GEOLOGICAL SURVEY OF NEW SOUTH WALES
DEPARTMENT OF MINERAL RESOURCES

SUPPLY AND DEMAND FOR CONSTRUCTION SAND IN THE SYDNEY PLANNING REGION

by

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Geologists

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Map Reference:	1:250,000 sheets	1:100,000 sheets
	Sydney	Sydney, Penrith, Gosford, Katoomba, Lake Macquarie, St Albans, Wallerawang
	Wollongong	Wollongong, Port Hacking, Burragorang
	Newcastle	Port Stephens, Newcastle
	Singleton	Cessnock, Howes Valley, Camberwell
	Bathurst	Bathurst, Oberon
	Goulburn	Taralga, Goulburn

EXECUTIVE SUMMARY

Construction sand is used in large volumes by any modern society. Its main uses are in concrete manufacture, mortar and as fill material. Construction sand has low unit value and should preferably be obtained from sources close to markets to minimise both transport costs and the adverse environmental impacts associated with transporting large quantities of material.

The Sydney Planning Region consumes up to 7 million tonnes of construction sand annually. Nearly half (48%) of this is fine- to medium-grained sand, just over a third (36%) is medium- to coarse-grained sand and 15% is clayey/mortar sand.

Currently, about 85% of the demand is obtained from deposits along the Hawkesbury-Nepean River, Georges River (medium- to coarse-grained sand), coastal dunes at Kurnell Peninsula (fine- to medium-grained sand) and from friable Hawkesbury Sandstone deposits (clayey/mortar sand) at Maroota and on the Somersby Plateau. In addition, about 900,000 tonnes of sand is obtained annually from outside the region.

Using population growth forecasts and a predicted per capita demand of 1.611 tonnes per annum the future demand for construction sand was estimated for short term 2000-2010, medium term 2010-2020 and long term 2020-2040.

In the short term, the predicted demand for construction sand can be supplied by continuing extraction from the current sources within the planning region and by continuing imports at their present or slightly increased levels. However, a large shortfall in the supply of fine- to medium-grained sand will occur if extraction ceases at Kurnell. This shortfall, if it eventuates, will have to be made up by either substantially increasing imports and/or by sourcing more fine- to medium-grained sand from friable sandstone deposits within the planning region and/or by opening new deposits for extraction within the planning region.

Once the Penrith Lakes Development Scheme ceases, about 2010, around 2.2 million tonnes of medium- to coarse-grained sand will obviously need to be sourced annually from somewhere within or outside the planning region.

There are large identified resources of construction sand within the planning region at Richmond Lowlands, Somersby Plateau, Maroota and offshore which have the potential to become long term suppliers of construction sand. There are, however, environmental and societal constraints with all these.

If these deposits are not utilised, the planning region will need to import increasing quantities of construction sand from external sources to supply the predicted demand. Large deposits of friable sandstone occur at Newnes Plateau near Lithgow and at Wingello and Penrose in Wingecarribee Shire. These have the potential to become major sources of sand in the longer term. In the short and medium term moderate amounts of fine- to medium-grained sand can be imported from the Stockton Bight and from the Illawarra. Currently, alternative materials such as crusher fines,

excavated material and manufactured sand are considered to have only limited potential as an alternative to natural construction sand at present.

Given that the remaining resources at Penrith Lakes will be exhausted in the short term and that the future of sand extraction at Kurnell is uncertain, it is essential that a strategy is developed for sourcing of construction sand from other identified resources.

Such a strategy would need to consider the following elements;

- Protection of the currently operating construction sand quarries from encroachment by incompatible land uses, and prevention of significant identified undeveloped resources from being unnecessarily sterilised by incompatible alternative land use. To achieve this, Local Environmental Plans and Regional Environmental Plans need to take appropriate account of important known and potential construction sand resources.

- Identification of potential major long term sources of construction sand.

- Formulation of a plan for transporting large quantities of construction sand, and other construction materials, long distances by means other than road. Eventually the planning region will have to import the bulk of its construction materials. Therefore the extractive industry, the transport industry, and local and relevant State government agencies need to examine alternative modes of transport for quarry products. Transport by rail and by sea via Sydney Harbour or Port Botany has the potential to make remote resources more economical, and would benefit the consumer and the community in general, through reduction of truck movements.

- Provision of access to multiple sources of construction sand rather than just a few. This would provide a range of product types and guard against the market becoming dominated by a small number of suppliers. Continued competition in the market will result in lower prices and thus benefit the consumer and the community in general.

- Encouragement of greater use of alternative materials. At present, alternative materials occupy only a small portion of the market. Their greater use would prolong the availability of sources of natural sand.

- Maximisation of utilisation of suitable excavated material (mainly crushed sandstone) from large excavations and tunnel projects.

- Incorporation of the management of construction sand resources into a wider strategy for management of all construction materials of the region and surrounding areas.

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INTRODUCTION

Construction sand is a material used in large volumes by modern society. The main uses of construction sand are in concrete manufacture, mortar and as fill material. There are different types of sand, and the end use of sand is determined by its physical and chemical properties.

Sand is a construction material of low unit value and it should therefore be obtained from sources close to markets so as to minimise transport costs as well as the adverse environmental impacts associated with transporting bulk materials.

Over the past decade the Sydney Planning Region (figure 1) consumed, on average, just over 6 million tonnes of construction sand per annum. This is approximately 60–65% of all construction sand produced in the State.

The planning region currently obtains about 85% of its construction sand from local deposits along the Hawkesbury-Nepean River, Georges River, coastal dunes at Kurnell Peninsula and from friable Hawkesbury Sandstone deposits at Maroota and on the Somersby Plateau. In addition, about 900,000 tonnes of sand is obtained annually from outside the region.

This situation however, is expected to change dramatically after Kurnell and Penrith Lakes cease operations. Kurnell supplies about 1.5 million tonnes of sand to the market and is expected to cease within the next five years. Penrith Lakes has an annual output of about 2.2 million tonnes and is expected to cease in about 2010. Unless new sand deposits are developed within the region, the amount of sand obtained from outside the region will need to increase substantially.

The aim of this study is to provide an improved knowledge of the construction sand resources of the Sydney Planning Region and surrounding areas and in doing so provide an informed basis for land use planning and resource management. This study is also an important input to a sector wide strategy being prepared by the Department of Urban Affairs and Planning.

As construction sand and other extractive resources are not minerals under the Mining Act (1992), the Department of Mineral Resources does not have a formal, statutory role in their development, except for the mine safety role flowing from the Mines Inspection Act. Not withstanding this, the Department does have an accepted role amongst State Government agencies of assessing extractive resources, and providing advice pertaining to their development and management.

The Department of Mineral Resources is providing to the sector strategy independent, authoritative advice relating to issues such as: the nature and importance of identified construction sand resources within the planning region; the availability of alternative sources locally and regionally; and present and likely future supply/demand considerations in the planning region. In identifying construction sand resources which have the potential to supply the planning region in the future the Department is not advocating their extraction. It is merely identifying areas containing important resources or potential resources which may need to be protected through planning instruments.

This report reviews production of construction sand within the Sydney Planning Region, documents and evaluates the current and potential construction sand resources of the planning region and the surrounding areas, and assesses current and future supply options.
The study commenced in October 2000 when a questionnaire (appendix 1) was sent to construction sand producers in the Sydney Planning Region and the surrounding areas. The

questionnaire was designed to capture general information about each quarry operation as well as specific data on current identified resources and potential resources. The data that was provided by the industry through this process forms the basis of this report.

PREVIOUS STUDIES

The construction sand resources of the Sydney Region have been previously documented by the Department of Mineral Resources in two position papers; Wallace (1980) and Spackman (1992), and a briefing paper (Oakes et. al. 1995) These studies reviewed past production within the region, forecast future demand, and proposed supply options. In addition a Government taskforce established by the Minister for Urban Affairs and Planning in 1995 examined the predicted supply and demand situation of construction sand for the Sydney Region. Issues relating to the supply and demand of construction sand were also canvassed in Extractive Industry – Draft Sydney Regional Environmental Plan No. 9 (2) (SREP 9(2)) (1993). Barnett (1992) reviewed the supply and demand of fine sand as a part of a proposal by Metromix P/L to extract marine aggregate off Sydney.

SYDNEY PLANNING REGION

Previous workers eg Wallace (1980) and Spackman (1992) defined the 'Sydney Region' as an area bounded by the Hawkesbury River to the north and the north-west, the Nepean River to the west, and the southern boundaries of Camden, Campbelltown and Sutherland Local Government Areas to the south. The Sydney Planning Region (figure 1) is a slightly larger area which covers 17 Local Government Areas from Wyong in the north to Wollondilly in the south and Blue Mountains and Hawkesbury in the west. As a result, total production, consumption and import tonnages reported in this report differ slightly from those reported by previous workers.

SAND DEPOSIT TYPES

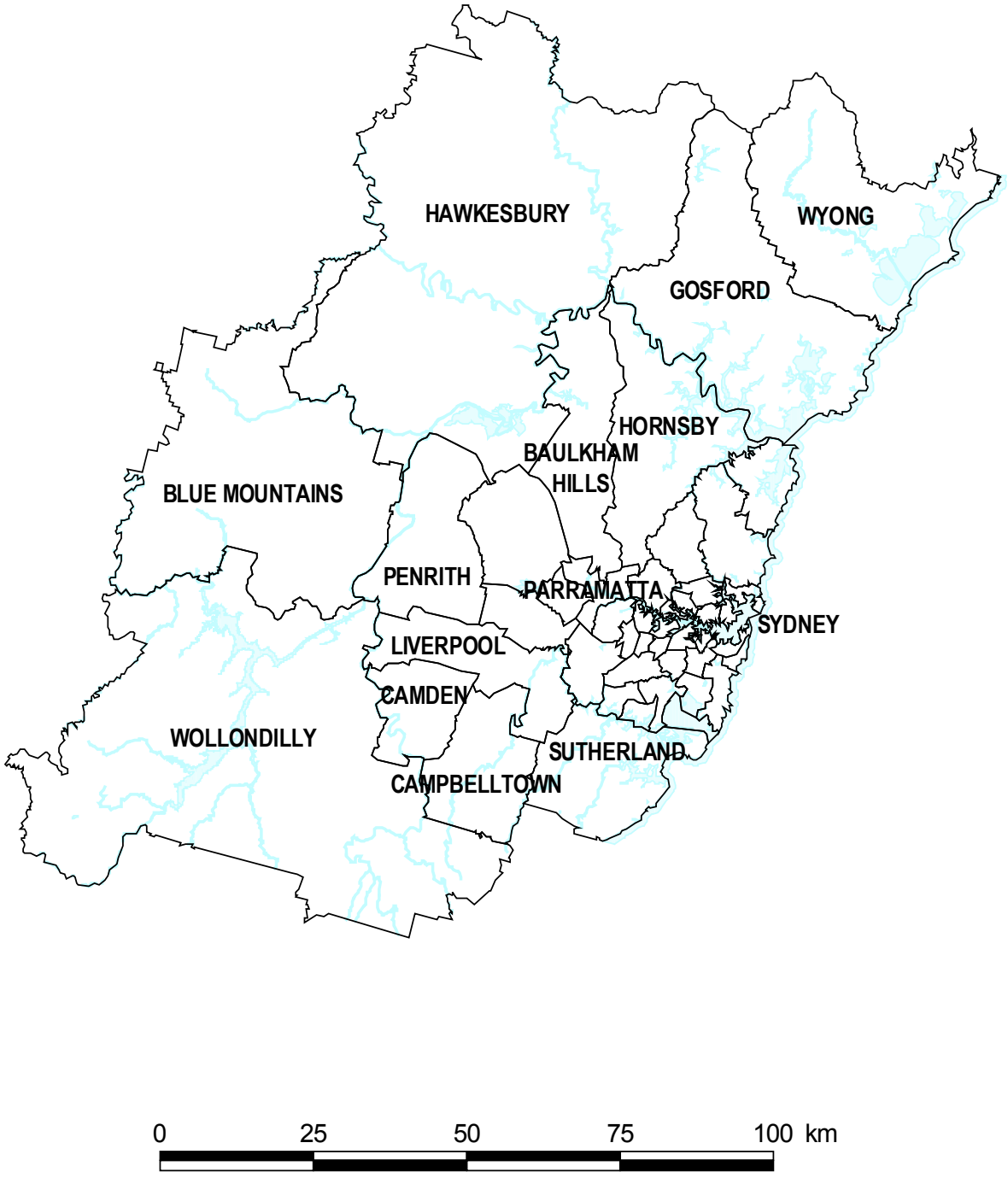
Natural construction sand consists mainly of quartz with varying amounts of impurities such as clay, iron oxide, mineral and rock fragments, shell and organic matter. The end use of sand is determined by its composition and physical properties, which are in turn, determined by the sand deposit type.

In the Sydney Planning Region construction sand is sourced from marine sediments, fluvial sediments and friable sandstone deposits.

MARINE SEDIMENTS

Marine sediments consist of coastal dunes, beach and estuarine deposits, and Quaternary sands on the inner continental shelf off Sydney.

Figure 1: Sydney Planning Region



Sand in *coastal barriers and dunes* is fine- to medium-grained, well sorted, well rounded and when highly weathered and leached also of high chemical purity (SiO_2 over 99%). In the past, sand dunes in the Botany area were an important source of glass making sand. The sand dunes on the Kurnell Peninsula currently supply a high proportion of the fine-grained sand used for concrete manufacture in the Sydney Planning Region.

Beach and estuarine sands are fine- to medium-grained, well sorted but poorly graded. Due to their grainsize they often require blending with coarser sand before they can be used in concrete manufacture (Spackman 1992). These sands may contain varying amounts of shell material which makes them unsuitable for many applications. In the past, deposits of this type were worked at Middle Harbour and Lake Narrabeen.

Marine sand on the inner continental shelf consist of uniformly sized, well sorted, well rounded, fine- to medium-grained quartz sand. Extraction of marine sand has yet to take place, and the future availability of this source is uncertain.

FLUVIAL SEDIMENTS

In contrast to marine sands, alluvial sands are typically more angular and contain a higher proportion of rock fragments. Two types of alluvial deposits have been worked in the Sydney Planning Region.

Quaternary age sediments contain fine- to coarse-grained sands, commonly with large quantities of gravel. Large quantities of medium- to coarse-grained sand and gravel have been extracted along reaches and on the flood plains of the Nepean-Hawkesbury River. The Penrith Lakes Scheme currently supplies the bulk of the planning region's medium- to coarse-grained sand and a large proportion of coarse aggregate (river gravel) requirements. In the past, considerable quantities of fine- to medium-grained river sand was extracted from the Georges and Lane Cove Rivers.

Fluvial deposits of assumed Tertiary age, which unconformably overlie Triassic rocks, mainly Hawkesbury Sandstone (Spackman 1992), include low level terrace deposits such as Agnes Banks (Londonderry), Pitt Town, and high level terrace deposits such as Maroota, and Elderslie, near Camden. These deposits contain clay-rich (commonly more than 20% clay and silt) fine- to medium-grained sand which has traditionally been used mainly as bricklaying sand. Increasing amounts of this type of sand are, however, washed to produce a clean fine– to medium-grained sand suitable for a wide range of applications such as concrete manufacture and asphalt.

FRIABLE SANDSTONE DEPOSITS

Friable (crumbly) sandstone deposits formed by prolonged weathering of poorly cemented sandstones of Triassic age (Whitehouse and Roy 2000). Because of their low strength, friable sandstones can be extracted by light ripping and crushing by bulldozers or mechanical excavators, without the need for drilling or blasting.

In the Sydney Planning Region, sand is extracted from friable sandstone at Somersby Plateau west of Gosford, at Maroota north of Baulkham Hills, at Colo Heights north of Hawkesbury and at Appin. The sand is similar to that extracted from the fluvial terrace deposits discussed above,

being predominantly fine- to medium-grained and containing variable amounts of kaolinite-rich clay and silt (up to 10–15%). Medium- to coarse-grained sand can, however, also be extracted from these deposits. The main uses for this sand are for bricklaying mortar, in readymixed concrete and in concrete products.

SAND TYPES AND USES

SAND CLASSIFICATION

The main characteristics which determine the end use of sand are particle size, particle shape and overall particle size distribution or grading. Wallace (1980) and Spackman (1992) classified sand produced in the Sydney Planning Region into the following categories based on grainsize and deposit type;

Medium-to coarse-grained: predominantly river sand from stream course and flood plain deposits along the Hawkesbury-Nepean River.

Fine- to medium-grained: predominantly from dune and estuarine deposits, some river sand along Georges and Lane Cove Rivers (mainly from flood plain deposits).

Clayey/mortar sand: predominantly fine- to medium-grained sand with varying amounts of clay, sourced from terrace deposits and friable sandstone.

This classification scheme is retained in this study, to preserve continuity with the previous studies. Other classification schemes based on grainsize and sand gradings are briefly discussed below.

Australian Standard A89-1966, classifies sand as coarse, medium or fine grained according to it's particle size (table 1).

Table 1: Australian Standard A89-1966 Sand Particle Size Ranges

Type of sand	Size range
Coarse-grained sand	0.600-2.000 mm
Medium-grained sand	0.200-0.600 mm
Fine-grained sand	0.060-0.200 mm

The quarrying and construction industries, however, classify sand into two categories (table 2) based on particle size and particle distribution or grading (Don Reed, pers comm 2000).

Table 2: Sand Gradings Used by Construction Industry

Type of sand	Size range
Coarse-graded	> 50% of particles sized > 0.600 mm
Fine-graded	> 50% of particles sized < 0.300 mm

Grading is a useful parameter and figure 2 shows the grading limits for sand according to Australian Standard AS2758.1-1985 which is the governing standard for sand used in concrete. As can be seen, the limits define an envelope which is extremely wide.

In practice, a more rigorously defined grading envelope is generally specified. This is shown as 'Industry Standard Limits' on figure 2.

Superimposed on these two grading envelopes on figure 2 are grading curves for some of the sand deposits within the Sydney Planning Region. Most of the curves fall either completely or partly within the wider AS2758.1-1985 envelope, but at the same time they fall outside the 'Industry Standard Limits' envelope. Therefore, most of the sand extracted in the Sydney Planning Region must be blended to produce a sand that meets the industry specifications. It is for example, common to blend medium- to coarse-grained river sand from Penrith Lakes with fine- to medium-grained dune sand from Kurnell to produce a sand suitable for concrete manufacture.

The shape of the sand grains is another factor which determines the suitability of sand for a particular application. Workability of readymixed concrete is enhanced by rounded sand grains as they migrate more easily past each other when the concrete is pumped. In the manufacture of concrete products such as pipes however, sub-angular sand grains are acceptable as their interlocking nature increases the strength of the final product.

END USES

End uses of sand produced and consumed in the Sydney Planning Region have been divided in to the following categories;

Readymixed concrete is the largest single end use of sand produced and consumed in the planning region. As mentioned above, medium – coarse grained sand is blended with fine – medium grained sand to produce a sand which meets the specifications for sand used in manufacture of concrete set by industry.

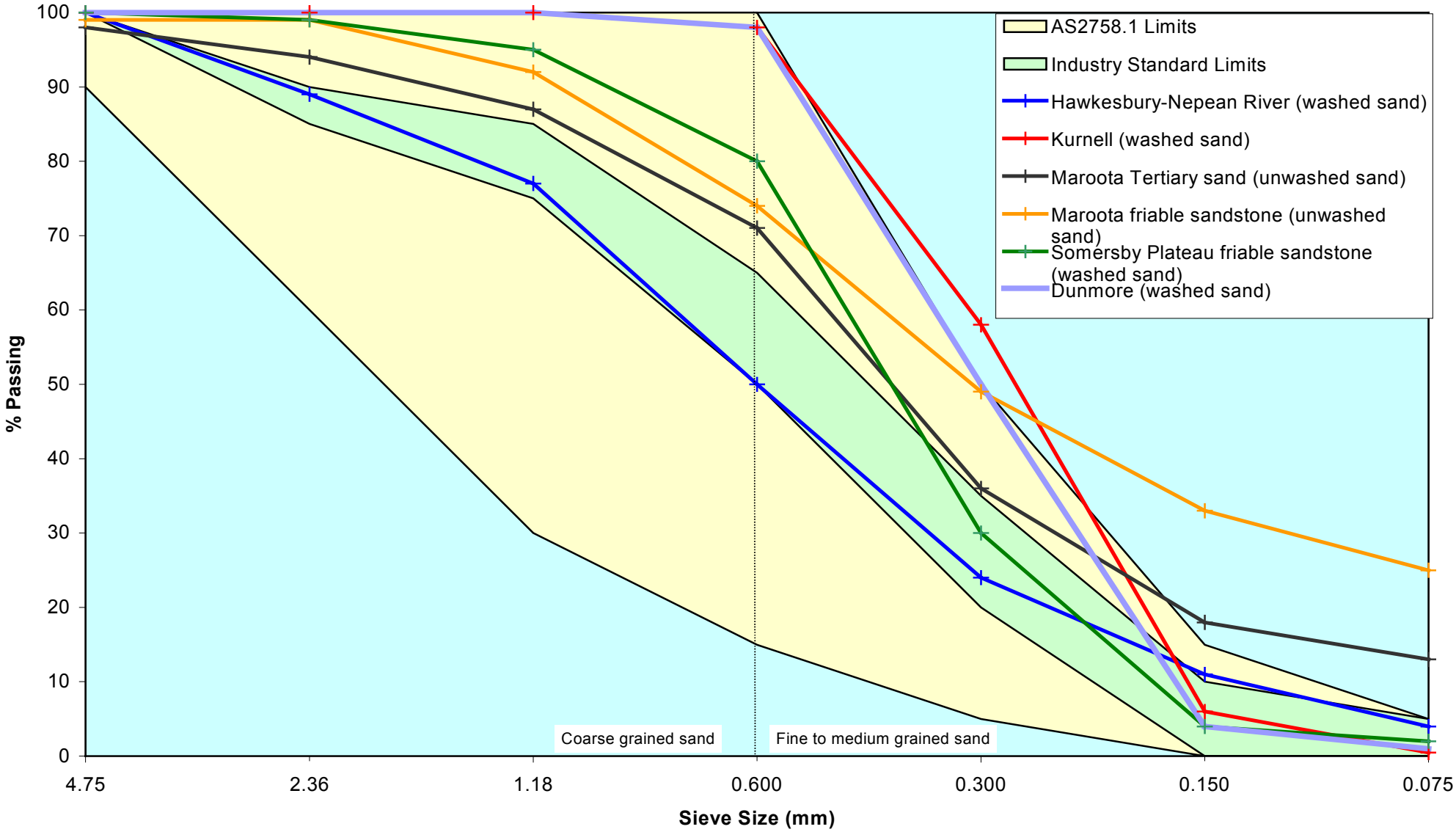
Sand suitable for *concrete products* such as pipes, masonry blocks, roof tiles and concrete poles must also comply with Australian Standard AS2758.1 – 1998. As previously mentioned, an angular grain shape is acceptable although a rounded particle is more desirable as it causes less wear on moulds and equipment (Spackman 1992). For some products the sand must have special gradings. For example, masonry blocks require a certain amount of coarse sand to give the product strength (Spackman 1992).

Clay - rich sand produced from friable sandstone and terrace deposits has traditionally been used mainly for *mortar sand*. The high clay content provides the sand with slip and workability which are desired qualities for this application (Spackman 1992).

Coarse and granular grains are required for sand used in *asphalt* as this provides skid resistance. Slag sand, which is a by-product of steel making, is especially suited for this application due to its angular nature.

There are no rigid specifications for sand used as *fill*. The sand should, however, be clean, ie free from organic material, not too fine-grained, and of adequate compressive strength (Spackman 1992).

Figure 2: Indicative Grading Curves for Construction Sand



A non-specific end use, *general construction*, refers to all sand which is known to be used in construction, but can not be assigned to any of the above categories by the producer. It is likely that a large proportion of this sand is eventually used in concrete and/or fill (Spackman 1992).

Industrial sand is not strictly a construction sand type. It is, however, included in this study as an end use category. Specifications for industrial sand vary according to the eventual end use eg, glass, filter, foundry, although high chemical purity is a common requirement.

The last category used in this study is *other,* which refers to sand that can not be assigned to any of the above categories. A large proportion of sand assigned to this category is used in horticulture.

SAND PRODUCTION IN THE SYDNEY PLANNING REGION

PAST PRODUCTION

Figure 3 shows the localities from which construction sand production was recorded by the Department of Mineral Resources between 1969/70 and 1999/00. Also shown are sand type and the total recorded production.

The major production sites for medium- to coarse-grained sand are concentrated on the Nepean-Hawkesbury River.

The bulk of past production of clean, fine- to medium-grained sand has come from dune deposits at Kurnell Peninsula and Botany, the fluvial deposits on the Georges River, and estuarine deposits in Middle Harbour and Narrabeen Lake.

Clayey/mortar sand has been sourced from high level deposits at Agnes Banks, Elderslie and Maroota as well as from a number of friable sandstone deposits at Maroota, Somersby Plateau, Colo Heights and Appin.

Some sand of variable grain-size ranges has also been produced from various crushed sandstone and friable conglomerate quarries.

Figure 4 shows the total construction sand production in the Sydney Planning Region for the period 1969-2000. Also shown is the annual production of sand and gravel (divided by 100 to fit it to scale) in the United States (data from Balazik et. al., 2001, fig. 9). The US data is included to illustrate that the local economy closely reflects world wide economic conditions.

Both data are cyclic, the troughs correspond to times of recession and low levels of investment in the construction industry, while the peaks correspond to boom times and high levels of investment and/or large scale public works. It is interesting to note that the increase in the production of construction sand in the Sydney Planning Region in the latter part of the 1990s, which could be, at least partly attributed to the 2000 Olympic Games, is also a reflection of the growth of the world economy.

Figure 3: Construction Sand Production Sites in the Sydney Planning Region 1969 - 2000

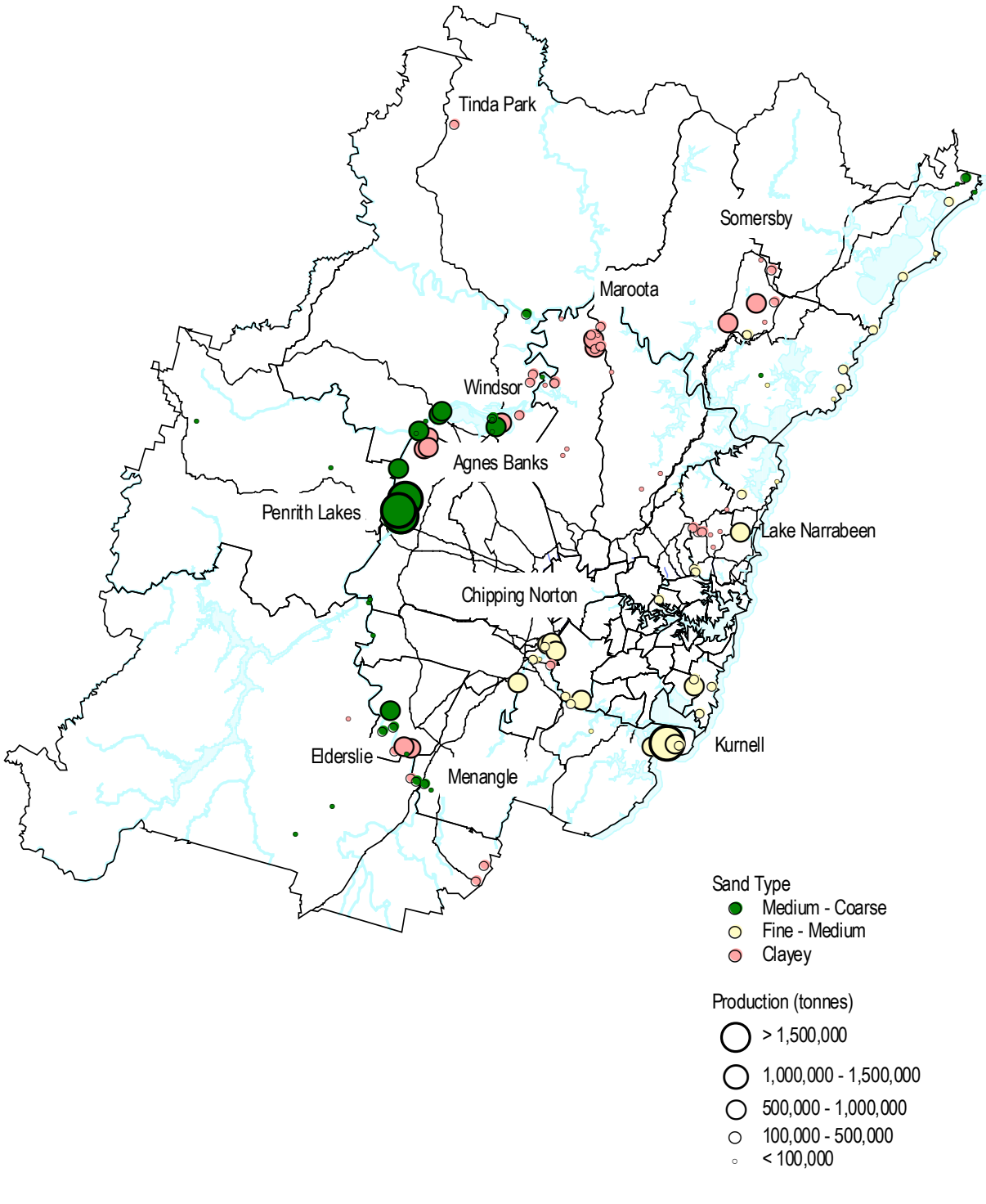


Figure 4: Production of Construction Sand in the Sydney Planning Region and Production of Sand and Gravel in the US 1969/70-1999/00

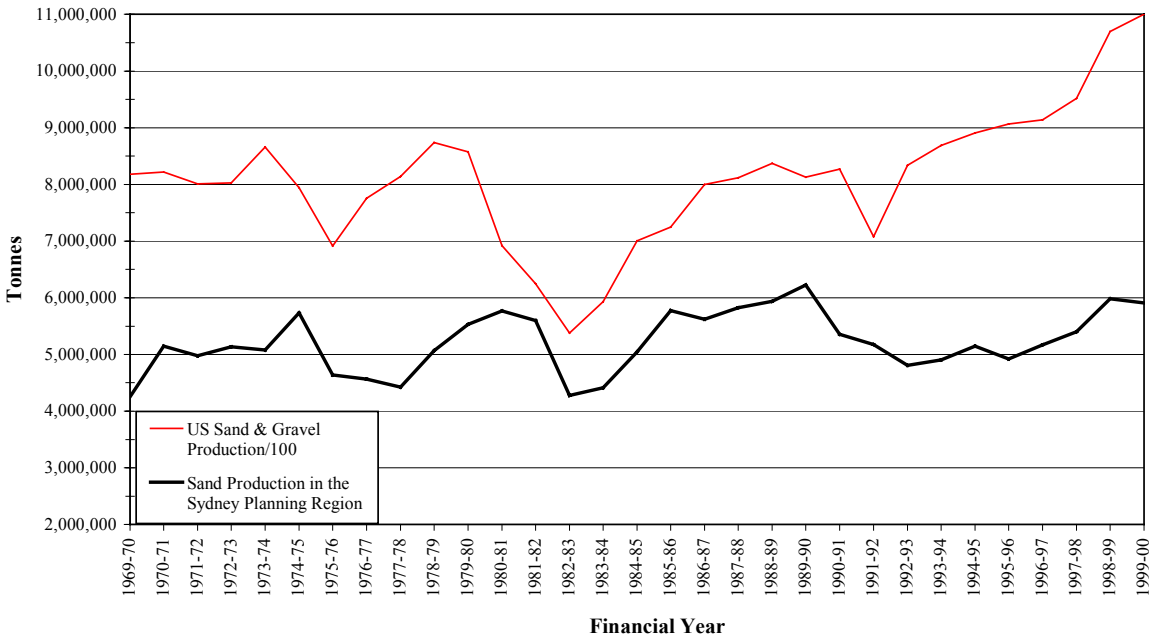


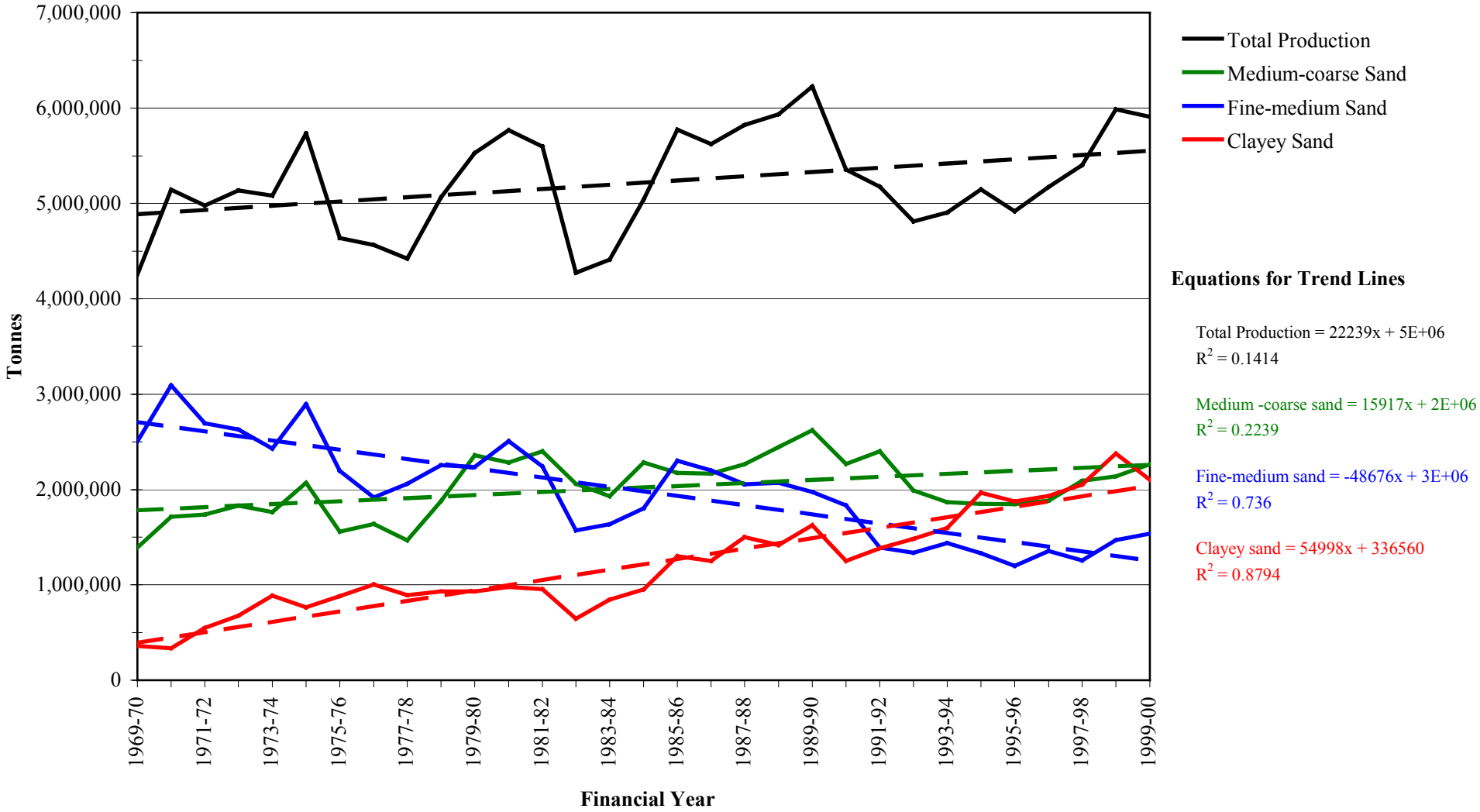
Figure 5 shows the total construction sand production in the Sydney Planning Region, as well as production by sand type. The average annual construction sand production for the period 1969/70-1999/00 was 5.22 million tonnes (table 3). The data however, are quite variable, and thus a raw mathematical average may not be the most useful parameter for evaluating past trends. A regression line fitted to the total production data (figure 4) gives an annual increase of 22,239 tonnes per annum (tpa) with an R-squared value of 14.14%. The R-squared value reflects the degree of fit of the trend line to the data, 100% being a perfect fit and 0 indicating that there is no correlation between the data and the trend line. As the R-squared value here is only 14.14%, the figure of 22,239 tpa can be considered to be a very unreliable estimate of the annual increase in sand production.

Table 3 shows the average production of construction sand for the past three decades. The average yearly total production rose from about 4.9 million tpa in the 1970s to 5.38 million tpa in the 1980s, and interestingly, declined slightly in the 1990s when it was 5.27 million tpa. This slight decrease in local production results from depletion of local sources rather than a lack of or a decrease in demand.

Table 3: Average Yearly Production of Construction Sand 1969/70-1999/00

Sand Type	1969/70-78/79	1979/80-88/89	1989/90-99/00	1969/70-99/00
Medium-Coarse	1,705,282	2,237,358	2,111,585	1,981,672
Fine-Medium	2,467,847	2,062,417	1,466,291	2,021,092
Mortar/Clayey	728,535	1,077,786	1,786,279	1,216,525
Total	**4,901,664**	**5,377,561**	**5,269,612**	**5,219,289**

Figure 5: Construction Sand Production in Sydney Planning Region 1969/70 - 1999/00



Overall, it appears that even though there were large fluctuations in the annual production of construction sand over the past 30 years, the average annual production increased at a slow rate from the 1970s to the 1980s and has remained static or declined slightly since then.

PAST PRODUCTION BY SAND TYPE

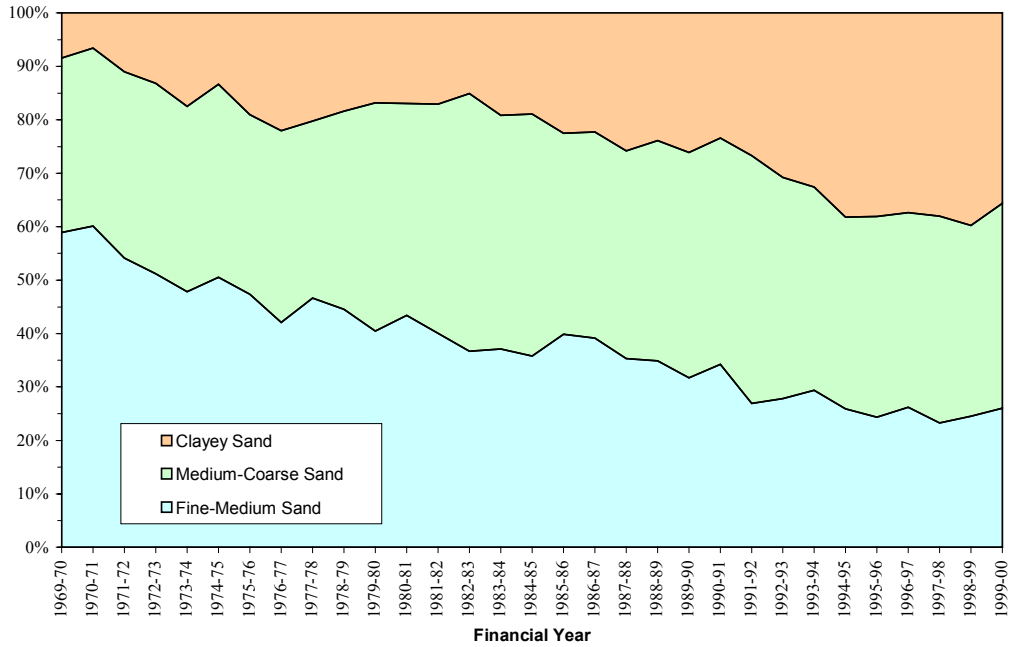
The data in table 3 show that production of *medium- to coarse-grained sand* increased from about 1.7 million tpa in the early 1970s to about 2.2 million tpa in the 1980s and has since steadily declined since, average yearly production in the 1990s being 2.1 million tpa. Figure 5 further illustrates this, ie the medium- to coarse-grained sand data show an increase until the late 1980s and a steady decline since. This trend is similar to that of the 'Total Production' data. A trend line fitted to the medium- to coarse-grained sand data in figure 5 shows an annual increase of about 15,917 tpa. The R-squared value for this estimate is, however, only 22 %, indicating that the estimate is not very reliable.

Average annual production of *fine- to medium-grained sand* declined from about 2.5 million tpa in the 1970s to about 1.5 million tpa in the 1990s (table 3). According to the trend line fitted to data in figure 5 the rate of decline was about 48,676 tpa. The R-squared value of nearly 74% indicates that this is a moderately reliable estimate. The decline appears to have been slightly greater between the 1980s and 1990s than it was between the 1970s and 1980s, indicating that the sources of fine- to medium-grained sand have been depleting at a greater rate in more recent times

Clayey/mortar sand production increased from less than 0.5 million tonnes in the early 1970s to over 2.1 million tonnes in the late 1990s. A trend line fitted to the data in figure 5 shows an annual increase of almost 59,000 tonnes. This estimate appears to be quite reliable as the R-squared value associated with it is 88%. Data in table 3 and the shape of the line in figure 5, however, suggest that the annual increase was higher from the 1980s to the 1990s than from the 1970s to the 1980s. Analysis of the data over the last two decades gives an annual increase of 74,296 tpa with an R-squared value of 87% (graph not shown), and if only the last decade is analysed the annual increase is 91,600 tpa with an R-squared value of 78% (graph not shown). The sharp increase in the production of this type of sand in the 1980s and 1990s is a direct result of the decline in the fine- to medium-grained sand production. As sources of clean fine- to medium-grained sand are depleted, more sand is produced from clayey/mortar sand deposits such as Maroota and Somersby Plateau and washed to produce a clean fine- to medium-grained sand suitable for applications such as readymixed concrete manufacture.

Figure 6 shows the relative amounts of construction sand types as percentages of total production. Fine- to medium-grained sand decreased from nearly 60% in the early 1970s to less than 30% in the late 1990s. Medium- to coarse-grained sand has remained fairly steady over the time period, being about 30-35% in the 1970s, about 40% in the 1980s and about 35% in the 1990s. Clayey/mortar sand accounted for less than 20% of the market until the mid 1980s, and has since increased to about 35%.

Figure 6: Sand Production by Sand Type 1969/70-1999/00



PAST PRODUCTION BY END USE

Table 4 and Figure 7 summarise the end use of construction sand produced within the Sydney Planning Region in 1999/2000.

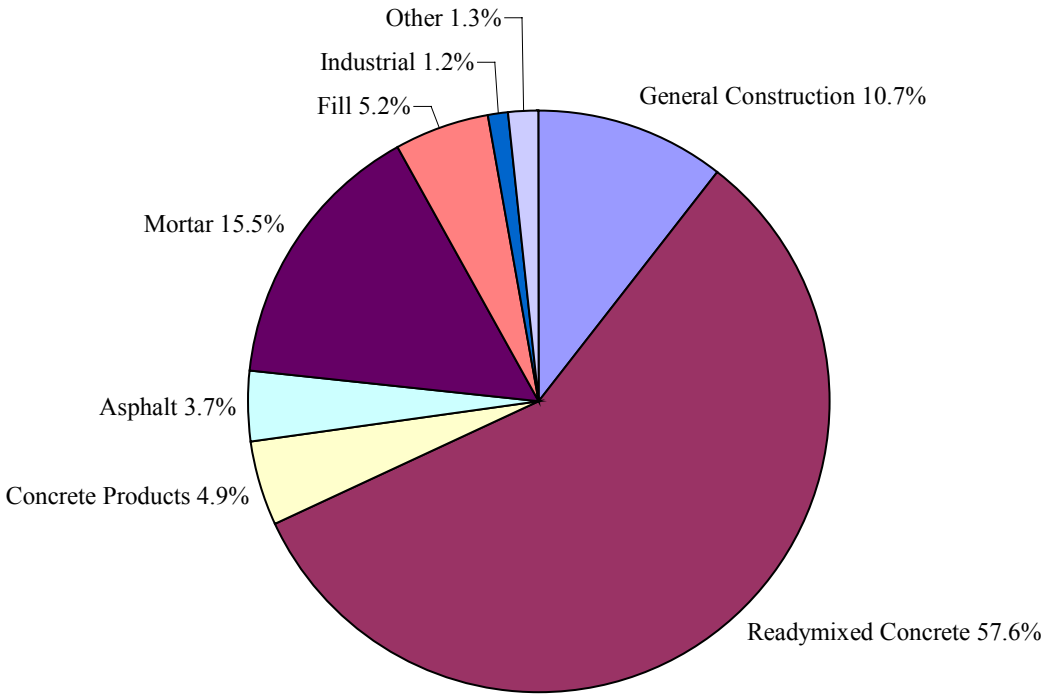
Table 4: End Use by Sand Type 1999/2000

Sand Type/ End Use	Medium-coarse %	Fine-medium %	Clayey/mortar %	Total %
General Construction	3.1	13.7	17.3	10.7
Readymixed Concrete	78.8	59.2	30.3	57.6
Concrete Products	2.7	4.6	7.8	4.9
Asphalt	5.6	2.1	2.9	3.7
Mortar	0	18.3	31.8	15.5
Fill	6.6	2.1	6.1	5.2
Industrial	0	0	3.7	1.2
Other	3.2	0	0.1	1.3

Readymixed concrete is by far the largest section of the sand market (57.6%). If the proportion of sand used for concrete products (4.9%) is added to this, the resulting total proportion of sand that

is used for concrete is 62.5%. Of the other end uses, mortar was the largest at 15.5%. General construction made up 10.7%, fill 5.2%, asphalt 3.7%, industrial uses 1.2% and other unspecified uses 1.3%.

Figure 7: End Use by Sand Type 1999/2000



Examination of end uses of each sand type shows that 81.5% of *medium- to coarse-grained* sand is used for readymixed concrete and concrete products. Only small proportions of the total medium- to coarse-grained sand produced are used for the other applications.

Concrete manufacture is the main use for *fine- to medium-grained* sand. A total of 63.8% is used for readymixed concrete (59.2%) and for concrete products (4.6%). A moderate proportion (18.3%) of this type of sand is used for rendering, which is reported as 'mortar' category. Of the other uses, general construction accounts for 13.7%. Minor amounts of this type of sand are used for asphalt and fill.

Almost equal proportions of clayey/mortar sand are used for mortar (31.8%) and concrete manufacture (38.1%). This means that over a third of this type of sand is washed to produce clean fine- to medium-grained sand. Unspecified general construction accounts for over 17% of the end use of this sand type. This indicates that a large proportion of this type of sand is sold to whole salers who resell the sand for various uses.

CURRENT SOURCES

Current sources of construction sand are shown on figure 8. Production for 1999/2000 is summarised in table 5.

Some aspects of individual deposits are discussed in the following. The reported reserve/resource data were obtained from a questionnaire sent to sand producers in October 2000 and/or from discussions with company representatives.

The terms 'resource' and 'reserves' used in the following are loosely based on the Australasian Code for Reporting Mineral Resources and Ore Reserves (JORC code) (Minerals Council of Australia 1999). 'Resource' refers to deposits or parts of deposits which have been identified as having potential for sand extraction, but are not currently available for extraction, ie do not have current development consent. Resources are quoted as one category which includes inferred, indicated and measured resources. 'Reserves' refers to those parts of resources which are economically extractable and which are available for extraction, ie those parts which have current development consent.

Fine- to Medium-Grained Sand

Kurnell Peninsula is the major source of fine sand in the Sydney Planning Region. Since 1969 over 37 million tonnes of fine-grained dune sand has been produced from the area by a number of operators. Rocla P/L is currently the only operator in the area. The company operates under existing use rights, held by the land owner Besmaw P/L, the validity of which have been questioned by Sutherland Council which ordered the operations to cease in May 2001. The company has current reserves of about 2.3 million tonnes which, if extraction is permitted to continue, will last for about 2-3 years at current rates of extraction. A resource of 4 million tonnes has been identified in an area adjoining the current extraction area and a further resource of 20 million tonnes on a property nearby.

The Penrith Lakes Scheme is mainly a source of medium- to coarse-grained sand (see below), however, a resource of fine-to medium-grained sand has been identified in material previously interpreted as overburden. It is estimated that about 4 million tonnes of fine-to medium-grained sand is available for extraction. At predicted rates of extraction of 600,000 tpa this resource would last for about 6-7 years.

Moorebank quarry, operated by Benedict Sand and Gravel, is the only other operation currently producing clay free, clean, fine-to medium-grained sand. The remaining reserves are 20,000 tonnes which are sufficient for less than one year's operation. The company has identified a further resource of 150,000 tonnes, which is yet to be developed.

Figure 8: Construction Sand Production Sites in the Sydney Planning Region 1999/2000

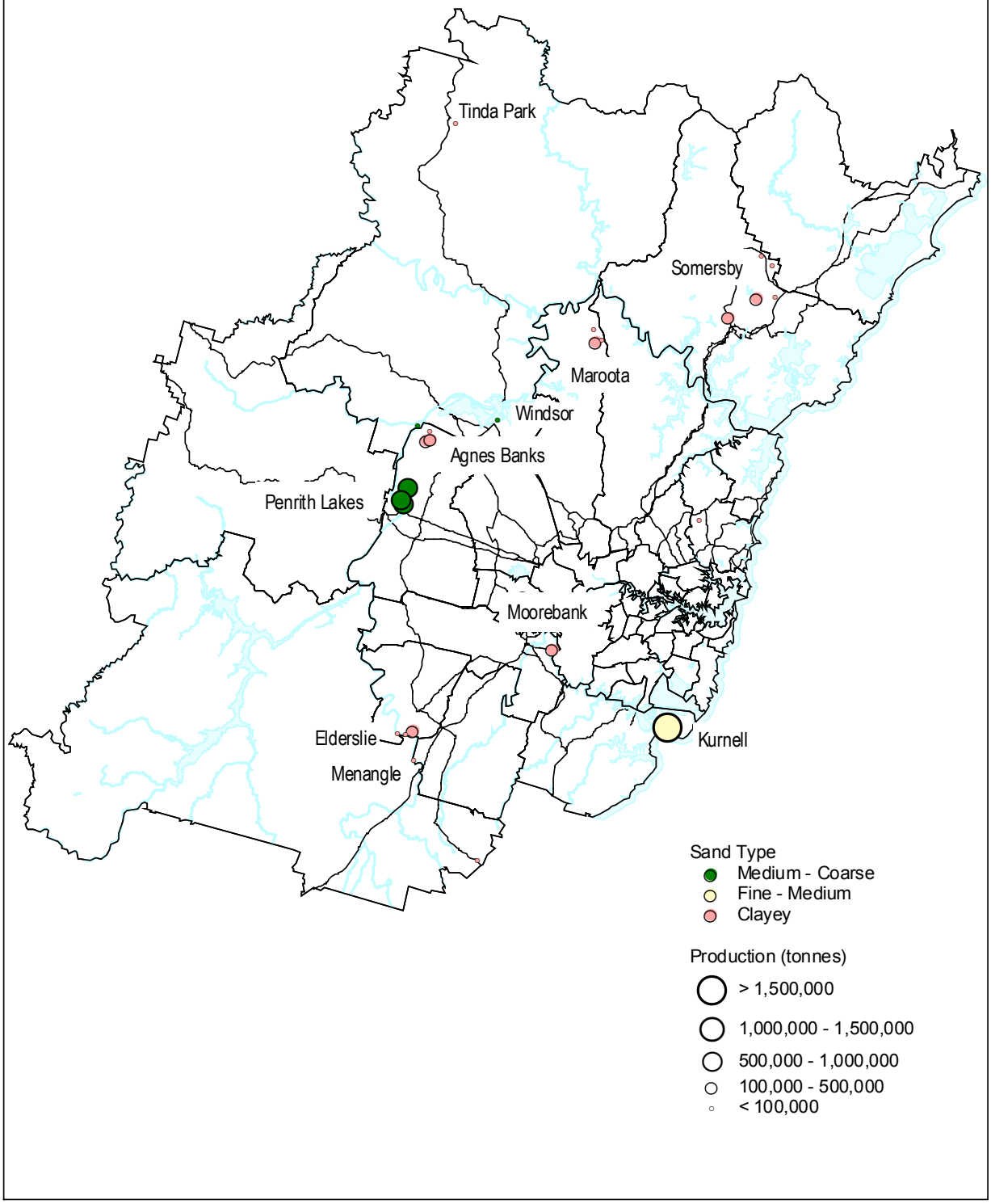


Table 5 Sand Production in the Sydney Planning Region 1999/2000

Sand Type/Locality	Company	Production 1999/2000	Reserves	Resources
Fine Sand				
Kurnell	Rocla P/L	1,539,572	2.3	24.0
Moorebank	Benedict Sand & Gravel	142,064	0.02	0.15
Penrith Lakes Scheme	CSR, Boral, Pioneer	0	4.0	0
Total Fine Sand		**1,681,636**		
Medium - Coarse Sand				
Penrith Lakes Scheme	CSR, Boral, Pioneer	2,215,035	22.0	0
Windsor	Rocla P/L	49,994	0.5	0
Yarramundi	Tilmunda Sand & Soil	1,250		
Total Medium –Coarse Sand		**2,266,279**		
Mortar/Clayey Sand				
High Level Deposits				
Agnes Banks	Dixon Sands	45,862	1.50	0
	P.B White	170,574	0.50	0
	CSR Readymix[1]	121,870	0	0
Elderslie	M. Collins & Sons	38,000	0	0
	Nepean Quarries	177,575	0.30	0.08
Menangle	Menangle Sand & Soil P/L	71,511	0.65	2.60
Maroota (Trig Station)	PF Formation	390,404	4.0	5.0
Warrah School	Hytech Sands	61,000	2.5	0
Sub - Total		**1,076,796**		
Friable Sandstone				
Maroota				
Old Northern Road[2]	PF Formation	100,000	1.0	5.0
Old Northern Road	Dixon Sands	0		
Somersby Plateau				
Reservoir Road	Pioneer	183,600	8.0	2.0
Calga	Calga Sands	340,832	2.0	3.0
Somersby	Rindean Sands	41,609	4.0	
Peats Ridge	Rindean Sands	62,757	1.0	0
Hoipos Road	Eastern Sand & Gravel	42,667	unknown	unknown
Colo Heights, Tinda Park	Birdon Contracting	68,682	2.0	10.0
Appin	J. Taylor	10,211	1.0	0
Sub - Total		**850,358**		
Total Mortar/Clayey Sand		**1,927,154**		
Others				
Belrose	Warringah Stone & Gravel	34,174		
TOTAL ALL SAND		**5,909,243**		

All figures in tonnes

[1] ceased early 2000

[2] includes both the company's operations

Medium- to Coarse-Grained Sand

The Penrith Lakes Scheme on the floodplain of the Hawkesbury-Nepean River at Castlereagh is the main source of medium- to coarse-grained sand within the planning region. River gravel and sand has been extracted from the Penrith-Castlereagh floodplain since the late 1950s. To coordinate extraction and rehabilitation operations in the area, Penrith Lakes Development Corporation Ltd was formed in 1980, and comprises representatives of the operators listed in table 5. Sydney Regional Environmental Plan No. 11-Penrith Lakes Scheme was gazetted in 1986 and provides a statutory framework for the coordinated extraction and rehabilitation of the Scheme area.
A total of more than 74 million tonnes of gravel and 30 million tonnes of sand has been extracted from the area since 1969. Penrith Lakes Development Corporation currently holds a development consent (Development Application 4, approved September 1998) over an area which contains about 22 million tonnes of medium- to coarse-grained sand. It is estimated that these reserves will be exhausted by about 2010.

Rocla P/L and Tilmunda Sand and Soil are the only other current operations producing medium-to coarse-grained river sand. Rocla P/L extracts about 50,000 tonnes of sand annually from the *Hawkesbury–Nepean River* at Windsor. The size of the resource is difficult to estimate as it is replenished by periodic flood events. It is probably realistic to expect for the operation to continue at current extraction rates for at least 10 years.

Tilmunda Sand and Soil produces small amounts of sand as a by product of soil extraction at Yarramundi. The company's current reserves are minor and are not expected to last for more than 2-3 years at current extraction rates.

Clayey/Mortar Sand

Agnes Banks

More than 10 million tonnes of fine- to medium-grained clayey sand have been produced from the Tertiary sand deposits in the Agnes Banks/Londonderry area north of Penrith. The largest quarry in the area, operated by CSR Readymix, ceased operations in early 2000 owing to depletion of resources.

Currently, two companies extract sand in the area. *Dixon Sands P/L* have reserves of about 1.5 million tonnes, these are expected to last for about 15 years at current extraction rates.

P.B. White Minerals P/L which produce industrial sand in addition to construction sand have reserves of about 500,000 tonnes, which are estimated to be sufficient for about 10 years at current rates of extraction.

Neither company has identified additional resources.

Elderslie

A number of companies have extracted sand and soil from high level Tertiary sand deposits at Elderslie in the past. Currently, two companies operate in the area; M. Collins & Sons and Nepean Quarries P/L.

M. Collins & Sons operate three sites which produce various amounts of sand and soil. *Spring Farm* produces about 20,000 tonnes of sand and small amounts of soil annually. The current sand reserves of about 750,000 tonnes are expected to last for more than 10 years at current extraction rates.

Sand production from the *Woodgrand* site is also about 20,000 tpa. Sand reserves at this site are less than 30,000 tonnes. The company has, however, identified an additional resource of about 250,000 tonnes adjacent to the current extraction site.

The *Nesbitt* property currently produces only soil, but the company has identified a sand resource of about 250,000 tonnes.

The sand quarry operated by Nepean Quarries produces 150,000 – 200,000 tonnes of sand annually. The current reserves are about 300,000 tonnes. A further resource of 80,000 tonnes has been identified by the company. The expected life of this operation is 3 - 4 years at current extraction rates.

Menangle

Menangle Sand and Soil P/L is the only operator at Menangle. The quarry produces about 50,000-100,000 tonnes of sand and over 100,000 tonnes of soil annually. Current sand reserves are about 650,000 tonnes. An additional resource of 2.6 million tonnes has been identified.

Maroota

Large deposits of fine- to medium-grained, clay-rich sand of Tertiary age and friable Hawkesbury Sandstone have been identified at Maroota south of Wisemans Ferry. A Plan of Management for these deposits was prepared by Resource Planning in 1991 for Baulkham Hills Shire Council, Hornsby Shire Council and the Department of Planning.

Three companies operate five quarries in the area. PF Formation extracts sand at three localities; around Maroota Trig station, along Old Northern Road and near Coopers Creek (Weavers-Trovato area) east of Old Northern Road. *The Maroota Trig* area contains large resources of Tertiary sand and clay/shale. According to Resource Planning (1991) the resources at the time of preparation of the Plan of Management were about 23 million tonnes of Tertiary sand and 3 million tonnes of clay/shale. PF Formation has reserves of 4 million tonnes of Tertiary sand on the land it owns and/or leases. In addition the company has identified a further resource of about 5 million tonnes.

The company's two other quarries in the area are in friable sandstone. Its quarry along the *Old Northern Road* has current resources of about 100,000 tonnes and it is expected that this operation will finish in 2002. The other operation, near *Coopers Creek (Weavers-Trovato area)* east of Old

Northern Road contains 5.9 million tonnes of extractable sandstone of which about 900,000 tonnes is under current development consent.

Dixon Sands P/L operate a quarry adjacent to PF Formation's site along the Old Northern Road. The quarry was non-operational from the end of 1998 to July 2000 to allow for large scale rehabilitation and remedial works. Resources under consent are 1.7 million tonnes. The company has defined a further 4 million tonnes of friable sandstone on land adjacent to the current site.

Hytech Sands (Sun-Arise) extract Tertiary Sand at Roberts Road. The company's current reserves are about 2.5 million tonnes. No additional resources have been identified by the company.

Somersby Plateau

Somersby Plateau west of Gosford contains large areas of friable sandstone. Currently four companies operate quarries in the area.

Pioneer Construction Materials P/L extract sand at Reservoir Road Somersby. Current reserves are about 8 million tonnes. In addition the company has identified additional resources of about 2 million tonnes.

Calga Sands P/L operate a quarry near Peats Ridge Road, Calga. The current reserves are 2 million tonnes with a possible further resource of 3 million tonnes.

Rindean Sands operate two quarries in the area. The company's quarry near Somersby produces about 50,000 tonnes of sand per annum and has reserves of about 4 million tonnes. The company's other quarry near Peats Ridge produces about the same amount of material annually and has reserves of about 1 million tonnes. No additional reserves have been identified adjacent to either quarry.

Eastern Sand and Gravel operate a small quarry on Hoipos Road and produce about 30,000 – 50,000 tonnes of sand annually. The reserves are unknown but are thought to be small.

Other Friable Sandstone Sources

Tinda Park quarry operated by Birdon Contracting produces 30,000-60,000 tonnes of sand annually at Colo Heights in the northern part of Hawkesbury LGA. The quarry has reserves of about 2 million tonnes and a possible further resource of about 10 million tonnes.

Small amounts of sand have been produced from the area between Darkes Forest and Appin in the eastern part of Wollondilly Shire. Currently only one small quarry is operated by *J. Taylor Sands P/L* which produces a few thousand tonnes of sand annually. Large resources have been identified adjacent to the quarry. Future extraction is, however, constrained by environmental factors.

ALTERNATIVE MATERIALS

Alternative materials such as slag sand, quarry sand (crusher fines), manufactured sand, recycled building and demolition materials, excavated rock and fly ash have been considered as potential alternatives for natural sand. As the Department of Mineral Resources does not collect data on the usage of these materials, it is difficult to estimate the quantities consumed. For the purposes of this study it is assumed that the proportion of the sand market occupied by these products is currently negligible. Their main characteristics and some of their limitations are discussed below.

Slag sand is a by-product of steel making. It has potential to replace coarse sand in some applications such as asphalt and as fill. The steelworks at Port Kembla currently produce about 1.6-1.8 million tonnes of blast furnace slag annually. Of this 470,000 tonnes is used as a substitute for natural sand in concrete and asphalt (A. Leshchinsky of Australian Steelmill Services, pers comm 2001), the bulk of which is used in the Illawarra. The amount of slag sand used in the Sydney Planning Region is thought to be very small.

Quarry sand (crusher fines/ crushed hard rock residue) is produced during the crushing of hard rock for coarse aggregate. This material is by nature very angular and, while it is available in a range of sizes, it is suitable only for those applications in which the shape of the grain has little importance or is required to be angular. In addition, the availability of crusher fines is limited by a number of factors. Firstly, they are produced in declining amounts due to improved crushing techniques; secondly, the bulk of crusher fines are utilised in other quarry products such as road base, and thus are not available for use as fine aggregate; and thirdly, the availability of crusher fines is governed by the demand for coarse aggregate.

Material termed *'manufactured sand'* is produced by either additional processing of crusher fines, or by crushing hard rock to sand size particles. In the first case, crusher fines are reprocessed to reduce the proportion of fine particles so as to improve the overall grading of the material. In the second case, where the primary objective is to manufacture sand, hard rock is crushed and then reprocessed to improve the shape of the resulting particles and the grading of the material.

Significant quantities of coarse-grained sand are manufactured in the other States. For example, 770,000 tonnes of coarse-grained manufactured sand was used in southeast Queensland in 1998/99 (O'Flynn and Stephens 2000). Manufactured sand may therefore be a long term supply option for coarse-grained sand. The use of manufactured sand in concrete, however, requires approximately 25% more fine- to medium-grained sand in the mix (O'Flynn and Stephens 2000) and fine- to medium-grained sand of adequate quality can not be manufactured with present technology (O'Flynn and Stephens 2000). Therefore there is a demand for fine- to medium-grained sand which can only be supplied by natural sources.

Furthermore, the availability of manufactured sand is constrained partly by similar factors as quarry sand above, and partly by the fact that using high quality hard rock to produce sand reduces the availability of such rocks for use as coarse aggregate.

Recycled building and demolition materials include crushed recycled concrete and brick. Crushed recycled concrete can be used as a coarse sand replacement in low strength concrete. At present, however, almost all crushed recycled concrete is used as fill, bedding and paving sand, or as aggregate in road pavements. Crushed recycled brick is only suitable for use as fill at present, though its use in concrete can be tolerated to some extent, depending on the application.

Excavated rock, commonly referred to as "spoil", is sourced from tunnelling and large scale excavation projects. The composition of this material is governed by the local geology of the project site. A number of infrastructure projects planned for the Sydney Planning Region over the next few years will be in areas where the local lithologies consist of sandstone with interbedded shale units. To produce good quality sand products from such rocks would require selective extraction during excavation or intensive reprocessing, either on site or elsewhere. This may be extremely difficult or impossible, and would almost certainly add to the cost of excavation and/or production. Therefore, due to its heterogeneous nature and physical characteristics, the amount of excavated material which may be used as a substitute for natural sand in high quality applications is likely to be small. The material is, however, suitable for use as fill.

Fly ash (precipitated fuel ash and furnace bottom ash) produced by coal fired power stations has some potential as a sand alternative. Its main advantages are its light weight and its self cementing properties. The weight of fly ash enables it to be used as a light weight aggregate in applications which require strength but in which there are restrictions on the weight of the structure. The self cementing properties of fly ash mean that it can be used as a cement extender in concrete, which is the main use for this material. The main constraints on the use of fly ash are the processing and transport costs. Fly ash initially consists of fine irregular fragments which must be reprocessed before the material is suitable as either coarse or fine aggregate. The economic viability of these processes has yet to be determined. Added to this are transport costs. The material would have to by transported long distances from Lithgow and the Hunter Valley, which are the nearest sources to Sydney.

It may be concluded from the above discussion that none of the materials under consideration has the ability to replace natural construction sand, particularly fine construction sand, in high quality applications such as concrete, to any significant degree. The most important constraints on their more widespread use are; cost of production and in some cases transport, limited availability, erratic quality, and technical difficulties in obtaining suitable ranges of particle sizes and particles of acceptable shape and soundness.

Materials that are not suitable in concrete are, however, appropriate for low quality applications such as fill.

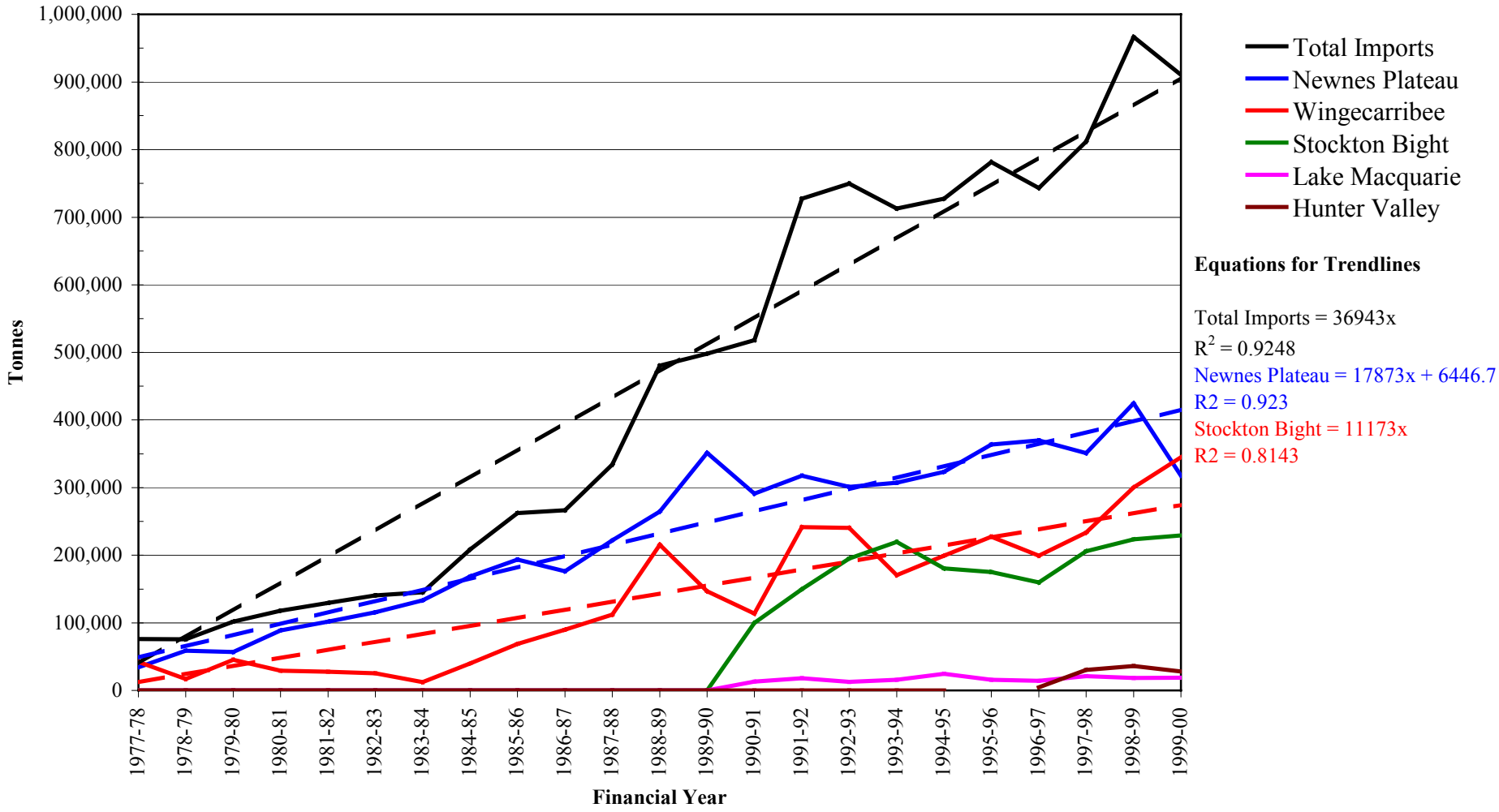
IMPORTS

Since the 1970s, considerable quantities of construction sand have been imported into the Sydney Planning Region from adjoining regions.

The main source areas of the imports have been Newnes Plateau, Wingecarribee Shire and, since 1992, Stockton Bight. Small amounts of sand have also been imported from Lake Macquarie and the Hunter Valley. About 70% of the imported sand is fine- to medium-grained and about 30% medium- to coarse-grained. Most of the fine- to medium-grained sand is sourced from Wingecarribee Shire and Stockton Bight, with small amounts coming from Newnes Plateau. Coarse- to medium-grained sand is sourced mainly from Newnes Plateau. Minor amounts come from Raymond Terrace near Stockton Bight.

Only minor amounts of sand were imported to the planning region prior to 1977/78. Figure 9 shows the total amount of imports and the tonnages imported from each area for the period 1977-2000.

Figure 9: Construction Sand Imports to Sydney Planning Region 1977/78-1999/00

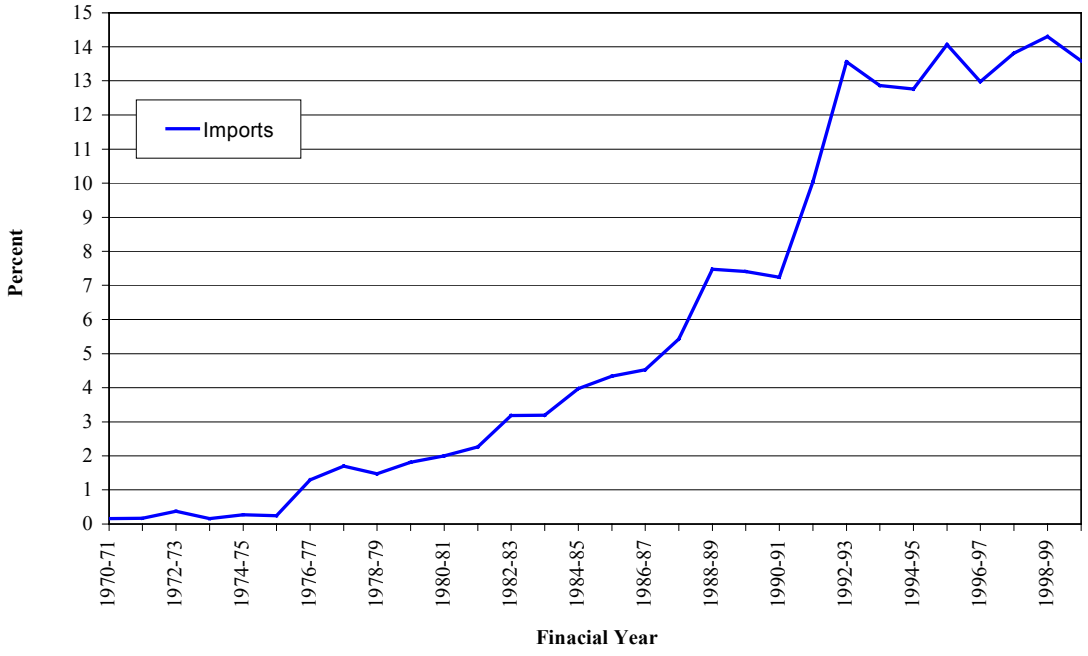


Total imports have increased from just over 60,000 tpa in 1977/78 to just over 900,000 tpa in 1999/2000, peaking at almost 1 million tonnes in 1998/1999. Regression analysis of the data indicates that imports have increased at an annual rate of about 37,000 tonnes since 1977/78.

Although this may be taken as a confident estimate of the growth in imports since 1977/78 (R-squared value 92.48%), it appears to underestimate the situation over the past decade or so. The data in figure 9 shows that annual imports have increased quite rapidly since about 1985/86. If the data are examined for the interval 1985/86-1999/00, the regression analysis (graph not shown) yields an annual increase of about 53,200 tonnes with a confidence level of 94.9%. This appears to be a more realistic estimate of the current situation and a more reliable basis for future forecasts.

The proportion of imports (figure 10) has risen from less than 5% of total consumption in the 1970s to about 14% in the 1990s. The data shows a steady rise through the 1980s followed by a sharp increase in the early 1990s corresponding to the commencement of sand imports from the Stockton Bight. It is expected that imports will remain at about their present levels whilst the Penrith Lakes Scheme and/or Kurnell are operational. The cessation of either or both of these operations will create a large shortfall in local production which will have to be made up by increasing imports.

Figure 10: Imports as a Percentage of Total Consumption



IMPORTS FROM NEWNES PLATEAU

The Newnes Plateau near Lithgow has been the largest source of imported construction sand over the past three decades. The area contains vast resources of friable sandstone and currently Pioneer Construction Materials (Kables quarry) and Rocla P/L (Bell quarry) operate in the area. In addition, Boral Resources (NSW) P/L operated Clarence quarry, during the 1980s and early 1990s. This quarry has been non-operational since 1994 and is currently under care and maintenance.

An average of 330,000 tonnes of sand has been imported annually from Newnes Plateau since the early 1990s, about two-thirds of which have been medium- to coarse-grained. A trend line fitted to the data in figure 8 shows a modest annual increase of 17,873 tonnes since 1977. Over the past decade, the annual increase was even less, about 6,000 tonnes (trend line not shown). It is probably reasonable to expect that imports from this area will remain at present levels in the short to medium term. They will, however, increase significantly if Boral Resources (NSW) P/L resumes operations at their Clarence quarry.

IMPORTS FROM WINGECARRIBEE SHIRE

Wingecarribee Shire, southwest of the Sydney Planning Region, also contains large identified resources of friable sandstone. Currently Rocla P/L (Soapy Flat) and Heggies Bulkhaul Ltd (Penrose quarry) extract predominantly fine- to medium-grained sand from two of these deposits. In addition, Menangle Sand and Soil extracted sand and gravel from Tertiary deposits at Kangaloon until 1999/2000 when extraction ceased. Most of the yearly production from these operations is trucked to the Sydney Planning Region.

Annual imports from these quarries has grown from about 100,000 tonnes in the late 1980s to about 350,000 tonnes in 1999/2000. The annual increase from 1977/78 (shown by the trend line on figure 9) is just over 11,000 tonnes. This estimate appears to be fairly modest, as the data shows a large increase in the yearly imports from 1983/84 onwards. If the data are examined from 1983/1984 to 1999/2000 the rate of annual increase is just over 16,000 tonnes (graph not shown), which although slightly higher, is not significantly different from the previous estimate.

The rate of increase of annual imports from this area is expected to continue to be modest in the short term, but can be expected to increase after Penrith Lakes Scheme and/or Kurnell cease operations.

IMPORTS FROM STOCKTON BIGHT

Sand imports from Stockton Bight commenced in 1991 at an initial rate of about 50,000 tpa. After a rapid initial increase, the amount has remained at about 200,000 tpa (figure 9) throughout the 1990s (average since 1992/93 is 198,544 tpa).

Boral Resources (NSW) P/L (Stockton), TollBulkSands (Williamtown) and Quality Sand and Ceramics P/L (Williamtown) currently extract fine construction sand from dune deposits at Stockton Bight to supply the local market as well as the Sydney Planning Region. In addition, Rocla P/L (Raymond Terrace) extracts medium- to coarse-grained sand from the flood plain of the Hunter River.

Sand from Stockton Bight is brought to the Sydney Planning Region as ‘back load’ by trucks which carry scrap steel to Newcastle. Without this ‘back loading’ the 190 km transport distance would make road haulage of sand uneconomic.

It is probably reasonable to expect that the imports from Stockton Bight will remain at current levels in the short to medium term. Large resources remain in the area outside the existing extraction sites, but environmental constraints could severely limit their development. The main

factor limiting the amount of sand that can be economically exported to the Sydney Planning Region is the availability of trucks which can 'back load' sand to Sydney.

IMPORTS FROM OTHER SOURCES

Small amounts of sand are imported to the Sydney Planning Region from Teralba quarry in Lake Macquarie and Sandy Hollow in Muswellbrook. This is a minor contribution and is expected to remain as such in the future.

CONSUMPTION

The apparent yearly consumption of construction sand in the Sydney Planning Region can be estimated to equal the total yearly production from all sources within the region plus the amount of imported sand. It is reasonable to assume that local production is consumed almost immediately as there is little or no long term stockpiling of material by sand producers; sand is produced at the rate at which it can be sold.

The consumption of construction sand in the Sydney Planning Region for the period 1969-1999 is shown in figure 11. Also shown are the total imports and the total production from within the Sydney Planning Region. As there is no data on the use of alternative materials, it is assumed that their usage is negligible.

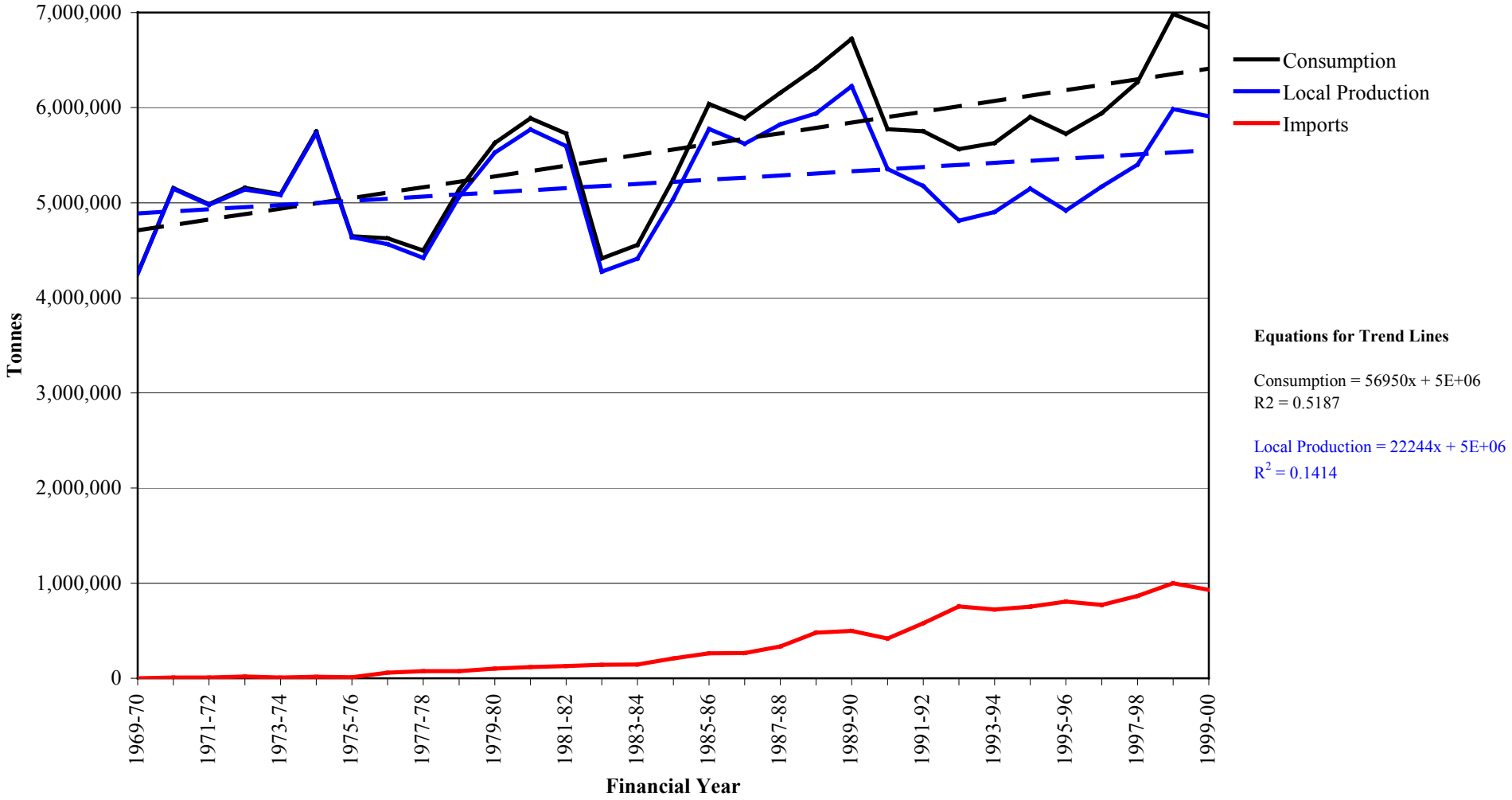
The long term trend for consumption closely resembles that of local production and is best described as cyclic. The cycles last 7-10 years and are a reflection of the economic conditions of the day. Consumption averages 5,560,273 tonnes annually (table 6) but, as the data is highly variable, such an estimate probably has little value. A trend line fitted through the consumption data shows the yearly increase in consumption to be 56,950 tonnes. The R-squared value for this trend line is 51.87%, indicating that this estimate is moderately reliable If consumption is examined over the past three decades (table 6) it can be seen that average annual consumption has increased from about 4.9 million tonnes in the 1970s to about 6.0 million tonnes in the 1990s. The overall average increase is thus just over a million tonnes and the average yearly increase about 50,000 tonnes, which is close to the estimate above.

The average yearly consumption increased by 66,655 tonnes from the 1970s to the 1980s, and by 42,984 tonnes from the 1980s to the 1990s. This indicates that, although more sand was consumed annually in the 1990s than in previous decades, the increase in the annual consumption during the 1990s was less than previously.

Table 6: Average Consumption of Construction Sand 1969-2000

	1969/70-78/79	1979/80-88/89	1989/90-99/00	1969/70-99/00
Local Production	4,901,664	5,377,881	5,309,648	5,219,392
Imports	28,363	218,693	716,765	340,881
Consumption	**4,930,028**	**5,596,574**	**6,026,412**	**5,560,273**

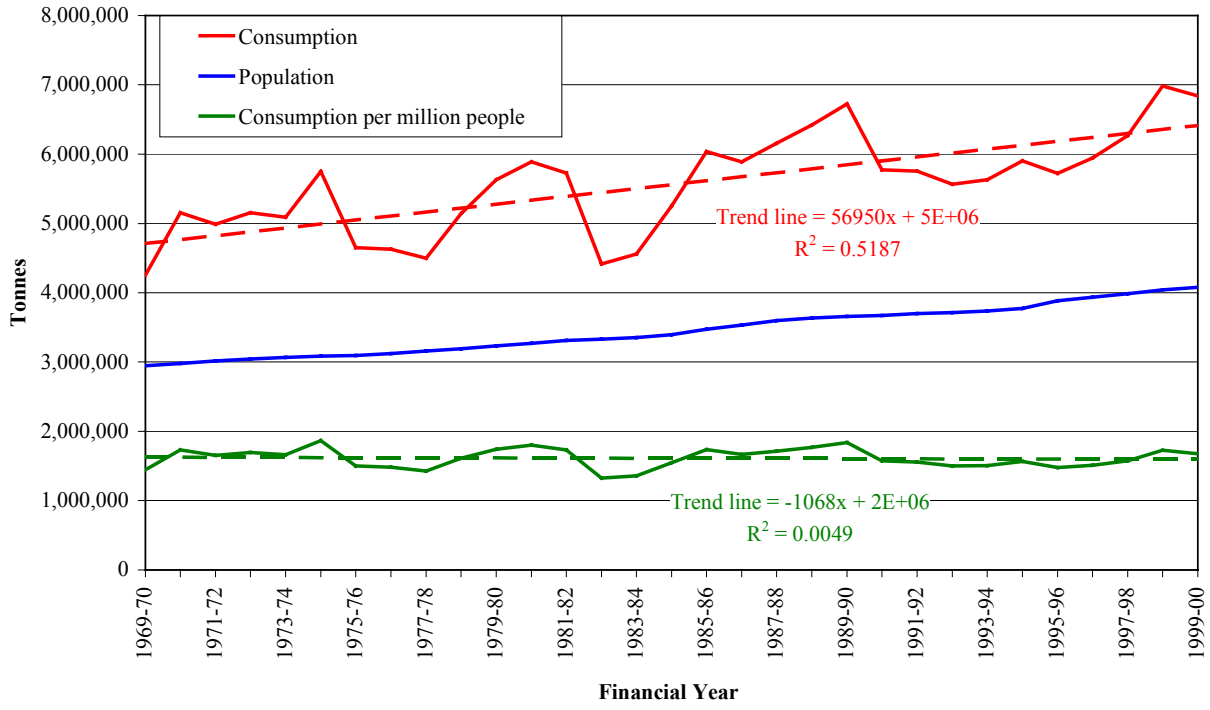
Figure 11: Consumption of Construction Sand in the Sydney Planning Region 1969-2000



As discussed previously the cyclic nature of construction sand production and consumption can be attributed to fluctuations in economic activity of the day. There appears to be, however, an underlying overall slow increase in consumption irrespective of the cycles of high and low demand. This slow increase is a reflection of the growth of the construction industry which in turn is a reflection of the increasing demand for aggregate products associated with increasing population of the Sydney Planning Region.

Figure 12 shows the consumption of construction sand (same data as in figure 11), Sydney Planning Region population from 1969/70, and consumption of construction sand per million people. The population figures supplied by Australian Bureau of Statistics show that the Sydney Planning Region population has grown very steadily over the past 30 years. It should be noted that a population census is carried out only every five years, and the size of the population for the intervening years is estimated using the results of the census and other relevant factors.

Figure 12: Consumption of Construction Sand and Population



The population data shows an annual increase of 37,550 people, the R-squared value associated with this estimate is 98.6% (the trend line is not shown as it is so similar to the data line that it would obscure it). As population growth has been steady, the peaks and troughs of the per capita consumption data reflect the pattern of the data for consumption. A trend line fitted through the per capita data has a negative slope of about 1.07 tonnes/million people/year, or 0.001070 tonnes per capita/year, which means that there is practically no change in the per capita consumption of construction sand. The R-squared value for this line is, however, less than 0.5% indicating that this estimate is extremely unreliable. As the estimate is so poor, it is impossible to deduce the change in yearly per capita consumption of construction sand from this data.

From the above it appears that there is no direct correlation between the yearly consumption of construction sand and population. This conclusion is probably valid since the large yearly variations in the consumption data can be attributed to the business cycle rather than changes in the

size of the population. However, the underlying slow increase in construction sand consumption is probably a reflection of the growth of the construction industry, which in turn reflects the population growth of the Sydney Planning Region.

FUTURE DEMAND

For planning purposes it is important to make estimates of the future demand for construction sand. The estimation of future demand can be done in a number of ways. Wallace (1980) based estimates of future demand on assumed growth rates of the quarry industry as well as on assumed per capita consumption trends. Spackman (1992) calculated future demand by correlating population growth with growth in sand demand.

For the purposes of this study it is reasonable to predict construction sand demand up to year 2040, as 40 years is a realistic period for future resource planning. In the following, future demand is estimated by using past trends in consumption and by using population statistics.

FUTURE DEMAND BASED ON PAST CONSUMPTION TRENDS

A simple method for estimating future demand for construction sand is to extrapolate the past consumption trend into the future. The trend line fitted for the consumption data shown in figures 11 and 12 indicate an annual increase of 56,950 tonnes over the past 30 years. Using this figure estimates of cumulative construction sand demand were calculated for years 2010, 2020 and 2040, and these are listed in table 7.

The total demand can be divided into demand for different sand types based on past trends and the following assumptions. The demand for medium- to coarse-grained sand can be estimated to be 35–40% of the local production (figure 5) plus about 30% of the annual imports, which equates to about 36.5% of total consumption.
The demand for fine- to medium-grained sand can be approximated by assuming that:

- In addition to the fine- to medium-grained sand produced in the planning region about 70% of the imported sand is fine- to medium-grained sand
- At least 50% of the clayey/mortar sand produced within the planning region is washed to produce clean fine- to medium-grained sand suitable for concrete, asphalt and industrial uses.

Using these assumptions the proportion of fine- to medium-grained sand is calculated to be 48.2% of total demand, and the proportion of clayey/mortar sand is simply 100 – (36.5 + 48.2) = 15.3%. These proportions were used to calculate the demand for different sand types listed in table 7.

Table 7: Predicted Construction Sand Demand Based on Past Consumption Trends

Sand Type	2000-2010	2000-2020	2000-2040
	Short Term	Medium Term	Long Term
Medium – Coarse	25.08	50.08	106.32
Fine – Medium	33.11	66.13	140.41
Clayey/mortar	10.51	20.99	44.57
Total	**68.7**	**137.2**	**291.3**

All figures are cumulative totals in millions of tonnes. Discrepancies in totals are due to rounding

FUTURE DEMAND BASED ON POPULATION STATISTICS

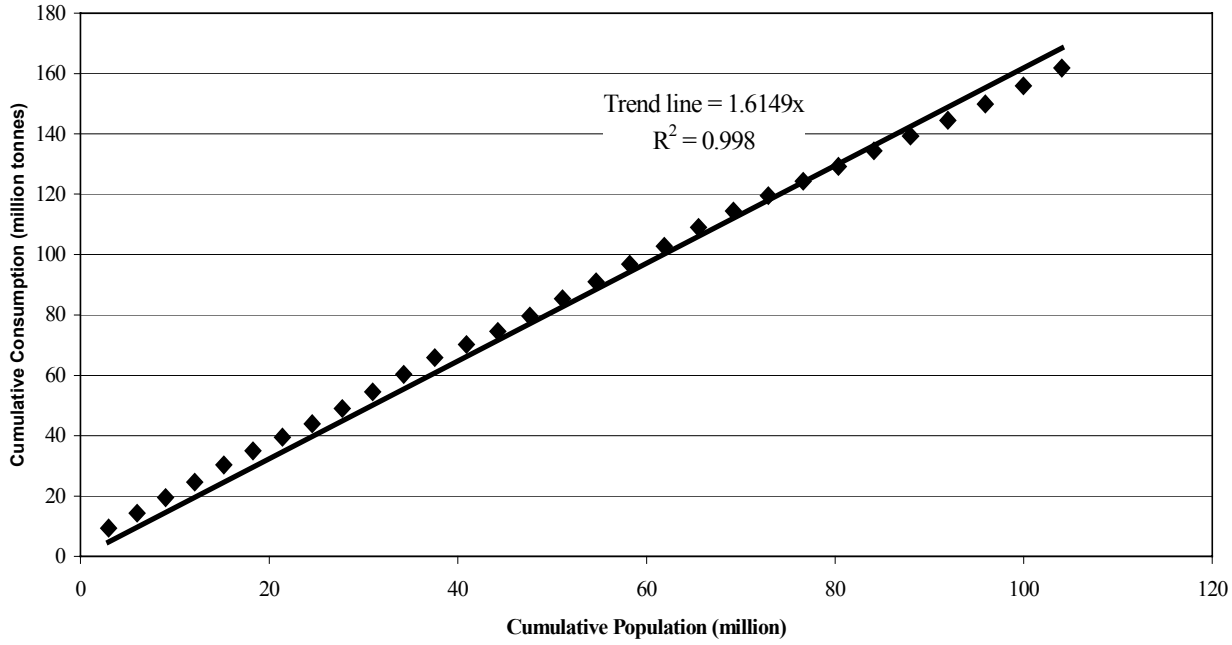
Future demand for construction sand can also be estimated by using population statistics. The simplest way is to project past average yearly per capita consumption of construction sand into the future. Table 8 shows the average yearly per capita consumption for the period 1969-1999 as well as the averages for the 1970s, 1980s and 1990s. The long term yearly average is 1.611 tonnes per capita. The average yearly per capita consumption was highest in the 1980s at 1.64 tonnes per capita and lowest in the 1990s at 1.58 tonnes per capita. The average yearly per capita consumption in the 1970s was equal to the long term average of 1.61 tonnes. These figures indicate that over the past 30 years per capita consumption has remained fairly steady and thus it would not be unreasonable to use the long term average 1.611 tonnes per capita per year as a figure to make forecasts of the future demand.

Table 8: Average Annual Per Capita Consumption of Construction Sand 1969-2000

	1969/70-79/80	1980/81-88/89	1989/90-99/00	1969/70-1999/00
Average Annual Per Capita Consumption (tonnes)	1.61	1.64	1.58	**1.611**

Another way of estimating the yearly per capita consumption over the past 30 years is to plot the cumulative consumption against cumulative population, as in figure 13. This process eliminates most if not all of the cyclicity in the raw consumption data and thus produces a result that is more reliable to work with when estimating future demand. It should be noted that the graph does not indicate that construction sand consumption is directly related to population, nor does it show directly the consumption of sand on any particular year, or give any indication whether the consumption per capita is decreasing or increasing.

Figure 13: Cumulative Consumption of Construction Sand Vs Cumulative Population



The slope of the line in figure 13 represents the 'average' consumption of aggregate per capita over the past 30 years. This graphically derived average is, in theory at least, a more reliable estimate of the per capita consumption than the arithmetic estimate (1.611, table 8), as this method removes uncertainties associated with the estimation of an arithmetic mean from highly variable data such as this. The data points define a line with a slope of 1.6149 with an R-squared value of 99.80%, which is not significantly different from the arithmetic mean. However, as it is considered to be more reliable, it will be used as a basis for estimates of future demand in the following.

The Australian Bureau of Statistics has estimated the Sydney Planning Region's population for up to year 2050 for three scenarios; low, medium and high population growth, the medium estimate being the 'most likely' to eventuate according to the Bureau. Population estimates based on these scenarios are listed up to year 2040 in table 9 below.

Table 9: Predicted Population of the Sydney Planning Region

Estimate\Year	2010	2020	2040
High	4,544,500	5,080,900	5,891,100
Medium	4,405,700	4,714,400	5,150,200
Low	4,313,700	4,528,600	4,748,200

Using the data in table 9 and population estimates for each individual year for the period 2000-2040 cumulative population estimates were calculated (these figures not listed). Based on the cumulative population estimates and the assumed constant per capita demand of 1.6149 tpa, the cumulative total construction sand requirement for the periods 2000-2010, 2000-2020 and 2000-2040 were calculated. These are listed below in table 10. The demand for different sand types is estimated using the proportions calculated previously, ie medium- to coarse-grained sand 36.5%, fine- to medium-grained sand 48.2% and clayey/mortar sand 15.3%.

Table 10: Predicted Demand for Construction Sand

Low Population Estimate/Sand Type	**Short Term 2000-2010**	**Medium Term 2000-2020**	**Long Term 2000-2040**
Medium-Coarse	24.7	50.7	108.5
Fine-Medium	32.6	67.0	143.3
Clayey/Mortar	10.3	21.3	45.5
Total	**67.6**	**139.0**	**297.4**
Medium Population Estimate/Sand Type	**Short Term 2000-2010**	**Medium Term 2000-2020**	**Long Term 2000-2040**
Medium-Coarse	25.0	51.9	113.1
Fine-Medium	33.0	68.5	149.3
Clayey/Mortar	10.5	21.8	47.4
Total	**68.4**	**142.2**	**309.8**
High Population Estimate/Sand Type	**Short Term 2000-2010**	**Medium Term 2000-2020**	**Long Term 2000-2040**
Medium-Coarse	25.4	56.0	122.8
Fine-Medium	33.6	74.0	160.8
Clayey/Mortar	10.7	23.5	51.1
Total	**69.7**	**153.5**	**333.7**

All figures are cumulative totals in millions of tonnes. Discrepancies in totals are due to rounding

Apart from the estimates based on the low population growth model these estimates are somewhat higher than the demand estimates based on past consumption trends (table 7). When considering supply options for the future, it is probably reasonable to use the demand estimates based on the high population growth model, so as not to underestimate the future demand.

SATISFYING FUTURE DEMAND

SHORT TERM 2000-2010

To make any predictions as to how the projected future demand may be satisfied, it is essential to identify the reserves which currently supply the region, as well as the resources which have the potential to do so in the future. These are listed in table 11. Resources under current development consent are reported as 'reserves'. 'Total Resources' include the reserves under current consent, as well as other resources identified adjacent to current operations. It is impossible to predict what proportion of the identified resources yet to gain development consent will become available in the future. Therefore 'a best case scenario' is assumed, ie that all identified resources will be granted consent and become available for extraction. The 'Total Production to 2010' figures have been calculated using extraction rates reported by quarrying companies. 'Resources Remaining After 2010' is an estimate of 'Total Resources' remaining after year 2010. It is assumed that Penrith Lakes Scheme will be exhausted by 2010.

The predicted total sand demand to year 2010 is 69.7 million tonnes (table 10). Total production for the same period is predicted to be 60.1 million tonnes. This leaves an apparent short fall of 9.6 million tonnes or about 960,000 tonnes per year, which is approximately equal the current level of imports (900,000 tonnes in 1999/2000).

The predicted demand for *fine- to medium-grained sand* for the period is 33.6 million tonnes (table 10). If the identified resources at Kurnell Peninsula remain available for extraction, in addition to those at Penrith Lakes, the region can be expected to produce about 16 million tonnes of fine- to medium-grained sand. In addition, about 50% of the clayey/mortar sand produced within the region is currently washed to produce clean fine- to medium-grained sand. This trend is likely to continue in the future, and therefore about 11 million tonnes of fine- to medium-grained sand can be expected to be sourced from clayey/mortar sand deposits over the next ten years (ie half the total mortar/clayey sand production shown in table 11). This gives a total of about 27 million tonnes and leaves an apparent shortfall of about 6-7 million tonnes for the 10 year period.

As mentioned previously, the planning region currently imports 900,000-1,000,000 tonnes of sand per annum of which about 70% is fine- to medium-grained grained. Therefore, over the ten year period about 6-7 million tonnes of fine- to medium-grained sand could be expected to be imported, which is about the amount of the predicted shortfall.

It therefore appears that the demand for fine- to medium-grained sand up to 2010 can be supplied by continuing extraction from current local sources and by continuing imports at about current rates. This, however, is dependent on the continuation of sand extraction on the Kurnell Peninsula, which could produce about 12 million tonnes of sand (roughly 30% of the predicted demand) over the next decade. Should extraction at Kurnell Peninsula cease prior to 2010, the amount of sand that would have to be imported would increase dramatically.

Table 11: Current Sources and Predicted Production in the Sydney Planning Region to Year 2010 (All figures in millions of tonnes)

Sand Type	Deposit/Company	Reserves	Resources	Total Resources	Total Production to 2010	Resources Remaining after 2010
Fine Sand	Kurnell/ Rocla P/L	2.3	24.0	26.3	12.0	14.3
	Moorebank/ Benedict Sand & Gravel	0.02	0.15	0.17	0.17	0
	Penrith Lakes Scheme/ CSR, Boral, Pioneer	4.0	0	4.0	4.0	0
	Totals Fine Sand	**6.32**	**24.15**	**30.47**	**16.17**	**14.3**
Medium-Coarse Sand	Penrith Lakes Scheme/ CSR, Boral, Pioneer	22.00	0	22.00	22.00	0
	Windsor/ Rocla P/L	.50	0	0.50	0.50	0
	Totals Medium-Coarse Sand	**22.50**	**0**	**22.50**	**22.50**	0
Mortar/Clayey Sand						
High Level Deposits	Agnes Banks/ Dixon Sands	1.50	0	1.50	1.00	0.50
	P.B White	0.50	0	0.50	0.50	0
	Elderslie/ M. Collins & Sons	0.78	0.50	1.28	0.50	0.78
	Nepean Quarries	0.30	0.08	0.38	0.38	0
	Menangle/ Menangle Sand & Soil P/L	0.65	2.60	3.25	0.50	2.75
	Maroota/ PF Formation	4.00	5.00	9.00	2.50	6.50
	Hytech Sands	2.50	0	2.50	1.50	1.00
	Sub-Totals	**10.23**	**8.18**	**18.41**	**6.88**	**11.53**
Friable Sandstone Deposits	Maroota/ PF Formation	1.00	5.00	6.00	2.5	3.5
	Dixon Sands	1.70	4.00	5.70	3.5	2.2
	Somersby Plateau/ Pioneer	8.00	2.00	10.00	2.5	7.5
	G.R Jones	1.00	8.00	9.00	1.0	8.0
	Calga Sands	2.00	3.00	5.00	3.0	2.0
	Rindean Sands	5.00	0	5.00	1.0	4.0
	Tinda Park/ Birdon Contracting	2.00	10.00	12.00	1.0	11.0
	Appin/J. Taylor	1.00	00	1.00	0.05	0.95
	Sub-Totals	**21.70**	**32.00**	**53.70**	**14.55**	**39.15**
Total Mortar/Clayey Sand		**31.93**	**40.18**	**72.11**	**21.43**	**50.68**
TOTAL ALL SAND TYPES		**60.75**	**64.33**	**125.08**	**60.10**	**50.68**
PREDICTED DEMAND					**69.70**	
APPARENT SHORTFALL					**9.60**	

The predicted demand for *medium- to coarse-grained sand* for the period 2000-2010 is 25.4 million tonnes (table 10). The predicted production from sources within the planning region for the same period is 22.5 million tonnes, which leaves an apparent shortfall of about 3 million tonnes. If imports continue at their present levels then about 3 million tonnes of this type of sand could be expected to be imported and the apparent shortfall is about 1 million tonnes. It is not unrealistic to expect that this could be made up by slightly increasing the imports or by increasing the production of this type of sand from friable sandstone deposits within the region.

The predicted *clayey/mortar sand* production for the 2000-2010 period is about 21.43 million tonnes. The demand for this type of sand is predicted to be 10.7 million tonnes. In addition, about 11 million tonnes of clayey/mortar sand is expected to be washed to produce fine- to medium-grained sand. This means that there appears to be no shortfall in the supply of clayey/mortar sand. However, shortfalls in the supply of fine- to medium-grained and medium- to coarse grained sand will increase the demand for clayey/mortar sand to be washed to produce clean sand. To meet this increased demand it is likely that more than the predicted 21.43 million tonnes of clayey/mortar sand will have to be produced.

Overall it can be concluded that the predicted demand for construction sand for the period 2000-2010 could be supplied by continuing extraction from the current sources within the planning region and by continuing imports at their present or slightly increased levels. However, a large shortfall in the supply of fine- to medium-grained sand will occur if extraction ceases at Kurnell Peninsula. This shortfall, if it eventuates, will have to be made up by either substantially increasing imports and/or by sourcing more fine- to medium-grained sand from friable sandstone deposits within the planning region and/or by opening new deposits for extraction within the planning region.

MEDIUM TERM 2010-2020

The predicted sand demand for the medium term can be calculated from data in table 10 by subtracting the demand estimate for 2000-2010 from the demand estimate for 2000-2020. The predicted total demand for the Sydney Planning Region for the period 2010-2020 is 83.8 million tonnes (table 10; 153.5-69.7) of which 31.2 million tonnes (table 10; 56.0-25.4) is predicted to be for medium- to coarse-grained sand, 40.4 million tonnes (table 10; 74.4-33.6) for fine- to medium-grained sand and 12.8 (table 10; 23.5-10.7) million tonnes for clayey/mortar sand.

The resources possibly remaining after 2010 are listed in table 12 for current operations within the planning region which are not predicted to cease before 2010 (same data as table 11). Although its future is uncertain, Kurnell Peninsula is included in this group. Also listed are those identified resources within the planning region which are considered to have potential to supply sand in the future. The location of these are shown on figure 14. The resources available within and adjacent to current operations are predicted to be about 65 million tonnes after 2010, of which about 14 million tonnes is fine- to medium-grained sand at Kurnell Peninsula, the rest being clayey/mortar type sand, most of which (38.9 million tonnes) is contained in friable sandstone deposits. Clearly, even if it was possible to utilise all of these resources, they are not sufficient to supply the predicted demand for the period 2010-2020. Only about 40 million tonnes can be expected to be produced within the planning region from the operations listed in table 12. Therefore, unless new deposits within the planning region are made available for extraction, 40-45 million tonnes of sand will have to be imported from the adjoining regions over the ten year period. This equates to just over 4-5 million tonnes per year, which is about five times the amount currently imported annually. If

the major mode of transport is by road, then the volumes of heavy traffic can be expected to increase significantly and consequently the problems associated with heavy traffic will become worse. The adverse effects of road transport can be reduced by increasing transport by other means, eg rail, or by making deposits identified within the planning region, which are within a short transport distance, available for extraction.

Large resources of sand have been identified within the planning region (table 12 figure 14). The deposits which are considered to have potential to be major sources of sand in the future are discussed below.

Resources in the Sydney Planning Region

Kurnell

As discussed previously Kurnell peninsula contains large resources of fine- to medium-grained sand. It is estimated that in addition to the present reserves of 2.3 million tonnes there is a further resource of about 24 million tonnes. If extraction continues at about present levels it is possible that these resources would last for about 20 years, and therefore Kurnell Peninsula has the potential to be a source of fine- to medium-grained sand at least in the medium term. There are, however, severe environmental and societal constraints on the development of these deposits and it is uncertain what proportion of these deposits will be developed, if any.

Maroota

Large resources of Tertiary Maroota Sand and friable Hawkesbury Sandstone have been identified at Maroota. The Plan of Management (Resource Planning 1991) identified a total of over 80 million tonnes of sand. It is estimated that in addition to the resources secured companies (table 12) there are a further 30 million tonnes of Maroota Sand and 30 million tonnes of friable sandstone. An additional 11 million tonnes of friable sandstone was identified by a drilling programme carried out by the Department of Mineral Resources at North Maroota (MacRae and Ferguson 1993). To consider that all of this is extractable would not be realistic and the resources available for future development are likely to be significantly less than this.

All of the identified Maroota Sand is clayey/mortar sand which can be washed to produce clean fine- to medium-grained sand. The friable sandstones have a wider grain size distribution and can produce both fine- to medium-grained and medium- to coarse-grained sand.

Spackman (1992) identified a number of constraints on the further development of these deposits these are re-iterated below:

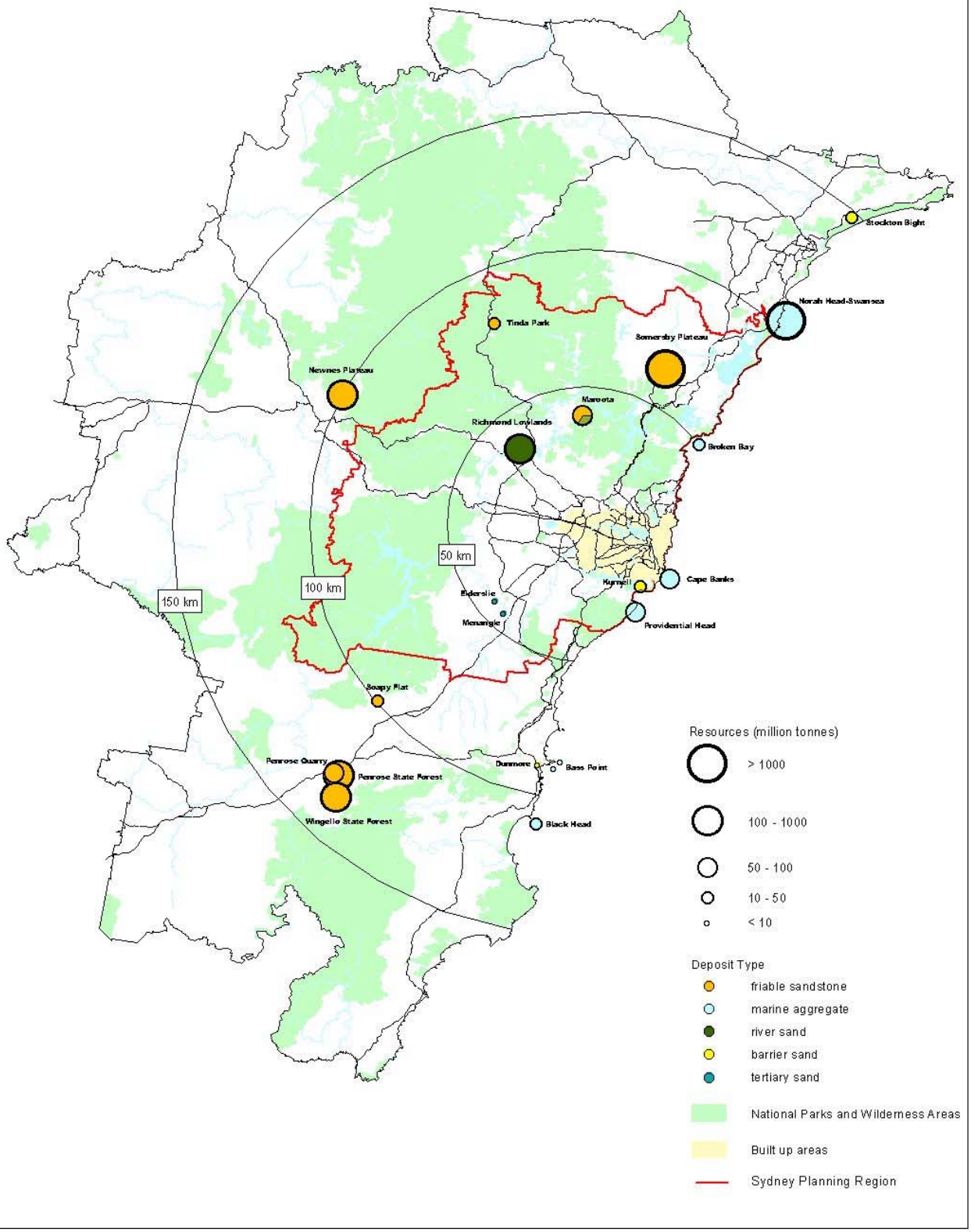
- The Old Northern Road which is the main transport route is not considered suitable for large volumes of heavy traffic.
- The Maroota Sand deposit is a significant aquifer. The ground water is used for agriculture and domestic uses therefore the effects that sand extraction may have on the ground water quality are a major concern.
- A large proportion of the land containing the sand resources is utilised by other landuses, principally orchards and market gardens, with relatively small lot sizes.

Table 12: Sand Resources Within Sydney Planning Region After 2010

Deposit	Current Total Resources	Resources After 2010	Possible Resources After 2020	Possible Resources After 2040
Current Operations				
Kurnell/ Rocla P/L	26.3	14.3	2.0	0.0
Maroota/ PF Formation	15.0	10.0	5.0	0.0
Maroota/ Dixon Sands/ friable sandstone	5.7	2.2	0.0	0.0
Maroota/ Hytech Sands/ Maroota Sand	2.5	1.0	0.0	0.0
Somersby Plateau/ Pioneer	10.0	7.5	3.0	0.0
Somersby Plateau/Calga Sands	5.0	2.0	0.0	0.0
Somersby Plateau/Rindean Sands	5.0	4.0	2.0	0.0
Somersby Plateau/G.R. Jones	9.0	8.0	4.0	0.0
Elderslie/ M. Collins & Sons	1.3	0.8	0.0	0.0
Agnes Banks/ Dixon Sands	0.0	0.5	0.0	0.0
Tinda park/ Birdon Contracting	12.0	11.0	8.0	3.0
Menangle/ Menangle Sand & Soil	3.2	2.7	2.0	0.0
Appin/ J. Taylor	1.0	0.9	0.7	0.0
Windsor/ Rocla P/L	0.5	0	0.0	0.0
Total	**107.3**	**65.3**	**26.7**	**3.0**
Other Identified Resources at Maroota				
CSR	4.8	4.8	?	0
Breen Holdings	1.3	1.3	?	0
Identified Maroota Sand and friable sandstone	60.0	60.0	> 50.0	> 40
North Maroota/ friable sandstone	11.0	11.0	11.0	> 5
Total	**77.1**	**77.18**	**> 50**	**> 40**
Other Identified Resources at Somersby Plateau				
Somersby Plateau/ Friable sandstone	3000	3000		
Total	**≅ 3000**	**≅ 3000**	**≅ 3000**	**≅ 3000**
Other Identified Resources				
Richmond Lowlands/ River gravel - sand	229	229	≅ 200	> 100
Cape Banks/ Marine aggregate	57	57	57	?
Providential Head/ Marine aggregate	55	55	57	?
Broken Bay/ Marine aggregate	21	21	21	?
Norah Head-Swansea/ Marine aggregate	2800	2800	2800	> 2800
Total	**3162**	**3162**	**> 3150**	**> 3100**

All figures in millions of tonnes

Figure 14: Remaining Construction Sand Resources After Year 2010



- Environmental and visual impacts on the surrounding areas: The deposits are surrounded by topographically lower terrain much of which is in National Park, therefore the impacts on drainage and visual impacts must be considered.
- There is growing opposition to sand extraction within the local community.

Despite these constraints, Maroota should be considered as a medium-long term source of construction sand, although, the constraints on transport will limit the amount that could be expected to be produced annually.

Somersby Plateau

Large areas containing friable Hawkesbury Sandstone have been identified on the *Somersby Plateau* about 60 km north of Sydney CBD. The deposits are similar to the friable sandstone deposits at Maroota, Wingecarribee Shire and Newnes Plateau. The current operators have collective resources of just under 30 million tonnes. The total sand resources, however, are considered to be much larger, as the area covered by friable sandstone is approximately 300 km^2 (Pecover 1984), which, equates to about 9000 million tonnes of friable sandstone assuming a thickness of 20 metres and a density of 1.5 tonnes/m^2. Even though it would be unrealistic to consider all of this is extractable, extremely large resources are present. The deposits can produce most types of construction sand.

The extraction of the sand at Somersby Plateau is constrained by the current planning framework. Much of the land containing friable sandstone deposits is classified as prime agricultural land, and only limited resources are potentially available within land not classified as such. Sydney Regional Environmental Plan No.8 – Central Coast Plateau Areas (SREP 8) sought to protect the prime agricultural lands by encouraging its use for agriculture and by limiting other land uses to land of lower agricultural capacity (Spackman 1992).

The planning framework is about to be changed to allow extraction in only a very small part of the Plateau. This may seriously reduce the potential of the Somersby Plateau as a major future source of sand for the Sydney Planning Region.

A further constraint on sand extraction is the nature of the land ownership, which is mainly small acreage, and there is pressure for further small scale rural residential subdivision (Spackman 1992). In addition, the deposits under current extraction are adjacent to National Parks and extraction at the margins of the area is constrained by similar environmental and visual constraints as at Maroota.

These deposits are very large, are situated relatively close to the centre of the planning region, and along, or close to, a major transport corridor and therefore have potential to supply a large proportion of the planning region's future demand for most types of sand.

The significance of these deposits was recognised in the planning report that accompanied SREP 9. They were not, however, included in the schedules of SREP 9, as further geological and environmental investigations were at that time required to identify potential extraction sites. The identification of Somersby Plateau as a potential major long term source of sand for the Sydney

Planning Region would be a critical element of the extractive industry sector strategy currently being developed by the Department of Urban Affairs and Planning.

Richmond Lowlands

The Richmond Lowlands deposit (identified in SREP 9) is a broad flat river terrace along the Hawkesbury River north of Richmond. The deposit contains 57 million tonnes of gravel, 115 million tonnes of fine- to medium-grained sand and 114 million tonnes of medium-to coarse-sand similar to that currently extracted at Penrith Lakes (Oakes 1980). However, development of these resources is constrained by existing zoning (which prohibits extraction), existing and surrounding land uses and the value ascribed to the land as prime agricultural land, conservation values of various wetlands, and the impact of possible extraction on the Hawkesbury-Nepean River system.

Marine Aggregate

The extraction of offshore sand and gravel (*marine aggregate)* is widespread in Europe, Japan and North America.

Because marine aggregate is a mineral under the Mining Act (1992), the Department of Mineral Resources has a role in the management of marine aggregate resources in the State and issues exploration licences and mining leases for the development of those resources.

Draft SREP 9 (2) 1986 identified marine aggregate as a resource of regional significance for further investigation by the industry. Almost 3000 million tonnes of marine aggregate, mostly fine- to medium-grained sand, have been identified offshore from the Sydney Planning Region (table 12, figure 13). These deposits contain sand suitable for concrete manufacture and general construction, and therefore have the potential to become a major supplier of construction sand for the planning region in the future and to replace diminishing sand resources onshore.

Extraction of marine aggregate would reduce the environmental impacts of onshore extraction, and as several of these deposits are located within a short transport distance from Sydney Harbour and Port Botany, impacts of onshore transport would also be reduced.

The development of these resources is a contentious issue.

Minor Deposits within the Sydney Planning Region

In addition to the deposits discussed above, Spackman (1992) and Oakes et al (1995) identified a number of deposits which they considered to have potential to supply sand for the Sydney Planning Region. These are listed in table 13 below, with broad constraints.

In the past few years it has become evident that these deposits have only very limited or no potential and thus they cannot realistically be considered as significant future sources.

Table 13: Minor Sand Deposits Within the Sydney Planning Region

Deposit	Resources[1]	Constraints
Wrights and Wellums Creeks	40.0	Access, transport distance, environmental.
Macdonald River	18.6	Extraction prohibited except for remedial purposes
Colo River	25.9	Extraction prohibited except for remedial purposes
Hawkesbury River/ Penrith to Gunderman	25 - 40	Extraction prohibited except for remedial purposes
Berowra Creek	2.2	Small, environmental
Nepean River/ Wallacia to Menangle	5.0	Extraction prohibited except for remedial purposes
Budgewoi Lake	7.0	Extraction prohibited except for remedial purposes
Tuggerah Lake	7.5	Extraction prohibited except for remedial purposes
Narrabeen Lagoon	4.8	Extraction prohibited except for remedial purposes
Port Hacking	35.0	Extraction prohibited except for remedial purposes
Pitt Town	7.0	Sterilised by residential development
Botany (Bonnie Doon)	1.5 –5.0	Residential development, environmental
Darkes Forest (O'Hares Creek)	100	State Recreation Area, water catchment

[1] Estimated, million tonnes

Note: Georges River State Rec. Area and Glenfield were listed in Oakes et al (1995) have been excluded here because the resources have been exhausted.

It can be concluded from the above discussion that, although the total identified resources within the Sydney Planning Region are quite large, the resources available for extraction after 2010 will not be sufficient to supply the predicted demand for 2010-2020 and beyond. It can thus be expected that more sand will have to be imported from outside the region.

Resources Outside Sydney Planning Region

As it is uncertain as to which, if any, of the potential deposits discussed in the previous section will be developed in the future it is important to consider long term supply options from outside the planning region. These include the deposits which currently import sand to the planning region and have the potential to do so after 2010, as well as, other, identified deposits which have the potential to do so in the future. They are listed in table 14, and resources remaining after year 2010 are shown on figure 13.

Resources in the Greater Lithgow City

Large resources of friable sandstone occur at the Newnes Plateau near Lithgow (Pecover 1986). The total resources remaining in this area after year 2010 are shown on figure 13 as a composite symbol. The two currently operating quarries and Clarence quarry have combined resources of 47 million tonnes under current development consent. The resources at Bell quarry are expected to be exhausted by 2010, but Kables and Clarence quarries have the potential to supply sand in the long term, ie up to and possibly past 2040 at current or elevated extraction rates.

Table 14: Sources of Construction Sand Outside Sydney Planning Region

Area/ Deposit/ Operator	Reserves Under Consent	Total Resources	Total Resources After 2010	Possible Resources After 2020	Possible Resources 2040
Greater Lithgow					
Kables Quarry/ Pioneer	25.0	25.0	20.0	10.0	2.0
Bell Quarry/ Rocla P/L	1.0	1.0	0	0	0
Clarence Quarry/Boral	21.0	21.0	19.0	15.0	10.0
Others on Newnes Plateau		536.0	536.0	536.0	> 530.0
Total	**47.0**	**583.0**	**575.0**	**561.0**	**> 500.0**
Stockton Bight					
Stockton/ Quality Sands & Ceramics	5.0	5.0	3.0	0	0
Stockton/ Boral	1.5	6.5	3.5	0	0
Lavis Lane/ TollBulkSand	2.0	12.0	8.0	4.0	0
Raymond Terrace/ Rocla P/L	0.3	0.3	0	0	0
Total	**8.8**	**23.3**	**14.5**	**4.0**	**0**
Wingecarribee Shire					
Penrose Quarry/ Heggies Bulkhaul Ltd	12.0	87.0	82.0	75.0	65.0
Soapy Flat/ Rocla P/L	7.0	23.0	20.0	15.0	10.0
Penrose State Forest		648.0	648.0	> 640.0	> 600.0
Wingello State Forest		277.0	277.0	> 270.0	> 270.0
Total	**19.0**	**1035.0**	**1027.0**	**> 920.0**	**> 945.0**
Illawarra					
Dunmore/ Dunmore Sand & Soil P/L	2.75	9.75	5.0	0	0
Bass Point North – marine aggregate		4.8	4.8	4.8	?
Bass Point South – marine aggregate		5.2	5.2	5.2	?
Blackhead – marine aggregate		30.0	30.0	30.0	> 25
Total	**2.75**	**49.75**	**45.0**	**40.0**	**> 25**

In addition to the current operations, large resources of friable sandstone have been identified in the area. Pecover (1986) identified six resource areas which he considered to have potential for extraction. The total sand resource contained in the six areas are in the order of 500 million tonnes, mainly in State Forests. Even if only a proportion of these resources is extractable, the resources are very large and should therefore be considered as a major potential source of sand for the future.

The main constraints on the development of these resources are the transport distance to Sydney CBD (over 125 km by road); the management of clay tailings which will result from the washing of the sandstone; and the visual and other possible environmental impacts on the National Parks and Wilderness Area which are in close proximity to some these deposits.

The feasibility and cost of transporting sand by rail from these and other distal deposits to Sydney were studied by the Task Force set up to investigate options for the supply of sand for the Sydney Region in 1996 (NSW Department of Urban Affairs and Planning 1996). The Task Force found that there was potential for using rail to transport material, but the cost of freight and handling made this option uneconomic at the time. Furthermore, it was recognised that rail infrastructure improvements were required before large scale rail transport of sand or other construction materials would be possible.

Resources in the Stockton Bight Area

The reserves currently secured in the Stockton Bight area by companies exporting sand to the Sydney Planning Region are in the order of 9 million tonnes, which at current extraction rates are expected to last for less than 10 years. A further 15 million tonnes have been identified by these operators adjacent to their current extraction sites, but these additional resources do not have development consent. As it is impossible to predict what proportion of these resources may become available in the future, the figures in table 14 area based on a ‘a best case scenario’, ie that all identified resources will be granted consent and become available for extraction.

These operations export about 200,000 tonnes of sand to the Sydney Planning Region annually. Although the amount is only moderate, it is significant, provided that it can reliably delivered every year. Environmental concerns and the transport distance are the main constraints on the continued extraction and export of sand to the Sydney Planning Region. In addition, Port Stephens Council’s current Local Environmental Plan places further restrictions on the extraction of sand in the area. The transport distance of about 190 km is such that the export of sand is likely to continue for only as long as it is economically viable, ie for as long as it is possible to ‘back load’ trucks which carry scrap metal to Newcastle.

If it is assumed that ‘back loading’ will continue in the future, then these deposits have the potential to supply a moderate annual amount of sand to the Sydney Planning Region for at least the short and medium term. These resources are, however, likely to be almost exhausted by 2020 and thus do not constitute an option for long term supply.

Resources in the Wingecarribee Shire

Large resources of friable sandstone have been identified in Wingecarribee Shire. The two companies which export sand to the Sydney Planning Region have development consent to extract about 19 million tonnes. A further 90 million tonnes of extractable sandstone has been identified by the companies adjacent to their current operations. In addition, two large potential sand resources, in Wingello (277 million tonnes) and Penrose (648 million tonnes) State Forests have been identified by the Department of Mineral Resources (MacRae and Ferguson 1994). The resources listed in table 14 were estimated on the basis that the areas covered by these State Forests contain friable sandstone to a depth of 25 metres. Although it is unlikely that all of these resources are extractable, the resources are, nevertheless, very large and should therefore be considered as a potential major source of sand for the future.

Clearly, the resources contained within the two operating quarries are sufficient to supply the local market and the Sydney Planning Region at current or elevated levels in the medium and long term. The total resources within the Shire are well over 1000 million tonnes, they are located away from population centres and National Parks, and are situated near to a major transport corridor less than 150 km from Sydney. These factors make them attractive for development and they must therefore be considered as a major potential supply source of sand for the Sydney Planning Region in the future.

Resources in the Shellharbour City

Dunmore Sand and Soil P/L recently commenced extracting sand at Dunmore Lakes in the Shellharbour City Local Government Area. The company has identified resources of almost 10 million tonnes of fine- to medium-grained sand comparable to the sand at Kurnell Peninsula. The company plans to extract this resource in three stages. The recently commenced stage 1 contains about 2.75 million tonnes which is expected to be extracted over a ten year period. Stages 2 and 3 contain a further 7 million tonnes of sand and will operate partly concurrently with stage 1. The company estimates that these resources will last for 15-20 years at the expected production rates of up to 650,000 tpa. Although a large proportion of the sand produced at Dunmore will be consumed in the Illawarra, it is likely that 100,000-200,000 tpa will be trucked to Sydney. As the resources are relatively small, Dunmore has the potential to be a supplier of small to moderate quantities of sand to the Sydney Planning Region in the medium term.

Three marine aggregate deposits have been identified off the coast of Illawarra. The combined resources in these two areas are over 40 million tonnes of sand depending on the extraction method used. These deposits have the potential to be a significant medium to long term source of sand. The extraction of these deposits is, however, constrained by factors similar to those affecting the marine aggregate proposals off Sydney, and is similarly contentious.

LONG TERM 2020 – 2040

The total predicted cumulative demand for construction sand for the period 2020-2040 is 180.5 million tonnes (table 10; 333.7-153.5). Of this, 66.8 million tonnes (table 10; 122.8-56.0) is estimated to be medium- to coarse-grained sand, 86.8 million tonnes (table 10; 160.8-74.0) fine- to medium-grained sand and 27.6 million tonnes (table 10; 51.1-23.5) clayey/mortar sand.

Possible resources remaining within the known deposits in the Sydney Planning Region and the surrounding regions are listed under heading "Possible Resources After 2020' in tables 12 and 14 respectively.

Clearly, only a fraction of the predicted demand can be supplied from deposits currently available for extraction within the planning region. However, the other identified deposits within the planning region discussed in the previous section (table 12) are predicted to have large remaining resources, even if extraction commences during the period 2010-2020.

These deposits, namely; Somersby Plateau, Richmond Lowlands, marine aggregate and possibly Maroota have the potential to become reliable, long term sources of construction sand within the planning region and should be considered as such, and the merits of each should evaluated within this context.

Outside the region, large resources will remain only at Newnes Plateau and in Wingecarribee Shire. Resources at Stockton Bight and in the Illawarra (Dunmore Lakes) are likely to be exhausted soon after 2020. Thus the importance of the deposits at Newnes Plateau and in the Wingecarribee Shire will increase with time, as they are the major external supply options, whether or not any of the deposits within the Sydney Planning Region are developed in the future.

FACTORS INFLUENCING SUPPLY

The low unit value of construction materials is one of the main factors in determining the identification of resources for exploitation, since it defines the distance over which transport is economic. Generally this is about 100 km between source and destination In the case of construction sand, the other major factor is the type of sand contained in the deposit. Other factors which must be considered are location, size and access.

TRANSPORT

The Sydney Planning Region currently sources the bulk of its construction requirements from within the planning region, from deposits at Penrith Lakes, Kurnell, Maroota and at the Somersby Plateau. This situation will change after the Kurnell and Penrith Lakes deposits cease operations, which is expected to occur by about 2006 and 2010 respectively New sources within the region will need to be developed or the amount of imports will need to increase to 4-5 million tonnes annually.

Sand deposits outside the planning region which have the potential to become major supply sources are further than 100 km (direct distance) away from the centre of the planning region. Currently road haulage is the primary means of transport for sand imported from these deposits, and this is likely to continue for at least the short term.

The continued use of road transport as the major mode of sand haulage means that volumes of heavy traffic can be expected to increase significantly. Consequently the problems associated with heavy traffic such as wear on roads, road safety and the environmental impact of road haulage will worsen.

In addition, increased transport distance will affect the price of the final product and increased transport costs will ultimately have to be borne by the consumer.

By developing some of the identified sand deposits within the planning region the environmental and economic impacts of long haulage distances to markets in the central part of the planning region would be minimised. It must, however, be recognised that whether or not some or all of the identified deposits within the planning region are developed, the planning region will have to import the bulk, if not all, of its sand requirements from the surrounding areas in the future. Therefore, a strategy to assess alternative methods for the transport of large quantities of sand (and other construction materials) needs to be developed.

Sea or rail transport offer potential cost advantages over road transport over long distances. Transport by sea may be an option only for marine aggregate deposits. Rail transport, however, should be considered for the transport of material from Newnes Plateau and Wingecarribee Shire, as it has the potential to transport large quantities of material at a lower cost and with lesser environmental impacts than road haulage.

COMPETING LAND USES

Access to identified and/or potential deposits has become increasingly restricted over the past decades owing to other competing land uses such as rural residential, agriculture, urban development and conservation.

With increasing population densities in the Sydney Planning Region and surrounding areas, the area of land available for extractive industry is continually decreasing. At the same time, expansion of urban development adversely impacts on currently operating quarries and future extractive operations tend to be located further and further away from populated areas. In addition, current and potential extractive developments are constrained by increasing awareness of the environmental impacts of extraction and transport of quarry products. This leads to a situation where there is less land available for the industry and the available land is further away from the main markets, resulting in increased transport costs and increased adverse impacts associated with increased traffic.

To ease this conflict and to prevent unnecessary sterilisation of identified and potential construction sand resources, informed land use decisions are required, especially when implementing broad acre re-zoning of land in the rural and semi-rural areas surrounding the Sydney Planning Region. Therefore, close co-operation between local councils and government agencies such as the Department of Urban Affairs and Planning and the Department of Mineral Resources is needed when considering these issues.

ENVIRONMENTAL IMPACTS

The environmental impacts of the extractive industry are generally perceived as negative by the general community. These perceptions are usually based on past practices in the industry and little credence seems to be given to the vastly improved practices and performance of the industry today. One of the major challenges for the industry is to change the negative image by the general public. Responsible quarry management and product transport practices, community consultation and education are measures which can be taken by the industry to improve this image. At the

same time, closer scrutiny of current and proposed extractive proposals by the public and government agencies should ensure that standards of practice are continuously improved by the industry.

CONCLUSIONS

The Sydney Planning Region consumes up to 7 million tonnes of construction sand per annum, the bulk of which comes from within the region. Of the 7 million tonnes required annually, the planning region imports 900,000-1,000,000 tonnes from areas outside the region. This amount is expected to significantly increase in the future, unless new local sources are developed.

In the short term, the predicted demand for construction sand can be supplied by continuing extraction from the current sources within the planning region and by continuing imports at their present or slightly increased levels. However, a large shortfall in the supply of fine- to medium-grained sand will occur if extraction ceases at Kurnell Peninsula. This shortfall if it eventuates will have to be made up by either substantially increasing imports and/or by sourcing more fine- to medium-grained sand from friable sandstone deposits within the planning region and/or by opening new deposits for extraction within the planning region.

Once the Penrith Lakes Development Scheme ceases about 2010, around 2.2 million tonnes of medium- to coarse-grained sand will obviously need to be sourced annually from within or outside the planning region.

There are large identified resources of construction sand within the planning region at Richmond Lowlands, Somersby Plateau, Maroota and offshore which have the potential to become long term suppliers of construction sand for the planning region. There are, however, environmental and societal constraints which may prevent any or all of these resources from being developed.

If none of these deposits were to be developed, the planning region would need to import increasing quantities of construction sand from more distant sources to supply the predicted demand. This would result in significant additional transport costs and additional environmental problems associated with increased traffic unless other modes of transport, such as rail and/or sea, could be utilised.

Eventually the bulk or all of the construction sand consumed by the planning region will have to come from outside the region. Large identified deposits exist at Newnes Plateau near Lithgow and in the Wingecarribee Shire, southwest of Sydney. These have the potential to supply the planning region's construction sand needs in the long term. In the short and medium term, deposits at Stockton Bight and in the Illawarra also have the potential to supply moderate amounts of sand to the planning region annually.

Given that the remaining resources at Penrith Lakes will be exhausted in the short term and that the future of sand extraction at Kurnell Peninsula is uncertain it is imperative that a strategy for sourcing and transporting large quantities of construction sand from other identified deposits within the region, as well as from outside the region, be established.

Such a strategy would need to consider the following elements;

- Protection of the currently operating construction sand quarries from encroachment by incompatible land uses, and preventing significant identified undeveloped resources from being unnecessarily sterilised by incompatible alternative land use. To achieve this, Local Environmental Plans and Regional Environmental Plans need to take proper account of important known and potential construction sand resources.

- Identification of potential major long term sources of construction sand.

- Formulation of a plan for transporting large quantities of construction sand, and other construction materials, long distances by means other than road. Eventually the planning region will have to import the bulk of its construction materials. Therefore the extractive industry, the transport industry, and local and relevant State Government agencies need to examine alternative modes of transport for quarry products. Transport by rail and by sea via Sydney Harbour or Port Botany has the potential to make remote resources more economical, and would benefit the consumer and the community in general, through reduction of truck movements.

- Provision of access to multiple sources of construction sand rather than just a few. This would provide a range of product types and guard against the market becoming dominated by a small number of suppliers. Continued competition in the market will result in lower prices and thus benefit the consumer and the community in general.

- Encouragement of greater use of alternative materials. At present, alternative materials occupy only a small portion of the market. Their greater use would prolong the availability of sources of natural sand.

- Maximisation of utilisation of suitable excavated material (mainly crushed sandstone) from large excavations and tunnel projects.

- Incorporation of the management of construction sand resources into a wider strategy for management of all construction materials of the region and surrounding areas.

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APPENDIX 1: QUESTIONNAIRE AND ACCOMPANYING NOTES SENT TO CONSTRUCTION SAND PRODUCERS

DEPARTMENT OF MINERAL RESOURCES QUESTIONNAIRE
CONSTRUCTION SAND FOR THE SYDNEY REGION

1. GENERAL

Name of Site/Quarry:	
Company Name:	
Postal Address:	
Contact Name:	
Telephone:	Mobile:
E-Mail:	Fax:

2. LOCATION DETAILS

Locality/Address:	
Local Council Area:	
County:	Parish:
Portion(s):	
DP and Lot Numbers:	

3. DEVELOPMENT CONSENT DETAILS

Date of Development Consent:
Period of Development Consent:
Annual production limit (if any):
Any other conditions which limit production:
Was an EIS prepared for this development?:
If Yes, by whom:
Date EIS was prepared:

4. LAND TENURE

If Freehold Land

Name of owner(s)

If Crown Land

Crown Land License:	Date of Grant:
Permissive Occupancy:	Date of Grant:
Quarry Licence:	Date of Grant:
Other (please specify):	

5. HISTORY OF EXTRACTION SITE

When did extraction by you begin at this site:	
Was there previous extraction at this site:	
If yes, by whom:	
When did quarrying commence (if known):	
Do you provide annual production statistics to this Department:	YES/ NO

6. DEPOSIT TYPE (please tick appropriate box)

River/Stream Course	
River Floodplain	
Dune	
Estuarine	
Sandstone	
High Level/Terrace Deposit	
Other (specify)	
Other (specify)	

7. GRAIN SIZE

Grain Size	Percentage
Fine (-0.200 mm +0.060 mm)	
Medium (-0.600 mm +0.200 mm)	
Coarse (-2.000 mm +0.6000 mm)	
Other (specify)	
Other (specify)	
Other (specify)	
Clay Content	

8. TYPE OF EXTRACTION (please tick appropriate box)

Dry Extraction	
Dredge	
Ripping	
Other (specify)	
Other (specify)	

9. PROCESSING DETAILS (please tick appropriate box)

Processed		Unprocessed	

10. PROCESSING METHODS (please tick appropriate box)

Crushing	
Screening	
Washing	
Other (specify)	
Other (specify)	

11. TAILINGS

Disposal Method……

Do the Tailings have a potential use(s)……..……

END USES

End Use	Percentage
General Construction (use unknown)	
Readymixed Concrete	
Concrete Products (eg pipes)	
Asphalt	
Bricklaying Mortar	
Fill	
Horticulture/Agriculture	
Glass	
Foundry	
Other (specify)	
Other (specify)	
Other (specify)	

13. OTHER MATERIAL QUARRIED AT THIS SITE

Product	Percentage
River Gravel	
Clay	
Loam	
Sandstone	
Other (specify)	
Other (specify)	

14. MARKET LOCATIONS

Market Area	Estimated Percentage of your production to this market
Sydney Region	
Other areas, specify below	

15. PRODUCTS AND BUYERS

Product	Major Customer	Estimated Percentage

16. PRICES (You may wish to attach a price list)

Product	Price/ton

17. RESERVES OWNED OR SECURED BY YOU AT THIS SITE FOR WHICH YOU HAVE VALID DEVELOPMENT CONSENT FROM COUNCIL

Reserves (tonnes)	Category (proven, probable, possible)

18. RESOURCES OF MATERIAL OWNED OR SECURED BY YOU AT THIS SITE FOR WHICH YOU DO NOT HAVE A VALID DEVELOPMENT CONSENT FROM COUNCIL

Resources (tonnes)	Category (proven, probable, possible)

19. EXPECTED QUARRY LIFE: ……..years at ……tonnes/year

20. CONSTRAINTS

……
……
……
……
……
……
……
……

21. OTHER COMMENTS

……
……
……
……
……
……
……
……

NOTES TO ACCOMPANY QUESTIONNAIRE FOR CONSTRUCTION SAND

IT IS ESSENTIAL THAT A SEPARATE QUESTIONARE BE COMPLETED FOR EACH EXTRACTION SITE.

QUESTION 1: GENERAL

This section identifies the extraction site (which may consists of one or more pits) under consent and the company operating the site.

QUESTION 2: LOCATION

Locality details assist in identifying the site.

QUESTION 3: DEVELOPMENT CONSENT DETAILS

Details of the date and period of the development consent.

QUESTION 4: LAND TENURE

Land tenure information.

QUESTION 5: HISTORY OF EXTRACTION SITE

Information on the history of the site would be helpful in relating the current extraction to any previous extraction.

QUESTION 6: DEPOSIT TYPE

Identify the type of deposit quarried by ticking the relevant box. 'High level/terrace deposit' refers to old river course and old flood plain deposits such as Londonderry and Agnes Banks.

QUESTION 7: GRAIN SIZE

List the grain sizes and the estimated percentages.

QUESTION 8: TYPE OF EXTRACTION

Identify the method of extraction by ticking the relevant box.

QUESTION 9: PROCESSING DETAILS

Identify the processing details by ticking the relevant box.

QUESTION 10: PROCESSING METHODS

Identify the processing methods by ticking the relevant box.

QUESTION 11: TAILINGS

Identify the tailings disposal method.

QUESTION 12: END USES

List the end uses for the products and estimate the percentage for each.

QUESTION 13: OTHER MATERIALS QUARRIED AT THIS SITE

List any other materials quarried at this site and estimate the percentage for each.

QUESTION 14: MARKET LOCATIONS

List the market areas and the estimated percentages of your product to each market.

QUESTION 15: PRODUCTS AND BUYERS

List the buyers of products and the estimated percentage of your product that each buyer buys.

QUESTION 16: PRICES

List products and prices.

QUESTION 17: RESERVES

List the amounts of material available for extraction under the current Development Consent.

QUESTION 18: RESOURCES

List the amounts of material available for extraction on site for which you do not have current Development Consent, i.e. Material which may be available for quarrying in the future.

QUESTION 19: QUARRY LIFE

State the expected life of the quarry and the expected extraction rate.

QUESTION 20: CONSTRAINTS

List factors which may adversely affect your operation now or in the future. Things included here could be; urban development, national parks etc.

QUESTION 21: OTHER COMMENTS

Please write any other relevant comments here.

APPENDIX 2

CONSTRUCTION SAND PRODUCTION SITES AND PRODUCTION STATISTICS 1969-1999

Sites are sorted first by sand type i.e. fine – medium sand, medium – coarse sand, clayey sand, and secondly by LGA.

All figures in tonnes. Figures in *italics* are estimates.

Quarry Name	Operator	LGA	Sand type	Map Sheet	AMGE	AMGN	Abs Ref	1969-70	1970-71
Georges River State Rec Area	Quality River Sands	Bankstown	fine/med	9130-3-S	317400	6238400	5059, 5794		
Unnamed	Botany Municipal Council 1983-92	Botany	fine/med	9130-3-S	335000	6242000	1022001		
Bonnie Doon Sand Deposit	Eric Newham (NSW Mining Co P/L)	Botany	fine/med	9130-3-S	335100	6243800	2987	4,664	
Mutch Park, Pagewood	McDonals Constructions	Botany	fine/med	9130-3-S	335400	6242800	4479		188,396
Astrolabe Park, Daceyville	Eric Newham 1964,1966	Botany	fine/med	9130-3-S	335600	6244000	620	158,389	315,104
Glenfield	Monier	Campbelltown	fine/med	9030-2-S	306800	6239800	5235		
Chipping Norton	Hollywood Sands P/L	Fairfield	fine/med	9030-2-S	312000	6245900	3537	44,709	5,654
Lansvale, BMG	Boral Resources	Fairfield	fine/med	9030-2-S	311500	6246900	4040	100,045	
Lansvale, Hi Quality Sands	Hi-Quality Sands P/L	Fairfield	fine/med	9030-2-S	311900	6246100	5736		
Mooney Mooney	JC Renehan	Gosford	fine/med	9131-2-S	337500	6299500	1125	13,116	
McMasters Beach	Moloney, RJ	Gosford	fine/med	9131-2-S	354000	6293000	2950		4,260
Woodlands Pit	Mid Coast Minerals	Gosford	fine/med	9130-1-N	353100	6291300	2952		
Woy Woy	Matthews, SE	Gosford	fine/med	9131-2-S	341900	6292200	3897		2,200
Avoca Lake	Bay River Sands	Gosford	fine/med	9131-2-S	353900	6296100	5777		
Mooney Mooney Creek	Able Dredging P/L	Gosford	fine/med	9131-2-S	337800	6299800	5113		
Mooney Mooney Sand	Sand & Mineral Supplies P/L	Gosford	fine/med	9131-2-S	337700	6299800	996; 4202		25,659
Wamberal	Wamberal Sand Co P/L	Gosford	fine/med	9131-2-S	358200	6303100	997	4,400	21,000
Lane Cove River	Sand Classifiers P/L	Lane Cove	fine/med	9130-3-N	328400	6255900	4596, 630	103,639	125,726
Chipping Norton, Riverside Road	Skevington, AK 1971-75	Liverpool	fine/med	9030-2-S	309500	6243800	2128	186	
Chipping Norton	Davidson Washed Sands	Liverpool	fine/med	9030-2-S	310900	6246600	2915	139,798	246,293
Chipping Norton, Moorebank	Audley Sand Dredge	Liverpool	fine/med	9030-2-S	311500	6246800	2970, 638, 634	36,545	242,592
Glenfield Quarry	Kleensands (NSW) P/L	Liverpool	fine/med	9030-2-S	306700	6239800	3541	92,000	88,679
Davidsons Sand Dredge	W. Davidson P/L	Liverpool	fine/med	9030-2-S	310100	6244300	4053	9,173	
Chipping Norton	Benedict Sands	Liverpool	fine/med	9030-2-S	312300	6245500	4822		
Moorebank, Bridges Road	HS Hatton & Sons P/L	Liverpool	fine/med	9030-2-S	309100	6244000	611	15,868	14,558
Chipping Norton	Davidson P/L	Liverpool	fine/med	9030-2-S	310700	6246200	631	61,934	24,071
Moorebank	Demarco Sands Pit P/L	Liverpool	fine/med	9030-2-S	309000	6244000	687	22,970	
Storey Street, Maroubra	Eric Newham (NSW Mining Co P/L)	Randwick	fine/med	9130-2-S	338450	6243100	4168		36,658
Anzac Pde Little Bay	ST Bradshaw	Randwick	fine/med	9130-3-S	337100	6238600	842	101,833	28,909
Kurnell, Hooker Sand Pit	Metromix P/L	Sutherland	fine/med	9129-4-N	329800	6232300	2109	364,275	445,500
Sandy Point	CS Day & Sons	Sutherland	fine/med	9030-2-S	314900	6238700	2115	141,262	142,535
Kurnell Sand Pit, Rocla	Rocla Quarry Products	Sutherland	fine/med	9129-4-N	332100	6233100	2118	343,670	394,282
Woronora Sand	Wilkinson AJ	Sutherland	fine/med	9129-4-N	319800	6233800	3890	8,000	
Kurnell, Pioneer	Pioneer Concrete (NSW) P/L	Sutherland	fine/med	9129-4-N	333500	6233000	601	309,000	228,000
Kurnell Calsil Dune	Calsil 1970-73	Sutherland	fine/med	9129-4-N	334400	6233100	3769	33,731	70,479
Georges River (Picnic Point)	Byram Brothers	Sutherland	fine/med	9130-3-S	316000	6237800	4257	143,529	144,823
Roseville Bridge Sand	Farley & Lewers (NSW) P/L	Warringah	fine/med	9130-3-N	333550	6261600	2880, 855	118,218	140,742
Lake Narrabeen	Warringah Sand & Gravel	Warringah	fine/med	9130-1-S	340000	6268000	2948	45,705	84,194
Roseville Bridge Sand	Northside Sand Co P/L	Warringah	fine/med	9130-3-N	333800	6261100	2989, 2982	8,804	5,200

Quarry Name	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
Georges River State Rec Area	58,822	59,884	66,833	42,316	36,037	35,201	27,123	5,449	35,645	106,200
Unnamed										
Bonnie Doon Sand Deposit										
Mutch Park, Pagewood	0	85,183	133,498	195,422	164,164	123,852	102,209	77,334	19,972	
Astrolabe Park, Daceyville	127,838	2,826								
Glenfield										165,800
Chipping Norton				120,591	169,910	168,412	269,042	298,905	330,683	183,152
Lansvale, BMG	43,932	104,499	46,996	384,464	84,393	12,217				
Lansvale, Hi Quality Sands										
Mooney Mooney										
McMasters Beach	5,533	5,630	4,628	6,091	3,157	3,712	8,185	7,693	16,021	13,142
Woodlands Pit					1,300					
Woy Woy	1,650	8,507	353							
Avoca Lake										
Mooney Mooney Creek										2,810
Mooney Mooney Sand	26,369	58,443	40,226	54,551	31,656	4,202	2,809	2,809		
Wamberal	39,600	26,727	71,383	44,222	76,489	35,560	12,470			
Lane Cove River	107,186	52,350	38,500	24,000						
Chipping Norton, Riverside Road	22,605	4,813	67	38						
Chipping Norton	301,845	345,248	332,004	342,184	221,218	177,900	211,400	140,000	81,530	
Chipping Norton, Moorebank	269,890	236,538	184,257	127,205	67,815	22,592				
Glenfield Quarry	51,947	0	27,167	9,103	106,335	51,925	64,846	144,035	129,000	195,380
Davidsons Sand Dredge										
Chipping Norton							187,437	73,670	107,980	147,236
Moorebank, Bridges Road	14,456	10,979	3,960							
Chipping Norton	8,567	19,321	22,012	0	16,427					
Moorebank	31,769	32,086	22,000	75,000	40,000	11,500				
Storey Street, Maroubra	92,424	4,025								
Anzac Pde Little Bay										
Kurnell, Hooker Sand Pit	383,500	413,228	397,100	313,500	248,100	338,700	358,400	390,600	456,100	500,100
Sandy Point	78,950									
Kurnell Sand Pit, Rocla	362,288	377,953	364,994	342,250	351,970	336,835	227,526	357,000	318,000	641,319
Woronora Sand										
Kurnell, Pioneer	298,680	420,907	415,685	512,170	389,629	368,954	339,680	406,146	461,299	325,555
Kurnell Calsil Dune	64,251	66,043								
Georges River (Picnic Point)	49,064	62,097	65,700	47,910	29,055	33,062	29,301	39,039	39,415	27,812
Roseville Bridge Sand	118,322	96,849	71,735	58,063	13,261					
Lake Narrabeen	72,223	85,078	52,478	99,719	106,763	99,105	133,752	163,640	145,990	177,323
Roseville Bridge Sand	9,000	8,128	10,000	9,660	3,162	2,854	9,469	50,000	50,000	15,000

Quarry Name	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
Georges River State Rec Area	60,895	56,763	39,469	46,691	69,885	67,343	83,835	94,202	110,450	23,450
Unnamed			2,000	1,000	650	540	600	1,000		
Bonnie Doon Sand Deposit										
Mutch Park, Pagewood										
Astrolabe Park, Daceyville										
Glenfield	126,300	91,546	64,732	126,900						
Chipping Norton	360,000	302,000	149,598	158,033	132,389					
Lansvale, BMG										
Lansvale, Hi Quality Sands						191,888	211,898	197,628	219,072	192,435
Mooney Mooney										
McMasters Beach	5,607	5,793	7,967	7,261	7,920	6,413	100			
Woodlands Pit										
Woy Woy										
Avoca Lake						11,946	21,995	57,870	69,438	55,538
Mooney Mooney Creek	7,884	37,472	56,269	38,420	102,675	51,961	56,835	61,554	16,303	
Mooney Mooney Sand										
Wamberal										
Lane Cove River										
Chipping Norton, Riverside Road										
Chipping Norton										
Chipping Norton, Moorebank										
Glenfield Quarry	150,126	34,987	36,201	46,185	60,530	25,881	34,257	19,847	30,000	61,025
Davidsons Sand Dredge										
Chipping Norton	155,912	70,311	41,940	171,978	254,967	265,109	297,754	355,610	239,692	194,331
Moorebank, Bridges Road										
Chipping Norton										
Moorebank										
Storey Street, Maroubra										
Anzac Pde Little Bay										
Kurnell, Hooker Sand Pit	406,400	422,700	389,223	423,633	440,279	424,087	447,754	440,476	486,048	536,396
Sandy Point										
Kurnell Sand Pit, Rocla	641,877	299,000	601,000	483,251	837,100	782,000	508,000	711,049	658,098	636,000
Woronora Sand										
Kurnell, Pioneer	165,430	188,047	246,308	240,415	386,673	373,090	392,623	133,019	146,090	134,150
Kurnell Calsil Dune										
Georges River (Picnic Point)	15,720	4,814	3,189	59,387	7,976					
Roseville Bridge Sand										
Lake Narrabeen	143,296	56,160								
Roseville Bridge Sand	2,043									

Quarry Name	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00
Georges River State Rec Area	35,790	35,199	10,261						
Unnamed									
Bonnie Doon Sand Deposit									
Mutch Park, Pagewood									
Astrolabe Park, Daceyville									
Glenfield									
Chipping Norton									
Lansvale, BMG									
Lansvale, Hi Quality Sands	134,579	236,105	188,954	56,299					
Mooney Mooney									
McMasters Beach									
Woodlands Pit									
Woy Woy									
Avoca Lake	65,510	60,000							
Mooney Mooney Creek									
Mooney Mooney Sand									
Wamberal									
Lane Cove River									
Chipping Norton, Riverside Road									
Chipping Norton									
Chipping Norton, Moorebank									
Glenfield Quarry	19,148		10,959						
Davidsons Sand Dredge									
Chipping Norton	192,744	118,141	207,994	325,180	200,000	211,803			
Moorebank, Bridges Road									
Chipping Norton									
Moorebank									
Storey Street, Maroubra									
Anzac Pde Little Bay									
Kurnell, Hooker Sand Pit	339,095	320,592	263,149						
Sandy Point									
Kurnell Sand Pit, Rocla	512,116	510,783	703,481	951,556	998,325	1,144,173	1,257,446	1,469,039	1,539,572
Woronora Sand									
Kurnell, Pioneer	92,844	55,851	54,000						
Kurnell Calsil Dune									
Georges River (Picnic Point)									
Roseville Bridge Sand									
Lake Narrabeen									
Roseville Bridge Sand									

Quarry Name	Operator	LGA	Sand type	Map Sheet	AMGE	AMGN	Abs Ref	1969-70	1970-71
Avalon Sand Pit	R Shaw, Narrabeen Sands	Warringah	fine/med	9130-1-S	345200	6276900	3771	5,588	
Bobbin Head	Pymble Sands P/L	Warringah	fine/med	9130-4-S	329500	6273700	4828		
McCarrs Creek, Church Point	Sands (NSW) P/L	Warringah	fine/med	9130-1-S	339800	6274400	627	19,230	
North Entrance	DF Batchelor	Wyong	fine/med	9231-3-N	362000	6312000	1105	46,488	58,643
Norah Head, Soldiers Point	KO Mascord 1966	Wyong	fine/med	9231-3-N	366800	6316200	1116	8,447	8,376
Norah Head	Mitchell NF	Wyong	fine/med	9231-3-N	366800	6316300	4553		
Elizabeth Bay	Rex Datson P/L	Wyong	fine/med	9231-4-S	368200	6324850	4748		
O'Briens Road, Donglen	Donglen P/L 1978-82	Baulkham Hills	med/coarse	9030-1-N	305200	6289300	4769		
Blackheath, Connaught Road	Processed Sand P/L	Blue Mountains	med/coarse	8930-1-S	249750	6275525	1429	486	348
Faulconbridge, Grose Road	Tony Brown P/L	Blue Mountains	med/coarse	9030-4-S	272500	6270700	9238, 3576		
Wallacia	Witwall P/L	Camden	med/coarse	9030-3-N	281000	6250000	3947, 4387	15,480	12,500
Camden	Monier	Camden	med/coarse	9029-4-N	285800	6229600	4600		
Elderslie	C Terry & Sons	Camden	med/coarse	9029-4-N	290100	6226700	4742		
Camden, Ellis Lane	Nepean Dredging	Camden	med/coarse	9029-4-N	286500	6232900	4843		
Camden, Macquarie Grove Road	Menangle Sand & Soil P/L	Camden	med/coarse	9029-4-N	287500	6230500	5386		
Menangle Park	Cleary Bros (Bombo) P/L	Campbelltown	med/coarse	9029-1-N	293680	6222020	1580, 4445		
Mt Gilead, Appin Road	Benedict Sands	Campbelltown	med/coarse	9029-1-S	294700	6221400	6038		
Bulls Hill Quarry, Woy Woy	Rudd	Gosford	med/coarse	9131-2-S	340700	6293700	5091		
Yarramundi, Boral	Boral Resources (NSW) P/L	Hawkesbury	med/coarse	9030-4-N	285900	6278000	1146	244,713	203,262
Windsor, Putty Road	Rocla Quarry Products	Hawkesbury	med/coarse	9030-1-N	298400	6280100	1150	173,838	78,342
East Kurrajong, Singleton Road	Martin Bros Transport P/L	Hawkesbury	med/coarse	9030-1-N	298000	6288000	3697	3,140	4,081
Richmond Lowlands Andersons	EH & PP Anderson	Hawkesbury	med/coarse	9030-1-N	297700	6281600	3876	470	
Ridges Lane, Hymix	Hymix Quarries P/L	Hawkesbury	med/coarse	9030-4-N	289550	6281750	4164		32,761
Richmond Bridge	/Pioneer Concrete (NSW) P/L	Hawkesbury	med/coarse	9030-4-N	288800	6281200	4165		
Colo River	Bate Walls P/L	Hawkesbury	med/coarse	9031-2-S	301300	6298900	4829		
Cordners Corner	AE Cordner	Hawkesbury	med/coarse	9030-1-N	297800	6281700	5391, 1538		
Clark Island, Richmond	Whatley Sands P/L	Hawkesbury	med/coarse	9030-4-N	287000	6280100	5545		
Windsor	J Gough	Hawkesbury	med/coarse	9030-1-N	298000	6279500	5664		
Yarramundi, Tilmunda	Tilmunda Sand & Soil	Hawkesbury	med/coarse	9030-4-N	285600	6277700	5670		
Freemans Reach, Whatley Sands	Whatley Sands P/L	Hawkesbury	med/coarse	9030-1-N	297700	6281500	6041		
Smiths Road, Castlereagh	Boral Resources; BMI	Penrith	med/coarse	9030-4-S	283300	6271800	1147	259,450	306,277
Sheens Lane Penrith	Gravel & Sand Suppliers	Penrith	med/coarse	9030-4-S	283500	6265050	1148	69,249	82,500
Penrith Lakes Scheme	Pioneer Concrete (NSW) P/L	Penrith	med/coarse	9030-4-S	285000	6267000	1149	224,907	234,460
Penrith Lakes Scheme	Boral Resources (NSW) P/L	Penrith	med/coarse	9030-4-S	284500	6264250	1153, 4208	206,843	194,926
Penrith Lakes Scheme	Readymix Group;	Penrith	med/coarse	9030-4-S	284000	6265000	1155	188,150	268,045
Ridges Lane, Boral	Albion Reid (NSW) P/L	Penrith	med/coarse	9030-4-N	289250	6281600	4171, 4172		296,000
Thirlmere	Cleary MG & FM	Wollondilly	med/coarse	9029-4-S	273620	6211560	3747	4,180	2,182
Bents Basin Rd Wallacia	Maxwells Sand & Soil Supplies	Wollondilly	med/coarse	9030-3-S	282300	6244700	4801		
Menangle	Benedict Sands	Wollondilly	med/coarse	9029-4-N	292250	6222300	4888		

Quarry Name	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
Avalon Sand Pit										
Bobbin Head								39,046		
McCarrs Creek, Church Point	8,690	25,402	26,353	36,046	32,812	21,875				
North Entrance	30,452									
Norah Head, Soldiers Point	13,492	17,729	7,653							
Norah Head			23,697	51,860	3,049					
Elizabeth Bay						71,219	76,751	59,114	44,835	5,529
O'Briens Road, Donglen								24,000	18,000	14,000
Blackheath, Connaught Road	1,624	750								
Faulconbridge, Grose Road										
Wallacia	3,600	5,467	23,745	31,220						
Camden				19,855	15,000	49,200	33,900	35,000	7,000	10,500
Elderslie						5,650	4,190			
Camden, Ellis Lane								60,941	70,265	64,300
Camden, Macquarie Grove Road										
Menangle Park		29,465	43,394	90,479	33,475	65,945				
Mt Gilead, Appin Road										
Bulls Hill Quarry, Woy Woy										
Yarramundi, Boral	216,050	276,505	234,758	197,701	95,480	61,535	168,057	231,636	387,955	328,747
Windsor, Putty Road	63,424	56,875	44,583	67,272	170,314	76,600	84,300	126,000	127,600	54,000
East Kurrajong, Singleton Road	5,622	5,588	5,698	6,717	0	12,000	12,500			
Richmond Lowlands Andersons	60,000	41,327	20,744	33,381	22,853	29,163	15,369			
Ridges Lane, Hymix	70,719	77,225	65,791	42,790	42,520	35,479	26,552	40,723		
Richmond Bridge	73,515	115,830	97,000	100,000	73,930	108,724	81,222	54,303	105,662	81,312
Colo River								30,000	95,000	43,500
Cordners Corner										
Clark Island, Richmond										
Windsor										
Yarramundi, Tilmunda										
Freemans Reach, Whatley Sands										
Smiths Road, Castlereagh	192,763	125,710	121,341	103,153	21,924					
Sheens Lane Penrith	89,637	67,113	67,358	68,093	74,912	60,651	60,504	67,823	86,450	82,005
Penrith Lakes Scheme	297,727	322,883	364,099	391,641	292,494	391,404	349,132	337,163	451,354	396,765
Penrith Lakes Scheme	194,640	191,723	278,653	400,827	376,181	308,627	381,072	530,154	570,277	575,825
Penrith Lakes Scheme	266,335	357,138	266,076	269,241	208,822	159,766	180,432	209,845	243,082	241,412
Ridges Lane, Boral	196,478	156,296	126,966	249,899	129,416	276,673	57,260	101,243	154,418	293,246
Thirlmere	3,452	393	3,357							
Bents Basin Rd Wallacia							12,000	8,500	8,000	28,000
Menangle								20,747	34,691	67,600

Quarry Name	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
Avalon Sand Pit										
Bobbin Head										
McCarrs Creek, Church Point										
North Entrance										
Norah Head, Soldiers Point										
Norah Head										
Elizabeth Bay										
O'Briens Road, Donglen	14,000									
Blackheath, Connaught Road										
Faulconbridge, Grose Road			3,500	2,368	4,434	2,506	2,462	2,622	804	7,692
Wallacia										
Camden	19,600	4,854								
Elderslie										
Camden, Ellis Lane	99,280	84,680	87,600	90,520	41,030	65,808	65,500	62,595	89,341	73,971
Camden, Macquarie Grove Road		18,784	18,955	20,704	34,957	100,624	66,809	0	5,300	
Menangle Park										
Mt Gilead, Appin Road										341
Bulls Hill Quarry, Woy Woy							15,056	3,000	22,500	11,000
Yarramundi, Boral	388,688	266,632	217,048	210,961	187,778	127,820	112,361	153,981	144,635	100,992
Windsor, Putty Road	18,600	740	51,156	85,400	8,600	64,900	110,348	107,234	115,349	78,500
East Kurrajong, Singleton Road										
Richmond Lowlands Andersons										
Ridges Lane, Hymix										
Richmond Bridge	105,736	105,436	136,737	68,180		72,600	20,099	16,219	11,960	
Colo River	180,866	142,167	28,908	19,484						
Cordners Corner		87,628	105,207	153,164	149,102		12,000	66,053	171,462	169,876
Clark Island, Richmond				75,000						
Windsor					30,000					
Yarramundi, Tilmunda					798	12,632	20,886	12,231	7,680	2,229
Freemans Reach, Whatley Sands										
Smiths Road, Castlereagh										
Sheens Lane Penrith	81,490	54,132								
Penrith Lakes Scheme	415,863	368,694	377,850	476,477	535,324	657,849	667,368	658,921	610,962	550,302
Penrith Lakes Scheme	558,564	342,000	358,889	463,691	463,721	480,071	540,741	501,920	559,935	566,450
Penrith Lakes Scheme	289,729	379,997	489,866	557,810	598,431	534,461	602,646	858,693	820,088	646,915
Ridges Lane, Boral	122,355	96,241	25,800							
Thirlmere										
Bents Basin Rd Wallacia	15,000			7,500	1,000	1,000	1,000	1,300	1,417	
Menangle	86,380	54,431	14,657	8,811	9,722	18,300	4,992		7,500	10,771

Quarry Name	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00
Avalon Sand Pit									
Bobbin Head									
McCarrs Creek, Church Point									
North Entrance									
Norah Head, Soldiers Point									
Norah Head									
Elizabeth Bay									
O'Briens Road, Donglen									
Blackheath, Connaught Road									
Faulconbridge, Grose Road	50	740	200	1,250	300	500	1,000		
Wallacia									
Camden									
Elderslie									
Camden, Ellis Lane	34,284	15,385							
Camden, Macquarie Grove Road									
Menangle Park									
Mt Gilead, Appin Road	174		1,541	10,402					
Bulls Hill Quarry, Woy Woy	8,000	7,000	9,000	2,000	400				
Yarramundi, Boral	60,469								
Windsor, Putty Road	93,149	106,558	100,705	91,330	83,586	58,278	42,366	38,653	49,994
East Kurrajong, Singleton Road									
Richmond Lowlands Andersons									
Ridges Lane, Hymix									
Richmond Bridge									
Colo River									
Cordners Corner	157,234	158,857	121,000						
Clark Island, Richmond									
Windsor									
Yarramundi, Tilmunda	2,575	7,495	6,052		681	964	2,983	1,800	1,250
Freemans Reach, Whatley Sands			10,000						
Smiths Road, Castlereagh									
Sheens Lane Penrith									
Penrith Lakes Scheme	607,298	439,720	481,995	607,951	584,200	626,163	650,699	610,324	655,032
Penrith Lakes Scheme	727,426	717,230	689,697	585,431	748,519	626,234	710,670	760,978	789,502
Penrith Lakes Scheme	639,283	452,803	364,438	479,323	395,368	532,793	643,804	670,002	770,501
Ridges Lane, Boral									
Thirlmere									
Bents Basin Rd Wallacia									
Menangle	22,461	32,751	35,714	31,780	798				

Quarry Name	Operator	LGA	Sand type	Map Sheet	AMGE	AMGN	Abs Ref	1969-70	1970-71
Wallacia, Silverdale Road	Wallacia Sands	Wollondilly	med/coarse	9030-3-N	281250	6250500	6316		
Stonequarry Creek Sand Pit - Picton	EE Emmett & Sons P/L	Wollondilly	med/coarse	9029-4-S	278900	6216750	6342, 2214		
Sea Cave - Frazer Park	HJ Frisby	Wyong	med/coarse	9231-4-S	372000	6326900	1115		
Frazer Park	Alsek Holdings P/L	Wyong	med/coarse	9231-4-S	370200	6328850	4589		
Gwandalan Quarry	Alsek Holdings P/L	Wyong	med/coarse	9231-4-S	369100	6327900	6251, 5529		
Cheesemans Road Sandstone	Valley Sands	Baulkham Hills	clayey	9030-1-N	307150	6288680	5118, 5511		
Maroota	Leranto P/L	Baulkham Hills	clayey	9031-2-S	313500	6295650	5290		
Maroota, Hitchcock Road	PF Formation	Baulkham Hills	clayey	9031-2-S	313100	6294600	5301, 5535		
Maroota, various portions	PF Formation	Baulkham Hills	clayey	9031-2-S	312600	6296000	5535		
Kenthurst, 275 Pitt Town Road	Kenthurst Developments P/L	Baulkham Hills	clayey	9030-1-N	310475	6278250	5538, 3863		
Maroota, Monaldo	PF Formation	Baulkham Hills	clayey	9031-2-S	313400	6297000	5540		
Maroota, Lot 167, Hitchcock Road	TTC Contractors	Baulkham Hills	clayey	9031-2-S	313300	6294600	5541		
Wisemans Ferry Road	Western Sand Mining P/L	Baulkham Hills	clayey	9030-1-N	307300	6288300	5621, 6080		
Kenthurst, 214 Pitt Town Road	A Flakus	Baulkham Hills	clayey	9030-1-S	309900	6277100	5663		
Maroota, Old Northern Road	Dixon Sand (Penrith) P/L	Baulkham Hills	clayey	9031-2-S	312401	6296900	6184		
Maroota, Warrah School	Dr LS Martin (Sun-a-Rise Sands)	Baulkham Hills	clayey	9031-2-S	314100	6295300	6319		
Elderslie, Springs Road	EA O'Neill	Camden	clayey	9029-4-N	289200	6227500	266, 622	771	1,380
Elderslie	Curtis, CJ	Camden	clayey	9029-4-N	290100	6227700	4709		
Elderslie, Springs Road	Donohoe PB	Camden	clayey	9029-4-N	289450	6227350	4747, 2212	14,104	9,312
Elderslie, Macarthur Road	M Collins & Sons	Camden	clayey	9029-4-N	288627	6227250	5122		
Elderslie - Richardson/Springs Road	Premium Sands	Camden	clayey	9029-4-N	290700	6227500	6008		
Elderslie Sand Pit	Nepean Quarries P/L	Camden	clayey	9029-4-N	290600	6227400	6191, 5334, 4844		
Elderslie, Woodgrand	Woodgrand P/L	Camden	clayey	9029-4-N	289500	6226750	6334		
Elderslie (Narellan), Springs Road	Menangle Sand & Soil	Camden	clayey	9029-4-N	289450	6227350	649		
Menangle, Menangle Road	Menangle Sand & Soil P/L	Campbelltown	clayey	9029-4-N	291300	6222700	6162		
Somersby, Main Road	Murray Sand & Clay Holdings	Gosford	clayey	9131-2-S	340400	6302200	4555		
Calga Sands Quarry	Calga Sands	Gosford	clayey	9131-3-S	334300	6301100	5996		
Somersby, Hoipos Road	Eastern Sand & Gravel Quarries	Gosford	clayey	9131-2-N	340500	6310600	9170; 5578		
Somersby, Wisemans Ferry Road	Rindean P/L,	Gosford	clayey	9131-2-S	341500	6305600	6233; 5192		
Somersby Reservoir Road	Pioneer Concrete P/L	Gosford	clayey	9131-2-S	338500	6304900	4570		
3260 Wisemans Ferry Road Somersby	Somersby Quarries	Gosford	clayey	9131-2-N	338600	6311960	9226		
Pitt Town Bottoms	Breen Organisation	Hawkesbury	clayey	9030-1-N	299200	6281000	3777	59,074	50,415
Pitt Town, Farley and Lewers	Farley & Lewers (NSW) P/L	Hawkesbury	clayey	9030-1-N	302100	6282700	4099		
Ebenezer Quarry	TTC Contractors	Hawkesbury	clayey	9030-1-N	303625	6289500	4614		
Ebenezer, Sackville Road	Bricksand P/L	Hawkesbury	clayey	9030-1-N	303350	6288200	4649		
Portland Sand Pit	Tallon E&J	Hawkesbury	clayey	9031-2-S	307200	6298950	5528		
Kurrajong Bull Ridge Road	Supafortuss Soil Supplies	Hawkesbury	clayey	9030-1-N	305750	6287950	5536		
Colo Heights "Tinda Park"	Birdon Contracting	Hawkesbury	clayey	9031-4-S	286000	6327900	5966		
Montview Parade, Hornsby	Turramurra Industries	Hornsby	clayey	9130-4-S	323400	6273300	322, 4212		1,845

Quarry Name	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
Wallacia, Silverdale Road										
Stonequarry Creek Sand Pit - Picton	20							870		
Sea Cave - Frazer Park	330									
Frazer Park										4,000
Gwandalan Quarry										
Cheesemans Road Sandstone										14,799
Maroota										
Maroota, Hitchcock Road										
Maroota, various portions										
Kenthurst, 275 Pitt Town Road								24,000		
Maroota, Monaldo										
Maroota, Lot 167, Hitchcock Road										
Wisemans Ferry Road										
Kenthurst, 214 Pitt Town Road										
Maroota, Old Northern Road										
Maroota, Warrah School										
Elderslie, Springs Road	1,322	1,519	1,161	581	295	295				
Elderslie						1,444	17,837			
Elderslie, Springs Road	13,278	11,177	13,395	15,000	44,142	64,077	101,327			
Elderslie, Macarthur Road										
Elderslie - Richardson/Springs Road										
Elderslie Sand Pit								51,000	37,469	93,628
Elderslie, Woodgrand										
Elderslie (Narellan), Springs Road				27,415		40,191	101,327	142,875	183,625	163,523
Menangle, Menangle Road										
Somersby, Main Road			1,300							
Calga Sands Quarry										
Somersby, Hoipos Road										
Somersby, Wisemans Ferry Road										
Somersby Reservoir Road			20,250	54,693	55,346	58,213	59,500	126,989	98,590	96,439
3260 Wisemans Ferry Road Somersby										
Pitt Town Bottoms	69,135	81,524	109,623	60,477	215,192	161,287	95,446	0	0	4,058
Pitt Town, Farley and Lewers	117,485	77,450	179,133	193,036	131,613	24,971				
Ebenezer Quarry				34,500	11,727	14,073	7,300	25,300	1,000	292
Ebenezer, Sackville Road					16,300	49,000	45,000	25,300	22,000	21,247
Portland Sand Pit										
Kurrajong Bull Ridge Road										
Colo Heights "Tinda Park"										
Montview Parade, Hornsby										

Quarry Name	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
Wallacia, Silverdale Road										
Stonequarry Creek Sand Pit - Picton		5,635	4,560	10,110	4,369	4,199	2,213			
Sea Cave - Frazer Park										
Frazer Park	4,200	47,896	7,500	34,656	105,394	24,972	22,196		53,777	50,000
Gwandalan Quarry			1,200	200						
Cheesemans Road Sandstone	29,000	19,037	37,549	20,616	20,801	13,000				
Maroota	11,148	8,130								
Maroota, Hitchcock Road	2,131				150,058	210,710	253,895	285,175	364,027	330,000
Maroota, various portions										
Kenthurst, 275 Pitt Town Road										
Maroota, Monaldo				18,486	3,459					
Maroota, Lot 167, Hitchcock Road				50,000	50,000		11,369			
Wisemans Ferry Road						21,584				44,000
Kenthurst, 214 Pitt Town Road					5,000			1,500	800	800
Maroota, Old Northern Road										
Maroota, Warrah School										
Elderslie, Springs Road										
Elderslie										
Elderslie, Springs Road										
Elderslie, Macarthur Road										
Elderslie - Richardson/Springs Road									216,563	91,866
Elderslie Sand Pit	96,000	93,601	127,732	110,011	101,237	130,524	159,966	98,745	92,938	22,300
Elderslie, Woodgrand										
Elderslie (Narellan), Springs Road	142,543	97,746	163,063	123,996	143,900	159,000	248,417	169,689	104,000	72,953
Menangle, Menangle Road										10,771
Somersby, Main Road										
Calga Sands Quarry									38,000	8,344
Somersby, Hoipos Road				50,159	56,000	72,000	72,000		17,096	
Somersby, Wisemans Ferry Road	69,810	40,753								
Somersby Reservoir Road	109,435	89,554	195,337	140,968	149,832	130,114	220,479	297,274	279,260	258,488
3260 Wisemans Ferry Road Somersby										
Pitt Town Bottoms	0	0	0	45,909	216,700	147,469	198,000	163,000	58,000	
Pitt Town, Farley and Lewers										
Ebenezer Quarry	15,328	2,318	168	950	2,000	3,423	11,369			
Ebenezer, Sackville Road	935									
Portland Sand Pit			1,650	4,000						
Kurrajong Bull Ridge Road				1,400	7,630					
Colo Heights "Tinda Park"									14,000	27,000
Montview Parade, Hornsby										

Quarry Name	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00
Wallacia, Silverdale Road			210						
Stonequarry Creek Sand Pit - Picton						4,200	4,900		
Sea Cave - Frazer Park									
Frazer Park	48,648	53,100	48,116	40,622	32,420	34,362	34,792	55,228	
Gwandalan Quarry									
Cheesemans Road Sandstone									
Maroota									
Maroota, Hitchcock Road	491,272	355,040	445,990	486,807	472,383	523,396	462,836	519,339	490,404
Maroota, various portions									
Kenthurst, 275 Pitt Town Road									
Maroota, Monaldo									
Maroota, Lot 167, Hitchcock Road									
Wisemans Ferry Road	61,000	62,849	37,383	19,485					
Kenthurst, 214 Pitt Town Road	1,300	2,500							
Maroota, Old Northern Road	7,126	32,125	73,512	139,953	100,000	100,000	191,232	114,810	0
Maroota, Warrah School						17,904	26,100	55,214	61,000
Elderslie, Springs Road									
Elderslie									
Elderslie, Springs Road									
Elderslie, Macarthur Road	16,876	17,601	7,977	25,534	22,083	18,126	17,907	27,802	18,000
Elderslie - Richardson/Springs Road	126,778	126,941							
Elderslie Sand Pit	32,145	81,881	119,431	118,319	157,584	188,180	131,682	162,252	177,575
Elderslie, Woodgrand					75,823		40,331	18,250	20,000
Elderslie (Narellan), Springs Road	57,614	36,847	89,654	89,190	34,654				
Menangle, Menangle Road							52,501	47,493	71,511
Somersby, Main Road									
Calga Sands Quarry	31,600	136,668	180,342	250,191	265,656	342,945	318,070	330,262	340,832
Somersby, Hoipos Road							32,184	49,250	42,667
Somersby, Wisemans Ferry Road	60,000	60,000	72,000	68,000	55,000			35,595	41,609
Somersby Reservoir Road	199,351	280,838	267,487	316,330	348,580	263,659	306,176	202,858	183,600
3260 Wisemans Ferry Road Somersby							8,385	30,000	62,757
Pitt Town Bottoms									
Pitt Town, Farley and Lewers									
Ebenezer Quarry									
Ebenezer, Sackville Road									
Portland Sand Pit									
Kurrajong Bull Ridge Road									
Colo Heights "Tinda Park"	21,000	24,000	26,000	30,000	20,000	22,000	32,902	64,980	68,682
Montview Parade, Hornsby									

Quarry Name	Operator	LGA	Sand type	Map Sheet	AMGE	AMGN	abs_ref	1969-70	1970-71
Gilliot's Quarry	A. H. Gilliot	Hornsby	clayey	9130-4-S	326100	6276100	3685	6,590	
Canoelands Road, Glenorie	Len Jones	Hornsby	clayey	9130-4-N	316420	6291350	5537		
Maroota, Trovato-Weavers Area	PF Formation	Hornsby	clayey	9031-2-S	313800	6298400	6152		
Moorebank Quarry	Benedict Sands	Liverpool	clayey	9030-2-S	311800	6243500	4824		
Agnes Banks, PB White	PB White Minerals P/L	Penrith	clayey	9030-4-S	287100	6275200	2357		
Agnes Banks, Dixon Sands	Dixon Sand (Penrith) P/L	Penrith	clayey	9030-4-S	287500	6277050	4337, 1422	93,990	33,299
Agnes Banks, CSR Readymix	CSR Ltd	Penrith	clayey	9030-4-S	287700	6275500	447, 1144	182,903	238,366
Ingleside and Oxford Falls	Warringah Shire Council	Warringah	clayey	9130-4-S	336950	6268050	1053001		
Crozier Road, Belrose	Warringah Stone & Gravel	Warringah	clayey	9130-4-S	333500	6267500	2133	442	
Mona Vale Road, St Ives	R Greenwood Contracting	Warringah	clayey	9130-4-S	332400	6268000	324, 317		
Annangrove-Terrey Hills Quarry	Ron Davis & Sons P/L	Warringah	clayey	9130-4-S	337575	6271500	5217		
Cabbage Tree Quarry, Belrose	Davis Earthmoving & Quarrying P/L	Warringah	clayey	9130-4-S	336200	6265400	604		
Belrose	Belrose Stone & Sand Supply	Warringah	clayey	9130-4-S	334000	6267500	607		
Belrose, Morgan Road	TG & BJ Brown	Warringah	clayey	9130-4-S	335400	6267400	798		
Taylors Sand Pit, Appin	Joe Taylor Sand P/L	Wollondilly	clayey	9029-2-N	303725	6207525	4668		
Bulli Tops, Wedderburn	J Taylor Sands	Wollondilly	clayey	9029-1-S	304800	6210100	5279, 4204		2,714
Cobbitty, Brownlow Hill Loop Road	Nepean Quarries P/L	Wollondilly	clayey	9029-4-N	279900	6231100	5961		

Quarry Name	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80	1980-81
Gilliot's Quarry										
Canoelands Road, Glenorie										
Maroota, Trovato-Weavers Area										
Moorebank Quarry										
Agnes Banks, PB White	21,751	76,882	74,073	61,287	44,628	50,000	34,166		76,984	98,630
Agnes Banks, Dixon Sands	27,500	45,877	73,630	54,316	63,959	79,867	81,953	138,000	119,446	103,086
Agnes Banks, CSR Readymix	261,290	307,440	327,385	246,214	285,414	347,710	303,816	382,399	377,901	362,380
Ingleside and Oxford Falls						14,600				
Crozier Road, Belrose										
Mona Vale Road, St Ives	3,214	7,154	4,198	5,194	14,609	25,843	46,255	14,327	14,000	
Annangrove-Terrey Hills Quarry										
Cabbage Tree Quarry, Belrose										
Belrose	5,109	35,064	47,373	12,480						
Belrose, Morgan Road					197					
Taylors Sand Pit, Appin						72,600				
Bulli Tops, Wedderburn	28,583	32,395	36,570							20,266
Cobbitty, Brownlow Hill Loop Road										

Quarry Name	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
Gilliot's Quarry										
Canoelands Road, Glenorie										
Maroota, Trovato-Weavers Area									30,000	30,000
Moorebank Quarry										
Agnes Banks, PB White	112,262	53,725	60,392	57,720	39,127	8,349	6,080	11,467	18,186	29,679
Agnes Banks, Dixon Sands	84,222	67,990	67,160	64,845	56,325	61,303	41,061	33,178	34,380	37,824
Agnes Banks, CSR Readymix	281,940	171,096	159,116	231,819	281,367	280,397	262,130	328,961	352,624	264,386
Ingleside and Oxford Falls			30,000	10,482	1,488			15,100		
Crozier Road, Belrose						6,500	3,800	2,760	3,217	20,424
Mona Vale Road, St Ives										
Annangrove-Terrey Hills Quarry	150	1,000	750	750						
Cabbage Tree Quarry, Belrose			1,500	600			6,120	6,000		
Belrose										
Belrose, Morgan Road										
Taylors Sand Pit, Appin				20,450	14,451	8,260	5,804	5,717	4,527	3,804
Bulli Tops, Wedderburn										
Cobbitty, Brownlow Hill Loop Road								3,200		

Quarry Name	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00
Gilliot's Quarry									
Canoelands Road, Glenorie	98								
Maroota, Trovato-Weavers Area	30,877	12,383	21,643						
Moorebank Quarry							145,725	233,858	142,064
Agnes Banks, PB White	24,155	38,638	57,935	126,878	92,150	115,203	30,020	177,342	170,574
Agnes Banks, Dixon Sands	37,955	22,706	38,040	47,225	40,000	40,000	46,540	41,845	45,862
Agnes Banks, CSR Readymix	166,302	181,329	158,597	246,565	186,591	226,182	207,592	201,357	121,870
Ingleside and Oxford Falls									
Crozier Road, Belrose	13,092	8,260				72,178		65,939	34,174
Mona Vale Road, St Ives					2,118				
Annangrove-Terrey Hills Quarry									
Cabbage Tree Quarry, Belrose									
Belrose									
Belrose, Morgan Road									
Taylors Sand Pit, Appin	3,576	1,465	175	1,699	2,175	2,282	2,706	708	10,211
Bulli Tops, Wedderburn									
Cobbitty, Brownlow Hill Loop Road									