Can marginal materials matter? You bet!
Central Goldfields unsealed road trial two years down the track

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ABSTRACT: *With more than sixty percent, or over 570,000 kilometres of Australia's roads being unsealed, most managed by local councils, innovative ways to use local materials and applying proven techniques to build and maintain these important connections are imperatives of huge value to communities.*

Since central Victoria's Central Goldfields Shire launched its nine-section Possum Gully 2.7-kilometre unsealed road trial in December 2016 it has been carefully measured and monitored. The results thus far provide information about pavement longevity, environmental and ride quality outcomes. The Council has applied ARRB's "Unsealed Roads Manual" guidelines upon two active local gravel pits, adding and comparing various mixes and treatments including blending with clays, local bluestone quarry products, polymers, enzymes, cement and bitumen emulsions additives.

Discrete defined locational cross-sections, roughness, dust, climate and traffic have been regularly measured over two years. The base course materials were extensively tested as were compaction and moisture content.

From a detailed report to Central Goldfields Shire Council completed in early 2019 about the outcomes of the trial, innovative approaches to the use of marginal pavement materials and improvements to methods and plant used by Council maintenance and construction crews are advocated. Decisions about application of marginal materials using sampling, testing, and blending techniques will lead to considerable cost savings and conservation of better-quality gravel and quarried rock resources, as will application of the excellent fifteen years of practical research work done by ARRB.
KEYWORDS: unsealed road pavements, road trial, innovative approaches, Central Goldfields Shire Council, marginal pavement materials, blending techniques.

1 Introduction

One may wonder what unsealed roads trials have to do with the theme "Vibrant Futures Solid Foundations". Australia has 574,660 kilometres of unsealed roads (Austroads 2016), and will have such roads for many years into the future. Other countries have more kilometres of unsealed roads, such as the USA with approximately 2.3 million kilometres (2012), and Canada with 627,000 kilometres (2011). Traditionally tertiary gravels have been provided as unsealed roads wearing courses in Victoria. Such gravels are becoming scarce, so identification of potential sources with needed properties, and trialling the use of additives, reducing deficiencies of the material of ever more marginal materials so as to provide stronger, smoother wearing courses on this infrastructure set makes potentially sound environmental, social and economic sense.

The application of scientific principles behind how to construct an unsealed road and combining the principles with the years of experiences of operators in the field is a huge solid leap into the future, and the Austroads (2016) and ARRB (2009) research results are, and not before time, beginning to make inroads at the local government level in Australia.

1.1 Why a trial at Central Goldfields?

Central Goldfields Shire Council is located in Central Victoria in Australia, with a population of 12,500 and has an area of 1,532 square kilometres. It has a rich history from gold mining during the 1800s. There are 1,300 kilometres of roads, 39% sealed and 48% paved.

The municipal district suffered major flooding during 2011 and 2012, and again in 2016. As a result of the flood rehabilitation works the Council's General Manager Technical Services became alarmed at how much good gravel resource was used. It became abundantly clear that the amount of its better tertiary gravels situated at Dunolly some 20 kilometres north of the township of Maryborough was being swallowed up in having to re-sheet many kilometres of damaged and scoured gravel unsealed roads. In fact, it had used for flood recovery works 225,000 cubic metres, being the equivalent of 22.5 years' normal gravel re-sheet use during the flood recovery period from 2011 to 2013. The Council also has access to another well-located gravel pit situated at Daisy Hill, 10 kilometres to the south-west of Maryborough. The remaining gravel at Daisy Hill has, however, displayed indications of being extremely marginal for unsealed roads' wearing course application purposes.

Because of the concerns about the huge reduction of valuable resources, this small Council decided to invest funds to conduct investigations of its readily available materials by modifying marginal properties to produce wearing courses that may be viable. A two-year monitored trial was established to test various applications over nine sub-sections of the one section of an unsealed road. The trial included practical application of the science described by the Australian Road Research Board (ARRB) in its publications and listed in references to this paper.

The Council also wanted to ensure that as much in-house plant and operators as possible be used in the trials.

This paper is about the conclusions reached after a two year trial period from trials of the two existing gravel sources; the trials were the subject of a paper written by this author for the International Public Works Engineering Conference held in Perth during August 2017, and where a presentation was made about the progress of the trial at that time.

2. Method

Preliminary testing was undertaken of the two major sources of material to establish potential improvements to the materials.

ARRB's *'Unsealed roads manual guidelines to good practice'* (March 2009) was adopted as a primary reference document because it has been developed with significant input from local government practitioners out in the field.

Initially trialling eight sub-sections of the same road was envisaged. A further section was added at the commencement to compare a simple dust-suppressant treatment upon a basic preparation of the existing road pavement. A consistent thickness of subbase over the first eight sub-sections comprising 150 millimetres' compacted thickness Dunolly gravel was built by Council staff. The trial wearing courses have been placed by overlaying the subbase, each to a compacted depth of 150 millimetres – except for two sections that were deliberately set at 100 millimetres (Sections 6 and 8).

2.1 Location of the trial road

The trial road is known as Possum Gully Road, and it is situated10 kilometres south-west of the township of Maryborough, Victoria, 13 kilometres from Daisy Hill material deposits, and 29 kilometres from the Dunolly deposits. The road carried 118 vehicles per day of which 18.6 percent were commercial vehicles (count November 2015) north of the trial site; 35 vehicles per day of which 8.6% were commercial vehicles (count May 2013) south of the trial site. The location was chosen as it is one of only a few relatively straight sections of unsealed road pavement that is around three kilometres long.

2.2 Description of the trial sections

The sections are described below. Detailed descriptions are provided within **Appendix A**.

In summary, four of the sections (labelled as sections 1 to 4) consisted of the Daisy Hill – sourced material with additives ranging from section 1 being a combination of 3% cement and 3% foam bitumen treatment, section 2 comprising 3% polymer additive, section 3 being the addition of an enzyme treatment, and the fourth section is a combination of 46% low-grade class 4 local crushed rock sourced from Hampstead Quarry, and Daisy Hill material with 8% clay added.

The next four sections (labelled as sections 5 to 8) comprised the Dunolly–sourced material; section 5 with an enzyme additive, section 6 being 100 millimetre depth crushed and screened to 30 mm minus direct from the pit, section 7 of cement-stabilised crushed and screened, and section 8 being 100 millimetre depth crushed and screened, with the addition of 5% clay.

Section 9, added later, comprises principally a base course of Dunolly gravel uncrushed or screened already there with the addition of a citrus-based dust suppressant.

Sub-base strength was tested using a field penetrometer, and the results are provided in

Appendix B to this paper. The test results indicated firm strength with field CBR averages adopted as 12.

2.3 Construction of the wearing courses

For application of the wearing courses, external quotations were invited for construction of five of the sections; the Council crew constructing the other four. Six separate quotations were received of which four quoted for all five sections. All five sub-sections of the works were awarded to a single contractor. The specification called for as much use as possible of Council plant and operators. This was quite deliberate, so as to simulate likely future works standards, at least initially, that might be attained for whatever results proved to be the most favoured.

2.4 Information supplied to tenderers and requirements

The specification called for the following base information and set of requirements:

-the possibility for the Council to award separable portions of the works;

-a detailed Schedule of Prices that described the requirements for each of the five sub-sections (**Appendix C** to this paper);

-a list of objectives of the trial and the need to establish all costs; and

-wearing course compaction requirements of the pavement.

An outline was included about the subsequent measurements that the Council will be conducting for the ensuing two years.

2.5 Test information supplied to tenderers

Detailed materials testing results were included within the specification documentation, as well as assessments of the materials when checked against the criteria suggested by ARRB (March 2009). Details of the criteria used and results of the two pit sources are provided in **Appendix D** to this paper.

2.6 Gravel sources and their features

Prior to the trial construction, the ARRB guidelines (March 2009) was used extensively to analyse various properties of both pit sources. A NATA - approved laboratory undertook the pre-testing on behalf of the Council using samples collected by the Council staff at the pits.

The analysis notes and comments were documented in the specification. These notes are reproduced in **Appendix E** to the paper. From the analysis, it was found that the Dunolly-sourced material, when screened and crushed, met the following desired characteristics:

-Ease of grading, compaction, and comfort of traffic; and

-stability and low permeability wearing course characteristics;

Adding clay was recommended to improve appropriateness of clay content (because Plasticity Index was generally less than the desired range of between 13% and 17%). Adding clay would also improve the material size particle range.

On the other hand, the Daisy Hill-sourced material had quite different characteristics. The material met the following desired characteristics:

-Ease of grading, compaction, and comfort of traffic; and

-stability and low permeability wearing course characteristics (although one sample result was marginal).

The Daisy Hill samples indicated that there were problems in meeting the desired characteristics of:

-appropriateness of increasing clay content because of a surfeit of silty fines;
material having a combination of high fines and high plasticity;

- Daisy Hill material lacking in cohesion and highly susceptible to the formation of loose material and corrugations in its natural form; and

-the materials grading characteristics outside the ARRB recommended envelope, particularly needing coarser (and stronger) stone in its natural state.

The results prompted the application of a methodology described in the ARRB guidelines (March 2009) 'granular/mechanical stabilisation' as described at pp. 3.27 to 3.31. The use of a local bluestone quarry material, close to the Daisy Hill pit, by the addition of 46%, plus 8% of good quality clay was considered to be worth trialling, and was applied upon Section 4 of the trials.

Those quoting for five of the sections were required under the specification to undertake their own tests. Some test results have been forwarded to the Council by the contractor. The tests were done to assist with their mixing and application on the roadbed – particularly the two enzyme treatments, and the combined foam bitumen and cement treatment.

2.7 Costs to construct & maintain each trial section

All of the costs associated with testing undertaken prior to the trial construction, investigations, setting up of trial section signage, survey and monitoring of the trial road are excluded from the cost comparisons.

The costs associated with sub-base construction are similarly excluded.

All costs of pit crushing and screening, clay blending, and transport to the trial beds, as well as geotechnical testing on the trial beds are included. The distance of the Dunolly pit to the trial site was 29 kilometres, and from the Daisy Hill pit was 13 kilometres.

The relative costs associated with the trial using the initial construction (by contract for five sections, and by Council for Sections 4, 6, 8, and 9) are indicated in the table below. It is stressed that these costs, due to the very short lengths of different treatments, should only be regarded as relative to each other. They may not reflect costs associated with constructing longer lengths of a roadway.

Section No.	Description	Unit Rate AU$	Maint. costs by end Year 2 AU$
1	Daisy Hill material with 3% cement plus 3% foam bitumen	22.97	255.30
2	Daisy Hill material with 3% polymer	10.64	254.49
3	Daisy Hill material with enzyme 1 litre to 30 m³	16.95	713.87
4	Daisy Hill material with 46% class 4 bluestone FCR plus 8% clay	15.10**	69.11
5	Dunolly material with enzyme 1 litre to 30 m³	18.14	281.32
6	Dunolly material crushed and screened	4.71**	139.85
7	Dunolly material crushed and screened with 3% cement	11.89	48.78
8	Dunolly material crushed and screened with 5% clay mixed at the source	10.38**	-
9	Dunolly material at the roadbed, uncrushed, unscreened, with citrus organic binder sprayed onto finished surface	4.83**	375.00

** Constructed by the Council.

TABLE 1 – RELATIVE COSTS

Most of the maintenance requirement was to fill potholes that went beyond intervention level during the trial period. Section 9 required a re-grade for 200 metres at month 7.

2.8 Cross-section measurement of trial sections

Cross-sectional measurements were regularly taken over the course of the trial

The trial sections had survey cross-sections set up at two locations per section approximately mid-section which were accurately measured for shape and unravelling using total station survey equipment. The measurements were initially taken approximately every month. At the start (during the first six months) there was little change to the profiles – not enough to analyse. A visual check of the wearing courses and simple measurement of the degree of unravelling taken 2.5 metres left of the centreline was also done approximately every month, and the results photographed. The results of visual measurements were reported in the author's paper Styles MDG (August 2017).

The actual measurements at the end of the trial period were compared at 1.0 metres left, and 1.0 metres right of the centreline for each section and form part of a "triple bottom line" analysis of the results of the trial as an environmental measure (refer to this paper below). Centreline measurements at the end of the trial are also compared in **Table 2**.

Ch. From start	Section	Centreline loss at trial end (2 years) – mm	Average loss at 1.0 m both	Remarks
140	1	-36	-17.5	
160	1	-43	-26.5	
490	2	-75	-49.5	
510	2	-82	-55	
740	3	-92	-77.5	Most loss Daisy Hill sourced
760	3	-96	-68	Most loss Daisy Hill sourced
1140	4	-53	-40	
1160	4	-57	-30.5	
1460	5	-61	-48.5	Most loss Dunolly-sourced
1480	5	-58	-45.5	Most Loss Dunolly - sourced
1720	6	-44	-37	
1740	6	-47	-40	
2000	7	-44	-41	
2020	7	-54	-31.5	
2230	8	-44	-40.5	
2250	8	-47	-37.5	
2500	9	-33*	-27*	*Regraded after 7 months
2570	9	-59*	-22*	*Regraded after 7 months

TABLE 2 – LOSS OF MATERIALS

A "Roughometer" instrument (ARRB) was used to measure the roughness of the trial road; this was done about every three months. A "Roughometer" instrument complies with World Bank Class 3 requirements. It produces International Roughness Index (IRI) results. Because of the relatively low traffic counts, and the wearing course width of 5.5 metres with steep drop-offs, the readings for this trial were single straddling the centreline outwards and similarly back again. The results of the measurements after two years have been analysed and are discussed later in this paper.

Dust measuring used a visual scale established by Mulholland (1972) -at a scale of 0 to 10, which was further refined by Boyd and Van Cauwenberghe (1980) with a scale of 0 to 5; maximum dust being zero. The scale is reproduced as follows:

Rating	Condition
5	Dust-free, no dust rises from passing vehicles
4	Thin dust, rises a few feet high when vehicle passes
3	Thin dust, rises well above passing vehicle, vision not restricted
2	Thin dust cloud, visibility fair-poor, dust drifting from roadway
1	Thick dust cloud, causes driver uncertainty when following heavy dust drifting
0	Extreme dust conditions, takes 1-5 seconds for visibility to improve; visibility greatly restricted

TABLE 3 BOYD & VAN CAUWENBERG DUST CALIBRATIONS

No dust fall measurement stations established for this trial.

3. Results of Trial:

3.1 Initial Observations

Within the first six - month period the wearing courses of the first eight sections were remarkably stable and smooth. Wet periods at the very beginning (27 to 30 December) concerned motorists at section 3 (Daisy Hill with enzyme treatment), and the first 70 metres of what became section 9 which appeared to comprise run-out of some of the trial material of Section 8 and indicating a high percentage of clay. The latter part of section 9 using the natural Dunolly gravel was observed early in the trial to be unravelling, and large stones were prolific.

3.2 Dust observations

The observations have been recorded over the two years as follows:

Trial Section	Observ.
1.Daisy Hill material with 3% foam bitumen and 3% cement stabilisation	4.1
2. Daisy Hill sourced with 3% polymer	2.6
3. Daisy Hill material with enzyme 1 litre to 30 m³	1.9
4. Daisy Hill material with 46% class 4 bluestone FCR plus 8% clay	1.3
5. Dunolly material with enzyme 1 litre to 30 m³	2.6
6. Dunolly material crushed and screened	2.7
7. Dunolly material crushed and screened with 3% cement	2.9
8. Dunolly material crushed and screened with 5% clay mixed at the source	3.2
9. Dunolly material uncrushed with citrus organic binder dust suppressant	2.5

*__Note:__ One of the four readings in the first five months was two days after a rain event.

Dust observations otherwise only taken if no rain event recorded for 1 week previously.

TABLE 4 - DUST OBSERVATIONS

3.3 Roughness observations

At a number of section - ends there were spikes of roughness, caused by the techniques used by the grader operator to treat each section individually rather than ignoring slight contamination at each end when setting up the trial sections. Steps were taken to eliminate these short rough spikes within the first twelve months of the trial.

Below is a recording of the roughness counts taken outgoing at the end of the trial (14 December 2018). The specific counts were averaged for each section and analysed to establish comparisons of roughness between each section. These results were used to establish part of a triple bottom line analysis of the sections which are discussed later within this paper.

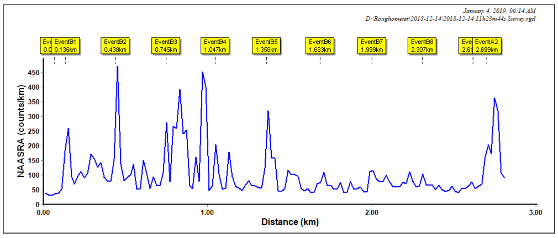

TABLE 5 - ROUGHOMETER RESULTS at 14 December 2018

Readings were as follows:

"Fair – good" (20-60 NAASRA cts. Sect 6, 7, 8

"Fair" (40-60 NAASRA counts) Sect. 1,5

"Poor" (60-100 NAASRA counts) Sect. 2, 4, 9.

"Bad" (>100 NAASRA counts) Sect. 3

3.4 Cross-sectional observations

Refer to **Table 2** above for details.
Readings within the first six months show little unravelling, except in Section 9, where intervention level had been reached about 100 metres past the start of the section, requiring a re-grade at 7 months.
The overall detailed cross-sectional checks, carried out monthly initially, then changed eventually to three monthly intervals indicated for centreline readings losses ranging from about 40 millimetres for Daisy Hill material at the foam bitumen section 1, to 94 millimetres in the Daisy Hill enzyme-treated Section 3. For the Dunolly – sourced sections, centreline readings losses ranged from 45 millimetres

(Sections 6 and 8) to 60 millimetres at the enzyme-treated Section 5.

From the above **Table 2**, indicative “life” of the unsealed pavement could be established for each section. A re-use factor by reclamation of material that is lost to the sides of the pavement would need to be established. It is suggested that a further check at 5 years could be done by “dipping” the cross-sections of the wheel paths to confirm the remaining pavement depths of this trial, thus establishing quanta of re-use.

3.5 Climatic observations

Daily weather observations were collected through the Bureau of Meteorology (BoM) website for Maryborough, Victoria. No detailed analysis is envisaged for the purposes of the trial. Rainfall has occurred for 270 days since the trial commenced on 1 January 2017. Of these, 27 events had daily precipitations of 10 millimetres or more, and the heaviest recorded rainfall in a day was 31.6 millimetres (16 November 2017).

3.6 Triple Bottom Line Assessments

A triple bottom line weighted assessment approach has been devised for this trial using the measurements of capital, and ongoing maintenance costs (economic); roughness (social); dust, and material loss (environmental).

For the assessment the material loss was measured by using averaged measured shape loss 1.0 m from the road centreline at two cross-sections per section. It was noted that dust was the only “qualitative” measure for this trial. Dust could also be regarded as a social measure but it was decided to call it an environmental measure because dust affects the full road reserve as well as abutting land. An iterative approach from close observation throughout the trial period was used to establish relative weightings. For example, relative weightings were established between maintenance and capital costs that took into account the likely overall maintenance costs during an assumed “life” against the one-off capital costs recorded. The workings are reproduced in **Appendix C1** to this paper. The following is a summary table of this assessment:

SECTION	Economic Factors Weighted Score	Social Factors	Environmental Factors	Total Score	Remarks
Daisy Hill material with 3% foam bitumen & 3% cement	-12.48	3.69	17.08	**8.29**	Little dust
2. Daisy Hill material with polymer added	0.01	-14.61	-4.54	**-19.14**	Rough
3. Daisy Hill material with enzyme added	-98.17	-32.06	-19.29	**-149.92**	Rough, high maintenance costs, loss of shape
4. Daisy Hill with Class 4 FCR and clay added	32.63	-18.31	-3.54	**10.78**	Rough, dusty
5. Dunolly material with enzyme added	-12.85	2.09	-2.92	**-13.68**	Loss of shape
6. Dunolly material crushed & screened	28.87	16.54	1.83	**47.24**	
7. Dunolly material crushed, screened and with cement added	39.90	15.39	3.96	**59.25**	Maintenance costs low

SECTION	Economic Factors Weighted Score	Social Factors	Environmental Factors	Total Score	Remarks
8. Dunolly material crushed, screened and with clay added	51.17	14.69	4.08	**69.94**	No maintenance required over the 2 - year trial
9. Dunolly material uncrushed, not screened with citrus dust suppressant	-18.28	17.04	7.83	**6.59**	Regrade was required at 7 months; (and by end of two-year trial – where cost was not added)

TABLE 6 – TRIPLE BOTTOM LINE RELATIVE SCORES

The scores were derived by comparing with the averaged scores of each factor.

From the above analysis at the end of two years, it is clear that the Dunolly-sourced screened and crushed material performed generally much better than the Daisy Hill - sourced material. Section 8, comprising crushed and screened Dunolly-sourced material mixing in 5% non-dispersive clay was indicated from the analysis to be the most successful section.

4. Issues and Constraints

There were a number of issues that arose, particularly at the setting up phase as part of the trial.

4.1 In-house and Contractor partnering

The specification called for the contractor to supervise the works – inclusive of Council plant operators - and to ensure that compaction was achieved. The test results for compaction indicated that the required compaction was not achieved for any of the trial sections. Just two days prior to the works commencing, the contractor asked the Council to arrange for a self-propelled 15 tonne steel vibrating roller to be hired on the contractor's behalf. At such very short notice only a multi-wheeled one was found, which the contractor decided to proceed with. The roller proved to be unsuitable particularly to achieve compaction of Section 3, being the enzyme treatment of Daisy Hill material. Section 3 proved to be problematic subsequently as water was not thoroughly mixed in, and compaction results were poor. The end- results of the trial at Section 3 indicate the serious issues around poor unsealed pavements compaction.

Cross falls of the finished surfaces were specified to be 6% plus or minus 0.5%, and the centre crown was required to be sharp, not rolled over. The Council grader operator was instructed to achieve the requirements, but was not supervised closely for all sections and the results for a number of sections were poor.

4.2 Road bed variances

At each of the section changes, the surface was not finished by the grader operator to achieve a seamless ride. That is, no "long blade" finish was undertaken by the grader operator. The section changes had to have maintenance work done to reduce the roughness a number of times during the trial. Costs associated with these initial deficiencies were not included for comparisons of the maintenance of each section.

4.3 Testing constraints

Although the materials additives testing results undertaken by the contractor were eventually forwarded to the Council, there was no detailed discussion or explanation offered by the contractor about them.

4.4 Why not seal?

Dust is an environmental as well as often a social concern. The economics of extending a 4 - metre wide seal was briefly examined. The outlay costs at Central Goldfields of sealing a section relative to the trial were established at AU$25 per square metre. So, an outlay of AU$270,000 would be required for sealing the section trialled, plus some required significant changes to the geometry of the road (particularly to address steep drop-offs with formation re-shaping) to cater for likely increases in traffic speeds and probably volumes.

4.5 What else is the Council trialling?

Organic binders and polymers have been trialled elsewhere as dust and surface trials to overcome high costs in summer of the maintenance of unsealed roads. Water and its carting costs are prohibitive. The citrus application is proving to be a simple, effective low-cost treatment with some promise. Works Effect analysis models (Austroads 2016) adaptations hold promise to apply in this area with an average annual rainfall of 560 millimetres.

As a result of the trial observations as it progressed, the Council's Manager Operations initiated the use of Dunolly-sourced crushed and screened gravel with the addition of some clay for the Council's 2018/19 re-sheeting program. Blacksmith Gully Road was recently inspected by the author, and the results appear to be of promise. Attention was paid to the basics of establishing 6% cross-falls, achieving better compaction, attention to good drainage and cut-off works, and attention to establishing sharp crowns were observed. There were still deficiencies in crossfalls – particularly where road longitudinal grades were flat, and the careful placement of guideposts. The screening of the Dunolly gravel was reduced to 20 millimetres minus, and that is assisting.

5. Conclusions

The two-year unsealed road trial conducted by Central Goldfields Shire Council comprising nine discrete sections of unsealed road pavement along the one road using a slightly marginal gravel, as well as a very marginal material has led the Council to seriously review whether the continued use of the very marginal Daisy Hill material source is worthwhile, as it is proving to have characteristics that are unable to be overcome – especially the generation of dust and the dispersal of material over time. Nevertheless, had only the Daisy Hill material been available in any quantity, there is some promise by improving its properties by addition of bluestone and clay. Application of the methodology described by ARRB indicated a lot of merit in such an approach.

From the two years of measurements, and by devising an innovative triple bottom line (economic, social and environmental) assessment using the measures, and from observations of the sections trialled, the more successful sections observed - outcomes were reinforced. The triple bottom line results were able to be used with confidence.

By their direct participation in the trial sections' construction, the Council staff and plant operators learned some lessons about the importance of understanding how to interpret test results, and to improve the properties of marginal and indeed all unsealed road wearing course materials. Paying attention to the need to base a scientific approach in achieving the construction of strong, fit for purpose pavements from locally sourced materials that may service its community for much longer useful lives is critical to achieving much better outcomes for local users of these roads.

It has been identified as a result of the trial that the Dunolly-sourced tertiary gravel is an important current and future material resource for Central Goldfields Shire Council to be able to access.
Steps will be taken by the Council to complete the identification of all these deposits, to secure the gravel resources.

The organising of regular, follow-up staff and operator training will enable the Council to minimise future unsealed road costs, and to optimise economic, environmental and social benefits when addressing the requirements of the current 625 kilometres of unsealed roads under the stewardship of the Council.

The results of this trial add to the body of knowledge that is aimed at addressing how to significantly improve the level of service upon the considerable but often neglected 63% length of unsealed Australian road network (Austroads 2016).

6. Appendices

Available appendices under separate cover are as follows:

Appendix A Detailed description of the Possum Gully Road trial wearing course pavements

Appendix B Possum Gully Road Trial - Subgrade Field Penetrometer Test results

Appendix C Possum Gully Road Trial - Detailed prices Quotation Schedule

Appendix C1 Possum Gully Road Trial – Triple Bottom Line workings

Appendix D Possum Gully Road Trial – ARRB-based criteria used to compare Daisy Hill-sourced and Dunolly – sourced materials

Appendix E Possum Gully Road Trial – Sample analyses, notes and comments

Appendix F Bibliography

Acknowledgements

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