Township of Esquimalt

2013 Long Term Pavement Budgeting

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CONTENTS

1 Introduction

1.1 Background

Municipalities across Canada, including the Township of Esquimalt are challenged with maintaining aging infrastructure which demands substantial rehabilitation at a time of competing need and budgetary constraints. Esquimalt's streets represent an integral part of the transportation network in Greater Victoria. Over the years, the Township's investment in maintaining its street network does not appear to have been keeping pace with the rate of pavement deterioration.

The Township has not completed a formal in-depth condition assessment in recent years, and does not possess tools to enable the systematic identification of the forward work programs and indicative budgets required to bring the network up to, and maintain it at, a defined level of service over the long term. The Township sought assistance from Opus International Consultants to carry out a condition assessment and develop a simplified spreadsheet based planning tool to enable the forecasting of indicative long term budgets.

1.2 Purpose

The purpose of this report is to;

- Describe the condition data collection process;
- Make observations on current network condition;
- Recommend a rehabilitation strategy and indicative long term budget;
- Document the development and workings of a simple spreadsheet based pavement budgeting model; and
- Recommend future actions the Township could take to improve its network knowledge.

2 Data Collection Program

2.1 Current Inventory

The Townships' road network comprises of approximately 50 kilometres of paved roads, made up of predominately urban collectors and local access roads. Opus was supplied with a section referencing spreadsheet that included section descriptions, dimensions and associated data.

The Township's road network is predominantly set in an urban environment and consists of major, collector, and residential roads. The major roads are a mix of two lane single highway and a small length of four lane divided highways, whereas the rest of the roads on the network are two lanes.

The network has been categorized into the following four classes for this study:

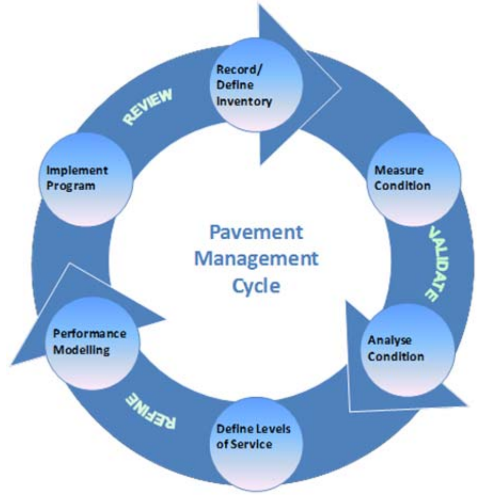
- Class 1 – Major Roads;
- Class2 – Collector Roads;
- Class 3 – Residential Streets; and
- Class4 – Bus Routes in Collector or Residential Streets.

Table 1 below shows the road length and lane length for each road Class.

Table 1: Current Road Inventory by Class

Road Class	Length (Road-Km)	Length (Lane-Km)
Class 1 Major Roads – Less than 4 lanes Major Roads – 4 lanes	7 2	15 8
Class 2 - Collector Roads	7	14
Class 3 - Residential Streets, excluding bus routes	31	62
Class 4 -Bus Routes in Residential Streets	3	3
Total	**50**	**104**

2.2 Pavement Condition Data Collection



A comprehensive pavement condition data collection program was undertaken for the Townships streets during September 2012 by DCL Siemens as part of this study. The surveys consisted of the following data capture:

(a) ***Pavement Surface Condition*** – detailed visual assessment of the pavement surface condition (i.e. cracks, etc.) by experienced raters according to a standardized rating methodology and recorded in real time as the vehicle traveled the road network;

(b) ***Pavement Rutting*** – the transverse profile of the travel lane was measured on a continuous basis by laser sensors and used to calculate the average rut depths for each wheel path; and

(c) ***Pavement Roughness*** – longitudinal profile roughness measurements collected for each wheel path on a continuous basis using a Class II laser profiler (according to ASTM) to determine the pavement roughness as per the International Roughness Index (IRI).

(d) ***Pavement Strength*** - assessed by deflection testing, which was completed by using a Falling Weight Deflectometer (FWD) to measure the pavement structural capacity.

DCL Siemens owns and operates an International Cybernetics Corporation (ICC) data survey vehicle that simultaneously collects surface condition, roughness, rut, and GPS data streams. With the inclusion of the latest technology into the on-board systems, the data collection process has proven to be repeatable and extremely reliable. Details of this equipment can be supplied on request

The Township's road network comprises of approximately 50 kilometres of paved roads made up of predominately urban collectors and local access roads. Surface distress, rutting and roughness testing was undertaken on the entire network. Details of the Surface Condition Rating Methodology can be supplied on request.

Investigation of the collected data and the inventory supplied showed that there was one road section within the current inventory that was not surveyed, and two new roads that do not appear in the current inventory that were surveyed. These are shown in Table 2 below. Note that the name Esquimalt Place was listed in the supplied inventory, but no such street exists within Esquimalt's jurisdiction.

Table 2: Differences in Inventory and Data Collection

Surveyed but not in Inventory			
Road Name	**From Description**	**To Description**	**Section Length (m)**
Naden Road	Coles Street	End	74
South Joffre Street	Heald Avenue	Lyall Street	109
Total Section Length			183
In inventory but not Surveyed			
Road Name	**From Description**	**To Description**	**Section Length (m)**
Esquimalt Place	Esquimalt Road	End	114

2.3 Pavement Strength Data Collection

The structural strength data was collected with a JILS FWD 20 unit, which is a fully automatic, objective, and non-destructive testing device.

The FWD testing was completed on the majority of the Townships' major and collector road network and, in order to reduce cost, on a 30% sample of the Townships' residential road network.

Structural strength data is not reported as a defect but can be used as an input for project pavement design. Table 3 below shows the length and number of tests performed for each road class in the Townships' network.

Table 3: Pavement Strength Data Collection

Road Class	Survey Length (Km)	No. of Tests
Class 1 - Major	9	77
Class 2 - Collector	7	66
Class 3 and Class 4 - Residential	11	96

3 Current Network Condition

This section highlights the current condition of the Township of Esquimalt's road network with regard to the following pavement condition parameters:

- Roughness;
- Cracking,
- Rutting;
- Ravelling, and
- Overall Pavement Condition.

The data has been aggregated by road hierarchy and displayed as cumulative distributions for Major, Collector, and Residential road classes.

A cumulative distribution of each dataset shows the percentage of network length by road class that has a certain condition level or defect severity.

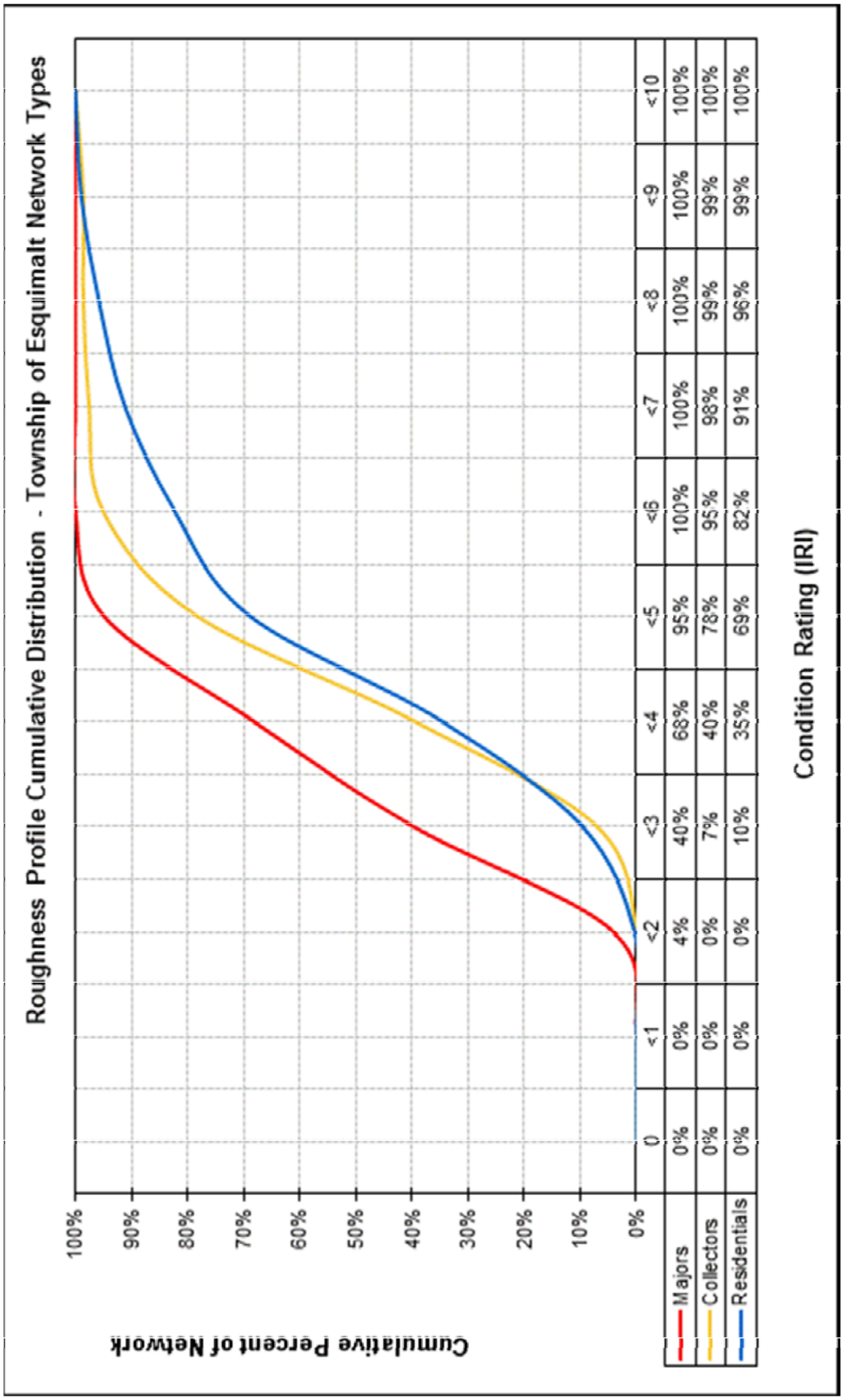
3.1 Current Network Pavement Roughness Condition

Pavement roughness is used to measure the longitudinal profile of highways, and is measured using the International Roughness Index (IRI), an internationally recognised measurement. Roughness equates to the difference in road surface level over a defined length. Typical values in paved municipal environments would be between 1.5 for newly paved construction through 5-6 for deteriorated pavements. Values greater than 5-6 are often due to surface obstructions such as utility trenches or surface hardware (i.e. manhole covers, catch basins, etc.) located in the driving lanes.

The cumulative distribution curves as shown in Figure 1 indicated that as expected, there was some difference in roughness between the road classes as follows:

- ***Major Road Network*** – the roughness levels were significantly better than the other road classes. The average IRI was 3.4 with 100% of the network having an IRI value less than 6;
- ***Collector Road Network*** – the average IRI was 4.5 with 95% of the network having an IRI value of 6 or less. The remaining 5% of the network had an IRI between 6 and 10; and
- ***Residential Road Network*** –the average IRI was 4.7 with 82% of the network having an IRI value of 6 or less. The remaining 18% of the network had an IRI between 6 and 10.

The average roughness values for each road class are consistent to those of other local municipalities within Greater Victoria.



	0	<1	<2	<3	<4	<5	<6	<7	<8	<9	<10
Majors	0%	0%	4%	40%	68%	95%	100%	100%	100%	100%	100%
Collectors	0%	0%	0%	7%	40%	78%	95%	98%	99%	99%	100%
Residentials	0%	0%	0%	10%	35%	69%	82%	91%	96%	99%	100%

Figure 1: 2012 Pavement Roughness Cumulative Distributions

3.2 Current Network Pavement Cracking Condition

Cracking, if left untreated, enables the ingress of water into the underlying pavement and can lead to increased rates of pavement deterioration.

The cumulative distribution curves for pavement cracking above are based on a crack index derived from the following cracking defects and calculated as per Table 4:

- Transverse Cracking;
- Longitudinal Cracking, and;
- Alligator Cracking.

The crack index can range from 0 to 100, with 0 being no cracks and 100 being cracked throughout. It is derived by combining the severity and density ratios of each crack defect, then applying a weighting factor to each cracking type. The weighting factors are applied to each cracking type dependent on the failure mechanism. For example, alligator cracking has a higher weighting in the index as it is considered to be the greatest factor to bring on rapid deterioration if not treated. Longitudinal and transverse cracking share the same, lesser weighting in the index as shown.

Table 4: Weightings and Calculations for Cracking Index

Cracking Type	Severity	Weighting	Extent	Score	Cracking Index Weighting
Transverse	Low	0.50	0-100%	0.50 x Extent	0.6
	Moderate	0.75	0-100%	0.75 x Extent	
	High	0.90	0-100%	0.90 x Extent	
				Transverse Score = Sum of above	
Longitudinal	Low	0.50	0-100%	0.50 x Extent	0.6
	Moderate	0.75	0-100%	0.75 x Extent	
	High	0.90	0-100%	0.90 x Extent	
				Longitudinal Score = Sum of Above	
Alligator	Low	0.50	0-100%	0.50 x Extent	1.0
	Moderate	0.75	0-100%	0.75 x Extent	
	High	0.90	0-100%	0.90 x Extent	
				Alligator Score = Sum of Above	
Cracking Index = 0.6 x Transverse + 0.6 x Longitudinal + 1 x Alligator					

A review of the current pavement cracking condition cumulative distribution curves in Figure 2 indicated the following:

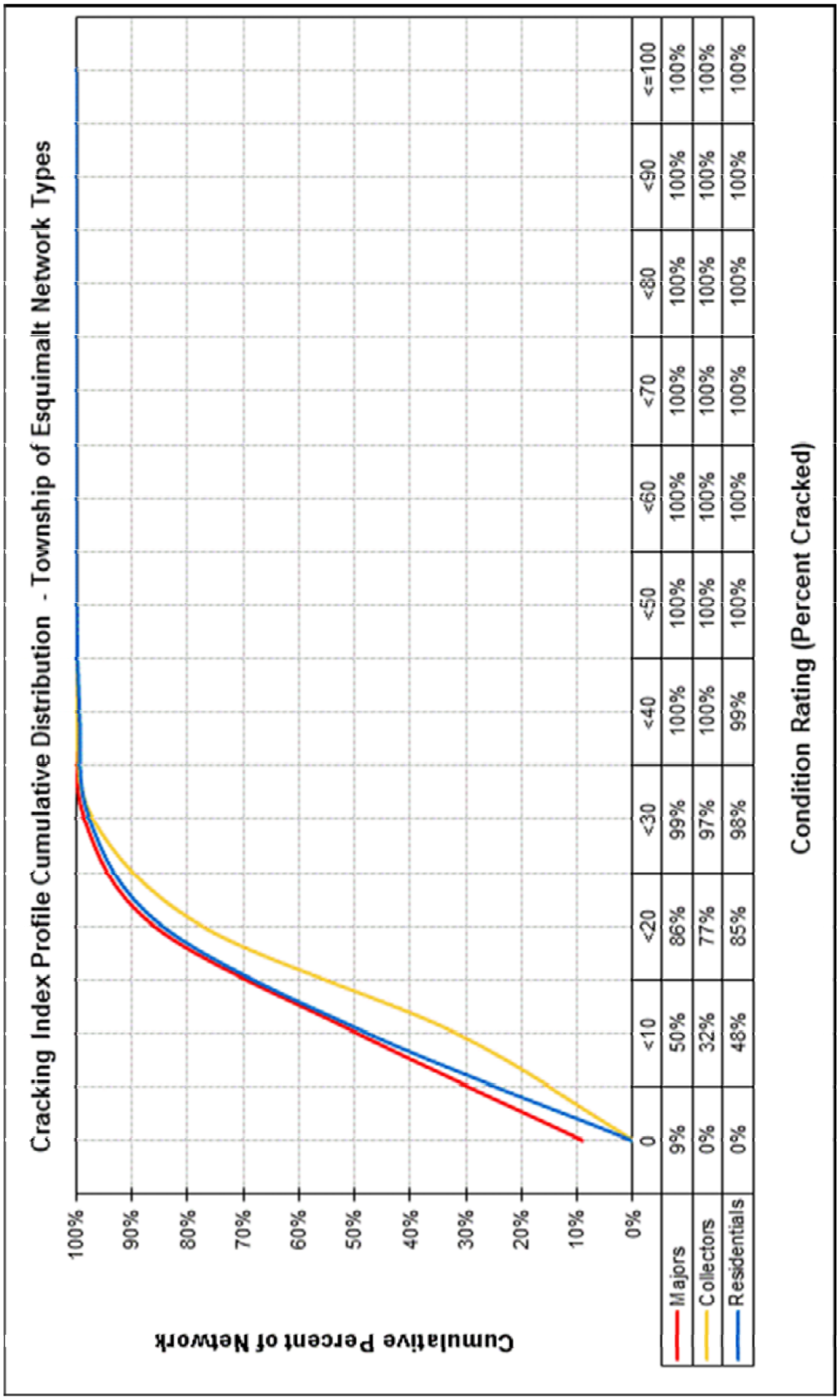
- ***Major Road Network*** –as expected, Major roads have significantly less cracking than the other road classes due to recent pavement rehabilitation activities. As the Figure 2 shows 9% of the major rural network as having no cracking, 50% with a cracking index of 10 (which signifies low severity and/or low density cracking) and the remaining 50% had a cracking index ranging from 10 and 40;
- ***Collector Road Network*** – the level of cracking on the collector road network was worse than the major and residential networks. All sections on this network had some cracking present with 32% of the network having either low severity and/or low density cracking present, 45% of the network at an index of 20, 20% of the network at an index of 30, and 3% of the network at an index of 40; and
- ***Residential Road Network*** – all sections had some cracking with a higher percentage of the network having low severity and/or low density cracking as compared to the collector road network, 37% of the network had an index of 20, 13% of the network at an index of 30, 1% of the network at an index of 40 and is 1% of the network at an index of 50.

3.3 Current Network Rutting Condition

Rutting is the calculated average depth of rut in each wheelpath as measured from below a 2m straight edge. For this analysis the rut measurement for each 50m section was calculated as the average from the 10m collected survey data.

Overall, the level of rutting throughout the network by road segment was less than 7mm, and therefore not sufficient to warrant specific attention. The cumulative distribution curves as shown in Figure 3 indicated:

- ***Major Road Network*** – 24% of the network with rutting at less than 2mm, 23% of the network with rutting at less than 3mm, 26% of the network with rutting at less than 4mm, 17% of the network with rutting less than 5mm, and 5% of the network with rutting less than 6mm and 7mm respectively;
- ***Collector Road Network*** – substantially less than the major road network due to lesser traffic loading with the maximum average rut value of 4mm, 78% of the network with rutting less than 2mm, 14% of the network less than 3mm, and the remaining 8% of the network with rutting less than 4mm; and
- ***Residential Road Network*** - similar to the collector road network due to less traffic loading with 90% of the residential road network has rutting less than 2mm.



	0	<10	<20	<30	<40	<50	<60	<70	<80	<90	<=100
Majors	9%	50%	86%	99%	100%	100%	100%	100%	100%	100%	100%
Collectors	0%	32%	77%	97%	100%	100%	100%	100%	100%	100%	100%
Residentials	0%	48%	85%	98%	99%	100%	100%	100%	100%	100%	100%

Figure 2: 2012 Pavement Cracking Cumulative Distributions

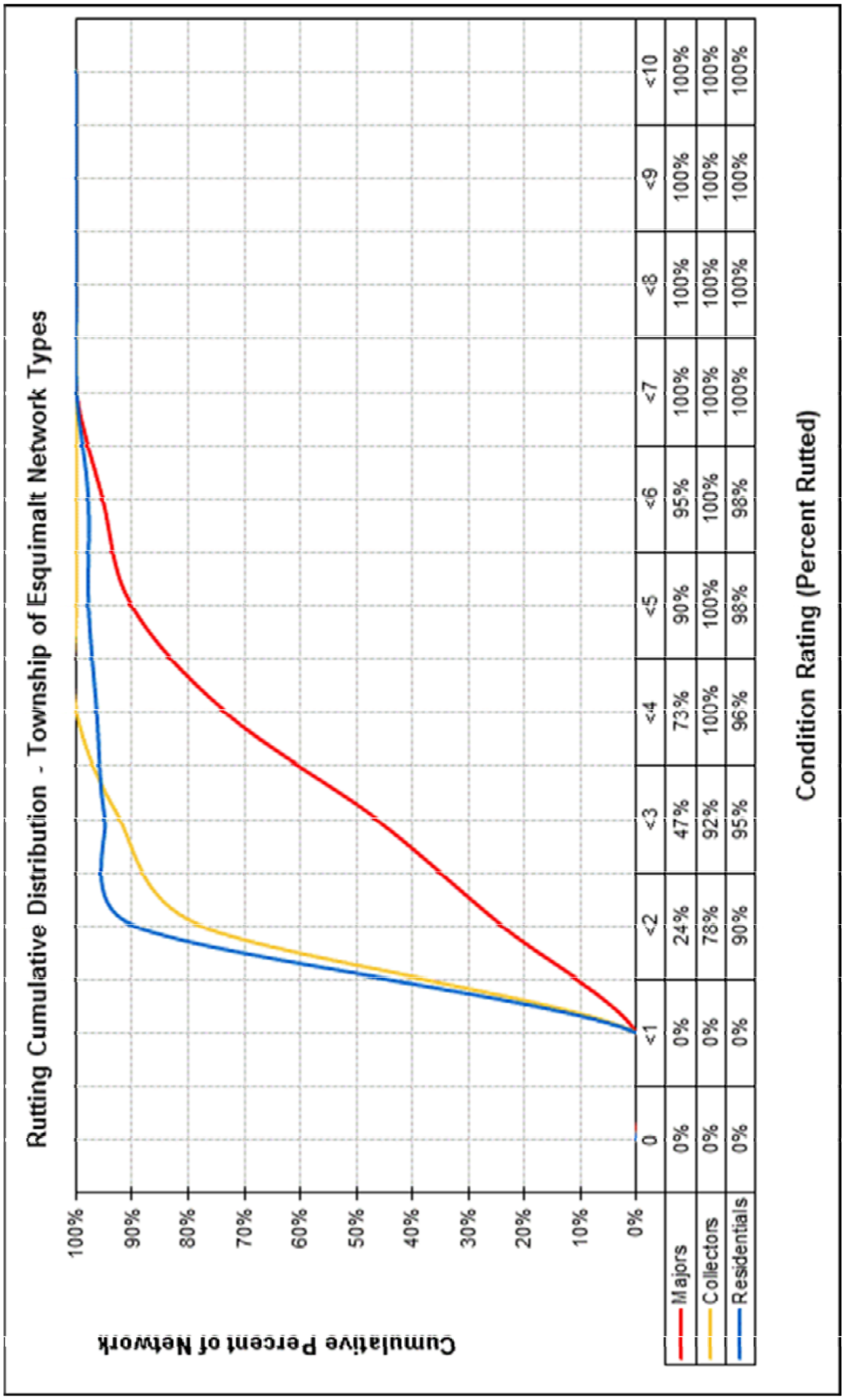

Rutting Cumulative Distribution - Township of Esquimalt Network Types
Cumulative Percent of Network
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Condition Rating (Percent Rutted)
	0	<1	<2	<3	<4	<5	<6	<7	<8	<9	<10
Majors	0%	0%	24%	47%	73%	90%	95%	100%	100%	100%	100%
Collectors	0%	0%	78%	92%	100%	100%	100%	100%	100%	100%	100%
Residentials	0%	0%	90%	95%	96%	98%	98%	100%	100%	100%	100%

Figure 3: 2012 Rutting Cumulative Distributions

3.4 Current Network Raveling Condition

Raveling is the disintegration of the pavement from the surface downward due to the loss of aggregate particles. Raveling usually occurs as a result of the aging of the asphalt binder, but can also be attributed to poor mixture quality, segregation, or insufficient compaction during construction. A ravelled surface enables the ingress of water into the underlying pavement and, if left untreated, can lead to increased rates of pavement deterioration.

Ravelling was collected similarly to cracking based on severity and extent with an overall index calculated as described in Table 5.

Table 5: Weightings and Calculations for Ravelling Index

Severity	Weighting	Extent	Score
Low	0.50	0-100%	0.50 x Extent
Moderate	0.75	0-100%	0.75 x Extent
High	0.90	0-100%	0.90 x Extent
		Ravelling Index =	**Sum of Above**

Records of approximate age indicate that ravelling in the network is age related rather than due to material or construction issues. The cumulative distribution curves as shown in Figure 4 showed that ravelling is a significant defect and that there was a noticeable difference between road classes as follows:

- ***Major Road Network*** –30% of the network has no raveling present with 44% of the network having 10% ravelling, 16% of the network with 20% raveling, 4% of the network with 30% raveling, 2% of the network with 40% raveling, 1% of the network with 50% raveling, 2% of the network with 60% raveling, and 1% of the network with 70% raveling;
- ***Collector Road Network*** – similar to the major road network with 30% having no ravelling, but there was a higher percentage of the collector road network with higher severity raveling and 34% of the network with 10% raveling, 8% of the network with 20% ravelling, 7% of the network with 30% raveling, 12% of the network with 40% raveling, and 9% of the network with 60% raveling; and
- ***Residential Road Network*** – worst performing road class with 95% of the network having some level of raveling present probably attributed to wear and tear on an aging paved surface. Also with high percentages of the network at higher severity or a higher density of raveling, with the largest being 20% of the network with 60% raveling.

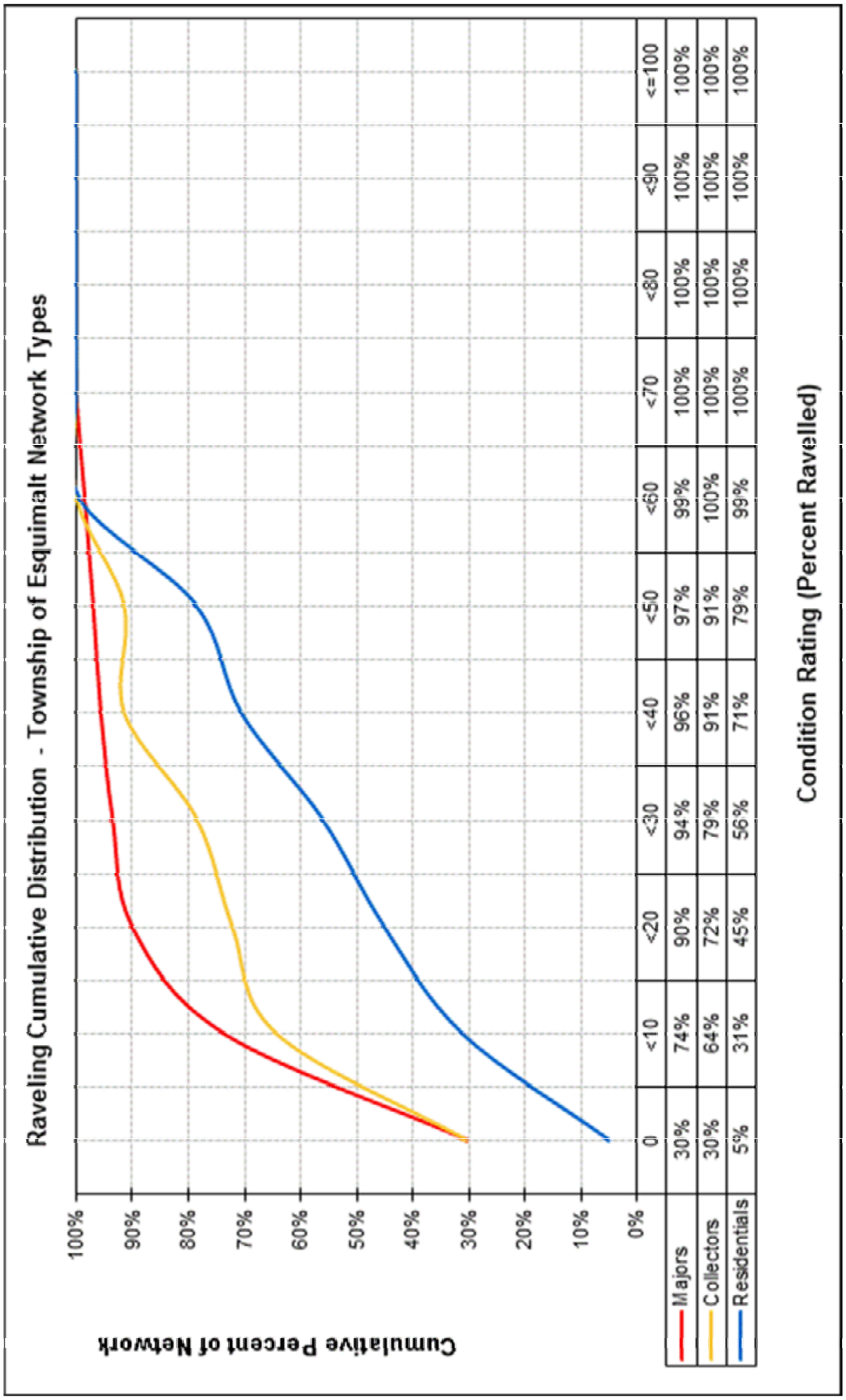


Figure 4: 2012 Raveling Cumulative Distributions

3.5 Current Pavement Condition Index

The Pavement Condition Index (PIndex) is a summary of overall pavement condition and was developed using the cracking, ravelling and pothole surface distresses, pavement roughness, and pavement rutting. The PIndex was calculated using the following equation:

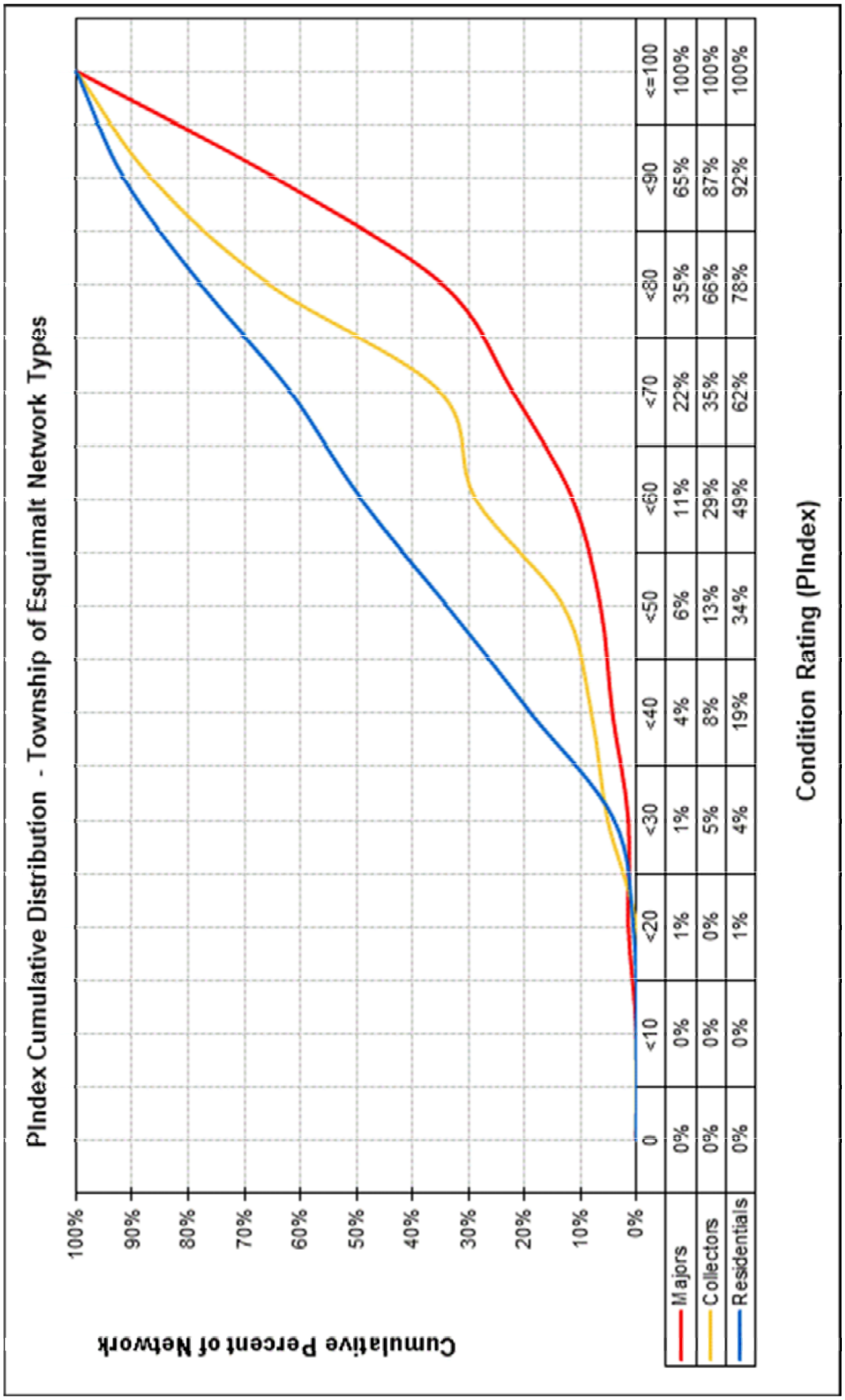
PIndex = 100 – Cracking – Ravelling - Potholes - max (Ruttingmean – 3, 0) – max (Roughnessmean – 3, 0)

The results of the PIndex analysis are shown in Figure 5 as a cumulative distribution of the network by road class. It should be noted that this curve runs in the opposite way to the other cumulative distribution charts (i.e. 100 = Excellent condition).

A review of the current PIndex condition indicated the following:

- ***Major Road Network*** – appears to be in good condition with an average PIndex value of 73 that is a reflection of the rehabilitation work carried out on this network in recent years;
- ***Collector Road Network*** – majority is in a good condition with the average value being 70; and
- ***Residential Road Network*** – in the poorest condition with the average value being 62;

The defect with the greatest impact on the overall pavement condition was ravelling. The reasons for the extent and severity of ravelling should be investigated. The average PIndex values for each road class are significantly less than those of other local municipalities, indicating a poorer overall condition



	0	<10	<20	<30	<40	<50	<60	<70	<80	<90	<=100
Majors	0%	0%	1%	1%	4%	6%	11%	22%	35%	65%	100%
Collectors	0%	0%	0%	5%	8%	13%	29%	35%	66%	87%	100%
Residentials	0%	0%	1%	4%	19%	34%	49%	62%	78%	92%	100%

Figure 5: 2012 PIndex Cumulative Distributions

3.6 Structural Number - Pavement Strength

Structural Number is an index that is indicative of the effective pavement depth. It can be converted to an actual layer thicknesses by using a layer coefficient that represents the relative strength of the construction materials in that particular layer.

The FWD device measures pavement deflections by applying known impulse loads to the pavement. The back calculation of Structural Number uses an assumed layer depth for each of the surface, base, and sub-base layers.

Comparison of Structural Number statistics from Esquimalt, City of Victoria, and District of Saanich are shown in Table 6.

Table 6: Local Municipal Structural Number Comparisons

Class	Statistic	Esquimalt	Saanich	Victoria
Major	Average Minimum Maximum	93 67 129	88 56 133	147 48 380
Collector	Average Minimum Maximum	74 32 125	88 56 133	127 45 233
Residential	Average Minimum Maximum	56 29 103	N/A	104 45 248
Network	Average	75	88	138

The results from the data collected indicated that;

- Esquimalt pavement strength is comparable to that of Saanich;
- Pavement strength is greater in the more heavily loaded road classes;
- There did not appear to be any trend of anomalies of low strength pavements in high road classes or vice versa; and
- There is a uniform distribution of pavement strength within the classes.

4 Rehabilitation Strategy and Budgets

4.1 Rehabilitation Strategy

Budget expectation calculations, described further in Section 5, indicated that the current annual budget for pavement rehabilitation is lower than required over the long term to sustain the expected service levels. Given this, the recommended rehabilitation and maintenance strategy must be one of asset preservation - using the current budget to maintain pavement performance at current condition levels as a minimum.

The foundational principal of preserving pavement assets is to ensure that they are protected from the damaging effects of water ingress into the pavement and underlying sub-grade layers. All forms of surface distress that will allow entry of water should be treated. (Sections 2 and 3 above have described the Township's data collection and current surface distress condition.)

Cracking and ravelling have been identified as the most significant defects allowing water ingress into the Esquimalt network. While it is considered that cracking generally allows easier ingress of water, the extent of ravelling in the Townships network means that ravelling must be given consideration as well. Cracking and ravelling have been combined into a composite index in the budget model, described further in Section 6.3.

The rehabilitation tactics recommended for this strategy are to;

- Identify road sections with cracking and/or ravelling that need to be treated; and
- Apply the most cost effective treatment that will maintain current service levels.

While this asset preservation strategy is being implemented, whole section treatments triggered solely by rutting or roughness should be limited to those sections where;

- Rutting depth is creating a safety hazard, generally by hydroplaning, or
- Roughness has reached an extremely high level leading to public complaints.

The current condition data does not indicate there are any sections which would meet either of the above criteria.

4.2 Treatments

The Township's rehabilitation treatments are all variations on asphalt overlays – simple overlay, grind & pave or remove & replace. The latter treatment tends to be used for the most severely deteriorated pavement conditions and/or where underground services replacement require wide-spread pavement excavations.

Chipsealing and micro-surfacing are treatments that have been used by some municipalities in greater Victoria, but are not currently used in Esquimalt. Their use could be considered as a way of restoring waterproofing and/or arresting ravelling at a lesser cost than asphalt treatments.

4.3 Current Budget

The Township's current rehabilitation budget is approximately $230,000 per year. This is made up of a $150,000 annual maintenance budget and the annualization of large upgrading projects - $80,000.

The annual maintenance budget of $150,000 is currently for public works team costs and the purchasing of materials or contracted services.

The Township tends to fund major upgrading projects every few years. It has been assumed that $400,000 spent every five years contributes $80,000 annually to the rehabilitation and major maintenance budget.

5 Life Expectancy and Budget Requirements

Life expectancy of treatments is the key factor in determining sustainable rehabilitation budget requirements. Typical industry practice and experience of surrounding municipalities would suggest that Esquimalt could expect to achieve pavement service lives of at least 25-30 years with its combination of a relatively dry climate and traffic loadings.

Some simple calculations for three scenarios are presented in Table 7 in order to understand the budget range that could be required to sustain the Township's network.The assumptions of treatment lives, treatment mix, and average costs are from Opus experience with local municipal networks. The quantities for each scenario were derived by dividing the total surfacing area of the network by the assumed average life expectancy for each scenario. The weighted average cost for each scenario is the product of the cost and proportion of each treatment. The annual budget for each scenario is then the product of the annual surfacing area and the weighted treatment cost

Table 7: Budget Range Calculations

Total Surfacing Area		450,000 m2		
Treatment Average Life Expectancy		27 years	30 years	25 years
Annual Surfacing Area		16,000 m^2	15,000 m^2	18,000 m^2
Treatment	**Cost**	**With More Cost Effective Treatments**	**Current Treatments**	
			Lower Service Level Mix	**Higher Service Level Mix**
Chipseals and Micro-surfacing	$\$5.00 / m^2$	20%	0%	0%
Overlay	$\$21.00 / m^2$	80%	100%	96%
Grind and Pave	$\$34.00 / m^2$	0%	0%	3%
Remove and Replace	$\$120.00 / m^2$	0%	0%	1%
Weighted Treatment Cost		$\$17.50 / m^2$	$\$21.00 / m^2$	$\$22.50 / m^2$
Annual Budget Range		$280,000	$315,000	$405,000

The assumed current budget availability of $230,000 applied with the three service levels of the above table will require treatments to have an average life expectancy of 34, 41 and 44 years respectively. This is an unrealistic expectation over the whole life of the network.

6 The Budgeting Model

6.1 Purpose of the Model

The purpose of the model is to enable forecasting of network budgets for each of the next 30 years. The model does not contain any logic that caps total budgets or "smooths" peak budget calculations across a number of years. The Township's engineering staff will use the model outputs to forecast future budget requirements and as the basis for producing forward work programs.

6.2 Road Sections

The network inventory supplied by the Township has been used as the base for the model. Divided highways have been treated as two roads, one in each direction.

6.3 Model Deterioration Parameters

It was originally envisaged that the budgeting model would use deterioration of a single pavement condition parameter to trigger the scheduling of treatments required to meet a defined level of service. The asset condition data analysis has indicated that the asset preservation maintenance strategy is best served by this parameter being a combination of cracking and ravelling.

The model uses a composite index ('cracking + ravelling') by combining the cracking and ravelling indices in proportions set by the user. This composite index is then used as the deterioration parameter in the model.

The user defines the relative weightings given to cracking and ravelling to create the composite index. As cracking is generally going to allow more water ingress into the pavement than ravelling, it should be given a greater weighting. It is suggested the weighting be 0.8/0.2.

A road section without any cracking or ravelling will have an index of zero, with the index increasing towards, but not reaching, 100 as its cracking and ravelling worsens.

6.4 Deterioration Rate

The 'cracking + ravelling' index for each road section is calculated from the current network condition data. That index is then projected each year at a deterioration rate as set by the user until it reaches a user set trigger level, at which time a treatment is scheduled.

The deterioration rate and the trigger levels, see Section 6.5, work together to determine the average life for each treatment. The user can choose different deterioration rates for each class, in recognition that more heavily trafficked roads tend to deteriorate fastest.

The model resets the 'cracking+ravelling' index to zero once the initial treatment is triggered. The next rehabilitation treatment occurs when the calculated service life is reached.

6.5 Treatment Triggers and Selection

The user sets the 'cracking + ravelling' index level at which a treatment is triggered, which is called the Distress Trigger. Each road class has its own trigger level, in recognition that a lower level of service may be acceptable for lower road classes. The 'cracking + ravelling' index is reset to zero after a treatment has been triggered.

The models default treatment is an overlay treatment. The user defines a 'cracking + ravelling' limit beyond which the model will choose grind & pave, and a further limit beyond which the remove and replace treatment will be chosen.

6.6 Treatments

The overall condition of the network is indicative of the need to treat a backlog of street sections in the next few years and then to match future treatment levels with network deterioration. The condition of the highest priority backlog street sections is likely to require more intensive treatments than an overlay. These treatments could range from selective grind and pave through to complete removal of existing materials and replaced by new construction.

This model allows the choice of up to four treatments. Three have been used for Esquimalt's model – overlay, grind and pave, remove and replace. The model will choose one of the more extensive treatments for the first treatment if the current condition is worse than the Distress Trigger for the default treatment – an overlay. All subsequent treatments will be overlays.

The user sets an average $cost/m^2 for each treatment. These should be an average rate that reflects the achievable productivity and material costs for the range of construction locations and treatment variations likely to be encountered. For the overlay treatment this must also allow for pre-overlay repairs.

6.7 Model Outputs

The model calculates a budget cost for each of the selected treatments for each of the next 30 years.

The Dashboard sheet of the model presents a summary of model outputs in tables and graphs to enable visual assimilation of the overall modelled budget trends. More detailed outputs are in The Model sheet.

An example of the Dashboard tables and graphs are shown in Table 8 and Figure 7 and 8 below (note $ rounded to the nearest $1,000). The model settings that produce these results are included in the Table 9.

Figure 8 shows the models output of 'Cracking + Ravelling' index change over time.

Table 8: Example of Summary Modelled Budget

Block Budget	Five Year Blocks
$2,140,000	1-5
$1,655,000	5-10
$1,595,000	10-15
$2,778,000	15-20
$1,596,000	20-25
$1,547,000	25-30

Table 9: Model Settings for Table 8 Output

Cracking / Ravelling Mix	0.8 Cracking / 0.2 Ravelling			
	Class 1	Class 2	Class 3	Class 4
Cracking + Ravelling Deterioration Rate	1	0.9	0.75	1
Treatment Trigger Values	18	20	25	22
Treatment Costs per m^2	Overlay - $21	Grind & Pave - $34	Remove & Replace - $120	

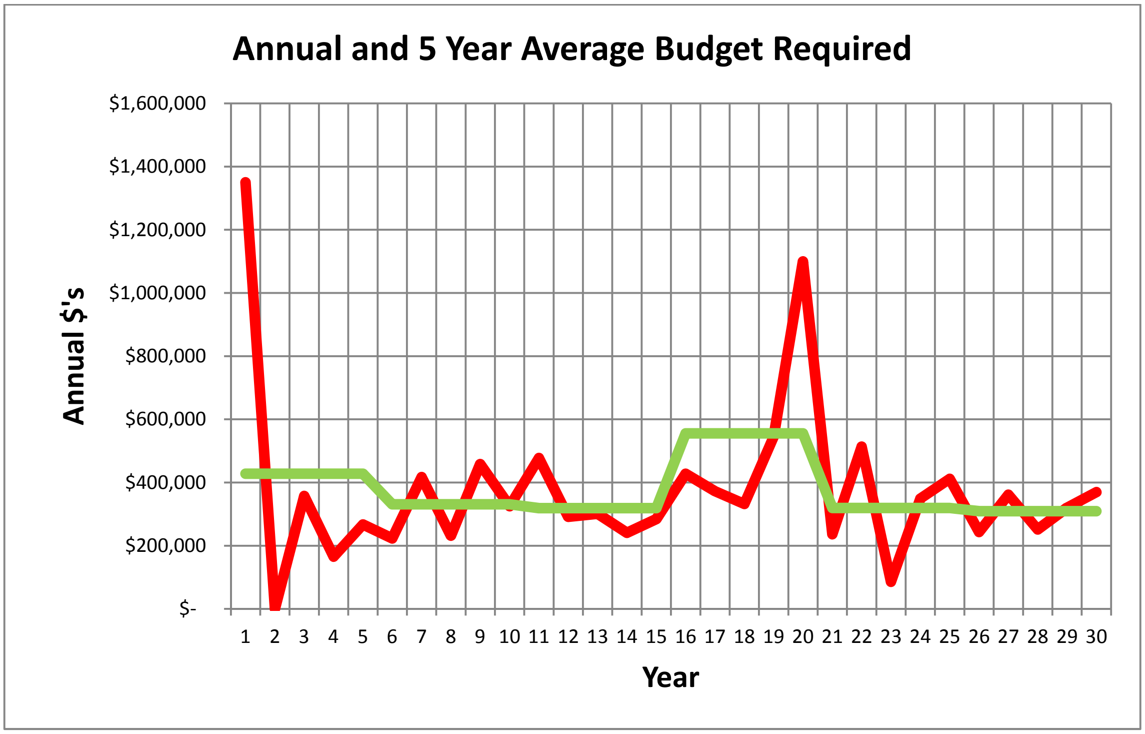


Figure 7: Example of Annual and 5 Year Budgets Required

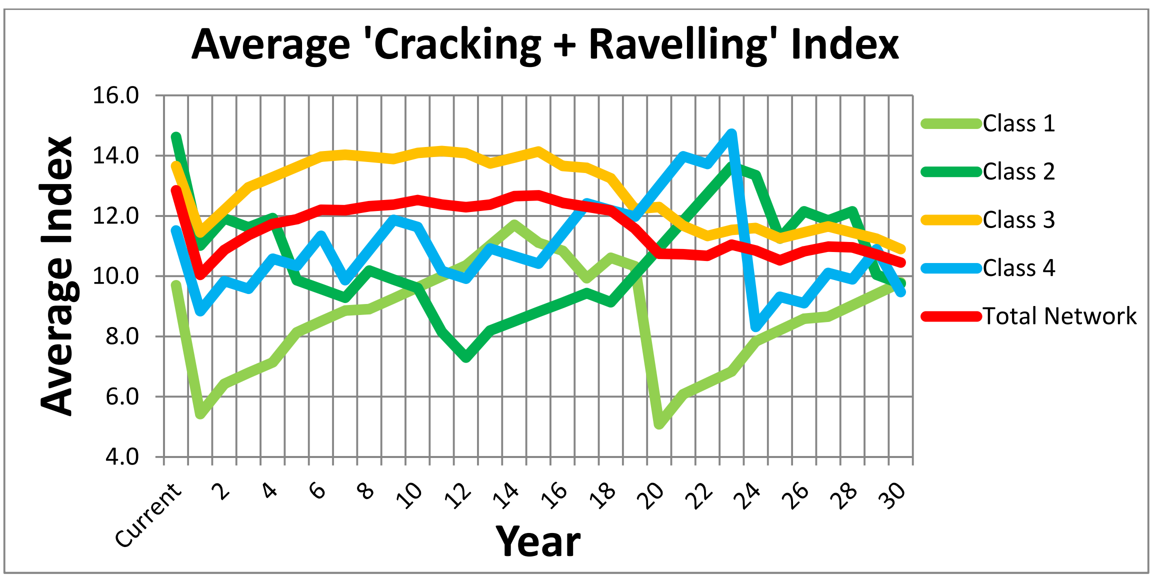


Figure 8: 'Cracking + Ravelling' Index Change Over Time

6.8 Overview of Model Operation

The model is operated as follows:

1. User entered weightings for cracking and ravelling to create a new composite 'cracking+ravelling' index.

2. User entered deterioration rates for each Class of road are used to deteriorate the 'cracking+ravelling' index each year, for 30 years.

3. The Reset Value is left at 0. This is the value that the "cracking+ravelling' index is set to after a treatment has been scheduled.

4. Intervention Distress Trigger values are set by the user for each road classification. When the deteriorated index exceeds the set trigger value, the model schedules a treatment and resets the index to the reset value.

5. User entered Treatment Triggers for each Class/Surface Type/Treatment combination are used by the model to determine which treatment to schedule. This allows more extensive treatments to be scheduled for rehabilitating the initial backlog of street sections.

6. User entered unit rates for each treatment type are used by the model to calculate the cost of each scheduled treatment.

7. The model presents annual and summarised costs in tabular and graphic forms.

6.9 Model Calibration

The model requires calibration by engineering staff to meet the following requirements:

- Treatments are triggered in line with Esquimalt levels of service – choosing the Distress Trigger and Deterioration rate; and

- The treatments used to treat backlog street sections are suited to the condition that triggers them – choosing the Treatment Triggers.

Distress Trigger and Deterioration Rate

Inspection should be made of a selection of street sections from each Class that engineering staff consider are approaching or well past requiring treatment and, preferably, for which the year of the last rehabilitation treatment is known. The average 'cracking+ravelling' index of those sections that are considered to require treatment should be set as the Distress Trigger value for each Class. After determining the average rehabilitation life for each class, the 'Cracking+Ravelling' Deterioration Rate / Year can be set so that the model's Resulting Average Life is as close as possible to this average found from inspection.

Treatment Triggers

The highest priority backlog street sections from each Class should be inspected, with a view to determining the values of 'cracking+ravelling' index that should be used to trigger Grind & Pave and Remove & Replace treatments.

7 Recommended Future Actions and Conclusions

7.1 Recommended Future Actions

- The budget model has been delivered with the user defined settings derived from analysis of the condition data and pavement life assumptions. These assumptions and settings need verifying, as described in 6.9 above.

- The Distress Triggers, Treatment Triggers, and Deterioration rates should be reviewed every two years.

- At the completion of future rehabilitation work, the 'cracking + ravelling' index should be reset.

- Further attribute data should be created for all street sections. This data should include pavement width, pavement layer construction details of depth, material, and construction date. Where this data does not exist, the process may include a mix of making assumptions for all street sections, and then seeking every opportunity to validate the assumptions over a defined period of time. A business process should be established that then updates this data over the next four years.

- Condition data should be collected again in four years' time. The suitability of the budget model should be reviewed at the same time. It may be that a more sophisticated deterioration and optimization model is appropriate.

- Investigation should be made into the potential for use of chipsealing or micro-surfacing. These should generally be more cost effective treatments for cracking and ravelling in residential road classes.

7.2 Conclusions

- The new budgeting tool should assist the Esquimalt Engineering staff to identify long term budgeting requirements to bring the network up to, and maintain it at, a defined level of service over the long term.

- This tool and the associated calibration and verification work should signal the commencement of a long term business processes which has an objective of ensuring that a sustainable level of investment in pavement rehabilitation maintains the street network at an agreed level of service.