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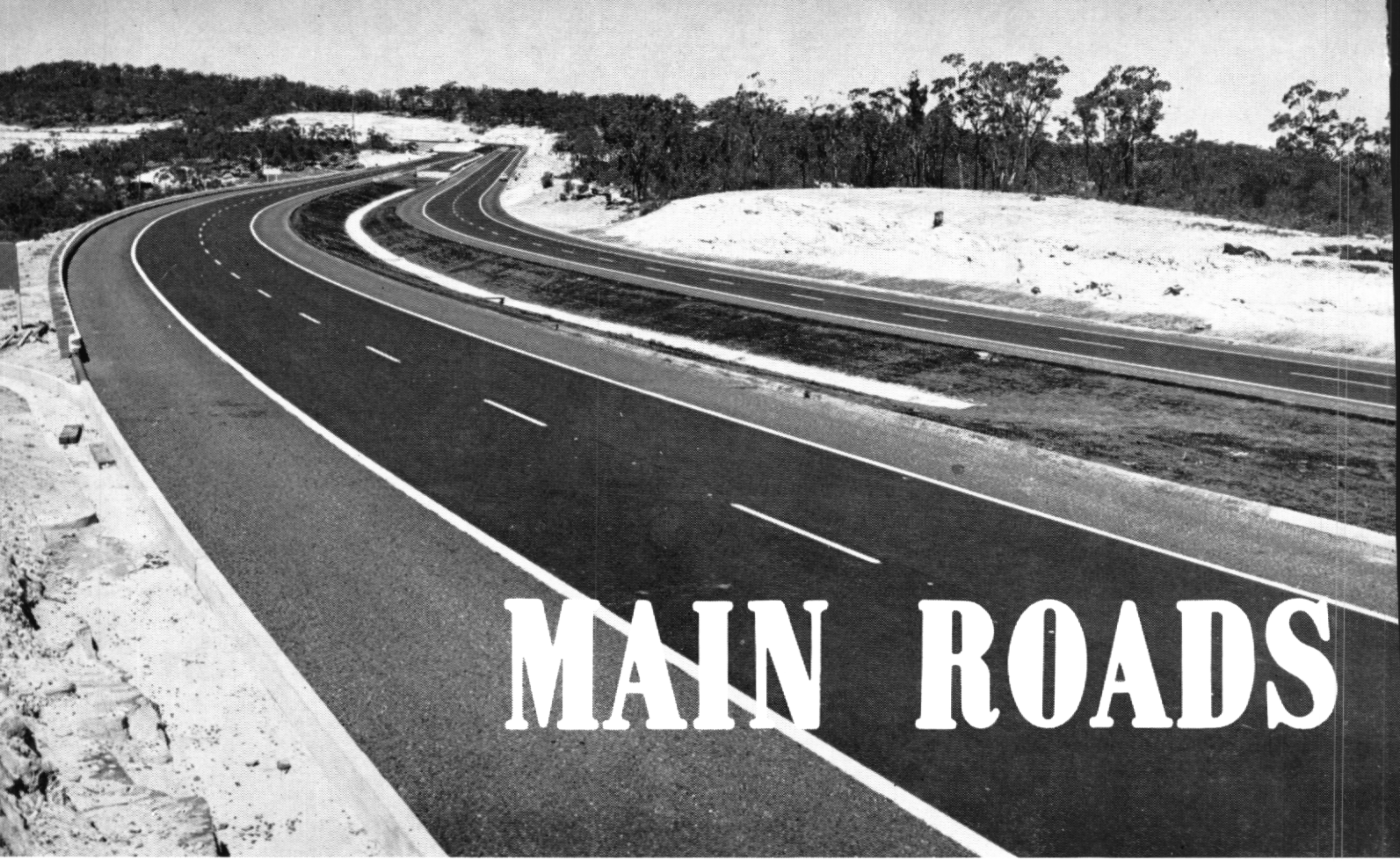
MAIN ROADS

JOURNAL
OF THE
DEPARTMENT
OF MAIN ROADS
NEW SOUTH WALES
SEPTEMBER, 1965



MAIN ROADS

section of the Hawkesbury River to Mount White Toll Way

SEPTEMBER 1965 Volume 31 Number 1

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COVER SHEET

Nature provides her own landscaping on Lady Carrington Drive south of Sydney

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Garden Paths

The livid gashes across the countryside that are made during the construction of highways will inevitably be healed by time and nature.

Most people appreciate this, but they may not appreciate the thought and study that go into ensuring that this healing process is not only encouraged, but that the result is harmonious, and introduces elements conducive to road safety.

A thought-provoking article, "Highway Landscaping" by Associate-Professor Peter Spooner in this issue provides an insight into contemporary thinking on this subject.

One hears so much of motorways, freeways, highways and byways, that an article by Mr E. R. Jefferay, Urban Investigations Engineer, on the planning of Sydney's Expressway system is most timely.

The explanation of just what an "expressway" is, should go far to help the layman understand the true purpose of these expensive projects.

It is fairly widely understood that the purpose of expressways is to move large volumes of traffic quickly and safely, but does the layman understand that to do this effectively, points of access to expressways must be kept a considerable distance apart? It is possible, because of this, that, within an urban area, material parts of journeys will still be made on surface streets, even when an expressway goes past the front door.

For the road user to enjoy the very considerable advantages of an urban expressway system it is most important that it be fed by a good main roads system.

In his article Mr Jefferay makes the very important point that an expressway system and an arterial surface road system are devised on a balanced plan; neither is a substitute for the other.

Highway Landscaping

by Professor Peter SPOONER

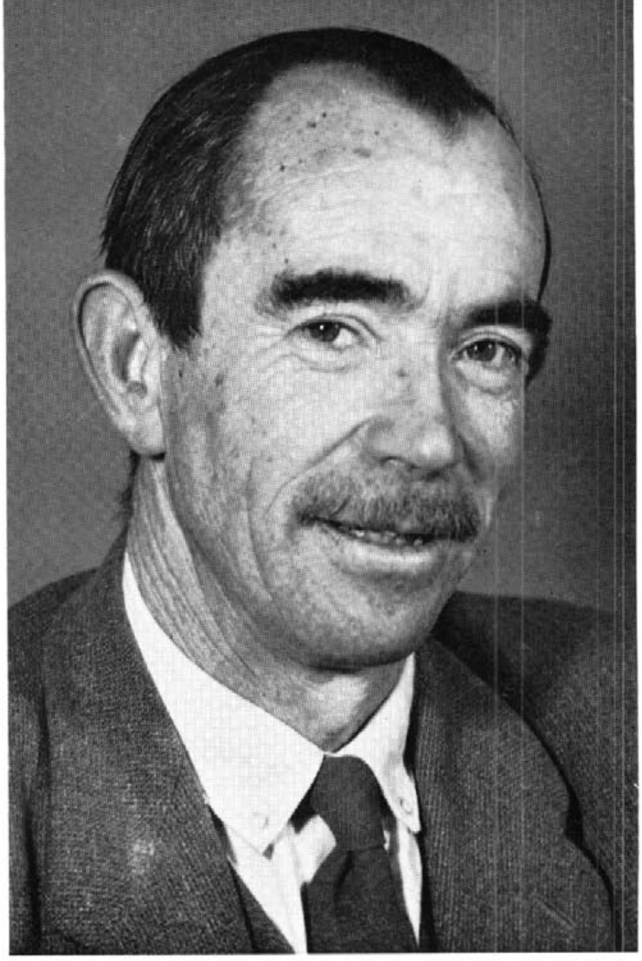
THE evolution of landscaping as a creative art may be traced through every stage of civilisation from ancient Egypt to the present day, but its application to highways is a development of the twentieth century.

Paintings and literature which have come down to us from previous ages, and extant man-made landscapes that predate the industrial revolution, all point to the fact that it was an art of indulgence restricted to a wealthy and hence powerful minority. Certainly there are references to monastic gardens which provided food during the dark ages, and to physic gardens which produced medicinal herbs and simples, but for the most part landscaping as opposed to mere gardening was limited to the grounds of royal palaces and great estates. Apart from the unintentional contribution of owners who planted their roadside boundaries for privacy or wind protection, and the formal urban avenues of renaissance times, the adornment of highways was left to nature.

Ample reason for this concentration upon private estates may be found in the prevailing social and economic structures, but there can be little doubt that the very nature of early highways made all but the most elementary of landscaping redundant. Transport was primitive and slow-moving and roads were adjusted by usage to the grades and incidental features of the countryside. It is perhaps for this reason that they now provide some of our most beautiful roadside scenery, but whilst their visual charm is incontestible, it must be attributed to nature and the mellowing passage of time rather than to any preconceived design.

With the development of the motor vehicle, highways underwent a revolution, and in the short space of fifty years they have grown from something that was totally subservient to nature, to something that now has the latent capacity to dominate all but the most rugged mountain scenery. It would be flattering to believe that the dangers of this situation were foreseen, but in fact our present preoccupation with the overall appearance of highways only arose as the result of earlier widespread scenic damage.

In this capacity to dominate nature lies at one and the same time, the highway's greatest potential both for beauty and ugliness. There is a unique splendour in the uncompromising geometry of high speed traffic routes, but a consistent design standard in terms of pure function may produce alignments and earthworks that are incompatible with the natural terrain through which the route must pass. Alternative routes may sometimes be found which for little or no additional outlay, will avoid damage to the countryside and even where this proves impossible, a marked improvement may be achieved by minor adjustment, by sensitive grading and by appropriate planting.



Professor Peter Spooner, F.R.A.I.A., F.I.L.A., A.R.I.B.A., has been highway landscaping consultant to the Department for the Captain Cook Bridge approaches and for the Hawkesbury River to Mount White Tollway

LANDSCAPING OBJECTIVES

In the foregoing paragraphs I have endeavoured to state the case for highway landscaping as simply and unemotionally as possible. In so doing it was inevitable that I should refer to the scenic damage latent in modern highways design and construction techniques, and mention some of the means whereby damage can be avoided. It follows that the landscape architect's ultimate, indeed his only, aim is to so influence highway design within the limits of sound engineering design, that a complete integration is achieved between the highway and the landscape. However, in common with most over-simplified statements, this one breaks down upon examination and loses much of its simplicity, while a host of lesser objectives arise to take upon themselves the appearance of independent aims.

(1) *LOCATION AND ALIGNMENT*

Considerations of a purely engineering nature tend to govern the initial location and alignment of our highways, and this may be expected to continue as rising geometric design standards demand wider formations, greater minimum radii on curves and easier grades. The dangers of scenic damage are much greater in rolling and mountainous country than in flat country, yet in the former cases it is seldom possible to find more than one practical route. It is, however, often possible to vary the route over relatively short distances, and to shift the alignment between controls, in order to ensure a more harmonious integration of highway and landform.

The Department of Main Roads already reviews the landscape implications of many new or relocated highways during the initial stages of design, and significant improvements have been achieved in a number of cases by so doing.

Stage 1 of the Newcastle Expressway presented an unusually difficult problem in that the rugged terrain surrounding the Hawkesbury River offered only one practical route, involving a succession of deep cuts and high fills. Because these occurred along the spine and flanks of an exposed ridge, their appearance assumed unusual importance in an overall landscape context. As a result of model analysis it was decided to retain upstanding rock medians in a number of cuttings which would otherwise have appeared as gaps silhouetted against the sky. In the case of one rather straight cutting, no solution could be found until it was realised during a field inspection that a relatively small shift in alignment would bring the cutting in line with a distant hill, a fact which could not be deduced from model analysis. As Stage 1 of this project nears completion the value of these earlier decisions becomes increasingly apparent for although the landscape is scarred, the disruption of landform has been markedly reduced.

(2) *REMEDIAL*

Within this category fall all landscaping operations that are undertaken with the express purpose of controlling erosion, increasing soil stability and encouraging the re-establishment of vegetation upon roadside scars, and in this work the Department has received valuable assistance from the N.S.W. Soil Conservation Service.

A wide variety of techniques has been developed to meet specific cases, ranging from the mere flattening of slopes to the application of bituminous emulsion, straw mulches or fibrous mats supported by wire netting. Costs may range from a few pence to 10s. per square yard, but in all cases the object is the same—to provide stability in the surface layer, and to induce conditions which will encourage the germination of seed or the growth of young plants.

In certain areas local peculiarities of soil and/or climate may prevent the early establishment of a permanent vegetative cover. In these cases, of which the Snowy Mountains area is an example, temporary cover may be achieved by the use of grasses and plants which are foreign to the area, and which will ultimately succumb to the invasion of local native species. However, throughout most of the State's eastern districts, suitable permanent grasses and plants are commercially available and should be used from the outset.

Ground cover plants such as ivy and pigface have lately acquired an exaggerated reputation as universal panaceas, largely due to their extensive use in England and America. It is my opinion that under Australian conditions, stoloniferous grasses such as Couch and Kikuyu are the logical and appropriate choice for all

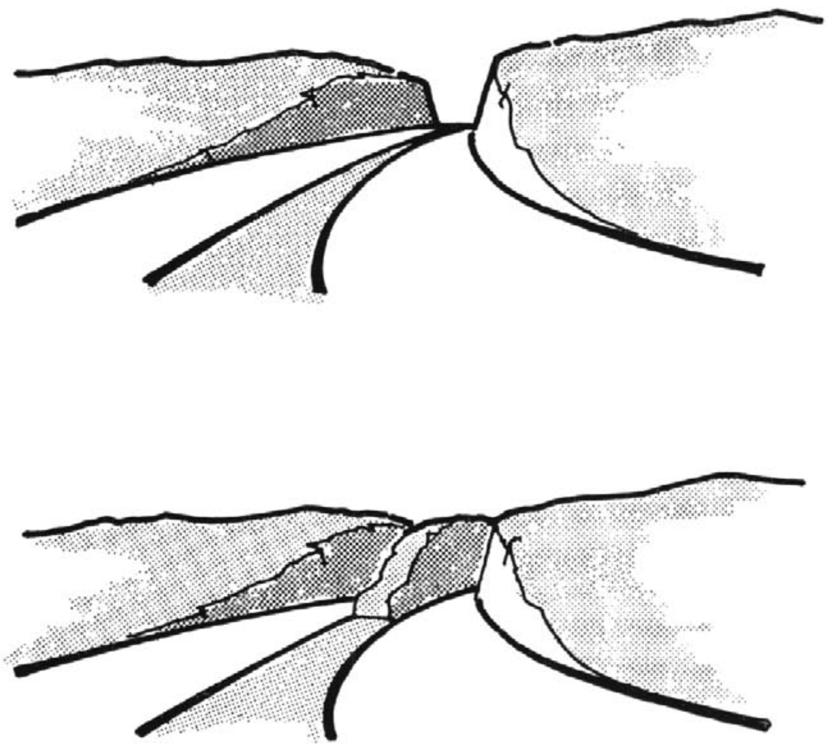


DIAGRAM 1

Skyline saved by retention of median

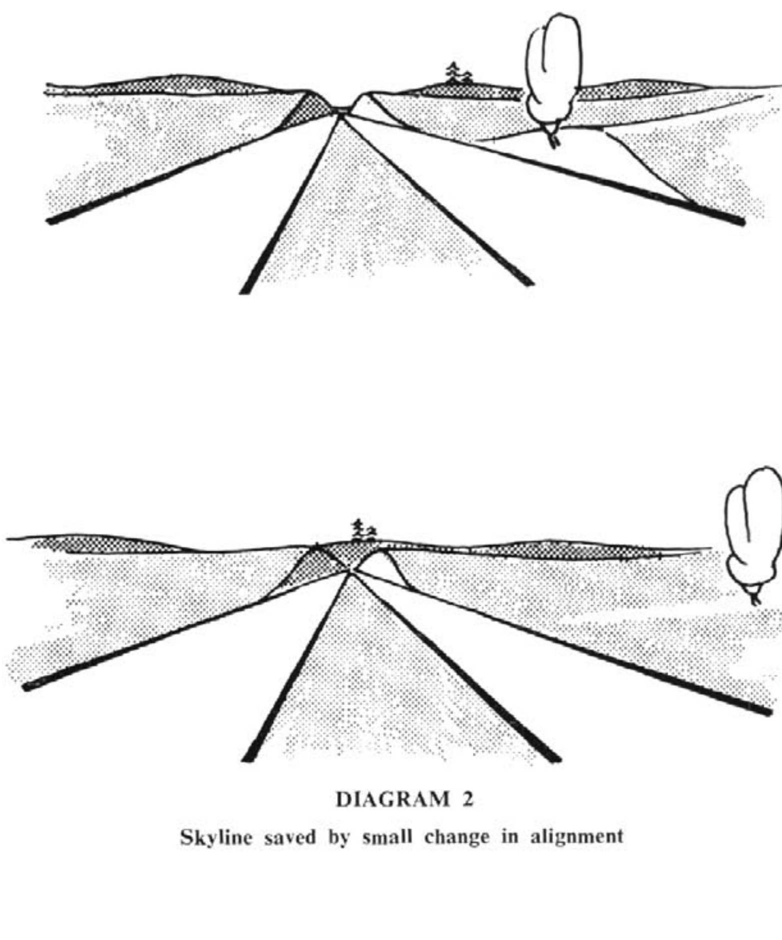


DIAGRAM 2

Skyline saved by small change in alignment

A dramatic photograph, taken from above the Mount White interchange, of how the building of a major roadwork temporarily disfigures the countryside. Nature, however, is a great healer; especially if assisted by man

but the steepest of slopes, and that in the latter case every effort should be made to find hardy native plants with the required ground covering characteristics. To this end the Department, in its landscaping of the Newcastle Expressway, is grassing all slopes flatter than 2½ to 1, and planting the steeper sections with Kennedya, Hardenbergia, Sollya and a prostrate form of Grevillea.

Success of vegetative erosion control depends upon a number of related factors:—

(a) Initial preparation of the planting medium.

(b) Effective temporary stabilisation of surface, and interception of coincident run-off.

(c) Choice of seed mixtures, plants and fertilizers.

(d) Time of seeding or planting.

(e) Adequate early maintenance.

The N.S.W. Soil Conservation Service has already achieved a great deal in this specialised field, and it is to be hoped that continuing research will lead to a significant reduction in the number of barren scars and conspicuous side drains currently associated with new construction.

(3) *FUNCTIONAL*

Functional landscaping includes all grading and planting operations which are designed to increase safety or to assist in the efficient usage of a highway. The driving process involves amongst other things a visual appreciation of what lies ahead coupled with a subconscious assessment of speed, and it has been suggested that good highway design should assist in this process to the point where interpretation merges into an instinctive pre-knowledge. Whether or not this suggestion has any scientific validity is open to argument, but there can be no doubt that the disposition of trees beyond crests and around the outside of curves will assist driver interpretation and remove a dangerous element of uncertainty, particularly at night. In addition I believe that a subtle variation in roadside grading may be employed to infer a hidden change of direction, and it does not seem unreasonable to believe that a combination of planting and grading could lead to an interpretation bordering on pre-knowledge.

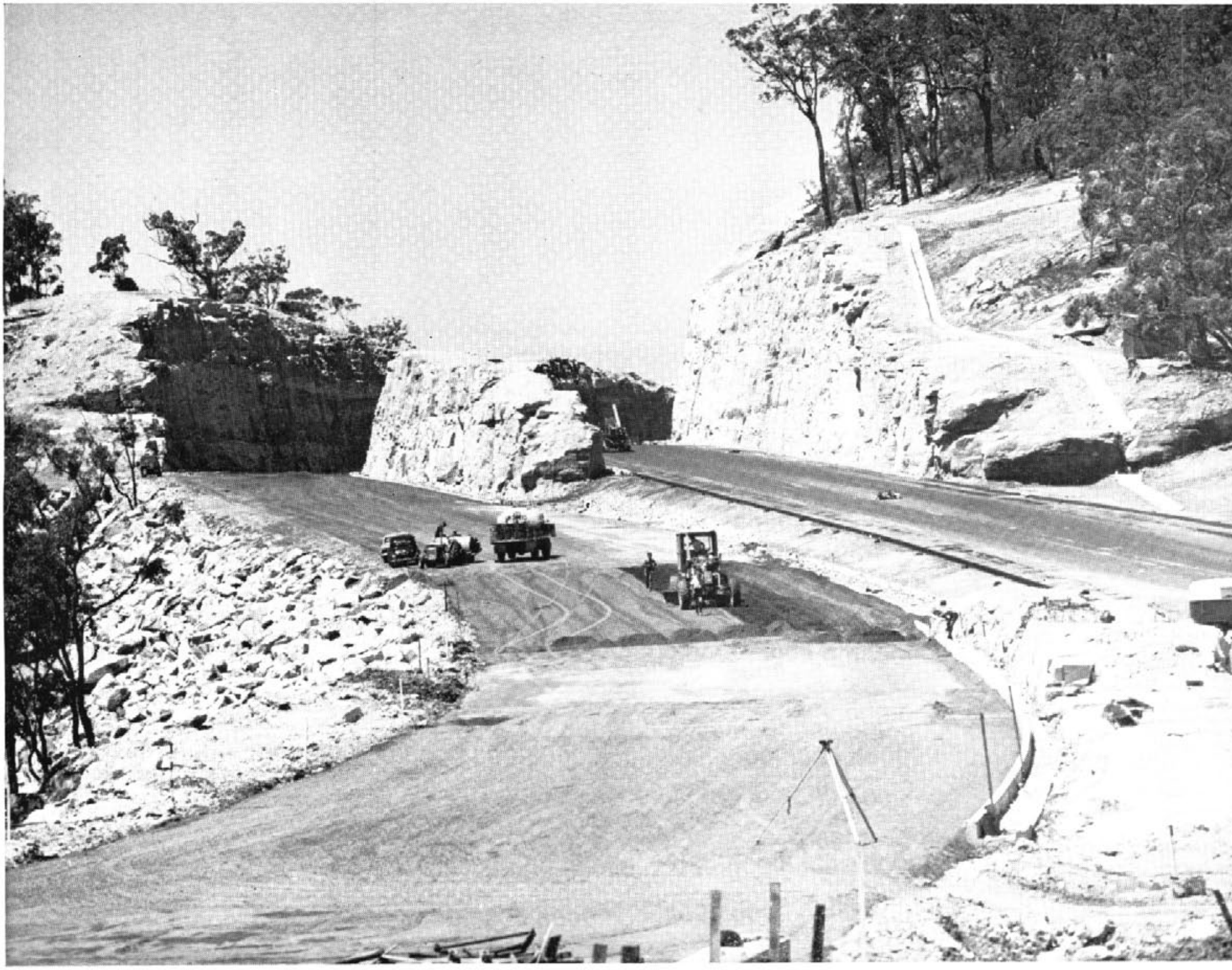
The obvious value of landscape material as screening against oncoming headlights and as flexible crash barriers is already well known, however there are other potential uses which warrant investigation:—

(a) Use of dense fine-foliaged plants as a background or foil for signs.

(b) Use of dense tree groups as "sighting boards" where oncoming traffic may have the setting sun directly behind it—for example on long tangents climbing towards a westerly horizon.

(c) Constrictive planting set at intervals along otherwise open highways to convey a true sense of speed.

(d) Use of distinctive types of vegetation to mark critical points, e.g., crossings, junctions and narrow bridges, and to differentiate roadside amenities such as



Shows the practical application of the principle illustrated in Diagram 1

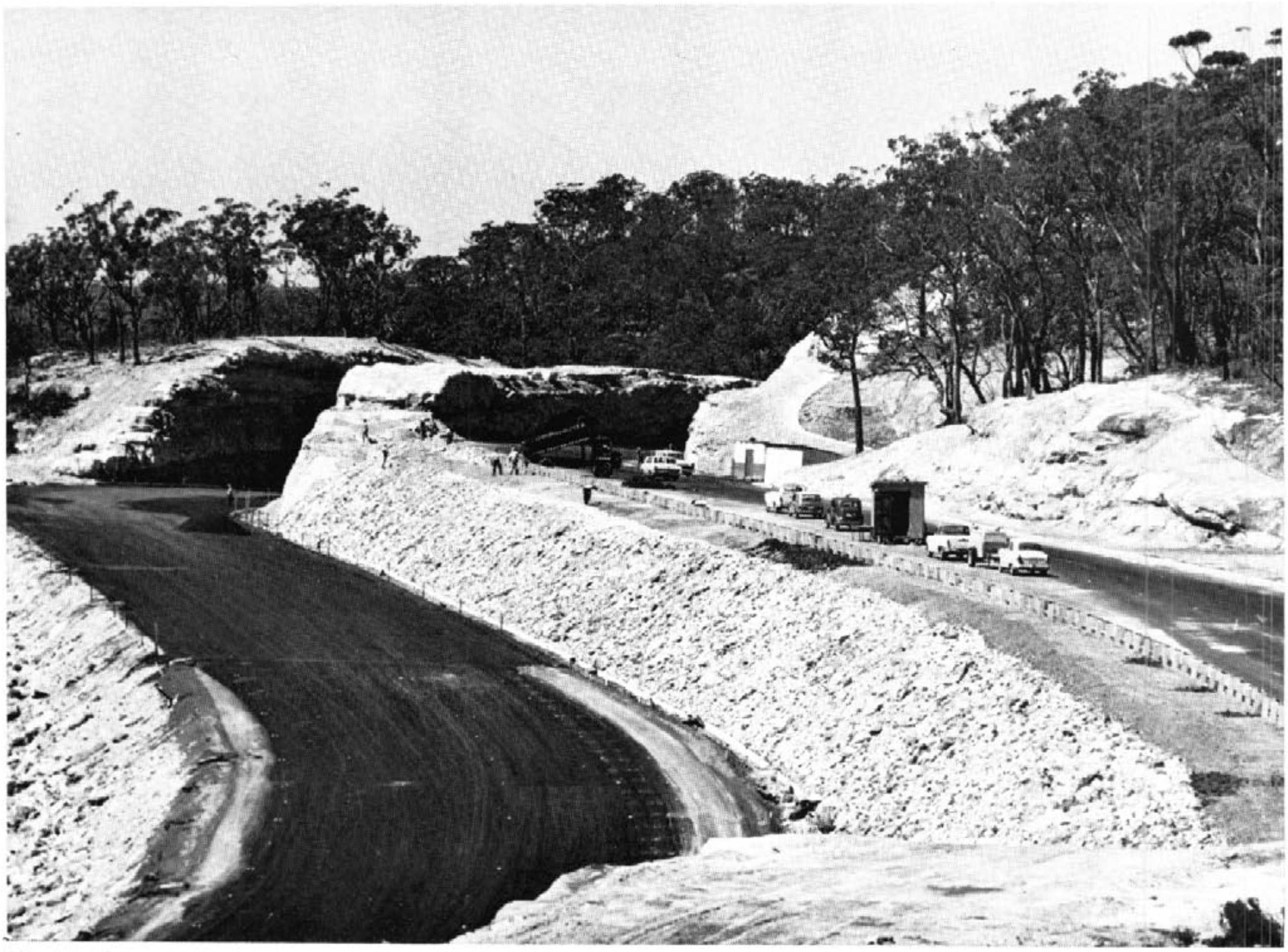
lay-bys and rest areas where they would be otherwise indistinguishable from the surrounding bushland.

(e) Use of grey-foliaged light reflective shrubs on western highways where the featureless flat country makes night driving hazardous.

(4) *AESTHETIC*

Of the landscaping categories here discussed, this is the least amenable to orderly dissection and the one which most closely approximates the designer's ultimate aim of integration. In fact it may be argued that aesthetics and integration in the context of highway design are one and the same thing, but I am inclined to believe that a positive search for beauty may at times lead away from absolute integration in its most restricted sense.

Mention has been made of the splendour inherent in modern geometric design, and this probably is the key to landscaping aesthetics, for the contemporary highway is in itself a thing of beauty with a purposeful sense of movement that cannot and should not be ignored. Landscaping should never attempt to disguise the highway nor to lessen its intrinsic strength, but should be directed at the reduction of incidental discords in order that the flowing continuity of the highway may be fully appreciated. Roadside grading should in general reflect the character of the surrounding country by adopting rugged outlines in rough mountainous terrain and gentle rolling slopes in undulating pastureland, and planting should be restricted to large simple masses of predominantly local species. These basic rules are certainly conducive to integration, but from this point forward, aesthetics begin to diverge.



This view shows a section of the Tollway where various landscaping features are being carried out—

(a) The rocks of the median embankment are hand packed.

(b) Grass is sown along the median strip above the embankment.

(c) The rocky edges of cuttings are contoured to avoid harsh lines.

(d) Where ugly gashes occur, the rock surfaces are artificially coloured to harmonise with their naturally weathered neighbours.

Scale

The scale of roadside development should be related to the highway's designed speed more than to that of the adjacent countryside. In rural locations there is seldom any conflict between the two, but the close interval, small scale, planting of surburban areas would be inappropriate to the flanks of high-speed throughways. Ideally there should be a gentle transition from one scale to the other, but with restricted rights of way this is seldom possible.

Contrast

In order to exploit the drama of a highway it may be desirable to introduce localised contrast in planting or landform, the value of which is purely visual and has nothing whatever to do with integration. Australia's indigenous vegetation is beautiful in its own particular way, but the weakness of all arguments for its exclusive use lies in the fact that our appreciation is dulled by a uniform visual diet whereas it is heightened by occasional contrast.

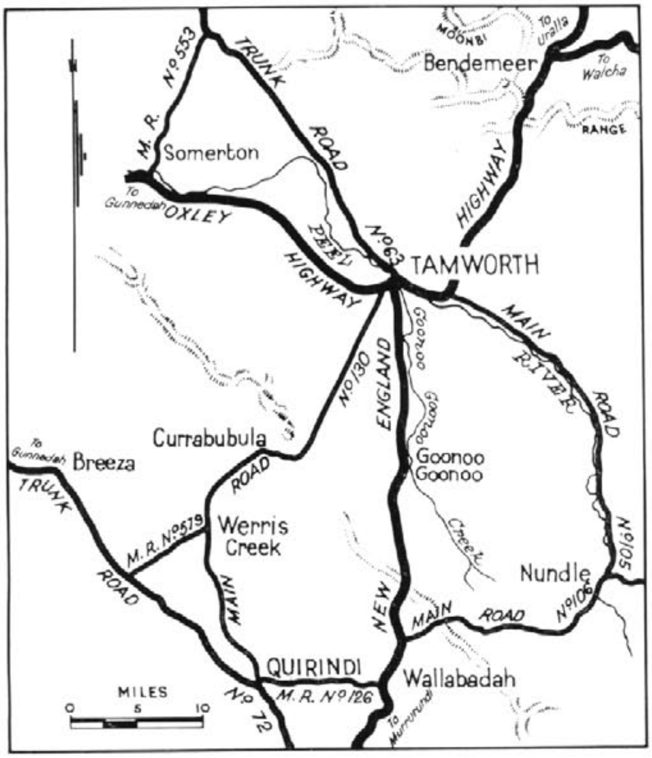
Distant Views

Complete integration might well suggest that in timbered country, the trees should be encouraged to crowd in upon the highway throughout its length. There is on the other hand every reason to create or preserve outstanding views by clearing sections of the roadside and preventing the natural regeneration of plants which would obscure the view.

In conclusion it may be advisable to point out that highway landscaping is a very young and very inexact science, more particularly in Australia, where its practice is but a few years old. We may learn a great deal from the United States, Germany and latterly from Britain, but in every instance the results of overseas research must be tested under local conditions, whilst techniques and methods must be adapted to suit our special requirements. The need for comprehensive landscaping will become increasingly obvious as our highway standards are improved, but at present there is an urgent need to encourage an awareness of landscape values, and to create a background of practical means whereby they may be preserved.

A NEW BRIDGE AT TAMWORTH

In his opening speech, the Hon. P. H. Morton, M.L.A., Minister for Highways, emphasised the need for an adequate bridge at this focal point of the northern New South Wales Main Roads System



A FESTIVE air pervaded the City of Tamworth on the morning of 14th August, as guests and onlookers gathered at the new bridge over the Peel River for the official opening ceremony.

In brilliant sunshine, the music and scarlet uniforms of the Police Boys' Club Band; the flags; and the blue and gold decorated dais, added to the excitement of the occasion.

The bridge is situated in the heart of the city and hundreds of Saturday morning shoppers and children were able to witness the opening ceremony, together with the three hundred official guests.

A welcome was extended by the Hon. W. A. Chaffey, M.L.A., Minister for Agriculture supported by the Deputy Mayor of Tamworth, Alderman N. L. McKellar, to the Hon. P. H. Morton, M.L.A., Minister for Local Government and Minister for Highways, whom the Deputy Commissioner for Main Roads, Mr R. J. S. Thomas, invited to officially open the bridge.

In his address prior to cutting the ribbon and unveiling a commemorative plaque, Mr Morton said that the bridge was part of a network of first-class roads and bridges being established by the Department of Main Roads throughout the State, to make road travel safer, faster and more economical.

The old bridge and the new. Average traffic is 20,000 vehicles per day

The discovery of the Peel River and the first crossing by John Oxley in 1818 were referred to by Mr Morton, and warrant some enlargement here.

Writing in his Journal on 2nd September, 1818, John Oxley recorded the bridging of a "deep and rapid stream". This he named the Peel River after the English statesman Sir Robert Peel, who represented the Staffordshire town of Tamworth in the British Parliament.

Oxley wrote that "finding it (the stream) too deep to be forded, we constructed a bridge across a narrow part of it, by felling such large trees as would meet, by which the baggage was taken over: the horses swum across". Oxley added that one of the men "foolishly attempting to swim over on a horse, nearly paid for his imprudence with his life".

When the new bridge was opened in August 1965, Tamworth was suffering the effects of a severe drought, and Oxley would have found it difficult to recognise the Peel as the same river he discovered in 1818.

Whilst the history of the bridging of the Peel from that date is not clearly defined, it is known that in 1882 a 295 feet long, timber and wrought iron bridge was constructed at Tamworth, and has been in use ever since.

It was a two-lane bridge 21 feet wide, with a narrow footway, and as time went on it became a traffic bottleneck; hardly strong enough to continue supporting the increasingly heavy loads being transported along the Highways.

This old bridge could not be widened and a modern replacement was therefore designed by the Department and built adjacent to the old structure, as this site was still considered the most suitable.

The new bridge has piled foundations and reinforced concrete piers and abutments. The superstructure is made of precast prestressed concrete bridge units with reinforced concrete deck.

Consisting of six spans with a total length of 387 feet, the bridge is 44 feet wide between kerbs and provides four traffic lanes. Pedestrians are catered for by footpaths approximately 8 feet wide on both sides.

The cost of the project, with its approaches, was £208,000 and, of this sum, two-thirds of the cost was met by the Department and the remainder by the Tamworth City Council.

One of the most heavily trafficked bridges in the country districts of New South Wales, with a daily traffic flow of 20,000 vehicles, it performs the vital function of linking east Tamworth with the western and southern sections of the City. It also carries the traffic using the New England Highway, and the nearby Oxley Highway.

The ceremony at Tamworth on 14th August, 1965, was therefore a fitting tribute to an engineering achievement intended to provide a vital link in the State's road system for many years.

Planning Sydney's Expressways

by

E. R. JEFFERAY

Mr E. R. Jefferay, B.E., A.M.I.E. (Aust.), Urban Investigations Engineer, Department of Main Roads, N.S.W.

THE movement of people and goods rapidly, cheaply and safely in urban areas is perhaps one of the most pressing problems facing cities throughout the world. In many cities the existing system of surface streets is proving inadequate to handle expanded traffic volumes. Conventional streets designed for limited traffic are being required to provide services beyond their capacity.

In Sydney, the traffic capacity of main roads generally has been increased by improvements such as widening the roadway and the provision of channelised intersections. While the capacity of some of these main roads could be further increased, roads of the existing type cannot cater fully for anticipated future traffic requirements. One feasible answer is the construction of "expressways".

Expressways are designed specifically to move large volumes of motor vehicles at speed, with safety and minimum delay. The term "expressway" is synonymous with "freeway" used in some other countries. The major difference between an expressway and a surface street lies in controlled access.

The expression "controlled access" is used to describe conditions where there is denial of access to the expressway from adjoining property and all cross traffic is carried

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The extent of the multi-million pound Warringah Expressway with its carriageways and access roads, may be appreciated from this aerial view

over or under the expressway, with vehicular access between the expressway and the normal street system at certain predetermined points called "Interchanges", where traffic joining the expressway merges with the expressway traffic and departing traffic diverges from the expressway traffic without any conflicting traffic movement.

Control of access is one of the most important features of an expressway, but other vital characteristics are a high standard of alignment and profile, and adequate width. An expressway also derives its level of service from the elimination of hazards created by right turns, blind intersections, sharp curves, distractions close to the roadway, and pedestrian and vehicle crossing movements at the expressway level. On surface streets where a driver is faced with all these hazards fatal accidents occur much more frequently than on expressways. In the United States of America, where there are many miles of expressway and a reasonable comparison can be made, the fatal accident rate per 1,000,000 vehicle miles is three times greater on surface streets than on expressways.

Properly planned expressways benefit the community by distributing traffic more efficiently, providing access to centres of activity, reducing traffic accidents, stimulating business and industry, and contributing to land development.

True expressways, embodying the best safety and capacity standards, cannot be constructed within the boundaries and alignment of existing streets unless the streets are of exceptional width. Even where streets are of exceptional width the standards of expressways constructed within their boundaries are usually inferior and costlier than those constructed on new routes.

It is essential that expressways be integrated with other elements of the transportation system including terminal facilities, mass rail and bus transit operations, facilities for vehicle parking and the movement of pedestrians into the central city area. It is most important that an expressway system and an arterial surface road system are devised on a balanced plan; neither is a substitute for the other. Expressway design should be in harmony with existing and proposed land use patterns, and attention should be paid to the design and location of the corridor in which an expressway is to be built. It should permit of aesthetic treatment; and the attractiveness of the areas adjoining should remain unspoiled.

In the late 1930's the Department of Main Roads decided to make a study of the future Sydney Metropolitan main roads needs on a more comprehensive basis than had been attempted previously. This was interrupted by the 1939-45 war. The Main Road Development Plan which was evolved immediately after the war formed, with some small amendments, an important element of the subsequent County of Cumberland scheme. The Department's planning to this stage was based on the requirements of a county population not exceeding 3 million people, of which 2½ million would be in the metropolitan area, by the end of the 20th century.

The County of Cumberland has an area of 1,630 sq. miles and the length of expressway-type facilities included in the Main Road Development Plan was approximately 150 miles. The planned reservation for expressway purposes was about 0.5 per cent of the total area of land in the County. In the areas close to the city centre with denser population, the proportion reserved for expressways was greater, and in the less densely populated outskirts of the area the proportion reserved was less.

Although the Department's planning up to the adoption of the Cumberland County plan had been based upon a study of population and motor vehicle trends and anticipated land use, these factors have since varied somewhat from the original assumptions due to the increased migration programme and release of green belt land by rezoning for residential and industrial use. In consequence, the plan has had to be reviewed from time to time to ensure that new corridors for expressway and arterial road construction are reserved to meet the increased future growth. On the basis of a population of 5 million people in the County of Cumberland by the turn of the century, there would need to be a corresponding increase of about 50 per cent in the planned arterial road and expressway mileage.

In selecting expressway corridors it is necessary to consider the number of travel lanes which will be provided in each section, the capacity per lane being based on 1,500 vehicles per hour. The Department proposes to provide right of way width to accommodate 8-lane expressways southerly to Tempe, westerly to Westmead, north-westerly to Drummoyne and on the Warringah Expressway to Cammeray. Proposed expressway reserve width will allow for six travel lanes to be provided ultimately to Bulli Pass in the south, Campbelltown in the south west, Penrith in the west, Hornsby in the north and Seaforth on the Warringah route. Beyond these points the Department proposes that there be not less than two travel lanes in each direction.

The travel lanes will each be 12 feet wide and the outside of each carriageway will have a 10 feet shoulder provided to enable disabled vehicles to be stopped clear of the travel lane. The width and continuity of this breakdown strip may be varied on long bridge structures, according to the availability of funds to meet its cost. In urban areas the carriageways will be separated by a median area at least 24 feet wide and on the 6-lane and 8-lane expressways the median area will include in addition 8 feet wide breakdown strips. These will enable vehicles travelling alongside the median area to obtain refuge in an emergency without having to cross a number of traffic lanes.

In the initial stages some sections of urban expressway will be provided with only two travel lanes in each direction, and as far as possible this will be achieved by completing the outer lanes and leaving a very wide median area. Subsequent provision of additional lanes and inner breakdown strips will be carried out in the median area. Access ramps will be constructed between the expressway and the surface road system.

The North Western Expressway at the Gladesville, Tarban Creek and Figtree Bridges

Tarban Creek Bridge, as completed, differs slightly in constructional detail from this artist's impression.

The grades will generally be less than 3 per cent, but an absolute maximum of 6 per cent has been adopted for the more difficult topography. Wherever the length of grade would result in the speed of a 40,000 lb vehicle falling below 30 m.p.h., an additional hill climbing lane will be provided.

If the pattern of expressways and arterial roads could be ideally devised there would be interchanges perhaps every two miles in built-up areas, five miles in the outskirts of the metropolis, and 10 miles in rural areas. In the areas close to the city centre these interchange arrangements cannot be related to any particular spacing pattern, and special techniques have to be adopted for dealing with each case on its own merits. In areas such as Sydney's inner suburbs, where much of the arterial road pattern already exists, and the topography is variable, an ideal pattern is not practicable and a compromise must be made. As interchange areas not only interfere with the smooth flow of expressway traffic, but are expensive, their number should be limited and the interchange pattern adopted should aim at an integrated transportation system on the surface streets and expressways giving a level of service as high as possible, without encouraging the use of the expressway for short distance travel.

Access controlled facilities already exist on the Cahill Expressway, at Gladesville Bridge, and at Captain Cook Bridge. The smooth traffic flow and feeling of safety on even these short sections indicate clearly enough the possibilities of rapid safe traffic movement over the whole of Sydney's metropolitan area when the expressway concept is implemented to the full.

The Cahill Expressway seen from the eastern end

BOREWATER AND BITUMEN on road to Barringun

WITH the completion of the reconstruction and bitumen surfacing of the Mitchell Highway between Nyngan and Bourke, there is now a dustless surface between Sydney and Bourke, a distance of 488 miles.

One of the difficulties overcome by the Central Northern Division in reconstruction of the road from Nyngan to the Queensland border north of Bourke, was the shortage of natural water sources.

This is always a problem in low rainfall zones, and much depends upon the resourcefulness of the engineers in charge.

On the Nyngan to Barringun stretch of the Mitchell Highway, and especially in the Bourke to Byrock area, in addition to obtaining water from private properties, and from ground tanks controlled by the Pastures Protection Board and the Railways Department, a number of ground tanks had to be excavated along the route for water storage for roadworks. Also, in the later stages of reconstruction, water had to be hauled by rail from Bourke to Byrock to enable preparation of the pavement to be carried out prior to sealing. All these water sources were insufficient to meet requirements, and to complete construction between Nyngan and Bourke it became necessary to seek the cooperation of the Water Conservation and Irrigation Commission in sinking two bores at 26 miles and 38 miles south of Bourke.

Progressive reconstruction and bitumen sealing of the Mitchell Highway, State Highway No. 7, from Nyngan to the Queensland Border was commenced in 1960. When this 214 miles is finished, the whole 578 miles that lie between Sydney and Barringun will have a sealed pavement.

Over this far north-western section while water shortage has been the main problem it has not been the only difficulty. Although the country is generally flat and the alignment of the existing road prior to 1960 was for the main part satisfactory and required little realignment, transportation of men and materials called for very careful planning.

Coolabah and beyond . . .

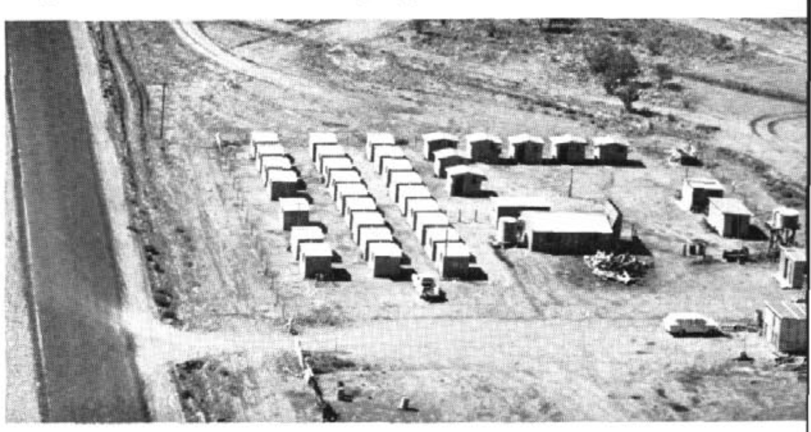
The supervision and placement of man-power was solved by setting up works offices at Nyngan and Bourke and by commencing reconstruction simultaneously from these two places. As the project progressed, camps were established along the road for the work force.

Interesting technical problems arose from the unsuitability of the naturally occurring gravels for use in the surface course layer of the pavement; and suitable material was not always available within an economical distance.

It was therefore necessary to cement modify and mechanically stabilize various sections. This has required experiment, and trial lengths of pavement have been laid in which bitumen emulsion has been incorporated. Cement-stabilised edge-strips have also been constructed.

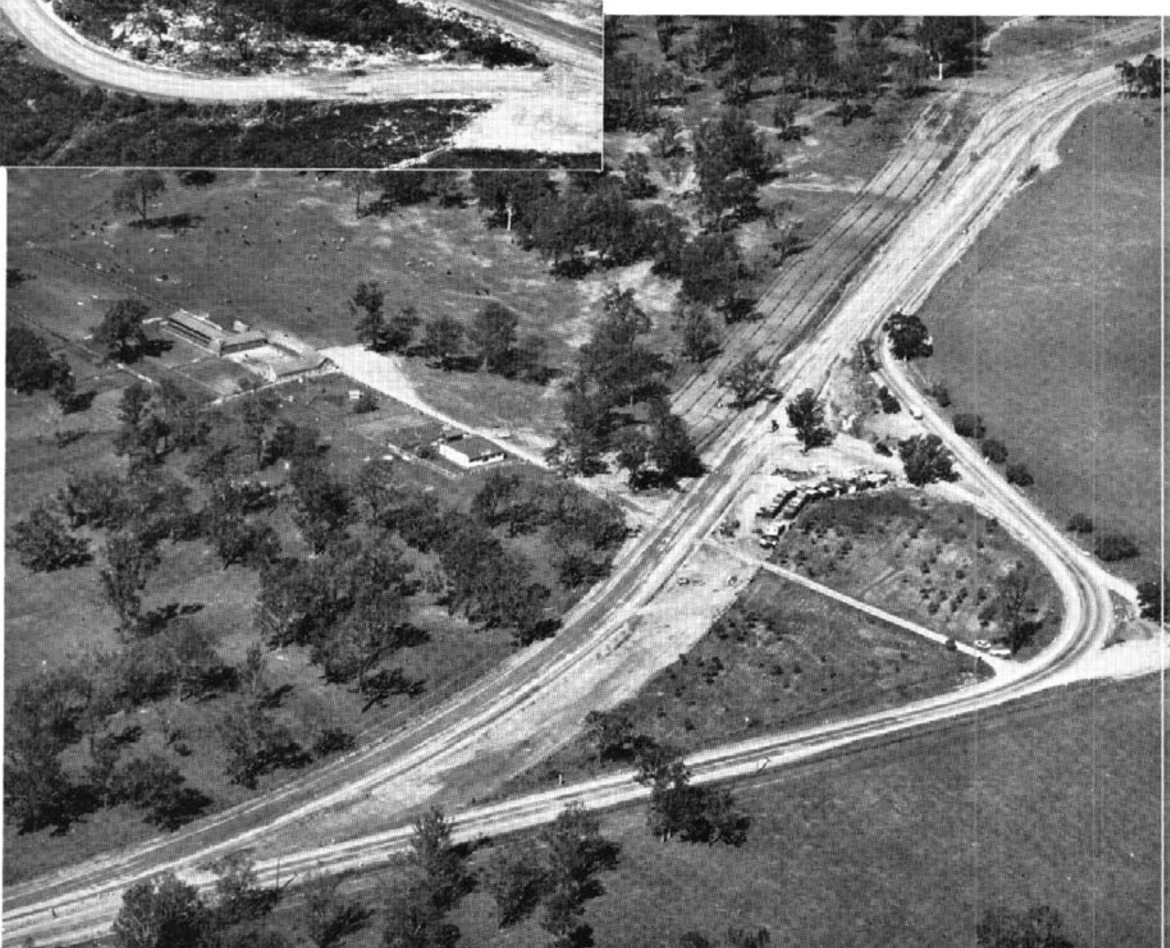
To date 148 miles of reconstruction and bitumen surfacing have been completed, at a cost of £1,450,000. Work is at present proceeding on the section north of Bourke, the last lap between Enngonia and Barringun and when this is finished there will be a bitumen surface stretching all the way from Sydney to the Queensland border at Barringun.

A road construction camp at Byrock, one of several established along the section of Mitchell Highway under reconstruction



FOUR DEVIA NEAR

Three bends less on the Prince's Highway south Helensburgh



Four miles south of Camden at the Cawdor Road Junction, a Hume Highway deviation provides for safer movement of through traffic

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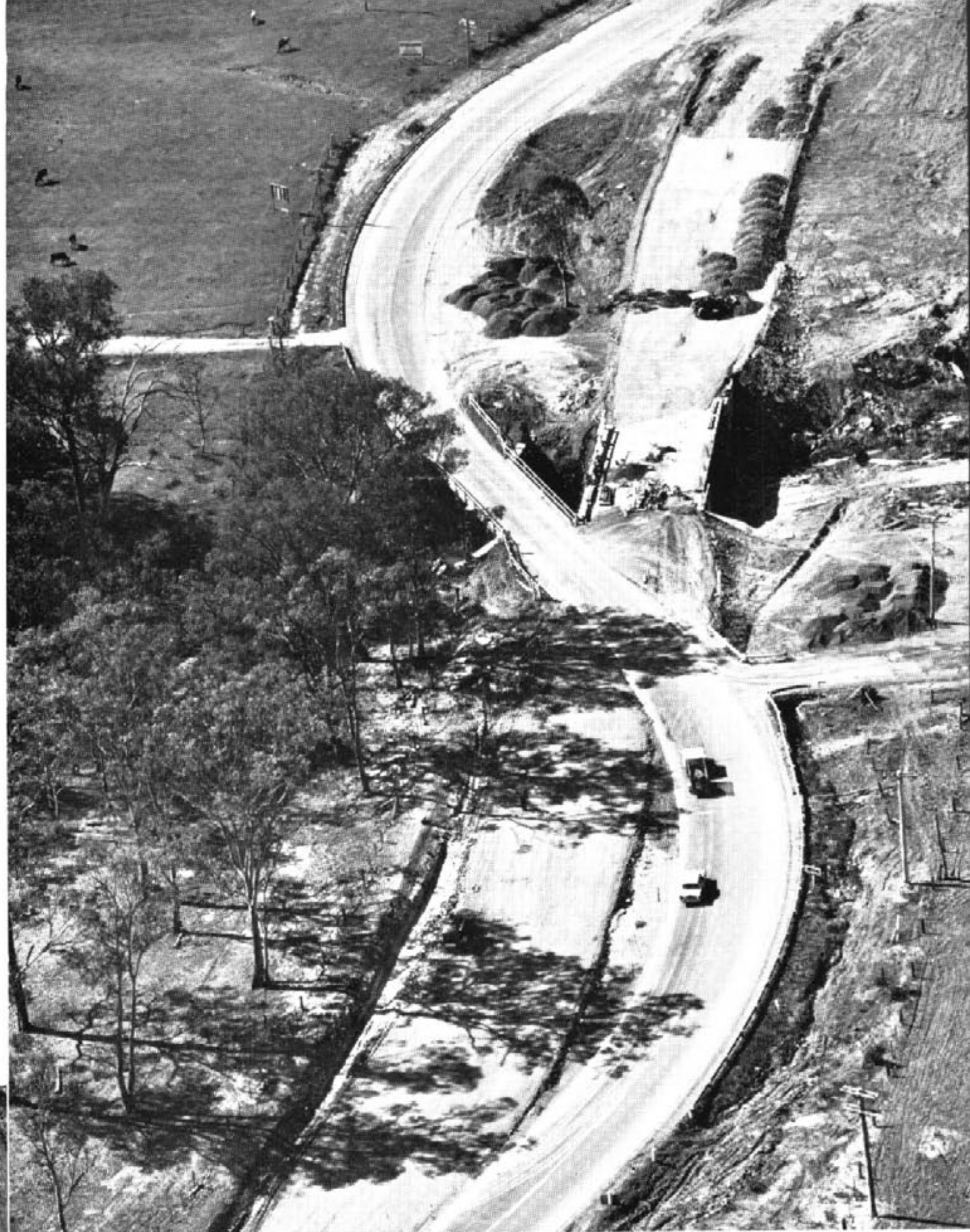


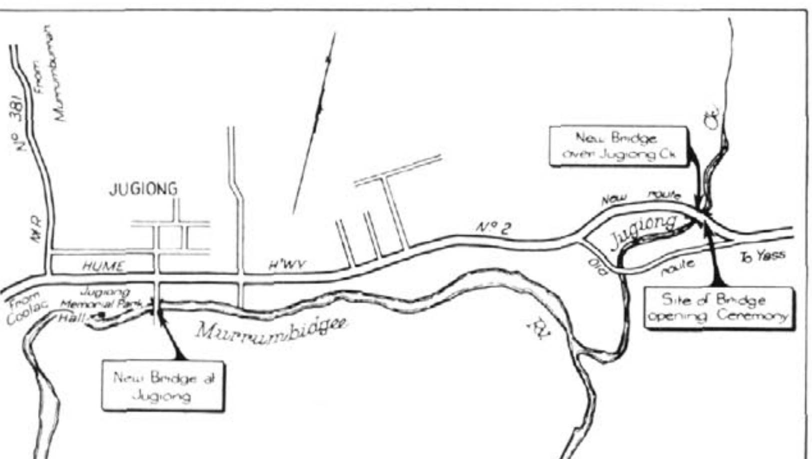
ew 28 feet bridge over Myrtle Creek, one mile north
Tahmoor, carries a deviation of the Hume Highway
right across a dangerous S-bend

In addition to the elimination of the small railway overbridge with a very tight curve on the southern approach, the planned deviation of the Hume Highway at the Bargo River will also dispose of the one remaining single-lane road bridge on this Highway in New South Wales. The deviation will follow the broken white line.

The Jugiong Bridges

SATURDAY 3rd July was a big day for the people in the Jugiong area, 225 miles from Sydney, when two new bridges were officially declared open.

The Hon. P. H. Morton, M.L.A., Minister for Local Government and Minister for Highways, opened the bridge over Jugiong Creek, three miles east of the town; and the Hon. W. F. Sheahan, Q.C., LL.B., M.L.A., severed the ribbon on the new low level bridge over the Murrumbidgee River close by.



The importance of Jugiong, "U-go-wong—Valley of the Crows" is not to be measured by its population, but rather by the prosperity of the pastoral industry which thrives in the surrounding hills and river flats; and by the wealth of local history.

This was bushranger country, and it is only a hundred years ago that Hall, Gilbert and Dunn held up the coach near Jugiong, shot a police sergeant and made off with their plunder.

The Jugiong Hotel, an historic inn, was built by the Hon. W. F. Sheahan's grandfather in 1855 and has remained in the family ever since. The folklore of the surrounding country is rich in anecdotes of Sturt, O'Brien and Tyson, among many others.

This, then, was the setting for the two ceremonies on July 3rd.

The larger of the two new bridges, carrying the Hume Highway over the Jugiong Creek, with its approaches, cost £107,000 to build. But it is built to last, with five 70 foot spans of prestressed concrete girders, and a cast-in-place concrete slab deck which is 9 feet above the highest recorded flood level.

It is 396 feet long and its 28 feet width ensures safe passage to the considerable traffic of the Hume Highway. In 1964 this amounted to an annual daily average of 1,683 vehicles, thirty per cent of which could be classed as heavy vehicles.

The Hon. P. H. Morton, M.L.A., Minister for Highways, addresses the gathering prior to declaring open the Hume Highway bridge 3 miles from Jugiong

The new bridge carrying the Hume Highway over Jugiong Creek

The timber bridge, which the new one replaces, was built in 1900, and cost £3,386. It was a narrow bridge suitable for only a single lane of traffic and its replacement means that there is now only one remaining single-lane bridge on the Hume Highway in New South Wales. This is across the Bargo River at Tahmoor and a contract has been let for its replacement.

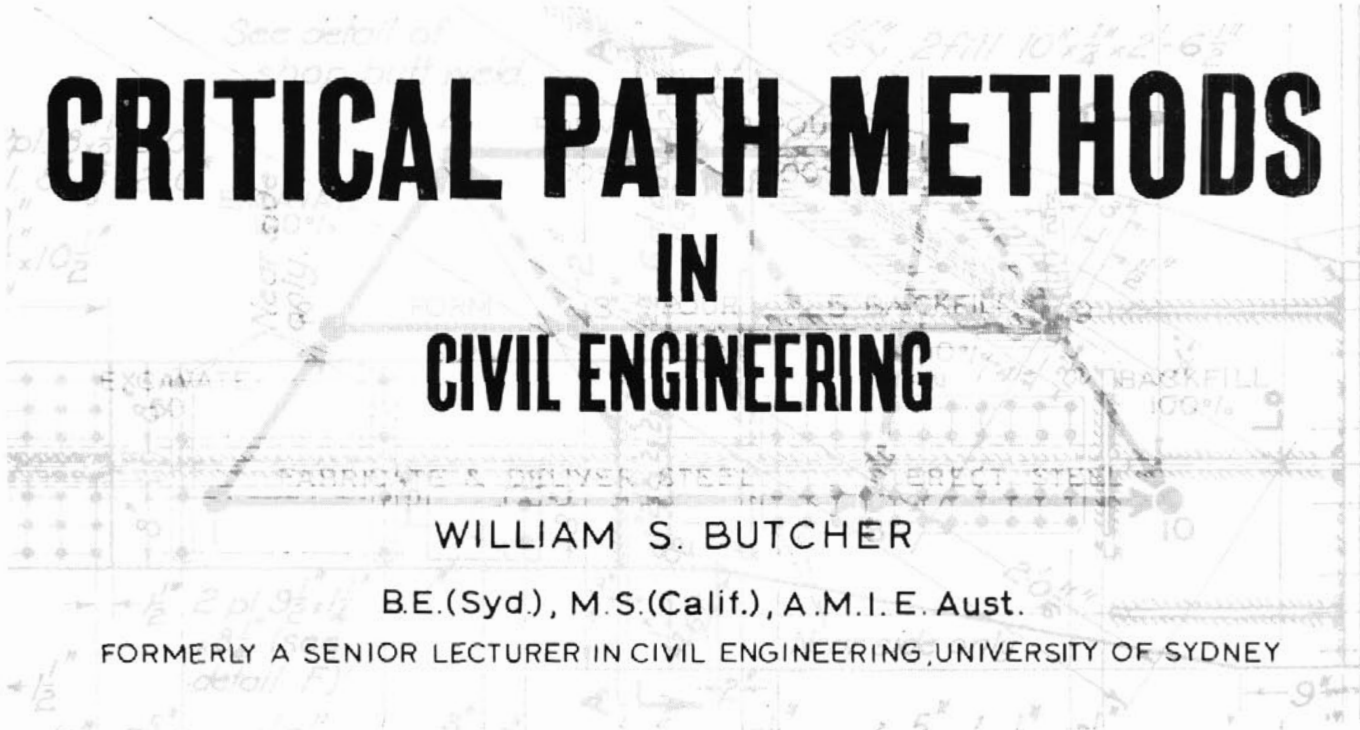
The new low-level bridge over the Murrumbidgee which was also opened on 3rd July 1965, cost £47,500 and is the only one over the Murrumbidgee between Gobarralong and the Taemas Bridge to the south of Yass. The prestressed concrete deck, supported on steel piles, covers 10 spans, and a length of 340 feet.

This bridge will provide better access to existing grazing property, accelerate development of a large area south of the river, and will also facilitate stock movement to snow leases via Tumorrama.

The opening ceremonies were the culmination of ten years of investigation, planning, and effort by officers of the Department, and of the Demondrille Shire Council, within whose administration Jugiong lies.

Collapsible handrails to lessen damage by debris during floods are a feature of the new Murrumbidgee River bridge

The Hon. W. F. Sheahan, Q.C., LL.B., M.L.A., Member for Burrinjuck, opened the bridge over the Murrumbidgee



CRITICAL PATH METHODS IN CIVIL ENGINEERING

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This is an extract from a paper presented to Sydney Division, The Institution of Engineers, Australia, October 1963; *and published in the Journal of the Institution of Engineers Vol.* 37, *No.* 1-2, *Jan.-Feb.*, 1965.

The author is a Research Engineer at the Water Resources Centre, University of California, Los Angeles, and was formerly a Graduate and Senior Lecturer in Civil Engineering of the University of Sydney.

IT is now about five years since a technique was developed for use in the managing of projects that are both large and complex. While projects of this kind do occur outside civil engineering, it is within it that this tool now makes possible a new approach to project planning, scheduling and control.

Broadly speaking it can be said that no civil engineering project is the same as any other. This technique's ability to deal with work of a non-repetitive nature makes it especially relevant to the civil engineer, and while applications of it outside civil engineering are fairly common and can be expected to become more so, it can be truly said that the civil engineer now has available to him a new management tool of considerable range and power.

This new management tool can be described generally as "critical path method" or "network analysis". With it, the large projects become manageable in a way that was not possible before. The manipulations it makes possible are ones which before have been intuitively made by experienced people on projects of limited size. By means of network analysis, explicit planning and control of a project of any size becomes available. It has been said by one U.S. authority that these methods '. . . are in their infancy. Likened to the development of the automobile, we have here a 'Model T' management tool—simple, yet far advanced compared with the horse and buggy'. Even though network analysis is so new and far from fully developed, uses have been made of it in many areas of government, business and industry. No doubt the fields of application will broaden as time goes on. In this country there is a great interest in it and new recruits to the group of users are appearing all the time. This new approach has become known under a number of names, some of which apply to particular varieties of it, others to the topic as a whole. At this stage of development the terminology is not settled and this can be a source of confusion. The commonest names would be 'critical path method (CPM)', 'critical path planning and scheduling', 'PERT' (standing for *P*rogram *E*valuation and *R*eview *T*echnique),'LESS'(*L*east-cost *E*stimating and *S*cheduling) etc., all of which are approximately equivalent with the term 'network analysis' as a general one covering all.

Network analysis is actually an example of linear programming which itself is one of the mathematical methods of operations research. From the user's point of view, the knowledge of mathematics required goes little beyond simple arithmetic but in large or special applications of the method, the quantity of calculations becomes such that it is more economical to pass this burden of work to a computer.

In the minds of many people, an association is made between computers and network analysis. This is because the computer companies have been fairly aggressive in extending the application of such analysis. However, it would be a mistake to assume that a computer is necessary to use network analysis. In fact, some workers claim that the principal benefits of the system are realised before a computer comes into the picture.

Like all technological developments, this one came about because of the bringing together of suitable problems and the techniques that were currently available. The techniques available were the methods of operations research (i.e., linear programming) and computers to make manageable the extensive calculations needed. The two problems to which these tools were first successfully applied were actually attempted about the same time by different groups but both groups arrived at very much the same answer. The E.I. du Pont de Nemours Company in the U.S.A. was concerned to develop a method by which they could control in a more positive manner the construction of chemical plants. In their method a deterministic view of project times is used. This method is usually referred to as CPM. At much the same time the U.S. Navy had under way its Polaris Missile project, and it used a firm of consultants to develop a method by which they could keep control over this large and complex programme. The method developed from this application was called PERT and it differs from CPM in that it uses estimates of time that have a probability attached to them. Broadly speaking it can be said that PERT with its probabilistic view of time is best suited to reporting on the progress of a project which has uncertain factors involved, while CPM with its deterministic view of time is best suited to project planning, scheduling and control. PERT has found its greatest use in U.S. defence contracts where it is specified that it must be used. Apart from this, the overwhelming majority of users of network analysis use CPM on account of its greater power for job planning and control, while being easier and cheaper (of computer time) than PERT.

The important feature of network analysis in any form is the description of a project plan by a network. This is common to CPM and PERT.

The essential feature of a project is that it is the accomplishing of a complex task by carrying out a number of sub-tasks leading to the achieving of the final objective. Network analysis allows us to express the relation between the parts of a project by means of a graphical representation. Then with this representation or model, it is possible to manipulate the plan of a project to meet specific requirements such as completing it in minimum time, carrying it out at a minimum cost or analyse it to find time needed to complete it under different conditions.

Network analysis makes it possible to separate out the two tasks of planning and scheduling a project so that each can be attended to separately. By 'plan' is meant the method of work that will be adhered to—the sequence of steps that will be taken to bring about the desired result. To carry out any project there will always be several ways of going about it and in the planning stage all of these must be examined in some way so as to choose the one that will be put into practice. With network analysis we have a method of 'writing down' a project plan. Then when a project plan has been committed to paper, it is possible to schedule it, i.e., determine the timing of all the tasks that comprise the project and the time to complete the whole of it.

In the preliminary phases of a project, many plans may be considered and possibly judged by the schedules they make necessary, the demand they make on resources, or more likely by the cost of running the project in that way.

For any project, there will always be some measure of its value to us (the project utility function). For example we may want to carry it out in such a way as to minimise cost, effort, manpower or capital required or maximise profit, sales, efficiency, quality, etc. Whichever of these criteria is used in judging a project is a management decision. If cost is the one chosen and this is usually the case, critical path methods allow the relation of this to other features of the project to be determined.

The cost of a project will be fixed by several things which will include:

1. the technique chosen for its execution,
2. the resources available to do the work and,
3. the time available.

With network analysis, for a given technique using appropriate resources, we can determine (i) the minimum time required to complete the project at minimum cost (normal time—normal cost); (ii) the lowest cost for completing the project in a time less than that for minimum cost; (iii) the lowest cost for completing the project in the shortest possible time (crash time—crash cost).

While it is not possible directly to determine the technique to give minimum cost, it is possible to evaluate the cost and minimum time when using a chosen technique. This allow us to compare one technique with another. Methods are also available to allow the determination of the relation between project duration and limitations on resources.

CONCLUSION

Because of their special use to the civil engineer, critical path methods have made and will continue to make a big impact in this field. No doubt like many new techniques, they will be applied in unsuitable as well as suitable applications until they become sufficiently well known so that the uses and limitations are clearly recognised.

The application of these methods to civil engineering has opened up a whole new approach to the planning and management problems that are encountered in this field. The answers provided by a CPM analysis of a project could at first sight be regarded as a solution to the scheduling problem. But in a real project there are factors at work which are not taken into account in the analysis. One of these is the need to make steady use of equipment or to avoid wide fluctuations of the labour force. It may not be possible to have all activities start at their earliest start time and at the same time provide continuity of work for all (both men and machines) on the project. Attempts have been made to solve the problem of the optimum schedule for a project with limited resources and some progress has been made in this direction. Other limitations of the method are also receiving attention and no doubt the results of these efforts will become available in due course. Instead of regarding the schedule with minimum project duration as the end of the planning and scheduling effort, we should regard this as a point from which to start to refine the plan to meet all requirements and as a criterion by which to judge alternative plans.

Planning, scheduling and controlling of a project using the critical path approach has provided a technique allowing a firmer grip on some of the factors at work in a project and with the necessary effort this knowledge can be put to use to help solve or to solve in more satisfactory ways problems that have always existed.

The help gained from critical path methods will to some extent be proportional to the effort put into getting good data and to the use made of the results derived from that data. As well the results will depend on the state of the art and our knowledge of it. The state of the art is changing all the time and our responsibility is to make the best use of what knowledge is available and possibly add to it at the same time.

MAIN ROADS FUNDS

Receipts and Payments for the period from 1st July, 1964 to 30th June, 1965

	County of Cumberland Main Roads Fund	Country Main Roads Fund
	£	£
RECEIPTS—		
Motor Vehicle Taxation (State)	2,870,158	11,480,631
Charges on heavy commercial goods vehicles under Road Maintenance (Contribution) Act, 1958 (State)	1,024,564	4,098,256
Commonwealth Aid Roads Act, 1964	2,155,606	8,342,622
Road Transport and Traffic Fund	....	1,055,690
From Councils under Section 11 of Main Roads Act and/or for cost of works ..	2,887,642	41,515
Other	346,376	227,521
Total Receipts .. .. £	9,284,346	25,246,235
PAYMENTS—		
Maintenance and minor improvement of roads and bridges	1,579,697	6,992,247
Construction and reconstruction of roads and bridges	4,802,013	13,573,798
Land Acquisitions	1,307,202	399,719
Administrative Expenses	533,850	1,146,488
Loan charges, payment of interest, exchange, management and flotation expenses ..	147,251	576,135
* Miscellaneous	983,089	2,574,869
Total Payments .. .. £	9,353,102	25,263,256

* Includes transfers to Special Purposes Accounts in respect of finance for Operating Accounts, Suspense Accounts and Reserve Accounts.

Science in Australia Exhibition 1965

AN excellent opportunity for showing the youth of Australia the futures open to them in research and engineering was provided by the "Science in Australia" Exhibition held this August in Sydney at the R.A.S. Showground.

The Department's stand, displaying models and a large number of blown-up photographs had its fair share of visitors. Adults and the older youths seeking information, and the rest prepared to be informed.

Although today's child may be tomorrow's engineer, today he is still a child; and must be attracted to the Department's stand by bright lights and attractive displays. Otherwise, tomorrow he may still be an engineer—but not in the employment of the Department.

To get a fair share of this potential talent, the Department must attract much more than its fair share of visitors.

Taken all round, it was a good stand. The working model, showing the raising of the arch and the movable steel falsework of the Gladesville Bridge, gave the curious much to think about; while the large Figtree, Tarban Creek, and Gladesville Bridges model drew the property-conscious, among others.

There is no doubt that the most should be made of opportunities for the display of the Department's activities—particularly to the young.

AUSTRALIAN ROAD RESEARCH BOARD

Formation

THE National Association of Australian State Road Authorities (then the Conference of State Road Authorities, Australia) first discussed the need for formal organisation of road research (prior to 1950), following a report prepared by Mr C. G. Roberts, then Chief Engineer for the Country Roads Board of Victoria. When the suggestions were examined at a later date, Mr C. G. Roberts and Dr L. F. Loder (who was subsequently knighted in June 1962), Director General of the Commonwealth Department of Works, were asked to prepare a comprehensive proposition and this was the basis for agreement at the 22nd Meeting of N.A.A.S.R.A. in Sydney (1959) to establish the Australian Road Research Board.

It was agreed that the Board would consist of the head of each Australian State Road Authority and the Commonwealth Department of Works. The foundation meeting took place in Sydney in March 1960, and the members of the initial Board were: Messrs H. M. Sherrard (N.S.W.), D. V. Darwin (Victoria), C. N. Barton (Queensland), F. D. Jackman (South Australia), J. D. Leach (Western Australia), R. C. Sharp (Tasmania) and Dr L. F. Loder (Commonwealth).

Mr D. F. Glynn was appointed Director of the Board in 1960. He is responsible to the Board for the management and control of the organisation and is assisted by a staff of secretarial, engineering and other scientific personnel.

At the present time the offices of the Board are located in the new laboratory building adjacent to the Head Office of the Country Roads Board in Melbourne.

Incorporation as a Company

On 5th January 1965, the Australian Road Research Board was incorporated under the Companies Act, 1961, as a Public Company. The existing Board, as originally constituted, was disbanded and subsequently the former members of that Board, with the exception of Mr J. J. G. Punch, Commissioner for Main Roads, Western Australia, who died on 17th January, 1965, were appointed as the first Directors of the new Company.

The First Annual General Meeting and the First and Second Meetings of the Board of Directors were held on 12th May 1965, at Melbourne. Prior to that date there had been twelve meetings of the incorporated Board since its inception, including the foundation meeting in March 1960.

At the first Annual General Meeting, Mr D. H. Aitken, who succeeded the late Mr J. J. G. Punch as Commissioner for Main Roads, Western Australia, was also appointed as a Director.

The present Board of Directors is comprised of—Mr G. B. D. Maunder, O.B.E., B.E., B.Ec., M.I.E.Aust. (Commonwealth) Chairman, Mr I. J. O'Donnell, O.B.E., E.D., B.C.E., A.M.I.E.Aust., F.A.I.M. (Victoria) Deputy Chairman, Mr J. A. L. Shaw, D.S.O., B.E., M.I.E.Aust., F.A.P.I. (New South Wales), Mr R. C. Sharp, B.E., A.M.I.C.E., A.M.I.E.Aust., M.A.P.I. (Tasmania), Mr C. N. Barton, O.B.E., E.D., B.E., M.I.E.Aust., F.A.I.M. (Queensland), Mr E. D. Jackman, C.M.G., B.E., A.M.I.E.Aust., M. Inst. T. (South Australia), Mr D. H. Aitken, B.E., M.I.E.Aust., A.M. Inst. T. (Western Australia).

Funds

The finances of the Board are provided primarily by contributions from the various State Road Authorities and the Commonwealth Department of Works; the maximum amount required from each State being not more than $\frac{1}{2}$ per cent of the moneys made available to the State for that year under the Commonwealth Aid Roads Act. The Commonwealth Department of Works allocates up to 10 per cent of the total contribution for use by the six state road authorities.

Objects

The Board was established in order to:—

(a) Provide a national centre for road research information and for the correlation and co-ordination of road research activities.

(b) Ascertain the nature and extent of road research required, to undertake research studies and to make grants for carying out road research.

(c) Encourage and promote the undertaking of road research, including research into road planning, location, design, safety, materials, construction, maintenance, structures, equipment, transport economics, administration, financing, management, accounting and any other matters affecting the provision, upkeep, use, protection and development of roads.

Advisory Council

An Advisory Council was appointed for the purpose of making recommendations relating to research projects for consideration by the Board. The Director is the Chairman of the Advisory Council and its members are appointed having regard to their academic attainments and ability to contribute to the council on road research. They are selected from organisations such as the State Road Authorities, Commonwealth Scientific and Industrial Research Organisation, Australian Universities, Commonwealth Department of Shipping and Transport, Australian Local Government Authorities and Australian Road User Associations.

Specialist Committees

The Board also appoints Specialist Committees of experts in particular subjects. The main function of these Committees is to provide detailed counsel in the special field concerned and make recommendations for projects that should be undertaken. Specialist Committees have been appointed to deal with research on Traffic Flow and Operation, Human Factors, Road Transport Economics, Compaction and Pavement Design.

Project Committees

Project committees, comprised of specialists have also been established to guide progress on approved research projects being carried out under Fellowships granted by the Board, at Universities and at the Institute of Highway and Traffic Research at the University of New South Wales.

Research Staff

Apart from the Director, the main research staff engaged so far have been appointed to take charge of a division of the Board's research activities. There has been difficulty in recruiting suitable staff and much use has been made of part time assistance. Junior technical assistants such as university students have been employed to carry out routine testing, data collection and related sub-professional tasks, whilst a number of eminent retired engineers are working as Research Associates.

Conferences

The Australian Road Research Board's first Biennial Conference was held in the Academy of Science Building at Canberra in September 1962. The Conference was opened by the Hon. H. F. Opperman, Minister for Shipping and Transport, representing the Prime Minister, and about 350 delegates attended.

The principal address was prepared by Sir William Glanville, Director of the Road Research Laboratory in Britain. As illness prevented Sir William's attendance in person his address was read by Dr C. G. Charlesworth, Head of the Traffic Section of the Road Research Laboratory. Other overseas visitors included Dr P. J. Rigden, Director of the National Institute for Road Research in South Africa who presented his paper at a joint meeting with the Melbourne Division of the Institution of Engineers Australia; Mr J. Macky, Director of Roading, New Zealand and Mr N. G. Hansen, Tauranga County Council, New Zealand.

Seventy-six papers were presented. These were printed and distributed prior to the Conference and these together with the subsequent discussions were published in the Proceedings.

The second Biennial Conference, held at the Chevron Hotel in Melbourne between the 31st August and the 4th September 1964, was opened by the Hon. G. Freeth, Minister for Shipping and Transport, who represented the Prime Minister. The opening address was delivered by the principal guest, Sir William Glanville Director of the Road Research Laboratory in Britain. Professor J. R. Mehra who is Director of the Central Road Research Institute in New Delhi, India, also attended and delivered a paper on Stabilisation at a combined meeting with the Melbourne Division of the Institution of Engineers, Australia.

Seventy-eight papers were presented at the second Biennial Conference including many from overseas and among the 422 delegates registered there were representatives from the Philippines, British Solomon Islands, India, New Guinea, Pakistan, United Kingdom and New Zealand.

Arrangements are now being made for the third Biennial Conference which will be held in Sydney in September 1966.

Publications

Apart from the Proceedings of the Conference a Journal is published at quarterly intervals to describe the Board's activities and to present articles on topics related to road research.

Also to collate and compile available information on particular subjects Bulletins are prepared from time to time and circulated. Bulletin No. 1 deals with a review of the performance of compaction plant on pavement and subgrade materials.

In connection with the preparation of articles and papers for publication the Board has also had printed a booklet entitled "Directions to Authors and Contributors".

Overseas Visits

In 1961 the Director attended the Roading Symposium in Wellington, New Zealand, and in 1963 he attended technical sessions of the United Nations Conference in

Geneva and visited research establishments in Britain and the U.S.A.

In 1963, Mr D. J. Buckley, then the Board's Fellow in Traffic Research at the University of New South Wales, attended the Second International Symposium on the Theory of Road Traffic Flow in London and visited traffic research centres in the United Kingdom and the U.S.A.

In May 1964, Mr A. J. Scala, Chief of the Pavement Research Division attended the P.I.A.R.C. Conference in Rome, following which he visited France, Holland, England, Canada, and the U.S.A. (including Hawaii) to establish contact with co-workers in the field of Highway Research.

Projects

Research Projects being undertaken or considered at the present time are grouped into such classifications as—Human Factors, Pavement Structures, Bituminous Materials, Physical Testing, Soils and Concrete, Construction and Maintenance Practices, Statistics and Traffic Structure, Traffic Flow, and Operations and Economics and Planning.

Most of the work is being carried out by the Board's staff and at Universities in Perth, Adelaide, Melbourne, Sydney and Brisbane. The various State Road Authorities have provided assistance for a number of the projects by seconding specialist staff to the Universities concerned. The Department of Main Roads, N.S.W., has provided assistance of this nature in projects dealing with—Cost of Vehicle Operation on Urban Roads, Traffic Capacity, and Reinforced Concrete Members in Combined Torsion Bending and Shear, which are being carried out at the University of New South Wales, as well as supplying additional support to the project, "Composite Construction" at the University of Sydney.

Human Factors Research has been defined as being generally directed towards better understanding of the dynamic system comprising road-vehicle-driver and environment and all the interactions between components. In this field there are projects dealing with the Colour Code of Traffic Signals, Road and Vehicle Lighting, Evaluation of Motor Vehicle Characteristics, Windscreen Breakage, The Study of Vehicle-Driver-Road Interaction and several road accident studies. One of these projects, designed to obtain data under Australian conditions, was carried out in Adelaide and involved on-the-spot investigations of random samples of injury—producing accidents by an expert team comprised of a Doctor and an Engineer, equipped with a specially fitted vehicle. The data from over 440 accidents which were examined, are being analysed. A similar study is now in progress in Brisbane. In the Traffic Structure and Statistics Division, projects include a study of Australian Accident Rates for the last 30 years; Time Variations of Road Accidents in Australia 1950 to 1960; Road Accidents and Weather Traffic Patterns in New South Wales; Traffic Growth in Victoria 1939 to 1959; Recommended Practice for Traffic Counts in Australia; Brisbane Road Accidents 1961; Melbourne Road Accidents 1961 and a sample survey of Road Traffic in Queensland.

There are many projects being dealt with by the Pavement Division, including Assessment of Environment and Existing Pavements; Behaviour of Layered Pavements; Deflection Studies; Materials and Stresses; Elastic Behaviour; Dynamic Modulus Testing; Structural Equivalency of Layers of Different Materials; Moisture Strength Studies; and Stabilisation. The Department of Main Roads, N.S.W. has participated in one of the field projects for the pavement moisture and strength survey. For that survey testing staff from the Department's Divisional Office laboratories carried out in situ tests, tabulated site data and obtained normal and undisturbed subgrade samples from 146 locations distributed throughout New South Wales. Similarly sites were selected and samples taken by the other road authorities in South Australia, Victoria, Tasmania and Queensland.

During 1965 sites established throughout New South Wales previously for a pavement moisture and strength survey in 1963 were re-visited by A.R.R.B. staff for the purpose of carrying our deflection measurements with a Benkelman Beam, in connection with projects dealing with The Serviceability Concept in Pavement Design, and Structural Design using Deflection. The same sites were used in order to capitalise on the previous work when a considerable amount of data on the condition and composition of the pavements and subgrades was assembled.

The main projects initiated in the structural field are those dealing with Soft Foundations and Bridge Abutments; Slender Piles in Soft Media; Composite Construction; Brittle Fracture in Structural Steel; Composite Beam and Slab Bridges under Abnormal Loading; and Reinforced Concrete Members in Combined Torsion Bending and Shear.

The Traffic Flow and Operations Research Division is supporting Fellowships at the Universities of New South Wales and Adelaide and is engaged in studies of Traffic Capacity as well as an investigation into Traffic Measure Instruments at the Institute of Highway and Traffic Research at the University of New South Wales.

There are also a number of projects in progress in the other Divisions, including studies of Bituminous Surfacing; the Design of Asphaltic Concrete; Principles and Control of Compaction and Density, Analysis of Accident Statistics; and Traffic Patterns.

In the early stages of development, when work on projects was being started, it became evident that little useable information had been accumulated which was applicable to the Australian environments, so that the first efforts were mainly directed towards the collection of such data. Progress reports on current projects are now prepared at six monthly intervals and although some difficulty is experienced in recruiting suitable qualified research personnel, the activities of the Board are continuing to increase.

CONCRETING UNDER COVER

THE construction of two reinforced concrete box culverts between Jindabyne and Smiggin Holes on the Mount Kosciusko Road posed problems for the engineers of the South Coast Division.

A number of factors combined to make the completion of this work desirable as soon as possible, even though the early autumn snow falls had already started.

Cold was the enemy, and the concreting had to be completed under freezing conditions, while satisfying Departmental requirements, which included:

"No concrete shall be mixed or placed while the air temperature is below 40° F", *and*

"The temperature of the concrete placed in the work shall not be less than 50° F".

There were, then, two conditions to be met, correct air temperature, and correct concrete temperature.

A plastic igloo was the answer to the first condition. Tubular scaffolding was hired and transported from Sydney. This was built into a framework over the culvert site, and was the supporting structure for a skin of clear polythene sheeting, 0.008 inches thick.

The commercially available widths of polythene are 90 inches, and three widths were joined by a special process before despatch to provide rolls 22 feet wide and 120 feet long.

In certain sections the plastic was further supported by wire netting. Additional protection was provided by canvas covers secured to the frame.

It was necessary to extend the column struts through the culvert deck. Provision for this was made by using a tapered cone form, and after dismantling the igloo the conical holes were coated with two coats of a poly vinyl acrylic glue and filled with concrete rammed into place.

The translucent covering allowed sufficient natural light for the work to continue for a 10 hour working day. Two Salamander stoves burning diesel oil provided space heating.

The concrete ingredients were delivered dry by agitator truck from a ready-mix plant at Jindabyne. Water was heated at the site in two 400 gallon capacity tanks to a temperature of 120° F, over a wood fire.

Thus the temperature at which the concrete was mixed and placed was maintained within the 60° F. to 70° F. range, whilst a comfortable working temperature to 50° F. to 60° F. was sustained under the cover. This was despite blizzards, and outside temperatures below freezing point.

This was how these two box culverts—one a four cell 10 feet by 9 feet, and the other a three cell 12 feet by 12 feet—were completed to specification under very adverse conditions on the Mount Kosciusko Road.

National Association of Australian State Road Authorities Recent Publications

Highway Bridge Design Specification (1965)

This is a revised and enlarged edition. Previous editions were published in 1958 and 1963.

Price 10s.

Principles and Practice of Bituminous Surfacing—Volume 1—Sprayed Work

Volume I covers the issue of specifications, the ordering of plant and materials, stockpiling of aggregates, surface preparation and condition, field practice and control.

Volume II, to be published later, will deal with bituminous mixtures.

Price of Volume I—7s. 6d.

Guide to Traffic Engineering Practice

A manual for the guidance of highway engineers in understanding and analysing traffic problems.

Price 7s. 6d.

Copies of these publications are obtainable on application to any of the following addresses:

Department of Main Roads, Sydney, New South Wales.

Country Roads Board, Kew, Victoria.

Main Roads Department, Brisbane, Queensland.

Department of Public Works, Hobart, Tasmania.

Main Roads Department, Perth, Western Australia.

Highways and Local Government Department, Walkerville, South Australia.

Commonwealth Department of Works, Hawthorn, Victoria.

Highway Reconstruction

—SOUTH OF NIMMITABEL

A PART of the overall reconstruction of the Monaro Highway, State Highway No. 19, between Nimmitabel and Bombala, and the Snowy Mountains Highway, State Highway No. 4, between Nimmitabel and Bega, is the construction of an eight-mile deviation between Nimmitabel and Tea Gardens Creek.

This deviation will result in a very much better road alignment and will avoid the many steep grades of the old route of the Monaro Highway. It will also make possible the realignment of the Snowy Mountains Highway from the top of Brown Mountain to link up with the deviation six miles south of Nimmitabel.

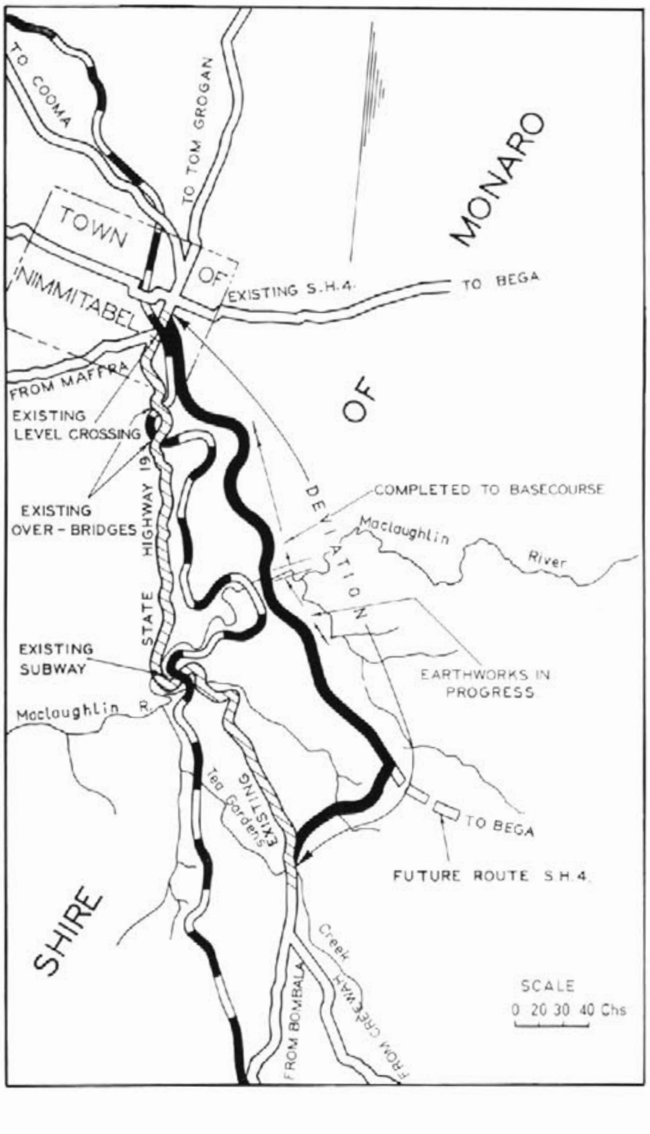
The new route runs between the existing Monaro Highway to the west and the Snowy Mountains Highway to the east. It keeps to the east of the Nimmitabel-Bombala railway and thus eliminates one level crossing, two narrow overbridges and one subway.

A 280 feet long bridge is being designed by the Department for a new crossing of the MacLaughlin River 3.6 miles south of Nimmitabel.

The overall effect will be the reduction of about 6½ miles in the total length of highway, with corresponding saving in cost, and provision for safe, speedy, economical driving in this rugged country.

The deviation is designed for a speed of 60 m.p.h., a maximum grade of 6 per cent, and a minimum curve radius of 1,200 feet. The bitumen sealed pavement will be 22 feet wide on a formation width of 30 to 34 feet. Table drains are provided in the cuts, which are up to 20 feet deep.

The new deviation has practically reached the MacLaughlin River, seen in the middle foreground of the photograph on the left. Earthworks progress south of the river



The winter snows highlight cuttings and embankments

The loamy, basaltic soil requires a pavement cover ranging up to 20 inches. For the lower levels of this pavement suitable granite base course material was obtained from borrow pits at an average haulage distance of four miles.

The work in hand includes the construction of culverts and channels, and many miles of rabbit-proof fencing erected on road boundaries.

Construction methods include ripping by hydraulic ripper-equipped tractor, haulage by tractor-drawn scrapers, and compaction by grid and sheepsfoot rollers; all under the supervision of the Divisional Engineer, Bega, with direct field control from Nimmitabel Works Office.

Testing of materials and compaction is being carried out in the Testing Laboratory at Bega Divisional Office.

Since work commenced in February of this year, four and a half miles of formation have been completed, despite the rough country and frequent snow-falls. Construction to base-course level has been completed between Nimmitabel and the MacLaughlin River.

TENDERS ACCEPTED BY COUNCILS

The following tenders (in excess of £3,000) were accepted by the respective Councils for Road and Bridge Works for the three months ended 30th June, 1965.

Council	Road No	Work or Service	Name of Accepted Tenderer	Amount £ s. d.
Bibbenluke	S.H. 19	Reconstruction and bitumen surfacing between 17 m. and 19 m. south of Nimmitabel.	Lundberg Constructions Pty Ltd.	24,152 12 6
Bogan	D.R. 1178	Supply and spreading of gravel between 8.45 m. from Girilambone and Bogan Bridge at 16.5 m.	A. T. & L. M. Hughes	4,818 0 0
Bogan	T.R. 57	Reconstruction and bitumen surfacing between 6.19 m. and 6.6 m. south of Nyngan.	J. L. Johnston Pty Ltd.	4,018 0 6
Boomi	M.R. 507	Construction of 2 span reinforced concrete bridge 50 feet long over Thorndale Creek 25 m. east of Mungindi	A Goor Pty Ltd.	12,304 16 0
Byron Bay	M.R. 524	Construction of 3 span reinforced concrete bridge 75 feet long over Kings Creek 1.28 m. from Mullumbimby	Kennedy Bros.	12,520 11 0
Cobar	T.R. 68, D.R. 1262	Supply and spreading of gravel 0 m. to 12 m. south of Tilpa on Trunk Road No. 68 and 52.1 m. to 59.5 m. from State Highway No. 8 on Developmental Road No. 1262.	J. L. Johnston Pty Ltd	11,675 0 0
Coonamble	M.R. 129	Bitumen resurfacing between 0.6 m. and 3.6 m. and bitumen surfacing between 6.7 m. and 9.7 m. west of Coonamble.	Boral Road Services Pty Ltd.	5,111 1 8
Dumaresq	T.R. 75	Construction of 6 cell 12 ft. x 10 ft. reinforced concrete box culvert at Little George's Creek 48 m. east of Armidale.	Austral Reinforcing Services.	22,473 13 0
Dumaresq	T.R. 75	Construction of 2 cell 10 ft. x 9 ft. reinforced concrete box culvert at Tibbs Gully 49 m. east of Armidale.	Colin Grout	5,194 13 4
Forbes	T.R. 56, M.R. 350	Bitumen resurfacing at various locations	Allen Bros Pty Ltd	3,012 16 10
Gilgandra	S.H. 17, S.H. 18	Bitumen surfacing at various locations	Shorncliffe Pty Ltd	8,335 18 6
Gilgandra	M.R. 205	Construction of 2 span reinforced concrete bridge 40 feet long over Rocky Creek 16 m. from Mendooran.	B. Coceancig & A. Cipolla	7,372 0 0
Leeton	M.R. 539	Supply and spreading of gravel and bitumen surfacing between 12.03 m. and 14.53 m. south of Trunk Road No. 80	Emoleum (Aust.) Pty Ltd	3,006 19 2
Macintyre	S.H. 12, M.R. 187	Bitumen resurfacing on State Highway No. 12 between 8.05 m. and 12.05 m. east and 6.52 m. and 8.52 m. west of Inverell including priming on Main Road No. 187, between 12.1 m. and 19.1 m. north of Inverell.	Emoleum (Aust.) Pty Ltd	8,287 7 10
Narraburra	T.R. 57, M.R. 241	Bitumen surfacing and resurfacing at various locations	Boral Pty Ltd	5,557 13 8
Peel	D.R. 1233	Construction of 3 span concrete and steel bridge 171 feet long over Goonoo Goonoo Creek, 0.3 m. from State Highway No. 9.	J. Parkinson	19,112 0 0
Port Stephens	M.R. 302	Supply and delivery of 9,000 cubic yards of gravel for pavement widening between 0.9 m. and 4.0 m. from Pacific Highway.	Halpin Bros	5,625 0 0
Timbrebongie	M.R. 347	Prime seal between 0.5 m. and 5.5 m. west of Mitchell Highway.	Shorncliffe Pty Ltd	5,636 3 5
Uralla	T.R. 73	Supply and delivery of 1,750 cubic yards of aggregate to stockpiles for bitumen surfacing at various locations	Pioneer Quarries (Tamworth) Pty Ltd.	4,484 7 6
Walcha	S H. 11	Reconstruction between 0.5 m. and 2.7 m. east of Walcha.	K. Tolhurst	42,463 0 0
Walgett	S.H. 12, M.R. 127, M.R. 333	Bitumen surfacing and resurfacing at various locations	Shorncliffe Pty Ltd	7,973 6 8
Walgett	S.H. 12	Supply and delivery of 665 cubic yards of aggregate to stockpile for bitumen resurfacing between 0.7 m. and 5.35 m. east of Collarenebri.	Union Building Co.	3,325 0 0
Walgett	M.R. 127, M.R. 333	Supply and delivery of 629 cubic yards of aggregate to stockpiles for bitumen surfacing and resurfacing at various locations.	Coonamble Shire Council	3,012 15 0
Walgett	S.H. 12, M.R. 329	Construction of Gwyder Highway between 5.38 m. and 10.98 m. east of Collarenebri including section 0 m. to 0.23 m. from Gwydir Highway on Main Road No. 329.	G. T. Muggleton Pty Ltd	52,769 9 10

TENDERS ACCEPTED BY COUNCILS—*continued*

Council	Road No.	Work or Service	Name of Accepted Tenderer	Amount
				£ s. d.
Weddin..	M.R. 237 M.R. 398	Supply and spreading of gravel at various locations ..	E. Burton..	6,011 18 0
Yallaroi	S.H. 12 T.R. 63	Bitumen surfacing and resurfacing at various locations, including Council works.	Shorncliffe Pty Ltd	15,295 1 8
Yallaroi	S.H. 12	Supply and delivery of 2,762 cubic yards of aggregate to stockpiles for bitumen surfacing at various locations.	R. E. Johnstone	7,201 7 6

TENDERS ACCEPTED BY DEPARTMENT OF MAIN ROADS

The following tenders (in excess of £3,000) for Road and Bridge Works were accepted by the Department during the three months ended 30th June, 1965.

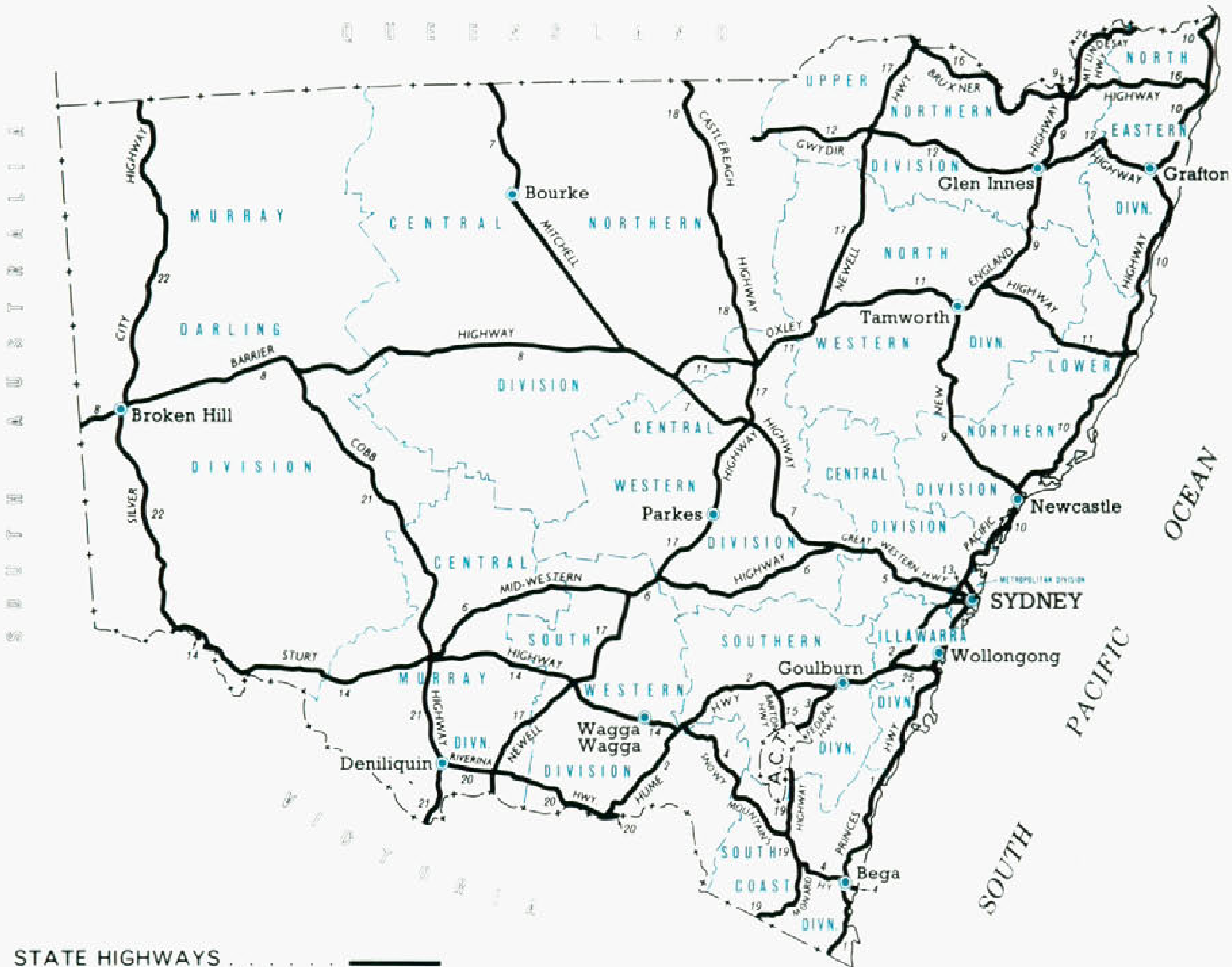
Work or Service	Name of Accepted Tenderer	Amount
		£ s. d.
State Highway No. 1—Prince's Highway, Shire of Eurobodalla. Construction of superstructure of a 9 span steel and concrete bridge 892 feet long over the Moruya River at Moruya.	Transfield Pty Ltd	252,500 13 0
State Highway No. 2—Hume Highway, Shire of Kyeamba. Construction of 4 cell reinforced concrete box culvert 52 feet long, over Kyeamba Creek 19 m. south of Tarcutta.	W. A. Winnett & Sons	10,584 14 0
State Highway No. 6—Mid-Western Highway, Shire of Carrathool. Supply and delivery of aggregate for reconstruction and bitumen surfacing between 35.65 m. and 67 m. east of Hay.	Griffith Sand & Gravel Pty Ltd	6,087 15 0
State Highways Nos. 7 and 11—Mitchell Highway and Oxley Highway, Shire of Gilgandra. Supply and delivery of 2,895 cubic yards of aggregate to various stockpiles.	Furney Bros (Dubbo) Pty Ltd	8,029 0 0
State Highway No. 11—Oxley Highway, Shire of Gilgandra. Supply and delivery of 1,100 cubic yards of aggregate to stockpiles between 23.25 m. and 25.30 m. from Gilgandra.	N. C. & A. D. Bennett	3,293 4 6
State Highway No. 17—Newell Highway, Shire of Talbragar. Supply and delivery of up to 105,000 cubic yards of fill material for deviation of Newell Highway near Troy.	J. L. Johnston Pty	27,500 0 0
State Highway No. 17—Newell Highway, Shire of Boolooroo. Construction of 9 span reinforced concrete bridge, 180 feet long over Little Bumble Creek 21 m. south of Moree.	Central Constructions Pty Ltd ..	24,159 0 0
Warringah Expressway—Municipality of North Sydney. Construction of Section 1—Sydney Harbour Bridge to Miller Street, Cammeray with a temporary connection to Chandos Street.	Reed and Mallik & Stuart Bros Pty Ltd	4,986,181 10 3
Main Road No. 145—Shire of Woodburn. Construction of 7 span reinforced concrete bridge, 369 feet long over Bungwalbyn Creek, 3.75 m. from Coraki.	Central Constructions Pty Ltd ..	95,700 0 0
Main Road No. 286—Shire of Snowy River. Supply and delivery of 60,000 cubic yards of basecourse and 13,940 cubic yards of aggregate to stockpiles at Snowy Adit, Island Bend.	Utah Constructions & Engineering Pty Ltd.	79,397 0 0
Main Road No. 328—Municipality of Ku-ring-gai. Construction of reinforced concrete overbridge 120 feet long at Malga Avenue.	M. R. Hornibrook (N.S.W.) Pty Ltd ..	36,905 0 0

SYDNEY HARBOUR BRIDGE ACCOUNT

Receipts and Payments for the period from 1st July, 1964 to 30th June, 1965

Receipts	£	*Payments*	£
Road Tolls	1,897,535	Cost of collecting road tolls	200,627
Contributions—		Maintenance and minor improvement	301,620
Railway passengers	142,934	Interest, exchange and management expenses on loans	581,000
Omnibus passengers	15,288	Alterations to structures	7,742
Rent from properties	53,439	Administrative expenses and Miscellaneous charges	41,776
Miscellaneous	434	Transfers to Expressways Fund	1,180,000
Loan Borrowings for the Warringah Expressway		Provision of traffic facilities	35,873
approach	250,000	Toll collection equipment and establishment	2,560
	£2,359,630		£2,351,198

State Highway System of the State of New South Wales



STATE HIGHWAYS . . . . . .

DIVISIONAL BOUNDARIES . .

DIVISIONAL OFFICES . . . . .

Area of New South Wales, 309,433 square miles.

Length of public roads within New South Wales, 131,200 miles.

MILEAGE OF MAIN AND DEVELOPMENTAL ROADS, AS AT 30th JUNE, 1964

State Highways	6,533
Trunk Roads	4,163
Main Roads	11,590
Secondary Roads (County of Cumberland only)	132
Tourist Roads	136
Developmental Roads	3,018
	25,572
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	1,030
TOTAL	26,602

Sydney: V. C. N. Blight, Government Printer—1965