MAIN ROADS

Wagga

September 1949

MAIN ROADS.

Issued Quarterly by and with the Authority of the Commissioner for Main Roads.

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CONTENTS.

	PAGE.
Before a Road is Built ...	1
Narrow Width Seal Coat ...	3
Payments from the Road Funds for period 1st July, 1948, to 30th June, 1949 ...	5
The Great Western Highway—A romance of early road-building ...	6
Coonabarabran to Narrabri direct road completed ...	16
S.A.A. Explosives Code Published ...	20
Bridge Construction to Aid Rural Settlement ...	21
Completion of Direct Main Road Link between Guyra and Dorrigo ...	25
Progress in Construction of Bridge over the Hunter River at Hexham ...	29
Tenders Accepted ...	31
Sydney Harbour Bridge Account ...	32

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Cover Page.

A view looking towards Sydney from the Great Western Highway where it ascends the Blue Mountains at Lapstone Hill.

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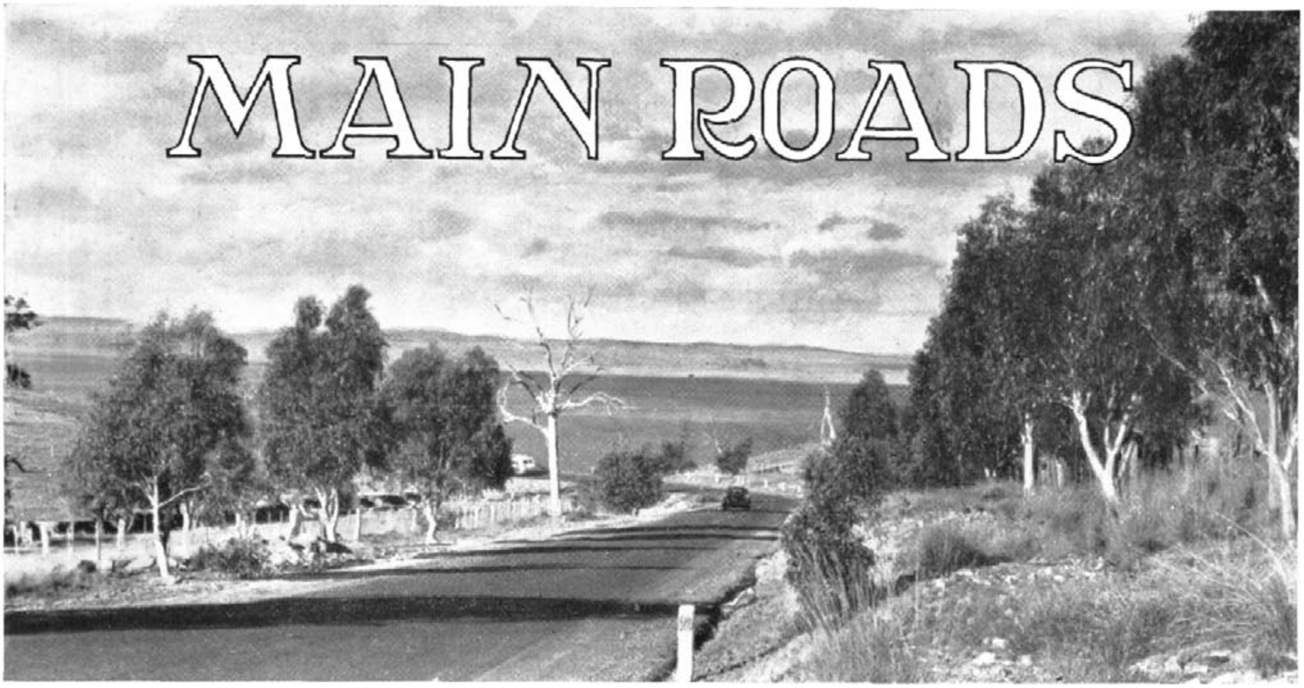
MAIN ROADS



Vol. XV, No. 1. *Sydney, September, 1949.* 1

Before A Road Is Built.

Certain preliminary actions are always necessary before any engineering work is undertaken. Unless these preliminaries are put in hand well in advance of the time when funds are to become available to carry out the work, then delay in commencing operations is inevitable.

This is not always realised by public bodies and citizen groups, who are sometimes at a loss to understand why works are not promptly started after authorisation. This is particularly the case at present when there is such a lag in road improvement to be overcome as a result of the suspension of such work during war years. The explanation is usually found to lie in the fact that those preliminary actions which can be carried out in advance, have not been completed.

It is the purpose of this article to describe the preliminary actions called for prior to the undertaking of road construction or reconstruction, in particular those actions which lend themselves to execution well in advance of construction.

Road works, in common with all engineering works, require preliminary investigation, study and design if the best construction results are to be secured. In addition, consideration has to be given to the interests of private persons and of public bodies who may be affected by the proposed work, and this also involves investigation, usually followed by correspondence, discussion and negotiation.

It is true that individual large road construction works, especially in the country, can be put in hand quickly by day-labour by a large constructional organisation, in times of emergency or other special need. This result is achieved by a concentration of effort in dealing with essential preliminaries, and in the establishment of a suitable field organisation backed by the necessary supply services. The number of individual jobs is usually few in number in such circumstances, and this facilitates action. In addition, the carrying out of road work by day-labour makes it possible to put operations in hand prior to the completion of all detailed survey and design, although this course is not to be recommended where it can be avoided.

In normal times, concentration of effort on particular jobs is not practicable, as there are always a great number of jobs of varying size at various stages of advancement, and each must receive individual consideration in the light of local circumstances. For example, the location, grading and alignment of a road should be such that the road will meet the traffic needs of the locality for many years to come, or that it can be readily amplified later without major alteration to existing work. Further, the work must be so planned and designed as to obtain the greatest value from the funds to be expended.

The investigation of these features entails much detailed work both in the office and in the field. In fact, the time required in advancing the plans and other preliminary actions to the point where work can start usually extends over a greater period than that involved in the actual construction.

Before the plans can be accepted as satisfactory, aspects to be investigated in detail include future volume and class of traffic, design speed, severance of private property, widening of road reserve, economy of construction, nature of ground and subgrades, availability and suitability of paving materials, and the type of excavation.

In rural road location work, great economy of time and money has resulted from the use of aerial surveys to define the limits within which the most economical line for a deviation or new road will be found. This method has been widely used by the Department of Main Roads in new construction projects in rough country, and also in the Western Division of New South Wales. Even so, the trial locations must be gone over in detail on the ground, examining such features as the nature of the excavation which will be met, i.e., hard or soft rock or earth, and any severance or disturbance of properties. Further examination of the trial lines on the photographs is then made in the office, and a comparison made of the cost and general suitability of available alternatives. The land-owners affected are consulted, and any objections considered.

In rural areas the type of pavement to be laid depends for the most part on the local materials available, such as stone, gravel or sand-clay. The thickness of pavement depends on the bearing capacity of the subgrade material as well as on the pavement material. Samples must be taken of all types of the subgrade soils on which the new pavement will be placed, and these, as well as available pavement materials, tested by the methods described in "Main Roads," March, 1948.

The preliminary actions necessary in the case of road construction in cities, are more numerous than those involved in country works. Further, the extent of the preliminary actions necessary in city work will usually depend on the extent to which the work will interfere with buildings or with public utility services, and whether road widening or new location is involved.

Future traffic requirements in both Sydney and Newcastle are now well established, as a result of planning work carried out during recent years. Future road locations have been shown on maps, and future traffic volumes have been estimated, so that required road widths may be readily determined. Where existing streets must be followed, location, grading and alignment must be largely accepted as it exists. Nevertheless, minor improvements are frequently required and the difficulty of effecting these in built-up areas is often much greater than would appear from their size, due to the various interests concerned. Apart from minor improvements, design for reconstruction of existing streets is more one of co-ordination and compromise than it is in rural construction. Alteration of levels at the kerb and property boundaries is reduced to a minimum consistent with the requisite crossfall of the new pavement, but where alteration of levels cannot be avoided the new levels are advertised under section 264 (2) of the Local Government Act. The Act allows one month for property owners to lodge their objections. If objections are received, the plans are reconsidered, with a view to adjustment to overcome the objections. If adjustment is not practicable the levels are fixed in terms of the Act, leaving the objectors the right to claim compensation for provable "damages."

Drainage is of paramount importance in all road work. In urban work it is of special legal as well as technical significance. It is generally necessary to amplify the existing underground drainage system to clear the water rapidly from the surface and the gutters. Most of the water usually arises from land outside the boundaries of the road, and the Main Roads Act provides that the cost of amplification of a drainage system on a main road in the County of Cumberland is to be shared between the Council and the Department in the proportions of the amount of water which arises from outside the road boundaries and that which arises from within the boundaries. Before the work is started, therefore, drainage proposals must be submitted to the Council for its consideration.

The established practice of public utility authorities using roads as a route for their mains and cables has created special problems in road construction and maintenance. Their solution to a large degree depends on the co-operation of all concerned. For many years past it has been the practice, in order to reduce to a minimum the subsequent opening of road pavements for repairs, to locate all new service mains in the footpaths. For this purpose definite widths under the footpath have been allotted to each authority. When plans for an urban road reconstruction are prepared, copies are forwarded to the utility authorities concerned, and the opportunity is taken to move any service mains in the roadway to the footpaths. Where widening of the road reserve or alignment is to be carried out concurrently with road reconstruction, all private property affected must be acquired before the mains are put into their new position. This involves the preparation of plans for the removal of fences and walls, and for the re-establishment of access on the new alignment. Following agreement being reached with the owners, this portion of the work must be completed to permit the formation of the new footpath. Only then can the movement of the public utility services take place.

The preliminary difficulties encountered in arranging for the commencement of road works have been aggravated during recent years in the metropolitan area of Sydney where the adjustment of buildings and of utilities is involved. The shortage of building materials and of iron and steel pipes has been the principal factor in these delays. As a consequence, where the alteration or the demolition of buildings is involved, the difficulties are such that it has generally been found necessary to defer the work until such time as the position improves.

The only way to reduce delays in commencing works after authorisation, is to make all possible preparations well in advance of funds becoming available. This involves the carrying out of all necessary investigations and surveys, preparation of plans, acquisition of land, testing of soils and gravels, etc. It means the planning of a construction programme over a period of years. This practice was widely followed in prewar years, but as a result of shortage of technical staff has not always been possible since the war, but it is only by construction planning and the making of preparations well ahead, that delays in starting works after authorisation can be minimised.

Narrow Width Seal Coat.

USE ON MITCHELL HIGHWAY

During the last ten years, bituminous surfacing has been extended west of Narromine towards Nyngan, on the Mitchell Highway. In order to secure the benefit of bituminous surfacing over as long a length as possible, the width of the seal coat was fixed at 10 feet 6 inches, although the gravel pavement is 18 feet wide and formation width 26 feet between Narromine and Trangie and 16 feet and 24 feet respectively between Trangie and Nyngan.

When the work was first undertaken, traffic was generally less than 100 vehicles per day. At present daily traffic on the section between Narromine and Trangie is about 140 vehicles per day, and between Trangie and Nyngan about seventy vehicles per day.

The total length from Narromine to Nyngan is 78 miles. The road throughout is over flat country, and has a high standard of alignment, except in the vicinity of two level-crossings near Trangie. Average annual rainfall in the area is between 15 and 20 inches.

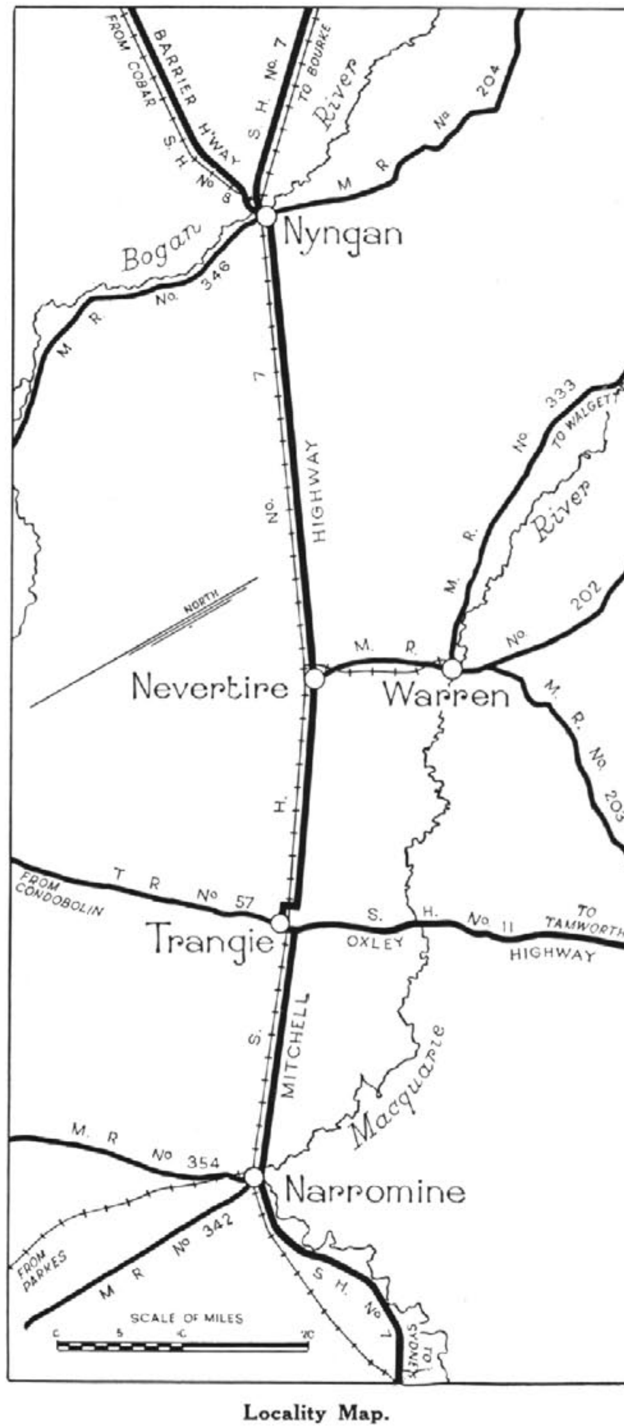
In flat country on roads of good alignment, travelling speeds tend to be high and where, as in this case, there is little tree shelter, losses of gravel are high. The relatively low rainfall and the high summer temperatures contribute to this.

The diagram on page 4 shows the years when sealing or resealing has been carried out over the various sections, and the binders used, and the rates of application per square yard. It will be noted that the bituminous surface remains to be completed on the last 14 miles to Nyngan. This is planned for the forthcoming summer.

Before the road was sealed, it was difficult to avoid the frequent occurrence of a corrugated surface, resulting in discomfort and added wear and tear on vehicles. At the same time, dust not only made travelling conditions unpleasant, but made overtaking and passing of vehicles hazardous due to the reduced visibility brought about by dust. Losses of gravel were high.

The application of the narrow seal coat has eliminated these features, and has given most of the advantages of a full-width sealed road at a much reduced initial cost. The seal coat is centrally located on the gravel pavement, and there has been no evidence that any special danger arises due to the narrow width. Passing or overtaking movements occur without difficulty, each vehicle running half on the bitumen and half on the gravel flank. Maintenance of junction of bitumen and gravel has not proved difficult or costly, and there is a noticeable lack of breaks along the edge of the seal coat.

On account of the fact that the bituminous surface has been extended gradually over the length from



Locality Map.

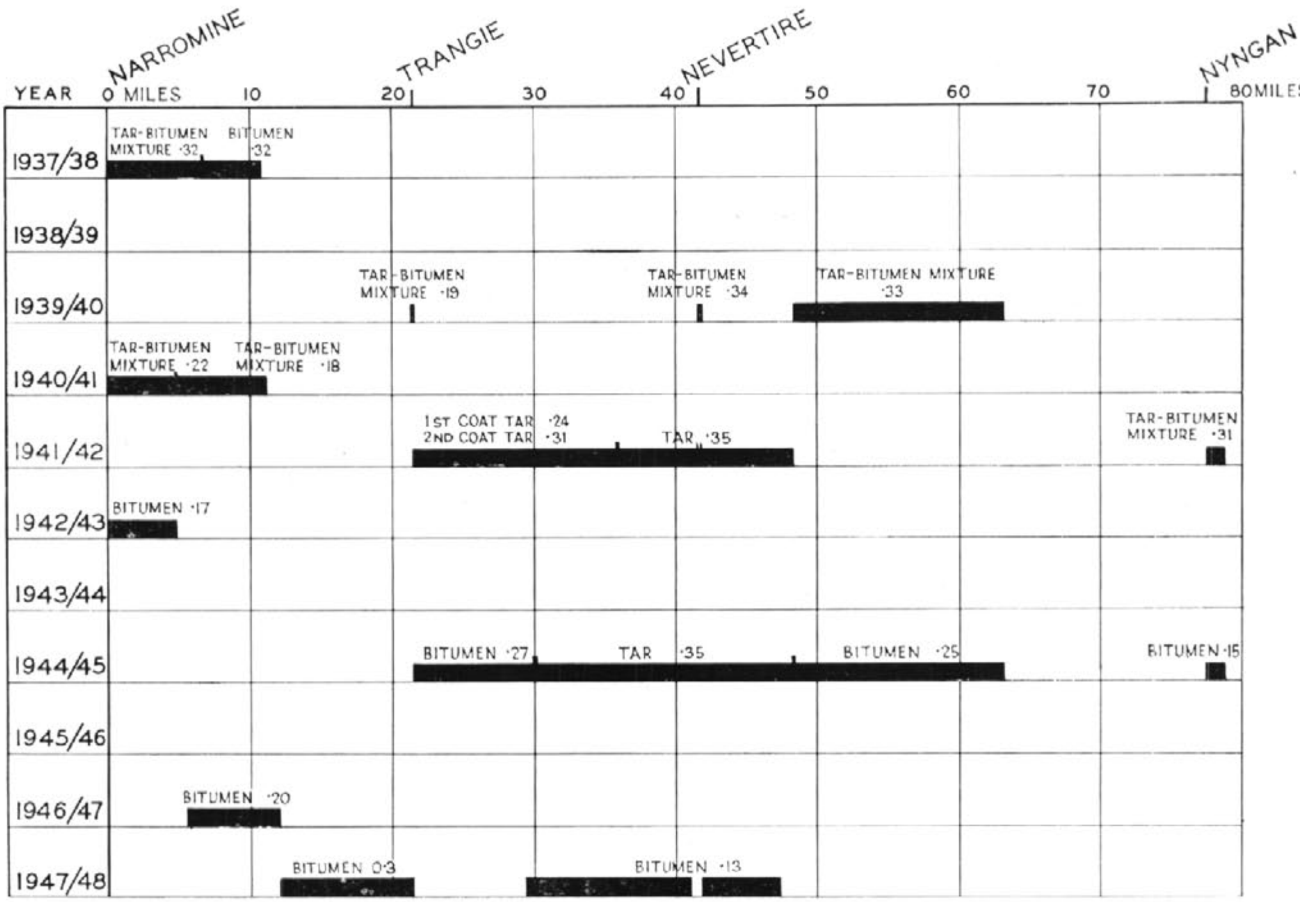


Diagram showing Bituminous Surfacing Work carried out between Narromine and Nyngan.

Narromine towards Nyngan, there are available comparative maintenance costs of sealed and unsealed sections extending over a period of years.

For the period 1939 to 1948 it is found that the average total cost of maintenance (including renewal) per annum for the gravel lengths has been 75 per cent. higher than the cost for the bitumen lengths (including re-seals). It should be noted, however, that gravel is scarce in the district, and thus costly.

Vehicles passing on a section of road with narrow width seal coat.

Comparison of maintenance costs of the half width seal west of Narromine with the full width seal east of Narromine, extending back to Dubbo, indicates that, under the conditions prevailing on this road, a narrow-width sealed road is substantially lower in maintenance cost than a full width sealed road carrying up to about 100 vehicles per day. It appears that maintenance costs of the two types under the conditions described will be equal at about 150 vehicles per day, or perhaps slightly more. This will not necessarily apply in other districts where different conditions prevail in regard to climate, nature and speed of traffic, availability of gravel. The exact economic maintenance limit in each case can only be determined by trial.

There appears to be good ground for concluding that on roads in inland areas carrying traffic in excess of fifty vehicles per day, the economics of undertaking bituminous surfacing should be fully considered in the light of local conditions. Further, that in inland areas a narrow seal coat of 10 feet 6 inches wide or thereabouts is generally economical in maintenance cost and sufficient for traffic of the order of 100 vehicles per day. On account of reduced initial cost of a narrow width seal coat as compared with a minimum width two-lane seal coat of 18 feet width, the length which can be done with a fixed amount of funds will be from 60 per cent. to 70 per cent. greater.

Narrow width sealed pavement between Nevertire and Nyngan (S.H. 7).

PAYMENTS FROM THE ROADS FUNDS FOR PERIOD 1st JULY, 1948 to 30th JUNE, 1949.

	Amt. Paid. £
County of Cumberland Main Roads Fund—	
Construction of Roads and Bridges	655,072
Acquisition of Land and Buildings for Road Widening	12,739
Maintenance of Roads and Bridges	433,922
Interest, Exchange and Repayment of Loans	32,742
Other Expenditure	97,242
Total	£1,231,717
Country Main Roads Fund—	
Construction of Roads and Bridges	1,100,662
Acquisition of Land and Buildings for Road Widening	7,574
Maintenance of Roads and Bridges	1,937,710
Interest, Exchange and Repayment of Loans	217,181
Purchase and Repair of Plant and Motor Vehicles	259,261
Other Expenditure	167,435
Total	£3,689,823
Developmental Roads Fund—	
Construction of Roads and Bridges	75,860
Other Expenditure	2,003
Total	£77,863
Summary, All Funds—	
Construction of Roads and Bridges	1,831,594
Acquisition of Land and Buildings for Road Widening	20,313
Maintenance of Roads and Bridges	2,371,632
Interest, Exchange and Repayment of Loans	249,923
Purchase and Repair of Plant and Motor Vehicles	259,261
Other Expenditure	266,680
Total	£4,999,403

The Great Western Highway.

A ROMANCE OF EARLY ROAD-BUILDING

The Great Western Highway from Sydney across the Blue Mountains to Bathurst is Australia's most historic road. Across it flowed a stream of settlers to the vast areas of slopes and plains in the western inland. Soldiers, convicts, and gold diggers have trudged and driven along it across the harsh and rocky ridges of the mountain barrier. In the early days of the Colony of New South Wales it was probably the construction of the road over the Blue Mountains that saved the small settlement around Port Jackson from abandonment.

The Great Western Highway, changed in form, but largely along the original route, still serves as the principal means of road access between Sydney and western New South Wales. Now, however, there are frequent towns along its length—ever-popular health and holiday resorts on the ranges, agricultural settlements where conditions are favourable, and coal mining and manufacturing. The Great Western Highway terminates at Bathurst, 130 miles from Sydney. Beyond Bathurst a network of highways and roads leads on to the western limits of the State.

The Passage of the Blue Mountains.

The first settlers in New South Wales found the narrow strip of country between the coast at Sydney and the Blue Mountains disappointing, both for agriculture and grazing. The poor quality of the land for grazing was emphasised during a severe drought in 1812 which caused such big losses of stock as seriously to deplete the food supply, and threaten the lives of the settlers. It became apparent that, if good agricultural and grazing country were not found, the future of the colony was imperilled. It was the urge to extend and consolidate the resources of the colony, as well as the spirit of adventure, that prompted the first attempts to find the route for a road across the Blue Mountains.

Governor Phillip saw the Blue Mountains for the first time in 1788 from a point near Pennant Hills during an exploration on the northern side of Sydney Harbour. He gave the name of "Carmarthen Hills" to that part which is the present day Kurrajong, and "Landsdown Hills" to that part between Lapstone and Pyramid Hill (Razorback). The name "Blue Mountains" was adopted soon after, because of the bluish haze enveloping them. Governor Phillip had no reason to believe that the Blue Mountains were anything more than a range of hills that could be explored when time permitted. As Captain Tench put it, "Should nothing intervene to prevent it, the Governor intends shortly to explore their summits." The next 25 years were to show how difficult it would be to force a passage to the grassy plains beyond the Blue Mountains.

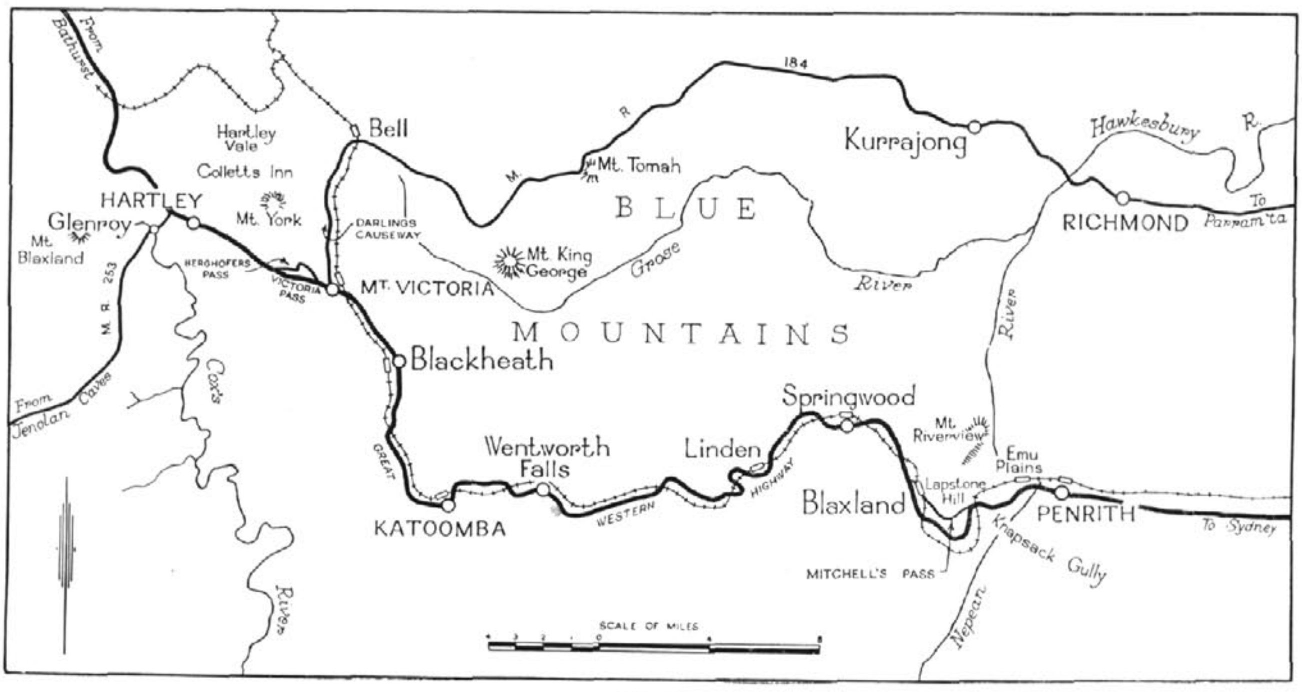


Fig. 1.

A track west from Sydney was formed as far as Rosehill (Parramatta) in 1788, when Phillip established a farm there. In June, 1789, Captain Tench pushed farther west and discovered the Nepean River which flows from south to north at the foot of the eastern ascent to the Blue Mountains. When he gave the name of "Nepean," he was not aware that it was the upper part of the stream already named "Hawkesbury."

From 1793 onwards, several attempts were made to find a route across the Blue Mountains. In that year William Paterson set out from Richmond and entered a canyon-like valley of the Grose River, a tributary of the Nepean, but the tangle of valleys and precipitous slopes forced him to turn back. Quartermaster Hacking of the "Sirius" made another attempt in 1794, but there is no detailed record of his route. Two years later George Bass, who had accompanied Hacking, tried to find a track via Mount Tomah and Mount King George, but again the roughness of the country proved too great, and the expedition was forced to return.

Governor King was keen to find out what lay beyond the Blue Mountains, and the circumstances of Lieut-Barrallier's attempt in 1802 are amusing. King admitted that it was nothing more than a ruse. He was anxious that Barrallier should lead a party, but owing to a squabble at the time and a rule forbidding military personnel from leaving their posts to undertake works of exploration, the Governor could not instruct Barrallier to carry out his purposes. He therefore had Barrallier appointed to the Vice-Regal staff as an aide-de-camp "and that the object of discovery should not be totally relinquished. I sent him on an embassy to the King of the Mountains." Barrallier's direction was via the present-day district of Picton and the Nattai River. He gave up after becoming lost in the valley of the Kowmung River, an area still inaccessible except to those on foot or horseback.

In 1804 George Cayley set out from the junction of the Grose and the Hawkesbury Rivers and reached Mt. King George before he was forced to return. He put in a dismal report on the prospects of ever finding a route across the Blue Mountains.

After years of disappointment Governor King wrote, "As far as respects the extension of agriculture beyond the first range of mountains, that is an idea that must be given up as the rocks to the west of that range wear the most barren and forbidding aspect, which men, animals, birds and vegetation has ever been strangers to, a better proof of which may not be adduced than the remarks of one of Cayley's party in returning, who exclaimed on seeing two solitary crows that they had lost their way."

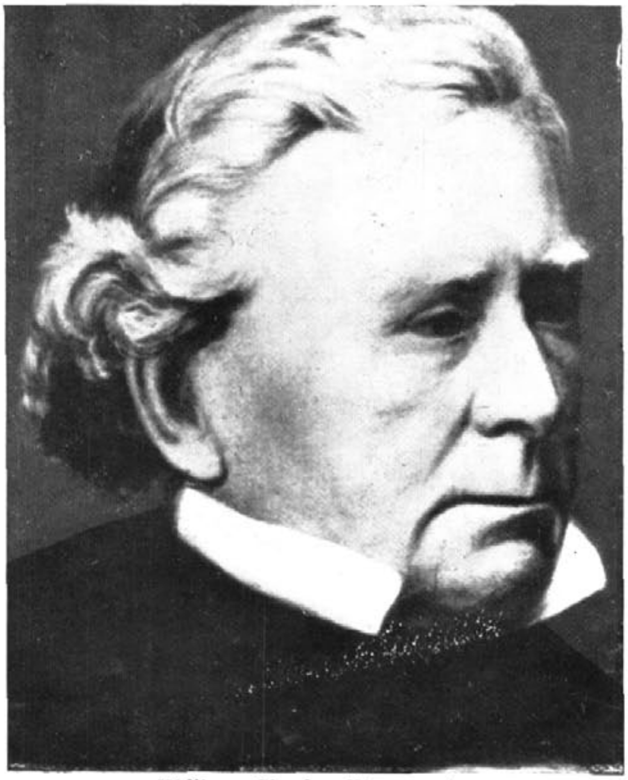
Gregory Blaxland who was interested in grazing and breeding cattle and sheep, was worried by the poor pasture country in the coastal belt. He felt that there if it was to be confined to such a narrow strip. He was one who had suffered heavy losses of stock during the was little hope for the continued existence of the colony drought of 1812 and determined to find out if good pasture country lay beyond the Blue Mountains. Reports of those who had attempted the crossing were

Gregory Blaxland.

discouraging. Cayley told him that the Blue Mountains "must inevitably remain an insurmountable barrier to the extension of the settlement."

Blaxland had been one of a party in 1811 that had accompanied Governor Macquarie by boat up the Warragamba River, a tributary of the Nepean. He had also explored the western side of the Cowpastures (the district around Camden) in an endeavour to find grass for his cattle. He had noted the course of the Warragamba and Grose Rivers and formed the opinion that the watershed between them might provide a ridge that would lead into the heart of the Blue Mountains and possibly serve as a track to whatever lay behind. He found that he could ascend the ridge at Emu Plains, about midway between the Grose and the Warragamba Valleys, which was what he had hoped.

At this time Governor Macquarie was worried by severe losses of stock and a poor harvest. He was, like previous Governors, ever anxious to find more land to provide food for the colony. He, therefore, encouraged Blaxland to put his "theory of the ridges" to the test and to organise an expedition to the west. Blaxland considered the undertaking too big for one man and invited Mr. William Wentworth and Lieut. Lawson to join him. They agreed to follow his plan to keep the streams which appeared to flow into the Warragamba River on their left hand and those that appeared to flow into the Grose River on their right hand.



William Charles Wentworth.

On Tuesday, 11th May, 1813, "Mr. Gregory Blaxland, Mr. William Wentworth and Lieut. Lawson, with four servants, five dogs, and four horses loaded with provisions, ammunition and other necessities, took their departure to endeavour to explore the interior of the country and effect a passage over the Blue Mountains between the Western River (Warragamba) and the River Grose."

The details of the journey are recorded in journals kept by the explorers. Those that followed in their path were amazed that the party were able to penetrate such rough and inhospitable country. Often the tree growth was so thick that progress could only be made by going over the same ground three times. The line of march would be explored and marked out one day. The following day the line would be cleared, the party returning to camp at night. The next day would be occupied in moving camp forward to the new site. They went up the side of the ridge near Penrith, kept along the top of the hills as due west as possible, avoiding every gully, and reached Mt. York on the western rim of the Blue Mountains and began to descend to the wide valley below on the 29th May, 1813. At the bottom they proceeded through "Meadow land clear of trees and covered with grass two and three feet high, sufficient to support the stock of the colony for the next thirty years." They had not crossed the

A view of Mount York in the vicinity of Little Hartley.

main range but they saw enough from the top of Mt. Blaxland, the point from which they commenced the return journey, to convince them that the worst part of the track had been traversed and that the Blue Mountains had been conquered at last.

Governor Macquarie was so impressed by the reports of the three explorers that he sent Surveyor Evans to survey the route and extend the exploration further west (Fig. 2.) Evans crossed the Nepean River on the 19th November, 1813, and reached Mount Blaxland on the 26th. Four days later he crossed the Main Dividing Range and camped on the Fish River. He followed the Fish River to its junction with Campbell's River, passing through Sidmouth Valley and O'Connell's Plains, close to the route of the present railway to the west. The stream formed by the junction of the two rivers he called Macquarie

William Lawson.

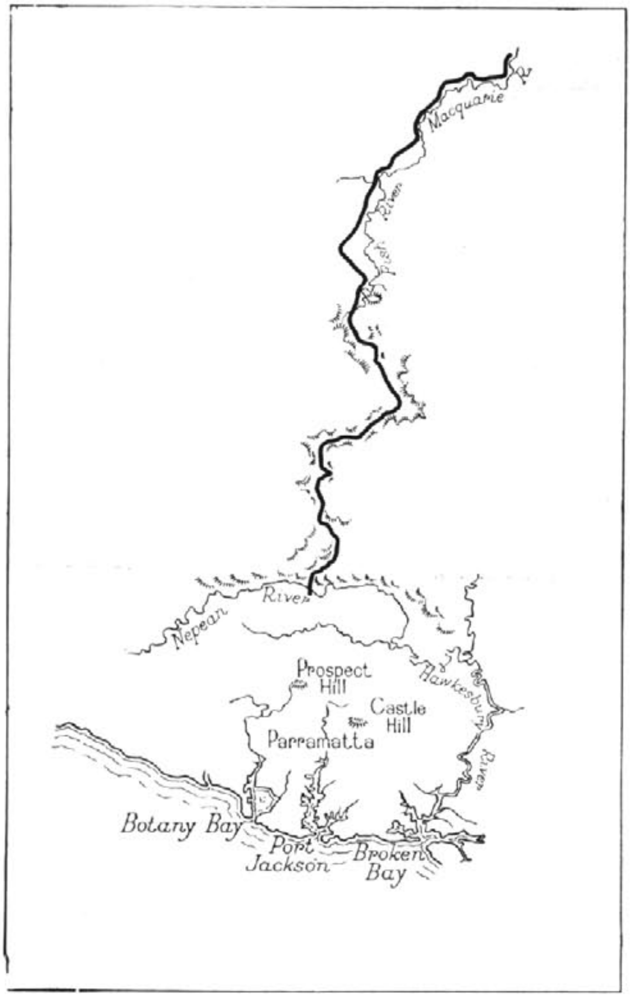


Fig. 2. G. W. Evans' Survey, 1813, of the Blue Mountains Road to which Cox constructed the First Road to Bathurst in 1814-15. (From G. W. Evans' original map in possession of the Mitchell Library.)

River. On the 9th December he camped on a site which subsequently became the city of Bathurst.

The exuberance of Evans' journal indicates the joy he felt on passing into this beautiful country. Typical extracts from his journal are: December 5, 1813, "I cannot speak too highly of the country, indeed I am at a loss what to say as it exceeds my expectations and daily gets better." December 6, "This place is worth speaking of as good and beautiful—I am at a loss for words to describe the country." Evans was quite sure that the country could not be developed properly until a road was built. "I beg to observe that it will be impossible to drive cattle or attempt sending a cart until the road is made, for the reasons that the stumps and brush and sharp granite rocks will run into their feet and lame them."

Evans' expedition proved that Blaxland, Lawson and Wentworth had discovered a practical route over the Blue Mountains, and that the country to the west of the mountains could solve the pressing problem of the colony for good grazing and farming land sufficiently extensive to permit of its growth.

George W. Evans.

The First Road.

Governor Macquarie decided that no time was to be lost in building a road across the mountains to Bathurst, and consulted William Cox, J.P., of Clarendon, near Windsor, a former Captain in the New South Wales Corps, regarding the project. As a result, Cox volunteered to undertake the work. Governor Macquarie gave Cox full authority to build a carriage road from the ford at Emu Plains "across the Blue Mountains to the Macquarie River and a centrical part of Bathurst Plains." Before Macquarie's written instructions reached him, Cox had started the job.

Macquarie instructed that the road was to follow Evans' survey, where possible. Full permission was given to deviate from this line where in Cox's opinion a better route was available. The road was to be made "at least 12 feet wide so as to permit two carts or other wheel carriages to pass each other with ease. The timber in forest ground to be cut down and cleared away 20 feet wide, grubbing up the stumps and filling up the holes, so that a four-wheel carriage or cart may pass without difficulty or danger. In brush ground it is to be cut 20 feet wide and grubbed up 12 feet wide. Any small bridges that may be found requisite to be made must be 12 feet wide. I conceive this to be a sufficient width for the proposed road at present, but where it can with ease and convenience be done, I should prefer the road to be made 16 feet wide."

Cox's party consisted of thirty convicts, with a guard of eight. He selected "well inclined hardy men who had been some years in the colony and accustomed to field labour." He assembled the party on the banks of the Nepean River near Emu Plains on 17th July, 1814, and on the 18th, "At daylight gave out the tools

William Cox.

for the workmen to handle and put in order and issued half a week's ration to the party." They crossed the river, and Cox examined the ground across Emu Plains and fixed on the point for the ascent. So that Cox would not be pestered by idlers watching the progress of the work, Governor Macquarie issued an instruction that no person was to cross the Nepean without a pass signed by himself.

The physical difficulties to be overcome were considerable. The route ahead went through thick timber and scrub. Sandstone cliffs lay in the path. The road had to climb to a height of nearly four thousand feet, and the work had to be done with tools which by modern standards were little more than primitive. Added to these difficulties was the fact that the work commenced in the middle of winter. The effects of exposure to the rigorous climate of the Blue Mountains at this season of the year soon reduced the strength of the working gang. In spite of this, over one hundred miles of road were built in the incredibly short time of six months. An idea of the rate at which the work was done may be gained from an entry in Cox's journal under date 4th October:—"Finished the road this evening to the 30th mile." Seventy-eight days after the commencement thirty miles of road had been built, through rugged country and under most unfavourable conditions. There was, for instance, the steep ridge near Linden. Of this Cox records, "We came to a high mountain which will cost much labour to make a road over," and later "had to remove an immense quantity of rock."

At the beginning of November the builders reached the western crest of the mountains at Mount York and were faced with their biggest problem, that of getting off the mountains to the "forest ground" below. The first reports brought by the men in advance were that the cliffs were so steep that it would be impossible to build a road down. When Cox himself went forward to inspect the descent on November 3rd, he was appalled at the sheer drop of the cliffs and "found it much worse than I expected." He examined the possibilities of putting a road down the mountain and wrote, "I have therefore made up my mind to make such a road as a cart can come down empty or with a very light load without a possibility of its being able to return with any sort of a load whatever, and such a road will also answer to drive stock down to the forest grounds. It is a very great drawback to the new country, as no produce can be brought from thence to headquarters except fat bullocks or sheep. The sheep will also be able to bring their fleeces up and be shorn on the mountains." Cox faced his tremendous task with characteristic resolve and ordered his men to "put up the forge for the blacksmith to repair all tools for the Herculean mountain. Issued to all hands a gill of spirits." The road in parts had a grade of 1 in 4. (Fig. 3, line "A".)

From the foot of Mount York it was comparatively easy. He continued his road through the present-day Hartley Vale and Glenroy. From Mount Blaxland it went south-west to the headwaters of Jock's and Antonio's Creeks, crossed the Fish River near

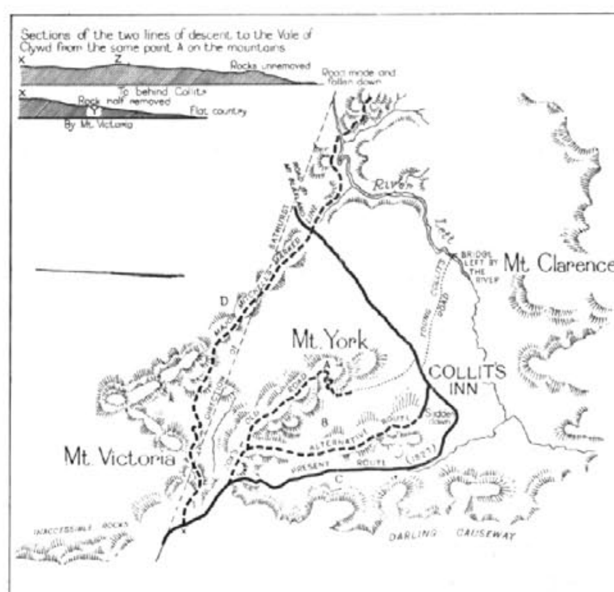
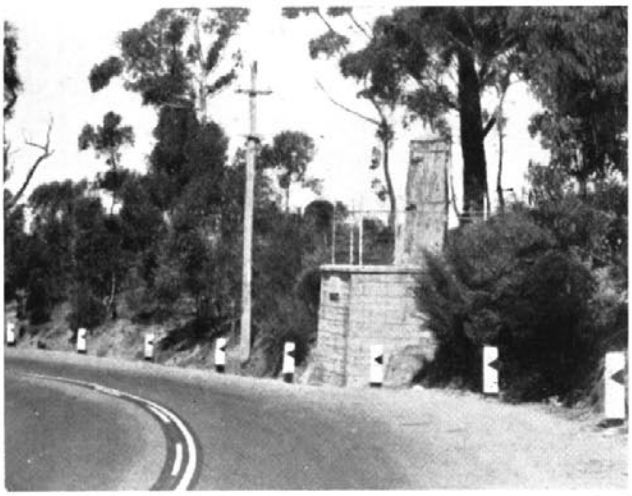


Fig. 3. Routes from Mount Victoria to Hartley, 1830. Cox's road followed the ridge to Mount York where it descended to Collit's Inn. When Mitchell assumed office a deviation had been in use for some years (marked "Present Route" in figure) and an alternative line was proposed, to be later discarded for the Victoria Pass (shown as "Major Mitchell's marked line" in figure) which was opened on 23rd October, 1832. (From Major Mitchell's Report on Roads, 1827-1855, in the Mitchell Library.)

Hobby's Creek and reached Bathurst by way of O'Connell's Plains, crossing the Campbell River at White Rock.

Governor Macquarie, with his wife and an official party, set out on the 26th April, 1815, to drive over the new road. The site of the stay on the first night, Macquarie called Springwood. The party arrived at the "Grand Depot, Bathurst Plains," on Thursday, May 4th. On Sunday, May 7th, with a good deal of ceremony, "the British flag was displayed for the first time in this new country," and Governor Macquarie gave the place and new town to be marked out, the name of "Bathurst."

The descent of Mount York was rather terrifying. Logs were tied behind carts to steady them down the



Explorers' Tree, Great Western Highway, Katoomba, marked by Blaxland, Wentworth and Lawson on the first crossing of the Blue Mountains.

steep grade. At the bottom the logs were unhitched and left strewn over the road. These accumulations became so bad at times that parties of convicts were sent to clear them. To bring a loaded cart up the pass was a laborious process. Heavy staples were fastened into the rocks at the steepest points with iron rings attached, which acted as anchors. With the aid of pulleys and ropes bullocks driven down the hill could assist laden vehicles up the worst pinches.

Reference has been made to Cox's observation that sheep on the western plains would have to carry the wool on their backs up the pass and be shorn on the mountains. Soon after the completion of the road a woolshed was established at Blackheath (near Mount York), where the shearing was done until the opening of the Victoria Pass in 1832.

Collits' Inn:

On the journey west from Sydney the traveller stayed the second night at the Golden Fleece Inn, or as it is more generally known, Collits' Inn. The inn was situated near the road at the foot of Mount York in the Vale of Clwydd. Pierce Collits, the proprietor, earned a reputation as a genial host who provided good food and accommodation. An account in 1825 says

Collit's Inn at the foot of Mount York. Built 1823.

that one partook "of the good cheer of mine host of the 'Golden Fleece', whose good humour and hospitality will tend to smooth the rugged asperities of the way."

The building is still standing, and is known today as Mount York Farm.

Cox's road apparently fell into a bad state of disrepair. On June 26, 1827, "The Monitor" complained bitterly, "The road is particularly bad at this time, for being full of springs, it is not uncommon for the vehicles to sink up to the nave in the swampy flat on the other side of Mount York. After passing Collits' house you find the bridge has been carried away. It was a good bridge but has not since been supplied with a new one. However for want of a bridge, to pass this place is fraught with such danger and difficulty as none but British settlers would overcome. You will see reputable men up to their middles in mud, straining their horses, till altogether give it up for a bad job."

Cox's descent of Mount York was abandoned in favour of a route, the discovery of which is credited to Lieutenant Lawson, who had accompanied Blaxland and Wentworth on the first exploration. The date of construction is uncertain, but the route was in use in 1827 and carried the traffic to the west until 1832. The line left the Mount Victoria-Mount York road immediately north-west of the present turn-off to Berghofer Pass. The road fell steeply to the valley, the grade being no better than Cox's line. It had the advantage, however, of getting stock to water and grass in the valley quickly. (See Fig. 3, Line "C".) The two constructed routes down Mount York can be traversed today, although not trafficable by vehicles.

Attempts to find other routes across the Blue Mountains:

On the 13th August, 1827, Governor Darling issued a Government Notice offering a reward of a "Grant of land, cattle, or such other reasonable indulgence as may be preferred" to any "free person" who reported to the Surveyor of Roads a better route to Bathurst. It was to be understood that the route was to "avoid if possible Mounts York and Blaxland, the passage of which presents serious Impediment to the Communication with the Country beyond the Blue Mountains."

Archibald Bell had discovered a route in 1823 from Richmond via Mount Tomah to Cox's River. The track was extremely rough and some of the grades very steep. The route was never popular and was abandoned in 1834. The present-day Main Road No. 184 from Richmond to Bell follows Bell's line closely, and provides an alternative route to portion of the Great Western Highway.

Hamilton Hume set out in an attempt to earn the Governor's reward. He avoided the descent of Mount York by turning north-west at Mount Victoria, and followed a range he called Darling's Causeway (Fig. 3), from which he claimed there was an easy descent to the valley. From the bottom he suggested three alternative routes to Bathurst. "The first of which is through Lithgow's valley about 10 or 12 miles from where I turned off the present road to Bathurst and leads in a direction for O'Connell's Plains leaving the Fish River at Mount Evans (or Evans Crown) a little to the southward. The other two tracks pass near Walerawang (the residence of Mr. Walker)—one is about 4 miles north of that gentleman's farm and crosses a new line of road (lately discovered) leading towards Mudjee—the other is to the south-east of Mr. Walker's and leads into a line of road proposed by Mr. McBrien from Collett's Inn to Bathurst and which was approved by Sir Thomas Brisbane."

In his capacity of Surveyor-General, Major Mitchell was instructed to report on Hume's line. He reported that while it fulfilled the conditions of avoiding Mounts York and Blaxland and was a fairly easy grade, he himself favoured a "valley road" and one in a more direct line to Bathurst. Another objection was that Hume's road would not be accessible to the settlers on the Fish River and O'Connell's Plains, "who must otherwise still use the hilly road of Mount Blaxland." From the foot of the mountain Mitchell advocated a line to Bathurst that would avoid Mount Blaxland and be more direct than the route taken by Cox. (Fig. 4.)

Major Mitchell.

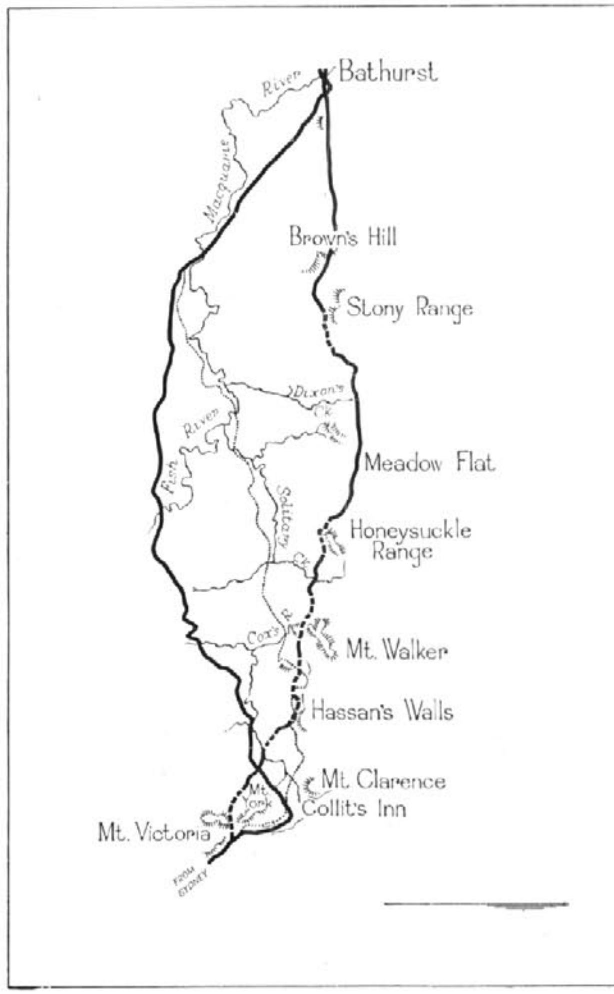
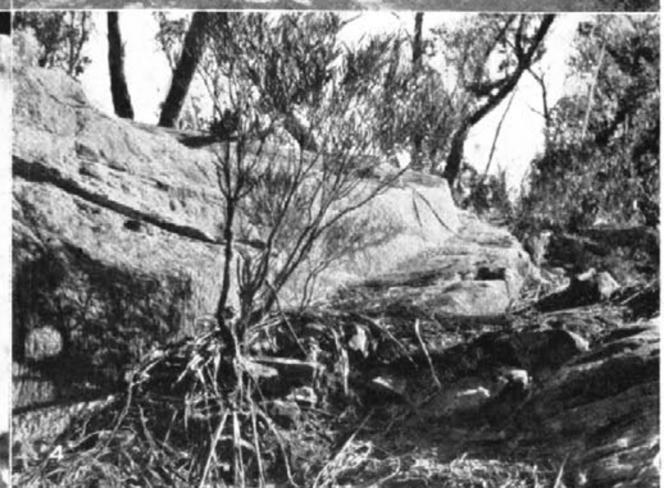


Fig. 4. New Location of Road between Mount Victoria and Bathurst suggested by Mitchell, 1827. Adopted 1830. Cox's road is shown on the left, crossing Mitchell's line and passing Collit's Inn. Lightly dotted line is the road cleared by mistake in 1829. (From Major Mitchell's Report on Roads, 1827-1855, in the Mitchell Library.)

Mitchell was much upset when he learned that young Collits (James) had received a grant of 640 acres in 1829 as a reward for a suggested line of road which practically followed that of Mitchell. The Colonial Secretary had to admit, when the matter was pointed out to him, that the credit for the line lay with Mitchell.

In 1827, Mitchell reported that "between the old descent on the Mount itself and the present descent there is an inferior ridge or *colline* which falls gradually, advancing into the valley near Collett's Inn. I rode up this extremity and it did not seem to present



1. **Mitchell Pass. Built 1834. View looking towards Emu Plains**
2. **Portion of original road across Blue Mountains, Woodford, built by William Cox. Observer is pointing to edge of road.**
3. **Brass plate on Mount York marking rock cut away to permit Governor Macquarie's carriage to descend Cox's road down Mount York.**
4. **Another section of road built under direction of William Cox down Mount York in 1814.**
5. **Original buttressed retaining walls on Victoria Pass leading from Mount Victoria to Hartley. Built under Surveyor-General Mitchell, October, 1832, and still in use.**
6. **Descent from Mount York via Berghofer Pass which is seen on the lower part of the picture. Opened 1912.**

difficulties, which a little practical skill and science might not overcome." A start was later made on the construction of this route (Line "C", Fig. 3) from the valley end, the route being cleared by Major Lockyer about 1829, and generally referred to as Lockyer's road. During construction a landslide occurred, completely blocking part of the road. It appears that nothing further was done to complete the construction of the road and it never came into use, but instead Mitchell put in hand a road down the Victoria Pass along a better route discovered by him. The construction work carried out by Lockyer can be traced on the ground in the vicinity of Collits' Inn.

Construction of the Victoria Pass:

Major Mitchell was always most keen to find the best routes for roads and in their improvement generally. He was impatient with the rigid procedures of the officials at Sydney, when they attempted to block his projects. He was criticised hotly by the Colonial Secretary over his proposal to build a pass down Mount Victoria which eliminated the steep descent of Mount York. Mitchell found that, with some construction, he could maintain a grade of 1 in 15 down Mount Victoria into the Vale of Clwydd, compared with a maximum grade of 1 in 4 down Mount York. (Fig. 3, Line "D".)

Mitchell regarded this deviation as so important that he commenced work immediately without informing his superiors, which irritated them very much. The main cause of their annoyance was that much labour and money had been expended on Mount York and, in fact, Mitchell had recommended a line down that mountain (*i.e.*, Lockyer's Road). The Colonial Secretary considered that future efforts should be concentrated on the Mount York line before any alternatives were considered. His letter to Mitchell contained the peremptory injunction, "I am accordingly directed to request that you will understand that the line of descent from Mt. York to Colletts now in progress, is to be completed, and that the line proposed by you is not to be adopted or commenced." Further, the principle was stated that even if certain roads had features which were not desirable, it was better to put up with them rather than incur the additional expense of starting new lines. An angry exchange of letters took place, and Mitchell resolved to resign rather than forego his desire to prove that he had found a better descent of the mountains. Mitchell stormed, "I defy any man ever to point out any material improvement in the lines laid down by me, for they have been marked only after a more careful survey of the ground than is made for such purpose even in Europe", and "I cannot conscientiously sit down in Sydney and pocket that salary without caring whether roads are made right or wrong." Mitchell eventually won his point and the Governor permitted him to build the Victoria Pass, which he declared open in 1832. Victoria Pass is the descent still in use, although slightly altered on its lower section since. From Mount Victoria the Victoria Pass, in part, traversed a narrow ridge from which valleys fell away on either side. In order to get a satisfactory grade, the road had to be built up. Mitchell directed his men in placing a tremendous amount of earth and rock filling, the sides of which were supported by buttressed walls of massive masonry. (See Fig. 3, Line "D".)

Berghofer's Pass:

Many of the early motor cars found the grade of the Victoria Pass too steep and often needed the assistance of horses. Agitation for a better route was led by Mr. J. W. Berghofer, who was the first president of Blaxland Shire after the passing of the Local Government Act in 1906. As a result of his efforts an extensive deviation of the Victoria Pass was constructed, and subsequently became known as Berghofer's Pass. This road had easy grades, but very sharp curves. Its construction was commenced in 1907, and after many delays, it was finished in 1912.

Berghofer's Pass became the main road down the mountains from Mount Victoria, and the Victoria Pass was neglected. In 1920 Victoria Pass was made trafficable again, the grade being more easily negotiated by the higher powered motor vehicles which had by then come into use. Both roads were used for some years, but in 1933-34 the Department of Main Roads improved the Victoria Pass by widening and reconstructing the gravel pavement. Near the foot of the Pass a steep pinch was eliminated by the construction of a minor deviation. The Pass was subsequently surfaced with bitumen, as part of the general bituminous surfacing of the Great Western Highway.

The Ascent at Lapstone Hill:

The first ascent of the Blue Mountains from Emu Plains as originally constructed by Cox was used for seventeen years. The ascent was steep and the frequent flooding of Knapsack Gully made another route desirable. A road known as the "zig-zag road" was built between Emu Ford and the Pilgrim Inn (Blaxland). (Fig. 5, Line "A".) This road left the site of the present Emu Plains Railway Station and reached the foothills about a mile north of where the road today crosses the railway line, and reached the top of Mount Riverview to join the old road at the Pilgrim Inn.

Governor Darling had instructed Mitchell to lay out the town of Emu. Before this could be done Mitchell contended that the line of the Great Western Road must be fixed particularly in relation to the ascent at Lapstone. While traversing the "zig zag road" in May, 1830, he found a gully that offered possibilities of a better route. "I therefore proceeded to examine the gully which descends most directly from the Pilgrim towards the proposed site and I found that it would admit of the most direct and least inclined road that can be possibly made between that point and Emu Plains." He referred to the gully through which Lapstone Creek flows. (Fig. 5, Line "B".)

A deviation was accordingly put in hand and finished in October, 1832, when Governor Bourke drove over it on a visit to Bathurst, and named it "Mitchell's Pass." Describing it in 1846, Lieut.-Colonel Munday wrote, "The highway is absolutely carved out of the living rock. Huge slices of the hillside have been blown off by blasting, hurled by convict crowds into

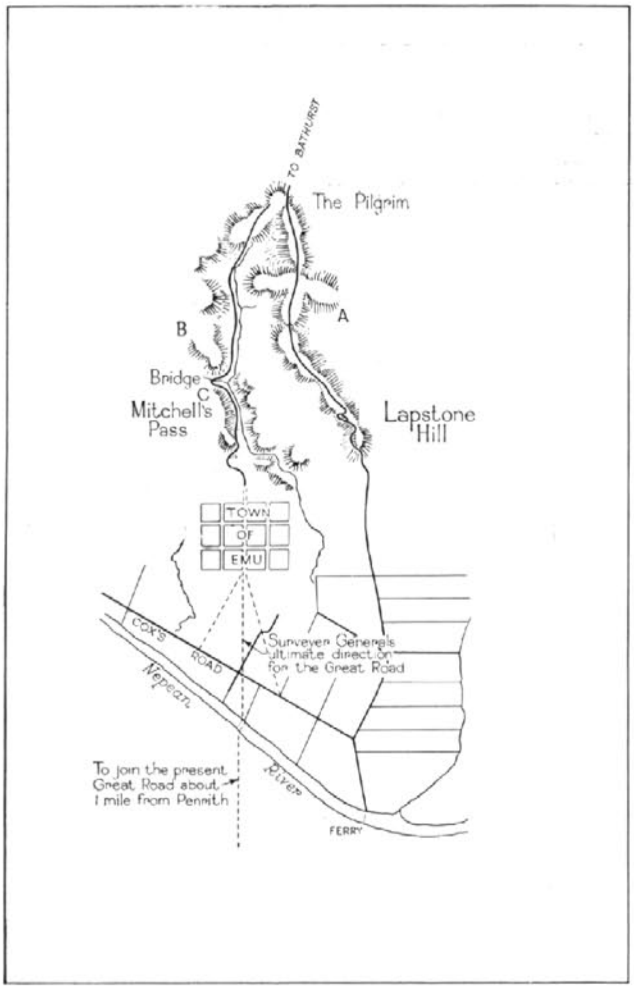


Fig. 5. The Zig Zag Deviation of Cox's Road and Mitchell's Lapstone Deviation, 1834.
Cox's road bore away south joining the deviation near the Pilgrim Inn. (From Major Mitchell's Report on Roads, 1827-1855, in the Mitchell Library.)

the gulph below or pounded by them into the material now called Macadam."

Lennox Bridge:

When Mitchell was constructing his pass from Emu Plains he found that a bridge would have to be built at the head of the gully across Lapstone Creek. (Fig. 5, "C".) He employed David Lennox to design and build the bridge, which thus became the first scientifically constructed stone arch bridge of any magnitude on the Australian mainland. The bridge is built of stone quarried about five hundred yards further up the gully. It is still standing and in use, and carried all the traffic to the west up till the construction of the deviation in 1926.

In 1926 a further deviation was built from Emu Plains, to obtain improved grade, alignment and width. A railway deviation had left an abandoned track, including a bridge across Knapsack Gully. A road was built by the Main Roads Board along the old railway track, using the bridge, and traffic ceased to use Mitchell's Pass as the main route. The deck of the old railway bridge over Knapsack Gully has been widened to accommodate the present-day volume of traffic.

Bridging the Nepean River:

The first permanent means of crossing the Nepean River was by ferry. As settlement developed around Penrith and Emu Plains and land was taken up in the west, the ferry over the Nepean became inadequate. The first bridge, a wooden structure, was opened on the 1st January, 1856. This was washed away by a flood at the height of a heavy storm in August, 1857. The bridge was re-erected, but was swept away again in 1860. Crossing by ferry was then resumed and remained till 1867. In that year the most severe flood in the history of the district to that time caused the water to rise to the centre of the present site of Penrith. The ferry was carried away.

In 1867 a bridge was opened to carry the extension of the railway from Penrith to Weatherboard (Wentworth Falls). The bridge was sufficiently wide to carry a single line of road traffic as well as the railway. "An electric bell gave audible notice that the road was occupied to any one at the farther end." Commenting in June, 1905, *The Herald* said "The bridge is said to be unique, but the bell is provenly erratic and is a gurgling tremolo as terrifying to the uninitiated horse as the sound of the train itself." This bridge is the present road bridge. It was given wholly to road traffic in 1907, when a new railway bridge was opened.

The Great Western Highway To-day:

The Great Western Highway to-day still follows for the most part the route of the early road builders. The building of the main railway to the west during the sixties and seventies of last century altered the line of road in some places. Local deviations have also been constructed to improve grade and alignment, particularly in the section beyond the mountains. An extensive deviation between Mount Victoria and Bathurst was described in the December, 1929, issue of this Journal.

ACKNOWLEDGMENTS.

Material for this article has been taken from the following publications:—

Road Engineering and its Development in Australia (H. H. Newell, C.B.E., M.Inst.C.E., M.I.E. Aust.);

The Woolshed at Blackheath (W. R. Glasson);

and the following made available by the Mitchell Library:—

Gregory Blaxland's Narrative and Journal.

Historical Records of Australia. Series 1, Vol. 8.

Memoirs of William Cox, J.P.

Major Antill's Diary.

Official History of the First Crossing of the Blue Mountains.

Australian Encyclopedia.

Major Mitchell's Report on Roads, 1827-1855.

Various Volumes of the Journal of the Royal Australian Historical Society.

—A.W.

Coonabarabran to Narrabri Direct Road Completed.

NEW SECTION OF NEWELL HIGHWAY. 69 MILES LONG.

Early in 1938, a south-north inland State Highway was proclaimed, extending from Tocumwal on the Victorian border to Goondiwindi on the Queensland border. The new State Highway was named Newell Highway, after the first Commissioner for Main Roads. The route adopted was from Tocumwal via Narrandera, West Wyalong, Parkes, Dubbo, Gilgandra, Coonabarabran, Narrabri and Moree to Goondiwindi. The route followed existing roads to the greatest possible extent. The section between Gilgandra and Coonabarabran already formed part of State Highway No. 11 (Oxley Highway). Two major sections of new construction were required, one between Narrandera and Wyalong, and the other between Coonabarabran and Narrabri. This article describes the construction of the Coonabarabran—Narrabri section, a length of 69 miles of new work.

The route adopted for the new road between Coonabarabran and Narrabri leaves the Oxley Highway about 3½ miles east of Coonabarabran, proceeds generally north to north-easterly, crossing the extremity of the Warrumbungle Range between 4 miles and 12 miles from Coonabarabran, and thence passing through the Pillaga State Forest. At 13 miles south of Narrabri it crosses a dog-proof fence on the northern boundary of the Pillaga East State Forest. The route then passes through the settlement of Bohena and, at 6 miles from West Narrabri, joins an existing road formation constructed by the Namoi Shire Council.

For the first 43 miles from Coonabarabran, the country is undulating and the road crosses a series of sandstone ridges, these becoming lower and less frequent as the road proceeds northward. For the last 29 miles the country has a slight fall only, and in places becomes virtually flat.

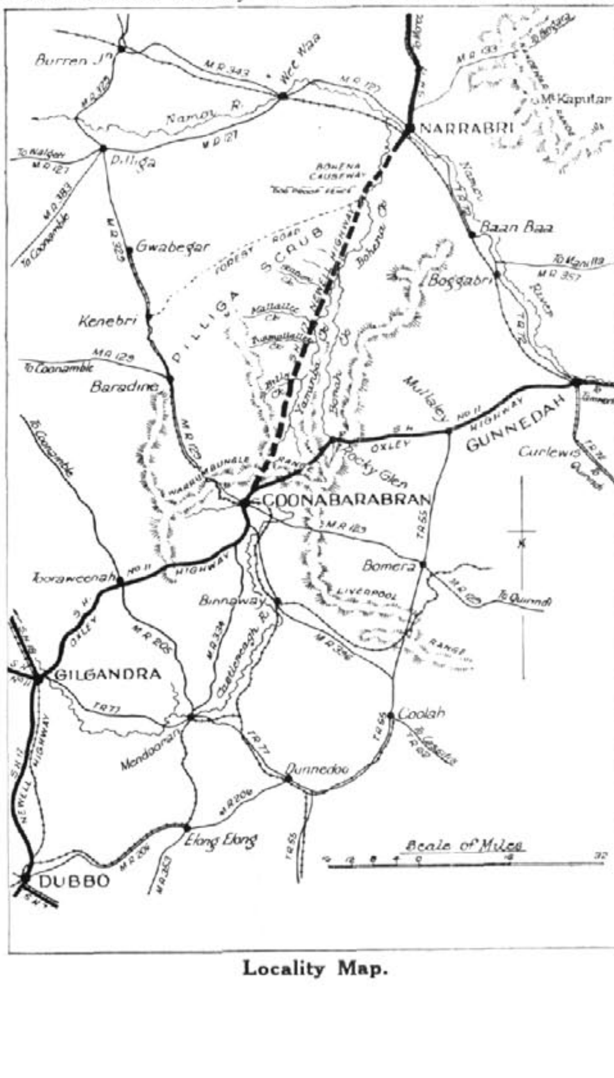
Levels along the route are as follows:—

Coonabarabran	1,669 feet above sea level.
Top of Warrumbungle Range (7 miles from Coonabarabran) ...	1,985 feet above sea level.
End of sandstone ridges (43 miles from Coonabarabran) ...	1,080 feet above sea level.
West Narrabri	698 feet above sea level.

Almost the entire belt through which the route passes is in the area known as the "Pillaga Scrub." The soil generally is poor, being a fine sandy loam which in places becomes almost raw sand. A hard clay or rock subsoil is frequently found at about 2 feet depth, making the country difficult for construction purposes in wet weather, as water collects in pockets on the impervious subsoil. The timber is mainly ironbark, bloodwood and gum, with some cypress pine in areas where the soil is deepest. In most places there is an undergrowth of bloodwood or gum suckers, wattle and other low scrub. Although eight major watercourses are crossed by the road, during the last two years running water was available for only a few days after heavy rain.

Survey.

Aerial photographs of the route were obtained in conjunction with the Forestry Commission, which had already arranged for aerial photographs of State Forests in the Pillaga Scrub area. The aerial photography was completed in May, 1939, and possible alternative routes were located on mosaics. These were then investigated on the ground, and finally a reconnaissance survey of the selected line was made.



Locality Map.

Camp. 17m. from Coonabarabran.

and the line blazed in readiness for final survey. Although the final survey was commenced in 1940, it was not finished until August, 1946, the work being suspended at the end of 1940 owing to the war.

Design Standards.

The minimum radius of horizontal curves is 1,600 feet, and curves of larger radii have been used wherever practicable. Vertical curvature is based on a 50 miles per hour design speed. A formation width of 28 feet was used in undulating country, a flat country type cross-section being used elsewhere over a total length of 35 miles. The width between kerbs on timber beam bridges is 20 feet.

Catchment areas of the larger streams were obtained either from parish and county maps, or from aerial photographs. In the flat areas towards Narrabri catchment areas could not readily be identified, and it was decided to place pipe culverts as seemed necessary during construction. Where channels were found to be well defined, culverts have since been built, but in a number of cases installation has been delayed until there is experience of the effects of heavy rain.

Construction.

Work was commenced from the Coonabarabran end, where the heaviest earthworks were located. A

Formation work in progress following clearing.

headquarters and depot were established at 3½ miles from Coonabarabran at the junction with State Highway No. 11 (Oxley Highway). A small advance party started the clearing of the depot site in June, 1946, and actual road construction was commenced in July, 1946.

The following principal plant items were used on the work.

- 2/110 H.P. Tractors operating 12 c. yd. scoop power ripper dozer blades.
- 2/90 H.P. Tractors operating 8 c. yd. scoop power ripper dozer blades.
- 1/60 H.P. Tractor operating 6 c. yd. scoop angle blade.
- 1/40 H.P. Tractor operating manual ripper or pulling trees with cable.
- 2/2 Hammer Air Compressors—For rock excavation.
- 2 Heavy Power Graders—For formation work.

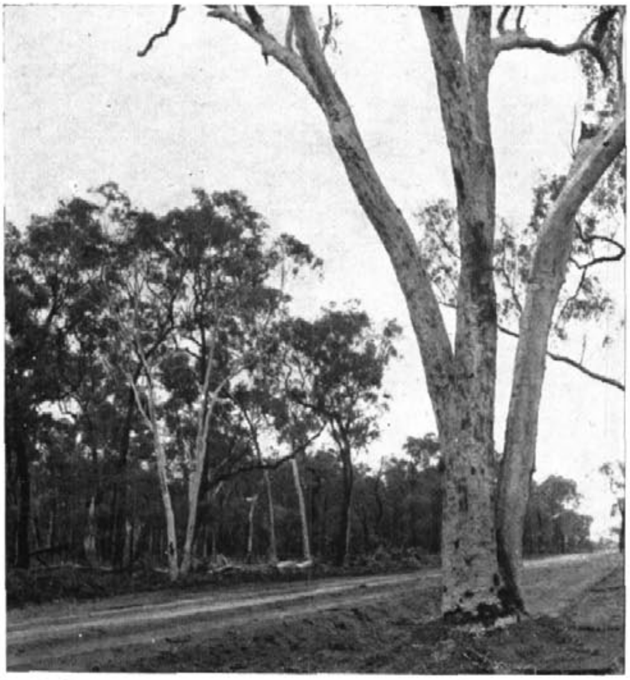
The plant was divided into two main units, the clearing and light formation unit, and the heavy earth moving unit, the former unit working in advance of the latter.

Causeway over Bohena Creek. Gravel filling being bladed into position.

Clearing and Light Formation.

The advanced unit normally comprised one 90 h.p. tractor with angle dozer blade and power ripper, and one or two power graders, one grader being used for about 25 per cent. of the time on trimming heavy earthworks and on maintenance.

The clearing was carried out by the 90 h.p. angle dozer, trees over 12 inches in diameter being either pulled with 4-inch wire rope, or loosened by blasting and then pushed over. The use of two tractors and heavy wire cable was not adopted for tree pulling as it was found that many of the larger trees were hollow and broke off near ground level if pulled without preliminary loosening. Under good weather conditions an average rate of ⅜ mile per day was obtained for pushing down standing timber, and removing the debris. After the preliminary clearing, the formation area was ripped to remove roots. At first a 40 h.p. tractor and small ripper were used, but this was found



Typical view of a section of completed road in flat country.

to be unsatisfactory, and was replaced by a 90 h.p. tractor and large ripper. The clearing was generally made about 10 feet wider than the formation on the high side of the road. This additional area was first used as a by-track during forming operations, and later for construction of catch drains. The light earthwork was moved by the power graders. These were also used for making and maintaining temporary by-tracks as required over rocky spurs, or around bridge sites. When not in use on other work, it was economical to use the 60 h.p. angle dozer for building up the grader formation, two passes being made down each table drain, thereby nearly halving the number of passes required by the graders.

Earth Moving.

The total earthworks as designed were estimated at 160,000 cubic yards, the major part of this being in the first 46 miles from the Coonabarabran terminal. The rock encountered, mainly on crests of ridges, was a soft to medium hard sandstone with some clay and ironstone bands. Where cuts were shallow, it was found possible to break up the rock with the power ripper for shifting by 8-cubic yard and 12-cubic yard scoops. Where the cuts were deeper and could not be handled by the power ripper, the rock was loosened by blasting, using Monobel as the explosive with primers of 60 per cent. gelignite.

The usual blasting procedure was to bore approximately twenty holes, which were fired electrically. After firing, a further round would be bored, this being repeated until the whole cutting was shot. "Bulling" of holes was not practicable, due to the soft nature of the rock. The loosened rock was then ripped and removed either by dozer or large scoops depending on the lead.

In the deeper cuttings the rock was taken out in lifts of 6 feet. Shooting to a greater depth tended to break the rock into pieces too large to handle, owing to the main force of the charge escaping through soft clay seams instead of shattering the rock.

The greater part of the heavier earthworks was moved by the 8-and 12-cubic yard scoop units. The shot rock from the cuttings was shifted by bulldozers on short leads not exceeding 200 feet.

Structures.

Structures have been kept to a minimum. They comprise six timber beam bridges ranging from single 20-ft. span to four 25-ft. spans, concrete box culverts, and concrete pipe culverts in sizes from 18 inches to 48 inches diameter. The number of concrete box and pipe culverts has been greatly reduced by the construction, where possible, of stone causeways with timber edge logs.

Grouted stone headwalls were used on all pipe culverts up to about 40 miles from Coonabarabran, owing to the absence of any suitable course aggregate in the area. On culverts nearer the Narrabri end concrete headwalls were used, the coarse aggregate being obtained from a quarry at Narrabri. Four motor grids were constructed, three of normal type and one specially designed for erection where the Highway crosses the dog proof fence. This grid is 14 feet long by 20 feet wide, in four sections to facilitate handling. The grid is raised above ground level so that wild dogs running along the fence will tend to pass beneath the grid. The length of 14 feet is considered sufficient to prevent dogs jumping across.

Bohena Creek Crossing.

At 8 M. 5,000 feet from Narrabri the Highway crosses Bohena Creek, which drains an area of approximately 750 square miles. The construction of a bridge, which would have been between 400 and 500 feet long, would have meant a heavy expense not warranted at this stage of development of the road. A crossing adequate for present needs was provided by the construction of a causeway 500 feet long.

Due to the absence of any suitable stone in the area, the causeway was constructed by first excavating to a depth of approximately three feet below finished surface level, then backfilling with approximately 18 inches consolidated thickness of good quality sandy loam, and on this placing 18 inches of consolidated gravel. The upstream edge of the causeway is provided with a log cut-off, and the downstream side with an apron constructed of logs on bearers bolted to driven piles to prevent scour.

The finished level of the causeway is slightly above the stream bed, which for a distance of 100 feet above and below the causeway has been graded off to give an even flow over the full length. Two defined channels upstream have been graded into "bell-mouths" to assist in ensuring an even flow over the causeway.

Pavement.

Experience on a forest road in the area had shown that the fine sandy loam forming the soil over much of the area traversed could itself serve as a running

Finished construction over foothills of Warrumbungle Range.

surface for light traffic, and it was therefore decided to use this wherever possible, as a form of "stage" construction, to be improved later when necessary. Deposits of gravel are very scarce and would have entailed haulage of up to 25 miles. Generally, the natural sandy loam proved to be suitable, but in some cases it was necessary to excavate borrow pits and use material found at a depth below 18 inches from the surface. This was handled economically by large scoops as the leads were short.

On some isolated sections suitable material was not available near the site, the natural material being either sandy or boggy. For these sections suitable sandy loam was secured at a distance, and loaded by scoops, operating over a loading ramp into lorries.

Organisation.

The first camp was located at the construction headquarters and depot within easy distance of the railway and other facilities in Coonabarabran. As the work progressed camps were built for employees at about 17-mile intervals, three advanced camps in all being constructed. Choice of camp sites was largely dictated by access and availability of water. The work was controlled by an engineer, with two clerical officers, two foremen and two gangers, the foremen and gangers moving out to the advanced camps as the work progressed.

The total job strength averaged 45 men, but more labour would have been used if available. This shortage of labour resulted in some delay in the construction of culverts.

Servicing of the plant was carried out by the plant operators with the assistance of a fitter, who had the use of a mobile workshop, trailer type electric welding plant and oxy-acetylene welding set. Top overhauls were usually carried out on the plant at the site, as on account of the distances to be travelled, it was not economical to bring plant into the depot. A mobile steam cleaning unit was also used on the job, and was found to be most efficient for cleaning large items of plants.

Completion of Works.

All work has been completed except the construction of six timber beam bridges, for which contracts have been let. Where necessary, all rock excavations in approach to the bridges have been completed, so that finishing off the approaches can be done by light plant.

Quantities and Costs.

The following are details of principal quantities and unit costs:—

Length of construction work: 69 miles.

Quantities for Main Items:

Clearing and grubbing 415 acres.
Earthworks (solid measurement)—Earth 127,955 cubic yards.
Rock 32,045 cubic yards.
Flat country Formation 183,543 lin. feet.
Trimming and consolidating subgrade and shoulders 337,073 lin. feet.
Pavement (sandy loam) 6 inches consolidated thickness 138,000 square yards.
Concrete pipe culverts sizes 18"—48" 5,946 lin. feet.
Grouted stone headwalls 355 cubic yards.
Concrete in box culverts 126 cubic yards.
Catch drains 151,000 lin. feet.
Gravel and stone causeways 2,295 lin. feet.
By-tracks and access tracks over rocky spurs, around bridge sites, etc., 15 miles.
Timber bridges (six) 20 feet wide between kerbs 340 lin. feet in all.

Unit Costs for Main Items:

(Direct costs only exclusive of Workers' Compensation Insurance, Pay Roll Tax, Holidays, Camp, Depot, General Engineering and Clerical Supervision costs.)

Clearing and grubbing £14 5s. od. per acre.
Earthworks (solid measurement).
Average for earth and rock 2s. 6d. per cubic yard.
Flat country formation £1 14s. 3d. per 100 lin. feet.
Trimming and consolidation of subgrade and shoulders £1 7s. 6d. per 100 lin. feet.
Pavement (sandy loam) 6 inches consolidated thickness 6d. per square yard.
Concrete pipe culverts average 19s. 5d. per lin. foot.
Grouted stone headwalls £4 5s. od. per cubic yard.
Concrete in box culverts £8 14s. od. per cubic yard.
Catch drains £1 12s. 6d. per 100 lin. feet.
Gravel and stone causeways £1 8s. od. per lin. foot.
By-tracks and access tracks £100 per mile.
Timber bridges (six) contract wok £42 per lin. foot.

Supervision.

The work of construction was under the general direction of the Department's Divisional Engineer, North Western Division, Mr. R. J. Butler. The Engineer in immediate charge was Mr. R. Fitzhardinge.

S.A.A. Explosives Code Published.

The Standards Association of Australia has recently published a standard explosives code, being rules for the storage and use of explosives. The purpose of the Code is the establishment of uniformity in explosives practice throughout the Commonwealth of Australia with the object of securing safety for person and property.

The preparation and publication of the S.A.A. Explosives Code will be of great value to all those authorities whose work embraces the use of explosives, not least to those responsible for the construction or improvement of roads. The committee entrusted with the preparation of the Code included representatives of government departments and scientific and industrial organisations. The Department of Main Roads was among those represented.

In introducing the Code, the Association states: "This Code applies to the essential requirements and precautions for ensuring safety in the industrial use of commercial explosives. It is not in substitution of, but is to be construed in conjunction with any legal and over-riding requirement, including licensing. It does not apply to ammunition or fireworks (rockets, fog-signals, etc.). Safety requirements for the transport of explosives by sea, land and air, are not included in this code, and no rules have been incorporated in the code for application in coal or metalliferous mines."

The Department of Main Roads has always aimed at securing a high standard of safety in the transport, storing, handling and use of explosives, and special instructions have in the past been issued to those of its employees concerned. These instructions have incorporated the requirements of the New South Wales Department of Mines (Explosives Branch).

The publication of the standard Australian Explosives Code is welcomed as representing a pooling by all concerned of accumulated knowledge and experience. The results of the Association's work are now available in convenient and readily accessible form for the guidance of all users of explosives.

The Code is divided into eleven sections, as follows:

Section 1, *Scope and Definitions,* sets out the scope and purpose of the Code, and defines the use of the more important terms used in the Code.

Section 2, *General Requirements,* contains recommendations regarding powdermen.

Section 3, *Storage of Explosives,* is separated into four parts: The licensing, construction and location of magazines, the precautions to be observed with the operation and maintenance of magazines, the storage of detonators, and the receipt, storage and issue of supplies.

Section 4, *Conveyance on or about the Site of Operations,* gives details of receptacles and of the handling, during conveyance, of the several types of explosives in commercial use.

Section 5, *Preparation,* deals with the methods of preparation for firing.

Section 6, *Charging,* deals with drill-holes, the insertion of charges and primers in the hole, tamping and bulling.

Section 7, *Firing,* deals with safety precautions at or in the vicinity of charged holes, methods to be adopted in the various types of firing, the manner of connecting detonating fuse, the counting of the number of holes fired, and the procedure after firing.

Section 8, *Misfires,* defines what determines a misfire, the precautions to be taken in the event of a misfire, and the procedure to be adopted with regard to misfired holes.

Section 9, *Equipment and its Maintenance,* sets out rules for the care of equipment and a complete list of the articles required. Descriptions of equipment used are included, together with instructions for maintenance and testing.

Section 10, *Special Applications,* gives the special precautions to be observed in the case of submarine work and in caissons and compressed air tunnels.

Section 11, *Disposal of Surplus and Defective Explosives,* describes the more common visible manifestations which indicate that an explosive has deteriorated and become defective. It indicates also what action should be taken where an explosive appears to be damaged or defective. As defective explosives are dangerous to handle, destruction should be carried out only by an experienced person, and for this reason, instructions for the destruction of explosives are not included in the general code.

Copies of the Code can be obtained on application to the Standards Association of Australia, Science House, Gloucester Street, Sydney.

Bridge Construction to Aid Rural Settlement

NEW DEVELOPMENTAL WORKS DESCRIBED.

•

The provision of bridges and culverts at stream crossings is usually the most important aspect in creating access to areas being opened up for more intensive settlement. In many cases, also, existing constructed roads serving rural lands are largely ineffective in times of heavy rain due to the absence of bridges. It is largely for this reason that the Main Roads Act provides not only that lengths of road may be proclaimed as "Developmental," but also that isolated works, such as the provision of bridges, may be proclaimed as "Developmental".

Hereunder are described some typical recent bridge construction works which are being financed by allocations made from the Developmental Roads Fund.

Bridge Over Cox's Creek on Warialda-North Star Road. Shire of Yallaroi. Developmental Work No. 3052.

Cox's Creek Bridge is situated on an unclassified road which branches off Trunk Road No. 63 (Warialda to Yetman) at a point 12 miles north of Warialda and runs in a north westerly direction to North Star Station on the Moree-Boggabilla railway. The bridge is 25 miles from Warialda and 30 miles from North Star. The road serves a large area of country between the railway line and Trunk Road No. 63 and gives access to Warialda, the principal town of the district, and to North Star.

The area served by the road carries sheep and cattle in large numbers and also produces wheat. Produce is carried west to the Moree-Boggabilla railway or south to the railway at Warialda according to the condition of access roads and length of haul. Prior to the construction of the bridge over Cox's Creek, the Yallaroi Shire Council had improved the road generally throughout its length, but the open crossing at Cox's Creek


Cox's Creek Bridge.

remained a serious obstacle to traffic. After heavy rains, traffic blockages of up to several days were not uncommon, due to silting up of the open crossing.

The type of structure selected for the Cox's Creek crossing was a two-span low level timber beam bridge 16 feet wide, on concrete cylinder foundations. A suitable site on a straight, clear-running stretch of the creek was available a short distance downstream from the open crossing.

Following proclamation as Developmental Work No. 3052 in October, 1946, tenders were called by the Yallaroi Shire Council for construction of the bridge and immediate approaches in April, 1947. As no tender was received the Council decided to proceed by day labour, using Shire employees.

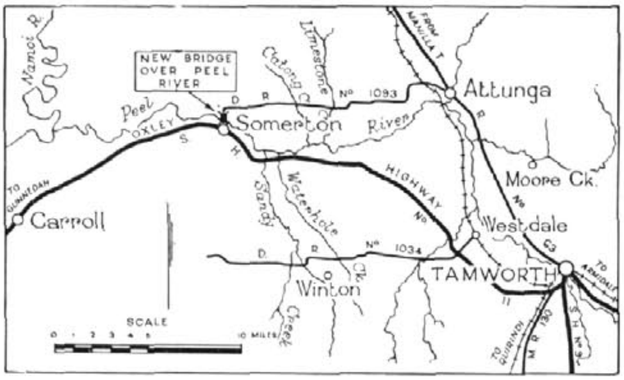
Work was commenced in October, 1947, and the bridge, including a road deviation in approach of approximately two miles, was completed in July, 1948. The cost of the bridge and immediate approaches, totalling £2,650, was financed by the Department of Main Roads from the Developmental Roads fund while the cost of deviation amounting to approximately £600 was met by the Council.

The completion of the work has materially improved transport facilities and fulfilled a long standing need for better communications in a steadily developing district.

New Bridge Over Peel River at Somerton on Somerton-Attunga Road. Developmental Road No. 1093. Shires of Cockburn and Peel.

Developmental Road No. 1093 links the villages of Somerton and Attunga, the former lying on State Highway No. 11, Oxley Highway, between Tamworth and Gunnedah, and the latter on Trunk Road No. 63 between Tamworth and Manilla. The road runs through well-developed wheat and sheep country for which the normal outlet is to rail at Attunga. On the outskirts of Somerton the road crosses the Peel River which is the boundary between the Shires of Peel on the south and Cockburn on the north.

A decision to replace the existing bridge at Somerton was reached by the Councils and the Department in 1941, but construction was deferred owing to war conditions.



The existing bridge was an old timber structure of two 30-feet and five 40-feet beam spans giving a total length of 260 feet. It was a high level bridge with short steep filled approaches at each end. While it carried all normal flows in the Peel River, on rare occasions when maximum floods occurred these would flow around the bridge and approaches and inundate both banks for a considerable width. The old bridge was located at the most economical position, *i.e.*, where the banks were highest and the width of the main stream channel the least, but the alignment of the road approaches was poor, there being two sharp bends on each side of the river.

The new bridge is located several hundred feet downstream from the old bridge, and has a straight road approach on the southern side and one 1000 feet radius curve on the northern side. It consists of two 30-feet and eight 35-feet timber beam spans totalling 340 feet in length. Deck level is 4 feet above designed high flood level and approximately 18 feet above the river bed. The approach on each bank has been kept low to allow for the passing of maximum floods on each side, but mainly to the north where the maximum flood could extend outwards for half a mile and cover the ground to a depth of up to 6 feet. Short earth-filled ramps with gravel pavement lead to deck level at each end.

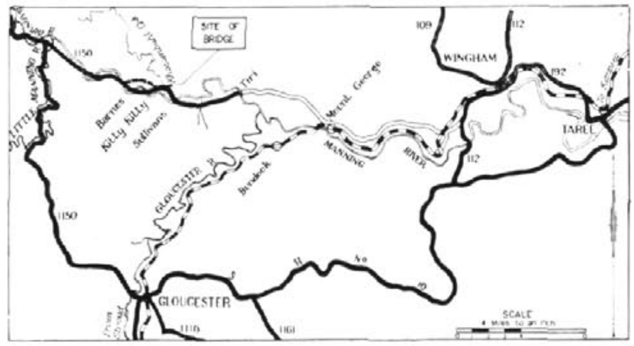
The work was carried out by contract by the Cockburn Shire Council, was commenced in October, 1948, and was in use by traffic in May, 1949. The cost of the bridge and approaches was £9,437, of which the Department of Main Roads met half from the Developmental Roads Fund, and the Cockburn and Peel Shire Councils one-quarter each.

Bridge Over Khatumbuhl Creek on Developmental Road No. 1150. Shire of Manning.

Extensive dairying and grazing lands adjacent to the Barnard and Manning Rivers are served by Developmental Road No. 1150. The eastern branch of this road, which generally follows the valley of the Manning River, provides an outlet to the North Coast Railway, to the sawmills at Mt. George, and to the bacon and butter factories at Wingham.

Settlement along both banks of these rivers took place many years ago, but the settlers were seriously handicapped in wet seasons by unreliable and frequently impassable fords across fast-flowing streams.

Bridge over the Peel River at Somerton.



Investigation surveys were made by the Department during 1934, with a view to eliminating the wet crossings. As the best lands in the valley are adjacent to the river on both sides, it was apparent that the elimination of river crossings by deviating the road to follow one side of the river would not provide the maximum assistance to the settlers, and accordingly a programme of bridge construction on the existing route was planned.

In 1935, a low level bridge was constructed at Tiri Crossing over the Manning River, the first obstacle on this road west of Mt. George. This was followed in the next year by the completion of another low level bridge at Sullivan's Crossing. A high level bridge over Callaghan's Creek, built in 1942, eliminated another ford on this road, so that by that year a reliable road communication, fully trafficable except for short periods during floods, had been provided from Wingham to a point 24 miles to the west.

Khatumbuhl Creek Bridge.

The next obstacle to be removed was a ford at Khatumbuhl Creek. The creek at this point, although dry for several months of the year, became a fast flowing stream after heavy rain, which blocked traffic for lengthy periods, on an average of six times each year.

A location suitable for a high level bridge was available just upstream from the existing ford, and plans were prepared for a high-level timber structure of three 30-feet spans, 16 feet between kerbs, founded on concrete cylinders taken down to rock, which existed about 10 feet below stream bed. However, due to the necessity to concentrate labour and materials on works required for the war effort, it was not possible to proceed with the work until 1946, when a contract for the construction of the bridge and approaches was let by the *Manning Shire Council.*

The new bridge was opened to traffic in December, 1947, but the approaches were not completed until early this year, due to shortage of materials. The cost of the bridge and approaches was £2,783 and the full cost was met by the Department of Main Roads from the Developmental Roads Fund.

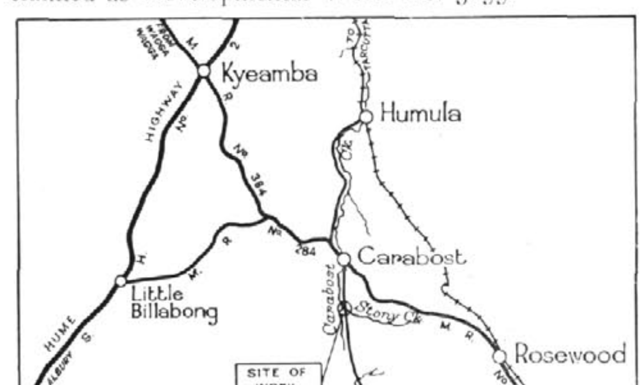
Culvert Over Stoney Creek on Carabost-Copabella Road. Shire of Holbrook. Developmental Work No. 3055.

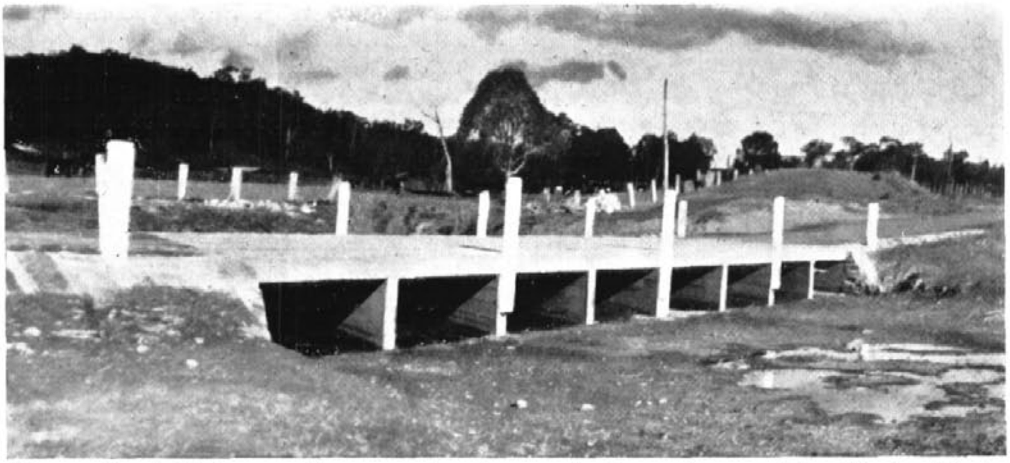
The village of Carabost, situated in the western foothills of the Great Dividing Range, is the centre of a district mainly taken up with dairying and small farming. The district is served by *Main Road No.* 284, which connects to the west with the Hume Highway at the village of Little Billabong, 15 miles away, and to the east with Main Road No. 278 at Tumbarumba, 25 miles away. The road proceeds south from Carabost through Copabella connecting with Main Road No. 278 near Jingellic.

The area between Carabost and Copabella is developing rapidly and recently arrangements were made for two large holdings, Carabost Station and Copabella Station, which are served by the Carabost-Copabella road, to be subdivided for Soldier Settlement.

Stoney Creek, approximately 2 miles from Carabost, was crossed by a causeway. Traffic was frequently blocked in wet weather and the causeway with the relatively heavy traffic was difficult to maintain. In addition, the approach on the northern side being over alluvial silt flat, created difficulties for traffic after rain.

To assist the Holbrook Shire Council in providing improved conditions the construction of a concrete culvert and approaches over Stoney Creek was proclaimed as Developmental Work No. 3055.





8-cell Box Culvert over Stoney Creek.

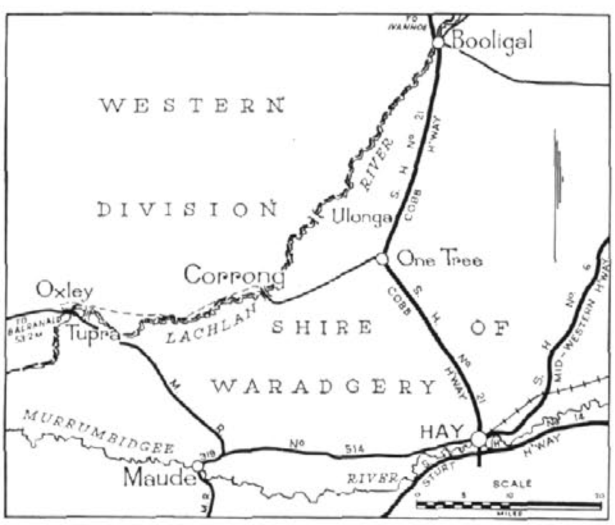
The work, which has now been completed, comprised the construction of an 8-cell 6 feet x 2 feet 6 inches box culvert over the main creek on a 30° skew and a 2-cell 4 feet x 1 foot box culvert over a watercourse running into the creek downstream from the larger culvert. Approaches to these culverts extending across the alluvial flat and covered with a gravel pavement were included in the work.

The work was carried out by the Holbrook Shire Council by day labour and was completed at a final cost of £1,844, funds being provided by the Department of Main Roads from the Developmental Roads Fund.

Bridge Over Lachlan River at Corrong. Shire of Waradgery. Developmental Work No. 3036.

The bridge at Corrong is centrally situated between bridges over the Lachlan River at Booligal and Oxley. It is the only means of crossing the 37 miles of river between a privately owned bridge at Eulonga and the public bridges at Oxley. The river at this location forms the boundary between Waradgery Shire and the Western Division.

For over 60 years access has been provided by a timber bridge, which with an embankment on the southern side was provided by the owners of Corrong and Culpataro Stations.



Areas of land in the Western Division north of the bridge have been made available for closer settlement since 1939 and this has led to the need for the provision of an improved structure. A crossing at this point is necessary to facilitate stock movements between properties separated by the Lachlan River and to provide an outlet to the railhead at Hay for stock and wool from the sheep-raising districts of Culpataro and Alma, north of Corrong.

It was decided to provide a new structure on the basis of the Department of Main Roads meeting the cost of the bridge, the northern approach and a culvert in the southern approach, and the Waradgery Shire Council meeting the cost of the remainder of the southern approach work. The work was proclaimed Developmental Work No. 3036 in 1942.

The new bridge is a high level timber beam structure comprising 4 spans each of 30 feet, supported on driven piles in piers and abutments, with a width of 10 feet between kerbs and with netted handrails for the protection of small stock.

Bridge over Lachlan River at Corrong.

The work, which was carried out by contract by the Waradgery Shire Council, was commenced in August, 1947, and completed in May, 1948. The cost of the bridge and approaches was £2,315, of which the Waradgery Shire Council provided £415 from its funds and the Department of Main Roads £1,900 from the Developmental Roads Fund.

Completion of Direct Main Road Link Between Guyra and Dorrigo.

The completion of the Guyra-Ebor-Dorrigo road, Main Road No. 135 from Guyra to Ebor, and Trunk Road No. 76 from Ebor through Dorrigo to Dorrigo Mountain, provides a new link between the New England Tableland and the Coast, and should substantially assist the development of the areas served by the road.

In 1935, the Government decided to construct a road from Guyra, situated on the New England Highway and the main northern railway, to the terminus at Dorrigo of the Glenreagh-Dorrigo railway, a spur from the Main North Coast railway at Glenreagh. A description of the new road construction between Guyra and Ebor was given in the August, 1938 issue of "Main Roads." As a result of the war it has only recently been possible to complete the remaining section, *i.e.*, Ebor to Dorrigo, which forms the subject of this article.

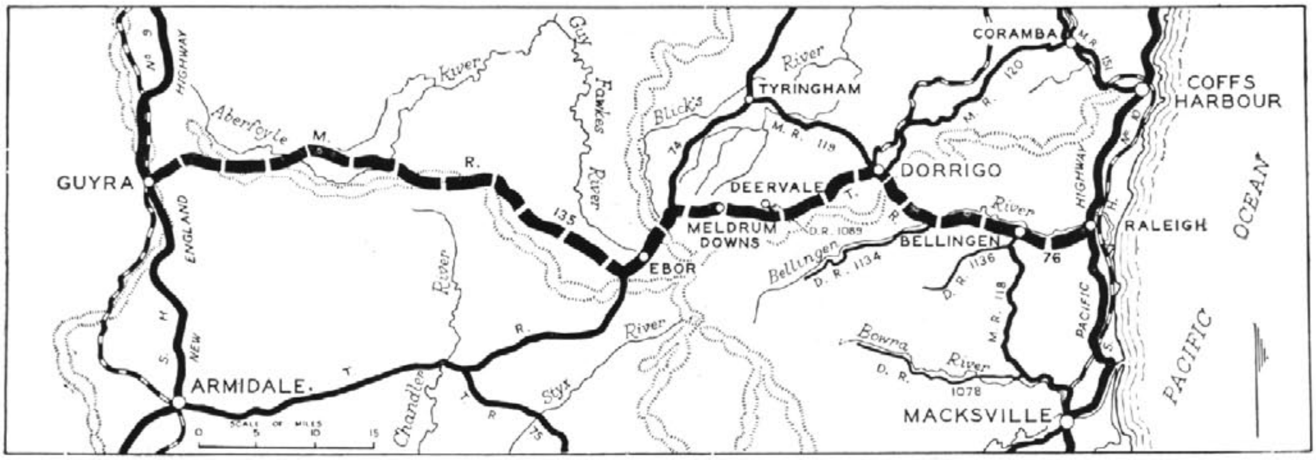
The New England Highway generally traverses the New England Tableland between the coastal and the inland areas and rises to a maximum height of 4,630 feet above sea level on the Ben Lomond Range, between Guyra and Glen Innes. The descent from the tablelands to the coast is partly through mountainous and broken country, and largely due to this a satisfactory direct connection from the Guyra district to the coast had not previously been provided. A road between Guyra and Dorrigo had existed prior to the construction of the new road, but was impassable to motor traffic during unfavourable weather conditions, and at any time travel was so slow owing to the width and condition of the surface, alignment, and grades, that traffic generally preferred to travel a longer distance and reached the coast by some other route.

The old road had been formed and lightly gravelled to a width of about 12 feet from Guyra towards Ebor for a length of some 14 miles, to serve the more closely settled area near Guyra. Elsewhere on the length of 50½ miles between Guyra and Ebor only light formations had been constructed on isolated lengths, and generally the track was unformed. From Ebor the old route followed a short section of the Armidale-Grafton road (now Trunk Road No. 74) and thence to Dorrigo via a road (then Main Road No. 120), much of which comprised a narrow winding mountan road, on a location not suitable for further improvement.

The new route adopted east from Ebor first followed a short length of the Armidale-Grafton road (Trunk Road No. 74), thence generally along Main Road No. 120 to near Deer Vale, and thence via the Yarrum Creek road (Developmental Road No. 1089) for about 11 miles, rejoining Main Road No. 120 approximately 3¼ miles from Dorrigo. From Dorrigo an existing main road was followed to the top of Dorrigo Mountain, the eastern end of the work undertaken. The new road between Trunk Road No. 74 near Dorrigo Mountain now forms part of Trunk Road No. 76 which extends via Bellingen to the Pacific Highway on the coast near Raleigh.

DESIGN.

The design adopted for the Ebor-Dorrigo section, including the short length easterly from Dorrigo to Dorrigo Mountain at the Bellingen Shire boundary, is in accordance with the Department's 1937 Road Design Standards for two lane rural highways, for a speed of 40 miles per hour. The formation width is 24 feet and pavement width 16 feet.



Locality Map.

Scoops and 'Dozer in operation.

CONSTRUCTION.

Construction of the Ebor-Dorrigo section was carried out by day labour by the Department. The construction organisation which had carried out the Guyra-Ebor work was transferred to Ebor-Dorrigo as the final sections of the former work were completed. Labour was obtained from the Dorrigo and Ebor districts. For construction purposes the work was divided into four parts as follows: (1) Dorrigo, eastward to Dorrigo Mountain, 2½ miles; (2) Dorrigo, westward for 3 miles to the junction of Main Road No. 120 and Developmental Road No. 1089; (3) Three miles to 11 miles, which followed the route of Developmental Road No. 1089; (4) Eleven miles to 31 miles near Ebor. Construction headquarters were established on the Deer Park River near Meldrum, about 16 miles west of Dorrigo.

Work on the section 0 miles to 3 miles west of Dorrigo was commenced in February, 1938. The new road closely followed the existing road which was widened, regraded and realigned to the required standard. Earthworks were comparatively light and were carried out largely by hand methods assisted by a tractor and 2 cubic yard scoop. A broken stone-base course was laid as earthworks were completed, the material being obtained from a quarry about 1½ miles west of Dorrigo. Work on the section included the construction of a three-span timber beam bridge over the Beilsdown River at Dorrigo, replacing a narrower structure which was in poor condition and on unsatisfactory alignment. This bridge, as well as all other timber bridges on the Ebor-Dorrigo work, was carried out by day labour.

The next section to be constructed was that between 11 miles and 31 miles west of Dorrigo. The intervening length between 3 miles and 11 miles had been previously constructed for light traffic as Developmental Road No. 1089 and the need for improvement was less urgent than on the rest of the work.

On the 11 miles-31 miles section earthworks were generally heavier than on the 0 miles-3 miles section. Cuttings up to 25 ft. in depth were required on the 11 miles-16 miles section which formed the connection between the end of Developmental Road No. 1089 and the existing main road near Meldrum, and much of the excavation was carried out in rock, mainly basalt and hard shales. Work on the section included the construction of eight bridges, the largest streams crossed being the Deer Park River, Meldrum Creek, Coutts Water and Jocks Water. These bridges were constructed by day labour in timber, as good quality tallow-wood was available in the district.

Work on this section was commenced in June, 1938, but progress was comparatively slow owing mainly to the continual wet weather which was experienced. The Dorrigo district is a high rainfall area, the average annual rainfall being approximately 80 inches.

By August, 1940, all work from 11 miles to 16 miles had been completed as well as earthworks to 20 miles. Work proceeded steadily westward till December, 1941. By that time, the section from 11 miles to 31 miles was almost completed throughout except for some timber bridges and approaches, which were held up owing to delays in the supply of timber. In addition, a start had been made, on clearing the section between 3 miles to 11 miles.

The development of the war situation at that stage, however, caused the whole organisation to be moved in March to strategically important work, and the Ebor-Dorrigo road was left incomplete during the remainder of the war period, although a few men were retained to finish the timber bridges and approaches.

During the period work was suspended, the partly completed earthworks on the 3 miles to 11 miles section caused trouble to traffic during wet weather and as a result, the Department authorised the Dorrigo Shire Council to construct two required minor deviations by day-labour.

At the beginning of 1946, conditions permitted a resumption of work and the Department put work in hand again by day-labour on the section, 3 miles to 11 miles west of Dorrigo and also on the length of about 2½ miles from Dorrigo to the Bellingen Shire boundary at Dorrigo Mountain. Progress at first was slow, on account of the slow rate of release of plant, equipment and staff from war work. A crushing plant was installed in a quarry to provide crushed rock for both base and surface courses. Construction was completed in April, 1948. Bituminous surfacing is proposed between the Bellingen Shire boundary and 3 miles west of Dorrigo. Pavement strengthening and crushing of aggregate for this work are now complete.

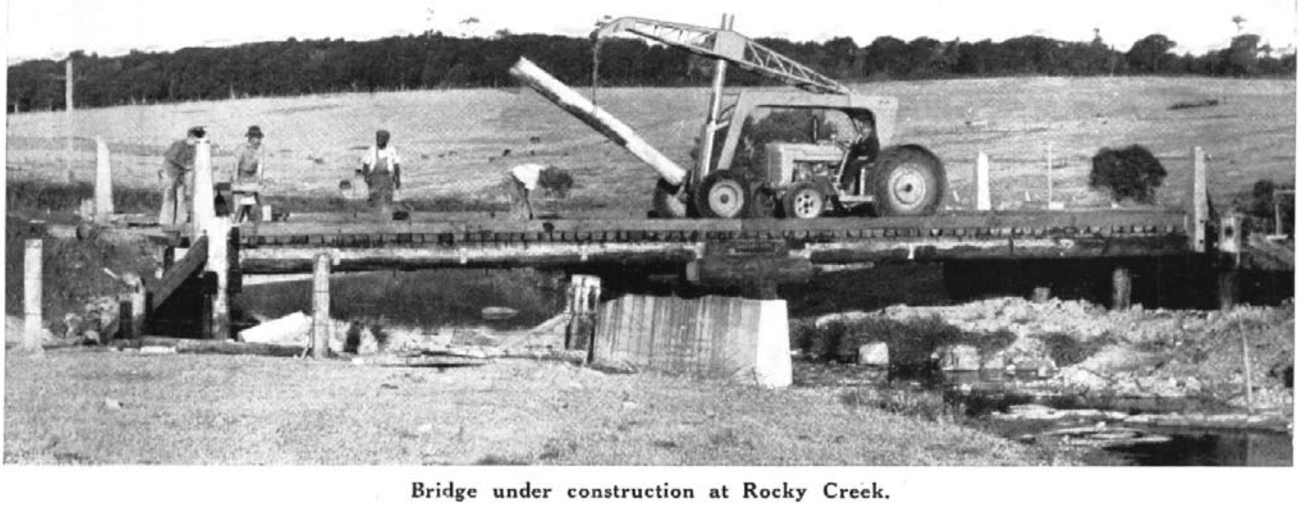
PAVEMENT.

One of the major difficulties in the construction of the Ebor-Dorrigo road was obtaining pavement materials for both base and surface courses. On the 0 miles to 3 miles section west of Dorrigo, a quarry was opened up near Dorrigo about 4 miles from the work because no suitable gravel was obtainable in the area. A broken stone-base course was laid, and fine crushed rock rolled into it to form a surface course. On the 11 miles to 31 miles section, some suitable gravels were found but not in sufficient quantities or within an economical distance. The gravels were used, however, wherever practicable. For example, at 19 miles, gravel was used for both the base and surface courses. Further west, the base course was broken stone with gravel surface course, while for the last two miles of the section gravel was again used for both courses. When work recommenced in 1946 a quarry was opened on the Dorrigo-Coramba Road (Main Road No. 120) at approximately two miles from Dorrigo. At this quarry pavement materials for both base and surface course were crushed for the sections 3M. to 11M. west of Dorrigo and 0M. to 2¼m. between Dorrigo and the Bellingen Shire Boundary.

Following are the details of the depth and type of pavement over the full length of reconstruction:—

Mileage		Base Course	Surface Course
0M–2·5M	west from Bellingen Shire Bdy.	5" crushed rock	3" fine crushed rock
0M–3M	west from Dorrigo	6" broken stone	2" do.
3M–11M	do.	5" crushed rock	3" do.
11M–19·6M	do.	3" broken stone	3" do.
19·6M–22·7M	do.	4" gravel	2" gravel
22·7M–28·9M	do.	4" broken stone	3" do.
28·9M–31M	do.	4" gravel	3" do.

The fine crushed rock surface course provided on the post-war work consisted of run-of-crusher broken stone, with a maximum size of ¾ inch. Difficulty was experienced in finding a suitable binder. A deposit of granite gravel existed within two miles of the road, but on test was found to have too high a plasticity and to be too micaceous. A deposit of weathered aplite was found on the Dorrigo Mountain about three miles east of Dorrigo, but was also found to be too micaceous. Both these deposits were considered unsuitable for binder in a fine crushed rock surface course which was intended to be sealed with bitumen. They were used in the 3 miles to 11 miles section which is not to be sealed. Great care was taken to mix well the finally selected binder and the fine crushed rock in the correct proportions. The work was done when weather con-



Bridge under construction at Rocky Creek.

Construction in progress west of Dorrigo.

ditions were most favourable and a minimum of artificial watering was required. The method adopted was :—

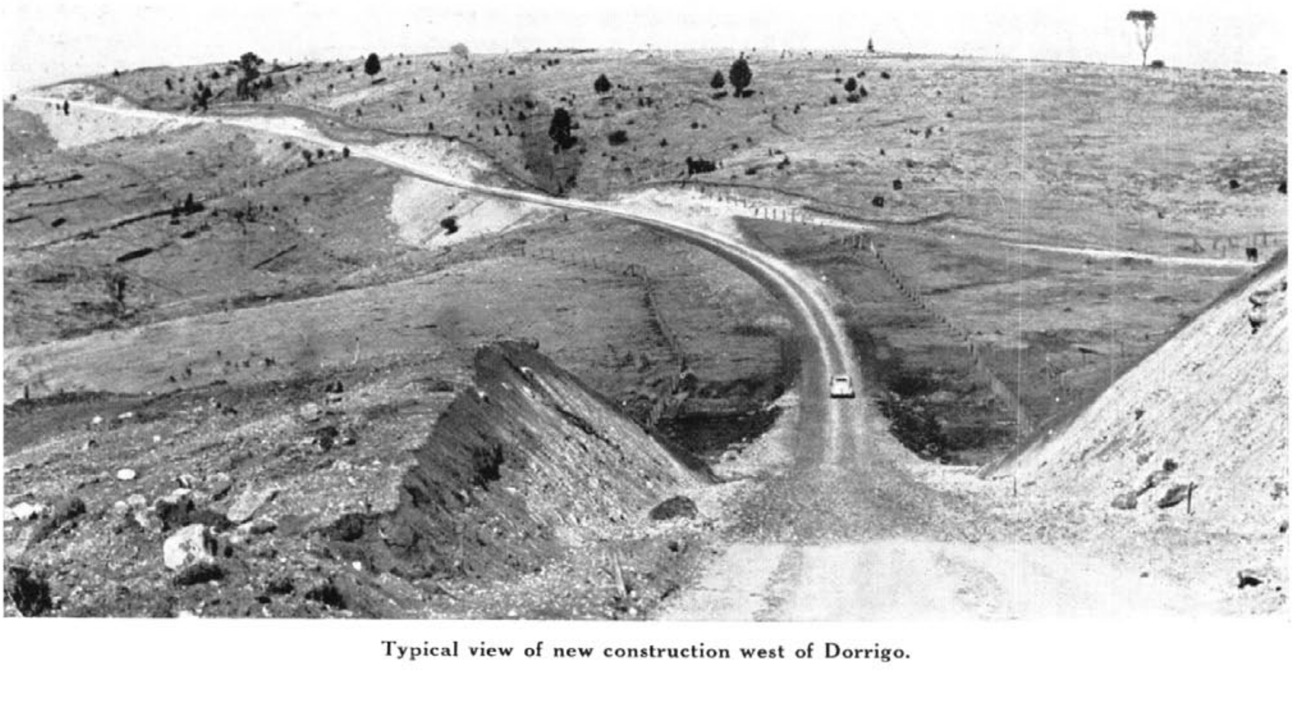
A. A base and temporary running course of fine crushed rock was lightly scarified and compacted by light rolling.

B. The binding material was spread in a layer along the road, being gauged at a predetermined rate designed to fill the voids in the scarified base.

C. Traffic was then allowed to use the road to drive binder into the base course.

D. Fine crushed rock was spread in a layer along the road to a depth that when consolidated would provide 3 inches of pavement.

E. The materials were thoroughly mixed by blading from one side of the road to the other three times with a heavy duty motor grader. Watering was applied to keep material moist until final spreading was completed.



Typical view of new construction west of Dorrigo.

F. *Consolidation was obtained by blading, rolling and by traffic, using a power roller, watering being continued until a firm and even surface was obtained.*

The total area of pavement construction carried out between Ebor and the top of Dorrigo Mountain comprised 320,000 square yards.

COST.

The following are the unit costs for main items, exclusive of Workers' Compensation Insurance, Holidays, Camp, Depot, General Engineering and Clerical Supervision Costs:—

Clearing and Grubbing, £30 1s. 0d. per acre.
Earthworks, including trimming and consolidation, 4/6.8 per cubic yard (solid measurement).
Catch drains, £1 5s. 0d. per 100 lin. ft.
Reinforced Concrete Pipe culverts, including excavation, back filling and headwalls, average for all sizes, 18s. 9d. per lin. ft.
Concrete in box culverts excluding steel reinforcement, £7 9s. 3d. per cubic yard.
Fencing, boundary post and wire, £2 9s. 8d. per 100 lin. ft.
Pavement, base and surface courses, variable 6 inches to 8 inches consolidated thickness, 3s. 6d. per square yard.

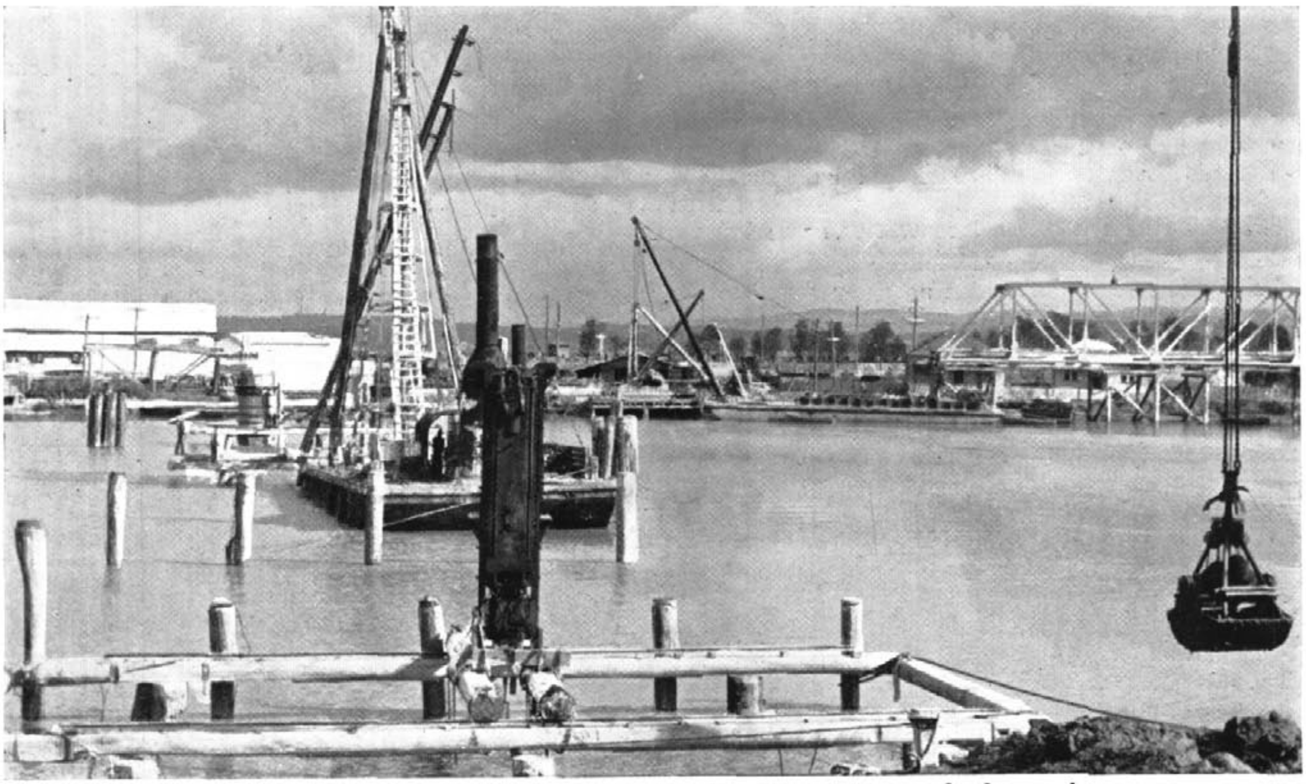
SUPERVISION.

The bulk of the construction work was carried out under the general direction of the then Divisional Engineer, Grafton (Mr. S. W. Down), the officers in immediate charge of construction during various stages of the work being Messrs. G. V. Fawkner, W. J. C. Orr, E. C. Gray and T. S. Hope.

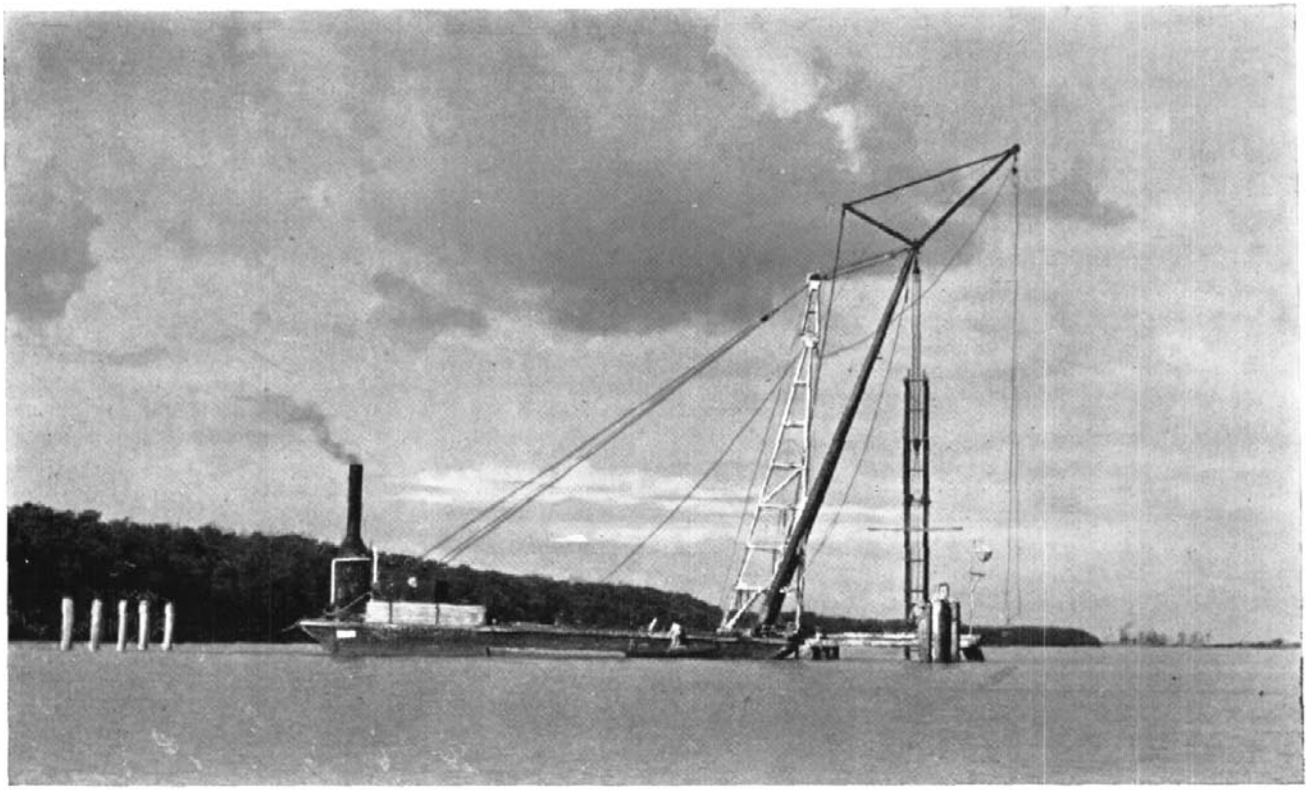
PROGRESS IN CONSTRUCTION OF BRIDGE OVER THE HUNTER RIVER AT HEXHAM—PACIFIC HIGHWAY.

Steady progress is being made with the construction of the new bridge over the Hunter River at Hexham on the Pacific Highway.

As mentioned in the December, 1946, issue of *Main Roads*, two contracts were let in November, 1945, one for the fabrication and supply of the steelwork to the



Construction of Piers of Bridge in progress. To the right will be seen the first steel truss span assembled prior to placement in permanent position.



Driving piles at Pier in centre of River.

firm of Thos. C. Pollard, Carrington, Newcastle, and one for the construction of the piers, erection of steelwork and laying of the deck of the bridge to J. King & Son of Adelaide.

The firm of Thos. C. Pollard was subsequently released from its contract and the completion of the steelwork was then placed in the hands of the State Dockyard, Newcastle. Sub-contracts for the supply of machinery and electrical equipment, which had been entered into by the original contractor, have become direct contracts with the Department.

Fabrication of steelwork has now progressed to the stage that only the lift span and the joists for the extension of the bridge remain to be done.

At the bridge site the contractor has completed construction of three of the seven piers supporting the truss spans, and the greater part of another. Operations are in hand on two further piers, one supporting the lift span and a truss span, and the other supporting two approach spans. The steelwork for one truss span is almost completely erected in preparation for placing in position on the piers.

Construction of the northern approach embankment and roadway is being carried out by the Department's day-labour organisation. Work on the southern approach has not yet commenced.

Subsequent to the commencement of the construction of the bridge it was decided to lengthen the structure, partly on account of the poor bearing value of the adjacent ground for the support of embankments, and partly to provide somewhat larger waterway. The bridge will, therefore, now comprise six truss spans, including lifting span, each 120 feet long, and thirteen spans 40 feet long of rolled steel joists.

Tenders Accepted.

The following Tenders (exceeding £1,000) were accepted by the Department during the months of April, May, and June, 1949.

Work or Service.	Name of Accepted Tenderer.	Amount of Accepted Tender.
		£ s. d.
Supply and delivery of one only ¾ c. yd. "Thew-Lorain" model L41 excavator.	Jaques Bros. Pty. Ltd., Richmond, Victoria.	7,794 0 0
Supply of up to 500 tons of 80–100 penetration bitumen and delivery thereof in drums f.o.r. Newport, Victoria, or into road vehicles ex refinery at Altona, Victoria.	Vacuum Oil Co. Pty. Ltd., Sydney	8,600 0 0
Supply of up to 500 tons of 60–70 penetration and up to 2,250 tons of 80–100 penetration bitumen, and the delivery thereof in bulk into road or rail tank waggons or into road vehicles ex the refinery at Clyde, N.S.W.	The Shell Co. of Aust. Ltd., Sydney	42,625 0 0
Supply of up to 500 tons of 60–70 penetration and up to 2,250 tons of 80–100 penetration bitumen, and the delivery thereof in bulk into road or rail tank waggons or into road vehicles ex the refinery at Matraville, N.S.W.	Bitumen and Oil Refineries (Aust.) Ltd., Matraville, N.S.W.	42,625 0 0
Supply of up to 1,650 tons of 80–100 residual bitumen and the delivery thereof in sound drums.	The Commonwealth Oil Refineries Ltd., Sydney.	24,750 0 0
Supply of up to 500 tons of 60–70 penetration Native Asphalte, and the delivery thereof into the Department's vehicles f.o.w. Sydney.	Neuchatel Asphalte Co. (A'sia) Pty. Ltd., Sydney.	9,750 0 0
Supply, assembly and erection of excavator—Blaw Knox "Insley" ½ c. yd. fixed cab skimmer shovel.	Noyes Bros. (Sydney), Sydney ...	7,650 0 0
Docking and overhaul of vehicular ferry vessel (D.M.R. No. 40)	Green Point Shipbuilding and Engineering Pty. Ltd., Concord, N.S.W.	9,241 11 7
Erection of two cottages in the Municipality of Deniliquin	Messrs. G. Muir and A. Wood, Carnegie, Victoria.	5,201 10 0

The following Tenders (exceeding £1,000) were accepted by the respective Councils during the months of April, May, and June, 1949.

Council.	Road No.	Work.	Tenderer.	Amount.
				£ s. d.
Amaroo S. ...	7	Supply of 954 c. yds. aggregate 181 m.–185.73 m. Orange–Molong Road.	Broula King Mineral Syndicate.	1,097 2 0
Apsley S. ...	11	Supply, delivery and spreading 9,407 c. yds. gravel east and west of Walcha.	W. H. Marshall ...	2,845 18 10
Bland S.	371	Gravel resheeting and scarifying pavement...	I. N. Miller	1,512 0 0
,, ...	57	,, ,, ,, ...	I. N. Miller and F. A. Lewington.	2,413 16 8
Boolooroo S. ...	12	Supply and delivery 14,000 c. yds. gravel	R. G. Gardner ...	3,500 0 0
Boree S.	61	Supply, delivery and spreading gravel at various locations	Dunn Bros.	1,046 10 0
,, ...	237 310	,, ,, ,, ,, ...	R. R. Barnes	2,700 0 0
Cobbora S. ...	206 233 358	Supply, delivery and spreading 15,530 c. yds. gravel ...	A. C. Stephens and Son	3,839 8 4
,, ...	77 205 206 334	Supply, delivery and spreading 14,095 c. yds. gravel ...	,, ,, ...	3,471 0 5
Conargo S. ...	59	Resheeting with loam between 15 m. and 16 m. 72 chs., 17 m. 52 chs. to 19 m. 40 chs., and 23 m. to 27 m.	D. D. McCallum ...	1,244 2 8
Concord M. ...	200	Reconstruction between chainage 5,640 ft. and Wellbank-street.	John Cassidy and Sons	21,549 16 8
Coolamon S. ...	243	Supply, delivery and spreading 8,997 c. yds. gravel ...	C. G. Staines and Grundy.	2,286 14 9
Coonamble M. ...	129	Supply, delivery and spreading sandy loam	G. Gillham	2,150 0 0
Eurobodalla S. ...	51	Operation of Nelligen Ferry over Clyde River at Nelligen for three years from 1st April, 1949.	Messrs. Daniels and Patrech.	2,700 0 0
Gosford S. ...	225 336 504 505	Delivery of slag from B.H.P. By-Products Pty. Ltd. for resealing.	R. N. Robson	2,723 17 6

Council.	Road No.	Work.	Tenderer.	Amount.
Holbrook S. ...	331	Supply and delivery of 4,900 c. yds. gravel	T. Carstens	1,919 0 0
Illabo S.	57 78 243	Supply, delivery and spreading gravel	G. A. Metcalfe and W. E. Grainger.	1,732 0 0
Ku-ring-gai M. ...	10	Removal and re-erection of retaining wall, picket fence and footpath.	E. Brown	1,150 0 0
Kyeamba S. ...	384	Supply, delivery and spreading 7,400 c. yds. gravel ...	G. A. Maloney ...	1,665 0 0
,, ...	211	Supply delivery and spreading 9,600 c. yds. gravel ...	,, ,, ...	2,040 0 0
Leeton S.... ...	80	Gravel and loam resheeting	Shuttleworth and Grace.	4,379 16 2
Liverpool Plains S.	72	Scarifying and reshaping 5,680 chs. of road	J. R. Shanley	1,024 0 0
Manning S. ...	111 112 192	Supply of 7,230 c. yds. aggregate for bituminous works...	Manning Sand and Gravel Co.	7,227 17 6
,, ...	192	Resurfacing with bitumen	B.H.P. By-Products Pty. Ltd.	1,278 18 6
,, ...	...	Operation of Forster-Tuncurry Ferry	C. A. Bows and Sons...	1,089 0 0
Murrumbidgee S.	321	Supply, delivery and spreading 8,220 c. yds. loam ...	J. Grace	1,540 0 0
Muswellbrook S....	208	Supply and delivery of aggregate to stockpiles	R. C. Barber	1,950 0 0
Patrick Plains S.	1051	Supply and delivery of 3,500 c. yds. gravel	W. A. Smith	1,093 15 0
Severn S.	9	Gravel resheeting 8,640 c. yds.	Frost and Spriggs ...	3,348 0 0
,, ...	9	Construction of approaches to Marowan Creek Bridge ...	,, ,, ...	2,423 8 0
Tomki S. ...	1125	Construction of Hildebrands Bridge	Kennedy Bros. ...	2,427 10 6
Tumut S. ...	279	Gravel resheeting	A. Sheather	1,118 15 0
,, ...	4	Reconstruction and regrading between Gilmore and Tumut	Hume Road Construction and Earth Moving Co.	1,762 5 0
,, ...	...	Supply and delivery of aggregate	Murrumbidgee Sand and Gravel Co.	3,428 2 0
,, ...	4	Supply and delivery 9,645 c. yds. gravel	A. Sheather	3,535 13 9
Uralla S.	9	Supply and delivery f.o.r. Uralla of 1,660 tons aggregate for bituminous seals and reseals.	R. C. Barber	1,867 10 0
Wakool S. ...	14	Supply and spread 4,400 c. yds. limestone gravel from 8.0 m. to 10.20 m.	J. C. Groves	1,091 13 4
Waradgery S. ...	514	Shouldering and resheeting with loam 14 m.-15 m., 15.21 m.-22.2 m. and 30.3 m.-33.5 m.	Vincent Murphy ...	1,507 0 0
Windouran S. ...	21	Construction around Black Swamp—earthworks and culverts.	Riverina Road Construction Co.	2,357 5 0
,, ...	21	Construction of loam pavement, supply of maintenance loam, etc., at Black Swamp.	J. C. Groves	1,575 18 4
,, ...	21	Construction of unformed road at Wanganella, 25 m. 1,500 ft. to 26 m. 2,500 ft.	,, ...	1,403 9 1

SYDNEY HARBOUR BRIDGE ACCOUNT.

Income and Expenditure for the period 1st July, 1948 to 30th June, 1949.

Income.	£	*Expenditure.*	£	£
Road Tolls	380,795	Cost of collecting road tolls		24,535
Contributions—		Maintenance and minor improvements		56,392
Railway Passengers	132,662	Alterations to archways		10,083
Tramway Passengers	14,955	Administrative Expenses		1,745
Omnibus Passengers	12,041	Loan Charges—		
Rent from Properties	11,247	Interest	245,974	
Miscellaneous	102	Exchange	26,752	
		Sinking Fund	67,887	
		Management Expenses	1,331	341,944
		Miscellaneous		335
	£551,802			£435,034

Sydney: Alfred Henry Pettifer, Government Printer—1949.

MAIN ROADS STANDARDS.

NOTE: Numbers prefixed by "A" are drawings, the remainder are specifications unless otherwise noted.

Form No.

EARTHWORKS AND FORMATION.

70* Formation. (Revised, June, 1949.
A 1532* Standard Typical Cross-sections.
A 1149* Flat Country Cross-section, Type A. (Revised, 1930.)
A 1150* Flat Country Cross-section, Type B. (Revised, 1936.)
A 1151* Flat Country Cross-section, Type D1. (Revised, 1936.)
A 1152* Flat Country Cross-section Type D2. (Revised, 1930.)
A 1476 Flat Country Cross-section, Type E1. (Revised, 1937.)
A 1101 Typical Cross-section One-way Feeder Road. (1936.)
A 1102 Typical Cross-section Two-way Feeder Road. (1931.)
A 114 Rubble Retaining Wall. (1941.)

PAVEMENTS.

71* Gravel Pavement. (Revised, January, 1939.)
228* Reconstruction with Gravel of Existing Pavements. (Revised, January, 1939.)
254 Supply and Delivery of Gravel. (Revised, August, 1939.)
72* Broken Stone Base Course. (Reprinted with amendments, August, 1947.)
68* Reconstruction with Broken Stone of Existing Pavement to form a Base Course. (Revised, October, 1933.)
296 Tar. (Revised, May, 1949.)
337 Bitumen. (Revised, February, 1939.)
305 Bitumen Emulsion. (Revised, September, 1942.)
351 Supply and Delivery of Aggregate. (Revised, July, 1941.)
65* Waterbound Macadam Surface Course. (July, 1939.)
301* Supply and Application of Tar and/or Bitumen. (Revised, December, 1948.)
122* Surfacing with Tar. (Revised, January, 1949.)
145* Surfacing with Bitumen. (Revised, January, 1949.)
93* Re-surfacing with Tar. (Revised, January, 1949.)
94* Re-surfacing with Bitumen. (Revised, January, 1949.)
230* Tar or Bitumen Penetration Macadam, Surface Course, 2 inches thick. (Revised, December, 1936.)
66* Tar or Bitumen Penetration Macadam, Surface Course, 3 inches thick. (Revised, September, 1936.)
125* Cement Concrete Pavement (April, 1939) and Plan and Cross-section A 1147 (March, 1932).
466 Bituminous Flush Seals and Reseals—Fluxing of Binders. (March, 1947.)

GENERAL.

342* Cover Sheet for Specifications, Council Contract. (Revised, April, 1939.)
24B*General Conditions of Contract, Council Contract. (Revised, August, 1948.)
64* Schedule of Quantities.
39* Bulk Sum Tender Form, Council Contract. (Revised, August, 1946.)
38* Bulk Sum Contract Form, Council Contract.
121* Provision for Traffic (Revised, June, 1947) with general arrangement, A 1323* and details A 1325* of temporary signs. (Revised, January, 1947.)
A 1342* Warning Signs, Details of Construction.
A 1346 Iron Trestles for Road Barriers.
A 1341 Timber Trestle and Barrier.
A 1824 Light Broom Drag. (1941.
A 1924 Pipe Frame Drag.
A 178 Mould for Concrete Test Cylinder.
A 1381–3, A 1452–5 } Tree Guards, Types A, B, C, D, E, F, and G.
197* Hire of Council's Plant. (Revised, April, 1937.)
A 478* Specimen Drawings, Rural Road Design, with drawings A478A* and A 478B*.
A 478C*Specimen Drawing, Flat Country Road Design.
A 1113* Rural Road Plan and Longitudinal Section Form (tracing cloth).
A 1114* Rural Road Cross-section Form (tracing cloth).
A 1115* Urban Road Plan Forms (tracing cloth).
193 Duties of Superintending Officer (instructions). (Revised, July, 1938.)
314 Standard Regulations for Running of Ferries. (Revised, January, 1947.)
A 1645 Stadia Reduction Diagram. (1939.)
355* Instructions for Design of Two-lane Rural Highways (1937).
A 1487* Horizontal Curve Transitions (diagrams).
A 1488*, A 1488A*, A 1488B*, and A 1488C*.—Horizontal Curve Transitions (tables for speeds of 30, 40, 50, and 60 miles per hour).
A 1614 Widening of Shoulders on Crests.
369* Instructions for Design of Urban Roads (1939).
288 Instructions for Design of Intersections (Revised, January, 1948.)
402 Instructions for Design of Rural Intersections (acceleration and deceleration lanes). (1941.)

Form No.

KERBS, GUTTERS, AND GULLY PITS.

243 Integral Concrete Kerb and Gutter and Vehicle and Dish Crossing (Revised, July, 1939) and Drawing. (A134A.)
245 Gully Pit (Revised, May, 1939) and Drawings (*a*) with grating (A 1042); (*b*) Kerb inlet only (A 1043); (*c*) with grating and extended kerb inlet (A 1352); (*d*) extended kerb inlet (A 1353).
A 190 Gully Grating. (1933.)
A 1418 Concrete Converter. (1936.)

FENCING.

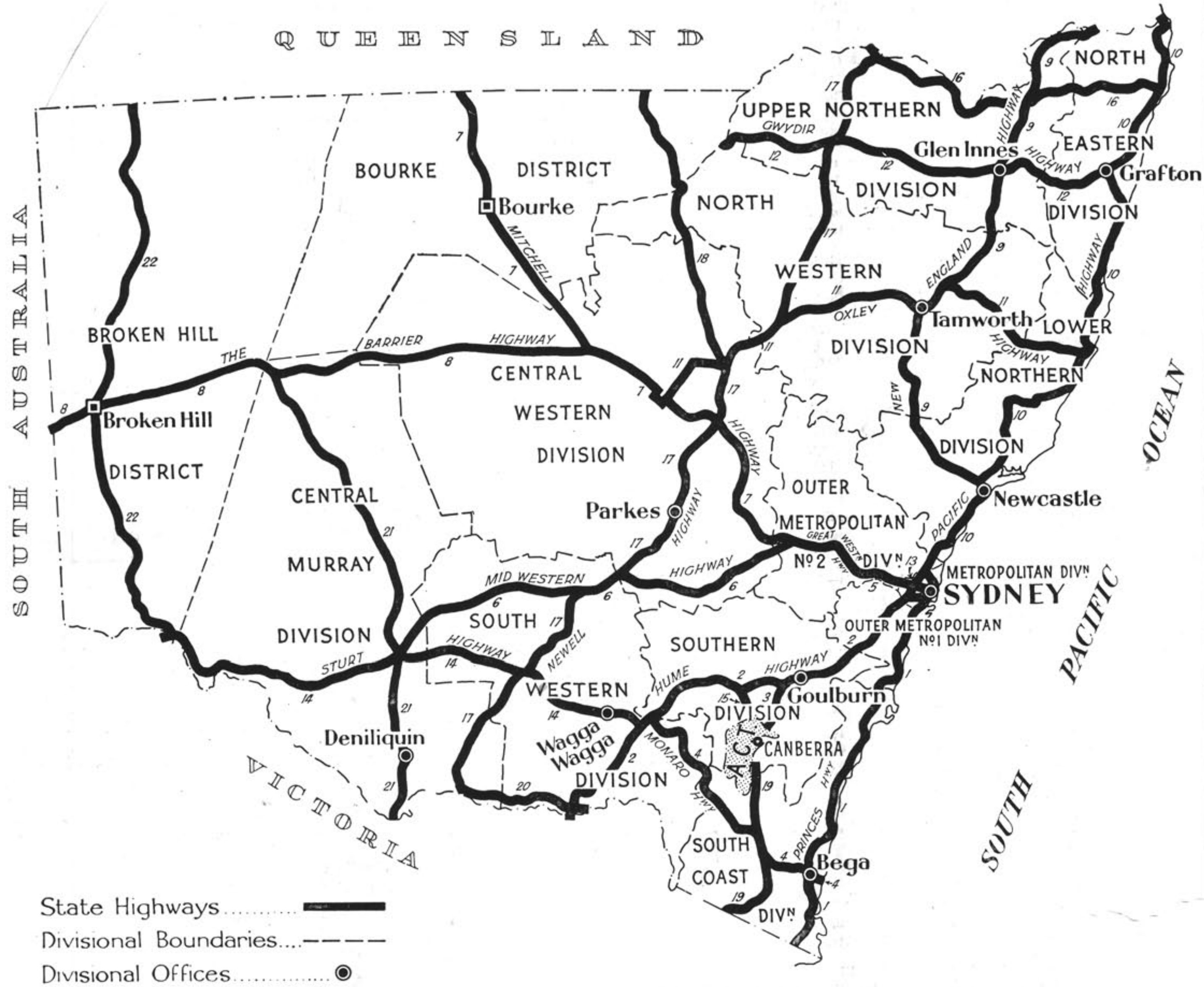
142 Split Post and Rail Fencing and Drawing (A 43).
141* Post and Wire Fencing (Revised, December, 1947) and Drawings (*a*) Plain (A 494); (*b*) Rabbit-proof (A 498); (*c*) Flood gate (A 316).
143 Ordnance Fencing (Revised, February, 1934) and Drawing A 7 (Revised, November, 1939.)
144 Chain Wire Protection Fencing and Drawing (A 140).
246 Location of Protection Fencing (instruction). (Revised, May, 1940.)
A 1301 Motor Traffic By-pass 9 feet wide. (1936.)
A 1875 Motor Traffic By-pass 20 feet wide. (1942.)

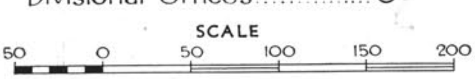
BRIDGES AND CULVERTS.

A 4 Standard Bridge Loading (general instruction). (1948.)
A 4A Standard Bridge Loading (instruction for dead-end Developmental Roads.) (Revised, 1938.)
18* Data for Bridge Design. (Revised, November, 1948.)
84* Data accompanying Bridge or Culvert Designs.
A 26 Waterway Diagram. (Revised, 1943.)
371 Waterway Calculations. (1939.)
A 421 Boring Gear, 2 inches. (1930.)
A 44 Boring Gear, 3½ inches. (1926.)
A 2847 Rod Sounding Apparatus. (1945.)
A 2995 Rod Sounding Apparatus, with tripod (1947).
25* Pipe Culverts and Headwalls (Revised, December, 1939) and drawings, Single Rows of Pipes, 15 in. to 21 in. dia. (A 143*), 2–3 ft dia. (A 139*), 3 ft. 6 in. dia. (A 172*), 4 ft. dia. (A 173*), 4 ft. 6 in. dia. (A 174), 5 ft. dia. (A 175), 6 ft. dia. (A 177); Double Rows of Pipes, 15 in. to 21 in. dia. (A 211*) 2–3 ft. dia. (A 203*), 3 ft. 6 in. dia. (A 215), 4 ft. dia. (A 208), 4 ft. 6 in. dia. (A 207), 5 ft. dia. (A 206), 6 ft. dia. (A 213); Treble Rows of Pipes, 15 in. to 21 in. dia. (A 210), 2–3 ft. dia. (A 216) and Straight Headwalls for Pipe Culverts, 15–24 in. dia. (A 1153*).
A 1* Joint for Concrete Pipes. (Revised, August, 1933.)
A 142* Inlet Sump Pipe Culverts for 3 ft. dia. or less. (Revised, December, 1947.
138* Pre-Cast Concrete Box Culvert (Revised, February, 1948) and drawings. 9 in. high (A 485*), 12 in. (A 446*), 1 ft. 6 in. (A 447*), 2 ft. (A 448*), 2 ft. 6 in. (A 449).
A 311 Concrete Arch Culvert, 5 ft. high. (1931.)
A 314 Concrete Arch Culvert, 10 ft. high. (1931.)
206* Reinforced Concrete Culvert (Revised, February, 1948) and instruction sheets (A 305, A 359, A 306, A 304).
A 1832 Cast-in-Place Concrete Pipe Culverts. (1942.)
A 309* Concrete Culvert Posts. (Revised, June, 1937.)
300 Pile Drivers, specification for 25 ft., and drawings for 50 ft. (A 209), 40 ft. (A 253), and 25 ft. portable (A 1148).
A 1886 Arrangement of Bolting Planks for various widths of deck. (Revised, September, 1948.)
A 45 Timber Bridge, Standard Details. (Revised, October, 1947.)
A 1791 Timber Beam Skew Bridge Details. (1941.)
164 Timber Beam Bridge (Revised, April, 1947) and instruction sheets, 16 ft. (A71), 18 ft. (A 68), 20 ft. (A 70) and 22 ft. (A 1761). (Amended August, 1946.)
A 1226 and A 1165 Low Level Timber Bridges, instruction sheets for 16 feet, and 18ft. between kerbs. (1932.)
A 1222, A 1166, and A 1223 Single Span Timber Culverts, instruction sheets for 16 ft., 18 ft. and 20 ft. between kerbs. (1931.)
139* Timber Culvert and drawings, 1 ft. 6 in. high (A 427), 2 ft (A 428), 3 ft. (A 429), 4 ft. (A 430), 5 ft. to 8 ft. high, (A 431). (1928.)
326 Extermination of Termites in Timber Bridges. (Revised, October, 1940).
A 222* Pipe Handrailing Details. (Revised, July, 1947.)
350 Reinforced Concrete Bridge. (Revised, January, 1946.)
495 Design of Forms and Falsework for Concrete Bridge Construction (September, 1947.)

Standards marked * may be purchased from the Government Printer, Sydney.
Others may be purchased from the Head Office of the Department of Main Roads, 309 Castlereagh Street, Sydney, single copies being free to Councils.

State Highway System
of the
State of New South Wales





Area of New South Wales, 309,433 square miles.
Length of public roads within New South Wales, 126,058 miles.

MILEAGE OF ROADS CLASSIFIED UNDER THE MAIN ROADS ACT, AS AT 1st JULY, 1948.

State Highways	6,490
Trunk Roads	3,741
Main Roads	12,635
Secondary Roads (County of Cumberland only)	56
Developmental Roads	2,801
	25,723
UNCLASSIFIED ROADS, in Western part of State, coming within the provisions of the Main Roads Act	2,309
TOTAL ...	28,032