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Resource assessment: The Calder–Flowerdale gravel pits

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INTRODUCTION

The Inglis River Valley, in Tasmania's northwest, contains substantial deposits of high quality quartz gravel and sand. These reserves have been exploited in the past by numerous operators, especially in the Calder and Flowerdale areas. The deposits are of considerable economic importance to the building and road construction industry on the northwest coast, as they supply concreting, paving and road aggregates, hot mix sealants for roads, and sand for concrete blocks and domestic purposes.

In common with many other municipalities, there has been a trend towards decentralisation of housing away from the towns into surrounding rural areas. This has resulted in increased competition for land and greater scope for land-use conflict. Some of the potential problems of housing encroachment into current gravel extraction areas involve both economic and social issues. These include the locking up of potential gravel reserves as a result of home construction on or near deposits, noise, dust and visual impacts, siltation of streams, and traffic problems.

In line with the principles of effective land management, this study was designed to investigate these conflicting land uses. The terms of reference for this report involved a resource assessment of currently operating pits, the potential for new reserves in areas outside existing operations, consultation with current operators to ascertain uses, and the impact of housing encroachment on operations.

The area under investigation extends from Flowerdale, approximately 5 km west of Wynyard, southward for 15 km to the township of Calder (fig. 1).

PHYSIOGRAPHY AND GEOLOGY

The topography of the area is characterised by a central alluvial plain rising on either side to basalt capped ridges. These areas have been extensively cleared, as they provide excellent dairying and farm land. In contrast, the slopes of the ridges remain well forested with wet schlerophyll forest species. These slopes, especially on the eastern bank of the Inglis River, provide the main focus for gravel extraction activities.

The north-flowing Inglis River has dissected the regional stratigraphy, exposing a basement of Permian glaciomarine sediments and Precambrian quartzite and schist in the valley floor and on adjacent spurs. Overlying the basement units is a thick sequence of fluvial quartz pebble conglomerate, gravel and sand of Tertiary age. It is inferred that these gravels are the result of a continuous wedge of coalescing alluvial fans (Threader, 1981). Widespread Tertiary basaltic volcanism subsequently covered these fans.

Regional mapping of the area shows that the quartz gravel is exposed over an east-west distance of four kilometres and a north-south distance of 12 km (fig. 2; Threader, 1981). The stratigraphic thickness of the quartz gravel varies considerably, from over 60 m thick (Gee, 1971) in the north to less than 10 m in the south (B. Cairnduff, pers. comm.). Both pre- and post-basaltic drainage have reworked and redistributed the gravel, as shown by the present form and sedimentary structures (Threader, 1981). Poorly developed soils, to a depth of 1 to 2 metres, cover the gravel over the extent of the area.

Previous work in the area has been largely restricted to regional geological mapping, associated with the production of the Table Cape and Burnie 1:63,360 scale geological maps and accompanying reports. One exception is the work of Threader (1981), who investigated the potential reserves of the Ballast Pit, at the northern end of the study area.

DEPOSIT CHARACTERISTICS

The top five to six metre thickness of quartz gravel is typically white to pale grey in colour, whilst below this the colour tends to be tan to mid brown, reflecting the leaching of iron through the soil profile. Highly ferruginous cemented layers are common in the Ballast Pit area but tend to be less

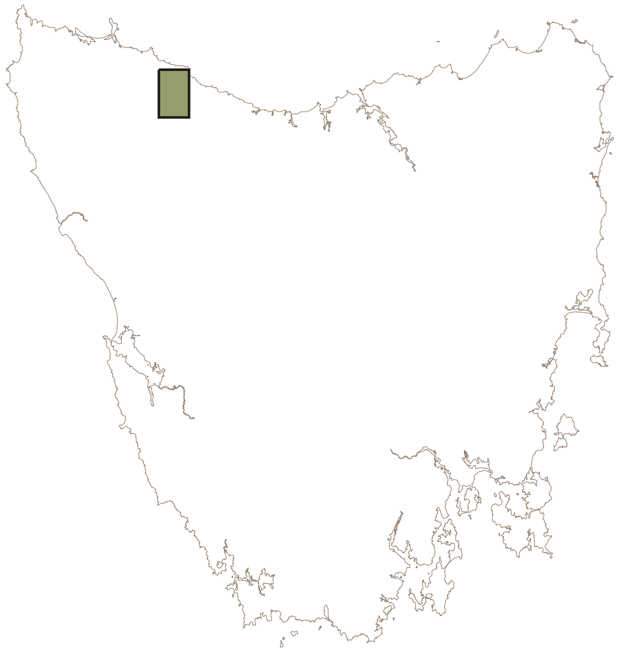
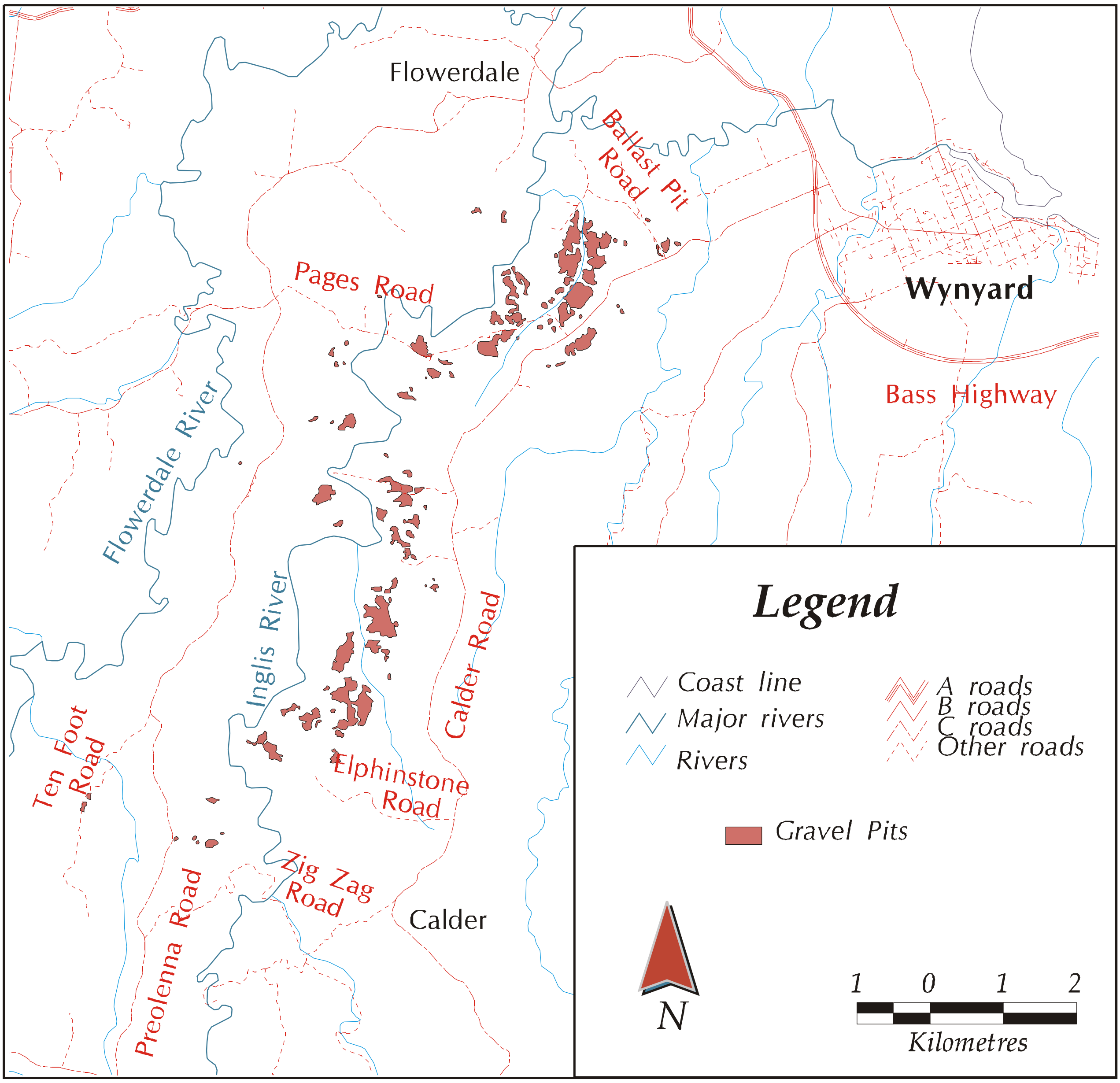


Figure 1

Location of the Calder gravel pits



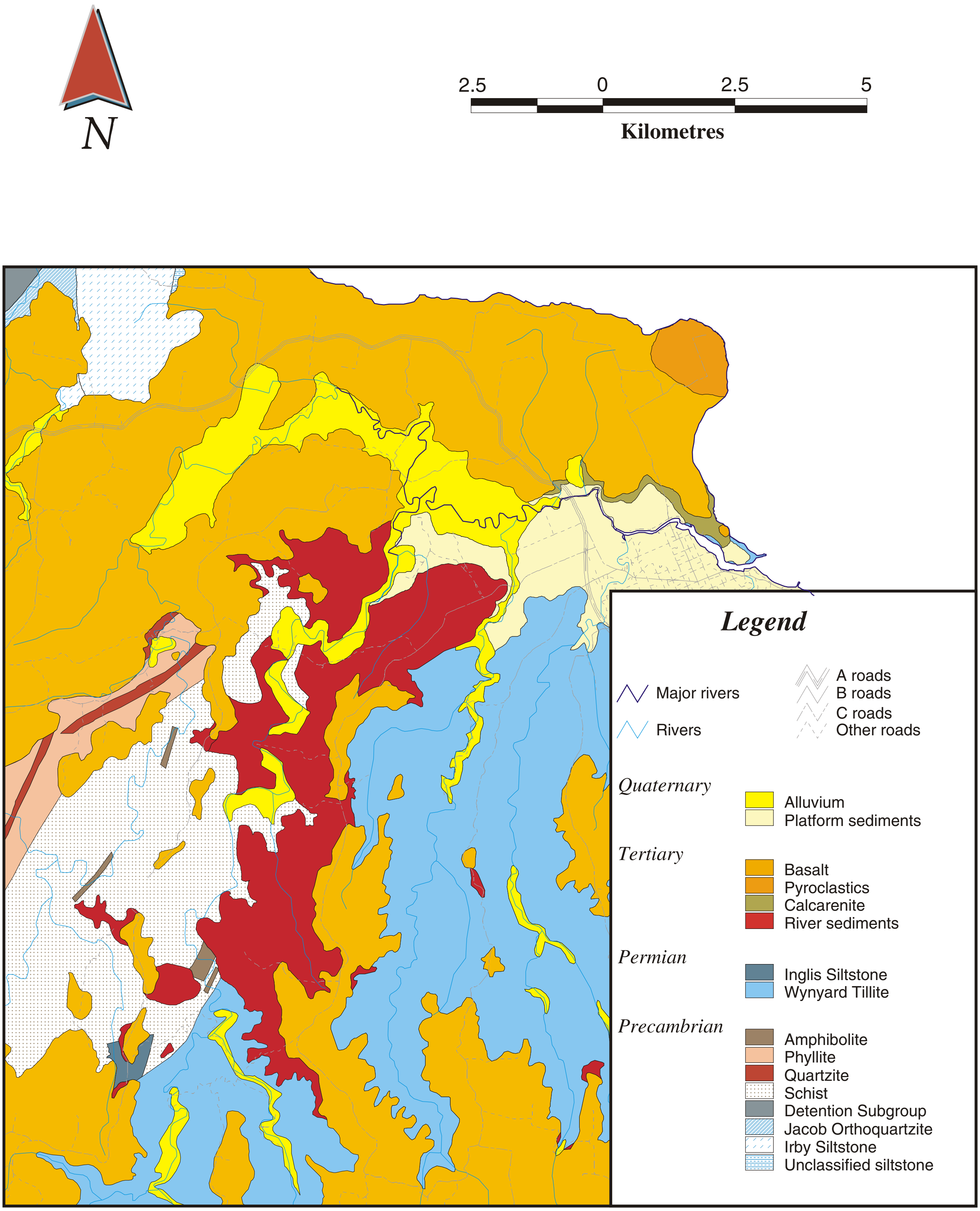


Figure 2

Geology of the Wynyard–Calder area (modified after Gee, 1966, 1968) evident in other areas. These bands, commonly called 'coffee bands', are the result of leaching and precipitation at the water table, the differing levels being attributable to seasonal fluctuations.

The gravel and sand vary considerably in grainsize and overall grain morphology throughout the area. Units may range from well-graded round pebble and granule conglomerate to poorly-graded fine-grained sand. Variations in the sand matrix content produce coarse and poorly defined stratification. Many of the layers are of well-sorted pure quartz sand. Individual units may range from several metres thick to 100 mm, but are dominantly in the range of 0.5 to 2 m thick. These units tend to pinch and swell over distances of several hundreds of metres, reflecting their high energy mode of formation. Festoon cross bedding is common within the finer grained units.

The coarsest units within the area contain clasts up to 150 mm, in a medium to fine-grained sand matrix. More typically the coarser units consist of well-graded pebble and granule conglomerate, with clasts approximately 50 to 100 mm in diameter. Clasts range from subangular to dominantly well rounded and are supported by a fine to medium-grained sand matrix. Cement and fine matrix material are noticeably absent and the gravel is porous and friable, except in proximity to the overlying basalt where minor silicification and induration has occurred. Finer grained units range from poorly-graded fine-grained to medium-grained sand. Grains tend to be dominantly rounded to subrounded in a poorly developed matrix of fine sand and rare clay. These units tend to be extremely friable and occasionally free flowing.

The quartz gravel and sand of the Inglis River Valley ubiquitously reflect a Precambrian provenance, with clasts composed dominantly of quartzite with minor schist, sandstone, agate, chert and detrital quartz. Some of the material would have been recycled by erosion of the Permian glacial sediments, which contain abundant siliceous clasts and clasts of other composition. Isolated fragments of coal and wood occur in certain layers (Gee, 1971).

USES

These deposits are of considerable economic importance to the building and road construction industry on the northwest coast, as they supply concreting, paving and road aggregates, hot mix sealants for roads, and sand for concrete blocks and domestic purposes. The quartz gravel deposits are typically highly variable in nature from one pit to another. Hence the final product from each pit is dependent on the material characteristics of that pit; these are discussed in more detail below.

GRAVEL PRODUCTION AND RESERVES

There are currently several mining operations of varying size within the Calder–Flowerdale area (fig. 3).

Besser Tasmania Pty Ltd is the main commercial operator in the area. This company provides material for Pioneer Concrete Tasmania Pty Ltd (for concrete bricks and general purpose concrete), Besser bricks and pavers (including a variety of shades),and sand and gravel for use in the building and gardening industries. Some minor sales are made to the general public.

Other operators within the area are:

Boral Concrete	sand and aggregate for concrete bricks and general purpose concrete;
F. N. Crawford	supplies Boral Concrete, sand and aggregates for the building trade, and rarely road construction materials;
L. G. Holloway	supplies Department of Transport with road construction materials, sells aggregate and sand to the general public and for use in the building industry;
J. M. Margetts	aggregate for road construction and sand for building trades;
Pioneer Concrete	sand and aggregate for concrete bricks and general purpose concrete;
D. J. Rowell	provides road base material, concrete sand and aggregate, as well as bricklayers' and coarse sand to a variety of customers;
P. M. Voss	supplies local building industry with sand and aggregate for concrete, as well as road construction materials;
Wynyard Council	road construction materials, including sealants.

Besser Tasmania Pty Ltd

Besser is the largest commercial operator in the Calder–Flowerdale area. The Besser operation is located 10 kilometres south of Wynyard and currently occupies an area of 349 hectares, having reduced the area under lease from 391 hectares, of which 90% is considered to be underlain by Tertiary gravel. The thickness of gravel in the area is generally less than ten metres (B. Cairnduff, pers. comm.).

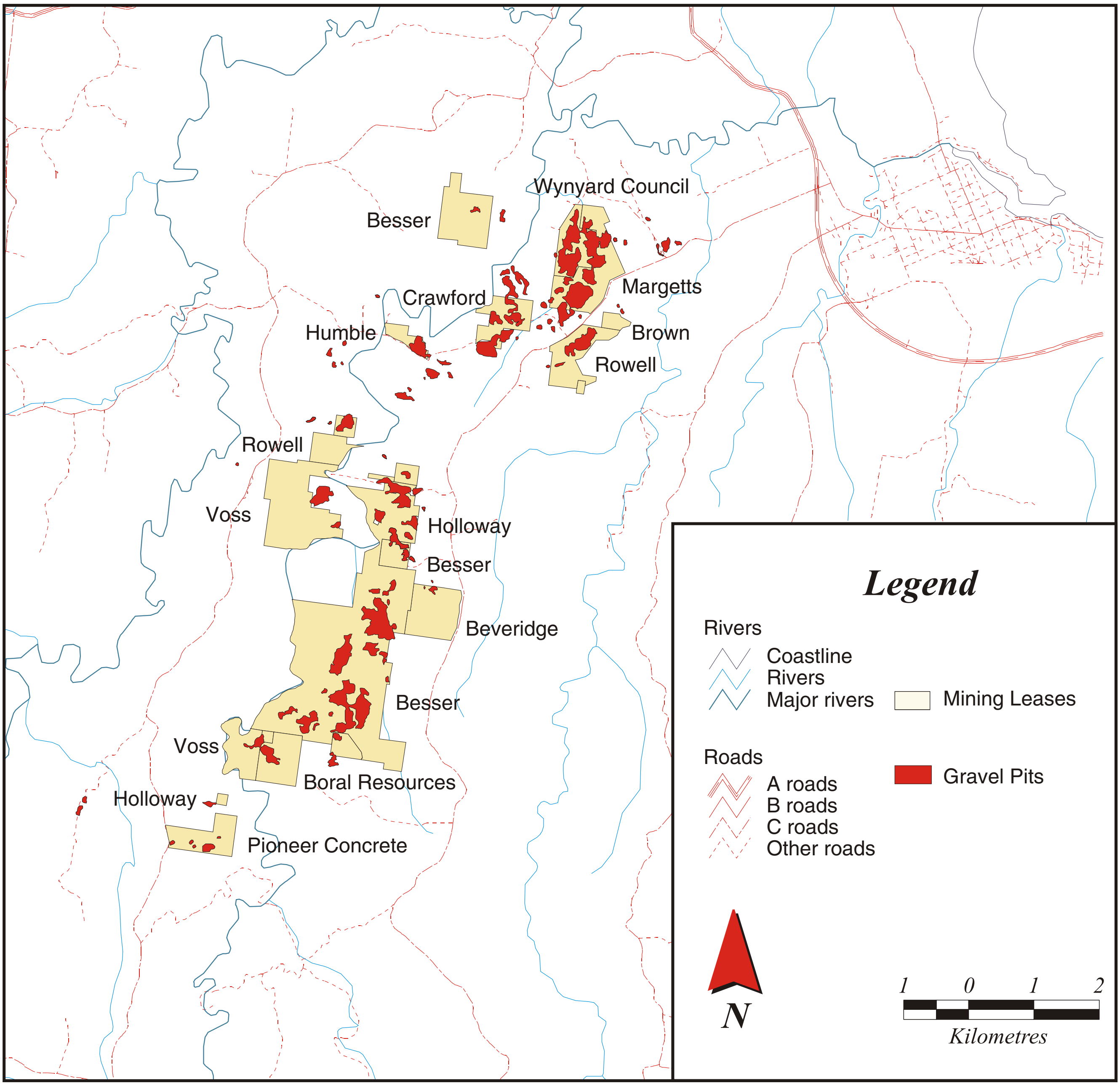


Figure 3

Tenement location and tenement holders (past and present)

Production and Reserves: Besser currently produces in excess of 20 000 tonnes of sand and aggregate annually. Resource estimates for the Besser pit, were carried out by M. D. Ware in 1981 and Amdel in 1982. These estimates were conservative, reflecting the requirement for high purity quartz gravel for the production of silicon metal, and hence did not account for much of the underlying ferruginous gravel. However they do provide a useful estimate of the amount of high quality white gravel present at the Besser pits and distributed throughout the Calder area.

Uses: Besser currently uses 90% of its annual production from the gravel pits at Calder for its block/brick/paving operations at Ulverstone, with the remainder being absorbed by other private companies. Overflow or surplus stock may be sold to the public. The Calder operations involve the extraction and stockpiling of material prior to screening and separation into a variety of grainsizes. The coarsest grainsizes (anything greater than 21 mm) are crushed to either 8 or 15 mm, and are then incorporated with the stockpile of those respective grainsizes. The 15 mm fraction is sent to Pioneer Concrete, whilst the 8 mm fraction is for use in the Besser operations at Ulverstone. The finer grainsizes are screened to 3 mm and 1.6 mm, for use in the Besser operations or sold as 'brickies sand' respectively. Anything less than 1.6 mm is sent to the coffer dams, which when cleaned provide the fines for rehabilitation purposes. Gardening shops provide an outlet for one of the coarser products of the pit, selling gravel (to 21 mm) for gardening purposes.

Table 1

Approximate historical production from the Calder area from 1958 to the present

Year	*Annual Production (tonnes)*
1958	38 365
1959	30 350
1960	70 690
1961	60 970
1962	38 010
1963	59 840
1964	93 420
1965	77 980
1966	72 280
1967	107 750
1968	196 285
1969	165 775
1970	123 890
1971	94 495
1972	162 010
1973	56 735
1974	75 035
1975	94 340
1976	223 420
1977	225 470
1978	248 990
1979	233 025
1980 (to June)	135 325
1981	202 550
1982	113 211
1983	179 505
1984	134 835
1985	12 920
1986	68 930
1987	54 280
1988	116 415
1989	141 790
1990	120 160
1991	115 350
1992	88 825
1993	82 585
1994	94 440
1995	55 380
Total	3 557 146

Note: These figures are not complete for many years as it has not been possible to extract figures for Calder that relate to government production, e.g. Railways use of ballast. After June 1980 figures are on a financial year basis.

Management Practises: Current management practises at Besser have ensured a philosophy of full utilisation of all the resource (as demonstrated above where all gravel and sand extracted are utilised in one form or another), with concentration initially on long standing areas prior to rehabilitation. The company has invested heavily in the area, with a recent upgrade of the mill and coffer dams, as well as identifying areas of future reserves and resource potential. New products, reflecting the range in gravel types found at Calder, have also been developed.

Previously the company concentrated on the pristine white gravel of the upper layers in the profile. However, the mixing of both 'red' and 'white' gravel, has resulted in the development of a new product 'Shannonstone', which is now out-competing traditional products. This policy of full utilisation has extended the life of the Besser pit a further 20 years to a total expected life of 40 years (B. Cairnduff, pers. comm.).

Wynyard/Waratah Council

The Wynyard/Waratah Council possesses two pits, one at the end of Ballast Pit Road and the other to the west of the Inglis River, known as Dysons Pit.

The Ballast Pit was originally owned by the Australian National Railways Commission before being sold to the Wynyard Council. The Flowerdale ballast pit occupies an area of 34 hectares near the northern extremity of the extensive gravel deposits to the east of the Inglis River.

Production and Reserves: Work by Threader (1981) placed a conservative estimate of 3 to 4 million tonnes of sand and gravel in the Ballast Pit. Resource drilling done at this time indicated that the gravel extended to a depth of approximately 20 to 25 m, with only the top 10 to 15 m being worked. Local contractors and the Wynyard Council currently extract approximately 7000 t of material per year from the pit.

Uses: The low clay content of the sand and gravel (Threader, 1981) restricts their use to road base material, although they have been used previously as a source of railway ballast and aggregate for the local building market (Threader, 1981). Although sand is abundant, both as matrix to the gravel and as individual sand beds in the Ballast Pit, sand is not segregated from the gravel for use.

Management Practises: The diverse range of operators of the Ballast Pit has resulted in the haphazard management of the resource, with extensive areas being opened up for gravel extraction. The poorer quality gravel (generally containing carbonaceous and ferruginous staining and concretions) has typically been left, resulting in a highly variable local topography. The large extent of cleared land, combined with the variable topography, has resulted in extensive erosion of the gravel pit. Losses attributed to erosion may be combined with the abandonment of significant reserves of poorer quality material at depth to significantly diminish the resource estimate for the

Ballast Pit. Improved mining practise should involve:

1. The total extraction of gravel, either to the underlying clay or some predetermined depth (so as to prevent drainage problems).

2. Screening and/or washing could be employed to improve the quality of the gravel, as could ripping and subsequent crushing of ferruginous hardpans for use as road base.

3. Where the gravel resources have been exhausted, rehabilitation should commence to slow the rate of erosion.

4. Identification of areas of significant reserves and planning for future development of these areas.

5. Similar commercial operations in the area should ensure that all the grainsize fractions and grades are being utilised, either through the identification of applicable market niches or through the development of such niches. In a similar fashion, the gravel and sand from the Ballast Pit may be able to be separated and used for municipal purposes, rather than the council deriving their sand from commercial operators in the area.

6. Drainage should be directed to one point, where it would enter a coffer dam or settling pond. This would allow water-borne sediment to settle, thereby decreasing losses from the pit and reducing sediment loads in the surrounding waterways.

Dysons Pit is located on the western side of the Inglis River off the Preolenna Road, with the lease encompassing the pit covering an area of five hectares. Production records show that the pit operated from 1959 to 1984, producing up to 80 000 t of gravel per year. The gravel tended to have a higher clay content than gravel from the Ballast Pit and hence was used for road sealants on country roads, requiring only minimal compaction.

Other Commercial Operators

In a similar fashion to Besser, many of the smaller commercial operators have found markets for their particular products and hence extract all possible grainsizes.

Production and Reserves: The production figures for commercial operation tend to fluctuate greatly, depending on the levels of consumer demand. Hence it is very difficult to provide an estimate of the total annual production from these smaller operators. Larger operators, such as F. Crawford, produce in excess of 15 000 tonnes of sand annually, with Boral Concrete and J. Margetts having an annual production of between 5000 and 10 000 t of sand and aggregate respectively. Other operators are generally producing less than 1000 t annually.

The emphasis in many operations is on reworking areas previously perceived as being of poor quality. Screening, washing and mixing of products has enabled these effects to be minimised in many cases. Many operators have installed waste water dams and left sufficient buffers around their operations to minimise the impact on adjacent land holders.

Most operators have tended to avoid resource drilling or trenching, as it was felt that this cost (which would be passed directly onto the consumer) was unjustified. However verbal estimates by operators suggested their operations had a further five to ten year mine life, beyond which they had little idea of future reserves.

Uses: Due to the myriad of different operators the number of uses was large. However the products generally range from road and general purpose aggregates, to building, concrete and general purpose sand.

Management Practises: The haphazard extraction of sand and gravel in previous years has meant that many abandoned pits scar the Inglis River valley. Many pits, including current operations, are laterally extensive due to the preoccupation with the extraction of white gravel. Fortunately this is changing. In all cases operators were aware of their responsibility to rehabilitate sites of gravel and sand extraction. By-products, such as overburden and fines, are used in the remediation process. In some cases, such as that of J. Rowell, operators have moved onto a specific site to firstly ensure as much of the gravel resource is extracted as is possible, and secondly to aid in the rehabilitation of the site.

As outlined earlier, there is a lack of forward planning by many operators. At present many possess little information regarding the extent (including depth) of their gravel resources and are unable to outline areas of future reserves. This *ad hoc* approach means operators are only able to provide verbal 'guestimates' on the longevity of their operations.

All parties agreed that there was a requirement for protection of the Calder–Flowerdale gravel resource, with most noticing the encroachment of housing into surrounding areas. Most operators reported few ill effects of this encroachment. One exception, however, was the provision of access to an adjacent block of land which had recently been purchased and subdivided. In this case the access to housing parallels the pit wall, being only five metres from the pit extremity. Sand and gravel underlie the road to a depth of at least several metres and the operator (who has been there for at least 20 years) wishes to extract these materials. However to do so he must provide access to these houses at his own expense. Some of this adjacent land has been offered for sale to the operator, as it possesses good potential for gravel operations. However the operator considers the land to be too expensive.

CASE STUDY: The use of aerial photography and PhotoGIS in determining the effect of residential properties on the gravel resource

In order to quantify the effects of residential housing within the Wynyard–Calder area, three sets of aerial photographs taken at twenty year intervals were studied. The photographs, taken in 1956, 1974 and 1994, demonstrate the increasing impact of both gravel extraction and residential housing on the Calder district over the past forty years.

Aerial photography was chosen as the preferred assessment technique as it provides a relatively cheap, yet reliable method of data collection over a large area. Unfortunately, aerial photography possesses a major disadvantage in that it contains several inherent errors, which has previously been a problem for mapping. These errors relate to the inconsistency of scale across the photograph due to topographic variability, as well as tilting of the aircraft as it flies through the air. Through the combined use of digital elevation models (DEM) and the software package *PhotoGIS*, these errors may be resolved for any given camera, provided the focal length and the position of the fudicial points of the camera are known. With the aid of a DEM, *PhotoGIS* may correct aerial photograph data into true ground co-ordinates (AMG co-ordinates). This has enabled accurate measurement of the lateral extents of the Calder gravel pits, as well as locating the position of buildings directly from aerial photographs.

To allow for effective measurement, all information relating to the gravel pits and adjacent housing must be in a digital format. This was achieved by digitising directly from the aerial photographs, or in the case of the 1994 photographs, from a scanned image of each photograph. Both the extremities of the gravel pits and the surrounding buildings were digitised. At this point it should be stressed that inaccuracies in digitising may arise due to poor quality photographs, an unsteady hand, or unfavourable sun angle, etc. In this study resection errors (the error between the calculated and actual position of ground control points) was less than 20 metres in all cases. Hence, the position, or lack thereof, of some features may merely reflect imported errors rather than inherent features.

Once digitised the data are corrected into AMG co-ordinates using the DEM and *PhotoGIS*. Several coverages, such as rivers and roads, may then be overlain on the corrected 'photo' data, verifying the correct positioning of the pits and buildings in relation to cultural and topographic features. An example of this is Figure 1, which shows the position and extent of the gravel pits in 1994 in relation to the rivers and roads surrounding the Wynyard area.

Two relationships were deemed important in assessing the Calder gravel pits. Firstly, and of most concern to operators, is the total resource of Tertiary gravel remaining and its relationship to the operating pits. Secondly, and of historical significance, is the change in areas under exploitation as a function of time. Figures 4 to 6 show the distribution of gravel pits in relation to the Tertiary river gravel from 1956 to 1994. These figures demonstrate a substantial increase in the lateral extent of the pits in the twenty year period from 1956 to 1974, with a subsequent slowing of this increase in the period to 1994. This may relate to an increase in the level of building activity and associated infrastructure on the North West Coast following the end of the Second World War, and subsequent consolidation and utilisation of the resource after that period.

Figures 4 to 6 incorporate the Tertiary sediments with the major cultural (roads and gravel pits) and topographic features of the Calder area. These diagrams demonstrate that whilst the gravel pits are currently distributed widely over the Tertiary gravel, there remain large areas of gravel left unexploited. However, the consideration that all the gravel is available for exploitation is taking a fairly simplistic view of the overall land tenure situation in the Calder area. Consideration must also be given to the areas covered by residential housing, farms, State Reserves, State Forests, roads and watercourses.

Quarrying has the potential to directly impact on residential housing via visual, dust and noise pollution, as well as contaminating adjacent watercourses. The *Quarry Code of Practice* produced by the Department of Environment and Land Management recommends acceptable distance standards from quarry sites to existing residences and watercourses. These are:

- 40 metres around any permanent watercourse, or within 10 metres of obvious drainage lines.
- Quarries where no blasting, crushing or screening occurs — 300 metres.
- Quarries where vibrating screens are used — 500 metres.
- Quarries where material is crushed — 750 metres.
- Quarries where regular blasting occurs — 1000 metres.

As many of the operators within the Calder area simply extract the sand and gravel and cart them away, the minimum requirement of a 300 m 'buffer zone' around each building was used. Some of the larger operators either crush or use vibrating screens in their operations, imposing larger 'buffer zones' around buildings in their general vicinity. However for purposes of simplicity these were ignored in the calculation of the total area of

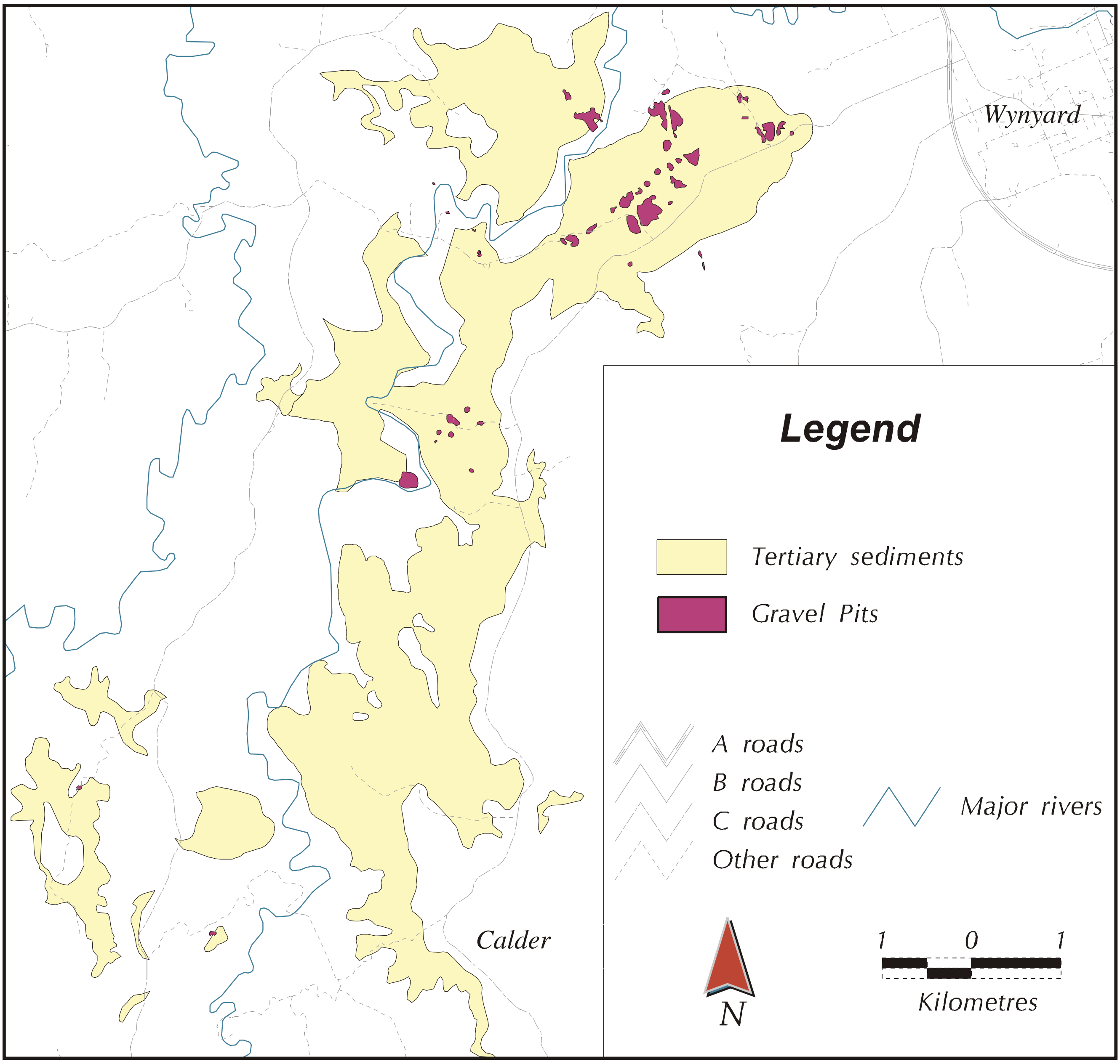


Figure 4

1956 distribution of the Calder gravel pits, in relation to Tertiary river gravel.

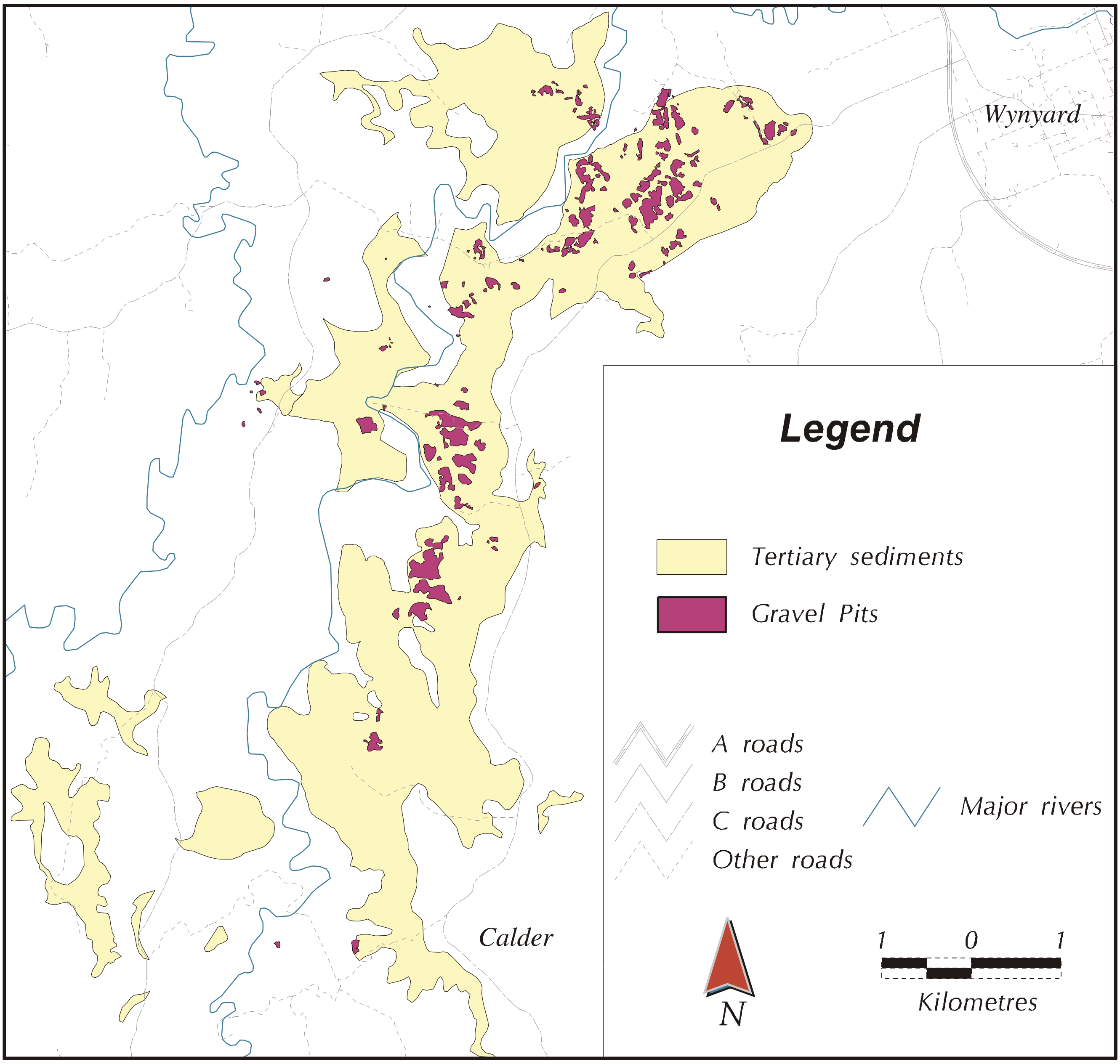


Figure 5

1974 distribution of the Calder gravel pits, in relation to Tertiary river gravel.

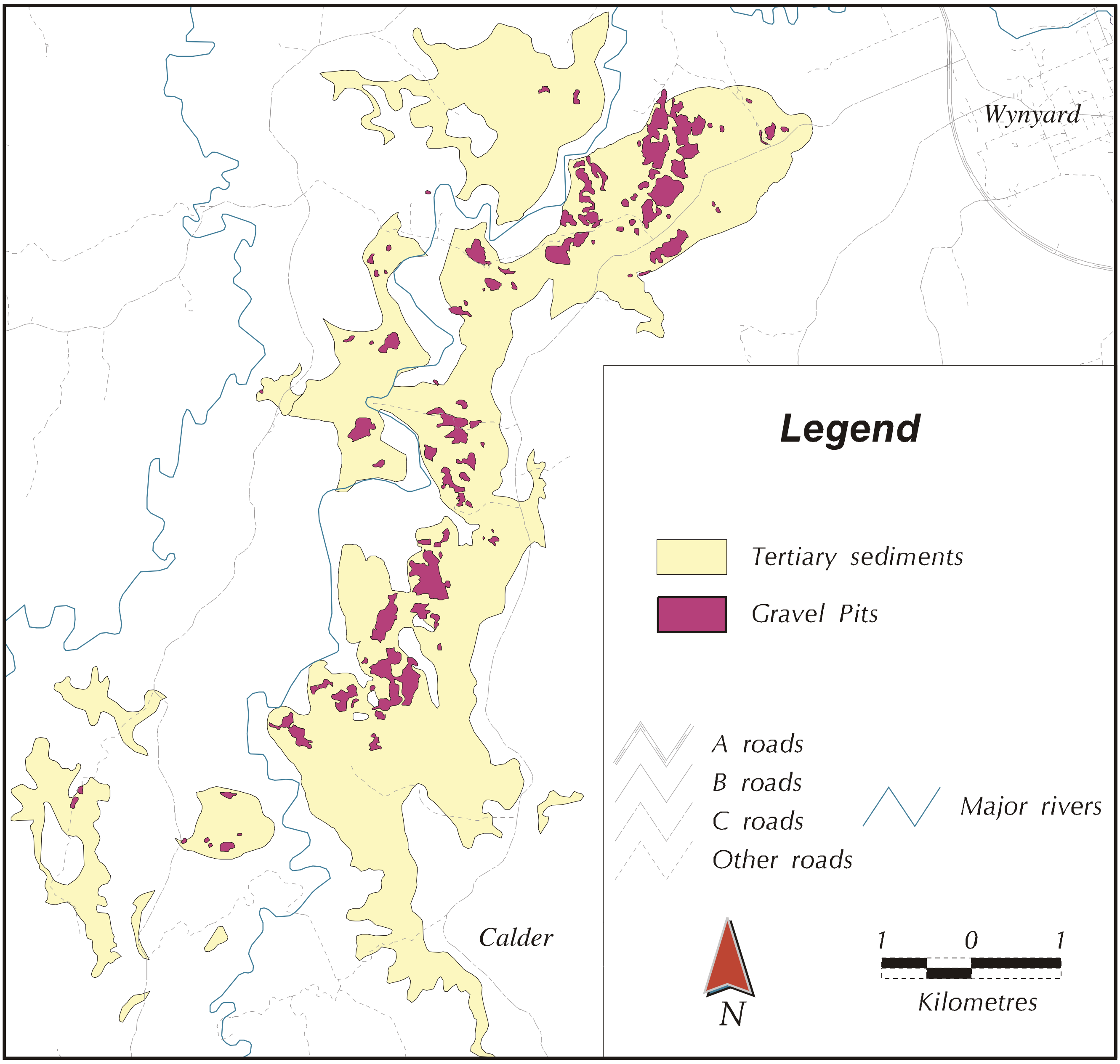


Figure 6

1994 distribution of the Calder gravel pits, in relation to Tertiary river gravel.

Tertiary gravel sterilised by buildings. Note that the quarry code refers to residential buildings; from air photos it is difficult to distinguish between residential and other buildings, hence the buffer zones may be exaggerated.

Figures 7 to 9 show the change in the areas of potential gravel resource and operations that may lie within the current buffer zone as defined by the *Quarry Code of Practice* (in grey) from 1956 to 1994. Also shown are the outlines of the gravel pits as they were at that time. These diagrams show that the total area sterilised by buildings has dramatically increased from 1956, although stabilising in the later twenty year period. Many of the pits already lie well within the minimum buffer zone around residential housing, a situation which although undesirable, would be exacerbated if consideration was given to the accepted standard distances required around operations involving screening and crushing of material.

CONCLUSIONS AND RECOMMENDATIONS

The Calder–Flowerdale gravel deposits provide a source of high-quality quartz sand and gravel for use in a wide variety of commodities. Extensive reserves of quartz gravel occur over a large area along the eastern bank of the Inglis River. Effective resource management and an emphasis on rehabilitation has resulted in more effective use of the deposit in many areas. This has been demonstrated by only small increases in the lateral extent of the gravel pits in the last twenty years.

It is not currently possible to provide an accurate resource assessment for the Calder area. The thickness and quality of sand and gravel varies greatly throughout the area, and an extensive programme of drilling, trenching and costeaning is required before any estimate of the total gravel resource in the valley, let alone at individual operations, could be given. The undertaking of such an exploration programme by the lease holders would involve considerable expenditure, which would ultimately be passed on to the consumer. However such a programme is recommended to effectively delineate further reserves and provide a basis for effective land management decisions.

The encroachment of housing will result in the reduction in available gravel reserves. Many gravel pits already lie within an area deemed unacceptable in order to minimise visual, dust or noise impacts on adjacent residential areas, thereby increasing the likelihood of these operations being considered an environmental nuisance. Planning decisions should therefore ensure that the gravel resource is protected and that pit operators maintain an effective 'buffer zone' between operations and adjacent housing. Similarly, housing development should be directed towards areas away from pit operations or at the very least to rehabilitated areas or areas with insignificant gravel reserves.

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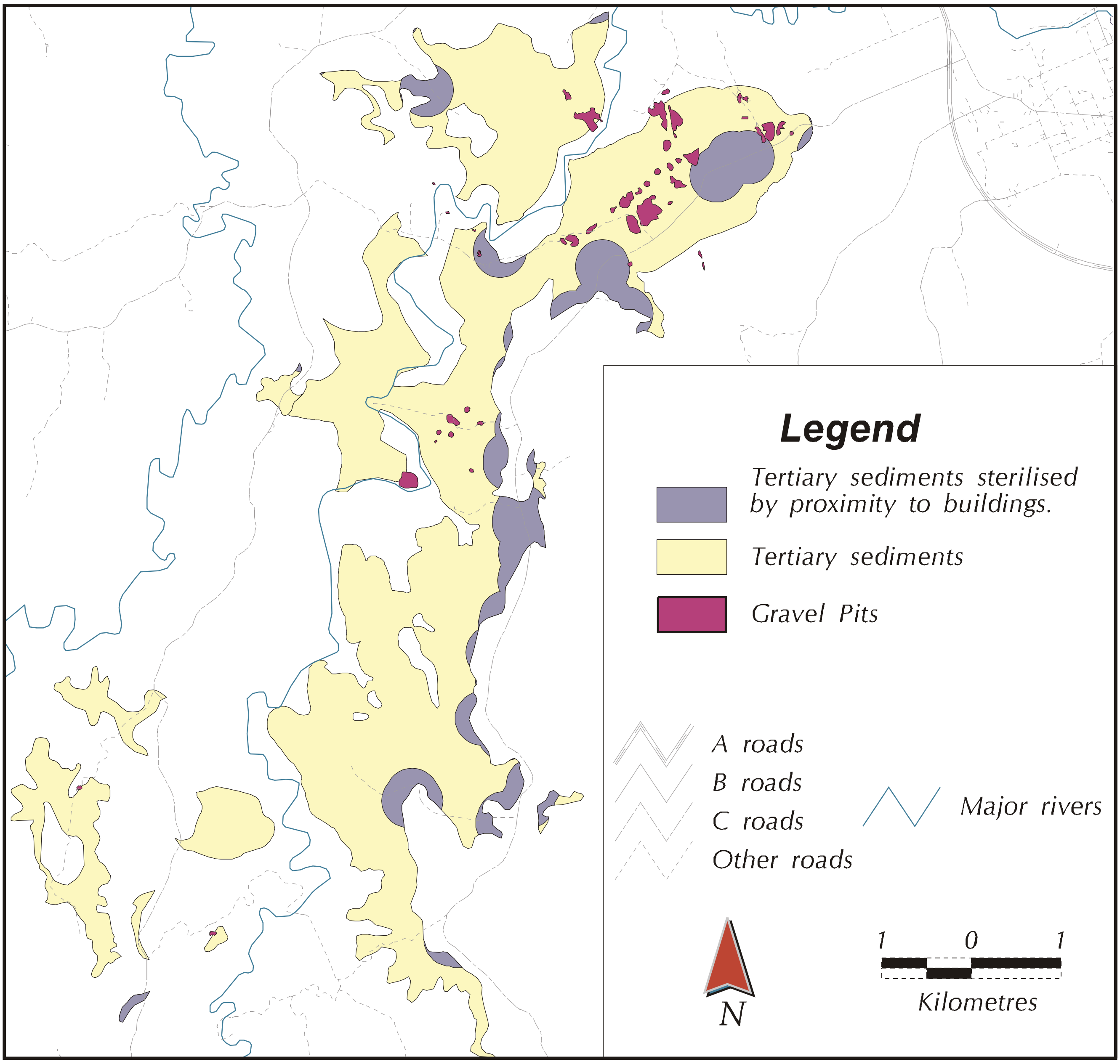

Figure 7

Area of Tertiary sediments sterilised by proximity to buildings in 1956. Buffer zone of 300 m around each building taken from Quarrying Code of Practice. The gravel pits of 1956 are also shown.

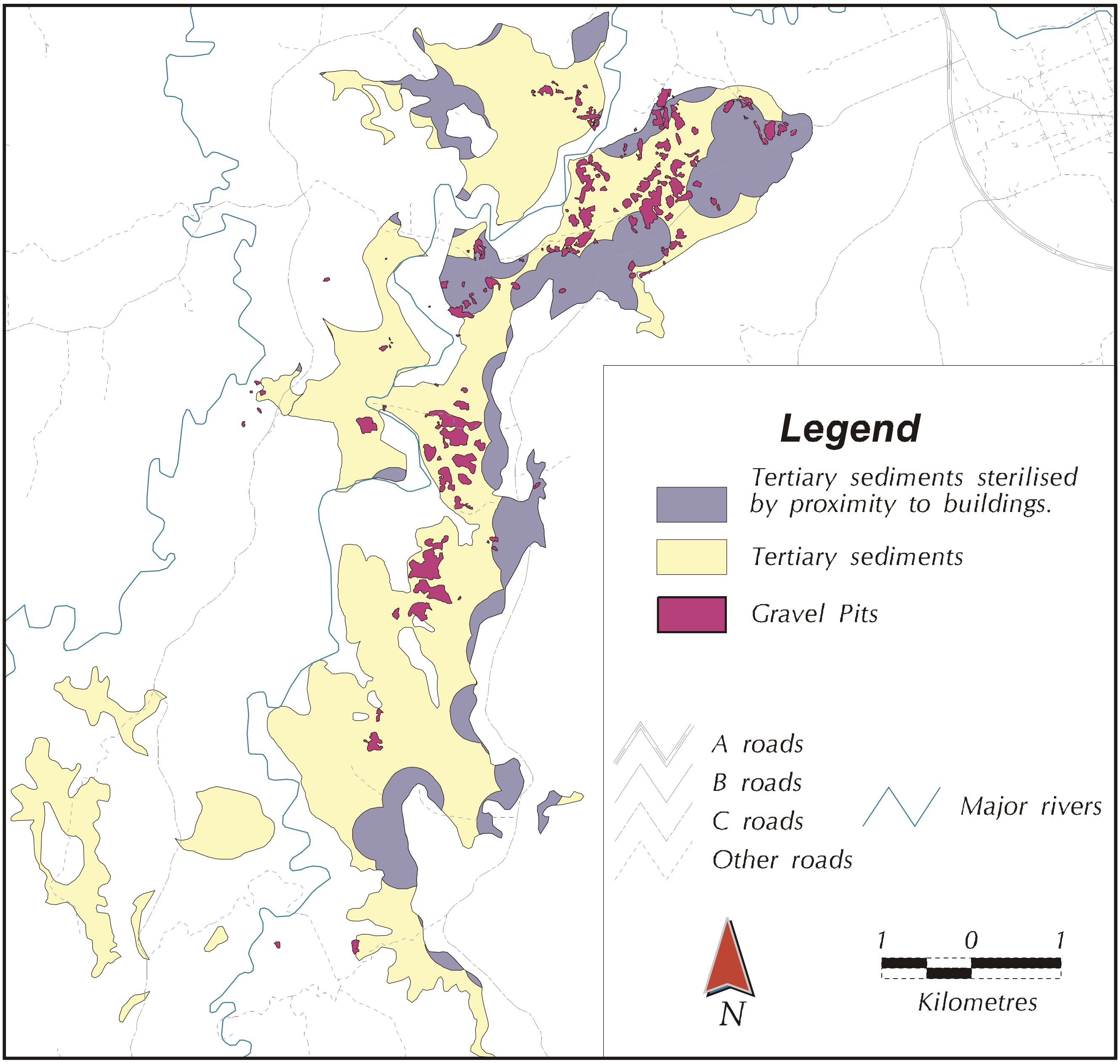

Figure 8

Area of Tertiary sediments sterilised by proximity to buildings in 1974. Buffer zone of 300 m around each building taken from Quarrying Code of Practice. The gravel pits of 1974 are also shown.

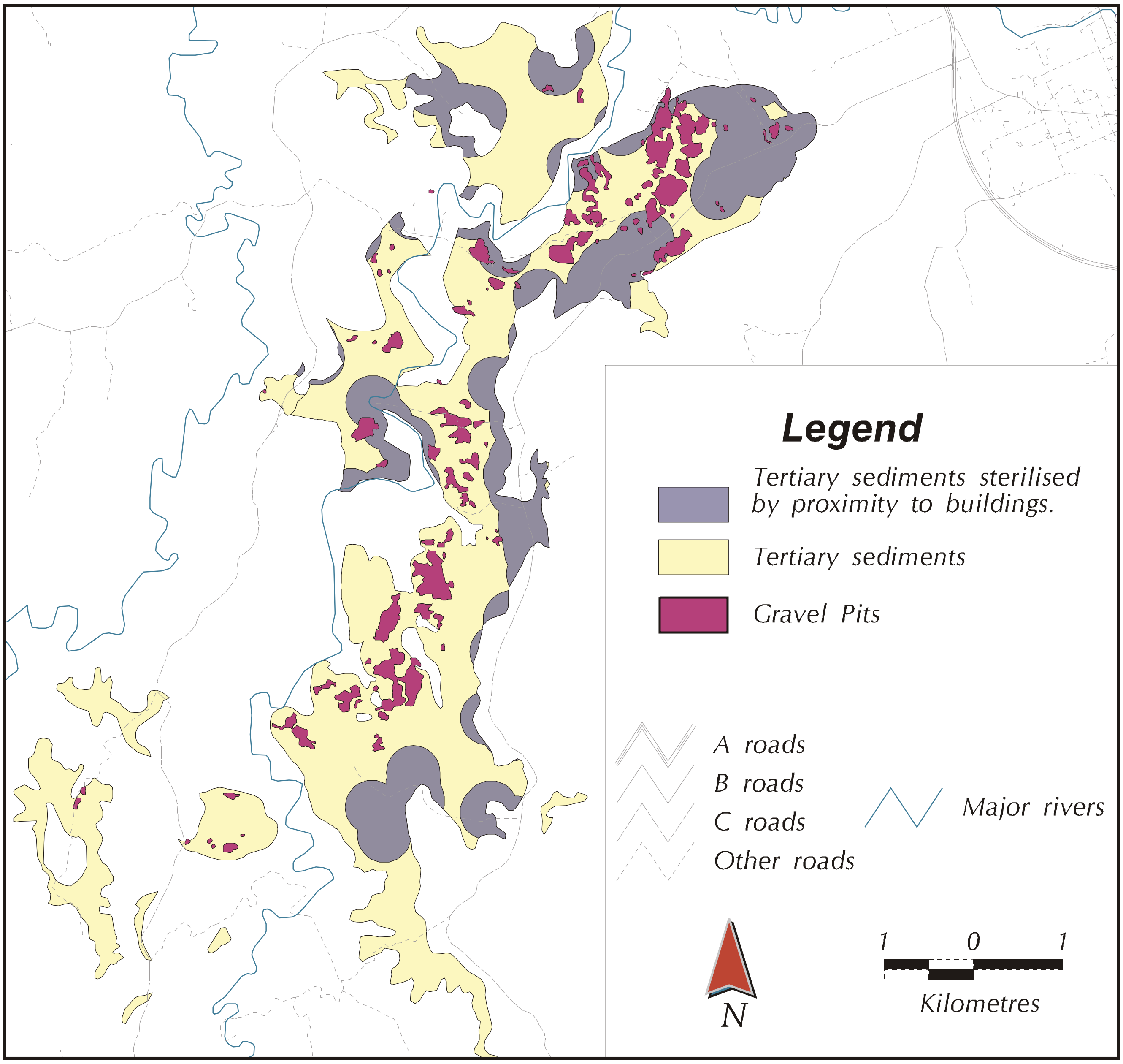

Figure 9

Area of Tertiary sediments sterilised by proximity to buildings in 1994. Buffer zone of 300 m around each building taken from Quarrying Code of Practice. The gravel pits of 1994 are also shown.