Appendix D

Carriageway & Footway Lifecycle Planning

Carriageway Life Cycle Planning

1 Introduction

Carriageways are formed of pavement structures which are designed to carry all kinds of transport, these are commonly called roads. The pavement structures are formed of a foundation (usually this is unbound) and pavement layers (which are typically a bituminous bound material). The pavement is designed to carry the load by protecting the natural ground from deformation. The surfacing layer of the pavement provides the functional characteristics of the carriageway, a smooth ride and friction (or skidding resistance) to maintain control of vehicles.

Over time, the carriageway is subject to deterioration. This deterioration seldom renders the asset inoperable but does have a direct influence on the function or value delivered by the asset through its effect on safety, comfort and, where unplanned reactive works are required, increased levels of disruption which reduce its availability.

This life cycle plan has been produced to:

- Determine the performance that will be achieved for the expected level of funding and/or future investment.
- Determine the level of investment needed to achieve the required performance.
- Predict future performance of carriageway assets using different maintenance strategies.

The life cycle plan supports the asset management strategy by:

- Assisting the authority to understand the risks that are present in the medium term to inform decision making.
- Presenting a robust calculation of the requirements for maintaining the current condition (steady state).
- Enabling whole life costs to be incorporated into long-term financial planning through a life cycle modelling.

2 Approach to life cycle analysis

A range of life cycle modelling approaches are available to undertake life cycle analysis of the carriageway ranging from simple steady-state estimates based around assumed life spans for treatments to very detailed approaches where the behaviour of individual assets is assessed.

For this analysis, the HMEP life cycle planning toolkit has been used. The HMEP toolkit uses Markov-chain theory to predict the probability of carriageway asset being in a certain condition. The model relies upon transition matrices which define the probability of change from one condition state to another for each time period. The toolkit allows the constraint of treatments by budget and by target condition. It is possible to specify treatments and define a maintenance strategy for these treatments using this toolkit. The toolkit provides a prediction of the performance of groups of assets e.g. Cat 3A roads and presents the treatments done and the calculated expenditure.

Transition matrices are the core element of the toolkit. Although default transition matrices are provided, local transition matrices have been formed to model Rutland County Council's highways.

3 Asset inventory and initial condition

The road hierarchy has been used to define groups of assets; these were considered to be more robust groups than road classes.

The inventory for the model was obtained from the County Council's Confirm system.

Road Category	Length (m)
3A	96,218
3B	38,977
4A	133,576
4B	263,693

The initial condition for the model was determined from a carriageway condition survey that was undertaken in 2018 by Gaist.

4 Condition states

A limitation of the Markov chain approach is the assumption that the behaviour of the next time period can be predicted from states in the preceding time period. This assumption is justified in most cases but it can lead to sensitivity where large amounts of a single state are defined. To dampen volatility due to this effect in this modelling exercise, multiple states of condition requiring ‘No treatment’ were defined. This helped reduce the sensitivity of the model but also enable the transition of condition from ‘as-new’ to ‘requiring treatment’ to be monitored.

5 Treatment types and rates

Table 1: Treatment rates and effects

Treatment	Unit Rate
Patching	£30 per m^2
Surface Dressing	£4 per m^2
Renewal	£25 per m^2

* rate adjusted for area from per linear metre rate

Treatment costs have been supplied by the Council. The treatments rates are defined per unit area.

For surface dressing treatments, a proportion of pre-dressing patching has been allowed for in addition to the cost of dressing. Data from similar networks suggests that an average figure of about 10% patching is typical; this gives a treatment cost for surface improvement of £7 per m^2.

Renewal can be either replacement of the surfacing where the structure allows or an overlay up to 100mm thick.

6 Treatment strategies

A treatment strategy allows the specification of the maximum percentage of the asset in a particular condition state which is treated in any one period. A simple setting would be to allow all the assets in a single state to be treated (e.g. 100%), in this case no lengths in any other states would be treated. This does not adequately reflect reality in which a carriageway will exist in a range of condition states along its length and hence a treatment will affect many states. The treatment strategy has been defined to reflect this behaviour by spreading expenditure across multiple condition classes.

7 Budgets

The initial budget has been set for each treatment type based on outline capital budgets in recent years. The proportion of the budget has been allocated across each asset group on the basis of surface area and using a multiplier that was determined from these recent budgets to reflect the expenditure on major roads compared to minor roads.

8 Scenarios

A range of scenarios have been considered in the life cycle analysis.

Scenario Name	Description
Baseline	Budgets at the outline 2019 level, allocated to hierarchy and treatments according to current proportions.
Baseline Plus	Budgets at the outline 2019 level, allocated to reduce the amount of network requiring treatment.
Steady State	The distribution of condition is maintained over 10 years.
Steady State Prevent	The Steady State budget which is biased towards preventative treatments to reduce the amount of network requiring treatment.
Steady State Prevent Opt	The Steady State budget which is biased towards preventative treatments and trimmed such that the overall amount of network requiring treatment is maintained at current levels.
Do minimum	No planned investment, reactive patching and potholing is done. It is assumed that these treatments have no material effect on the overall condition of the carriageway.

9 Results

The following charts present the output of the life cycle modelling scenarios. Two parameters have been presented in Figures 1 and 2 for simplicity: the amount of the network potentially requiring a treatment and the amount of the network requiring a renewal treatment.

Specific outputs from each of the modelled scenarios are presented in Appendix A.

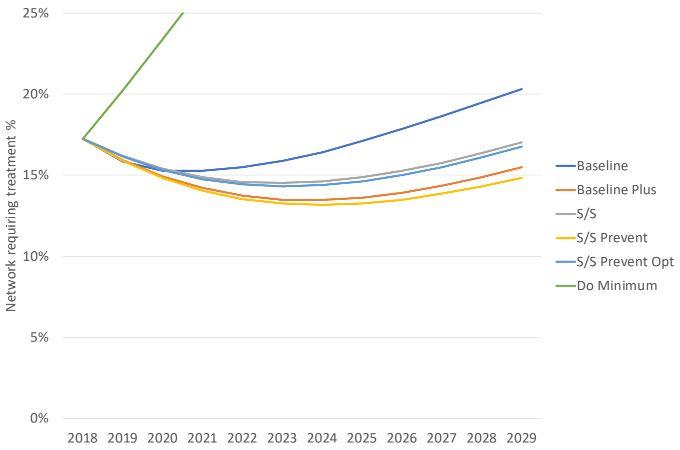

Figure 1: Impact of scenarios on network requiring treatment

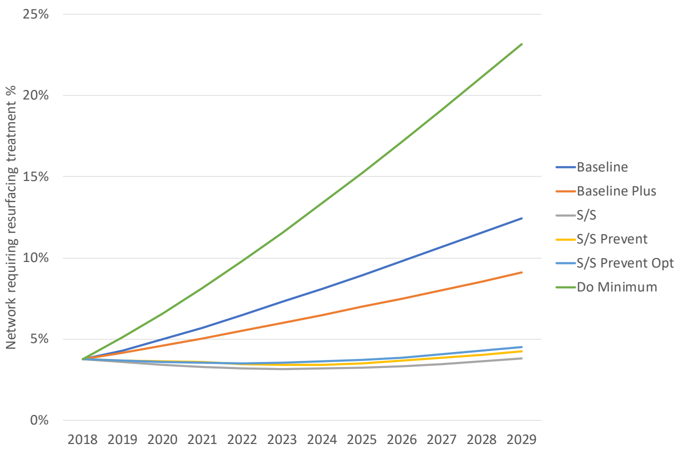

Figure 2: Impact of scenarios on network requiring renewal treatment

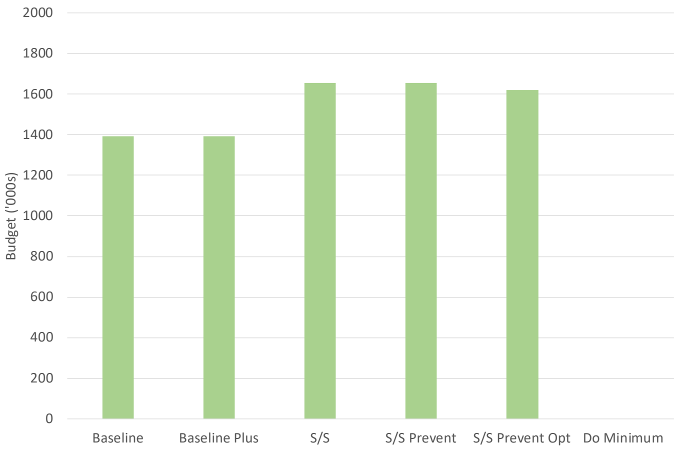

Figure 3: The budget requirements for each scenario

The following comments are made about each of the scenarios considered in this analysis.

Scenario name	Comments
Baseline	There is an increase in the length of network that requires treatment overall, particularly for renewal. As the budget is distributed, the Cat 3A network improves to almost no length requiring treatment while degradation of minor Cat 4A and Cat 4b road is observed.
Baseline Plus	There is no increase in the length of network that requires treatment overall, but the length of network that requires renewal continues to increase. Small increases in the length of Cat 3B and 4A roads requiring maintenance while on other roads the network condition is maintained.
Steady State	In this scenario the condition of all hierarchies of road is maintained.
Steady State Prevent	The length of network that requires treatment is reducing overall but the length requiring renewal treatment is maintained. By hierarchy, the amount of network that requires maintenance is reducing across all hierarchies of road.
Steady State Prevent Opt	Overall the length of network that requires treatment and the amount of network that required renewal is being maintained. By hierarchy, the amount of network that requires maintenance is maintained across all hierarchies of road.
Do Minimum	The amount of the network that requires treatment grows rapidly to more than 50% after ten years.

Table 2: Financial estimates from life cycle planning scenarios

	Budget Requirement	Change from current budget	Average additional cost per annum
1. Baseline	£1,391,000	-	-
2. Baseline Plus	£1,391,000	-	-
3. Steady State	£1,656,000	19%	£265,000
4. Steady State Prevent	£1,656,000	19%	£265,000
5. Steady State Prevent & Opt	£1,620,000	16%	£223,000
6. Do Minimum	-	-100%	-

10 Discussion

1. The ‘Baseline’ scenario is a model which reflects as closely as possible the balance of recent investment in the highway network and outline funding for 2019. Of particular note in this scenario is the bias of budget to the Category 3A and 3B roads which results in a rapid improvement in their forecast condition while the condition of the minor road network is forecast to degrade. The length of minor network forms 75% of the whole network and is therefore significant. As a result, after ten years, this scenario does not preserve the condition of the network as a whole.
2. The ‘Baseline Plus’ scenario was formed based on the budget used in the ‘Baseline’ scenario but with a more balanced budget; the ‘Baseline Plus’ scenario assigns 71% of the total budget to minor roads whereas the ‘Baseline’ budget assigns just 48%of the budget to these roads. In the ‘Baseline Plus’ scenario it has been possible to forecast that the amount of network requiring some form of treatment is maintained over ten years with the current budget levels, accepting that within this quantity of roads that require treatment, a greater amount of road will require a more significant renewal treatment after 10 years.
3. A ‘Steady-State’ scenario has been formed to investigate the level of funding which may be needed to achieve this forecast condition. It is calculated that the overall capital budget would need to be increased by 19% to achieve this (as shown in Table 2). In this scenario the amount of network requiring a renewal or a surface treatment is the same after 10 years.
4. The ‘Steady State Prevent’ scenario was formed to investigate possible benefits that could be achieved by adjusting the balance of expenditure in the ‘Steady State’ scenario to favour more preventative surface improvement activities. The scenario shows that overall length of network requiring maintenance could be significantly improved without significantly affecting the amount of network that is forecast to require a renewal treatment.
5. A final scenario followed the ‘Steady State Prevent & Optimise’ analysis which looked to reduce the overall expenditure to a point where the overall length of network requiring maintenance is maintained at current levels; labelled ‘Steady State Prevent & Opt’. The overall level of funding needed to achieve this scenario was forecast to be an increase of 16% on current levels.

6. A ‘Do Minimum’ scenario has been included to explore the effect of removing planned investment altogether. As expected, this shows a rapid decline in the condition of the network with more than half of the network requiring treatment after 10 years.

Excluding the ‘Do Minimum’ Scenario, none of the investment scenarios forecast a doomsday situation where network condition rapidly deteriorates. Rather, the condition in the long-term is forecast to change in a moderate fashion.

11 Summary

- The current proposed levels of funding have been calculated to be insufficient to maintain the condition of the network in the long-term.
- An adjustment of strategy to a more preventative approach to maintenance could bring some benefits. However, this adjustment alone does not appear sufficient to maintain the overall condition of the network with the current level of funding.
- Additional funding requirements have been calculated in order to maintain the condition of the network.

12 Recommendations

The following recommendations are made:

- The Council should consider the calculated impacts on the condition of the carriageway asset in the long-term at the current levels of funding.
- The Council should consider whether additional funding can be made available to preserve the condition of the carriageway asset in the long-term.

ANNEX A: Life cycle charts for all roads for each scenario

Figure A1 - Baseline Scenario

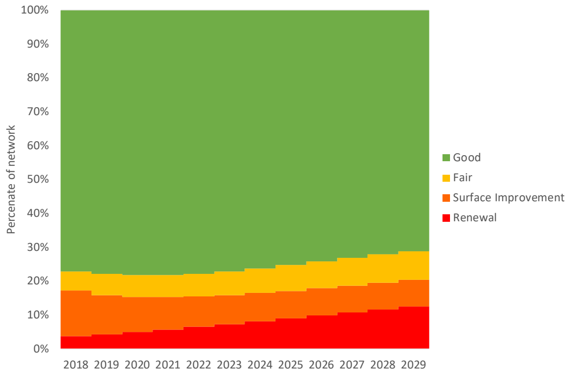

Figure A1a: Forecast condition for all roads

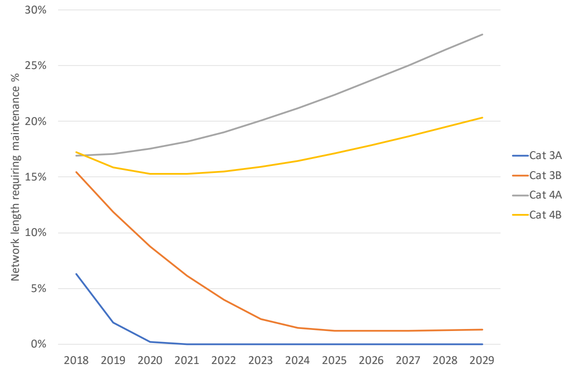

Figure A1b: Forecast length requiring maintenance by hierarchy

Figure A2 – Baseline Plus Scenario

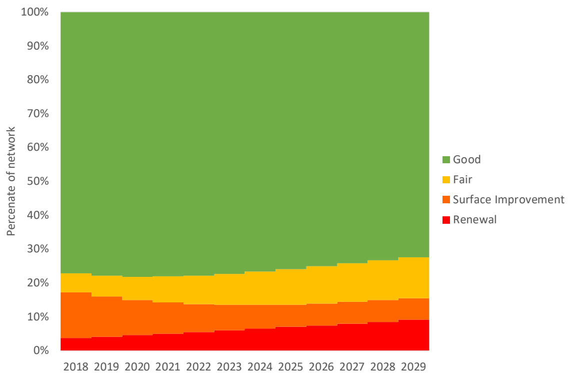

Figure A2a: Forecast condition for all roads

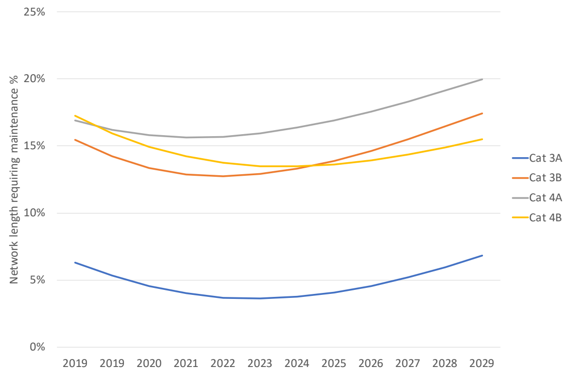

Figure A2b: Forecast length requiring maintenance by hierarchy

Figure A3 – Steady State Scenario

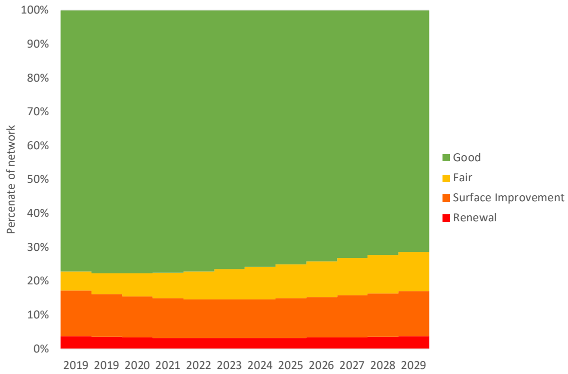

Figure A3a: Forecast condition for all roads

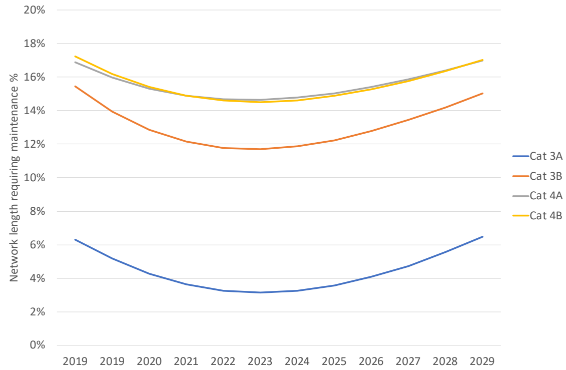

Figure A3b: Forecast length requiring maintenance by hierarchy

Figure A4 - Steady State with Preventative Bias Scenario

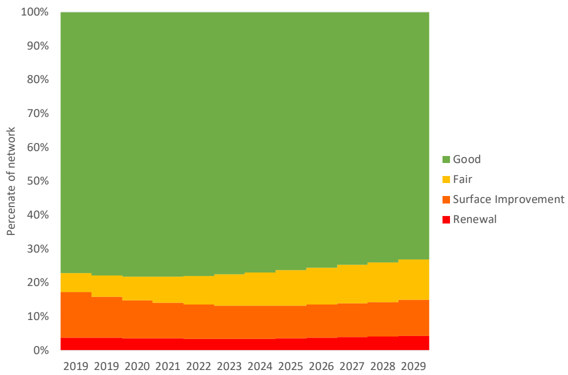

Figure A4a: Forecast condition for all roads

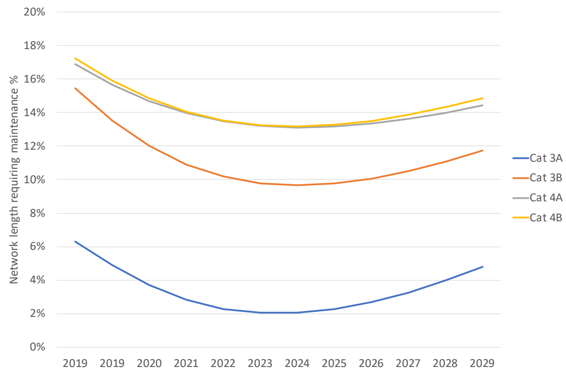

Figure A4b: Forecast length requiring maintenance by hierarchy

Figure A5: Steady State Optimum Scenario

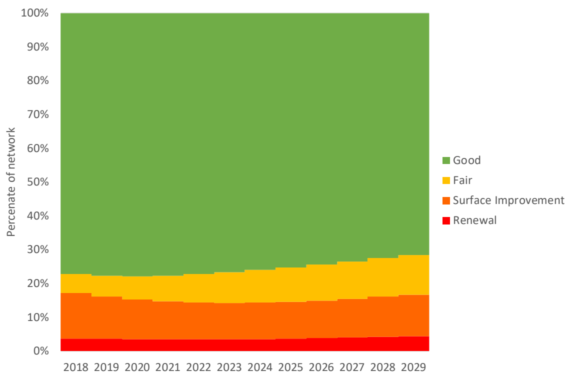

Figure A5a: Forecast condition for all roads

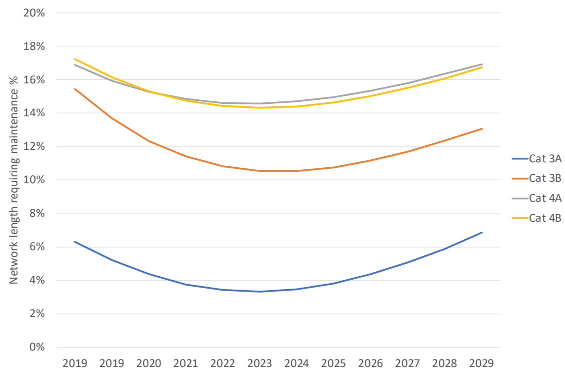

Figure A5b: Forecast length requiring maintenance by hierarchy

Figure A6: Do Minimum Scenario

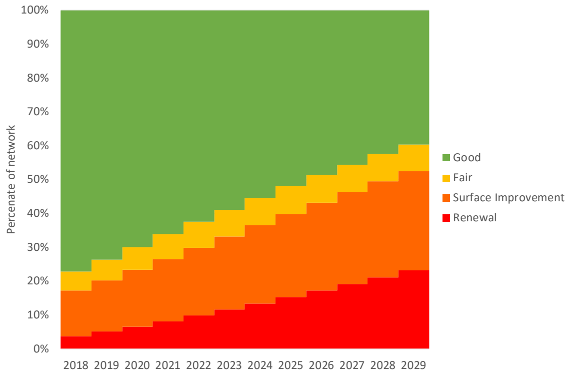

Figure A6a: Forecast condition for all roads

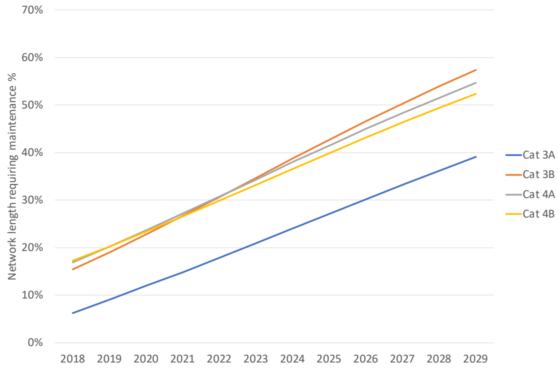

Figure A6b: Forecast length requiring maintenance by hierarchy

Footway Life Cycle Planning

1 Introduction

Footways are an essential component of highway infrastructure which help all road users to safely use the highway. While it is clear that footways facilitate travel by vulnerable road users, they are also used by almost all road users at the beginning and end of their journeys. Most commonly, footways are surfaced with a bituminous material but in high value areas, a range of surface types can be used including stone setts and modular paviours; concrete footways are sometimes used.

This life cycle plan has been produced to:

- Determine the performance that will be achieved for the expected level of funding and/or future investment.
- Determine the level of investment needed to achieve the required performance.
- Predict future performance of footway assets using different maintenance strategies.

The life cycle plan supports the asset management strategy by:

- Assisting the authority to understand the risks that are present in the medium term to inform decision making.
- Presenting a robust calculation of the requirements for maintaining the current condition (steady state).
- Enabling whole life costs to be incorporated into long-term financial planning through a life cycle modelling.

2 Approach to life cycle analysis

A range of life cycle modelling approaches are available to undertake life cycle analysis of footways ranging from simple steady-state estimates based around assumed life spans for treatments to very detailed approaches where the behaviour of individual assets is assessed.

For this analysis, the HMEP footway life cycle planning toolkit has been used. The HMEP toolkit uses Markov-chain theory to predict the probability of footway asset being in a certain condition. The model relies upon transition matrices which define the probability of change from one condition state to another for each time period. The toolkit allows the constraint of treatments by budget and by target condition. It is possible to specify treatments and define a maintenance strategy for these treatments using this toolkit. The toolkit provides a prediction of the performance of groups of assets e.g. Cat 2 footways and presents the treatments done and the calculated expenditure.

Transition matrices are the core element of the toolkit. Although default transition matrices are provided, local transition matrices have been formed to model Rutland County Council's footways.

3 Asset inventory and initial condition

The footway hierarchy has been used to define groups of assets. The inventory for the model was obtained from the County Council's Confirm system.

Category		Length (m)
Cat 1	Primary Walking Route	10,318
Cat 2	Secondary Walking Route	11,030
Cat 3	Link Footways	26,059
Cat 4	Local Access Footways	278,847

Footways in the county are almost all formed using a bituminous surface; therefore, this lifecycle analysis has not differentiated the surface type, as it is unlikely to have a significant effect on the output.

Condition information was taken from a legacy set of Footway Network Surveys from 2013 and 2014; in the absence of more recent condition information, the condition of footways was assumed to have remained unchanged. The County Council is implementing a system to collect information on the condition of footways whilst undertaking highway safety inspections and it will review this lifecycle plan once sufficient data has been collected.

4 Treatment types and rates

Treatment costs have been supplied by the Council. The treatments rates are defined per unit area. Slurry sealing was assumed to be approximately the same rate a surface dressing for this analysis.

Table 1: Treatment rates and effects

Treatment	Unit Rate
Slurry sealing	£4 per m^2
Patching	£30 per m^2
Resurfacing	£25 per m^2

5 Treatment strategies

A treatment strategy allows the specification of the maximum percentage of the asset in a particular condition state which is treated in any one period. A simple setting would be to allow all the assets in a single state to be treated (e.g. 100%), in this case no lengths in any other states would be treated. This does not adequately reflect reality in which a footway will exist in a range of condition states along its length and hence a treatment will affect many states. The treatment strategy has been defined to reflect this behaviour by spreading expenditure across multiple condition classes.

Surface Improvement is typically slurry sealing supported by patching. Renewal is typically resurfacing but can also be more extensive areas of patching.

6 Budgets

The baseline budget has been set for each treatment type based on outline capital budgets in recent years. The proportion of the budget has been allocated across each asset group on the basis of surface area.

7 Scenarios

A range of scenarios have been considered in the life cycle analysis.

Scenario Name	Description
Baseline	Budgets at current levels, allocated to hierarchy and treatments according to current proportions.
Steady State	The distribution of condition is maintained over 10 years.
Steady State Prevent	The Steady State budget which is biased towards preventative treatments to reduce the amount of network requiring treatment.
Steady State Prevent Opt	The Steady State budget which is biased towards preventative treatments and trimmed such that the overall amount of network requiring treatment is maintained at current levels.

8 Results

Figure 1 presents the output of the life cycle modelling scenarios. Figure 2 provides an indication of the funding requirements for each scenario assessed.

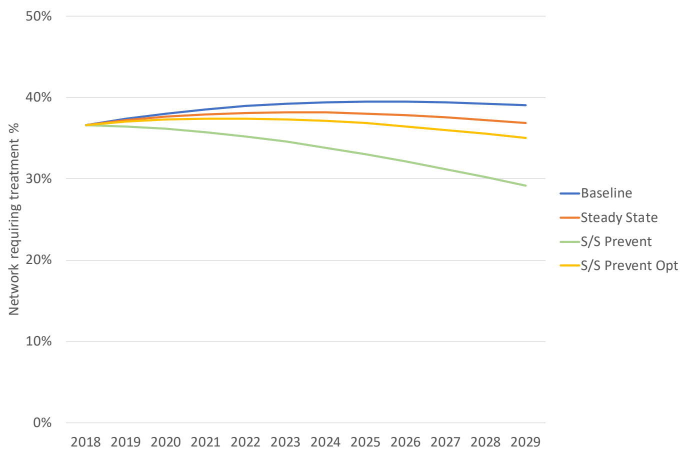

Figure 1: Impact of options on network requiring treatment

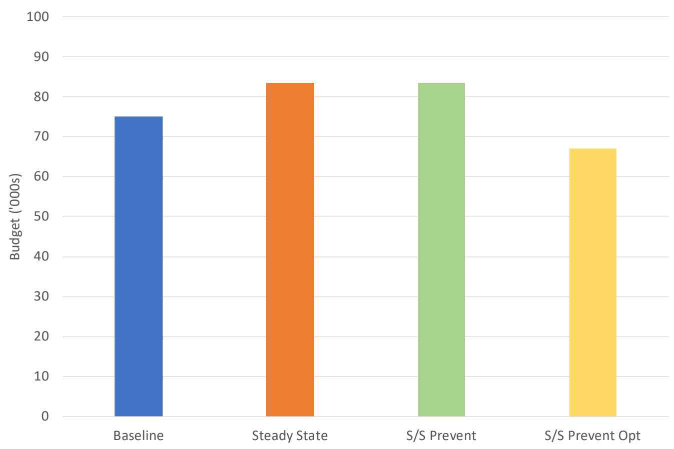

Figure 2: The annual budget requirements for each scenario

The following comments are made about each of the scenarios considered in this analysis.

Scenario name	Comments
Baseline	Overall there is a small increase in the length of the footways that require treatment.
Steady State	In this scenario the condition of all hierarchies of footway is maintained over 10 years.
Steady State Prevent	The amount of footway that requires maintenance is reducing across all hierarchies of footway.
Steady State Prevent & Opt	The length of footway that requires treatment is being maintained at a lower cost than the Steady State option.

Table 2: Financial estimates from life cycle planning scenarios

	Average annual budget	Change from steady-state budget	Average additional cost per annum
As Is	£75,000		
Steady State	£83,500	11%	£8.500
Steady State Prevent	£83,500	11%	£8,500
Steady State Prevent & Opt	£67,000	-11%	-£8,000

9 Discussion

The overall changes in condition due to the different scenarios assessed are relatively small.

The current baseline scenario does not retain the initial condition and the analysis suggests that there is a slow decline in condition of the footway network over 10 years.

Based on the initial allocation of the budget, a steady state forecast was achieved by increasing the budget by 11%. This forecast was improved further by using a more preventative maintenance strategy; in this scenario the amount of network that required maintenance was reduced by almost a quarter after 10 years.

A further ‘Steady State Prevent & Opt‘ scenario used the benefit created by the bias towards a preventative maintenance strategy to reduce the budget to a point where a steady state condition was again reached. In this scenario, a budget that was 11% lower than the baseline was forecast to be sufficient to maintain a steady-state.

10 Summary

- The baseline level of funding has been calculated to be insufficient to maintain footway condition in the long-term albeit there is a small amount of deterioration.
- An adjustment of strategy to a more preventative approach to maintenance could bring some benefits, either as improved condition or facilitating budgets to be reduced.

11 Recommendations

The following recommendations are made:

- The Council should consider the calculated impacts on the condition of the footway asset in the long-term.
- The Council should consider whether the strategy for the maintenance of footways could be adjusted to realise further benefits in the long-term.

ANNEX A: Life cycle charts for all roads for each scenario

Figure A1 - Baseline Scenario

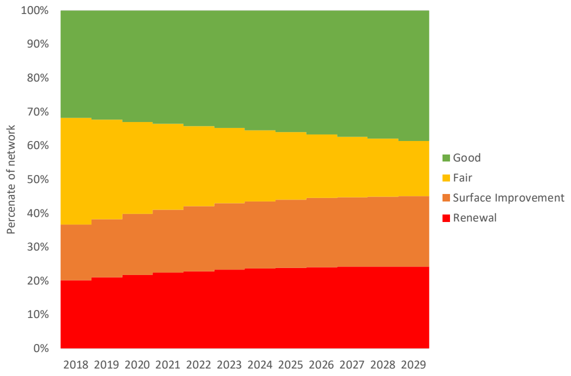

Figure A1a: Forecast condition

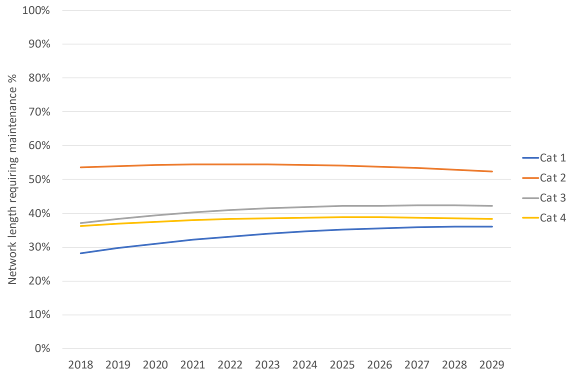

Figure A1b: Forecast length requiring maintenance by hierarchy

Figure A2 – Steady State option

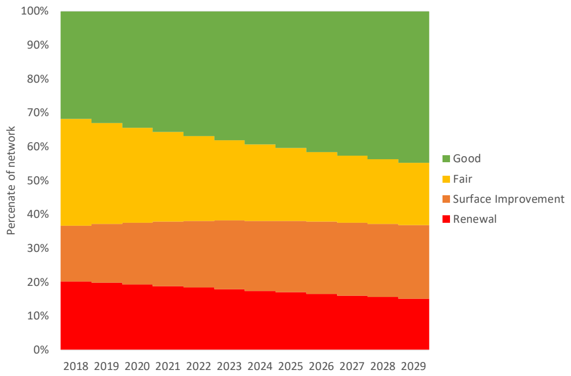

Figure A2a: Forecast condition for all footpaths

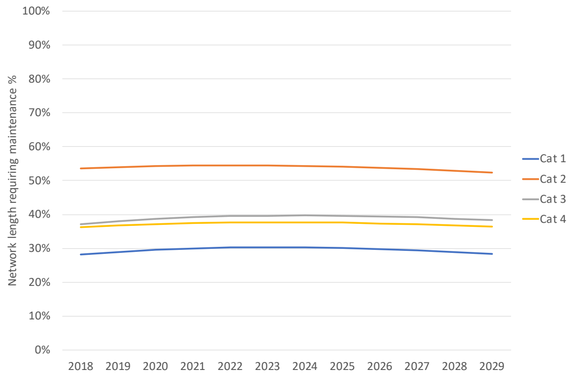

Figure A2b: Forecast length requiring maintenance by hierarchy

Figure A3 – Steady State with Preventative Bias option

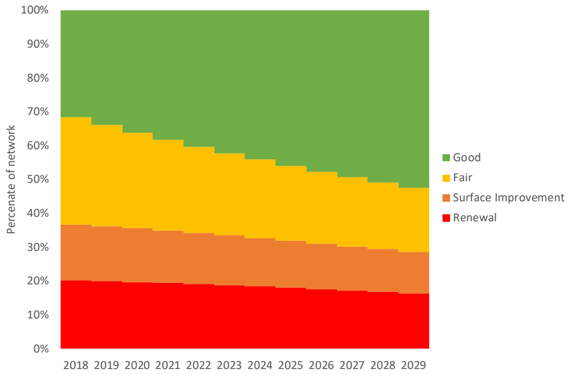

Figure A3a: Forecast condition for all footpaths

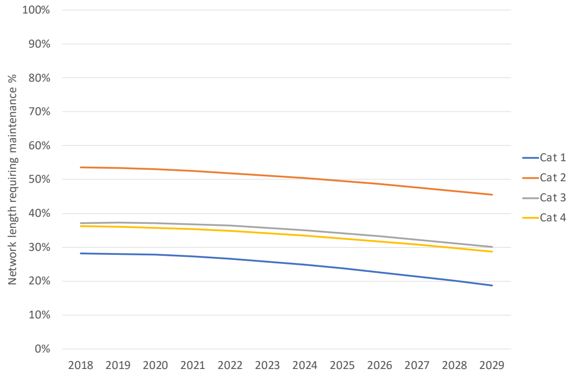

Figure A3b: Forecast length requiring maintenance by hierarchy

Figure A4 - Steady State Prevent & Optimised Option

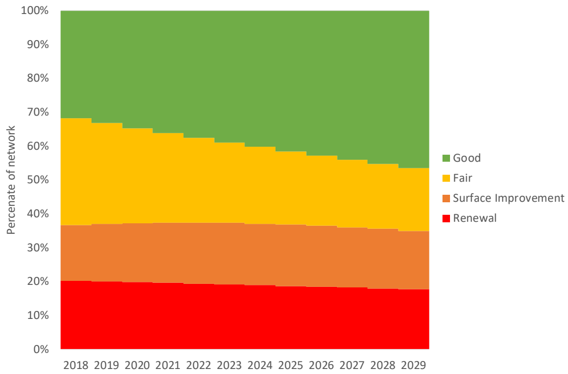

Figure A4a: Forecast condition for all footpaths

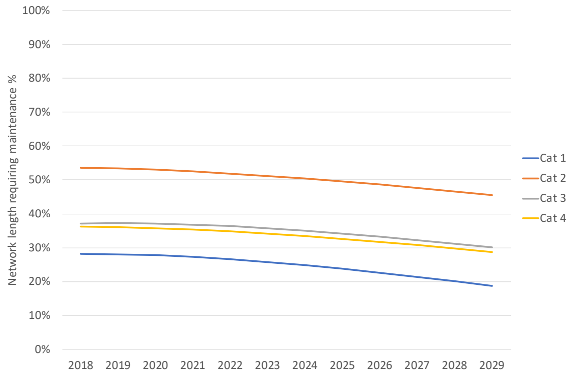

Figure A4b: Forecast length requiring maintenance by hierarchy