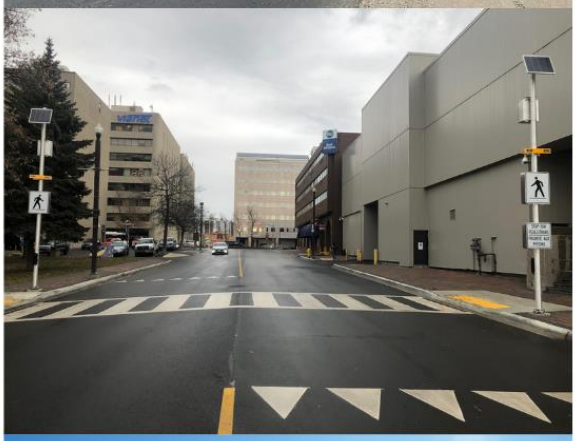
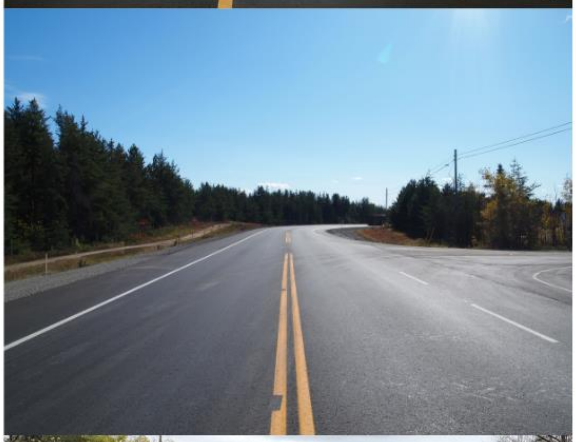
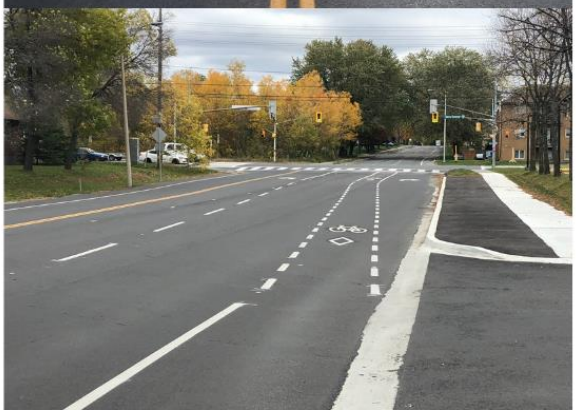






Greater | Grand Sudbury

ROADS AND TRANSPORTATION ASSET MANAGEMENT PLAN

2021

JULY

Contents

1 Executive Summary

1.1 Introduction

Asset Management is the systematic coordination of activities and practices of an organization to optimally and sustainably deliver on its service objectives through the cost-effective lifecycle management of assets.

The Roads and Transportation Asset Management Plan (RTAMP) describes asset planning work which will be completed in two parts. This document presents Part 1 of the work associated with Phase 1 of the Enterprise Asset Management Plan. This includes identification of the current state of the infrastructure, levels of service, review of expenditures and funding. Also included are discussions regarding risk, future demand, the Community Energy and Emissions Plan, Climate Change and identification of next steps and improvement opportunities.

Section 9.1 Next Steps will identify work to be completed during Part 2 of the work associated with Phase 3 of the Enterprise Asset Management Plan. This will include a review of proposed options for various levels of services with associated costs and risks, valuation and continued review of asset condition performance projections. Part 2 work will also include a review of long term financial strategy options in conjunction with sustainability, future network demands, impacts of climate change, recommendations for continued data collection for all road assets and continuous improvements to integration of Operational and Capital Programs.

The City of Greater Sudbury is unique due to its large area and relatively high number of road lane kilometres per capita. The City's northern location also differentiates this community from others due to factors such as higher construction costs, harsher climate and the reliance on the industrial base that affect service level alternatives.

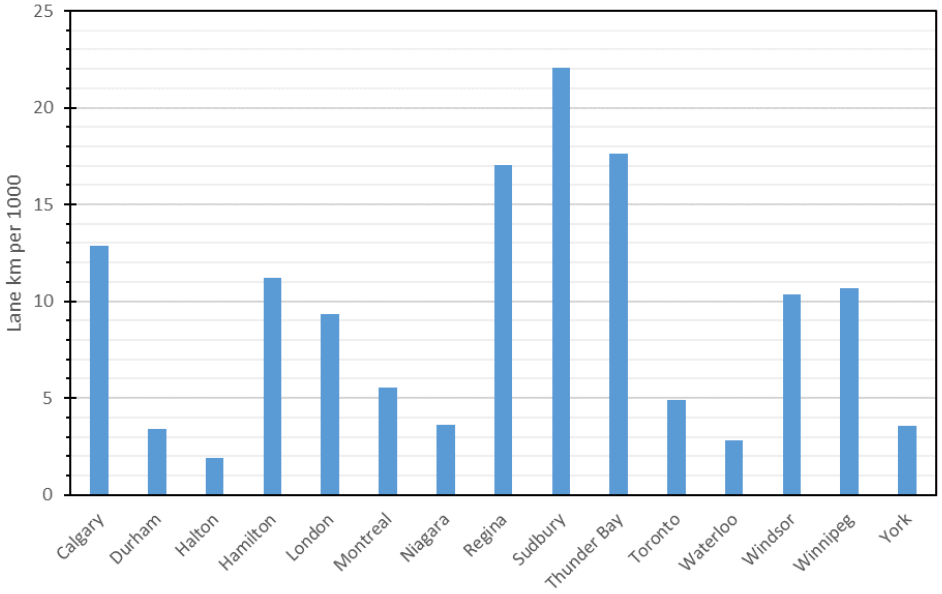


Figure 1.1 - Municipality Comparison of Road Length versus Population

Funding of road asset capital improvements for roads projects has significantly increased over the last five year period. Average road investment from 2016-2020 for all road capital projects increased by approximately 30% over the previous five year period. In 2019, the budget process was transformed from an envelope system where previously defined funding levels were distributed to the various operating departments to an enterprise prioritization system which ensures funds are distributed to projects on a city wide priority basis. In addition to the prioritization process, Council provided an additional investment in roads infrastructure of approximately $4 million in 2019.

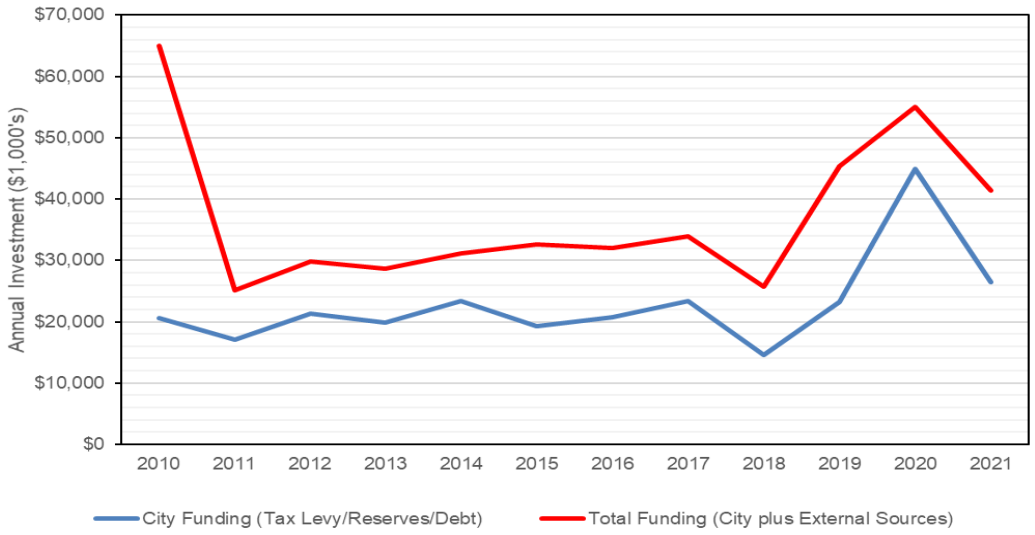


Figure 1.2 Historical Funding - Roads

Council has encouraged the use of new technologies and materials to explore methods for reduction of infrastructure maintenance costs and economic extension of expected asset life. These include:

- Review of capital construction and operational activities for opportunities to employ asphalt recycling treatments;
- Hot In-place Recycled Asphalt Pilot Study; and
- Pothole Patching Study Initiative

The Stormwater Asset Management Plan has been finalized and Council will be reviewing alternatives for implementation of recommendations resulting from the plan. Investment in City drainage assets associated with roads will improve road drainage and extend the life of the road network structure.

Enhancements to coordination of road improvement projects with the improvement of other assets such as water and wastewater infrastructure have been made in recent years to better align the preferred road structure treatments with underground infrastructure work.

The City remains committed to continuous improvement in review of existing internal and external processes, emerging technologies and alternative construction standards to enhance work activity efficiencies and provide efficient capital program recommendations.

1.2 Current State of the Infrastructure

This plan is prepared for the roads and transportation assets owned and operated by the City of Greater Sudbury. Assets reviewed in this plan include road asphalt and granular structure, curbs, sidewalks, cycling infrastructure, street light poles and street light fixtures. Other assets to be reviewed for future inclusion in this document include signs, guide rails, rock cuts, traffic signals, street trees, and retaining walls.

Paved and gravel road condition summaries are indicated in Figure 1.3 and Figure 1.4 below. Paved road conditions are based on evaluation using *ASTM D6433 – Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys*. Gravel road conditions were established using methods based on the Ministry of Transportation document "SP-025 Manual for Condition Rating of Gravel Surface Roads."

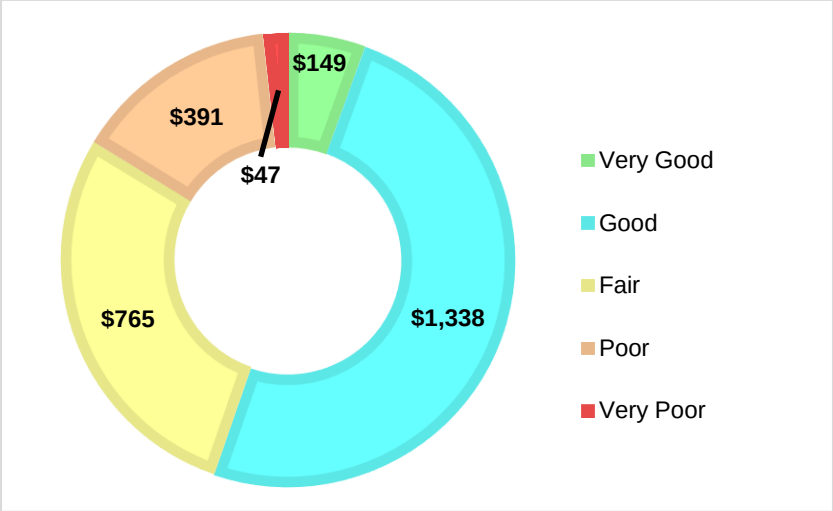


Figure 1.3 - Condition and Replacement Cost of Paved Roads (millions)

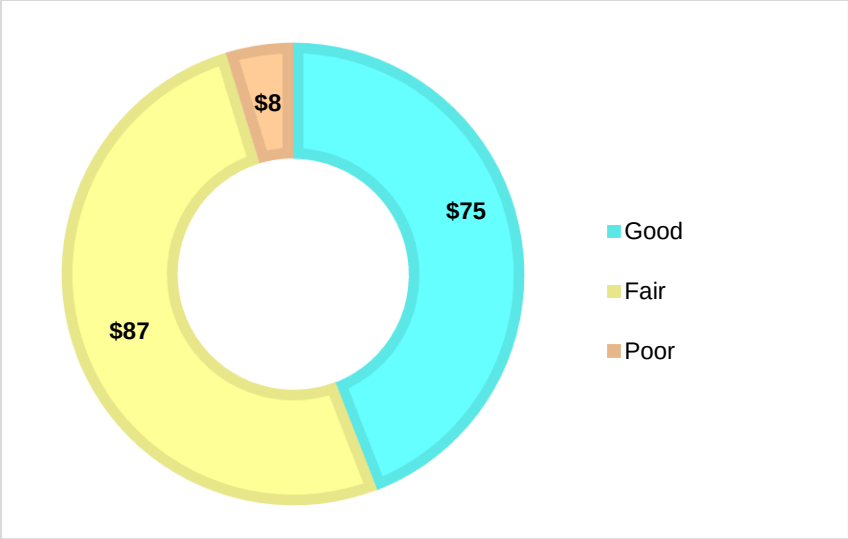


Figure 1.4 - Condition and Replacement Cost of Gravel Roads (millions)

Figure 1.5 indicates the replacement value of the assets included in Part 1 of this report. This cost estimate does not include traffic signals, signs, rock cuts, guide rails, street trees and retaining walls that may be deemed appropriate for inclusion into future versions of the RTAMP. The total replacement cost of these assets is approximately $3 billion.

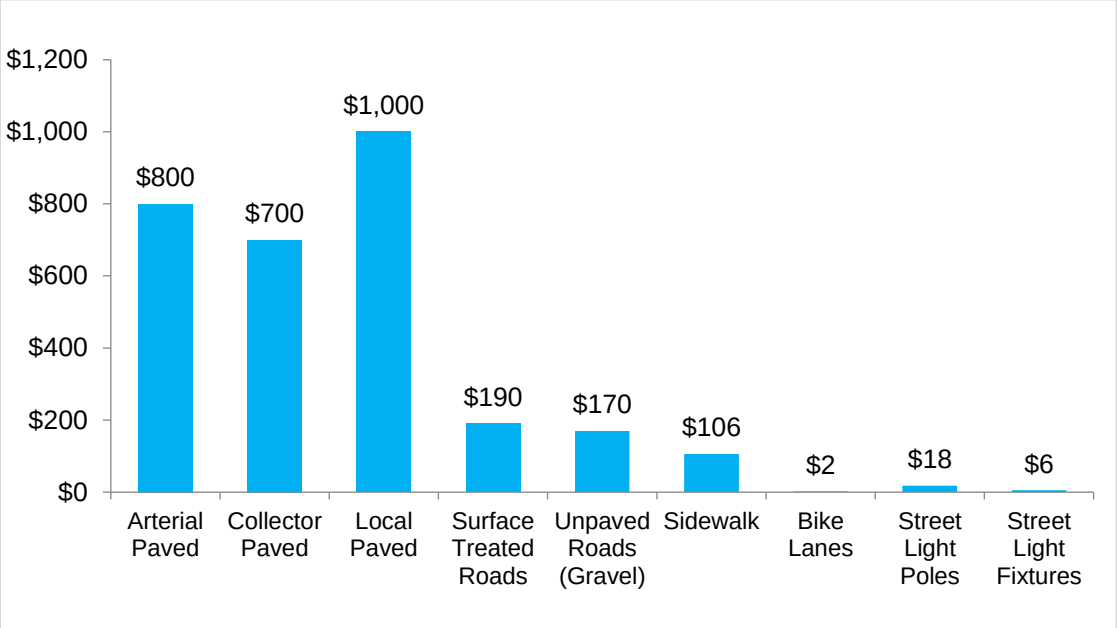


Figure 1.5: Road Network Replacement Value (Millions)

1.3 Level of Service

The levels of service discussion in this document outlines current service levels at current funding levels. Part 2 of the Asset Management Plan will review a variety of alternatives for Council to consider to achieve an acceptable level of service at an acceptable cost. These future alternatives will be evaluated considering various levels of acceptable condition, risk and financial alternatives.

The future review will provide insight of establishing the criticality of assets and on the long-term financial sustainability of the various options and impacts of accelerating or deferring projects.

The work required to prepare the level of service framework has included consultation with staff, review of current activities, review of financial data and upgrades to the pavement management system. The level of services indicated below are considered to be a starting point for preparation of target levels of service and will be subject to further review, revision and addition through the Part 2 work and evolution of this plan.

1.3.1 Community Level of Service

Community levels of service are high level statements which indicate what the City currently strives to achieve. The actual service levels achieved on individual road segments will vary depending on a variety of factors including road class, traffic levels and type, road maintenance levels, road structure, accessibility and employment activities. The level of services will be further reviewed in Part 2 to prepare alternatives for target levels of service and definition of service levels the community can expect on different types of roads.

- Roads are safe, accessible, and have sufficient capacity.
- Roads are in a fair state of repair and maintained at an acceptable cost.
- Roads are capable of supporting essential services and multimodal transportation.
- Roads are constructed and maintained in an environmentally responsible manner.

1.3.2 Strategic Level of Service

The strategic levels of service indicated below support the community levels of service.

Roads are maintained in accordance with *Ontario Regulation 239/02 Minimum Maintenance Standards for Municipal Highways* (minimum maintenance standards), as amended and with approved City policies. These strategic level of service activities include:

- Class 1 to 3 roads are to be plowed within 8 hours (after end of storm)
- Class 4 to 6 roads are to be plowed within 24 hours (after end of storm)
- 80% of all sidewalks to be cleared of snow within 24 hours (after end of storm)
- 100% potholes are repaired in accordance with minimum maintenance standards
- Nine weeks to remove winter sand
- Road line painting and markings are completed one time per year
- 5% of regulatory signs are replaced annually
- 3% of road crossing culverts are replaced annually
- 2.5% of curb and sidewalk are replaced annually
- 500 aged trees are removed annually
- Average network road pavement condition is currently subject to gradual deterioration of approximately one (1) pavement condition index point annually. At the current funding level, the road network will maintain an average condition of “fair” over the next 10 years.

- Road maintenance classes which range from Class 1 (arterial) to Class 6 (local) are subject to different levels of road maintenance and capital repair service levels. Class 1 to 5 roads are reviewed annually for resurfacing or rehabilitation.
- Roads with condition scores of Poor and Very Poor are reconstructed or rehabilitated when work aligns with strategic priorities such as the Transportation Master Plan and Industrial Lands Strategy or when work can be coordinated with other asset priorities such as watermain or sewer replacement.
- Surface treated roads and gravel roads are maintained and repaired through maintenance activities.

1.3.3 Asset Level of Service – Key Performance Indicators (KPI)

The key performance indicators currently included in the asset levels of service are indicated below. During Part 2 of this study, other asset levels of service will be reviewed for inclusion into this category and may include items relating to work backlog, congestion, access and safety.

- Pavement Condition Index
- Gravel Condition Index
- International Roughness Index (IRI)
- Road summer maintenance cost per lane km
- Percentage of roads in Fair or better condition based on asset replacement value
- Percentage of total annual road investment based on asset replacement value

1.3.3.1 Pavement Condition Index (PCI)

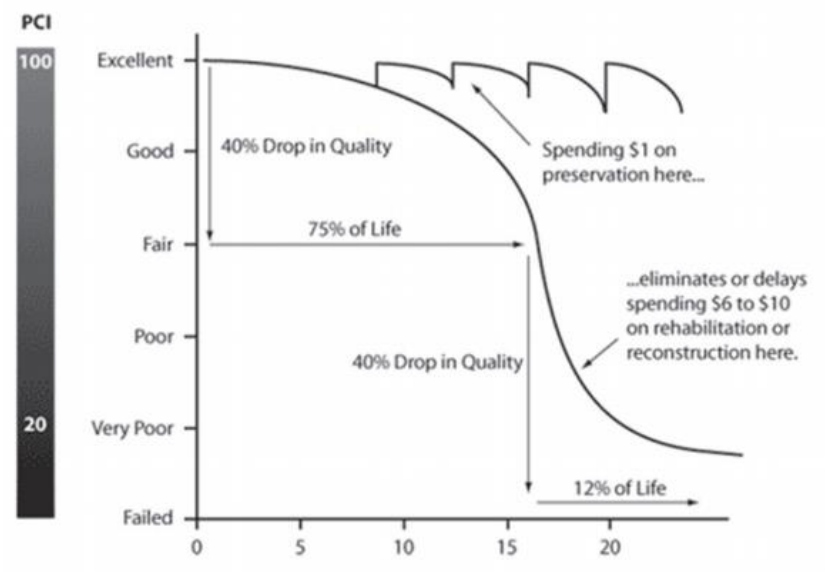
The development of a level of service for pavement condition will be an important component of Part 2 of the plan. Average Pavement Condition Indexes measured in 2016 and 2019 are indicated in Table 1.1. Proposals for PCI levels were identified in the July 2012 report entitled *Financial Planning for Municipal Roads, Structures and Related Infrastructure Final Report*, prepared by KPMG (2012 KPMG Report) for the purposes of the financial analysis. These recommendations included aiming to maintain an average PCI of 70 for arterial/collector roads and an average PCI of 60 for local roads. Alternative PCI service levels will be explored and presented to Council for their discussion and consideration in the next part of the plan.

Table 1.1 - City of Greater Sudbury PCI by Road Class (2019)

Road Classification	Average PCI (2016)	Average PCI (2019)	Average Condition
Arterial	58	57	Good
Collector	49	48	Fair
Local	50	47	Fair
Network Average	52	49	Fair

In order to establish the optimal future PCI service level, an analysis of conditions that will provide the maximum benefit for the road network with proposed funding will be reviewed during Part 2 of this study. This includes an analysis of the required treatments or optimum interventions proposed throughout the lifecycle of the road, costs of proposed treatments and risk evaluation.

When a road asset is permitted to deteriorate beyond a condition where rehabilitation cannot be selected as an effective treatment strategy, the asset becomes more expensive to maintain than the asset that has received recommended treatments at the recommended timing. The result of not completing recommended treatments at the right time is the asset network becomes more costly to maintain year after year. This is demonstrated in Figure 1.6, illustrating a typical pavement deterioration curve.



Road Projects: Paved road resurfacing or rehabilitation treatments are selected for roads fair and better.

Road and Pipes Projects: Paved road reconstruction are selected when pipework required for roads poor and very poor.

Figure 1.6 - Pavement Deterioration Curve

From Bouali, El Hachemi Y., "ANALYZING THE LIFE-CYCLE OF UNSTABLE SLOPES USING APPLIED REMOTE SENSING WITHIN AN ASSET MANAGEMENT FRAMEWORK", Open Access Dissertation, Michigan Technological University, 2018. https://digitalcommons.mtu.edu/etdr/649

Under the current municipal investment funding levels, reconstruction is not a recommended treatment unless there are other factors contributing to project rationale such as coordination with recommended water and wastewater improvements. The replacement cost of paved roads currently in Poor and Very Poor condition is estimated to be $438 million. This replacement cost can be considered to be an immediate need of recommended work on Poor and Very Poor roads. Other recommended annual maintenance and rehabilitation work costs on the remaining roads such as crack sealing, spreader laid patches, mill and pave, pulverize and replacement of asphalt structure would be in addition to the reconstruction treatments.

Figure 1.7 represents the life cycle costs of a typical two lane local urban road using recommended treatments at regular intervals for the purposes of estimating total costs of recommended maintenance and rehabilitation treatments over the assumed 60 year life cycle of the road. These life cycle activities and costs are presented solely to demonstrate an order of magnitude and will vary with existing conditions based on road class and type, road width, traffic, and existing conditions.

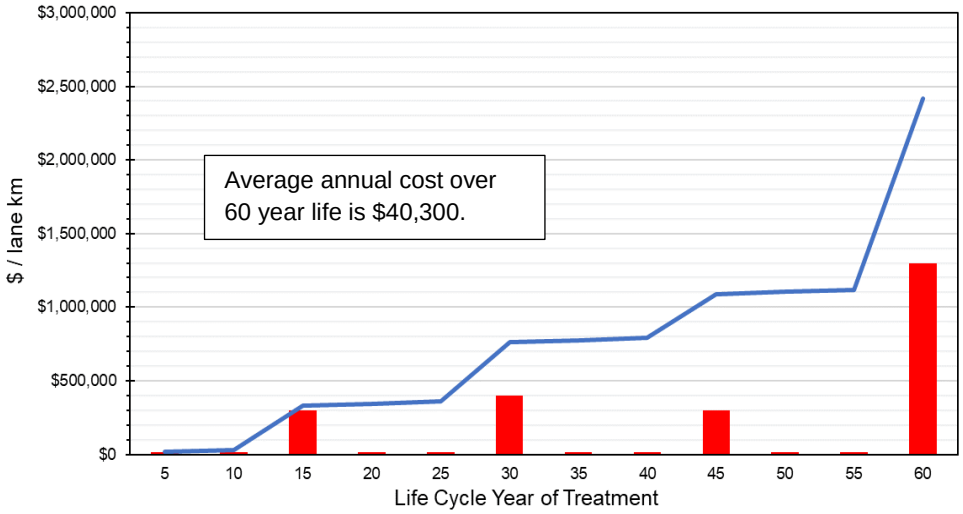


Figure 1.7 - Lifecycle Costs for Two Lane Hot Mix Paved Urban Road (60 Year Life Cycle)

Figures 1.8 and 1.9 demonstrate the anticipated PCI for the two road groups used to prepare road capital construction programs at various levels of funding, including the annual average investment over the previous five years of $26 million for arterial/collector roads and $9 million for local roads.

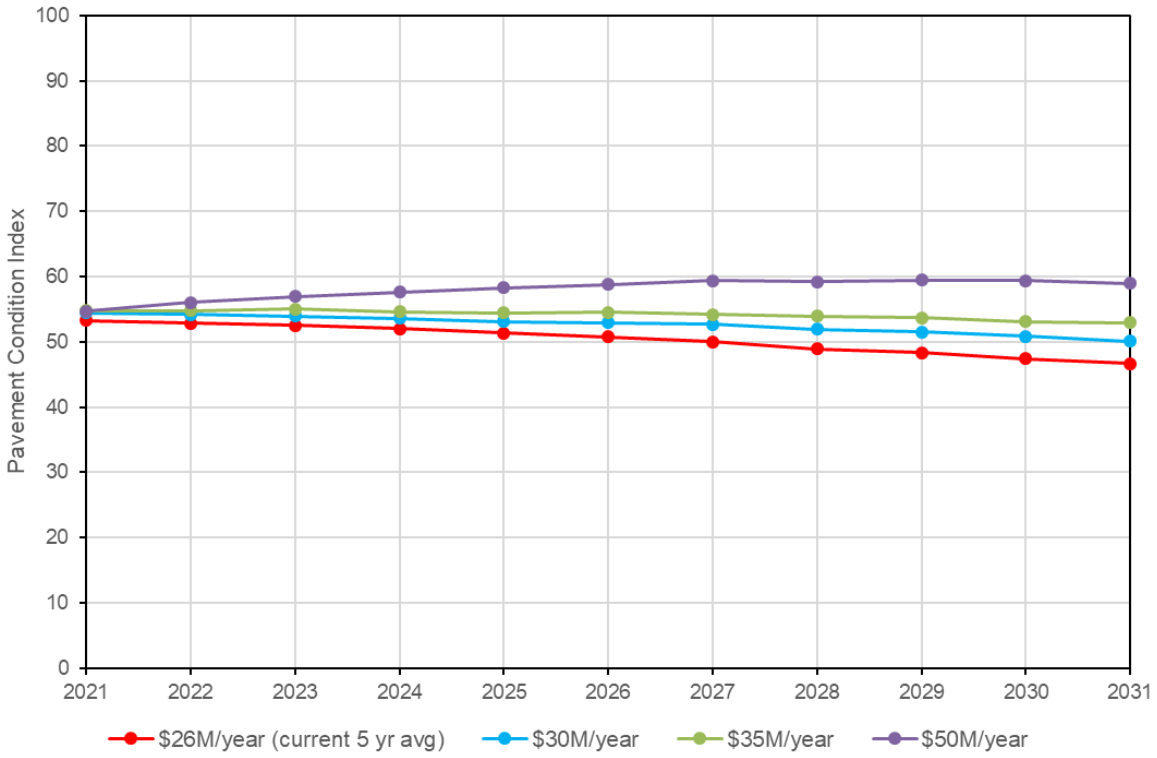


Figure 1.8 – Arterial/Collector Roads: Projected PCI at Various Annual Investment Levels

There are four levels of funding for Arterial/Collector roads illustrated in Figure 1.8. These include annual funding of $26 million, $30 million, $35 million and $50 million. The average annual investment in arterial/collector road capital projects over the last five years is approximately $26 million. At this funding level, the pavement management system anticipates the PCI will continue to decrease from an average of 53 or Good (as measured in 2019) over the next 10 years to a PCI of approximately 47 or Fair.

The road network was analyzed with annual funding of $30 and $35 million to demonstrate how the PCI could be improved with an additional $4 or $9 million increase in annual funding. The $50 million annual investment option was analyzed to demonstrate the funding necessary to maintain the PCI at an approximately steady level, with a slight increase over the next 10 years.

Further financial forecasting work is required to prepare detailed options and associated risks to inform decisions regarding future arterial/collector road conditions and associated service levels.

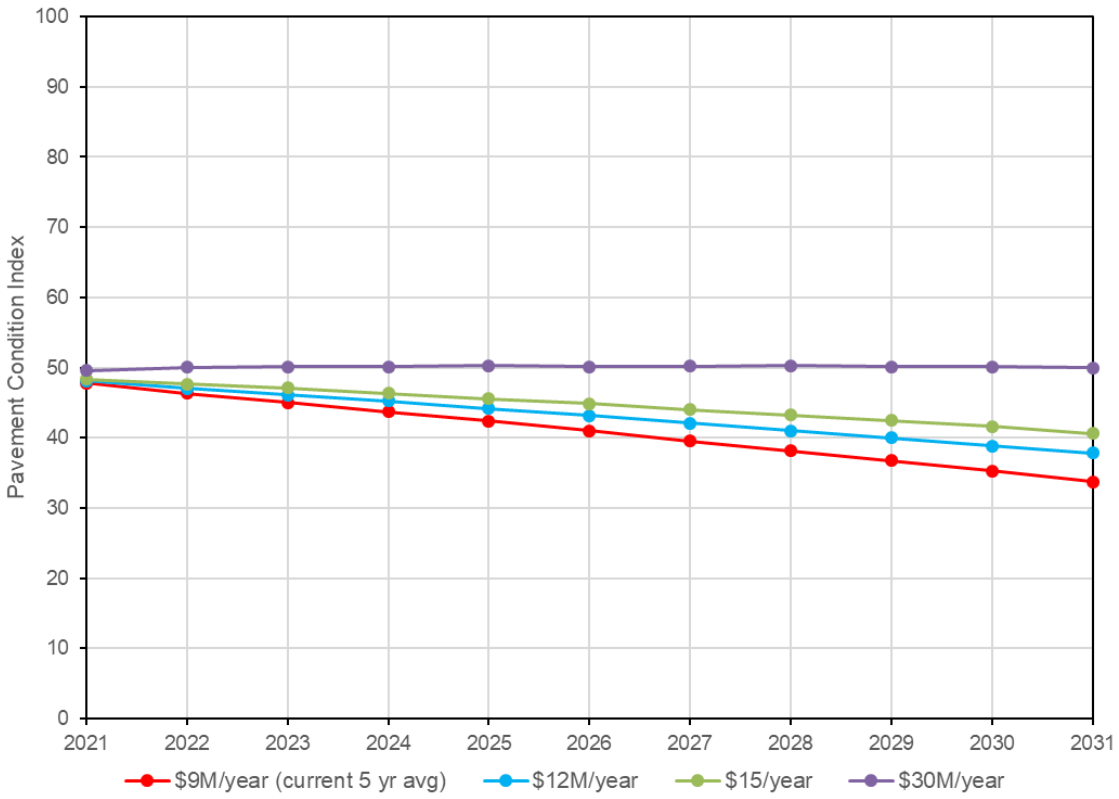


Figure 1.9 - Local Roads: Projected PCI at Various Annual Investment Levels

There are four levels of funding for Local roads illustrated in Figure 1.9. These include annual funding of $9 million, $12 million, $15 million and $30 million. The average annual investment in local road capital projects over the last five years is approximately $9 million. At this funding level, the pavement management system anticipates the PCI will continue to decrease from 47 or Fair (as measured in 2019) over the next 10 years to a PCI of approximately 34 or Poor.

The network was analyzed with annual funding of $12 and $15 million to demonstrate how the PCI could be improved with an additional $3 or $6 million increases in annual funding. The $30 million annual investment option was analyzed to demonstrate the funding necessary to hold the PCI at an approximately steady level over the next 10 years.

Further financial forecasting work is required to prepare detailed options and associated risks to inform decisions regarding future local road conditions and associated service levels.

1.3.3.2 Gravel Condition Index

Similar to paved roads, gravel road conditions will be dependent on the acceptable balance between capital investment and operational funding as determined in consultation with Council. A review of the City's inventory of gravel roads was undertaken in 2020 and results of the review indicate an average condition of Fair. Future work in Part 2 of this plan will include a more detailed

review of gravel road maintenance practices, as well as capital activities and financial requirements.

1.3.3.3 International Roughness Index (IRI):

The International Roughness Index is a roughness measurement developed to standardize roughness data collection and analysis techniques for pavement. An IRI value of 0 m/km indicates absolute smoothness and a value of 10m/km would represent a very rough roadway. IRI is calculated for all paved road segments in the City using the asphalt condition data collected for the pavement management system. Table 1.2 indicates average IRI for each road planning class, as measured in 2019.

Target IRI levels of service for the City are not yet established. Acceptable limits will vary with road classification and operating speed. Two examples of different grading scales have been used in Table 1.2 to illustrate different approaches to assessing IRI scores. The Transportation Association of Canada (TAC) conditions were developed for highways and not necessarily applicable to many municipal roads. Other municipalities have developed their own grading system and are included for information and illustrative purposes. The development of a unique grading system for the City will be undertaken in Part 2 of the plan.

Table 1.2 – International Roughness Index (IRI)

Road Class	IRI m/km (2019)	Condition (TAC - Highway Roads)	Condition (Other Municipality Guidelines)
Arterial	3.4	Poor	Fair
Collector	4.9	Poor	Good
Local	6.0	Poor	Good

1.3.3.4 Roads Summer Maintenance Costs per Lane Km:

Summer road maintenance costs are relatively consistent and can be evaluated from year to year. As a result, this is a useful metric to report as a KPI, with the annual investment level to be determined in consultation with Council. The work included in this metric is a contributing component to the overall road condition of the network for both paved and gravel roads, while also providing year to year costs for these activities.

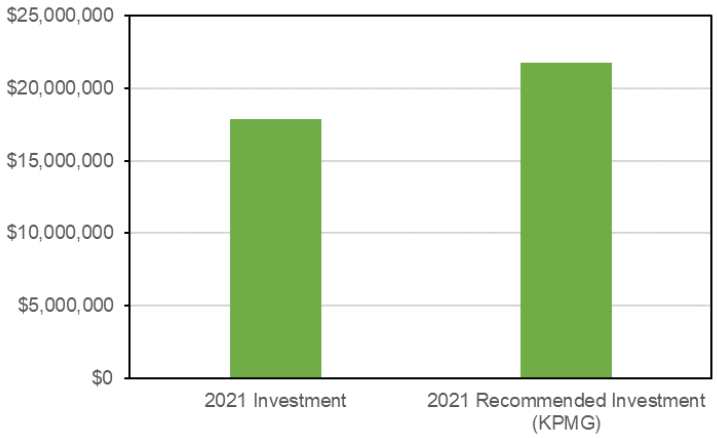


Figure 1.10 - Paved Road Summer Maintenance Investment (Actual)

A review of operational funding for paved and unpaved roads was initiated. Findings to date indicate anticipated funding shortfalls of approximately $3.9 million in paved road summer maintenance activities, based on the zero based budget prepared for the 2012 KPMG Report (Figure 1.10). In 2006, a summer maintenance best practice model was prepared for the City to assist in preparation of operational budgets. Using this model, a funding shortfall of approximately $2.3 million in gravel road maintenance was estimated (Figure 1.11).

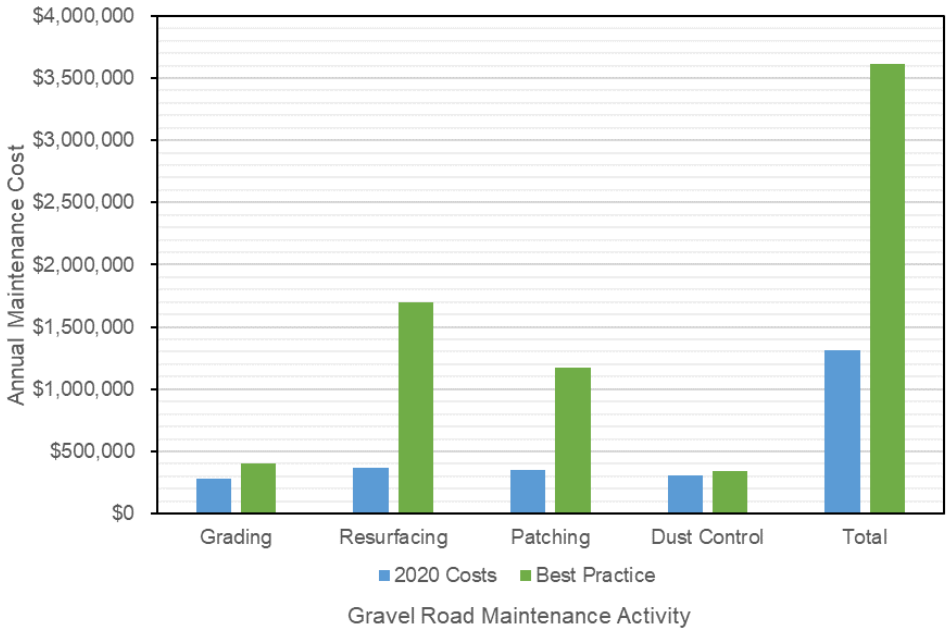


Figure 1.11 - Gravel Road Maintenance Activities 2020 vs Best Practice

1.3.3.5 Percentage of roads in Fair or better condition based on replacement value

The current percentage of roads in Fair or better condition based on 2019 data is 84%. Recommended target percentage levels vary between municipalities from 75% to 90% with

unique municipal requirements based on condition, extent and age of road network. A target level of service for this metric in Greater Sudbury will be established in Part 2 of the plan.

1.3.3.6 Percentage of total annual road investment based on asset replacement value

The current percentage of annual road investment based on the recent five year average is 1.22% of the asset replacement value. Recommended target percentage levels of other municipalities vary from 1.7% to 2.5% with unique requirements based on condition, extent and age of road network. The percentage will also vary with the immediate requirements of the network or backlog of work that does not get prioritized. A target level of service for this metric will be established in Part 2 of the plan.

Funding shortfalls identified within this plan will be the subject of further review. Development of target levels of service as part of Part 2 of the RTAMP will include proposals for future funding levels to accommodate infrastructure need and associated risk.

1.4 Community Energy and Emissions Plan/Climate Change

A primary goal of an asset management plan is to maintain infrastructure in a way that is environmentally resilient and sustainable. This means the level of service will meet the needs of the present community without compromising the needs of the future community. In September 2020, Council authorized staff to proceed with the next steps in the implementation of the Community Energy and Emissions Plan (CEEP). The CEEP identifies 18 goals that need to be met to attain the City's target of becoming a net-zero GHG emission community by 2050.

As part of the work of asset management planning and prioritization, environmental scans of different technologies will be completed and the evaluation will result in recommendations for integration of new technologies into operational and capital programs. Levels of service will be reviewed with a CEEP, climate change and risk assessment lens during Part 2 of the RTAMP preparation.

1.5 Next Steps and Improvement Opportunities

Following completion of Part 1 of the Roads and Transportation Asset Management Plan, the next steps will be to initiate work toward the goals of Part 2, which are listed in detail in Section 9.1 of this plan. Goals for Part 2 include the development of target levels of service options for various KPIs with costs and risks, options for life cycle management and long-term financial strategies, opportunities for use of green technologies and management of risks associated with climate change.

Asset management is a process of continuous improvement to data collection, program planning, financial planning, and asset condition monitoring. When Part 2 of the plan is complete, future success will rely on continuation of work to provide improved methods of developing service level options and asset investment alternatives. Future opportunities are identified in Section 9.2.

2 Introduction

2.1 Roads and Transportation Asset Management Plan (RTAMP)

The Roads and Transportation Asset Management Plan (RTAMP) supports the Enterprise Asset Management Plan (EAMP) which is being developed and implemented in a phased approach to meet the requirements of *O. Reg. 588/17: Asset Management Planning for Municipal Infrastructure.* The Enterprise Asset Management Plan will be completed in three phases. Phase one generally describes current levels of service for core assets (roads, bridges, water, wastewater, stormwater) and the costs associated with maintaining existing levels of services. Phase two of the EAMP applies to municipal assets that do not fall into the core asset category and as such, does not apply to this document. Phase three of the EAMP builds upon phase one as outlined in this report.

The RTAMP supports the achievement of goals under five of the pillars of the City of Greater Sudbury Strategic Plan 2019-2027. These reinforce the need to maximize the value of investments in physical infrastructure and initiatives to enable service delivery, climate change resilience, community health and promote economic competitiveness. The supported strategic plan pillars include:

The RTAMP will provide guidance to future updates to the City's Transportation Master Plan (TMP). The TMP is prepared to support and inform the vision of the City's Official Plan as a modern and vibrant city that is healthy and sustainable. It presents background information, policy recommendations and network improvements to be considered through the development of a sustainable, multi-modal transportation system. The TMP recommends a sustainability-focused transportation network which places an emphasis on modes of transportation other than motorized vehicles, including walking, cycling and supporting greater public transit use.

First recommended in the TMP, in June 2018, Greater Sudbury adopted the Complete Streets Policy, becoming only the sixth municipality in Ontario to do so at the time of adoption. This policy commits the City to plan, design, construct, operate and maintain the transportation network to provide a comprehensive and integrated network of facilities that are safe and convenient for people of all ages and abilities travelling by foot, bicycle, public transit or vehicle. This policy applies only to capital projects where a reconstruction is required or where a roadway is planned to be substantially improved within the existing road allowance.

The objective of the RTAMP is to inform the decision making processes required for establishing a method of sustainable management of assets in consideration of acceptable condition, risk, costs and other influencing factors. The goals of this plan include:

1. Identify existing asset data information;
2. Document existing levels of service and the financial impact of potential alternatives;
3. Complete technical reviews of the assets using a life cycle approach;
4. Identify, assess and evaluate risks and establish risk tolerance;
5. Develop options or criteria for guiding long-term financial planning decisions;
6. Promote asset management strategies to attract growth and development, community health and build climate change resilience.

2.2 RTAMP Part 1

This document represents Part 1 of the Roads and Transportation Asset Management Plan which has been completed as part of Phase 1 of the Enterprise Asset Management Plan. In preparation of this document, the current state of existing roads infrastructure was reviewed, which includes identification of assets, condition, classes and types, and replacement cost. This plan also includes a review of existing service levels, current approach to lifecycle analysis, maintenance activities, renewal and rehabilitation activities, review of risk and review of asset funding requirements. Part 1 includes the following tasks:

- Assess existing paved and unpaved road conditions;
- Report on road asset inventory quantities, classes, replacement cost;
- Document existing levels of service;
- Outline existing maintenance, renewal and rehabilitation activities;
- Discuss incorporation of risk into the AMP;
- Review of current road asset investment and funding;
- Discussion of CEEP and climate change adaptation strategies;
- Establish preliminary list of demand drivers.

2.3 RTAMP Part 2

Preparation of the second part of the RTAMP will commence upon completion of Part 1. Part 2 of the RTAMP will be completed as part of Phase 3 of the Enterprise Asset Management Plan. The work included in this part requires a detailed review of proposed alternative service levels and long-term financial strategies. These tasks are outlined in Section 9.1.

3 Current State of Infrastructure

The City of Greater Sudbury is unique due to its large area and relatively high number of road lane kilometres per capita. The City's northern location also differentiates the community from others due to factors such as higher construction costs, harsher climate and the reliance on the industrial base which will affect service level alternatives. The City of Greater Sudbury's largest

asset class in terms of replacement cost is the road network. Figure 3.1 provides an overview of the City's transportation network.

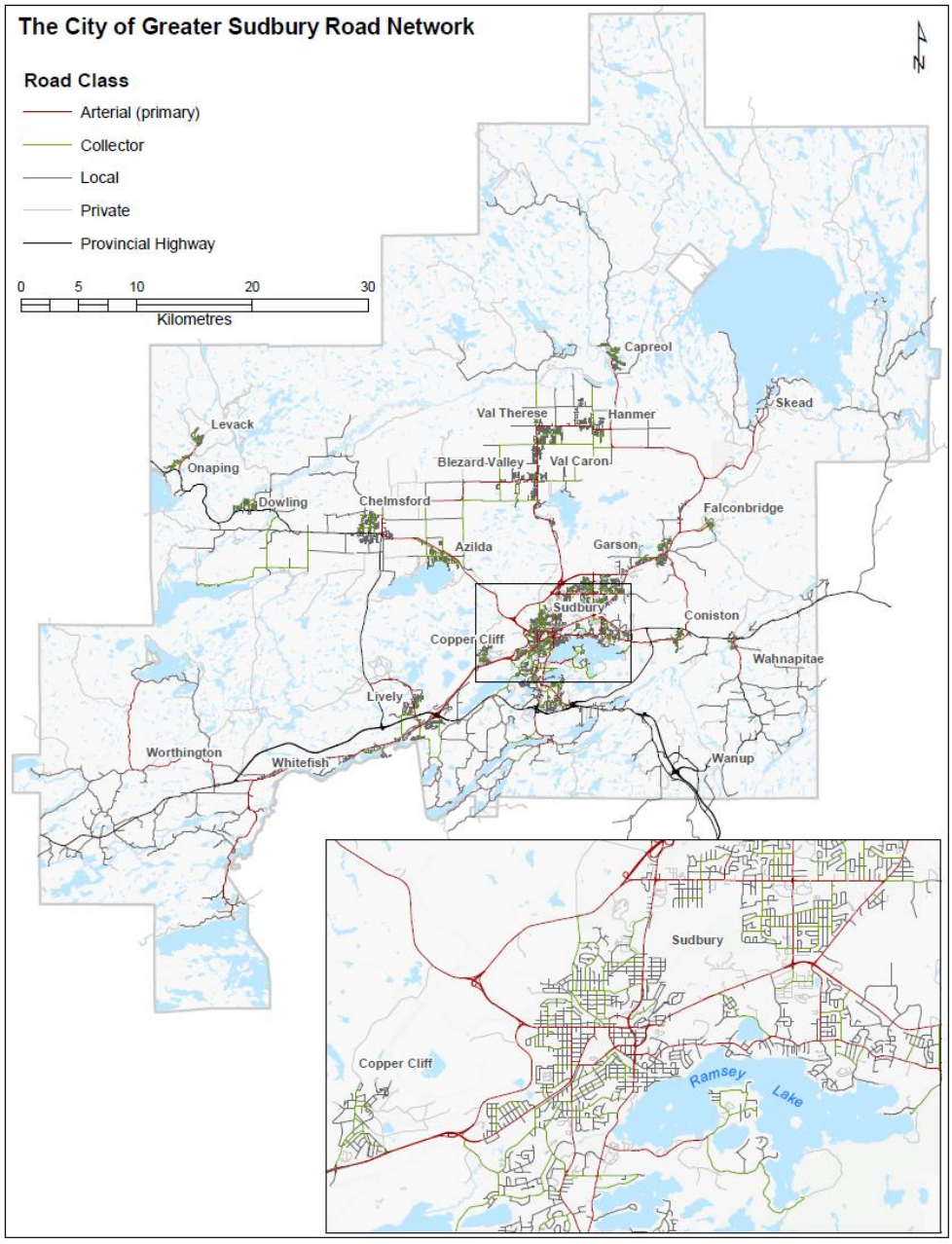


Figure 3.1 - The City of Greater Sudbury Road Network

The City's road network consists of approximately 2,974 paved lane km and 618 unpaved lane km for a total for 3,592 lane km of municipal roads. This equates to a total of approximately 22 lane km per 1,000 population; which is the largest value submitted by participating municipalities that reported to the 2019 MBNCan data call. Figure 3.2 provides a comparison of other municipality's road lane km inventory relative to their population.

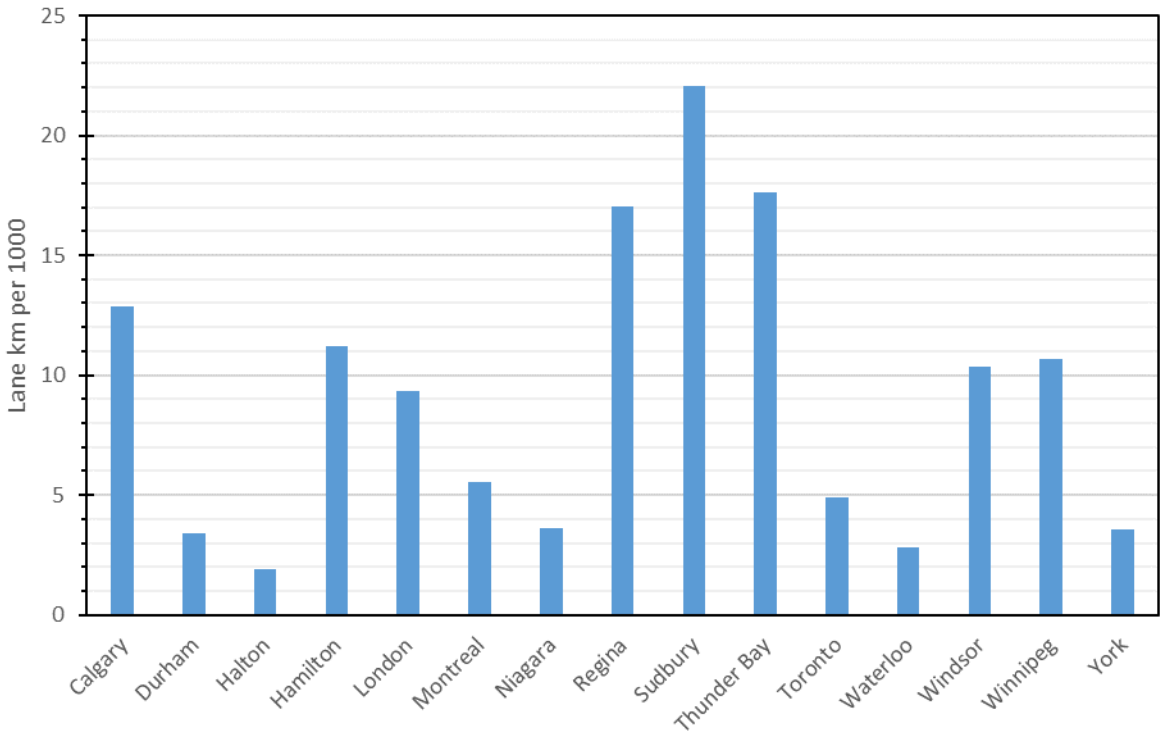


Figure 3.2 - Municipality Comparison of Road Length versus Population

All 3,592 km of roads in Greater Sudbury are classified according to function, in five classes. The Transportation Master Plan outlines five functional classifications which are described in Table 3.1.

Table 3.1: Road Network Classifications

Priority Class	Function
1. Primary Arterial	• Connect the City with other major centres outside the City and/or communities within the City; • Facilitate long distance person or goods movement travel through the City or between major activity areas within the City; • Traffic movement is primary consideration.
2. Secondary Arterial	• Connect two or more communities or major activity centres; • Connect two primary arterial roads; • Connect a community or activity centre with a primary arterial road; • Traffic movement is major consideration.
3. Tertiary Arterial	• Connect small / rural communities; • Connect communities to primary or secondary arterial roads; • Traffic movement is major consideration.
4. Collector	• Connect neighbourhoods; • Connect a neighbourhood with an arterial road; • Traffic movement and land access of equal importance.
5. Local	• Connect properties within a neighbourhood; • Land access is primary function.

3.1 Asset Data Inventory

The road network inventory is stored in the City's corporate GIS database. The GIS data is shared with other enterprise systems which use road network data including the pavement management system, the roads work order management system and traffic engineering system. Information within these data sets include location, traffic information, pavement structure, lengths and many more. The pavement management system stores up to approximately 120 fields of data information for each paved road segment. Paved road segments are generally defined as road segments between the two closest road intersections.

Collection and detailed identification for the purposes of inclusion in datasets for unpaved roads, sidewalks, cycling facilities etc. into City's GIS datasets is a work in progress. Recommendations for the priority and completion of this work are expected to be identified in Part 2 of this Plan. The City's road network and asset inventory are highlighted in Table 3.2. Existing assets not included in this part of the RTAMP are signs, guide rails, traffic signals, street trees, retaining walls, and rock cuts. These will be added to the inventory as deemed appropriate during Part 2 of this study process.

Table 3.2 - Road Network Inventory

Road Classification	**Quantity (lane km)**
Arterial	763
Collector	616
Local	2213
Total	3592
Road Surface	**Quantity (lane km)**
Paved Roads (Hot Mix Asphalt, Surface Treatment, and Concrete)	2974
Unpaved Roads (Gravel)	618
Total	3592
Other Assets	**Quantity (lane km)**
Sidewalk (km)	441
Bike Lanes - On-road bicycle lanes (lane km)	32
Bike Lanes - Multi-use paths (lane km)	4
Bike Lanes - Cycle tracks (lane km)	10
Street Light Poles	3601
Street Light Fixtures	14916

3.2 Asset Valuation

Asset valuation is determined by reviewing construction costs, current market demand, supply issues, construction standards and legislation. Evolving standards and legislation, technological improvements, or the announcement of a significant funding program from a senior level of government can lead to a sharp increase in material costs over a short duration and an increase in market demand.

Valuation of paved and unpaved roads must also consider road cross-section type and structure. This will include rural (roads with ditches) or urban (roads with curbs) cross sections, road pavement structure, gravel road structure and subsurface drainage systems (road subdrains). Drainage systems including storm sewers and ditches are incorporated into the Storm Water Asset Management Plan.

Enhancements to the pavement management system which include valuation of paved road assets is currently in progress. This will be developed with data that can be used to calculate asset value from historic record and capital construction programs from previous years.

3.3 Asset Lifecycle

The estimated life of road pavement and granular structure will vary with existing road structure, drainage, traffic, maintenance activities and weather. In previous financial analyses, the City has assumed 60 year life cycles for paved roads and estimated 75 year service life for unpaved roads.

Over the life of an asset, appropriate maintenance and rehabilitation treatments should be implemented at appropriate times to maximize the useful life of the asset prior to full reconstruction. Treatments for paved roads would include crack sealing, resurfacing (mill and

overlay) and rehabilitation before reconstruction of the road. The proposed scheduling of these treatments and costs associated with a typical two-lane local urban road is outlined in Section 6 of this document. Currently, reconstruction of paved roads is not a scheduled activity unless work is coordinated with other assets such as water and wastewater. A detailed analysis will review current activities, best practice activities and provide any recommendations for modifications to current practices in Part 2 of the RTAMP.

3.4 Paved Road Assessment Approach

Since 2000, the City has used a pavement management system to assist in evaluation of the condition of the road network and preparation/planning of road maintenance and construction projects. The pavement management system provides an objective analysis of the road network and provides proposed multi-year construction programing that reflects the City's established criteria based on planned capital budgets. Every two years the city reviews the condition of the asphalt including cracking, rutting and roughness to calculate four defined indices. These indices are rutting, roughness, non-structural cracking and structural cracking. The methods and procedures of this data collection are completed in conformance with *ASTM D6433 – Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys*.

All road segments are categorized with three characteristics including traffic load (low, medium and high), pavement structure (strong and weak), and drainage conditions (adequate and poor). Twelve categories of roads are established using these characteristics and based on the measured indices (cracking, roughness and rutting), various pavement management strategies for each road segment are determined. These strategies are compiled and analyzed to develop the program which will deliver the highest benefit to the road network given various budget scenarios.

Maintenance and construction treatments provided in the pavement management system output include crack sealing, surface treatment, overlay, single grind and single overlay, double grind and double overlay, rehabilitation, reconstruction, widening and drainage improvements.

The measured condition data is also used to calculate the Pavement Condition Index (PCI) using life cycle deterioration curves developed for the measured indices. These curves provide a means of preparing a roads program that considers the continued deterioration of individual road segments over time.

The pavement condition index in the pavement management system is evaluated as follows:

Table 3.3 - Paved Road Condition Index Summary

Condition	Pavement Condition Index (PCI)	Description
Very Good	>85 to 100	Sound pavement with few defects perceived by drivers
Good	>55 to 85	Slight rutting and/or cracking and/or roughness becomes noticeable to drivers
Fair	>40 to 55	Multiple cracks are apparent, and/or rutting may pull at wheel and/or roughness causes drivers to make minor corrections
Poor	>25 to 40	Significant cracks may cause potholes and/or rutting pulls at vehicles and/or roughness is uncomfortable to occupants. Drivers may need to correct to avoid road defects.
Very Poor	0 to 25	Significant cracks with potholes and/or rutting pulls at vehicles and/or roughness is uncomfortable to occupants. Drivers will need to correct to avoid road defects.

The pavement management system also currently utilizes an Overall Condition Index (OCI) to prioritize road segments and provide a recommended capital road program. The road construction treatments are triggered as described above and the road capital program is adjusted by the Overall Condition Index. The OCI is currently comprised of five (5) categories being pavement condition index, safety opportunity index, water and wastewater opportunity index, economic development opportunity/public needs assessment index and a mobility opportunity index (environment and congestion). These indices are currently under review and revisions are expected to be recommended. In particular, coordination with other assets and the economic opportunity index will be reviewed, and the assessment of risk will be incorporated.

The resulting recommended construction program provided by the pavement management system provides the alternative for maximum benefit to the network pavement condition. The recommended program is then reviewed and adjusted as required to suit coordination opportunities with development, other City assets such as water and wastewater, and other priorities that arise.

The current road segment age database is incomplete. In Part 2 of the work of this plan, alternatives for updating road segment age will be reviewed to assist in development of long term financial goals. These alternatives will include review of historical information and use of existing condition data to estimate asset age.

3.5 Gravel Road Assessment Approach

The gravel road network is evaluated through a visual dashboard review using methods outlined in Ministry of Transportation document *"SP-025 Manual for Condition Rating of Gravel Surface Roads"* and modified to suit local data requirements. The evaluation framework is based on *Table B-1 A Guide for the Estimation of Pavement Condition Rating, Gravel Surface Pavement Condition Evaluation Form from SP-025* and local experience of CGS Roads Operations staff to establish a condition rating for gravel roads and deficiencies within the right-of-way.

Gravel road parameters reviewed include road platform width, ditching/drainage, road shoulders, roadside vegetation, roadside embankments and alignment. Temporary conditions such as surface deficiencies were not included in the evaluation. Table 3.4 indicates conditions used to establish an estimate of the Gravel Road Index (CGI).

Table 3.4 - Gravel Road Condition Summary

Condition	Gravel Condition Index (GCI)	Description
Good	>60	Routine maintenance is required, existing conditions generally include adequate platform width, existing ditches may require cleaning, horizontal and vertical alignment are generally comfortable, no or few roadside hazards exist, roadside vegetation is minor.
Fair	40 to 60	Corrective maintenance is required, improvements may be required, existing conditions may include platform width that requires widening, existing ditches that require cleaning, significant ditching work, deficiencies may exist in horizontal and vertical alignment, roadside hazards may be present, roadside vegetation in ditch area may be significant and require normal clearing maintenance work.
Poor	<40	Increased maintenance or road rehabilitation or significant roadside work is required, existing conditions may include existing platform width which requires improvement, ditches that need to be established, issues exist with horizontal and vertical alignment, roadside hazards may be present, roadside vegetation in ditch area is significant and will require extensive removals.

3.6 Road Safety Network Screening

A road safety network screening program is used to evaluate road segments and intersections to determine if there is a higher than expected number of collisions. The screening program is based on the Highway Safety Manual (HSM), produced by the American Association of State Highway and Transportation Officials (AASHTO). This screening provides a quantitative approach to determine sites that are most likely to respond to safety improvements. Screening analysis considers the number of predicted collisions, traffic volumes, and observed collisions.

The safety evaluation results in a score called Potential for Safety Improvement (PSI). All roads and intersections in the City have been scored and prioritized by the screening program using the PSI score and the top 20 locations have been identified. Each of the prioritized locations are reviewed to determine what countermeasures may be implemented to improve safety. Where countermeasure improvements have been identified in the prioritized locations, they are scheduled into the City's capital works program.

Currently, five locations plus those locations that are within an identified capital project are reviewed on an annual basis to determine if suitable countermeasures can be implemented. The development of possible metrics for a safety level of service will be reviewed in Part 2 of the RTAMP work.

3.7 Lighting

Within the City of Greater Sudbury, street light fixtures may be mounted on City owned poles or mounted on shared poles owned by electrical and telephone utilities. Sharing of poles reduces the cost of installation, but may result in a less than optimal mounting height and angle.

The City has developed a service life consumption model for street light poles that can vary by the pole material type.

Table 3.5 - Street Light Pole Condition Summary

Condition	Service Life Consumption	Condition Score
Very Good	0% to 20%	80 to 100
Good	21% to 40%	60 to 79
Fair	41% to 60%	40 to 59
Poor	61% to 80%	20 to 39
Very Poor	>80%	0 to 19

Table 3.6 - Street Light Fixture Condition Summary

Condition	Service Life Consumption	Condition Score
Very Good	0 to 20,000 hours	80 to 100
Good	20,001 to 40,000 hours	60 to 79
Fair	40,001 to 60,000 hours	40 to 59
Poor	60,001 to 80,000 hours	20 to 39
Very Poor	>80,000 hours	0 to 19

The City has recently retrofitted the entire street light network to new LED technology. The new street lights are individually controlled by a photocell and have an estimated useful life of 100,000 hours of light projection. The photocell mounted on the light activates the light at a preset level of darkness. Maintenance of a street light consists almost entirely of replacing a spent fixture. The street lights are periodically inspected by Greater Sudbury Utilities (GSU) and fixture replacement may be triggered when reported by community members.

3.8 Current RTAMP Asset Condition

The following tables provide average Pavement Condition Index (PCI) and Gravel Road Condition Index (GCI) data on a network level.

Table 3.7 - Paved Road Average PCI by Road Classification

Road Classification	Average PCI (2019)	Average Condition
Arterial	57	Good
Collector	48	Fair
Local	47	Fair
Network Average	49	Fair

Table 3.8 - Paved Road PCI Condition Category Summary

Road Condition (PCI)	Lane Km	Repl. Cost Percentage	Replacement Cost (Millions)
Very Good	90	6%	$149
Good	1100	50%	$1,338
Fair	981	28%	$765
Poor	713	14%	$391
Very Poor	90	2%	$47
Total	2974	100%	$2,690

Table 3.9 - Gravel Road Average GCI

Surface Type	Average Network GCI (2020)	Average Network Condition
Gravel Road	59	Fair

Table 3.10 - Gravel Road GCI Category Summary

Road Condition (GCI)	Lane Km	Repl. Cost Percentage	Replacement Cost (Millions)
Good	272	44%	$75
Fair	315	51%	$87
Poor	31	5%	$8
Total	618	100%	$170

The following tables provide condition information on street light poles and fixtures on a network level.

Table 3.11 - Street Light Average Condition

Street Light Asset	Average Condition Score	Average Network Condition
Street Light Poles	36	Poor
Street Light Fixtures	88	Very Good

Table 3.12 - Street Light Condition Category Summary

Condition	Poles	Fixtures	Repl. Cost Percentage	Replacement Cost (Millions)
Very Good	475	10799	28%	$6.5
Good	715	4117	22%	$5.2
Fair	539	0	11%	$2.7
Poor	465	0	10%	$2.3
Very Poor	1407	0	30%	$7.0
Total	3601	14916	100%	$23.8

4 Levels of Service

4.1 Background

In order to assess services to the public and determine if services are deemed to meet established goals, it is important to define current and target service levels the City provides. The work required to prepare the current level of service framework has included consultation with staff, review of current activities, financial data and upgrade to the pavement management system.

The following levels of service discussion indicates current service levels at current funding levels. Part 2 of the Asset Management Plan will review a variety of alternatives for Council to consider to achieve an acceptable level of service at an acceptable cost. The alternatives will be evaluated considering various levels of acceptable condition, risk and financial alternatives. The review will provide insight on development of establishing criticality of assets and on the long term financial sustainability of the various options and impacts of accelerating or deferring projects.

All level of service statements indicated below will be reviewed and further developed in Part 2 of the plan to set community expectations and reflect the unique character of the City. A few examples of some of the services to be reviewed will include:

- Operating and capital investment.
- Safe and accessible definitions and application to various types of roads.
- Emergency access and types of emergency vehicles that may be required.
- Road condition and geometry based on road type details and use.

4.2 Level of Service Definitions

Level of Service refers to a series of statements that describe the services provided to maintain and operate the assets included in the Roads and Transportation asset category. Service levels have been defined within the following 3 categories which align with the Enterprise Asset Management Plan:

- Community - Qualitative descriptions that define the community, stakeholder and individual expectations.
- Strategic - These include qualitative and quantitative measures that describe what is being provided to customers. Examples of how this can be defined can include reliability, legislative compliance, quantity, quality and safety.
- Asset (Technical) - An asset level of service is a quantitative measure that defines the performance expectation for a given asset in order to produce the desired levels of service. These services are measurable and can include asset condition, responsiveness, cost and asset value.

4.3 Community Level of Service

Community levels of service are high level statements which indicate what the City currently strives to achieve. The actual service levels on individual road segments will vary depending on

a variety of factors including road class, traffic levels and type, road maintenance levels, road structure, accessibility and employment activities. The level of service statements will be further reviewed in Part 2 to prepare alternatives for target levels of service and definition of service levels the community can expect on different types of roads.

- Roads are safe, accessible, and have sufficient capacity.
    - Roads and intersections are reviewed using a road safety network screening program.
    - Roads are maintained in summer and winter to provide access for the traveling public
    - Road capacity is reviewed in five year intervals as part of the Transportation Master Plan
- Roads are in a fair state of repair and maintained at an acceptable cost.
    - Roads are maintained and improved to be in a condition commensurate with use and traffic volumes.
    - Collector and Local roads are in fair condition based on average pavement condition index.
    - Arterial roads are in good condition based on average pavement condition index.
    - Total road costs per lane km are below average total MBNCan benchmarking costs.
- Roads are capable of supporting essential services and multimodal transportation.
    - All roads are maintained in a condition to allow passage of emergency vehicles and essential vehicles as seasonal conditions permit.
    - Roads will provide access to active transportation modes such as cycling, transit and walking where deemed appropriate.
- Roads are constructed and maintained in an environmentally responsible manner.
    - Capital construction and operational activities are reviewed for opportunities to employ asphalt recycling treatments. Advancements in recycled asphalt technology are monitored and implemented where appropriate.
    - A salt management plan was developed in 2017 and was followed with a salt optimization plan in 2018 to provide guidance to winter control activities and environmentally conscious road salt management.

4.4 Strategic Level of Service

The strategic levels of service indicated below support the community levels of service.

- Roads are maintained in accordance with provincial minimum maintenance standards and City policy. These activities include:
    - Class 1 to 3 roads – plowed within 8 hours (after end of storm)
    - Class 4 to 6 roads – plowed with 24 hours (after end of storm)
    - 80% sidewalk cleared of snow within 24 hours
    - 100% potholes repaired in accordance with minimum maintenance standards
    - 9 weeks to remove winter sand
    - Road line painting and markings 1 time per year

    - 5% regulatory signs are replaced annually
    - 3% road crossing culverts replaced annually
    - 2.5% curb and sidewalk are replaced annually
    - 500 aged trees are removed annually
- Average network road pavement condition is currently subject to gradual deterioration of approximately 1 pavement condition index point annually. At the current funding level, the road network will maintain an average condition of “fair” over the next 10 years.
- Road maintenance classes which range from 1 (arterial) to 6 (local) are subject to different levels of road maintenance and capital repair service levels. Class 1 to 5 roads are reviewed annually for resurfacing or rehabilitation.
- Roads with condition scores of Poor and Very Poor are reconstructed or rehabilitated when work aligns with strategic priorities such as the Transportation Master Plan and Industrial Lands Strategy or when work can be coordinated with other asset priorities such as watermain or sewer replacement.
- Surface treated roads and gravel roads are maintained and repaired through maintenance activities only.

4.5 Asset Level of Service – Key Performance Indicators (KPI):

The key performance indicators currently included in the asset level of service are indicated below. Other asset levels of service will be reviewed for inclusion into this category and may include items relating to work backlog, congestion, access and safety.

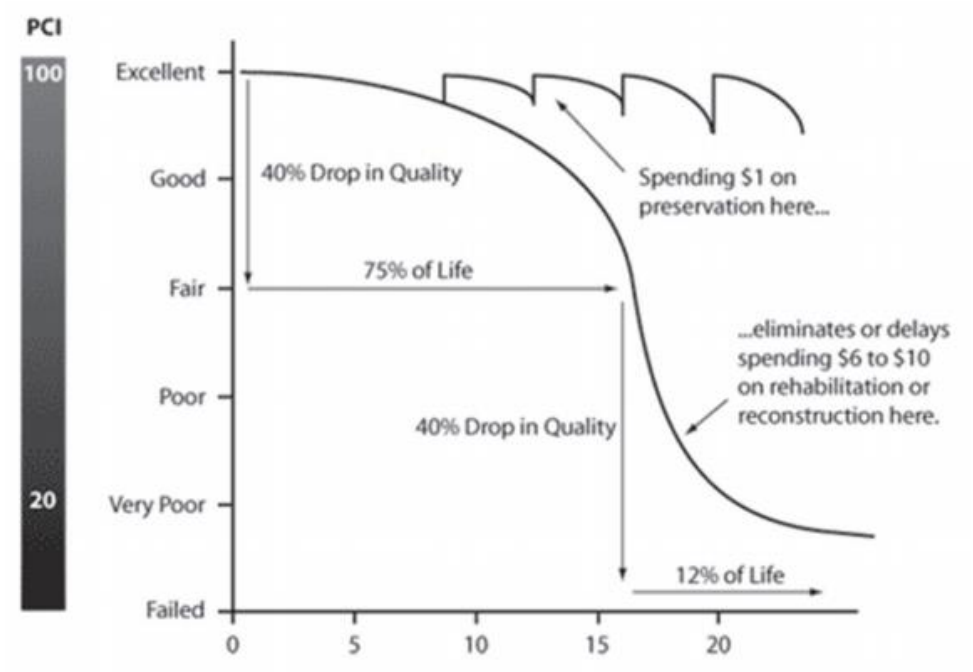
- Pavement condition index
- Gravel condition index
- Road summer maintenance cost per lane km
- International Roughness Index (IRI)
- Percentage of roads in fair or better condition based on asset replacement value
- Percentage of total annual road reinvestment based on asset replacement value

4.6 Current Asset Level of Service

4.6.1 Pavement Condition Index:

In order to establish the optimal future PCI service level, an analysis of conditions that will provide the maximum benefit for the road network with proposed funding will be reviewed. This includes an analysis of the required treatments or optimum interventions proposed throughout the lifecycle of the road, costs of proposed treatments and risk evaluation.

When a road asset is permitted to deteriorate beyond a condition where rehabilitation cannot be selected as an effective treatment strategy, the asset becomes more expensive to maintain than the asset that has received recommended treatments at the recommended timing. The result of not completing recommended treatments at the right time is the asset network becomes more costly to maintain year after year. This is demonstrated by the pavement deterioration curve indicated in the figure below. The City selects roads for resurfacing and rehabilitation that have a pavement condition in the upper part of this curve to maximize benefit of available budget. Investment in poor or very poor roads will occur if other priorities arise such as sewer or watermain pipework repair and road reconstruction will be required.



Road Projects: Paved road resurfacing or rehabilitation treatments selected for roads fair and better.

Road and Pipes Projects: Paved road reconstruction selected when pipework required for roads poor and very poor.

Figure 4.1 - Pavement Deterioration Curve

From Bouali, El Hachemi Y., "ANALYZING THE LIFE-CYCLE OF UNSTABLE SLOPES USING APPLIED REMOTE SENSING WITHIN AN ASSET MANAGEMENT FRAMEWORK", Open Access Dissertation, Michigan Technological University, 2018. https://digitalcommons.mtu.edu/etdr/649

Table 4.1 - City of Greater Sudbury PCI by Road Classification

Road Classification	Average PCI (2016)	Average PCI (2019)	Average Condition
Arterial	58	57	Good
Collector	49	48	Fair
Local	50	47	Fair
Network Average	52	49	Fair

The development of a level of service for pavement condition will be an important component of the plan. Proposals for PCI levels were identified in the 2012 KPMG report for the purposes of the financial analysis. These recommendations included an average PCI of 70 for arterial and collector roads and PCI of 60 for local roads. Some municipalities have set different PCI target levels for 90% of the roads in the individual road classes. Alternate PCI service levels will be considered and proposed to council for their consideration in the next part of the plan.

The 2 charts below demonstrate the anticipated Pavement Condition Index for the two road groups used for Capital Budget preparation at the annual average capital investment over the previous five years. The funding used in the analysis is $26 million for Arterial/Collector Roads and $9 million for Local Roads.

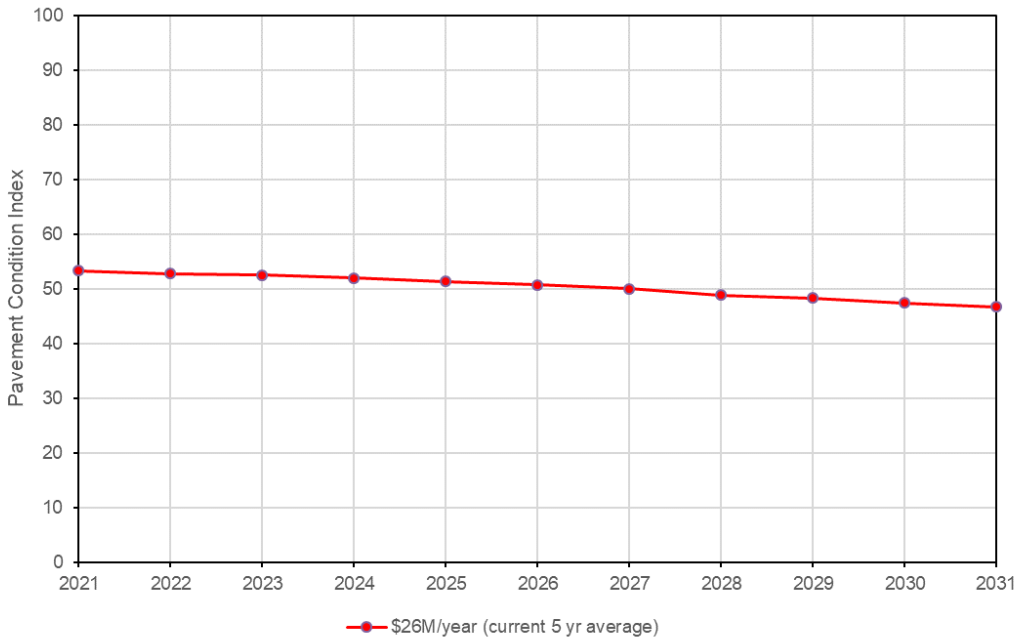


Figure 4.2 - 10 Year PCI Projection for Arterial/Collector Roads (Current 5 Yr $ Avg)

The PCI measured for the Arterial/Collector road group in 2019 was 57 and at the current rate of investment the pavement management system anticipates the PCI will continue to decrease over the next 10 years to a PCI of approximately 47 or “fair”.

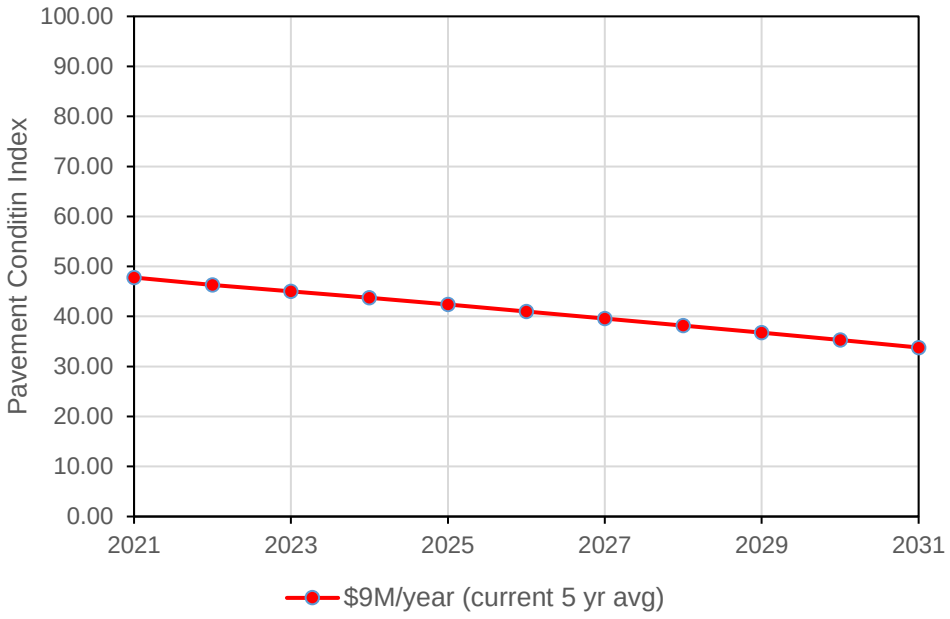


Figure 4.3 - 10 Year PCI Projection for Local Roads (Current 5 Yr $ Avg)

The PCI measured for the Local road group in 2019 was 47 and at the current rate of investment the pavement management system anticipates the PCI will continue to decrease over the next 10 years to a PCI of approximately 34 or “poor”.

The impact on the pavement condition at various funding levels is discussed further in Section 6.0 – Financial Review.

4.6.2 Gravel Condition Index

Similar to paved roads, gravel road conditions will be dependent on the acceptable balance between capital/operational investment as determined in consultation with council. The review completed in 2020 indicates an average condition of “Fair”. Future work will include a more detailed review of gravel road maintenance, capital and financial requirements.

4.6.3 Roads Summer Maintenance Costs per Lane Km

Summer road maintenance costs are relatively consistent and can be evaluated from year to year. As a result, this is a useful metric to report as a KPI, with the annual investment level to be determined in consultation with Council. The work included in this metric is a contributing

component to the overall road condition of the network for both paved and gravel roads while also providing year to year costs for these activities.

4.6.4 International Roughness Index (IRI)

The international roughness index is a roughness measurement developed to standardize roughness data collection and analysis techniques for pavement. An IRI value of 0 m/km indicates absolute smoothness and a value of 10m/km would represent a very rough roadway. IRI is calculated for all paved road segments in the City using the asphalt condition data collected for the pavement management system.

Table 4.2 – Average IRI by Road Planning Class

Road Class	IRI m/km (2019)	Condition (TAC - Highway Roads)	Condition (Other Municipality Guidelines)
Arterial	3.4	Poor	Fair
Collector	4.9	Poor	Good
Local	6.0	Poor	Good

Target IRI levels of service for the City are not yet established. Acceptable limits will vary with road classification and operating speed. Two examples of different grading scales are indicated in Table 4.2. The Transportation Association of Canada conditions are developed for highways and not necessarily applicable to many municipal roads. Other municipalities have developed their own grading system and are included for information. The development of a grading system unique for the City will be reviewed in Part 2 of the plan.

4.6.5 Percentage of roads in fair or better condition based on replacement value:

The current percentage of roads in fair or better condition based on 2019 data is 84%. Recommended target percentage levels vary between municipalities from 75% to 90% with unique municipal requirements based on condition, extent and age of road network. A target level of service for this metric will be established in Part 2 of the Plan.

4.6.6 Percentage of total annual road investment based on asset replacement value:

Greater Sudbury's current percentage of total road investment based on average investment over last five years is 1.22% of the asset replacement value. Recommended target percentage levels generally vary between municipalities from 1.7% to 2.5% with unique requirements based on condition, extent and age of road network. The percentage will also vary with the immediate requirements of the network or backlog of work that does not get prioritized. A target level of service will be established in Part 2 of the Plan.

Service levels will drive the investment forecasts in the RTAMP. Council will be provided with the opportunity to determine level of service targets to manage infrastructure within the City's capacity to renew and maintain assets with associated risks. Final levels of service will be based on regulations, standards, risk acceptance and Council approval. Annual capital and maintenance budget proposals will be developed to achieve the desired service levels as directed by council.

A long term financial strategy will be developed after a detailed review of acceptable service levels, affordability and risks. Service levels and the associated costs will be presented to council to determine the acceptable balance between these three parameters. Further study will develop achievable alternatives to review and determine acceptable service levels, expenditures and risks.

5 Risk Management

The City's risk management goals involve identifying risks and managing infrastructure assets to meet planned service objectives within the accepted levels of risk. Risk assessment will assist in prioritization and optimization of capital spending and decision making. The assessment process involves evaluation of Probability of Failure (PoF) and the Consequence of Failure (CoF). This will assist in clarification and development of a shared understanding about the risk associated with decisions made in Operating and Capital programs.

Risk factors not currently included in the pavement management system analysis will be reviewed for possible inclusion into the decision making process. These include:

- Potential for safety improvement;
- Congestion;
- Preventative and planned maintenance;
- Vulnerability (i.e. flooding);
- Climate change;
- Data quality;
- Truck and transit routes;
- Traffic Volume;
- Replacement Cost;
- Environmental considerations;
- Social consequence;
- Critical public use facilities.

The City's pavement management system is used in the preparation of the annual capital road construction program to provide maximum benefit to the road network condition. The anticipated reduction of the pavement condition is currently an identified risk requiring further review. The details of this risk will be reviewed in conjunction with existing and future investment and presented to council for consideration. Conditions associated with various funding levels is discussed further in Section 6.0 – Financial Review.

6 Financial Review

6.1 Investment

Funding of road asset capital improvements for roads capital projects has significantly increased over the last five year period. Average road investment from 2016 to 2020 for all road capital projects increased by approximately 30% over the previous five year period (Figure 6.1).

In 2019, the budget process was transformed from an envelope system where previously defined funding levels were distributed to the various operating departments to an enterprise prioritization system which ensures funds are distributed to projects on a city wide priority basis. In addition to the prioritization process, Council provided an additional investment in roads infrastructure of approximately $4 million in 2019.

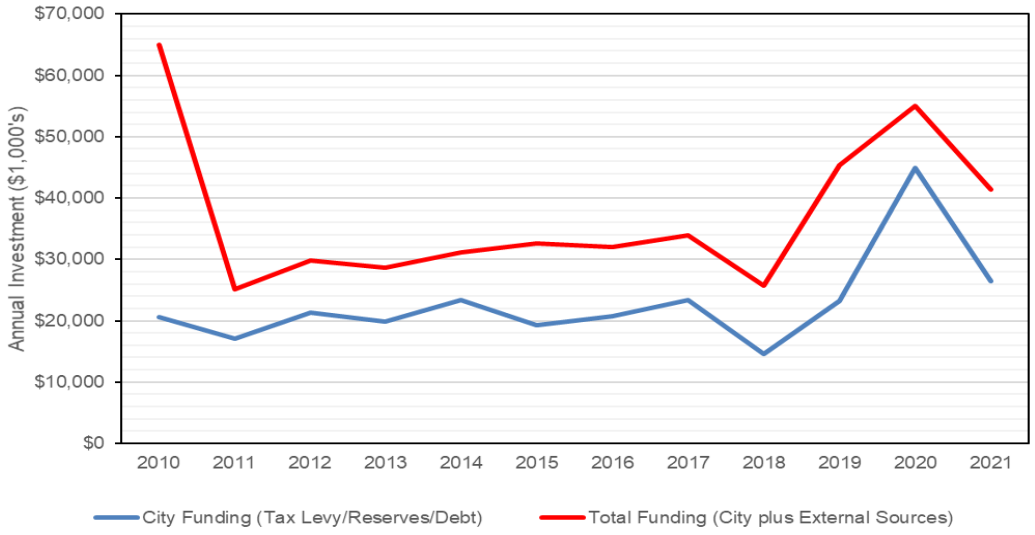


Figure 6.1 Historical Funding - Roads

Figures 6.2 and 6.3 demonstrate the anticipated Pavement Condition Index for the two road groups used to prepare road capital construction programs at various levels of funding including the annual average investment over the previous five years of $26 million for Arterial/Collector roads and $9 million for Local roads.

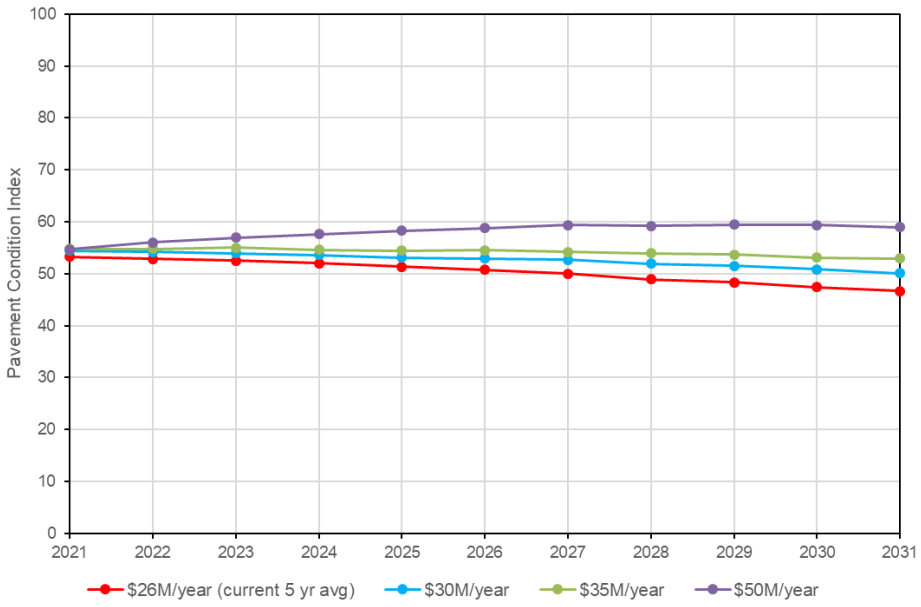


Figure 6.2 - Arterial Collector Roads: Projected PCI at Various Annual Investment Levels

There are four levels of funding indicated for Arterial/Collector in Figure 6.2. These include annual funding of $26 million, $30 million, $35 million and $50 million. The average annual investment in arterial and collector road capital projects over the last five years is approximately $26 million. At this funding level the pavement management system anticipates the PCI will continue to decrease over the next 10 years to a PCI of approximately 47 or Fair.

The network was analyzed with annual funding of $30 and $35 million to demonstrate how the PCI will be improved with $4 and $9 million increases in annual funding. The $50 million annual investment option will provide a slight increase to the PCI over the next 10 years.

Further financial forecasting work will be required to present detailed options and associated risks to inform decisions regarding future arterial and collector road condition and associated service levels.

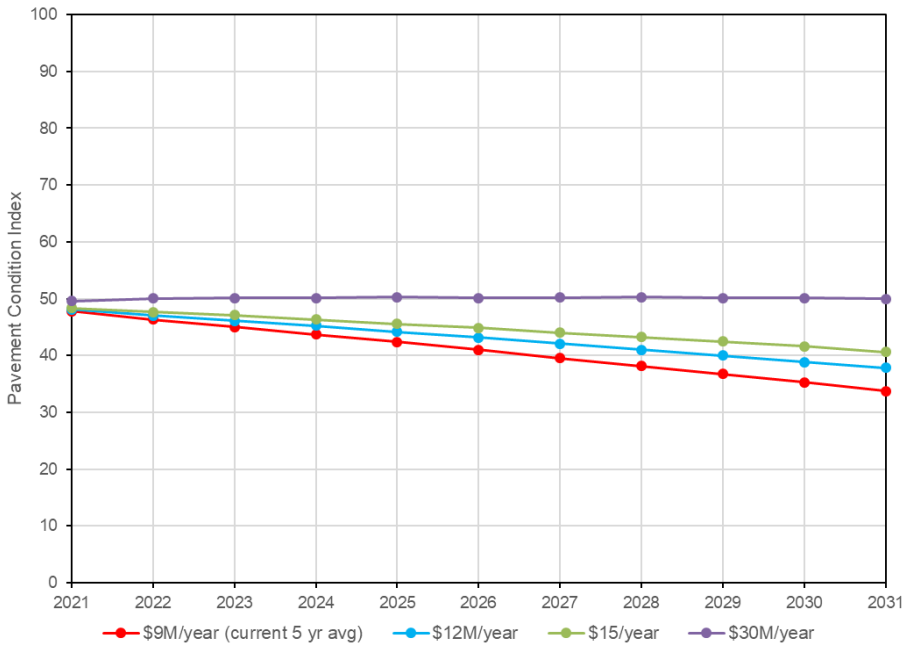


Figure 6.3 - Local Roads: Projected PCI at Various Annual Investment Levels

There are four levels of funding for Local roads in Figure 6.3. These include annual funding of $9 million, $12 million, $15 million and $30 million. The average annual investment in local road capital projects over the last five years is approximately $9 million. At this funding level the pavement management system anticipates the PCI will continue to decrease over the next 10 years to a PCI of approximately 34 or Poor.

The network was analyzed with annual funding of $12 and $15 million to demonstrate how the PCI will be improved with $3 and $6 million increases in annual funding. The $30 million annual investment option is analyzed to demonstrate the funding necessary to hold the PCI approximately steady over the next 10 years.

Further financial forecasting work will be required to present detailed options and associated risks to inform decisions regarding future local road condition and associated service levels.

6.2 Estimated Replacement Cost

A summary of the City's Road Asset Replacement Costs is provided in Figure 6.4.

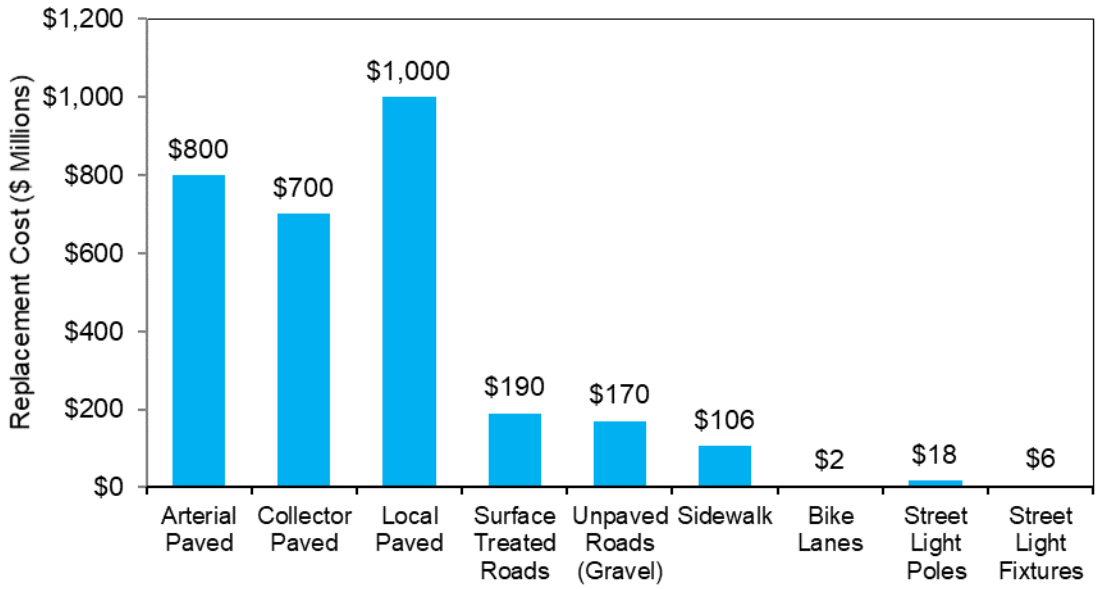


Figure 6.4 - Road Asset Replacement Costs

The estimated replacement value for all paved and gravel roads is $2.86 billion. In 2016, the KPMG Asset Management Plan indicated there was an estimated $896 million in immediate need for rehabilitation or reconstruction. They also projected 10 year need of $802 million for road replacement and rehabilitation for a total estimated investment requirement of $1.7 billion at that time.

Table 6.1 - Road Network Replacement Costs

Asset Type	Replacement Value
Arterial – Hot Mix Asphalt Paved Roads	$800,000,000
Collector – Hot Mix Asphalt Paved Roads	$700,000,000
Local – Hot Mix Asphalt Paved Roads	$1,000,000,000
Surface Treated Roads	$190,000,000
Unpaved Roads (Gravel)	$170,000,000
Sidewalk (km)	$106,000,000
Bike Lanes - On-road bicycle lanes (lane km)	Included with Road
Bike Lanes - Multi-use paths (lane km)	$600,000
Bike Lanes - Cycle tracks (lane km)	$1,500,000
Street Light Poles	$18,000,000
Street Light Fixtures	$5,800,000
Subtotal Hot Mix Asphalt Paved Roads	$2,500,000,000
Subtotal Paved and Unpaved (Gravel) Roads	$2,860,000,000
Grand Total	$2,991,900,000

The replacement value for all assets currently included in this plan is approximately $3 billion. This estimate does not include other road assets which include traffic signals, signs, rock cuts, guide rails, street trees and retaining walls that may be deemed appropriate for inclusion into the RTAMP.

6.3 Estimated Lifecycle Costing

Figure 6.5 represents the life cycle costs of a two lane local urban hot mix paved road using assumed treatments at regular intervals for the purposes of estimating total costs of recommended maintenance and rehabilitation treatments over the assumed 60 year life cycle of the road. These life cycle activities and costs are presented to demonstrate an order of magnitude and will vary with existing conditions based on road class and type, road width, traffic, and existing conditions.

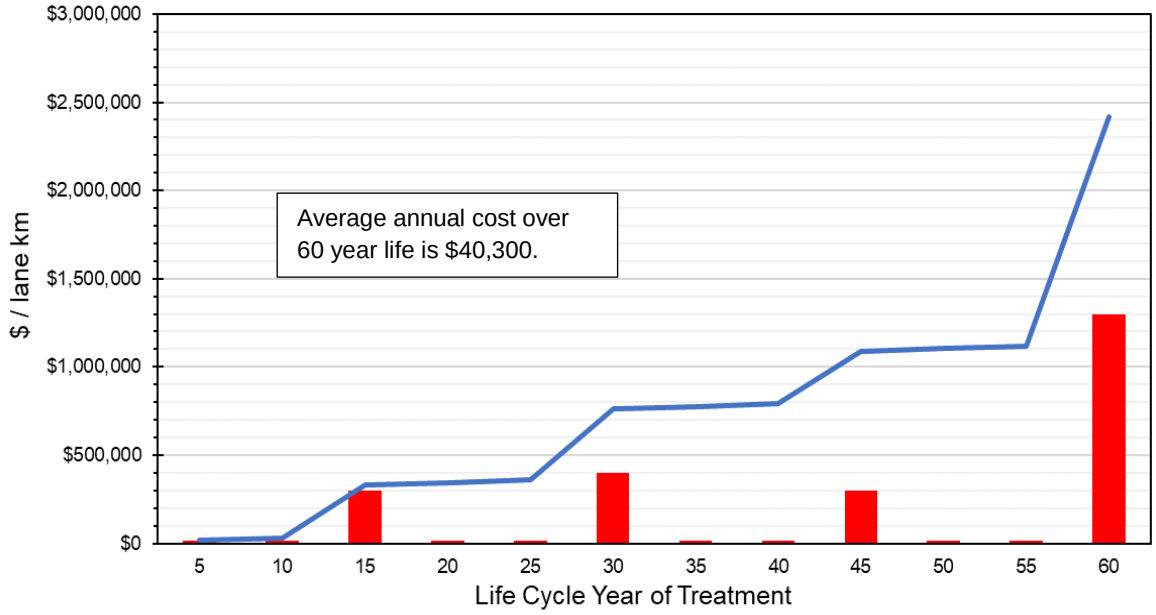


Figure 6.5 - Lifecycle Costs for Two Lane Hot Mix Paved Urban Road (60 Year Life Cycle)

Table 6.2 highlights the estimated costs and proposed treatment activities indicated in Figure 6.5. In this estimate the average annual cost is estimated to be approximately $40,000 per lane km and the total cost of maintaining a road with the recommended treatments is approximately $2.4 million.

Note that these costs will vary with road class, type and width of road. Asphalt thicknesses will vary with road class (arterial/collector and local). Reconstruction costs will vary with road type (urban and rural). All treatment costs will vary with asphalt surface width.

These costs represent a fully funded program to maintain one lane km of road on a recommended treatment cycle. This lifecycle cost review has been prepared to provide an order of magnitude as continuing work on the asset management plan will develop customized programs for different types of roads.

Table 6.2 - Paved Road Network Treatments for 2 Lane Local Urban Hot Mix Paved Road per Lane Km (2021CAD)

Year	Activity	Estimated Cost/Lane km
5	Crack Sealing	$15,000
10	Crack Sealing	$15,000
15	Resurfacing	$300,000
20	Crack Sealing	$15,000
25	Crack Sealing	$15,000
30	Rehabilitation	$400,000
35	Crack Sealing	$15,000
40	Crack Sealing	$15,000
45	Resurfacing	$300,000
50	Crack Sealing	$15,000
55	Crack Sealing	$15,000
60	End of Life Reconstruction	$1,300,000
Total Lifecycle Cost / Lane km (60 Years)		$2,420,000
Average Cost per Year / Lane km		**$40,300**

6.4 Paved Road Summer Maintenance Program

Summer maintenance costs in 2020 were approximately $16.8 million and the requested summer maintenance budget in 2021 was $17.85 million. Based on the Zero Based Budget analysis for summer road maintenance programs identified in the 2012 Report, the projected funding gap for paved road summer maintenance activities required to achieve a recommended standard of maintenance will be approximately $3.9 million for 2021 (Figure 6.6). Maintenance activities and service levels will be the subject of further review and analysis through the continuing asset management plan development in Part 2.

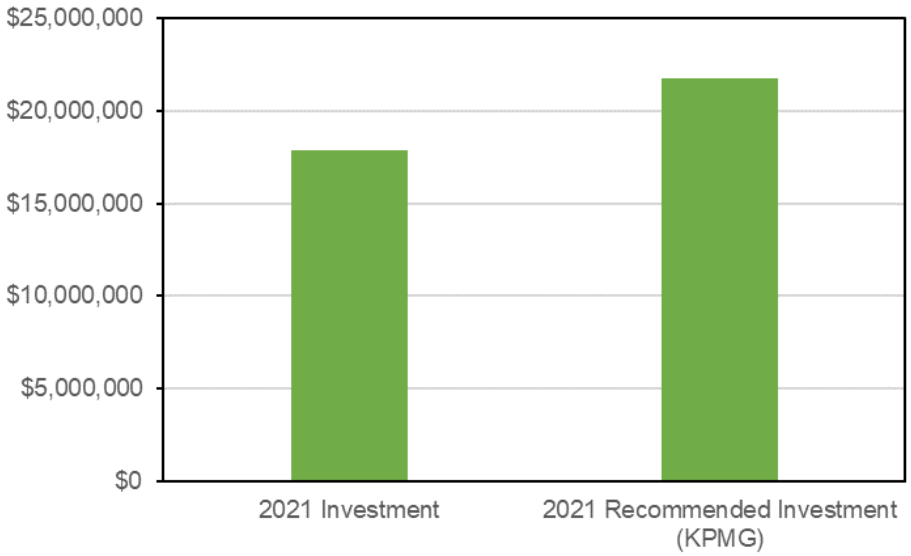


Figure 6.6 - Paved Road Summer Maintenance Investment

6.5 Gravel Road Maintenance Program

A sample of four budgeted gravel road maintenance activities were reviewed and compared to gravel road best practices that were identified in 2005 during the development of a maintenance model framework. Not all gravel road maintenance activities can currently be isolated to gravel road assets and as result, only maintenance activities that were dedicated to gravel roads were reviewed. These activities are indicated in Figure 6.7.

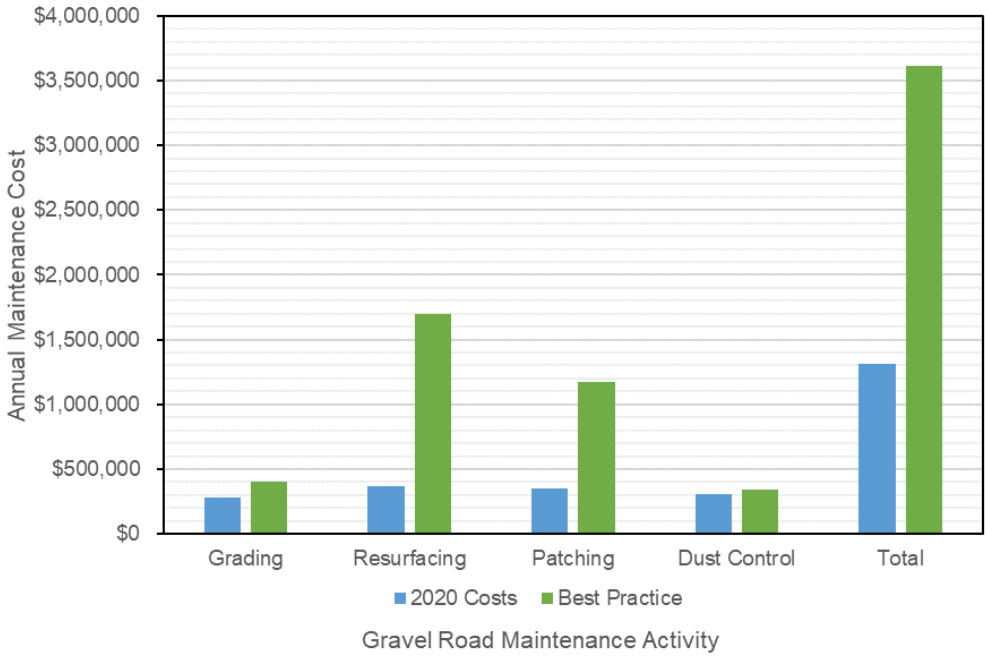


Figure 6.7 - Gravel Road Maintenance Activities 2020 vs Best Practice

The difference between the annual spending on the identified gravel road maintenance activities and best practices is estimated at $2.3 million. These activities do not include all maintenance activities completed on gravel roads. Maintenance activities such as mowing and brushing were not included in the analysis because to date, these activities are not attributed to specific assets and the actual maintenance expenditure on gravel roads could not be accurately estimated. Maintenance activities such as ditching have been evaluated as part of the Stormwater Asset Management Plan (SWAMP). Ditching activity estimates in the SWAMP have been completed with the assumption that ditches generally exist along all gravel roads however the assessment of gravel road conditions reveal that there are significant lengths of gravel road where no ditches exist. Treatment of these locations will be the subject of further review. The values estimated for these activities are indicated in the table below.

Table 6.3 - Gravel Road Activity Funding

Gravel Road Maintenance Activity	2020 Costs	Best Practice	Funding Gap
Grading	$280,000	$400,000	$120,000
Resurfacing	$370,000	$1,700,000	$1,330,000
Patching	$350,000	$1,170,000	$820,000
Dust Control	$310,000	$340,000	$30,000
Total	**$1,310,000**	**$3,610,000**	**$2,300,000**

7 Future Demand

The RTAMP must account for impacts and changes due to asset demand. Demand drivers include population, legislation, demographics, seasonal factors, technological advancement, economic, environmental awareness and Council directed service revisions. Table 7.1 indicates drivers, current and projected status, impact and actions.

The present position and projections for demand drivers, from the City of Greater Sudbury Outlook for Growth to 2046 developed in March 2018, will impact future service delivery. The City will monitor the demand on assets through a combination of managing assets, upgrading of assets and providing new assets to meet demand. Future opportunities will be developed in continuing improvements to the asset management plan.

Table 7.1 - Demand Drivers, Projections, Impact on Services and Management Plan

Demand Driver	Present Position	Projection	Impact on Services	Demand Management Plan
Population	City of Greater Sudbury Population: 166,130	Population (2046): • Low: 165,090 • Mid-Range: 172,990 (Reference Scenario) • High: 181,290	The City's population is anticipated to remain relatively constant. This will minimize the impact on the existing road network. However new development will require new road construction.	The City will continue to monitor population. Should the population deviate from the expected constant, the data will be analyzed to formulate an appropriate plan.
Legislation	Minimum Maintenance Standards Highway Traffic Act Accessibility for Ontarians with Disabilities Act (AODA)	Maintenance standards are anticipated to remain constant. AODA and Barrier-Free needs are expected to evolve.	Maintenance standards have been established. Review of potential for safety improvements i.e. pedestrian crossings, tactile strips and intersections.	Maintenance standards will be reviewed regularly. Additional investment may be required as items are identified within the capital program and with the potential for safety improvement.
Demographic	Households: 69,152	Households (2046): • Low: 72,890 • Mid-Range: 75,250 (Reference Scenario) • High: 77,590	The anticipated increase in housing will be monitored and services provided by the road network will be adjusted accordingly.	Through development approvals, the City plans for additional road network assets.
Aging Population	Median Age from 2016 Canada Census: 43.2	There is an anticipated increase in median age of population. By 2037 the population of seniors (75+) in Ontario is expected to increase to 2.1 times its current size.	The increase in median age of population is expected to have minimal impact on the road network.	Changes to use of public transit may affect traffic characteristics. The biennial pavement condition data collection will capture changes to pavement condition performance.

Table 7.1 (cont'd) - Demand Drivers, Projections, Impact on Services and Management Plan

Demand Driver	Present Position	Projection	Impact on Services	Demand Management Plan
Seasonal Factors	Shifts in temperature and precipitation from summer to winter months	Per climate change models, shifts in temperature and precipitation from summer to winter months are expected to continue for the foreseeable future.	Seasonal changes have an impact on the road network. The City's operations, maintenance and capital programs are driven by seasonal change. The City has and will continue to collect, analyze and monitor condition data as it relates to seasonal factors.	The road network will be monitored. The biennial pavement condition data collection will capture changes to pavement degradation due to seasonal factors. Maintenance and operational requirements may change with potential changes to snow removal, street sweeping and pothole repair.
Technological Advancement	The City reviews available technology to improve the level of service provided by the road network.	The need for additional investment in technology is anticipated.	Technological advancement will provide the opportunity to investigate process improvements.	Changes in technology will be reviewed for opportunities for implementation into the asset renewal program.
Economic	Jobs: 79,440	Jobs (2046): • Modest: 81,230 • Mid-Range: 85,750 (Reference Scenario) • High: 90,460	The City's employment is expected to grow with the minor projected increase in population. Impact on the road network is anticipated to be minimal.	The City will continue to monitor employment. Should the employment deviate from the expected constant, the data will be analyzed to formulate an appropriate plan.
Environmental Awareness	Through legislation and the City's own actions, the City has demonstrated that it recognizes the need for environmental and climate protection. The City has adopted the CEEP and a complete streets policy.	Environmental awareness is anticipated to result in additional legislative requirements and stricter best practices.	Addition of sidewalks and bike lanes may result. Investigation of Rapid Transit Bus Lanes on high importance GOVA routes.	Alternate green methods of road resurfacing and rehabilitation will be used, new methods will be reviewed and piloted where deemed appropriate. Active transportation planning included in capital projects where identified in Transportation Master Plan and deemed appropriate. CEEP and climate change considerations will become integral part of project planning.

8 Community Energy and Emissions Plan and Climate Change

8.1 Community Energy and Emissions Plan

In September 2020, Council authorized staff to proceed with the next steps in the implementation of the Community Energy and Emissions Plan (CEEP). The CEEP outlines 18 goals that are to be achieved to attain the City's target of becoming a net-zero GHG emission community by 2050.

The City has historically been involved in early adoption of asphalt recycling technologies such as Cold In-place Recycled Asphalt Expanded Asphalt Mix (CIREAM) or Cold In-place Recycling (CIR) asphalt. The City is currently in the process of completing a pilot project using Hot In-place Recycling (HIR) technology to determine if this technology will be a suitable substitute for mill and pave asphalt maintenance activities. The HIR process could result in savings in the scheduled resurfacing of roads that are indicated at the 15 and 45 year marks of the life cycle costing table indicated in Section 6.2.

Other City initiatives include annual funding for new sidewalks and bike lanes, and development of a Traffic Congestion Index for evaluation and development of solutions to traffic flow issues within the transportation system. Solutions will be expected to reduce travel times and reduce GHG emissions.

As part of the ongoing work of asset management planning and prioritization, environmental scans of different technologies will be completed and the evaluation will result in recommendations for consideration for technologies into operational and capital programs.

8.2 Climate Change

A primary goal of an asset management plan is to maintain the asset in a way that is resilient and sustainable. This means the level of service will meet the needs of the present community without compromising the needs of the future community. Levels of service will be reviewed with a climate change lens with risk assessment. Climate change may affect such parameters as freeze/thaw cycles, precipitation, storm intensity and changes to construction season length. In addition to the possibility of negative impacts, there could be some positive impacts which may result such as the potential for lower winter control costs. Service levels will be reviewed on an ongoing basis to determine if they need be adjusted or scaled back as a result of the potential for changes in priorities.

To analyze the effects of climate change, the City reviews online resources such as:

- Climatedata.ca, undertaken with the support of Environment and Climate Change Canada;
- Climateatlas.ca, undertaken with the support of Environment and Climate Change Canada, Public Health Agency of Canada, and Health Canada.

Climatedata.ca and Climateatlas.ca analyze parameters called pathways named RCP4.5 and RCP8.5. RCP means Representative Concentration Pathway which is a greenhouse gas

concentration trajectory. The greenhouse gas concentration trajectory is not to be confused with current emissions, although emissions impact the atmospheric concentrations. These are defined as indicated below:

RCP 4.5: This pathway is intermediate because global emissions would peak by 2040. CO2 emissions must reduce to half of the 2050 levels by 2100, CH4 emissions must decline by 75% in the decade leading to the year 2050, and SO2 emissions must decline by 80% of the SO2 emission level from 1980. Similar to RCP 2.6, this scenario requires negative CO2 emissions equivalent to a minimum of two Gigatons/year every year from natural sources to keep the global temperature rise between 2°C and 3°C by the year 2100. Many plant and animal species will not be able to adapt to the effects of RCP 4.5 or higher.

RCP 8.5: This pathway is business as usual. Emission will continue to rise on the current global pace throughout the 21st century.

Global Climate Models depict how the climate is likely to change in the future. As no single climate model is correct, the asset management plan will consider the effect of Low Carbon (RCP 4.5) and High Carbon (RCP 8.5) pathways on the road network. The two scenarios are appropriate as RCP 4.5 assumes a drastic and sustained reduction of emissions in the coming decades, while RCP 8.5 represents the current global pace; emission of very large amounts of carbon dioxide from the burning of fossil fuels.

Table 8.1 provides the results of several Global Climate Models for the City of Greater Sudbury geographic area with high and low carbon emission scenarios and the anticipated impact on the road network. It is important to note that the anticipated impact is of climate change on infrastructure, not the potential impact of infrastructure contribution to climate change.

Table 8.1 - Climate Change Scenarios and Impact on Services

Variable	Current Mean	RCP	2021 - 2050	2051 - 2080	Anticipated Impact
			Mean	Mean	
Precipitation (mm)	848	High 8.5 Low 4.5	904 890	938 924	The increase in precipitation may increase the risk of ROW flooding or washout and may increase stress on pavement structures. An increase in precipitation is expected to result in increased gravel road costs.
Mean Temperature	4.3°C	High 8.5 Low 4.5	6.5°C 6.3°C	8.8°C 7.3°C	Review of asphalt mix design.
Tropical Nights (+20°C)	1	High 8.5 Low 4.5	5 4	17 7	Review of asphalt mix design.
Very Cold Days (-30°C)	5	High 8.5 Low 4.5	1 2	0 1	The decrease in very cold days may reduce the frost penetration depth.
Very Hot Days (+30°C)	6	High 8.5 Low 4.5	18 16	39 24	Review of asphalt mix design.
Frost-Free Season (days)	137	High 8.5 Low 4.5	163 157	184 168	Impact cannot be projected as there could be benefits or drawbacks (i.e extended early spring temperatures and moisture or additional days of sound dry road structure)
Freeze Thaw Cycles	68	High 8.5 Low 4.5	64.2 65.4	61.5 64.3	The decrease in freeze-thaw cycles is expected to lengthen expected road service life.
Mild Winter Days (-5°C)	120.1	High 8.5 Low 4.5	103.6 104.5	84.2 96.6	Impact cannot be projected as there could be benefits or drawbacks. (i.e. less snow removal or negative impact on road structure)
Summer Days (+25°C)	42.9	High 8.5 Low 4.5	68.9 65.2	93.8 77.4	Review of asphalt mix design.
Winter Days (-15°C)	58.4	High 8.5 Low 4.5	42 43.9	24.8 35.3	Impact cannot be projected as there could be benefits or drawbacks. (i.e. less snow removal or negative impact on road structure)

9 Next Steps and Future Opportunities

9.1 Next Steps

Following completion of Part 1 of the Roads and Transportation Asset Management Plan, target level of service options required for Part 2 of the RTAMP work will be prepared for Council review and discussion. The target level of service framework will be an important driver of the sustainability strategy. Proposed service levels will have impact on asset condition, life cycles, financial commitments and associated risks.

The following tasks are the next steps in development of Part 2 of the Roads and Transportation Asset Management Plan:

- Develop proposed level of service options which will include a review of the following:
    a. Varying paved road surface condition levels based on road class and traffic;
    b. Strategies for investment in Poor and Very Poor roads;
    c. Review of maintenance activity levels of service;
    d. Establish target service level for percentage of roads in Fair condition or better;
    e. Establish target service level for investment as percentage of asset replacement value;
    f. Service levels for surface treated and gravel roads;
    g. Review other indices for possible addition to level of service metrics.
- Identify differences between existing service levels and proposed service levels;
- Assessment of risk for proposed level of service options;
- Estimate asset performance over 10 years for various level of service options;
- Review affordability of proposed service levels and determine if service levels are achievable;
- Select the target level of service that is appropriate for the community;
- Identify improvement opportunities to operating and capital programs, recommend action items to provide improved alignment between operating and capital activities;
- Update road network valuation and incorporate into pavement management system;
- Implement risk analysis into pavement management system;
- Provide options for lifecycle management and associated financial strategies;
    a. Lifecycle evaluation and assumptions;
    b. Lifecycle activities and activity options;
    c. Risks of lifecycle options;
    d. Identification of lowest cost lifecycle activity options;
    e. Estimates for activities identified (capital and operating costs);
    f. Projected available annual costs for activities;
    g. Review of alternate lifecycle options and evaluation;
    h. Management of risks associated with recommended activities not selected for implementation.
- Develop long term financial strategy options (60 years);
- Incorporate considerations for future growth and development demand;

- Identify opportunities for implementation of green technologies;
- Identify impacts and strategies to manage risks associated with climate change;
- Identify future improvement opportunities.

9.2 Future Opportunities

Asset management planning establishes a baseline of the current asset management practices that will guide asset management planning and will be subject to continuous review and improvement. Future opportunities and tasks will include:

- Continue to improve quality of data and incorporate assets into the management plan for all assets including those associated with paved and unpaved road data, sidewalks, signs, guide rails, traffic signals, street trees, retaining walls, rock cuts and other assets deemed to be appropriate for inclusion into the RTAMP;
- Develop and incorporate congestion index into level of service metrics;
- Improvement in asset management planning including improvements to valuation, lifecycle analysis through project reviews including cost analyses and review asset performance under various selected treatments;
- Continuous improvements to risk analysis including regular review and assessment for possible realignment and revisions as may be deemed by current requirements;
- Continuous review and monitoring of operational activities on paved and unpaved roads to evaluate expenditures, best practices and evaluation of activity impact on asset life cycle;
- Alignment of roads asset management drainage assets with those identified in the stormwater asset review;
- Development of a corridor approach to level of service and project prioritization with the objective to integrate level of service and prioritization review of multiple asset class projects including water and wastewater, drainage and storm water management, and bridges/large culverts;
- Continue to review methods for project alignment with CEEP and climate change resilience.