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SUMMARY OF STRATEGIC REVIEW OF SAND, CLAY AND SHALE RESOURCES FOR METROPOLITAN ADELAIDE

Submitted by
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Government of South Australia
Primary Industries and Resources SA

SUMMARY OF STRATEGIC REVIEW

of

SAND, CLAY & SHALE RESOURCES

for

METROPOLITAN ADELAIDE

Client: Primary Industries & Resources SA

by

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INTRODUCTION

This review has been undertaken to meet the Government's commitment to maintain a long term competitively priced supply of extractive minerals to the community, as mandated by Strategy 1.5H of the S. A. Government response to the Resources Task Force Report. It has come at a time of critical changes in the Extractive Industries generally, and in the concrete sand and brick industries in particular.

Concrete sand production has changed dramatically over the last decade, driven by the discovery of large, relatively clean construction sand deposits in a Tertiary Palaeochannel on Northern Yorke Peninsula. These deposits increased production from 49 860 tonnes in 1990 to 496 365 tonnes in 2000, gaining 41% of the Metropolitan concrete sand market.
During the past two decades there has been rationalisation in the brick industry, and the consumption of brick clay and shale has declined by almost two thirds. During the post-war building boom of the 1950s and 1960s when population was growing at 2-4% per year, companies acquired large resources of brickmaking materials. In recent years, they have begun to re-assess their long term requirements.

The Golden Grove Management Plan (Pain,1993) is due for review, and significant land use planning decisions need to be made. The last published review of Adelaide's construction materials was undertaken in 1988/89, using 1981 to 1987 production figures for trend prediction. (Pain and Keeling, 1990). This is now out of date. For the current review, reserves and resources of 47 deposits, (or groups of deposits), were assessed more rigorously than previously, and in addition production, transport, and rehabilitation costs were considered.

Initially it was hoped to make the main body of the original report available to the Industry, but for this to have happened, much of the really critical data would need to have been deleted or generalised to maintain confidentiality. This would have greatly reduced its relevance and usefulness, so the consultants were instructed to prepare a detailed confidential report for PIRSA use, and this summary report for wider circulation.

In compiling the main report, the consultants drew on a wide variety of sources, including the large range of open file geological reports compiled by MESA and PIRSA during the 1970s to 1990s. Where it has been necessary to quote individual reserve figures in this summary report, they have been sourced from the open file reports, even though more accurate figures may have been presented in the confidential report to PIRSA.

The generosity of all Companies in providing access to confidential data, and in making time available for detailed discussions is gratefully acknowledged.

NATURAL SAND.

PRODUCTION.

Adelaide's total natural sand market in 2000 was 1.99 million tonnes comprising 1.21 million tonnes of concrete sand, 203 000 tonnes of mortar sand, and 581 000 tonnes of filling sand.

Adelaide has traditionally obtained most of its supplies of natural sand from deposits of Tertiary age located in the Metropolitan and Outer Metropolitan areas. (Fig. 1) In particular:

- Maslin Beach has produced 24.4 million tonnes since production began in 1928.
- Golden Grove has produced 20.0 million tonnes since production began in 1947.
- Gawler East has produced 11.1 million tonnes since production began in 1959, and is now nearing the end of its life.
- Sandy Creek – Rowland Flat has produced 3.6 million tonnes since the early 1950s.
- Highbury – St Agnes, an important source particularly during the 1950s to 1980s is now nearing the end of its life with only CSR's pit in operation.

The Yorke Peninsula Tertiary palaeochannel deposits became an important source of concrete sand in the early 1990s.

Concrete sand production, 1990-2000.

This category includes all sand used in ready-mixed concrete or concrete products such as paving bricks, concrete pipes, pre-cast concrete panels etc. Concrete sand is generally well graded fine to very coarse sand with FMs between 2.0 and 3.0, and fines (silt plus clay) less than 5%, as specified by AS 2758.1-1988. Sand from Metropolitan deposits is washed to reduce fines contents, but clean deposits on Yorke Peninsula can produce concrete sand by dry screening.

Concrete sand production from all sources including Yorke Peninsula ranged from a low of 961 929 tonnes in 1996, to a high of 1 299 044 tonnes in 1990, averaging 1 136 279 tpa over the decade. This is shown graphically on page A1 of the Appendix.

Changes in concrete sand market share by region from 1990 to 2000 are shown in the charts on page A2. Most notable is the growth in the market share of Yorke Peninsula deposits from 3.8% to 41.0%, and Barossa deposits from 1.1% to 16.3% over the decade. Golden Grove and Maslin Beach each halved market share over this time. Regional market share on an annual basis is shown graphically on page A3.

Mortar sand production, 1990-2000.

Brick sand, render sand and plaster sand are grouped into this category. These sands are sometimes washed but generally dry screened with the aim of retaining some silt and clay for workability. These sands are usually finer grained than concrete sands with FMs in the range of 1.4-1.8, although mortar sand with FMs up to 2.2 is also marketed.

Mortar sand production ranged from a low of 135 284 tonnes in 1997, to a high of 203 063 tonnes in 2000, averaging 161 170 tpa over the decade. This is shown graphically on page A1.

Changes in mortar sand market share by region from 1990 to 2000 are shown in the charts on page A4. This market is dominated by Rocla's Maslin Beach and Golden Grove deposits. Regional market share on an annual basis is shown graphically on page A5.

Filling sand production, 1990-2000.

This category includes garden sand, specification filling sand (DS4b) and common fill materials such as clayey sand. These three materials service different markets and only compete within their own market area. Demand for garden sand and specification filling

sand is fairly constant, but sales of common fill sand are extremely variable as they depend on major civil contracts. Common fill is thought to comprise about half to two thirds of this category, so that annual filling sand production is much more variable than concrete or mortar categories, ranging from a low of 533 934 tonnes in 1996, to a high of 1 064 133 tonnes in 1993. Production averaged 756 145 tpa over the decade. This is shown graphically on page A1.
Changes in filling sand market share by region from 1990 to 2000 are shown in the charts on page A6, and annual regional production is shown graphically on page A7.

The single most important source of this material is Golden Grove, which supplied 38% at an average rate of 289 336 tpa.

Around the periphery of the Outer Metropolitan Area, are a number of deposits which are worked specifically for filling sand. These include deposits at Sandy Creek, Mount Compass, McLaren Vale, Callington, One Tree Hill, and Ward Belt, which collectively over the past decade, have supplied 34% of Adelaide's packing, filling and garden sand requirements.

CONCRETE SAND ECONOMICS.

Sand washing operations require greater capital expenditure for the washing plant, site works and mobile mining/transport equipment, than dry screening operations, but metropolitan quarries have lower product transport costs as they are located closer to markets. Dry-screening concrete sand operations on Yorke Peninsula require lower capital expenditure, but have higher transport costs to the Adelaide market. The low capital risk and the high variable cost structure of the Yorke Peninsula operations easily accommodates fluctuations in market volumes. This is particularly important in the Adelaide market where two main consumers of concrete sand, namely Boral and CSR, use their market strength to secure competitive prices. The cost component of sand in a m^3 of concrete, which currently sells for $95-$105, is only about 10%.
Concrete sand is sold to the trade (i.e. high volume sales) for about $11.50/t-$12.00/t ex-pit in the metropolitan area, and both washed and dry-screened sand are actively competing at these prices. An economic analysis has shown that although a new washing plant would be profitable (assuming it continues to sell sand at its design capacity), it would not meet the current financial criteria required for a new business investment by a public company. As the cost of capital is currently at historical lows, this situation is unlikely to change in the foreseeable future. It is interesting to note that less demanding ROI's are required when seeking capital to maintain existing business, although obviously an existing business has less risk than a new business.

Three risk factors associated with sand washing sites are; tailings dams safety, washing water shortages, and rehabilitation costs.

Safety of tailings dams.
Some tailings dams contain in excess of 20m depth of silty-clay at a solids contents of ~40%. There is potential dam wall failure due to inadequate dam wall design, earthquakes, flooding rainfall etc., which could release vast volumes of tailings in a "mud" flow, and cause loss of life, equipment and resources. Such major failures have been recorded interstate.
Washing water shortages.
All existing concrete-sand washing plants are short of water. In some plants this has reduced operating hours, and in some others product quality has suffered. These water shortages are viewed as being due to a lack of supply from water bores, but under the current operating systems, a lot of water is being lost,

- from product stockpiles and in product sand sold,

- into the tailings dams which remain at ~60% water content after settling,
- water leakage through dam floors and walls,
- water lost through evaporation from water storage and tailings dams.

This problem is compounded by the slow re-cycle time (24 hours) in water re-use through the existing tailings settlement dams.

Rehabilitation costs.

During this study it became apparent that the current contribution of $0.10 per tonne to the Extractive Areas Rehabilitation Fund is inadequate to cover the cost for rehabilitation of sites with fine tailings dams.

- no sites with deep tailings dams have previously been rehabilitated so this situation has not previously arisen, and
- under the current system the EARF covers the rehabilitation cost, rather than the quarry operator, so there is no incentive to introduce operating systems or methods to reduce the rehabilitation cost.

Consequently, sand washing plants with deep tailings dams are not covering the full costs of their rehabilitation which is expected to be in the range of $0.60 to $0.70 per product tonne.

This situation needs to be addressed quickly as the EARF is currently short of funds, and at least 3 sites (Boral–Gawler, Pioneer-Noarlunga and CSR-Highbury) with tailings dams are likely to claim on the EARF for rehabilitation within the next 2 years. Rocla-Gawler and CSR-Gawler may also claim on the EARF soon after.

The three operating problems described above can be solved by utilising a modern operating system comprising a clarifier with flocculant, and shallow clay drying dams which are cleaned out to provide dried clay for sale or pit backfill. The total fixed and variable cost is estimated at $0.80 to $0.90 per product tonne, but most if not all of this cost can be recovered by savings in water usage (recycled in ~15 minutes), increased plant productivity, deep tailings dam construction, decreased rehabilitation costs, possible sale of dried tailings to brickworks as well as improved site safety.

The major component of the cost of Yorke Peninsula dry-screened sand is freight. PIRSA requested an analysis of the effect increased fuel prices would have on the long term sustainability of supplies. Confidential information from operators indicates that this industry would still be sustainable with a 50% diesel fuel price increase. Freight costs are actually expected to decrease in about 2 years when road trains carrying 58-60t are likely to be introduced. This will improve the current economics of road freighting sand from Yorke Peninsula.

RESERVES AND RESOURCES

In order to compile the reserve and resource figures tabulated in this section, all available drilling data from PIRSA and Company sources was re-appraised for each of the individual deposits and some GPS mapping was used to update quarry plans.

Sand Reserves and Resources in major Metropolitan and Outer Metropolitan deposits.

Reserves and resources tabulated below are contained within the major construction sand pits currently supplying Adelaide from the traditional Tertiary deposits. They comprise:

- *Golden Grove*: Rocla, Pioneer, Fricker (Dreckow).
- *Highbury*: CSR.
- *Maslin Beach – Pedlar Creek*: Rocla, Pioneer.
- *Gawler*: Rocla, CSR.

- *Sandy Creek to Rowland Flat*: Rocla (Rowland Flat), Trenel, Sloans.

Deposits which contain only filling sand have not been included.

Major Metro., & Outer Metro. pits. Reserves and Resources. (million tonnes)

Category	*Coarse Construction Sand*	*Fine Construction Sand*	*Filling Sand*
Proven Reserves	14.4	8.0	6.1
Probable Reserves	14.9	5.1	4.5
Total Reserves	*29.3*	*13.1*	*10.6*
Measured Resources	3.1	2.4	1.1
Total Reserves & Resources	**32.4**	**15.5**	**11.7**

Sand Reserves and Resources in the Yorke Peninsula Palaeochannel deposits.

Reserves and resources tabulated below are contained within the four main construction sand pits currently in operation, even though only three currently supply Adelaide markets. All have been investigated by drilling programs. They are the CSR pit at Kulpara, and the Direct Screen, Kenny, and Clinton Quarries pits in the Price area. (Fig. 3)

Yorke Peninsula Palaeochannel. Reserves and Resources. (million tonnes)

Category	*Construction sand*	*Filling sand*	*Overburden*
Proven Reserves	7.8	1.6	2.3
Probable Reserves	14.6		2.4
Total Reserves*	**22.4**	**1.6**	**4.7**
Measured Resources	3.1		
Indicated Resources	20.9		9.2
Total Resources**	**24.0**		**9.2**

**Reserves* status is given to dry screenable construction sand (<5% fines). Breakdown into coarse and fine categories has not been possible, but with blending all should be usable in concrete.

***Resources* includes potential construction sand which will, or may, require washing or other processing to reduce fines content to less than 5%. Includes much material for which no sizing analyses have been done.

Additional Sand Reserves in unworked deposits at Golden Grove.

Three sand deposits remain unworked: Hallett's Strachan deposit at the north of the Extractive Industry Zone, and the EMLs which Boral and CSR purchased from the SA Urban Land Trust in 1994. (Fig. 2) Reserve figures in the table below have been previously reported in McCallum, 1978 and Pain, 1994.

Golden Grove. Sand Reserves and Resources in Unworked Deposits. (million tonnes)

Category	*Deposit*	*Coarse Construction Sand*	*Fine Construction Sand*	*Filling Sand*	*Waste & O'burden*
Probable Reserves	Hallett PM109 (Strachan's)	2.9		1.1	0.9
	Boral EML 5893	3.2	0.4	0.1	2.0
	CSR EML 5892	6.9	3.2	6.3	4.1
TOTAL		**13.0**	**3.6**	**7.5**	**7.0**

If the Boral and CSR deposits are mined, additional sand resources will become available by mining batters which would otherwise be left in the adjoining Rocla (PM71) and Hallett (PM56) properties. Mining of the Boral and CSR properties will also facilitate recovery of sand from below the current water table level in PMs 71 and 56. In total 1.3 million tonnes of construction sand and 0.5 million tonnes of filling sand are involved.

Glass Sand.
Rocla have announced the Company's intention to wash and treat fine sand overlying the construction sand deposits in PM76, to supply the new Amcor container glass plant at Roseworthy. Similar raw material is classed as Filling Sand, and overlies construction sand and plastic clay on CSR's EML5892.

PROJECTED LIVES OF CURRENT SAND SOURCES.

In the confidential detailed review it was possible to determine a projected life for each sand pit, based on reserves, size gradings and fines contents of the raw materials, taking into account the current production and product mix of each individual operator. Individual projected pit lives ranged from less than 5 to around 100 years, with the Golden Grove sand pits in the 35–40 year range.

It is not possible to determine the life of a basin by totalling all reserves and production of individual companies operating within it, because when companies exhaust a quarry site, they typically take their market with them. They supply their concrete batching plants from one of their other quarry sites, or negotiate alternative sources of supply. For example, when CSR exhausted the Pedlar Creek sand pit, this market was not picked up by the two adjoining sand quarries, Rocla & Christies (now Pioneer).

For the purposes of this overview, it is necessary to place the reserves and production for the three groups of deposits tabulated above into some easily appreciated context. Probably the best way of doing this is to express the reserves in terms of how many years they could supply the total Metropolitan Adelaide market for each of the three main product groups. This concept of "*years' supply*" is quite different to the true projected life, which will depend on the ebb and flow of market share from basin to basin over time, as demonstrated by the graph of regional concrete sand production on page A3.

Concrete sand.
The cut-off grade between coarse and fine construction sand in the reserve and resource tables above is at FM of 2.0, so for this purpose it is assumed that coarse construction sand is concrete sand. At a consumption rate of 1.2 million tonnes per year:

- Reserves and Resources within existing Metropolitan and Outer Metropolitan sand pits could meet all of Adelaide's concrete sand requirements for 27.0 years.
- Total Reserves in the existing Yorke Peninsula palaeochannel deposits could meet all of Adelaide's concrete sand requirements for 18.7 years.
- In addition to the 45.7 years supply outlined above, additional drilling is likely to upgrade some of the Indicated Resources in the existing Yorke Peninsula deposits to Reserve status. This would increase the total supply of currently operating pits in both regions to more than 50 years.
- In the Yorke Peninsula Palaeochannel, many excellent intersections of potential construction sand are yet to be followed up, so large areas must be considered prospective for further discoveries. Extensive drilling programs may be necessary to locate dry-screenable deposits, and in the longer term it may be necessary to investigate

dry processing options, as it is believed up to 80% of all coarse construction sand in the Price area exceeds 5% fines.

- Corresponding "years' supply" for the three unworked deposits at Golden Grove are: Hallett PM109; 2.4 years, Boral EML 5893; 2.7 years, and CSR EML 5892; 5.8 years. The latter two increase to 3.0 and 8.4 years respectively, if fine and coarse construction sand categories are combined.

Mortar sand.

At present all of Adelaide's mortar sand requirements are met from the Metropolitan deposits, although some Yorke Peninsula sand could meet specifications. If all of the fine construction sand in the currently operating Metropolitan deposits was used for mortar, supply would last 94 years at a rate of 165 000 tpa. In reality, as sand is blended to meet the product mix of individual operator's markets, some of the fine construction sand will end up in other products including concrete sand.

Filling sand.

In addition to the 11.7 million tonnes of filling sand in the major operating Metropolitan sand pits, smaller filling sand deposits at Sandy Creek, Mount Compass, McLaren Vale, Callington, One Tree Hill, and Ward Belt contain known reserves and resources of 6.5 million tonnes. In total these represent a supply of 26 years.

Unworked deposits at Golden Grove contain an additional 1.4 years' supply in Hallett's PM109, and 8.8 years in CSR's EML 5892.

About 50 000 tpa of filling sand is produced as by-product of glass and foundry sand manufacture by Unimin at Mount Compass, where there is no effective limitation on reserves.

POTENTIAL ALTERNATIVE SAND SOURCES.

All other potential exploration targets for construction sand for metropolitan Adelaide have been tested and ruled out by drilling and mapping programs over many years, in particular the Freeling area (Scott, 1989), and the Barossa area (Keeling, 1982). It was the failure of these programs that led to MESA's work on the Yorke Peninsula palaeochannel (Pain, Valentine and Hayball, 1992). Reconnaissance drilling in the Mount Compass area in 1997 failed to locate coarse construction sand (Pain, Shaw, and Valentine, 1998).

MANUFACTURED SAND.

Quartzite supplied 43.8% of the total Metropolitan market for all hard rock quarry products in 1990, and this declined steadily to 34.7% in 2000. Carbonate quarry products increased from 56.2% to 65.3%, continuing a steady trend which has been evident for about 50 years.

Production of manufactured specification sand from 1990-2000 is shown graphically on pages A8, A9, and A10. Significant trends are detailed below.

- Manufactured specification sand production increased from 409 000 tonnes in 1990 to 580 000 tonnes in 2000.
- Quartzite washed and specification sand totalled 249 000 tonnes in 1990 and remained fairly constant throughout the 90's with production of 255 000 tonnes in 2000. The washed portion of this production was 85 000 tonnes in 1990 but declined to 1 000 tonnes in 2000.
- The proportion of washed and specification sand as a percentage of total quartzite quarry output increased from 11.2% in 1990 to 17.3% in 2000.

- Carbonate specification sand production doubled from 160 000 tonnes in 1990 to 326 000 tonnes in 2000. Virtually none of this is washed.
- The proportion of specification sand as a percentage of total carbonate quarry output more than doubled from 5.6% in 1990 to 11.7% in 2000.

Manufactured sand was not part of the brief for this project but this data was compiled for the sake of completeness. These trends are clearly significant, and should be investigated in a strategic review of Adelaide's rock resources.

BRICKMAKING MATERIALS. CLAY AND SHALE.

PRODUCTION.

During the past two decades there has been a significant decline in the consumption of brickmaking materials. A study by Keeling, (1989) reported that 1980 brick shale and clay production totalled 844 660 tonnes, comprising 731 738 tonnes of weathered shale, 95 658 tonnes of white plastic clay, and 17 264 tonnes of red plastic clay. Official production records are incomplete, but total consumption of brickmaking clay and shale in 2000 is believed to be about 280 000 tonnes, roughly a third of the level of two decades ago. A variety of factors have led to this long-term decline in brick consumption including slowing of population growth and changing construction methods, but this seems to have flattened off since the mid 1990s, and all producers report a current upturn in demand. Changing practices within the brick manufacturing process have led to a steady decline in clay consumption from over 4 tonnes of raw materials per thousand bricks to ~3.4 to 3.8.

Over this period there has been a concentration of the brick industry at Golden Grove, where about 90% of Adelaide's clay bricks and pavers are now produced. The major producers, Hallett and PGH have one plant each at Golden Grove. Hallett plants at Allenby Gardens and Lonsdale, and the PGH plant at Glen Osmond closed in the 1980s. Independent plants operated by Falzon Brick Company Pty Ltd at St. Agnes, and Inglewood Brick Company Pty Ltd at Inglewood have also closed. Independent operators Salisbury Brick Pty Ltd and Littlehampton Brick Products Pty Ltd are still in production.

Internal company figures were used in the Strategic Review, as PIRSA's production records are incomplete. Consequently it has not been possible to provide production graphs.

RESERVES AND RESOURCES. GOLDEN GROVE REGION.

About 75% of all brickmaking materials are weathered shale, predominantly red-firing. The remaining 25% is plastic clay, with red and white plastic clay consumed in roughly equal proportions. Plastic clay is necessary to improve extrusion characteristics of brick blends, increase green strength, and enhance firing characteristics.
Golden Grove is one of the few areas where both main types of raw material for brick manufacture occur together. Tertiary sediments comprising sand and white plastic clay overlie weathered Adelaidean shale deposits. White, coloured and red shale deposits occur beneath the Tertiary sediments, but shale along the eastern flank of the basin in the area known as the "eastern shelf" is predominantly red-firing.

Weathered Shale.

In order to compile the reserve and resource figures tabulated in this section, all available drilling data from PIRSA and Company sources was re-appraised for each of the individual

deposits, and some GPS mapping was used to update quarry plans. Figures tabulated below include all deposits currently used to supply the two plants at Golden Grove:

- *Hallett.* Dentons & Deacons (PM32, 81, 118, PMB206), Golden Grove Shale (PM79), Dreckows (PM56), and Poultons (PM79), located ~1km east of the main Golden Grove basin. Strachans (PM109) at the north of the basin is not included.
- *PGH.* Golden Grove No.1 & No.2 (PMA206), One Tree Hill (PM88), and Range Road South (PM201) at Anstey Hill.

Weathered Shale Reserves and Resources supplying Golden Grove (Million tonnes).

	White shale	*Coloured shale*	*Red shale*	*Unclassified shale*
Proven Reserves	1.14	0.15		
Probable Reserves	0.74	1.48	12.69	
Total Reserves	***1.88***	***1.63***	***12.69***	
Indicated Resources	0.40		1.30	
Inferred Resources				0.38

White Plastic Clay.

The main Tertiary plastic clay layer at Golden Grove is up to 15m in thickness and occurs at depths of 10m-40m below the surface. Overburden varies from fine silty-clayey sand to coarse concrete sand. The clay layer follows the eastern boundary of the basin for about 3km, from Hallett's PM's 32, 81 &118 in the NE, heading SW through the eastern side of Rocla's PM76, and the SE corner of Rocla's PM71, most of CSR's EML 5892 and further SW into Hallett's PM56. Distribution of this unit is well documented in McCallum, 1988. Probable Reserves total 8.25 million tonnes. Included in these reserves is a substantial quantity of plastic clay in Rocla's PM 76, although tailings disposal is proposed in this location.
Additional limited reserves are held by PGH, and an independent operator E.W. Ross at One Tree Hill.

Red Plastic Clay.

By far the most important source of this material is reclaimed sand washing tailings. Both companies use this material, but PGH also use some discoloured Tertiary plastic clay from their One Tree Hill deposit (PM88).

PROJECTED LIVES OF BRICKMAKING MATERIALS. GOLDEN GROVE REGION.

Weathered Shale.

Lives were calculated for white, coloured and red shale reserves for both PGH and Hallett. These 6 calculations ranged from 46 to 142 years. Hallett in particular are well supplied, even without the ~4 million tonnes in the Strachans (PM109) deposit at the north of the basin.

White Plastic Clay.

Hallett reserves in the Denton-Deacon and Dreckow deposits are sufficient to meet the Company's requirements for over 100 years at current rates
Significant reserves are located on Rocla's PM76, but this is almost all below and east of the existing pit floor level, and are unlikely to be available for mining in the long term.
PGH have only very limited reserves at One Tree Hill, and no reserves in their own right at Golden Grove. PGH's parent company, CSR has reserves of the order of 100 years on their unworked EML 5892.

Red Plastic Clay.
The rate of generation of sand washing tailings exceeds consumption rates, so they are regarded as a renewable resource.

BRICKMAKING MATERIALS. ALTERNATIVE SOURCES.
The study by Keeling, 1989 nominated areas prospective for weathered shale north of Adelaide in the She Oak Log, Concordia and Sandy Creek areas, and in the Echunga and Kuitpo areas south east of the city.
Alternative sources of white plastic clay are much more difficult to locate. Extensive programs in the 1970s and 1980s failed to locate any deposits outside of Golden Grove and One Tree Hill, except for Fricker's McLaren Vale deposit (PM 279) which has remaining reserves of only 0.6 million tonnes, and a small low grade deposit at Sandy Creek. (Keeling, 1981, Pain, 1976)
Salisbury Brick Pty Ltd obtain red shale from Rocla at Gawler, cream shale from Sandy Creek, red plastic clay from their Concordia deposit and white plastic clay from E.W Ross at One Tree Hill and from Geue's Sandy Creek pit.
Littlehampton Brick Products Pty Ltd obtain shale from their own deposits at Littlehampton and Echunga, and some is also supplied by L Fricker from the Baker Gully pit. White Plastic clay is supplied by L Fricker from McLaren Vale.

CONCLUSIONS AND RECOMMENDATIONS

Natural Sand

Adelaide has traditionally obtained most of its supplies of natural sand from deposits of Tertiary age located in the Metropolitan and Outer Metropolitan areas. Reserves and Resources remaining within operating sand pits in these areas could meet all of Adelaide's concrete sand requirements for 27.0 years.

Sand from Metropolitan deposits is washed to reduce fines contents, but cleaner deposits on Yorke Peninsula can produce concrete sand by dry screening. Over the course of the decade 1990-2000, output from these deposits grew to 41% of the total Adelaide concrete sand market.

Total Reserves in currently operating sand pits in the Yorke Peninsula palaeochannel could meet all of Adelaide's concrete sand requirements for 18.7 years.

In addition to the 45.7 years supply outlined above, additional drilling is likely to upgrade some of the Resources in the Yorke Peninsula deposits to Reserve status, which would increase the total supply from currently operating pits in both regions to more than 50 years.

Analysis of the cost structure of dry screened sand delivered to the Adelaide market indicated that even substantial rises in diesel fuel costs would not make this source uncompetitive in the foreseeable future.

The construction sand deposits on Northern Yorke Peninsula are essential for Adelaide's long term supplies of concrete sand, and their importance should be recognised in the State's Development Plan.

Apart from broadly spaced reconnaissance drilling by MESA in 1991-92, and some grid drilling at individual pits, there is little information on the geology of these important deposits, which in detail are quite variable. Many drillhole intersections of potential construction sand are yet to be followed up, so the palaeochannel is considered prospective for further discoveries. Extensive drilling programs may be necessary to locate dry-screenable deposits, as it is believed up to 80% of all coarse construction sand in the Price area exceeds 5% fines, and overburden in places exceeds 30m. In the longer term it may be necessary to investigate dry processing options for fines reduction.

It is recommended that PIRSA monitor any future drilling of construction sand deposits on Northern Yorke Peninsula, in order to better understand their geology and capture data which will aid in their long term management.

At Golden Grove there are three unworked deposits containing coarse construction (concrete) sand: In terms of years' supply of concrete sand for all of Adelaide, they are:

- Hallett's PM109 (Strachans deposit); 2.4 years.
- Boral's EML 5893; 2.7 to 3.0 years.
- CSR's EML 5892; 5.8 to 8.4 years.

These are in addition to the 27.0 years in operating Metropolitan pits.

At present all of Adelaide's mortar sand requirements are met from the Metropolitan deposits, although some Yorke Peninsula sand could meet specifications. This market is dominated by Rocla's Maslin Beach and Golden Grove pits.

Filling sand reserves and resources in the major operating Metropolitan sand pits, together with smaller deposits at Sandy Creek, Mount Compass, McLaren Vale, Callington, One Tree Hill, and Ward Belt in total represent a supply of 26 years.

Golden Grove is the single most important source of this material having supplied 38% of Adelaide's total requirements from 1990-2000 at an average rate of 289 000 tpa.

Unworked deposits at Golden Grove contain an additional 1.4 years' supply in Hallett's PM109, and 8.8 years in CSR's EML 5892.

None of the three unworked construction sand deposits at Golden Grove could be worked independently, as Public Companies are unlikely to achieve the return on capital required to justify new metropolitan sand washing plants. The currently operating sand pits at Golden Grove however are expected to continue in operation for around 35-40 years.

Brickmaking Materials

During the past two decades there has been a significant decline in the consumption of brickmaking materials. Total consumption of brickmaking clay and shale in 2000 was about 280 000 tonnes, roughly a third of the 1980 level. Over this period there has been a concentration of the brick industry at Golden Grove, where about 90% of Adelaide's clay bricks and pavers are now produced by Hallett and PGH. Golden Grove is one of the few areas where weathered shale and plastic clay occur together.

Lives of white, coloured and red shale reserves for PGH and Hallett at Golden Grove and environs are between 46 and 142 years. Hallett in particular are well supplied, even without the ~4 million tonnes in the Strachans (PM109) deposit at the north of the basin.

Hallett reserves of white plastic clay in the Denton-Deacon and Dreckow deposits are sufficient to meet the Company's requirements for over 100 years at current rates.

PGH have only very limited white plastic clay reserves at One Tree Hill, and none in their own right at Golden Grove. Their parent company, CSR has reserves of the order of 100 years on their unworked EML 5892.

Extensive programs in the 1970s and 1980s failed to locate any significant white plastic clay deposits outside of Golden Grove and One Tree Hill, except for Fricker's McLaren Vale deposit (PM 279) which has remaining reserves of only 0.6 million tonnes.

Golden Grove

It is recommended that the Golden Grove Management Plan Working Group be re-convened to revise the current management plan in the light of issues identified in this report.

Revision of the management plan should pay particular attention to the following points:

- The currently operating sand pits at Golden Grove are expected to continue in operation for around 35-40 years, and the brick industry for over 50 years. Consequently, the existing extractive and brick manufacturing industries at Golden Grove will continue to require a high degree of protection from the encroachment of housing, or other land uses incompatible with mining and brick manufacture.
- Shortages of water for sand washing are becoming an issue. Hydrological studies, including surface water run-off and ground-water supplies are a priority. The eventual rehabilitation of deep tailings dams remains a critical issue.

Maslin Beach / Noarlunga

The current Extractive Industry Zone to the east of sections 139 and 149 (the former CSR pit and current Pioneer pit) could be re-zoned for other uses. Additional drilling undertaken since the zone was determined has shown that these areas contain no significant construction sand resources, but only filling material which is unlikely to ever be mined.

Operational

Current sand washing operators should be encouraged to change to a system of flocculating tailings and drying in shallow dams for the following reasons:

- Deep tailings dams are a safety hazard, and can sterilise resources.
- The new system has rapid recycling of washing water and lower losses.
- Deep tailings dams represent a growing rehabilitation problem and liability.

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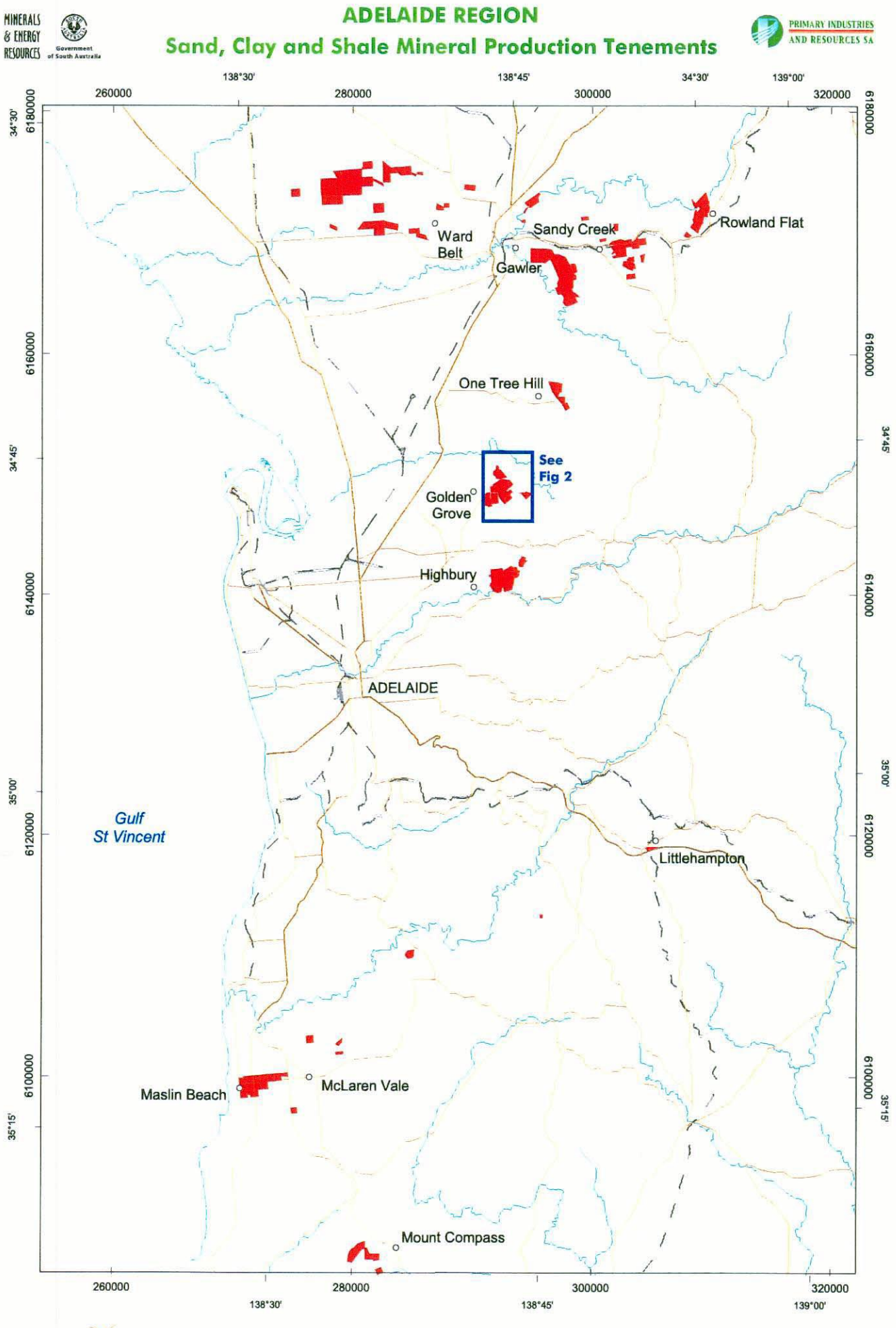

Figure 1

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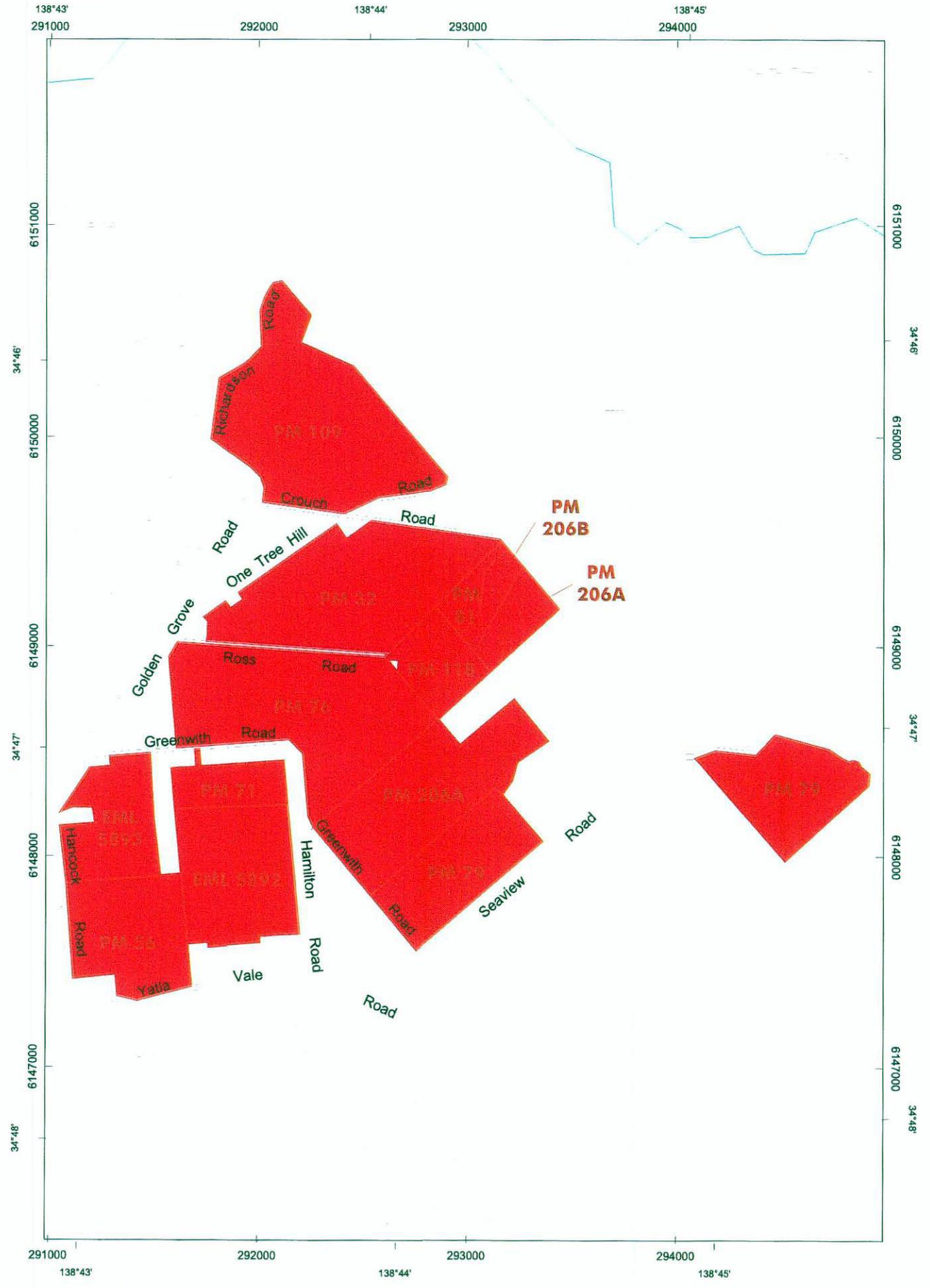
MINERALS & ENERGY RESOURCES

Government of South Australia

GOLDEN GROVE
Current Mineral Production Tenements

PRIMARY INDUSTRIES AND RESOURCES SA



0 250 500 750 1000 Meters

Projection: MGA Zone 54

GDA

Mineral Production Tenements

Figure 2

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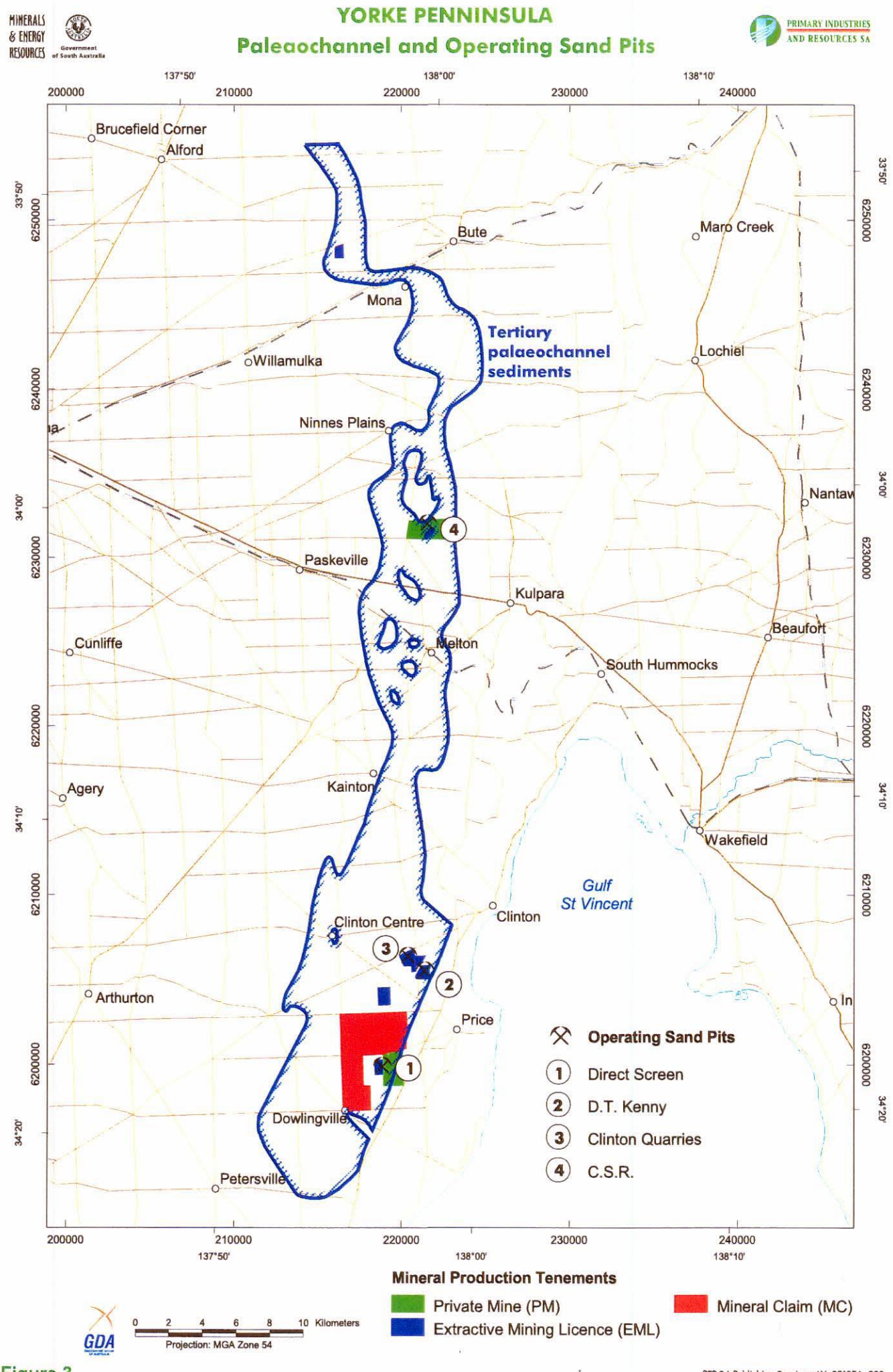

Figure 3

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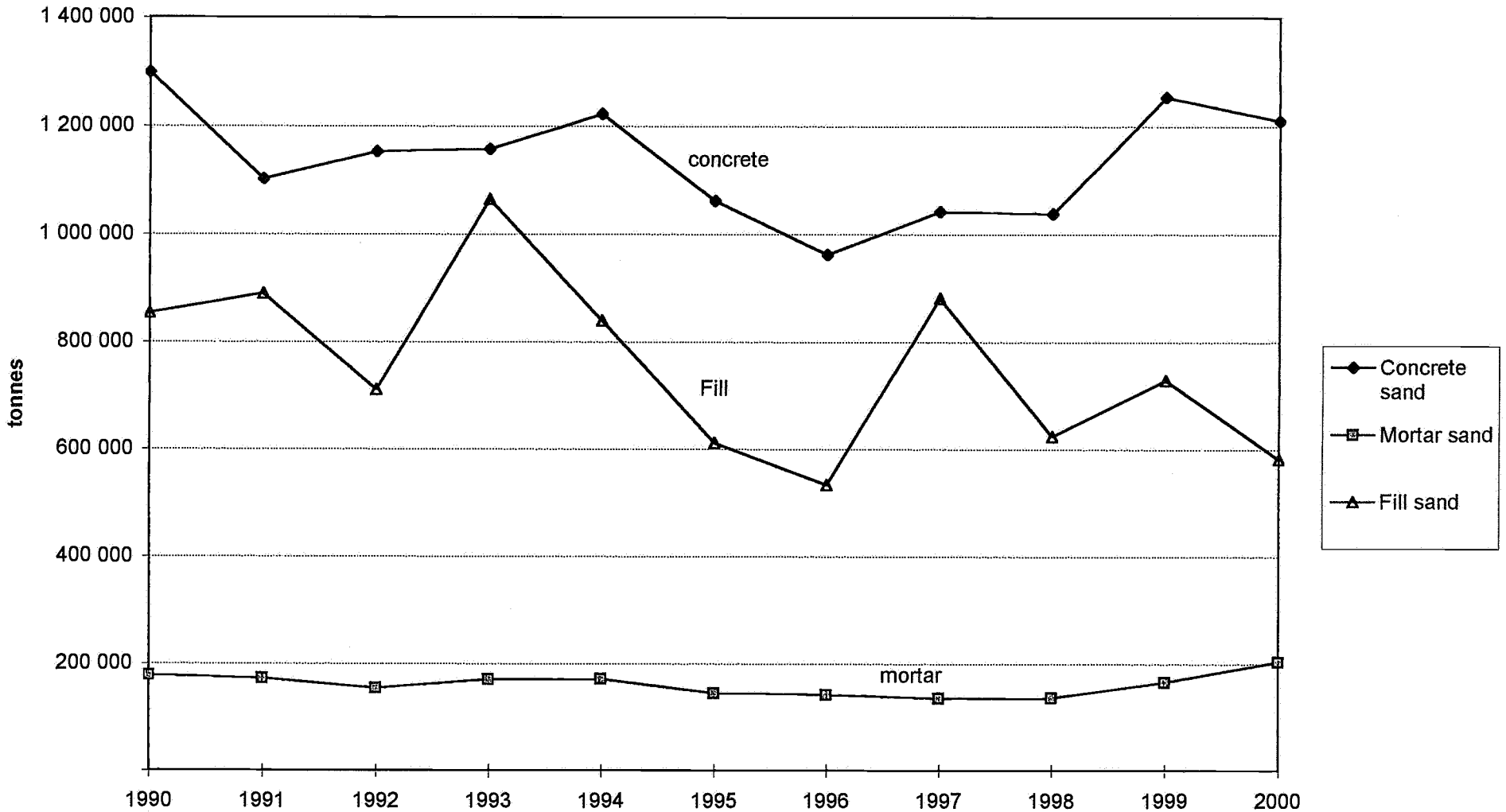
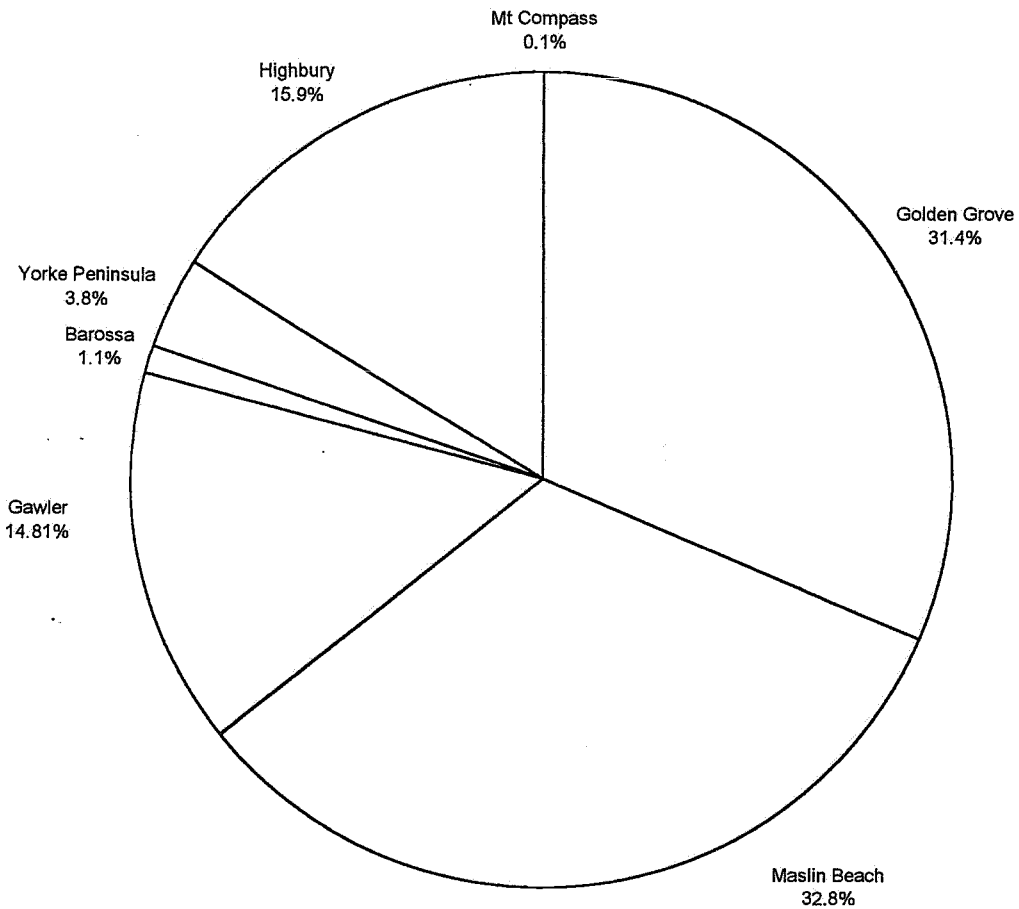
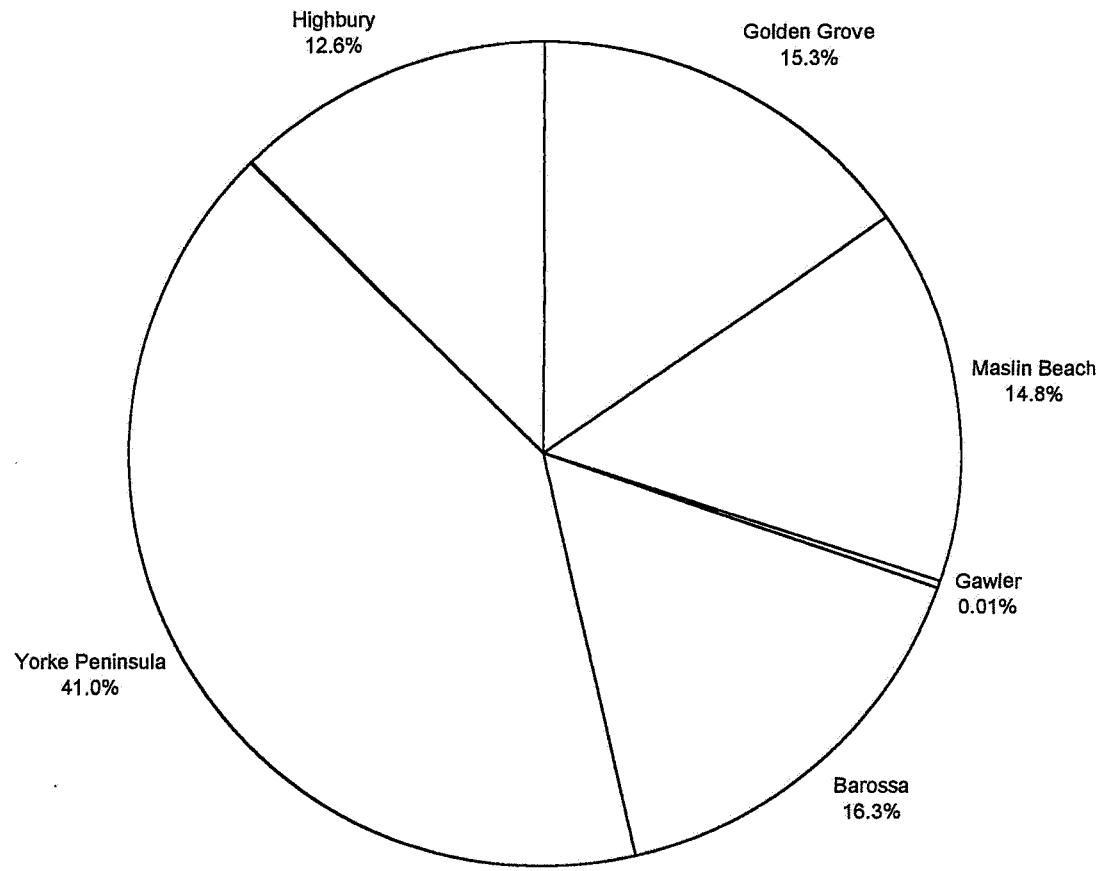
Total concrete sand, mortar sand, fill sand production 1990 - 2000



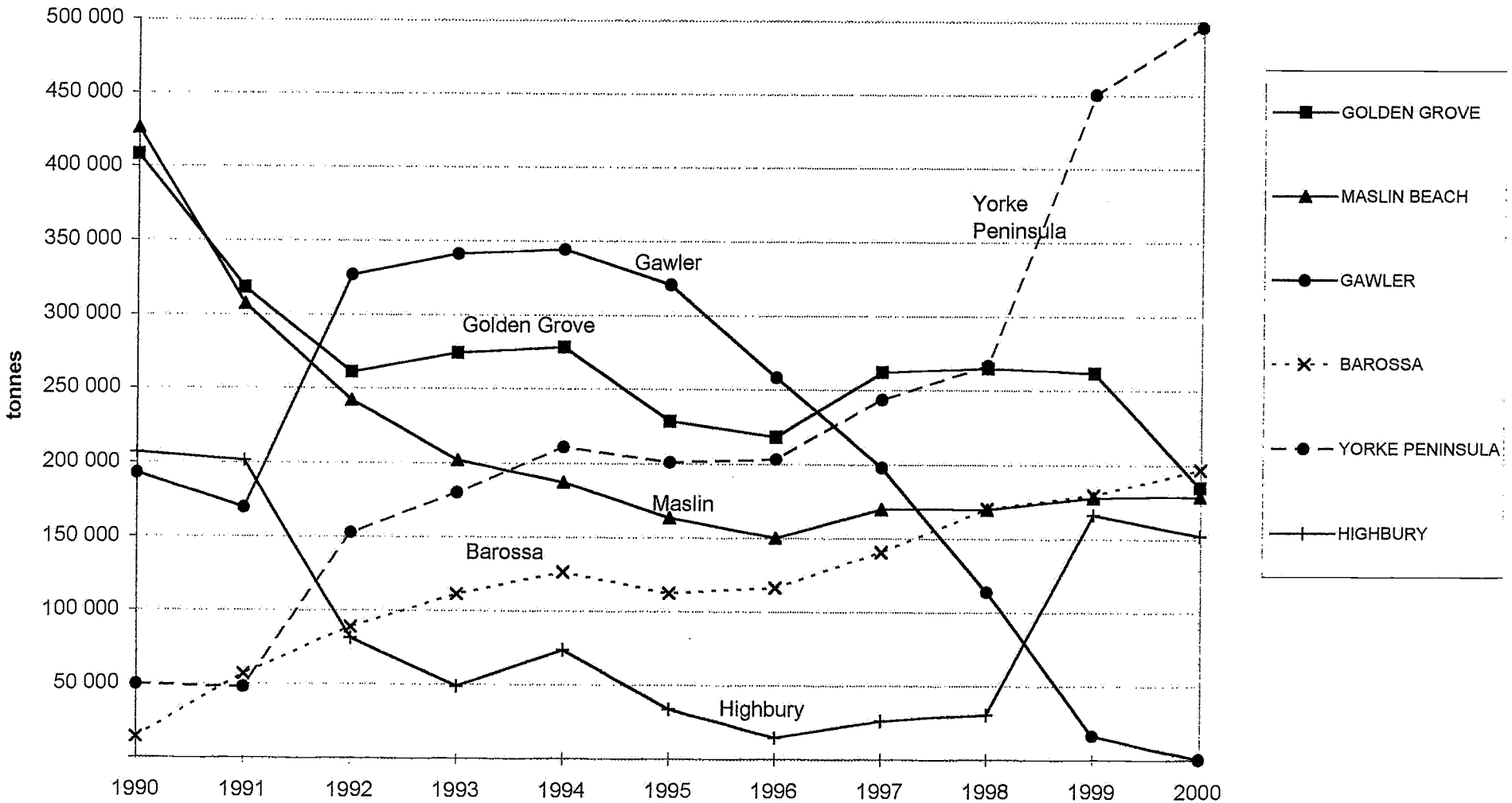
CONCRETE SAND Market Share by Region, 1990



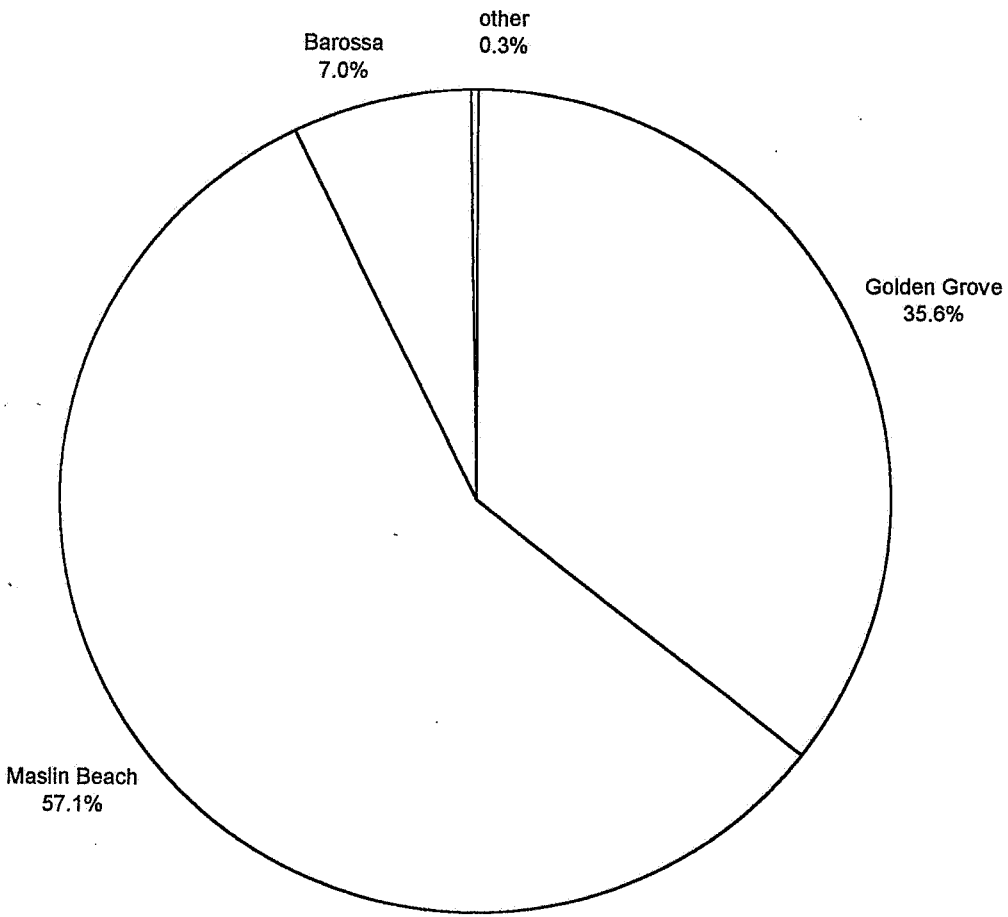
CONCRETE SAND Market Share by Region in 2000



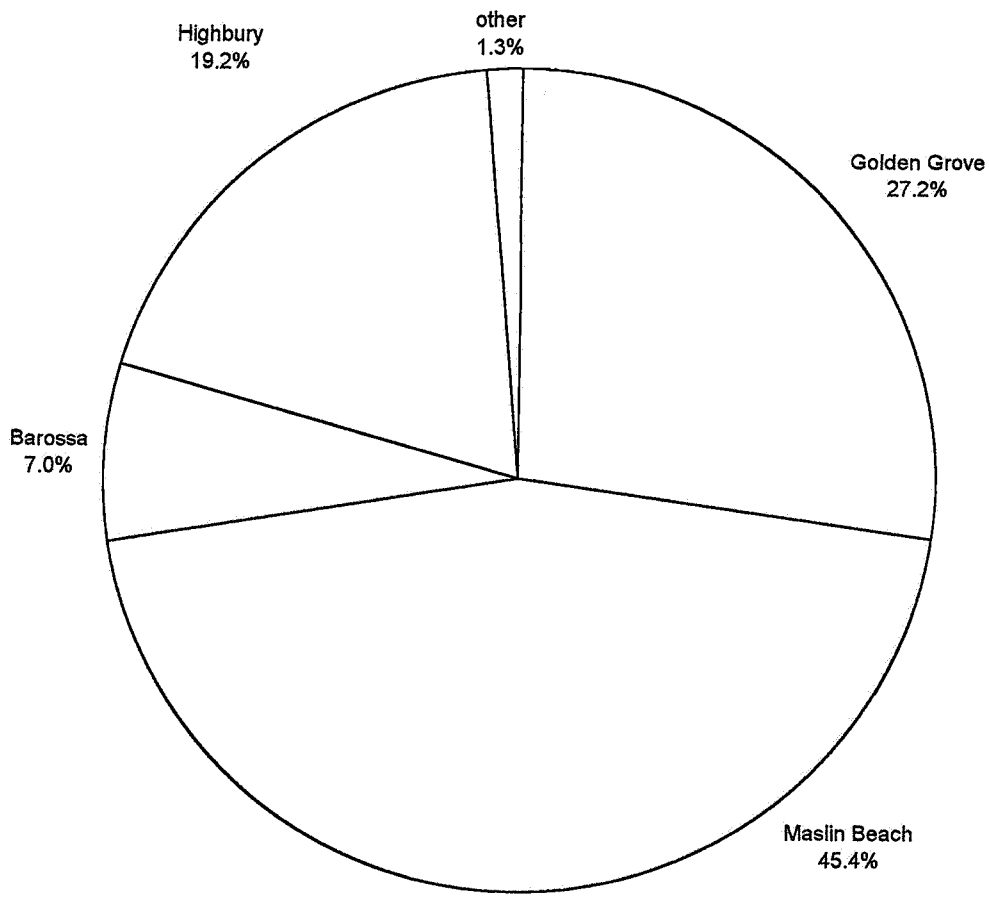
Regional concrete sand production 1990 - 2000



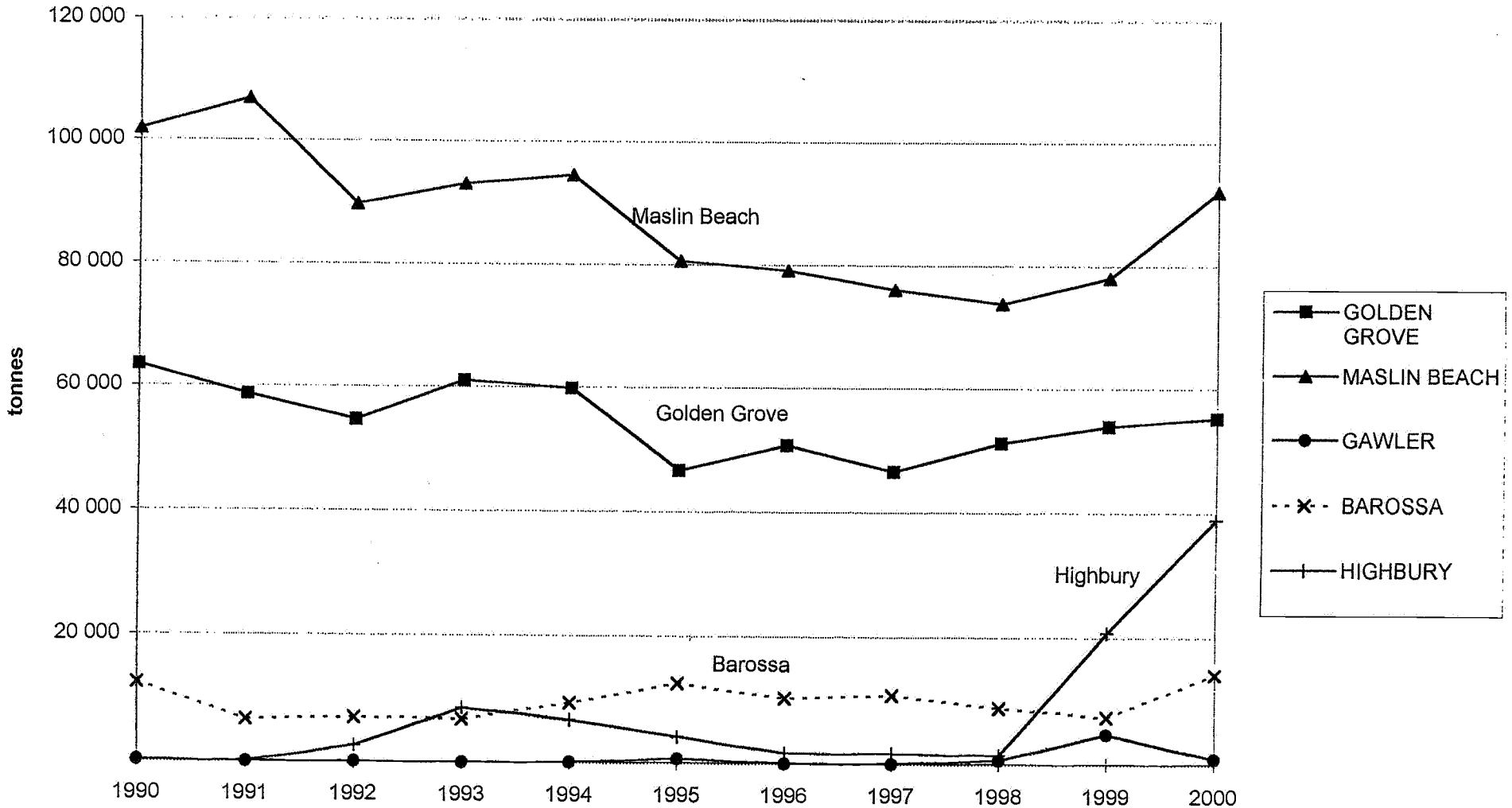
MORTAR SAND Market Share by Region, 1990



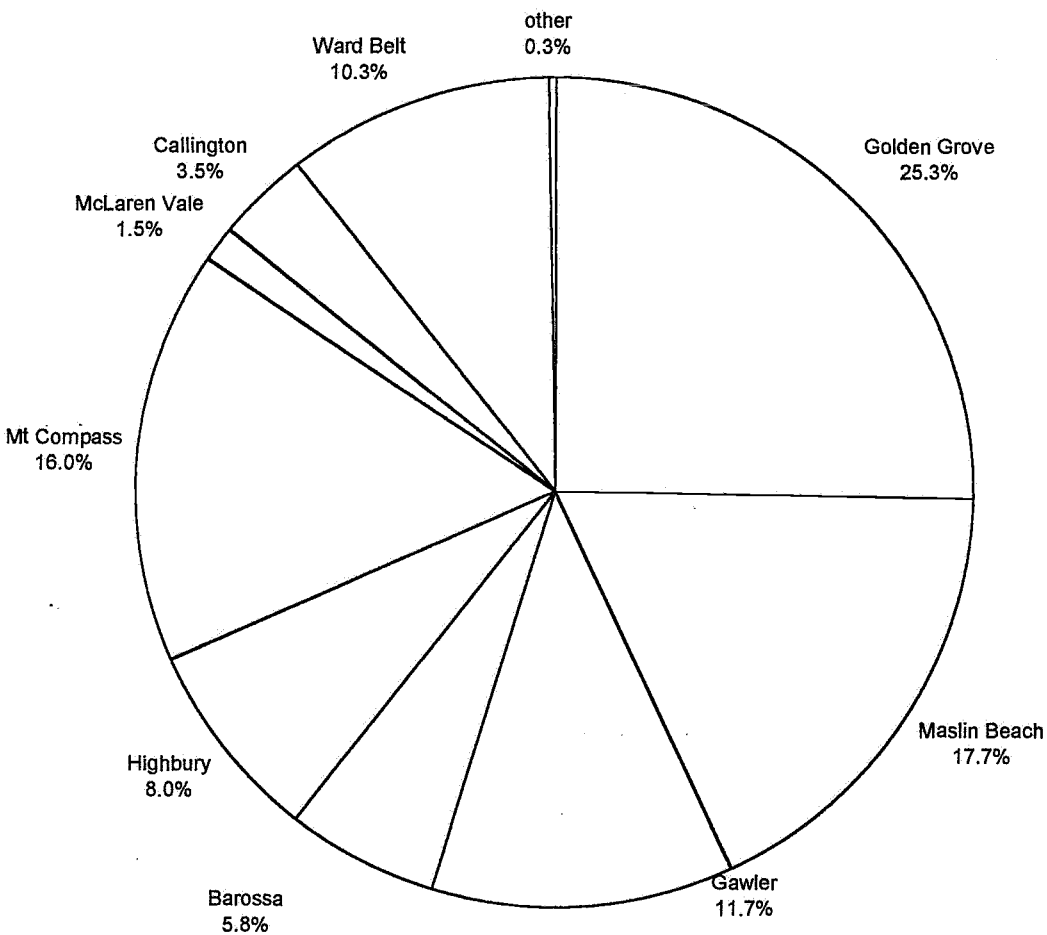
MORTAR SAND Market Share by Region, 2000



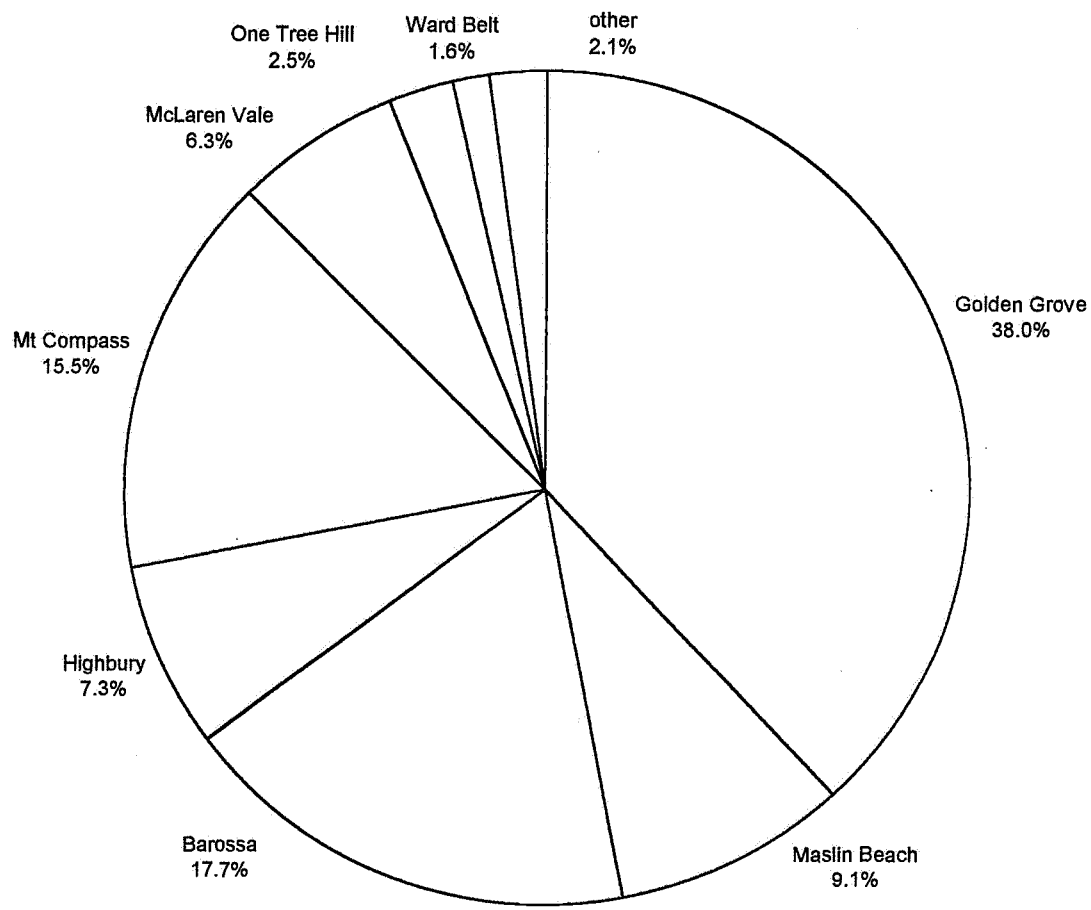
Regional Mortar Sand Production 1990 - 2000



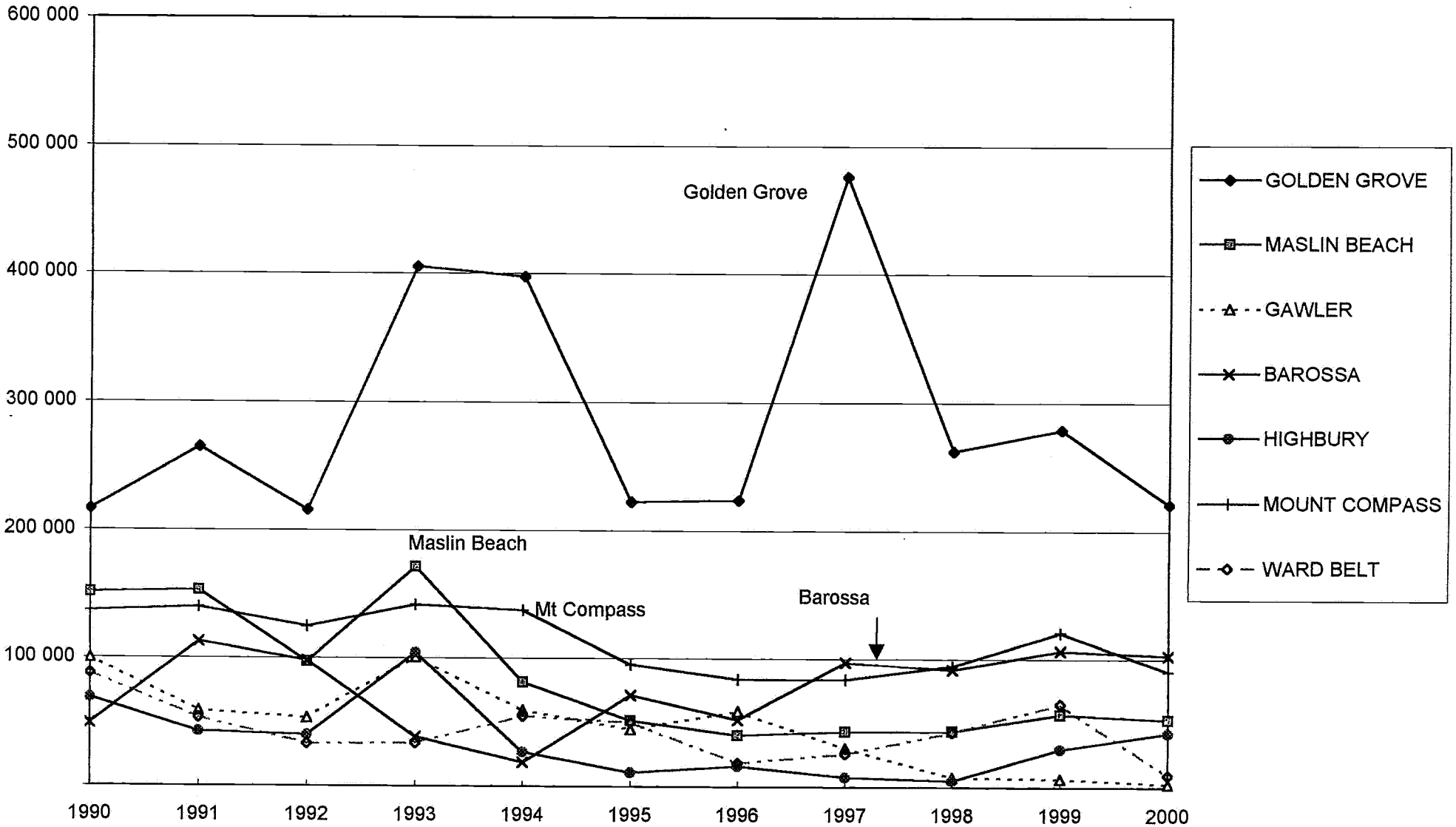
FILL SAND Market Share by Region, 1990



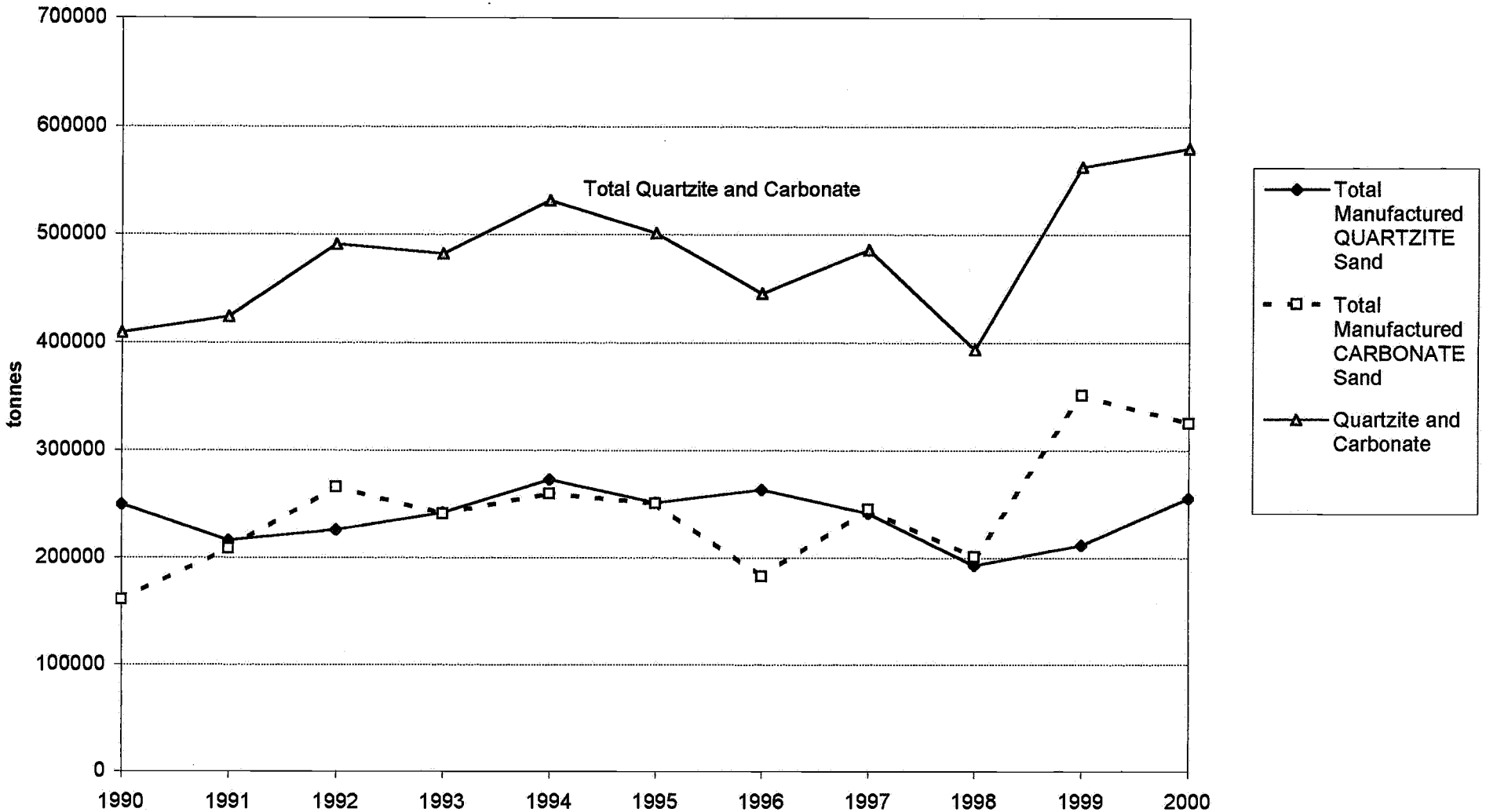
FILL SAND Market Share by Region, 2000



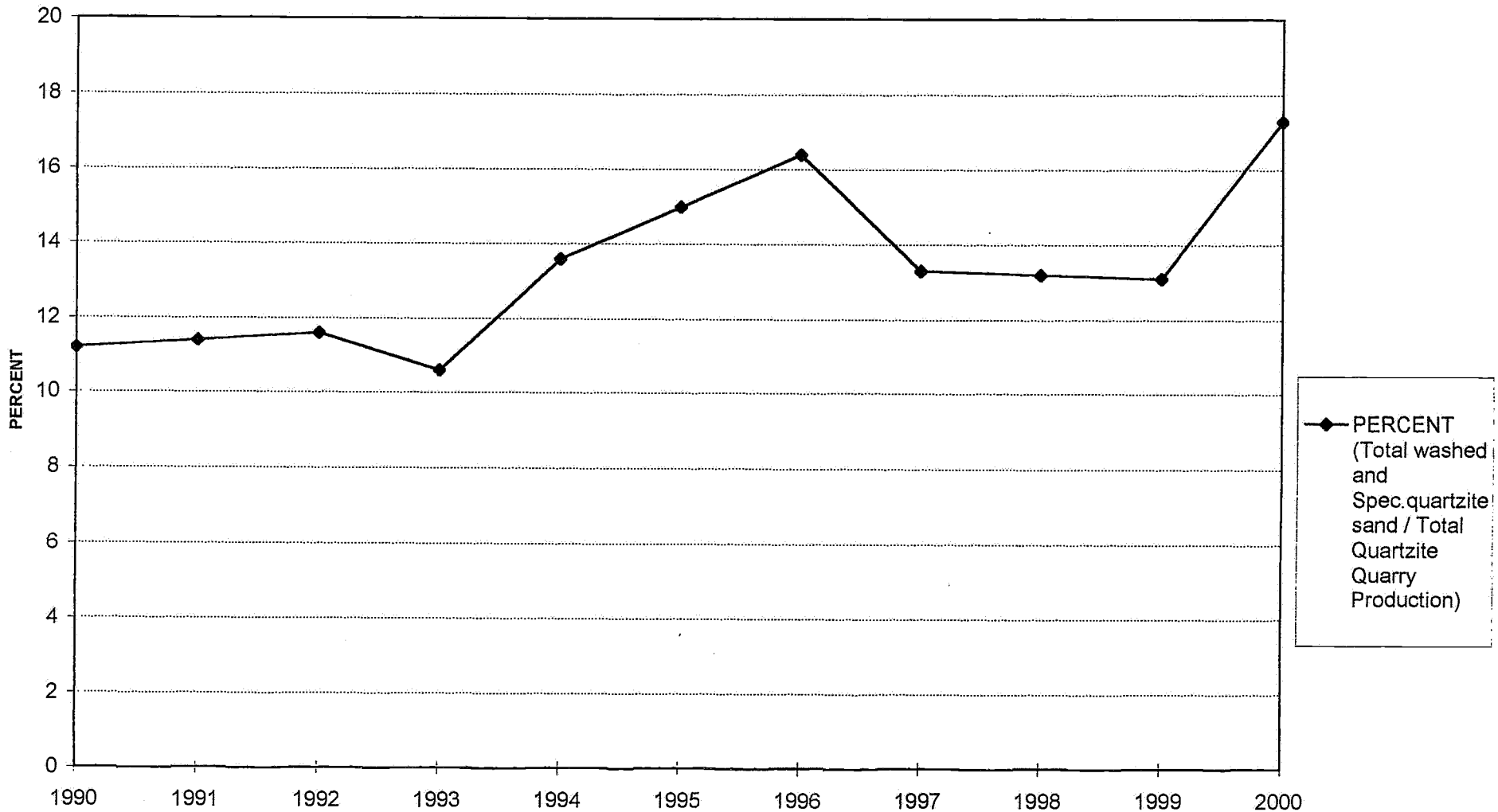
Regional Fill Sand Production 1990 - 2000



MANUFACTURED SAND 1990 - 2000



Washed and Spec. Sand as percentage of Quartzite Quarry Output



Washed and Spec. sand as percentage of Carbonate Quarry Output