# APPENDIX L

**Pavement Condition Analysis**

# Martins Creek Quarry Haul Routes

## Analysis of future pavement maintenance requirements resulting from a proposed increase in quarry truck traffic

Report prepared by SMEC Australia

For

Buttai Gravel Pty. Ltd.

May 2021

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# 1. EXECUTIVE SUMMARY

## 1.1. Background

Martins Creek Quarry (the Quarry) is located approximately 28 km north of Maitland in the NSW Hunter Region. The Quarry is licensed and operated by Buttai Gravel Pty. Ltd. (Daracon).

Daracon is seeking approval to extend the operations at the Quarry to extract and process up to 1.1 million tonnes per annum (Mtpa) of hard rock material over 25 years. Haulage of quarry product is proposed to involve:

- Transporting up to 500,000 tonnes per annum (tpa) of Quarry product via public roads, with up to 600,000 tpa transported via rail. Subject to market requirements at a later date, Daracon may seek DPIE approval to increase the amount transported by rail, on a campaign basis.
- Maximum of 140 loaded trucks (280 movements) per day, between 7.00 am and 6.00 pm Monday to Friday for up to 50 days per year. Maximum of 100 loaded trucks (200 movements) per day, for the remainder of the year.
- Maximum of 20 loaded trucks (40 movements) per hour, between 7.00 am and 3.00 pm Monday to Friday, and up to 15 loaded trucks (30 movements) per hour, between 3.00pm and 6.00pm Monday to Friday.
- Use of one primary haulage route i.e. Haul Route 1 as shown on Figure 1.1.

Material extracted from the Quarry will mainly be trucked to the south on public roads along Haul Route 1 that are maintained by the Dungog Shire Council and Maitland City Council. It is recognised that the truck traffic required to haul this production may lead to increased maintenance requirements for the pavements of the haul routes.

To quantify the effects of the increased traffic loading on the road pavements, Daracon engaged Umwelt (Australia) Pty. Ltd. who then sub-contracted SMEC Australia Pty. Ltd. to undertake a pavement deterioration modelling analysis using a software tool known as the SMEC Pavement Management System (SMEC PMS). To determine the current condition of the road pavements SMEC hired ARRB Group to conduct a pavement condition assessment of the haul route. This assessment (undertaken in November 2018) included a visual assessment of the road surface defects as well as laser profiler measurements to determine the road roughness and the measurement of rutting in the wheel paths. In addition, pavement deflection readings (measured in April 2019 using a Deflectograph Truck) were sourced from Dungog Shire Council and these were supplemented with Falling Weight Deflectometer (FWD) testing that was carried out during a previous survey in 2015.

The Haul Route required to be analysed is approximately 28km long and runs south from Martins Creek Quarry to Melbourne Street in East Maitland. It passes through two local government areas under the jurisdiction of Dungog Shire Council and Maitland City Council.

The length of road passing through each Council's jurisdiction can be seen in Table 1-1.

*Table 1-1 Length of haul route maintained by each Council*

| Council Name | Length of Haul Route | Comment |
|---|---|---|
| Dungog Shire Council | 12.75 km | Haul Route from quarry entrance to Dungog Shire / Maitland city boundary marker on Tocal Road. |
| Maitland City Council | 15.70 km | Haul Route from Dungog Shire / Maitland city boundary marker on Tocal Road to Melbourne Street in East Maitland. |

The quarry truck fleet used for the modelling was based on actual records supplied for the 2017/2018 financial year and consisted of a mixture of trucks in both 'Truck and Dog' configuration and three axle Rigid trucks. The study assumed that the ratio of trucks (between 'Rigid' and 'Truck and Dog') would be the same for each quarry extraction scenario that was analysed.

The haul route is shown on the map in Figure 1-1.


*Figure 1-1: Location of traffic count sites referred to in this study*

## 1.2. Study Methodology

The objective of the study was to determine the increased maintenance requirements and maintenance costs associated with the road transport of quarry material from the Martins Creek Quarry to South Maitland. The requirement for the study (as notified by Umwelt) was to model the performance of the road pavements over the next 25 years under the following scenarios:

1. Approved Scenario - Model the future deterioration assuming 134,700 tonnes per annum is transported south along the haul roads towards Maitland.
2. Proposed Scenario – Model the future deterioration assuming 500,000 tonnes per annum is transported south along the haul roads towards Maitland.

The modelling was carried out to determine the annual pavement resurfacing and rehabilitation treatments that would be required over the next 25 years in order to maintain the pavement condition at an average Pavement Condition Index (PCI) of 8.5. (Refer to APPENDIX B for a description of how the PCI is calculated).

For comparison purposes, the roads were also modelled assuming that there would be no quarry trucks using the roads over the next 25 years.

The tool used to model the road pavements over the next 25 years was the SMEC Pavement Management System (PMS). This tool utilises the World Bank's 'Highway Design and Maintenance Standards Model (HDM)' to predict the future deterioration of road pavements under the effects of traffic loading and the environment. The SMEC PMS can also optimise the future maintenance program required to maintain the roads at a nominated condition level. The SMEC PMS is currently being used by more than 45 Local Government Authorities throughout Australia to help manage their road networks. In the Hunter Region the SMEC PMS is being used by Maitland, Port Stephens, Lake Macquarie and Central Coast Councils. A more detailed overview of the SMEC PMS can be seen in APPENDIX A.

Prior to commencing the modelling, a detailed assessment was made of the current condition of the road pavements. This assessment included:

- Roughness and rutting testing using a laser profiler
- Surface Defects (including surface cracking)

Correspondence was sent to the Dungog Shire Council and Maitland City Council requesting data relating to treatment unit rates and previous treatment history for the affected haul roads. The treatment history was used to determine current age data relating to the surface and pavement layers. Where data was not available then estimated data, based on condition, was used for the models.

The condition assessment was conducted in each direction for each 100m segment of the haul road. The pavement testing was carried out by ARRB Group Ltd.

In addition to the roughness, rutting and surface defect data measured by ARRB, the analysis also utilised deflection data measured using a 2015 ARRB FWD survey and a Deflectograph survey of the Dungog roads that was carried out in 2019 by Pitt and Sherry. This data was provided by Dungog Shire Council as a result of the request for information.

Current traffic data was collected using classified traffic counters placed for 21 days at five different locations along the haul routes. The location of the five traffic count sites can be seen in Figure 1-1.

## 1.3. Summary of results of analysis

The current condition of the haul routes in November 2018 is summarised in Table 1-2. The summary data indicates that the Maitland roads tend to be in better condition and have stronger pavements as compared to Dungog.

*Table 1-2 Current condition of road pavements (Southbound lanes)*

| Condition Attribute | Dungog Roads | Maitland Roads |
|---|---|---|
| Road Length | 12.75 km | 15.70 km |
| Average Roughness (NAASRA) | 85.0 | 52.9 |
| Average Rut Depth (mm) | 5.7 mm | 4.7 mm |
| Average Cracking (% of surface affected) | 4.5% | 6.0% |
| Average Pavement Condition Index (PCI) | 7.9 | 8.2 |
| Average Strength (Modified Structural No.) | 3.8 | 6.0 |

As a result of the modelling, it was predicted that the addition of the extra truck traffic would result in additional road maintenance requirements for the haul routes over the next 25 years. A summary of the analysis is shown in Table 1-3. All costs are expressed in today's dollars and are exclusive of GST.

*Table 1-3 Future funding requirements for pavements (Includes Northbound and Southbound lanes)*

| Modelling scenario | Dungog Roads | Maitland Roads |
|---|---|---|
| Length of roads | 12.75 km | 15.7 km |
| | | |
| **Scenario 1: No quarry trucks using roads** | | |
| | | |
| Resurfacing and rehabilitation costs over 25 years. | $8,891,216 | $8,222,356 |
| | | |
| **Scenario 2: Quarry trucks hauling 134,700 tonnes per year** | | |
| | | |
| Resurfacing and rehabilitation costs over 25 years. | $10,478,640 | $9,140,006 |
| Increase in funding over Scenario 1. | $1,587,424 | $917,650 |
| Increase in funding over Scenario 1 per year. | $63,497 | $36,706 |
| Increase in funding over Scenario 1 per year per km. | $4,976 | $2,338 |
| | | |
| **Scenario 3: Quarry trucks hauling 500,000 tonnes per year** | | |
| | | |
| Resurfacing and rehabilitation costs over 25 years. | $11,650,390 | $9,511,640 |
| Increase in funding over Scenario 1. | $2,759,174 | $1,289,284 |
| Increase in funding over Scenario 1 per year. | $110,367 | $51,571 |
| Increase in funding over Scenario 1 per year per km. | $8,649 | $3,285 |
| | | |

The analysis predicts that the Dungog roads would need the highest level of additional funding in order to maintain the road pavements at their current condition level. In comparison, the requirement for the Maitland roads is significantly less. It is concluded that the reason for this is because the non-quarry related traffic loads on the Maitland roads are much higher than on the Dungog roads. Therefore, the incremental increase in pavement thicknesses in order to accommodate the additional quarry truck traffic, is much less significant on the Maitland roads in comparison to the Dungog roads.

In addition, the current Maitland pavements, with an average strength of 6.0 modified structural number and a current average roughness of 52.0 NAASRA Counts, are a lot stronger and newer compared to the Dungog pavements. This means that they are in a lot better position to cater for the increased axle loads associated with the increased quarry truck traffic.

It can be seen from Table 1-3 that the annual cost of future maintenance does not increase in a linear relationship, with the increase in the annual tonnage that is being hauled from the quarry. This is because the AUSTROADS formula used to calculate the pavement thickness required to carry the traffic loading is not linear. (Refer to Section 6 of this report).

# 2. ABBREVIATIONS AND ACRONYMS

*Table 2-1 Abbreviations and Acronyms*

| Abbreviation/ Acronym | Description |
|---|---|
| AADT | Average Annual Daily Traffic |
| CBR | California Bearing Ratio |
| ESA | Equivalent Standard Axle |
| EBM | Expenditure Budgeting Model |
| FWD | Falling Weight Deflectometer |
| HDM | Highway Design Maintenance Standards Model |
| IRI | International Roughness Index |
| Km | Kilometre |
| LGA | Local Government Authority |
| m | Metres |
| NAASRA | National Association of Australian State Road Authorities (now AUSTROADS) |
| NPV | Net Present Value |
| PCI | Pavement Condition Index |
| PMS | Pavement Management System |
| PHI | Pavement Health |
| PHNI | Pavement Health Roughness Index (NAASRA Counts) |
| PHRI | Pavement Health Rutting Index |
| SHI | Surface Health Index |
| SHCI | Surface Health Cracking Index |
| SHTI | Surface Health Texture Index |
| SMEC | Snowy Mountains Engineering Corporation |
| SN | Structural Number. A measure of the strength of the pavement |
| Modified SN | Strength measurement including the contribution from the sub-grade |
| Modulus | Pavement material strength measured in GPa |
| T&D | Truck and Dog |

# 3. TRAFFIC LOADING

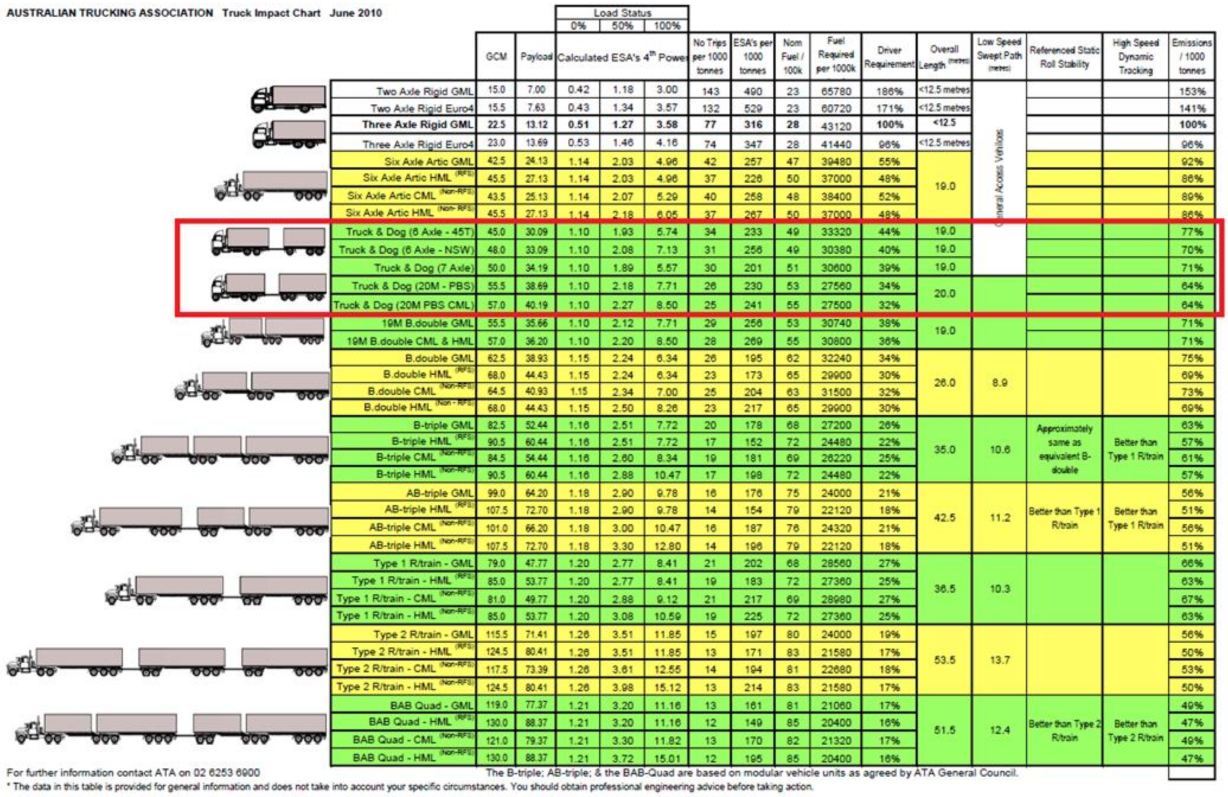
## 3.1. Haulage routes

It is proposed to haul product trucks on the road network along primary haulage route 1 as shown in Figure 1.1. SMEC has undertaken an analysis of this haul route. There would however be a need for quarry sale trucks to occasionally access other local roads as required to service local projects on a campaign basis. SMEC was asked to take a conservative approach (in terms of not under-estimating the damage that could occur on the southern end of the route) and assume that all quarry truck traffic would travel south to Maitland.

## 3.2. Axle loading

The loaded trucks travel south from the quarry and then return unloaded in a northerly direction. Because of the additional axle loading that is borne by the southbound lanes it is expected that these will deteriorate faster, and it will be this deterioration that will drive the requirement for future maintenance treatments. In this analysis it has been assumed that, when a treatment occurs, then it will be applied to the full width of the road.

SMEC was supplied with a record of the quarry trucks that left the quarry over the 2017/2018 financial year. Examination of these records showed that the truck configuration used for the haulage was a mixture of 'Truck and Dog' trucks having a medium load of 32 tonnes of material as well as smaller number of Rigid trucks having a medium load of 11.66 tonne. Each Truck and Dog truck was assumed to have a pavement load rating of 6.8 Equivalent Stand Axle Loads (ESAs) while the loaded Rigid truck was assumed to have a pavement load rating of 3.07 Equivalent Stand Axle Loads (ESAs). This information was interpolated from the 'Australian Trucking Association Truck Impact Chart Jun2 2010'. Refer to Figure 3-1.


AUSTRALIAN TRUCKING ASSOCIATION Truck Impact Chart June 2010

| | GCM | Payload | Calculated ESA's 4th Power – Load Status 0% | 50% | 100% | No Trips per 1000 tonnes | ESA's per 1000 tonnes | Nom Fuel / 100k | Fuel Required per 1000k | Driver Requirement | Overall Length (metres) | Low Speed Swept Path (metres) | Referenced Static Roll Stability | High Speed Dynamic Tracking | Emissions / 1000 tonnes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Two Axle Rigid GML | 15.0 | 7.00 | 0.42 | 1.18 | 3.00 | 143 | 490 | 23 | 65780 | 186% | <12.5 metres | General Access Vehicles | | | 153% |
| Two Axle Rigid Euro4 | 15.5 | 7.63 | 0.43 | 1.34 | 3.57 | 132 | 529 | 23 | 60720 | 171% | <12.5 metres | | | | 141% |
| **Three Axle Rigid GML** | **22.5** | **13.12** | **0.51** | **1.27** | **3.58** | **77** | **316** | **28** | 43120 | **100%** | **<12.5** | | | | **100%** |
| Three Axle Rigid Euro4 | 23.0 | 13.69 | 0.53 | 1.46 | 4.16 | 74 | 347 | 28 | 41440 | 96% | <12.5 metres | | | | 96% |
| Six Axle Artic GML | 42.5 | 24.13 | 1.14 | 2.03 | 4.96 | 42 | 257 | 47 | 39480 | 55% | 19.0 | | | | 92% |
| Six Axle Artic HML (RFS) | 45.5 | 27.13 | 1.14 | 2.03 | 4.96 | 37 | 226 | 50 | 37000 | 48% | | | | | 86% |
| Six Axle Artic CML (Non-RFS) | 43.5 | 25.13 | 1.14 | 2.07 | 5.29 | 40 | 258 | 48 | 38400 | 52% | | | | | 89% |
| Six Axle Artic HML (Non-RFS) | 45.5 | 27.13 | 1.14 | 2.18 | 6.05 | 37 | 267 | 50 | 37000 | 48% | | | | | 86% |
| Truck & Dog (6 Axle - 45T) | 45.0 | 30.09 | 1.10 | 1.93 | 5.74 | 34 | 233 | 49 | 33320 | 44% | 19.0 | | | | 77% |
| Truck & Dog (6 Axle - NSW) | 48.0 | 33.09 | 1.10 | 2.08 | 7.13 | 31 | 256 | 49 | 30380 | 40% | 19.0 | | | | 70% |
| Truck & Dog (7 Axle) | 50.0 | 34.19 | 1.10 | 1.89 | 5.57 | 30 | 201 | 51 | 30600 | 39% | 19.0 | | | | 71% |
| Truck & Dog (20M - PBS) | 55.5 | 38.69 | 1.10 | 2.18 | 7.71 | 26 | 230 | 53 | 27560 | 34% | 20.0 | | | | 64% |
| Truck & Dog (20M PBS CML) | 57.0 | 40.19 | 1.10 | 2.27 | 8.50 | 25 | 241 | 55 | 27500 | 32% | | | | | 64% |
| 19M B.double GML | 55.5 | 35.66 | 1.10 | 2.12 | 7.71 | 29 | 256 | 53 | 30740 | 38% | 19.0 | | | | 71% |
| 19M B.double CML & HML | 57.0 | 36.20 | 1.10 | 2.20 | 8.50 | 28 | 269 | 55 | 30800 | 36% | | | | | 71% |
| B.double GML | 62.5 | 38.93 | 1.15 | 2.24 | 6.34 | 26 | 195 | 62 | 32240 | 34% | 26.0 | 8.9 | | | 75% |
| B.double HML (RFS) | 68.0 | 44.43 | 1.15 | 2.24 | 6.34 | 23 | 173 | 65 | 29900 | 30% | | | | | 69% |
| B.double CML (Non-RFS) | 64.5 | 40.93 | 1.15 | 2.34 | 7.00 | 25 | 204 | 63 | 31500 | 32% | | | | | 73% |
| B.double HML (Non-RFS) | 68.0 | 44.43 | 1.15 | 2.50 | 8.26 | 23 | 217 | 65 | 29900 | 30% | | | | | 69% |
| B-triple GML | 82.5 | 52.44 | 1.16 | 2.51 | 7.72 | 20 | 178 | 68 | 27200 | 26% | 35.0 | 10.6 | Approximately same as equivalent B-double | Better than Type 1 R/train | 63% |
| B-triple HML (RFS) | 90.5 | 60.44 | 1.16 | 2.51 | 7.72 | 17 | 152 | 72 | 24480 | 22% | | | | | 57% |
| B-triple CML (Non-RFS) | 84.5 | 54.44 | 1.16 | 2.60 | 8.34 | 19 | 181 | 69 | 26220 | 25% | | | | | 61% |
| B-triple HML (Non-RFS) | 90.5 | 60.44 | 1.16 | 2.88 | 10.47 | 17 | 198 | 72 | 24480 | 22% | | | | | 57% |
| AB-triple GML | 99.0 | 64.20 | 1.18 | 2.90 | 9.78 | 16 | 176 | 75 | 24000 | 21% | 42.5 | 11.2 | Better than Type 1 R/train | Better than Type 1 R/train | 56% |
| AB-triple HML (RFS) | 107.5 | 72.70 | 1.18 | 2.90 | 9.78 | 14 | 154 | 79 | 22120 | 18% | | | | | 51% |
| AB-triple CML (Non-RFS) | 101.0 | 66.20 | 1.18 | 3.00 | 10.47 | 16 | 187 | 76 | 24320 | 21% | | | | | 56% |
| AB-triple HML (Non-RFS) | 107.5 | 72.70 | 1.18 | 3.30 | 12.80 | 14 | 196 | 79 | 22120 | 18% | | | | | 51% |
| Type 1 R/train - GML | 79.0 | 47.77 | 1.20 | 2.77 | 8.41 | 21 | 202 | 68 | 28560 | 27% | 36.5 | 10.3 | | | 66% |
| Type 1 R/train - HML (RFS) | 85.0 | 53.77 | 1.20 | 2.77 | 8.41 | 19 | 183 | 72 | 27360 | 25% | | | | | 63% |
| Type 1 R/train - CML (Non-RFS) | 81.0 | 49.77 | 1.20 | 2.88 | 9.12 | 21 | 217 | 69 | 28980 | 27% | | | | | 67% |
| Type 1 R/train - HML (Non-RFS) | 85.0 | 53.77 | 1.20 | 3.08 | 10.59 | 19 | 225 | 72 | 27360 | 25% | | | | | 63% |
| Type 2 R/train - GML | 115.5 | 71.41 | 1.26 | 3.51 | 11.85 | 15 | 197 | 80 | 24000 | 19% | 53.5 | 13.7 | | | 56% |
| Type 2 R/train - HML (RFS) | 124.5 | 80.41 | 1.26 | 3.51 | 11.85 | 13 | 171 | 83 | 21580 | 17% | | | | | 50% |
| Type 2 R/train - CML (Non-RFS) | 117.5 | 73.39 | 1.26 | 3.61 | 12.55 | 14 | 194 | 81 | 22680 | 18% | | | | | 53% |
| Type 2 R/train - HML (Non-RFS) | 124.5 | 80.41 | 1.26 | 3.98 | 15.12 | 13 | 214 | 83 | 21580 | 17% | | | | | 50% |
| BAB Quad - GML | 119.0 | 77.37 | 1.21 | 3.20 | 11.16 | 13 | 161 | 81 | 21060 | 17% | 51.5 | 12.4 | Better than Type 2 R/train | Better than Type 2 R/train | 49% |
| BAB Quad - HML (RFS) | 130.0 | 88.37 | 1.21 | 3.20 | 11.16 | 12 | 149 | 85 | 20400 | 16% | | | | | 47% |
| BAB Quad - CML (Non-RFS) | 121.0 | 79.37 | 1.21 | 3.30 | 11.82 | 13 | 170 | 82 | 21320 | 17% | | | | | 49% |
| BAB Quad - HML (Non-RFS) | 130.0 | 88.37 | 1.21 | 3.72 | 15.01 | 12 | 195 | 85 | 20400 | 16% | | | | | 47% |

For further information contact ATA on 02 6253 6900

The B-triple; AB-triple; & the BAB-Quad are based on modular vehicle units as agreed by ATA General Council.

* The data in this table is provided for general information and does not take into account your specific circumstances. You should obtain professional engineering advice before taking action.

*Figure 3-1: Australian Trucking Association Truck Impact Chart Jun2 2010*

## 3.3. Current traffic volumes

To determine the current traffic volumes using the routes, SECA Solution Pty Ltd was commissioned to undertake classified traffic counts at five different sites as indicated in Figure 3-2.


*Figure 3-2: Location of traffic count sites*

The traffic counts were taken over 21 days commencing from 28th April 2018. The counts were then averaged to obtain the Average Annual Daily Traffic (AADT) for each 13 different AUSTROADS traffic classification. The current traffic count data is shown in Table 3-1.

*Table 3-1 Southbound classified traffic counts (Current traffic based on SECA traffic surveys)*

| Week Starting | | C1 Short | C2 Short Towing | C3 2 axle Truck or bus | C4 3 Axle Truck or Bus | C5 4 or 5 Axle Truck | C6 3 Axle Articulated | C7 4 Axle Articulated | C8 5 Axle Articulated | C9 6 Axle Articulated | C10 B Double | C11 Double Road Train | C12 Triple Road Train | C13 Unclassifiable | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **South Bound Lane- Average AADT count for each Austroads Vehicle Classification** | | | | | | | | | | | | | |
| 28-Apr-18 | 1. Dungog Road | 613 | 23 | 25 | 9 | 1 | 0 | 1 | 0 | 52 | 10 | 1 | 0 | 0 | 735 |
| 5-May-18 | 1. Dungog Road | 692 | 21 | 24 | 10 | 1 | 0 | 0 | 0 | 48 | 13 | 2 | 0 | 0 | 812 |
| 12-May-18 | 1. Dungog Road | 617 | 18 | 25 | 16 | 1 | 0 | 1 | 0 | 43 | 10 | 1 | 0 | 0 | 733 |
| | Average over 3 Weeks | 641 | 21 | 25 | 12 | 1 | 0 | 1 | 0 | 48 | 11 | 1 | 0 | 0 | 760 |
| 28-Apr-18 | 2. Gresford Road | 1468 | 60 | 119 | 13 | 3 | 5 | 8 | 1 | 58 | 11 | 1 | 0 | 0 | 1748 |
| 5-May-18 | 2. Gresford Road | 1587 | 66 | 47 | 14 | 2 | 1 | 0 | 1 | 75 | 14 | 1 | 0 | 0 | 1809 |
| 12-May-18 | 2. Gresford Road | 1507 | 57 | 43 | 21 | 2 | 1 | 2 | 1 | 62 | 12 | 1 | 0 | 0 | 1710 |
| | Average over 3 weeks | 1520 | 61 | 70 | 16 | 2 | 2 | 4 | 1 | 65 | 13 | 1 | 0 | 0 | 1756 |
| 28-Apr-18 | 3. Tocal Road | 2135 | 79 | 65 | 13 | 5 | 2 | 4 | 2 | 54 | 12 | 1 | 0 | 0 | 2372 |
| 5-May-18 | 3. Tocal Road | 2577 | 89 | 68 | 19 | 9 | 4 | 5 | 2 | 56 | 19 | 1 | 0 | 1 | 2851 |
| | 3. Tocal Road | 1770 | 52 | 47 | 21 | 3 | 2 | 1 | 2 | 44 | 18 | 1 | 0 | 1 | 1961 |
| | Average over 3 weeks | 2160 | 73 | 60 | 17 | 6 | 3 | 3 | 2 | 51 | 16 | 1 | 0 | 1 | 2395 |
| 28-Apr-18 | 4. Paterson Road | 6076 | 134 | 130 | 43 | 13 | 2 | 6 | 4 | 60 | 19 | 5 | 0 | 5 | 6496 |
| 5-May-18 | 4. Paterson Road | 6453 | 146 | 135 | 38 | 17 | 4 | 10 | 4 | 74 | 18 | 4 | 0 | 5 | 6908 |
| 12-May-18 | 4. Paterson Road | 5815 | 118 | 115 | 35 | 14 | 3 | 4 | 2 | 55 | 16 | 3 | 0 | 8 | 6189 |
| | Average over 3 weeks | 6114 | 133 | 127 | 39 | 14 | 3 | 7 | 3 | 63 | 18 | 4 | 0 | 6 | 6531 |
| 28-Apr-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4612 | 91 | 68 | 24 | 8 | 2 | 3 | 2 | 23 | 8 | 1 | 0 | 2 | 4844 |
| 5-May-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4881 | 99 | 74 | 28 | 13 | 2 | 5 | 2 | 20 | 11 | 1 | 0 | 5 | 5141 |
| 12-May-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4606 | 74 | 62 | 30 | 12 | 2 | 4 | 2 | 17 | 9 | 1 | 0 | 5 | 4824 |
| | Average over 3 weeks | 4700 | 88 | 68 | 28 | 11 | 2 | 4 | 2 | 20 | 9 | 1 | 0 | 4 | 4936 |

### 3.4. Modelling Scenarios

For this study, Umwelt requested SMEC to model three separate scenarios:

1. Model the future maintenance requirements to maintain the road at its current average condition level if there were no quarry trucks using the road.
2. Model the future maintenance requirements to maintain the road at its current average condition level if 134,700 tonnes per annum was being transported along the road. This is based on a maximum of 449,000 tonnes per annum of product being produced of which 30% is transported by road.
3. Model the future maintenance requirements to maintain the road at its current average condition level if 500,000 tonnes per annum was being transported along the road.

The traffic data captured by the SECA traffic surveys included both quarry traffic and non-quarry traffic.

During the weeks over which the traffic counts were done, the Martins Creek Quarry records show that the following average number of loaded trucks per day, left the quarry:

| Week Commencing | Truck & Dog | Rigid |
|---|---|---|
| 28-Apr-18 | 59 | 19 |
| 5-May-18 | 78 | 19 |
| 12-May-18 | 66 | 18 |

More comprehensive records were also obtained from the quarry that covered all truck movements that used the haul route for the 2017/2018 financial year. A summary of this data is included in Table 3-2.

*Table 3-2: Quarry truck movements FY2017/2018*

| Truck and Dog FY2017/2018 | | |
|---|---|---|
| Total Movements | 17996 | Movements |
| Max Load | 34.14 | Tonnes |
| Min Load | 27.02 | Tonnes |
| Average Load | 31.79 | Tonnes |
| Median Load | 32 | Tonnes |

| Rigid FY2017/2018 | | |
|---|---|---|
| Total Movements | 4134 | Movements |
| Max Load | 14.90 | Tonnes |
| Min Load | 5.02 | Tonnes |
| Average Load | 11.20 | Tonnes |
| Median Load | 11.66 | Tonnes |

Based on the 2017/2018 data, the proportion of each truck type used by the quarry was 81% for Truck and Dog (T&D) and 19% for Rigid. For the purpose of this analysis, it was assumed same proportions of each truck type would be used when modelling the 500,000 Tonnes per annum scenario.

The Equivalent Standard Axle Load (ESA) for each loaded truck it was determined based on the Median Load for the Truck and Dog and Rigid configurations as supplied in the records. Using interpolation from the Axle Load data shown in Figure 3-1, it was determined that the ESA for each loaded Truck and Dog carrying 32 Tonnes was 6.8 and the ESA for Rigid Truck carrying 11.66 Tonnes was 3.07.

*Table 3-3: Calculated T&D and Rigid truck movements for each tonnage scenario*

| Haul amount (Tonnes per annum) | T&D movements per annum | Rigid Truck movements per annum | Total ESA's per annum |
|---|---|---|---|
| 134,700 | 3,884 | 892 | 29,152 |
| 500,000 | 14,418 | 3,312 | 108,212 |

In terms of the AUSTROADS traffic classification, the Truck and Dog vehicles were classified as Class 9 (6 axle articulated) while the Rigid Trucks were classified as Class 4 (3 axle truck).

By subtracting quarry truck counts from the SECA counts for Class 4 and Class 9 vehicles, then the resulting figures should reflect the traffic counts that would be seen if the quarry was to shut down i.e. modelling scenario 1.

Similarly, using the annual truck movement figures that were estimated in Table 3-3, it is possible to calculate the daily traffic data that would be expected if the road haulage was set at 134,700 tonnes and 500,000 tonnes respectively. These estimated traffic counts are shown in Table 3-5 and Table 3-6 and were analysed as Scenario 2 and Scenario 3.

Although the frequency of quarry truck traffic is greater if all trips occur during the week days, in terms of the axle loading causing pavement damage, it is irrelevant if the trips occur across a five-day week or a seven-day week.

*Table 3-4 Scenario 1- Traffic count (AADT) if no quarry trucks*

| | | South Bound Lane- Average AADT count for each Austroads Vehicle Classification | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | |
| Week Starting | | Short | Short Towing | 2 axle Truck or bus | 3 Axle Truck or Bus | 4 or 5 Axle Truck | 3 Axle Articulated | 4 Axle Articulated | 5 Axle Articulated | 6 Axle Articulated | B Double | Double Road Train | Triple Road Train | Unclassifiable | **Total** |
| 28-Apr-18 | 1. Dungog Road | 613 | 23 | 16 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 1 | 0 | 0 | 657 |
| 5-May-18 | 1. Dungog Road | 692 | 21 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 730 |
| 12-May-18 | 1. Dungog Road | 617 | 18 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 659 |
| | Average over 3 Weeks | 641 | 21 | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 682 |
| 28-Apr-18 | 2. Gresford Road | 1468 | 60 | 113 | 0 | 3 | 5 | 8 | 1 | 0 | 10 | 1 | 0 | 0 | 1669 |
| 5-May-18 | 2. Gresford Road | 1587 | 66 | 42 | 0 | 2 | 1 | 0 | 1 | 0 | 11 | 1 | 0 | 0 | 1712 |
| 12-May-18 | 2. Gresford Road | 1507 | 57 | 43 | 3 | 2 | 1 | 2 | 1 | 0 | 8 | 1 | 0 | 0 | 1626 |
| | Average over 3 weeks | 1520 | 61 | 66 | 1 | 2 | 2 | 4 | 1 | 0 | 10 | 1 | 0 | 0 | 1669 |
| 28-Apr-18 | 3. Tocal Road | 2135 | 79 | 64 | 0 | 0 | 2 | 4 | 2 | 0 | 7 | 1 | 0 | 0 | 2295 |
| 5-May-18 | 3. Tocal Road | 2577 | 89 | 68 | 0 | 9 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 2753 |
| | 3. Tocal Road | 1770 | 52 | 47 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1878 |
| | Average over 3 weeks | 2160 | 73 | 60 | 1 | 4 | 3 | 3 | 1 | 0 | 2 | 0 | 0 | 1 | 2309 |
| 28-Apr-18 | 4. Paterson Road | 6076 | 134 | 130 | 24 | 13 | 2 | 6 | 4 | 1 | 19 | 5 | 0 | 5 | 6418 |
| 5-May-18 | 4. Paterson Road | 6453 | 146 | 135 | 19 | 17 | 4 | 10 | 4 | 0 | 14 | 4 | 0 | 5 | 6811 |
| 12-May-18 | 4. Paterson Road | 5815 | 118 | 115 | 17 | 14 | 3 | 4 | 2 | 0 | 5 | 3 | 0 | 8 | 6105 |
| | Average over 3 weeks | 6114 | 133 | 127 | 20 | 14 | 3 | 7 | 3 | 0 | 13 | 4 | 0 | 6 | 6444 |
| 28-Apr-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4612 | 91 | 68 | 5 | 8 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 2 | 4792 |
| 5-May-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4881 | 99 | 74 | 9 | 13 | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 5 | 5088 |
| 12-May-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4606 | 74 | 62 | 12 | 12 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 5 | 4778 |
| | Average over 3 weeks | 4700 | 88 | 68 | 9 | 11 | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 4886 |

*Table 3-5 Scenario 2- Traffic count (AADT) for production of 134,700 tonnes per annum*

| Week Starting | | C1 Short | C2 Short Towing | C3 2 axle Truck or bus | C4 3 Axle Truck or Bus | C5 4 or 5 Axle Truck | C6 3 Axle Articulated | C7 4 Axle Articulated | C8 5 Axle Articulated | C9 6 Axle Articulated | C10 B Double | C11 Double Road Train | C12 Triple Road Train | C13 Unclassifiable | **Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **South Bound Lane- Average AADT count for each Austroads Vehicle Classification** | | | | | | | | | | | | | |
| 28-Apr-18 | 1. Dungog Road | 613 | 23 | 16 | 0 | 0 | 0 | 1 | 0 | 11 | 3 | 1 | 0 | 0 | 668 |
| 5-May-18 | 1. Dungog Road | 692 | 21 | 16 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 741 |
| 12-May-18 | 1. Dungog Road | 617 | 18 | 23 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 670 |
| | Average over 3 Weeks | 641 | 21 | 18 | 0 | 0 | 0 | 0 | 0 | 11 | 1 | 0 | 0 | 0 | 693 |
| 28-Apr-18 | 2. Gresford Road | 1468 | 60 | 113 | 0 | 3 | 5 | 8 | 1 | 11 | 10 | 1 | 0 | 0 | 1680 |
| 5-May-18 | 2. Gresford Road | 1587 | 66 | 42 | 0 | 2 | 1 | 0 | 1 | 11 | 11 | 1 | 0 | 0 | 1723 |
| 12-May-18 | 2. Gresford Road | 1507 | 57 | 43 | 3 | 2 | 1 | 2 | 1 | 11 | 8 | 1 | 0 | 0 | 1637 |
| | Average over 3 weeks | 1520 | 61 | 66 | 1 | 2 | 2 | 4 | 1 | 11 | 10 | 1 | 0 | 0 | 1680 |
| 28-Apr-18 | 3. Tocal Road | 2135 | 79 | 64 | 0 | 0 | 2 | 4 | 2 | 11 | 7 | 1 | 0 | 0 | 2306 |
| 5-May-18 | 3. Tocal Road | 2577 | 89 | 68 | 0 | 9 | 4 | 5 | 0 | 11 | 0 | 0 | 0 | 1 | 2764 |
| | 3. Tocal Road | 1770 | 52 | 47 | 3 | 3 | 2 | 0 | 0 | 11 | 0 | 0 | 0 | 1 | 1889 |
| | Average over 3 weeks | 2160 | 73 | 60 | 1 | 4 | 3 | 3 | 1 | 11 | 2 | 0 | 0 | 1 | 2320 |
| 28-Apr-18 | 4. Paterson Road | 6076 | 134 | 130 | 24 | 13 | 2 | 6 | 4 | 12 | 19 | 5 | 0 | 5 | 6429 |
| 5-May-18 | 4. Paterson Road | 6453 | 146 | 135 | 19 | 17 | 4 | 10 | 4 | 11 | 14 | 4 | 0 | 5 | 6822 |
| 12-May-18 | 4. Paterson Road | 5815 | 118 | 115 | 17 | 14 | 3 | 4 | 2 | 11 | 5 | 3 | 0 | 8 | 6116 |
| | Average over 3 weeks | 6114 | 133 | 127 | 20 | 14 | 3 | 7 | 3 | 12 | 13 | 4 | 0 | 6 | 6456 |
| 28-Apr-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4612 | 91 | 68 | 5 | 8 | 2 | 3 | 0 | 11 | 0 | 0 | 0 | 2 | 4803 |
| 5-May-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4881 | 99 | 74 | 9 | 13 | 2 | 5 | 0 | 11 | 0 | 0 | 0 | 5 | 5099 |
| 12-May-18 | 5. Flat Road/ Glenarvon Road/ Pitnacree Road | 4606 | 74 | 62 | 12 | 12 | 2 | 4 | 0 | 11 | 0 | 0 | 0 | 5 | 4789 |
| | Average over 3 weeks | 4700 | 88 | 68 | 9 | 11 | 2 | 4 | 0 | 11 | 0 | 0 | 0 | 4 | 4897 |

*Table 3-6 Scenario 3- Traffic count (AADT) for production of 500,000 tonnes per annum*

| | | South Bound Lane - Average weekly count for each Austroads Vehicle Classification | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | |
| Week Starting | Site | Short | Short Towing | 2 axle Truck or B | 3 Axle Truck or B | 4 or 5 Axle Truc | 3 axle Articulate | 4 Axle Articulate | 5 Axle Articulate | 6 Axle Articulate | B Double | Double Road Tra | Triple Road Trai | Unclassifiable | **Total** |
| 28-Apr-18 | 1. Dungog Road | 613 | 23 | 16 | 9 | 0 | 0 | 1 | 0 | 40 | 3 | 1 | 0 | 0 | 705 |
| 5-May-18 | 1. Dungog Road | 692 | 21 | 16 | 9 | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 0 | 778 |
| 12-May-18 | 1. Dungog Road | 617 | 18 | 23 | 9 | 0 | 0 | 0 | 0 | 40 | 0 | 0 | 0 | 0 | 708 |
| | Average over 3 Weeks | 641 | 21 | 18 | 9 | 0 | 0 | 0 | 0 | 40 | 1 | 0 | 0 | 0 | 730 |
| 28-Apr-18 | 2. Gresford Road | 1468 | 60 | 113 | 9 | 3 | 5 | 8 | 1 | 40 | 10 | 1 | 0 | 0 | 1718 |
| 5-May-18 | 2. Gresford Road | 1587 | 66 | 42 | 9 | 2 | 1 | 0 | 1 | 40 | 11 | 1 | 0 | 0 | 1761 |
| 12-May-18 | 2. Gresford Road | 1507 | 57 | 43 | 12 | 2 | 1 | 2 | 1 | 40 | 8 | 1 | 0 | 0 | 1675 |
| | Average over 3 weeks | 1520 | 61 | 66 | 10 | 2 | 2 | 4 | 1 | 40 | 10 | 1 | 0 | 0 | 1718 |
| 28-Apr-18 | 3. Tocal Road | 2135 | 79 | 64 | 9 | 0 | 2 | 4 | 2 | 40 | 7 | 1 | 0 | 0 | 2343 |
| 5-May-18 | 3. Tocal Road | 2577 | 89 | 68 | 9 | 9 | 4 | 5 | 0 | 40 | 0 | 0 | 0 | 1 | 2802 |
| 12-May-18 | 3. Tocal Road | 1770 | 52 | 47 | 12 | 3 | 2 | 0 | 0 | 40 | 0 | 0 | 0 | 1 | 1926 |
| | Average over 3 weeks | 2160 | 73 | 60 | 10 | 4 | 3 | 3 | 1 | 40 | 2 | 0 | 0 | 1 | 2357 |
| 28-Apr-18 | 4. Paterson Road | 6076 | 134 | 130 | 33 | 13 | 2 | 6 | 4 | 40 | 19 | 5 | 0 | 5 | 6465 |
| 5-May-18 | 4. Paterson Road | 6453 | 146 | 135 | 28 | 17 | 4 | 10 | 4 | 40 | 14 | 4 | 0 | 5 | 6859 |
| 12-May-18 | 4. Paterson Road | 5815 | 118 | 115 | 26 | 14 | 3 | 4 | 2 | 40 | 5 | 3 | 0 | 8 | 6153 |
| | Average over 3 weeks | 6114 | 133 | 127 | 29 | 14 | 3 | 7 | 3 | 40 | 13 | 4 | 0 | 6 | 6493 |
| 28-Apr-18 | 5. Flat Road/ Glenarvon Poad/ Pitnacree Road | 4612 | 91 | 68 | 14 | 8 | 2 | 3 | 0 | 40 | 0 | 0 | 0 | 2 | 4841 |
| 5-May-18 | 5. Flat Road/ Glenarvon Poad/ Pitnacree Road | 4881 | 99 | 74 | 18 | 13 | 2 | 5 | 0 | 40 | 0 | 0 | 0 | 5 | 5136 |
| 12-May-18 | 5. Flat Road/ Glenarvon Poad/ Pitnacree Road | 4606 | 74 | 62 | 21 | 12 | 2 | 4 | 0 | 40 | 0 | 0 | 0 | 5 | 4826 |
| | Average over 3 weeks | 4700 | 88 | 68 | 18 | 11 | 2 | 4 | 0 | 40 | 0 | 0 | 0 | 4 | 4934 |

# 4. ROAD ATTRIBUTE AND CONDITION DATA

## 4.1. Source of data

### 4.1.1. Pavement strength

For the Maitland maintained roads, pavement strength data was determined based on a Falling Weight Deflectometer (FWD) survey that was carried out by the ARRB Group Ltd. in 2015 on behalf of SMEC as part of an earlier study. During this testing, the pavement deflection was measured in the outer wheel path at every 50m in both directions. The deflection data was converted to a Structural Number of the pavement and a subgrade CBR as a measure of the subgrade strength. The conversion was undertaken using the Roberts / Jameson equation. (Refer to APPENDIX C).

For the roads maintained by the Dungog Council, SMEC was provided with deflection data that was measured during a DEFLECTOGRAPH survey that was commissioned by Dungog Council and carried out in April 2019. This data converted into a pavement strength by the pavement deterioration models used to model the road pavements over the next 25 years.

### 4.1.2. Road roughness and rutting

In order to undertake the analysis for this report, SMEC commissioned a roughness and rutting data survey to be undertaken along the haul route. Data was collected and averaged over each 100m segment of the roads for both the northbound and southbound lanes. The data was collected using a laser profiler and the work was commissioned by SMEC and carried out by ARRB Group Ltd. in November 2018 as part of this study.

### 4.1.3. Surface condition assessment

In November 2018, ARRB Group also conducted a visual condition assessment of the road surface using a vehicle instrumented with multiple video cameras integrated with GPS technology. The types of surface distresses that were captured are shown in Table 4-1.

*Table 4-1 Surface Defects*

| Distress | Unit |
|---|---|
| Crocodile Cracking | % of section affected |
| Block Cracking | % of section affected |
| Transverse Cracking | % of section affected |
| Longitudinal Cracking | % of section affected |
| Potholes | Count per section |
| Shoving | % of section affected |

### 4.1.4. Age data and pavement structure

Both Dungog Shire Council and Maitland City Council were able to supply a history of resurfacing and rehabilitation/reconstruction treatments that have taken place over the last ten to twenty years. This information was used to determine the current pavement structure and the age of the current road surface and pavement layers.

## 4.2. Road segments

Within the PMS the network is defined as roads and those roads are further sub-divided into one or more segments. Each road segment should be homogeneous in condition, strength, traffic and age.

During the condition assessment undertaken by ARRB, the haul routes were first divided into links. The links started and ended at physical features along the route such as intersections, bridge abutments etc.

For rating purposes, the links were further divided into approximately 100m sections with the final section often being shorter since it ended at the link termination point rather than an even increment of 100m. The road sections were modelled individually during the analysis to determine the future deterioration of the pavements under the effects of the traffic loading and the environment.

The analysis was undertaken on the southbound lanes since it was these lanes that were transporting the loaded trucks and therefore it was these lanes that would deteriorate the fastest.

In total there were 143 southbound road segments associated with the Dungog roads and 176 southbound road segments associated with the Maitland roads. Figure 4-1 shows the form used to enter roads and segments into the PMS software.

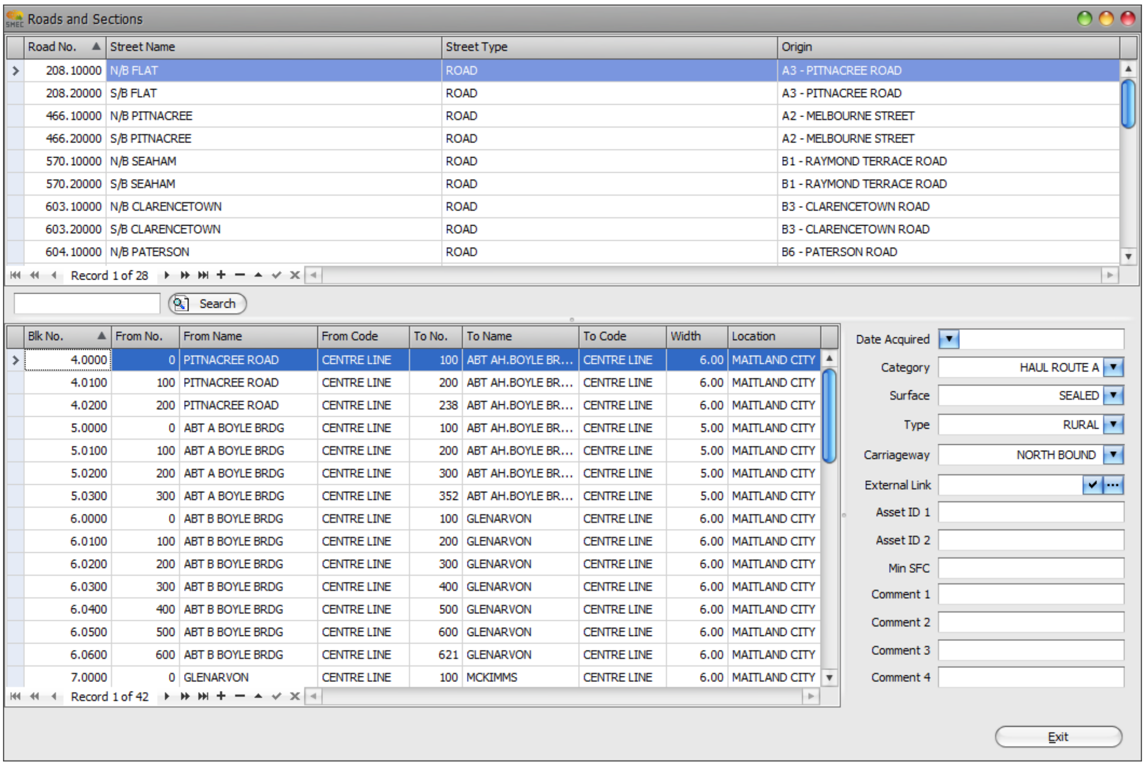



*Figure 4-1: PMS form used to view / edit roads and road segments*

Once each section was defined in the database, the section specific attribute and condition data was recorded and stored. Figure 4-2 shows an example of the types of data entered into the SMEC PMS in order to characterise the condition and attribute data for each road section.

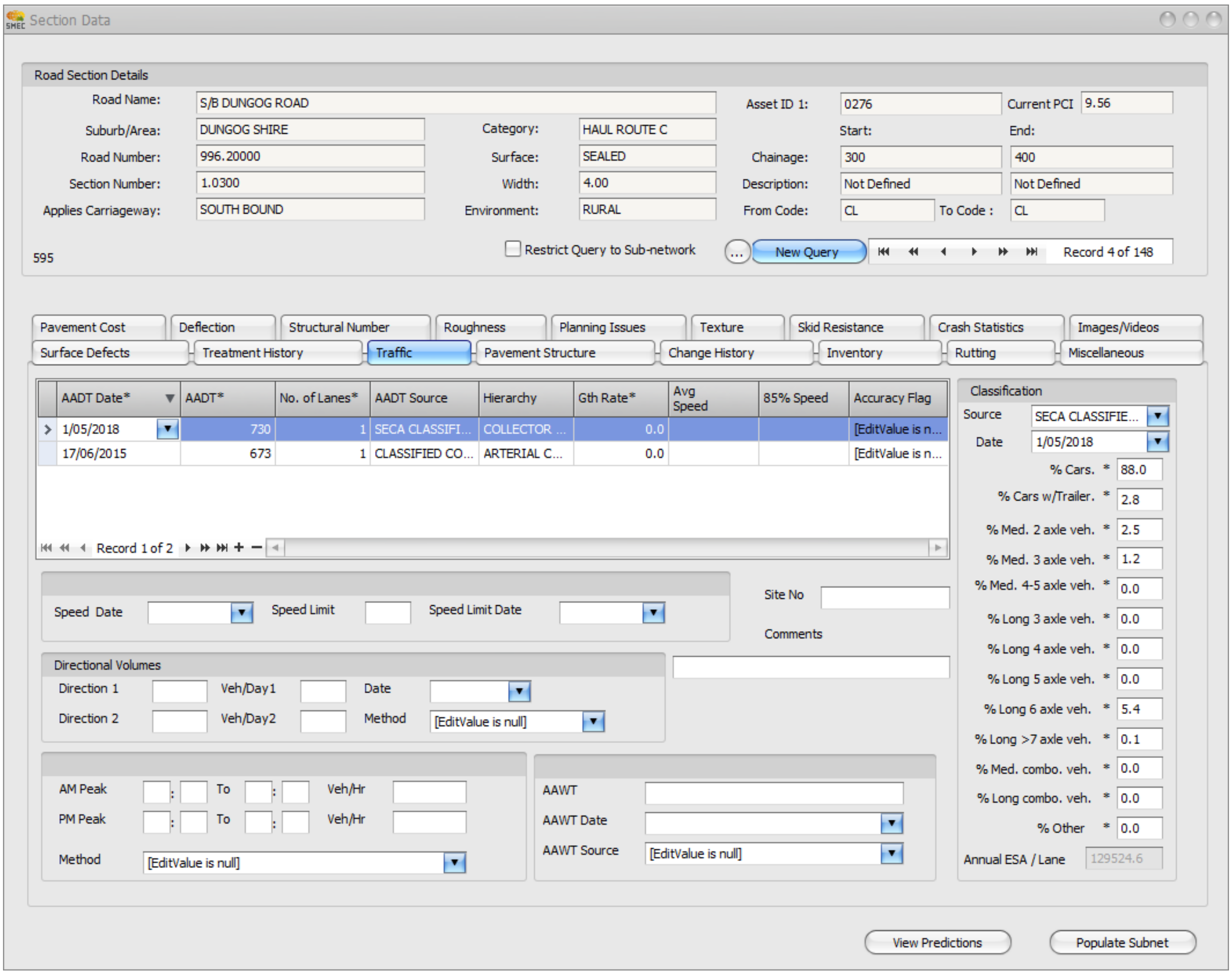


*Figure 4-2: PMS form used to view / edit segment specific attribute data.*

## 4.3. Pavement Condition Index (PCI)

The types of distresses that are considered when determining a PCI score include roughness, rutting, all cracking, wide cracking, stripping / ravelling and potholing. These distress types are the standard road pavement condition attributes used by AUSTROADS to quantify a pavement's condition. It is these individual distresses that the SMEC PMS models into the future based on the traffic loading and the influences of the environment.

The Pavement Condition Index (PCI) is a summarised score given to each road section based on a weighted combination of the different distresses affecting the pavement. A pavement without any distresses showing would have a PCI equal to 10. Each different type of distress discovered results in this score being lowered by an amount depending on the type and severity of the distress. A pavement with a PCI of zero would be in very poor condition (although PCI values can go negative when a pavement is very severely distressed).

The formulation of the SMEC PCI value can be seen in APPENDIX B.

The PCI is useful for reporting the summary condition of single road sections, but it can also be used to report the area weighted average condition of the entire road network (or any nominated sub-network such as the Maitland road sections).

The SMEC PMS is able to optimise future maintenance works programs to maximise the network PCI under budget constraint, or alternatively, determine the optimised works program (and funding required) to maintain the road network at a nominated average network PCI level. It is this second methodology that was used in this analysis.

# 5. CURRENT PAVEMENT CONDITION

The current condition of the southbound lanes of the haul routes based on the November 2018 condition survey, is summarised in Table 5-1. The summary data indicates that the Maitland roads tend to be in better condition and have stronger pavements as compared to the Dungog roads.

*Table 5-1 Summary of current condition of road pavements*

| Condition Attribute | Dungog Roads | Maitland Roads |
|---|---|---|
| Road Length | 12.75 km | 15.70 km |
| Average Roughness (NAASRA) | 85.0 | 52.9 |
| Average Rut Depth (mm) | 5.7 mm | 4.7 mm |
| Average Cracking (% of surface affected) | 4.5% | 6.0% |
| Average Pavement Condition Index (PCI) | 7.9 | 8.2 |
| Average Strength (Modified Structural No.) | 3.8 | 6.0 |

The condition survey showed that, although much of the haul route was in fair to good condition, there was also a proportion of the route that was in poor to very poor condition. The distribution of the haul route by condition (PCI) can be seen in Figure 5-1.

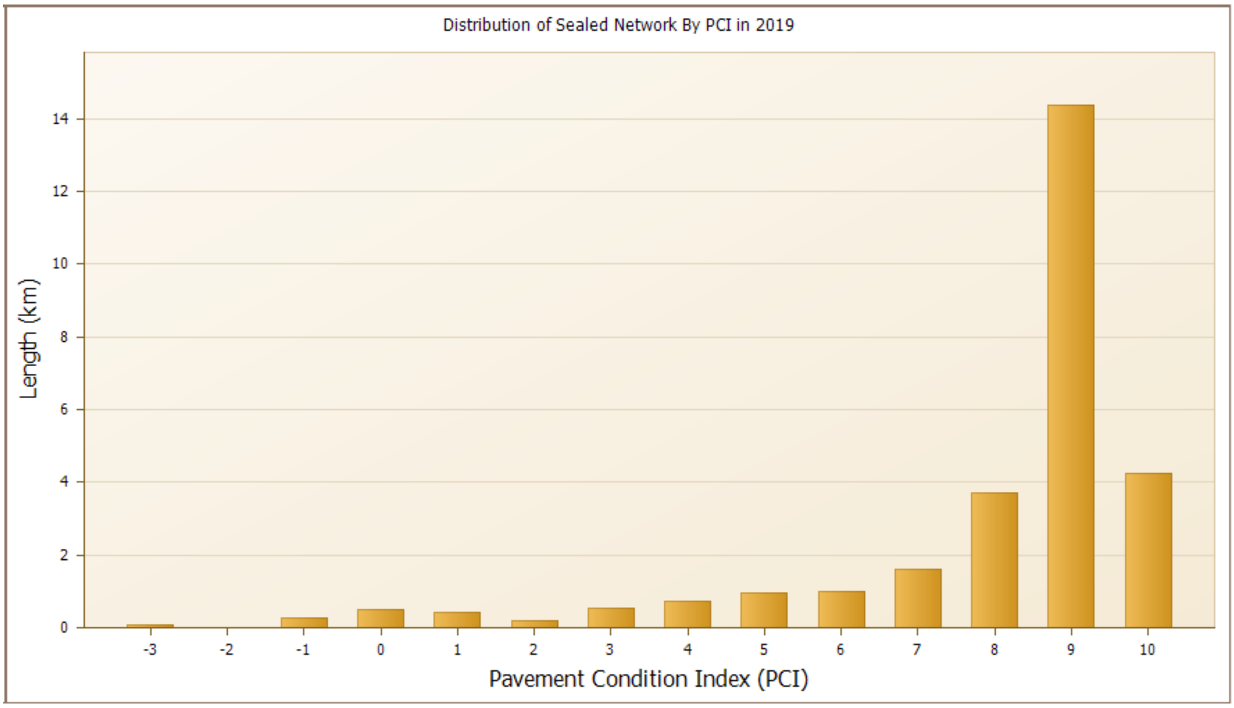



*Figure 5-1: Graph showing the variation in condition across the 319 S/B pavement sections*

# 6. PREDICTING FUTURE MAINTENANCE REQUIREMENTS

## 6.1. Pavement models

The SMEC PMS utilises the World Bank's HDM pavement deterioration models to predict the changes to the pavement condition while considering the effects of the environment, traffic loading and the application of future maintenance treatments. The models are incremental in that they look at the condition at the beginning of the year and then predict the annual changes to attributes such as:

3. Roughness
4. Rutting
5. Texture depth
6. Stripping
7. All cracking
8. Wide Cracking
9. Potholing

The models can be calibrated to suit local climate conditions. For this analysis it was decided to adopt the model calibration factors currently being used by the Maitland City Council in their implementation of the SMEC PMS. This Council is a long-term user of the system and is well experienced in its operation. Given that the environment would be expected to change very little over the length of the haul roads any environmental calibration factors developed for the Maitland network should also be applicable for the Dungog road sections.

## 6.2. Treatment Options

The SMEC PMS allows each client to customise a range of treatment options under the categories of Preventive, Spray Seals, Overlays and Reconstruction / Rehabilitation treatments. During the analysis the system will then be able to draw on these various treatment options in order to determine the timing and types of treatments to be used in the formulation of an optimised works program.

For this analysis, treatment options included a range of pavement reconstruction options, each designed to accommodate the varying traffic volumes along the route as well as the quarry truck volumes for each of the three quarry production scenarios being investigated.

As well as the pavement reconstruction options, the system also modelled resurfacing treatments for both the spray seal and asphalt surfaced road segments.

Pavement designs were carried out in accordance with the AUSTROADS manual titled 'Guide to Pavement Technology Part 2: Pavement Structural Design'. For the purpose of this analysis, a design based on a granular pavement with a thin bituminous surfacing was chosen although, with the benefit of a more detailed pavement investigation at the time of carrying out the treatment, the Councils may elect an alternative option based on lime/cement stabilisation of the existing pavement material. Both are legitimate designs and the Councils would probably choose the cheaper option once final costings are known. It is expected that the unbound granular pavement option used in this study may be the more expensive option as it may require additional disposal of the existing pavement material. Therefore, the treatment costs allocated in this study should be sufficient to cover an alternative pavement design if one was chosen.

The formula (taken from Figure 8.4 of the AUSTROADS Pavement Structural Design Manual) used to determine the pavement thickness for each of the different traffic levels was:

$$t = [\, 219 - 211(\log CBR) + 58(\log CBR)^2 \,]\log(DESA/120)$$

Where:

T = thickness in mm

CBR = Design CBR

DESA = Design ESA over the life of the pavement being analysed

The pavement surface used in the modelling was either a ‘spray seal’ or an ‘asphalt’ surfacing. The type of surfacing that was chosen at each location was dependant on the type of the existing surfacing prior to the treatment.

## 6.3. Treatment Costs

Requests were sent to both Dungog Sire Council and Maitland City Council for the current unit rates being used by each Council for each defined treatment option.

Unit rates were supplied by Maitland City Council but not Dungog Shire Council. It was therefore decided to use the Maitland unit rates for the entire haul route. The unit rates that were supplied by Maitland City Council can be seen in Table 6-1: Treatment unit rates.

*Table 6-1: Treatment unit rates*

| Layer | Unit Rate |
|---|---|
| Spray Seal (No quarry trucks) | $9.28 per sq m |
| Spray Seal (With quarry trucks) | $12.37 per sq m |
| 40 mm Asphalt Surface | $33.00 per sq m |
| 50 mm Asphalt Surface | $40.00 per sq m |
| Granular base material | $416.63 per cu m |

The unit rates relating to treating the trafficway only. They do not cover improvements relating to pavement width, sealing unsealed shoulders, drainage improvements, intersection improvements or geometry improvements. If such improvements are required, then it is assumed that the improvement costs would be required for both the ‘No quarry trucks’ scenario as well as the ‘Quarry Trucks’ scenario.

The following three tables the pavement reconstruction options based on the different traffic volumes over the five Traffic Count Sites and for each of the Quarry Truck modelling scenarios.

*Table 6-2: Reconstruction Treatment Options for Scenario without Quarry Trucks*

| Insitu CBR | Design CBR | Traffic Count | S/B Lane AADT | Annual ESA | Design ESA | Thickness (mm) | Base Modulus | SN | Modified SN | Surface Type | Treatment Code | Surf Cost (sq m) | Base Cost (Sq m) | Total Cost (Sq m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 5 | Site 1 | 682 | 23,621 | 590,525 | 369 | 0.12 | 1.9 | 3.4 | Seal | RH1 | $9.28 | $153.60 | $162.88 |
| 15 | 5 | Site 2 | 1,669 | 123,734 | 3,093,350 | 440 | 0.12 | 2.3 | 3.8 | Seal | RH2 | $9.28 | $183.52 | $192.80 |
| 15 | 5 | Site 2 | 1,669 | 123,734 | 3,093,350 | 440 | 0.12 | 2.6 | 4.1 | AC | AH2 | $33.00 | $183.52 | $216.52 |
| 15 | 5 | Site 3 | 2,309 | 91,535 | 2,288,375 | 427 | 0.12 | 2.2 | 3.7 | Seal | RH3 | $9.28 | $178.07 | $187.35 |
| 15 | 5 | Site 3 | 2,309 | 91,535 | 2,288,375 | 427 | 0.12 | 2.5 | 4.0 | AC | AH3 | $33.00 | $178.07 | $211.07 |
| 15 | 5 | Site 4 | 6,444 | 282,766 | 7,069,150 | 476 | 0.12 | 2.4 | 4.0 | Seal | RH4 | $9.28 | $198.45 | $207.73 |
| 15 | 5 | Site 4 | 6,444 | 282,766 | 7,069,150 | 476 | 0.12 | 2.7 | 4.2 | AC | AH4 | $33.00 | $198.45 | $231.45 |
| 15 | 5 | Site 5 | 4,886 | 116,195 | 2,904,875 | 438 | 0.12 | 2.2 | 3.8 | Seal | RH5 | $9.28 | $182.38 | $191.66 |
| 15 | 5 | Site 5 | 4,886 | 116,195 | 2,904,875 | 438 | 0.12 | 2.5 | 4.1 | AC | AH5 | $33.00 | $182.38 | $215.38 |

*Table 6-3: Reconstruction Treatment Options for Scenario where 134,700 Tonnes carried per year*

| Insitu CBR | Design CBR | Traffic Count | S/B Lane AADT | Annual ESA | Design ESA | Thickness (mm) | Base Modulus | SN | Modified SN | Surface Type | Treatment Code | Surf Cost (sq m) | Base Cost (Sq m) | Total Cost (Sq m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 5 | Site 1 | 693 | 49,652 | 1,241,300 | 401 | 0.12 | 2.1 | 3.6 | Seal | RR1 | $12.37 | $167.02 | $179.39 |
| 15 | 5 | Site 2 | 1,680 | 149,610 | 3,740,250 | 449 | 0.12 | 2.3 | 3.8 | Seal | RR2 | $12.37 | $186.95 | $199.32 |
| 15 | 5 | Site 2 | 1,680 | 149,610 | 3,740,250 | 449 | 0.12 | 2.6 | 4.1 | AC | AR2 | $40.00 | $186.95 | $226.95 |
| 15 | 5 | Site 3 | 2,320 | 123,361 | 3,084,025 | 440 | 0.12 | 2.3 | 3.8 | Seal | RR3 | $12.37 | $183.46 | $195.83 |
| 15 | 5 | Site 3 | 2,320 | 123,361 | 3,084,025 | 440 | 0.12 | 2.6 | 4.1 | AC | AR3 | $40.00 | $183.46 | $223.46 |
| 15 | 5 | Site 4 | 6,456 | 315,338 | 7,883,450 | 481 | 0.12 | 2.5 | 4.0 | Seal | RR4 | $12.37 | $200.42 | $212.79 |
| 15 | 5 | Site 4 | 6,456 | 315,338 | 7,883,450 | 481 | 0.12 | 2.7 | 4.3 | AC | AR4 | $40.00 | $200.42 | $240.42 |
| 15 | 5 | Site 5 | 4,897 | 140,764 | 3,519,100 | 446 | 0.12 | 2.3 | 3.8 | Seal | RR5 | $12.37 | $185.85 | $198.22 |
| 15 | 5 | Site 5 | 4,897 | 140,764 | 3,519,100 | 446 | 0.12 | 2.6 | 4.1 | AC | AR5 | $40.00 | $185.85 | $225.85 |

*Table 6-4: Reconstruction Treatment Options for Scenario where 500,000 Tonnes carried per year*

| Insitu CBR | Design CBR | Traffic Count | S/B Lane AADT | Annual ESA | Design ESA | Thickness (mm) | Base Modulus | SN | Modified SN | Surface Type | Treatment Code | Surf Cost (sq m) | Base Cost (Sq m) | Total Cost (Sq m) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | 5 | Site 1 | 730 | 129,524 | 3,238,100 | 442 | 0.12 | 2.3 | 3.8 | Seal | RQ1 | $12.37 | $184.34 | $196.71 |
| 15 | 5 | Site 2 | 1,718 | 228,916 | 5,722,900 | 467 | 0.12 | 2.4 | 3.9 | Seal | RQ2 | $12.37 | $194.63 | $207.00 |
| 15 | 5 | Site 2 | 1,718 | 228,916 | 5,722,900 | 467 | 0.12 | 2.7 | 4.2 | AC | AQ2 | $40.00 | $194.63 | $234.63 |
| 15 | 5 | Site 3 | 2,357 | 200,868 | 5,021,700 | 461 | 0.12 | 2.4 | 3.9 | Seal | RQ3 | $12.37 | $192.27 | $204.64 |
| 15 | 5 | Site 3 | 2,357 | 200,868 | 5,021,700 | 461 | 0.12 | 2.7 | 4.2 | AC | AQ3 | $40.00 | $192.27 | $232.27 |
| 15 | 5 | Site 4 | 6,493 | 372,765 | 9,319,125 | 488 | 0.12 | 2.5 | 4.0 | Seal | RQ4 | $12.37 | $203.44 | $215.81 |
| 15 | 5 | Site 4 | 6,493 | 372,765 | 9,319,125 | 488 | 0.12 | 2.8 | 4.3 | AC | AQ4 | $40.00 | $203.44 | $243.44 |
| 15 | 5 | Site 5 | 4,934 | 226,358 | 5,658,950 | 467 | 0.12 | 2.4 | 3.9 | Seal | RQ5 | $12.37 | $194.43 | $206.80 |
| 15 | 5 | Site 5 | 4,934 | 226,358 | 5,658,950 | 467 | 0.12 | 2.7 | 4.2 | AC | AQ5 | $40.00 | $194.43 | $234.43 |

## 6.4. Treatment rule-base

The SMEC PMS contains a rule-base that is used to select the various treatment options that are required to be analysed each year for each road segment. Based on the predicted condition for each analysis year, the rule-base applies a set of user-defined rules that consider factors such as surface condition, roughness, rutting, age, type of surfacing, location and traffic volumes in order to determine which possible treatment options should be selected for further analysis through life cycle modelling.

Although the rule-base can contain trigger points and selection criteria to determine possible treatment options at various stages of the pavement's life, further analysis is then undertaken to determine the whole of life performance of each treatment option. The final formulation of the 25 year works program will then be determined by the optimisation module which will select the most beneficial treatments that will meet the optimisation goals for the network analysis.

## 6.5. Analysis Criteria

The goal of the analysis was to determine the increased road maintenance funding requirements for the haul roads resulting from the increased production of the Martins Creek quarry.

The requirement for the analysis was to first predict the maintenance funding requirements over the next 25 years if no quarry truck traffic was to use the roads into the future. The analysis was then repeated assuming that the number of quarry trucks using the hauls routes would equate to the number of trucks required to carry:

- 134,700 tonnes of material per annum, and then
- 500,000 Tonnes of material per annum.

The analysis was broken down by the two different council jurisdictions through which the haul routes passed. The criterion for each analysis was to determine the annual funding required to maintain each sub-network at its current condition level for the next 25 years.

Although the data was collected, and the pavement models were set up, to model both the southbound and northbound lanes, it was assumed that any future resurfacing or rehabilitation treatments would be applied to both southbound and northbound lanes at the same time. The reason for this is because the roads are single carriageway and there would be less efficiency in treating each lane of the road at different times. Since the southbound lanes were carrying the loaded quarry truck traffic it was expected that these lanes would deteriorate more quickly and therefore dictate when a treatment should apply. The works programming was therefore carried out for the southbound lanes but then the costs were calculated based on the treatment being applied to the full width of the road.

## 6.6. Analysis results

Table 6-5 and Table 6-6 show the annual results of the modelling for each of the Council sub-networks. The left-hand side of the table shows the modelling based on the current traffic scenario while the right-hand side of the table shows the modelling based the addition of the quarry trucks required to haul 134,700 TPA and 500,000 TPA. The Dungog maintained road segments and the Maitland maintained road segments are presented separately.

As was seen in Figure 5-1, the condition survey indicated that there a number of road segments that were currently in poor to very poor condition. It was found that, if these sections were treated in the first year, then the average network PCI would increase from 7.9 to 8.5 for the Dungog roads and from 8.2 to 8.5 for the Maitland roads.

In Table 6-5 and Table 6-6, the 'Capital Cost' column contains the cost of all resurfacing and rehabilitation treatments that the system has chosen to maintain the PCI of the network close to a value of 8.5 for the next 25 years. The additional cost of treating the current backlog of roads in poor condition is reflected in the higher treatment costs shown for the year 2020.

All costs are expressed in today's dollars and are exclusive of GST. The capital costs don't include routine maintenance costs associated with minor pothole repairs, edge break repairs etc. However, it was found that this cost was a function of the overall condition level of the road surface. Since the annual works program was designed to keep the condition at a constant level then there was no increase in the routine maintenance requirements required under either of the scenarios that were modelled.

*Table 6-5 Modelling results for Dungog roads (SB lanes only)*

| | No Quarry Trucks | | | | | Haulage: 134,000 tonnes per annum | | | | | Haulage: 500,000 tonnes per annum | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Capital Cost | PCI | Cracking | Roughness | Rutting | Capital Cost | PCI | Cracking | Roughness | Rutting | Capital Cost | PCI | Cracking | Roughness | Rutting |
| 2020 | $1,602,152 | 8.6 | 1.90 | 80.00 | 5.00 | $1,735,564 | 8.6 | 1.9 | 79.8 | 5 | $1,820,477 | 8.6 | 1.9 | 79.9 | 5.0 |
| 2021 | $201,429 | 8.6 | 2.40 | 79.40 | 5.00 | $204,623 | 8.6 | 2.3 | 79.2 | 5 | $227,212 | 8.6 | 2.3 | 79.2 | 5.0 |
| 2022 | $166,023 | 8.6 | 2.70 | 78.50 | 4.60 | $177,457 | 8.6 | 2.6 | 78.6 | 4.7 | $205,875 | 8.6 | 2.6 | 78.6 | 4.7 |
| 2023 | $130,304 | 8.5 | 3.20 | 77.90 | 4.60 | $219,943 | 8.6 | 2.7 | 77.8 | 4.6 | $216,388 | 8.6 | 2.8 | 78.1 | 4.6 |
| 2024 | $225,598 | 8.6 | 3.10 | 76.10 | 4.50 | $121,574 | 8.6 | 3 | 77.9 | 4.5 | $147,533 | 8.5 | 3.2 | 77.8 | 4.6 |
| 2025 | $119,350 | 8.6 | 3.20 | 76.20 | 4.50 | $158,627 | 8.5 | 3.2 | 77.3 | 4.5 | $200,702 | 8.6 | 3.2 | 77.2 | 4.5 |
| 2026 | $16,542 | 8.6 | 2.70 | 78.00 | 4.50 | $99,720 | 8.6 | 2.8 | 78.1 | 4.4 | $17,104 | 8.6 | 2.6 | 79.2 | 4.5 |
| 2027 | $12,248 | 8.6 | 2.60 | 80.00 | 4.60 | $61,423 | 8.6 | 2.9 | 79.4 | 4.4 | $18,777 | 8.6 | 2.4 | 81.3 | 4.6 |
| 2028 | $74,917 | 8.6 | 2.70 | 81.10 | 4.50 | $68,763 | 8.6 | 2.8 | 80.7 | 4.4 | $64,075 | 8.6 | 2.4 | 82.8 | 4.5 |
| 2029 | $91,896 | 8.6 | 2.60 | 82.10 | 4.50 | $94,751 | 8.5 | 2.7 | 81.8 | 4.4 | $109,843 | 8.6 | 2.3 | 84.1 | 4.5 |
| 2030 | $48,419 | 8.6 | 2.50 | 83.60 | 4.50 | $29,030 | 8.5 | 2.6 | 83.7 | 4.3 | $82,310 | 8.6 | 2.3 | 85.4 | 4.4 |
| 2031 | $74,078 | 8.5 | 2.60 | 84.40 | 4.40 | $145,453 | 8.5 | 2.7 | 84.4 | 4.3 | $152,174 | 8.5 | 2.4 | 86.4 | 4.3 |
| 2032 | $45,536 | 8.5 | 2.60 | 85.70 | 4.40 | $87,076 | 8.5 | 2.5 | 86.8 | 4.3 | $216,425 | 8.5 | 2.3 | 87.9 | 4.3 |
| 2033 | $145,998 | 8.5 | 2.70 | 86.50 | 4.20 | $239,786 | 8.5 | 2.6 | 86.6 | 4.2 | $211,831 | 8.5 | 2.4 | 88.1 | 4.2 |
| 2034 | $186,998 | 8.5 | 3.00 | 86.70 | 4.10 | $206,091 | 8.5 | 2.9 | 86.8 | 4.1 | $143,839 | 8.5 | 2.3 | 89.2 | 4.1 |
| 2035 | $142,913 | 8.5 | 2.90 | 87.60 | 4.00 | $145,097 | 8.5 | 2.8 | 87.6 | 4 | $61,540 | 8.5 | 2.1 | 91.6 | 4.1 |
| 2036 | $69,012 | 8.5 | 2.60 | 90.00 | 4.00 | $64,361 | 8.5 | 2.5 | 89.9 | 4 | $155,306 | 8.5 | 2.1 | 92.2 | 4.0 |
| 2037 | $209,872 | 8.5 | 2.70 | 89.80 | 4.00 | $136,407 | 8.5 | 2.6 | 90.8 | 4 | $140,078 | 8.5 | 2.0 | 92.9 | 4.0 |
| 2038 | $82,140 | 8.5 | 2.60 | 91.40 | 4.00 | $150,676 | 8.5 | 2.7 | 91.3 | 3.9 | $80,152 | 8.5 | 1.9 | 94.9 | 4.0 |
| 2039 | $109,384 | 8.5 | 2.60 | 92.60 | 3.90 | $122,700 | 8.5 | 2.2 | 92.3 | 3.9 | $231,222 | 8.5 | 2.0 | 94.9 | 3.8 |
| 2040 | $29,108 | 8.4 | 2.60 | 94.60 | 4.00 | $51,468 | 8.5 | 2 | 94.5 | 3.9 | $229,593 | 8.5 | 2.0 | 95.4 | 3.7 |
| 2041 | $89,950 | 8.5 | 1.90 | 95.90 | 3.90 | $58,472 | 8.5 | 1.8 | 96.6 | 3.9 | $109,741 | 8.5 | 1.9 | 97.0 | 3.7 |
| 2042 | $87,606 | 8.5 | 1.90 | 97.40 | 3.90 | $213,349 | 8.5 | 1.9 | 96.5 | 3.8 | $292,525 | 8.5 | 2.1 | 96.3 | 3.4 |
| 2043 | $153,308 | 8.5 | 1.90 | 97.70 | 3.80 | $202,661 | 8.5 | 2 | 96.1 | 3.6 | $230,468 | 8.5 | 2.2 | 96.1 | 3.4 |
| 2044 | $185,754 | 8.5 | 2.00 | 97.50 | 3.60 | $213,954 | 8.5 | 2.1 | 96.3 | 3.5 | $243,842 | 8.5 | 2.4 | 96.2 | 3.2 |
| 2045 | $145,073 | 8.5 | 2.00 | 98.00 | 3.50 | $230,294 | 8.5 | 2.3 | 96.3 | 3.4 | $216,163 | 8.5 | 2.4 | 96.6 | 3.1 |
| Total | $4.445.608 | | | | | $5.239.320 | | | | | $5.825.195 | | | | |

*Table 6-6 Modelling results for Maitland roads (SB lanes only)*

| | No Quarry Trucks | | | | | Haulage: 134,000 tonnes per annum | | | | | Haulage: 500,000 tonnes per annum | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Capital Cost | PCI | Cracking | Roughness | Rutting | Capital Cost | PCI | Cracking | Roughness | Rutting | Capital Cost | PCI | Cracking | Roughness | Rutting |
| 2020 | $1,396,853 | 8.5 | 5.5 | 54.0 | 3.4 | $1,556,919 | 8.5 | 5.5 | 54.0 | 3.4 | $1,583,252 | 8.5 | 5.5 | 54.2 | 3.4 |
| 2021 | $289,434 | 8.5 | 6.1 | 55.1 | 3.0 | $349,472 | 8.5 | 6.1 | 55.1 | 3.0 | $349,472 | 8.5 | 6.1 | 55.3 | 3.0 |
| 2022 | $37,916 | 8.5 | 6.0 | 56.5 | 3.0 | $22,844 | 8.6 | 5.8 | 56.4 | 3.1 | $27,792 | 8.6 | 5.8 | 56.6 | 3.1 |
| 2023 | $15,960 | 8.6 | 5.8 | 57.8 | 3.1 | $16,328 | 8.6 | 5.6 | 57.7 | 3.1 | $16,328 | 8.6 | 5.6 | 57.9 | 3.1 |
| 2024 | $23,323 | 8.6 | 5.4 | 59.1 | 3.1 | $20,402 | 8.6 | 5.1 | 59.0 | 3.1 | $17,879 | 8.6 | 5.0 | 59.2 | 3.1 |
| 2025 | $16,775 | 8.6 | 5.0 | 60.5 | 3.1 | $30,205 | 8.6 | 4.7 | 60.3 | 3.2 | $25,962 | 8.6 | 4.6 | 60.6 | 3.2 |
| 2026 | $13,112 | 8.6 | 4.9 | 61.9 | 3.2 | $12,940 | 8.6 | 4.4 | 61.7 | 3.2 | $12,654 | 8.6 | 4.4 | 62.0 | 3.2 |
| 2027 | $9,186 | 8.6 | 4.8 | 63.3 | 3.2 | $32,656 | 8.6 | 4.7 | 63.2 | 3.2 | $28,574 | 8.6 | 4.6 | 63.5 | 3.2 |
| 2028 | $12,678 | 8.6 | 4.9 | 64.8 | 3.2 | $24,655 | 8.6 | 4.8 | 64.7 | 3.3 | $71,501 | 8.5 | 5.3 | 64.4 | 3.2 |
| 2029 | $80,132 | 8.5 | 5.4 | 65.8 | 3.2 | $25,970 | 8.6 | 5.0 | 66.3 | 3.3 | $129,601 | 8.6 | 5.2 | 65.3 | 3.2 |
| 2030 | $118,891 | 8.6 | 5.3 | 66.4 | 3.2 | $156,648 | 8.6 | 5.4 | 67.0 | 3.1 | $88,436 | 8.6 | 5.3 | 66.6 | 3.2 |
| 2031 | $27,227 | 8.6 | 5.4 | 67.9 | 3.2 | $81,502 | 8.6 | 5.5 | 68.2 | 3.1 | $36,446 | 8.6 | 5.5 | 68.2 | 3.2 |
| 2032 | $71,582 | 8.5 | 5.6 | 69.1 | 3.1 | $76,558 | 8.5 | 5.7 | 69.2 | 3.1 | $144,278 | 8.5 | 5.6 | 69.4 | 3.1 |
| 2033 | $108,171 | 8.5 | 5.7 | 70.5 | 3.1 | $100,990 | 8.5 | 5.7 | 70.4 | 3.1 | $162,057 | 8.5 | 5.5 | 71.0 | 3.1 |
| 2034 | $217,574 | 8.6 | 5.6 | 71.5 | 3.1 | $102,743 | 8.5 | 5.6 | 72.1 | 3.1 | $182,293 | 8.5 | 5.6 | 71.9 | 3.1 |
| 2035 | $93,609 | 8.5 | 5.6 | 73.1 | 3.1 | $145,979 | 8.5 | 5.6 | 73.4 | 3.0 | $219,610 | 8.5 | 5.7 | 72.4 | 2.9 |
| 2036 | $194,256 | 8.5 | 5.8 | 72.7 | 2.8 | $207,854 | 8.5 | 5.8 | 72.9 | 2.9 | $117,082 | 8.5 | 5.4 | 73.6 | 2.9 |
| 2037 | $112,986 | 8.5 | 5.8 | 73.6 | 2.8 | $108,610 | 8.5 | 5.4 | 74.1 | 2.9 | $164,760 | 8.5 | 5.5 | 73.8 | 2.8 |
| 2038 | $102,923 | 8.5 | 5.4 | 74.6 | 2.8 | $198,740 | 8.5 | 5.5 | 74.2 | 2.8 | $141,436 | 8.5 | 5.2 | 75.0 | 2.8 |
| 2039 | $242,388 | 8.5 | 5.5 | 74.0 | 2.7 | $313,774 | 8.5 | 5.6 | 73.4 | 2.7 | $157,748 | 8.5 | 4.8 | 75.7 | 2.8 |
| 2040 | $199,633 | 8.5 | 5.6 | 73.7 | 2.7 | $197,116 | 8.5 | 5.6 | 73.5 | 2.7 | $141,494 | 8.5 | 4.7 | 76.6 | 2.8 |
| 2041 | $136,275 | 8.5 | 5.6 | 73.9 | 2.7 | $145,926 | 8.5 | 5.5 | 74.2 | 2.7 | $174,877 | 8.5 | 4.7 | 77.1 | 2.7 |
| 2042 | $130,415 | 8.5 | 5.6 | 74.1 | 2.6 | $164,410 | 8.5 | 5.5 | 74.4 | 2.7 | $170,892 | 8.5 | 4.7 | 77.3 | 2.7 |
| 2043 | $138,600 | 8.5 | 5.8 | 73.8 | 2.6 | $139,351 | 8.5 | 5.5 | 74.8 | 2.6 | $201,935 | 8.5 | 4.8 | 77.3 | 2.7 |
| 2044 | $143,753 | 8.5 | 5.8 | 73.9 | 2.6 | $172,051 | 8.5 | 5.5 | 75.0 | 2.6 | $204,497 | 8.5 | 4.9 | 76.9 | 2.6 |
| 2045 | $177,526 | 8.5 | 5.8 | 74.4 | 2.5 | $165,360 | 8.5 | 5.6 | 74.6 | 2.6 | $184,964 | 8.5 | 5.0 | 76.8 | 2.6 |
| | $4.111.178 | | | | | $4.570.003 | | | | | $4.755.820 | | | | |

The cost figures in the above tables are based on treating the southbound lanes only. Assuming that both southbound and northbound lanes will be treated at the same time, then these costs will need to be doubled. A summary of the annual figures is shown in Table 6-7 below.

*Table 6-7 Future funding requirements for pavements (Includes Northbound and Southbound lanes)*

| Modelling scenario | Dungog Roads | Maitland Roads |
|---|---|---|
| Length of roads | 12.75 km | 15.7 km |
| | | |
| **Scenario 1: No quarry trucks using roads** | | |
| | | |
| Resurfacing and rehabilitation costs over 25 years. | $8,891,216 | $8,222,356 |
| | | |
| **Scenario 2: Quarry trucks hauling 134,700 tonnes per year** | | |
| | | |
| Resurfacing and rehabilitation costs over 25 years. | $10,478,640 | $9,140,006 |
| Increase in funding over Scenario 1. | $1,587,424 | $917,650 |
| Increase in funding over Scenario 1 per year. | $63,497 | $36,706 |
| Increase in funding over Scenario 1 per year per km. | $4,976 | $2,338 |
| | | |
| **Scenario 3: Quarry trucks hauling 500,000 tonnes per year** | | |
| | | |
| Resurfacing and rehabilitation costs over 25 years. | $11,650,390 | $9,511,640 |
| Increase in funding over Scenario 1. | $2,759,174 | $1,289,284 |
| Increase in funding over Scenario 1 per year. | $110,367 | $51,571 |
| Increase in funding over Scenario 1 per year per km. | $8,649 | $3,285 |
| | | |

# APPENDIX A SMEC PMS OVERVIEW

The SMEC Pavement Management and Road Inventory System (referred to as SMEC PMS) contains an integrated computer system which combines a powerful relational database, a sophisticated road deterioration predication model and an optimisation module to analyse, optimise and schedule maintenance and rehabilitation for a road network. It also contains a road inventory management module and facilities for records and reports. It contains an integrated computer system comprising the following modules:

- **database** including pavement condition, road inventory, pavement structure, traffic details and other records;
- **project analysis** including prediction modelling, candidate selection and life cycle costing;
- **network optimisation** covering budget allocation, optional and optimal treatments, maintenance implications, etc.;
- **scheduling and reporting** giving works programmes, management graphs and reports, network condition summaries, ad hoc queries, etc.; and
- **asset valuation** for road pavements and road inventory items such as kerbs, manholes, etc.
- **GIS display capability** allowing the data stored in the database to be linked to a map and for thematically displaying road attributes across the road network.

This structure is illustrated in Figure 6-1.

The SMEC PMS is project based and network operated with inventory, condition, structure, traffic and other data collected for each discrete road section. It undertakes road network analysis based on road section specific routine maintenance and treatments rather than global averages.

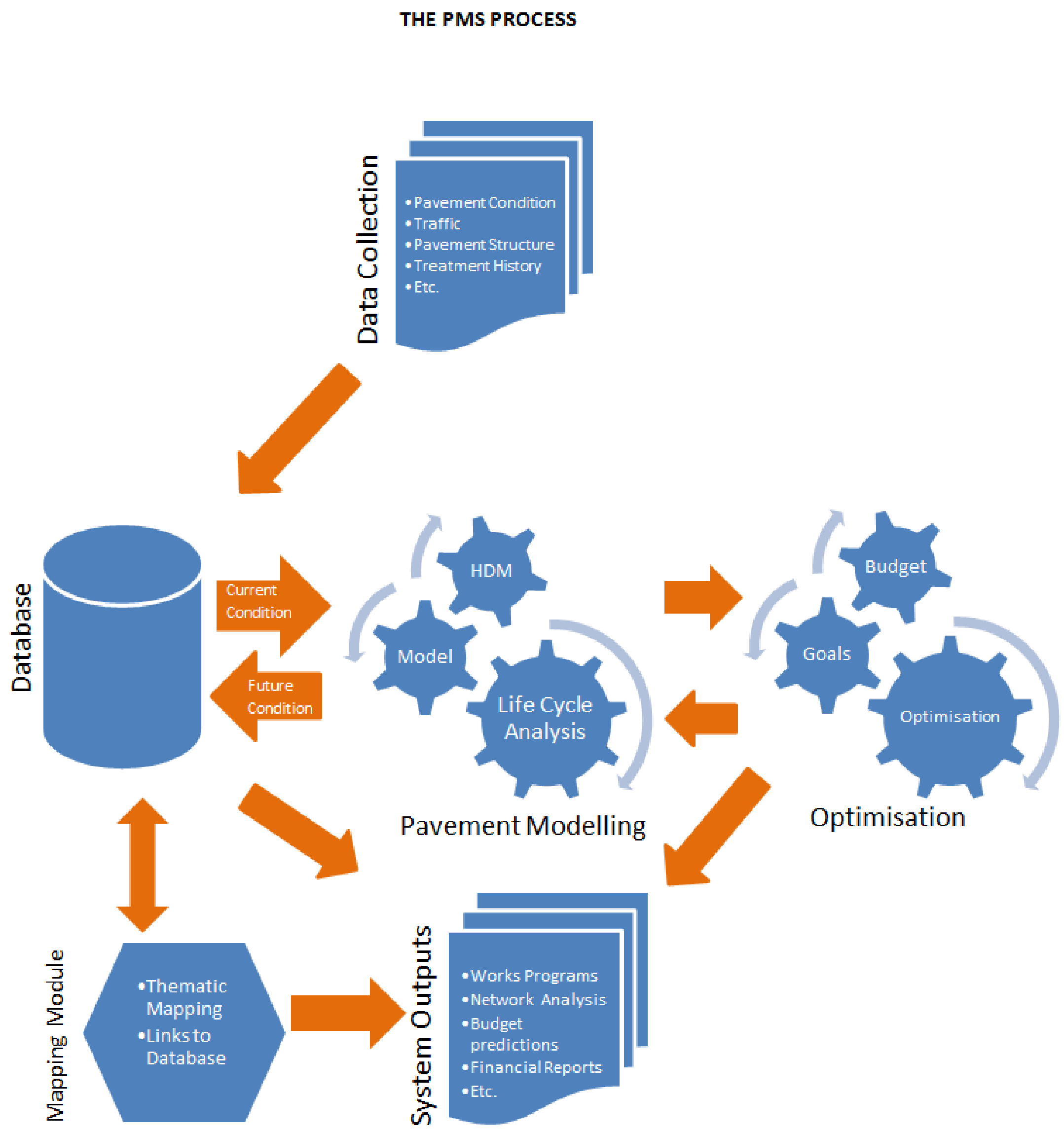



*Figure 6-1 : Schematic of the SMEC System*

The SMEC PMS is capable of both project level and network level optimisation under constraints of both budget and competing candidate projects and allows for consideration of 'must do' projects and restrictions on treatment.

The method of operation of the SMEC PMS, in simple terms, consists of:

- Obtaining road location, structural, traffic and condition data for each road section;
- Predicting future conditions and maintenance costs for different treatments, including minimum maintenance;
- Optimising the selection of treatments for different budget and other scenarios (e.g., 'must do' projects); and
- Determining the appropriate budget and treatments.

The minimum road related data required to operate the SMEC PMS is:

- Road pavement structure in terms of surface and base type, age, structural number and subgrade CBR;
- Road condition in terms of cracks, potholes, roughness, rutting and ravelling;

- Traffic in terms of number of vehicles in each classification and the average vehicle loading; and
- A pavement area (for costing).

In addition, it is necessary to have data on the different treatment options to be considered, the pavement deterioration model calibration factors and vehicles operating and maintenance costs.

The SMEC PMS is customised for each network, with information relating to the authority, the district, commencement date, environment and units of roughness and currency.

To assist in producing easily understood reports for different sets of roads (sub-networks), it is desirable to have additional data. These include:

- The location and classification of the road sections;
- The uses of the road (e.g. bus route, load limit); and
- Inventory items such as kerbs, manholes and drainage pits which may affect the maintenance and upkeep treatments selected.

In order to undertake relevant and specific analysis for a road managing agency, additional guidance / advice is required to enable effective use of the SMEC PMS and this includes:

- Objectives for the road network condition;
- The basis of optimisation to be used;
- The treatment options that are to be considered;
- Intervention policies to be considered (if any);
- Budgets to be considered; and
- Pavement treatment history.

The SMEC PMS utilises Relational Database Management System software to store, edit, update, query and report on the road inventory, condition, traffic and maintenance data and works programs and other outputs.

In a relational database system, the database is structured in tables. In the SMEC PMS the two basic types of database tables are:

- Those which store current and historical data relating to the survey condition, treatment history and inventory data and records for each location; and
- Those which store predicted future condition data based on the output of the prediction model, data summaries of past condition and output data (including works programs).

The road deterioration prediction model used by the SMEC PMS is the World Bank's HDM model. This model has been under development since 1969, with the production of HDM over an 18 year period of research and analysis by the World Bank in collaboration with major research institutions in Australia, Brazil, France, India, Kenya, Sweden, United Kingdom, Canada and United States. The model predicts maintenance and vehicle operating (i.e. user) costs, total life cycle costs and conditions and provides economic decision making criteria for consideration of multiple road design and maintenance alternatives.

The SMEC PMS undertakes optimisation and scheduling using the expenditure budgeting model (EBM) together with HDM life cycle cost data. The EBM performs a network level analysis to determine when and how each project is to be done. That is, it produces an optimised works program for a given year and budget.

# APPENDIX B SMEC PAVEMENT CONDITION INDICATOR

The health of the road pavements in measured in terms of a number of recognised condition attributes. For the surface wearing course (and water proofing layer) the SMEC PMS is able to model the initiation and progression of cracking (commencing with fine cracking and progressing into wide cracking), stripping / ravelling, texture depth and development of potholes. For the pavement structural layers SMEC PMS models the development of road roughness (a measure of the loss of pavement shape) and rutting in the wheel paths.

In order to summarise the overall condition of each pavement segment the PMS utilises a formula that uses a weighted combination of the distress types to determine an overall Pavement Condition Index (PCI).

The system reports on a number of different condition indices including the SMEC PCI and the AUSTROADS (formally NAASRA) Surface Health Index and Pavement Health Index. The derivation of these indices is described below.

## B.1 SMEC Pavement Condition Index (PCI)

A Pavement Condition Index is a way of summarising the condition of a pavement based the level of distresses that are either measured through condition surveys or predicted through pavement deterioration models. It should be stressed that the SMEC PMS analysis is based on the individual distress attributes that are standardised throughout the field of road asset management and that the PCI is simply summary figure that is used to report the overall condition after the analysis is carried out.

The way the SMEC PCI is calculated assumes a ranking of 10 for a road without defects (perfect) and deducts points from this ranking depending on the level and types of distresses present in the pavement. In general terms, the PCI value may be interpreted as shown in Table B1.

*Table B1: PCI Interpretation*

| PCI | Road Condition |
|---|---|
| 10 to 9 | Very Good |
| 7.5 to 9 | Good |
| 5.0 to 7.5 | Fair |
| 2.5 to 5.0 | Poor |
| < 2.5 | Very Poor |

The formula used to calculate the PCI is:

PCI = $10-D_1-D_2-D_3-D_4-D_5-D_6$

where:

$D_1$ = Deduct points for roughness

Max. (0,( (-4.361411 * $10^{-9}$ * $AADT^2$) + (4.91687 * $10^{-4}$ * AADT) +7.74) * ROUGH - 2.65)

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where AADT = annual average daily traffic

and ROUGH = pavement roughness in units NAASRA roughness. IRI results can be converted to NAASRA units using the following generic equation:

NAASRA = 26 x IRI

$D_2$ = Deduct points for all cracks

= Min (10, ACRACK*0.17)

where ACRACK = percentage of the pavement area cracked

| | | |
|---|---|---|
| $D_3$ | = | Deduct points for wide cracks |
| | = | WRCRACK*0.05 |
| | | where<br>WRCRACK = percentage of the pavement area with wide cracks |
| $D_4$ | = | Deduct points for potholes |
| | = | Min(5, POTH*10) |
| | | where POTH = percentage of the pavement area potholed |
| $D_5$ | = | Deduct points for rutting |
| | = | RUT*0.125 |
| | | where RUT = mean rut dept in mm |
| $D_6$ | = | Deduct points for ravelling |
| | = | RAREA*0.02 |
| | | where RAREA = percentage of the pavement area ravelled |

Note that the roughness deduction is a function of the roughness value and the traffic which the other deductions are a function of the extent only.

Because the deductions are accumulative, it is possible for a pavement which is in a bad condition to have a PCI ranking which is negative.

The following graphs show the deduct points calculated for each of the individual distress modes as a function of the extent of the distress.

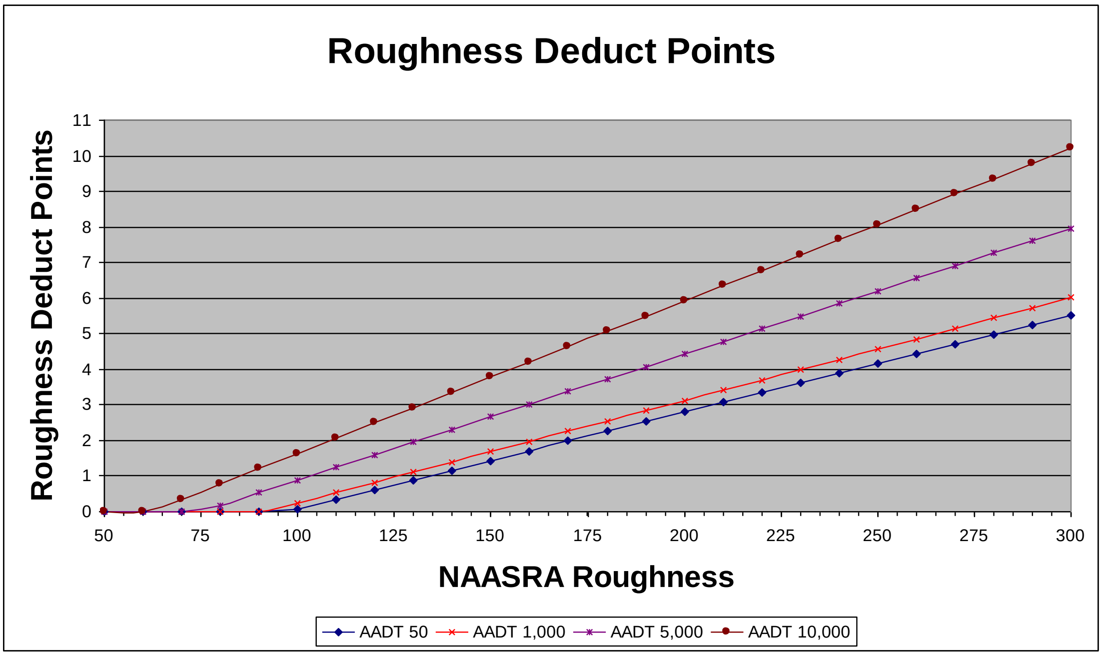


*Figure 6-2: SMEC PCI Deduct Points based on Roughness*

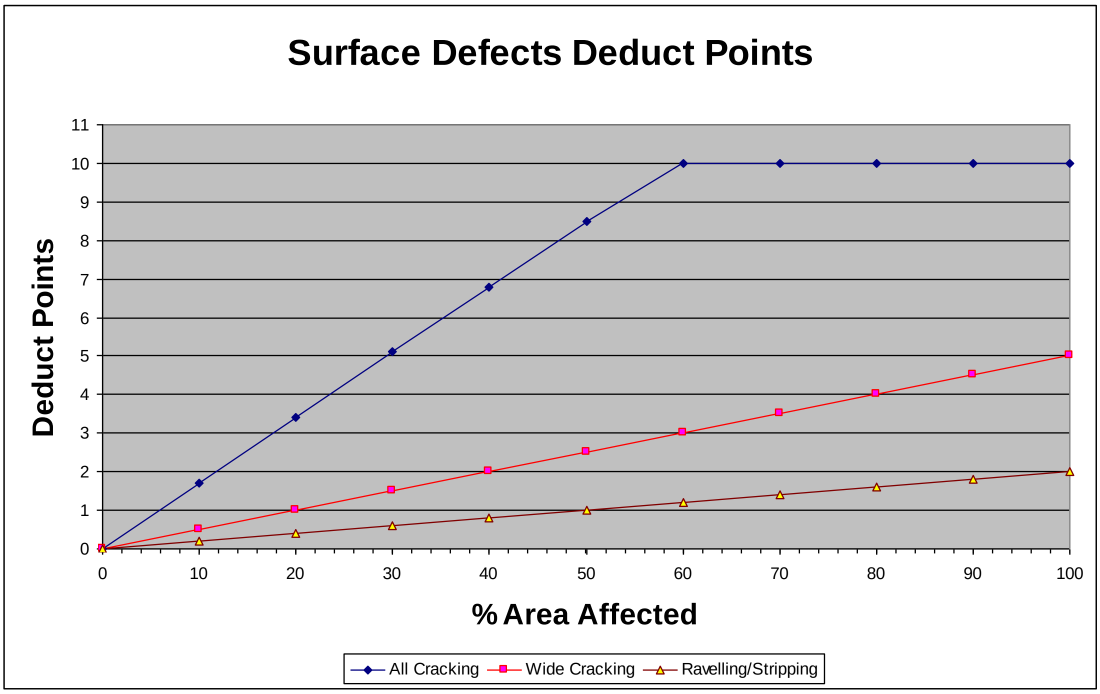


*Figure 6-3: SMEC PCI Deduct Points based on Surface Defects*

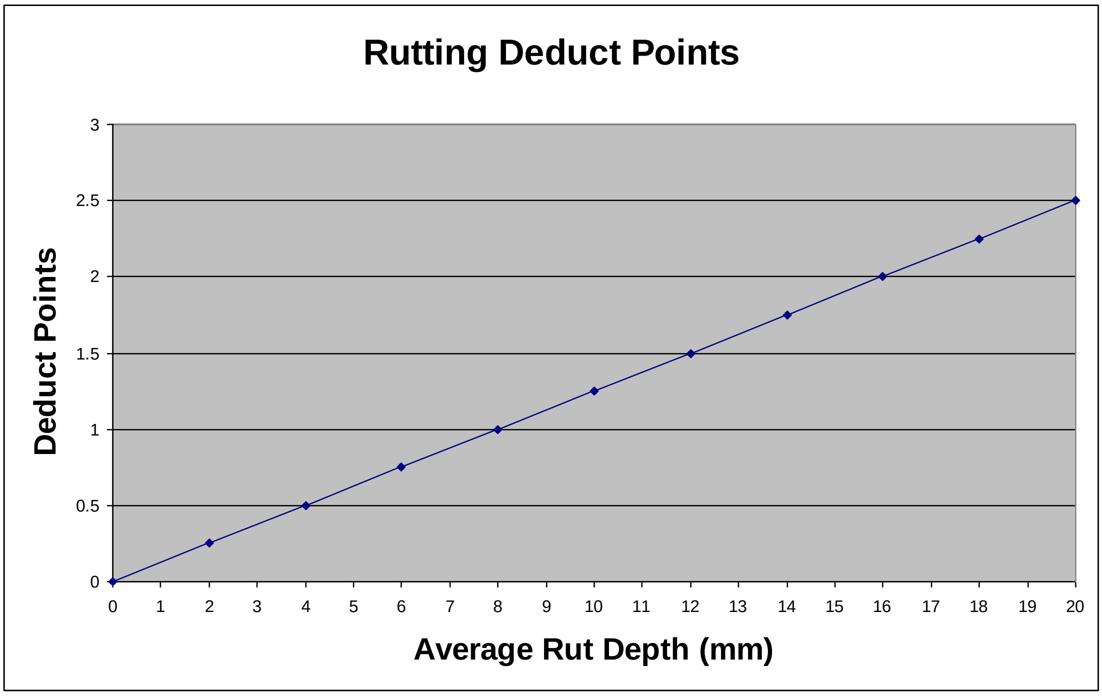


*Figure 6-4: SMEC PCI Deduct Points based on Rutting*

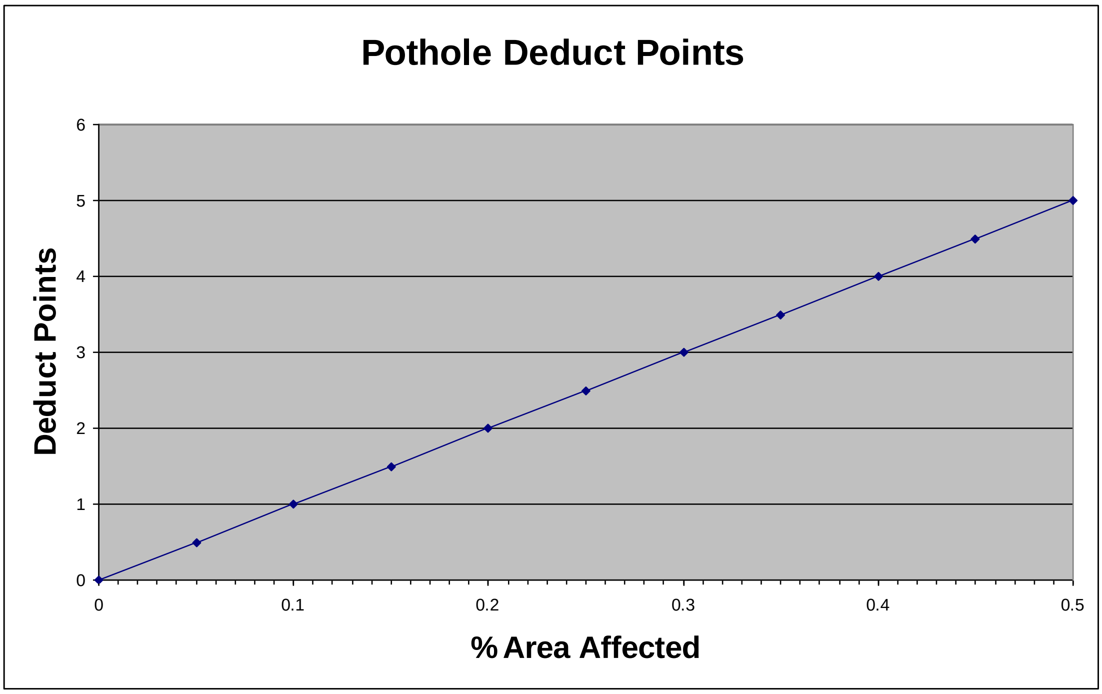


*Figure 6-5: SMEC PCI Deduct Points based on Potholing*

**Example:**

Take a road section with the following information:

| Parameter | Value | Deduct Code | Deduct Value |
|---|---|---|---|
| AADT | 535 ADT | | n/a |
| Roughness | 120 NRM | $D_1$ | 0.720 |
| All cracking | 2.5% | $D_2$ | 0.430 |
| Wide cracking | 0.1% | $D_3$ | 0.005 |
| Potholes | 0.1% | $D_4$ | 1.000 |
| Rutting | 2.3mm | $D_5$ | 0.288 |
| Ravelling | 6.5% | $D_6$ | 0.13 |

The PCI is then:

PCI = 10 – 0.720 – 0.430 – 0.005 – 1.000 – 0.288 – 0.13

= 7.4

# APPENDIX C ROBERTS / JAMESON EQUATION

The adjusted structural number, SNP, is determined by the sum of the structural number, SN, and the structural contribution of the subgrade, SNsg (refer to Equation A1.1).

$$\mathbf{SNP = SN + SN_{sg}} \qquad \textbf{Equation A1.1}$$

The structural number, SN, was developed by Roberts (1995) based on the deflection data collected in Australia and Philippines (refer to Equation A1.2).

$$\mathbf{SN = 12.992 - 4.167 \times Log_{10}(D_0) + 0.936 \times Log_{10}(D_{900})} \qquad \textbf{Equation A1.2}$$

The structural contribution of the subgrade, $SN_{sg}$ (refer to Equation A1.3), is calculate using the California Bearing Ratio (CBR) of the subgrade developed by Jameson (1993) (refer to Equation A1.4).

$$\mathbf{SN_{sg} = 3.51 \times Log_{10}(CBR) - 0.85 \times (Log_{10}(CBR))^2 - 1.43} \qquad \textbf{Equation A1.3}$$

$$\mathbf{Log_{10}(CBR) = 3.264 - 1.018 \times Log_{10}(D_{900})} \qquad \textbf{Equation A1.4}$$

Note: The $D_0$ and $D_{900}$ in the above equations were normalised to a surface stress of 700 kPa.

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