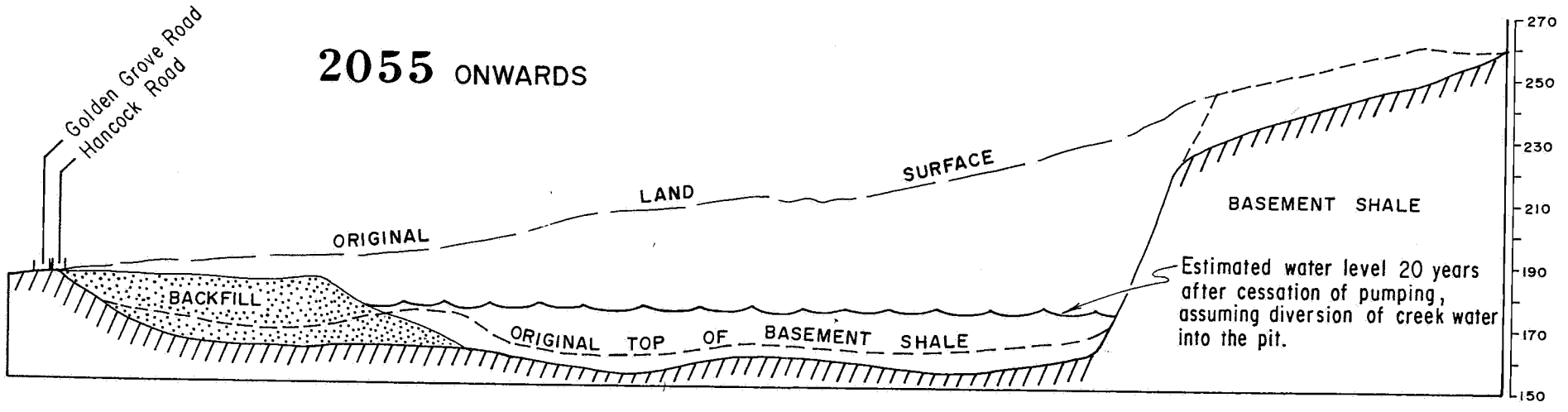
1988



2045



2055 ONWARDS



SCALE

500 0

metres

FIG. 8

DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GOLDEN GROVE MANAGEMENT PLAN

GEOLOGICAL CROSS SECTION A – A'

PROGRESSIVE MINING AND REHABILITATION
1989 – 2055

COMPILED W. M.	C.D.O. 13.6.89 DATE
DRAWN E. C.	SCALE As shown
DATE Mar. '89	PLAN NUMBER 89–106
CHECKED	

4796