

Transportation Asset Management Plan

Iteration No. 1, 2020

City of New Westminster

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1. Executive Summary

1.1 Key Performance Indicators

Eight performance indicators are utilized in the Transportation Asset Management Plan (AMP) to help the City of New Westminster (the City) develop an optimized program for the responsible stewardship of the transportation capital assets (See Table 1).

The suite of KPIs collectively "tell the story" of the physical and financial health of the assets. They are presented in the form of a dashboard that provides a useful "heat map" for benchmarking the relative performance of the different assets in the City's transportation portfolio and for monitoring changing conditions and progress over time.

Table 1 – KPI Matrix by Asset Class

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Classes	**Data Quality Score** (0-100)	**Asset Avg. Age**	**Asset Condition Score** (1-5)	**PoF (1-100)**	**CoF** (1-100)	**Risk** (1-5)	**Capital Needs, 10 years**	**Annual Reinvestment Rate**
Roads	67%	--	2.45	29	17	2.50	$35,071,464	1.08%
Bridges	37%	84.1	3.84	28	47	3.26	$585,829	0.17%
Retaining Walls	93%	46.4	1.71	45	67	3.86	$3,668,798	2.66%
Roads	67%	--	2.45	29	17	2.50	$35,071,464	1.08%
Tunnel	100%	49.0	1.87	25	42	3.04	--	--
Sidewalks	90%	--	1.89	42	16	2.94	$4,406,600	1.26%
Wheelchair Ramps	0%	--	1.00	--	--	0.00	$111,665	0.67%
Service Panels	87%	--	2.00	57	31	3.67	$92,006	4.72%
Signs	0%	15.3	2.11	66	24	4.00	$1,128,907	6.49%
Traffic Controllers	97%	--	1.88	38	40	3.35	$6,546,092	3.86%
Lighting	98%	18.0	2.18	43	29	3.24	$8,050,139	2.93%
Totals & Averages	**55%**	**42.4**	**2.15**	**49**	**23**	**3.23**	**$59,661,503**	**1.30%**

A brief description of each the eight KPIs is included below, including references to the corresponding sections of the AMP for information for further discussion.

Table 2 – Description of the Eight KPIs

KPIs		Description	Section(s) of the AMP
1	**Data Quality**	A measure of the degree of confidence in the transportation data, particularly data on asset condition. In cases where there is no empirical (i.e. evidence-based) data, the model in	Section 2

KPIs		Description	Section(s) of the AMP
		the AMP relies on age-based condition and risk-based condition.	
2	**Asset Average Age**	A measure (indirectly) of the remaining useful lives of the transportation assets, measured in years. Asset age has some correlation with asset condition and Probability of Failure (PoF).	Section 3
3	**Asset Condition**	A measure of the physical state of the transportation assets on a 5-point grading scale, as contemplated in the Canadian Infrastructure Report Card (CIRC).	Section 3
4	**Probability of Failure (PoF)**	A measure of the likelihood of transportation assets reaching potential failure and thereby requiring capital renewal or other treatment to extend service life.	Section 5
5	**Consequences of Failure (CoF)**	A measure of the criticality of the transportation assets relative to the City's goals and objectives. Criticality is an expression of the triple bottom line criteria of social, environmental and financial factors considered in decision making.	Section 5
6	**Risk Score**	A measure of the combination of PoF and CoF. Higher risk scores may suggest that assets are candidates for capital renewal projects earlier in the planning horizon. Sometimes, however, a high-risk score may suggest candidates for contingency planning (rather than capital investment).	Section 5
7	**Capital Needs**	A measure of the total value of all transportation capital projects that have been identified over the planning horizon (10 year from 2019 to 2028).	Section 7
8	**Reinvestment Rate**	A measure of the rate to maintain the in-scope transportation assets, expressed as a percentage of the overall asset replacement value.	Section 7 & 8

The eight KPIs are addressed in more detail throughout the report. A focus on the performance of each asset class is included in Appendix A.

1.2 Asset Inventory

The following table provides a high-level summary of the ten in-scope asset classes included in the Transportation AMP.

Table 3 – Asset Inventory

Asset Classes		Inventory	Section(s) of the AMP
1	**Pavement/Roads**	Comprised of 252 km of roads, including 23.8 km of MRN, 2.7 km arterial roads, and 133.3 km of local roads.	Appendix A

Asset Classes		Inventory	Section(s) of the AMP
2	**Bridges**	Comprised of 27 bridges, including 13 vehicle bridges, 6 pedestrian bridges, and 6 railroad bridges.	Appendix A
3	**Retaining Walls**	Comprised of 27 retaining walls.	Appendix A
4	**Tunnel**	Comprised on 1 pedestrian tunnel.	Appendix A
5	**Sidewalks**	Comprised of 475,000 m^2 of sidewalks.	Appendix A
6	**Wheelchair Ramps**	Comprised of 3262 wheelchair ramps.	Appendix A
7	**Service Panels**	Comprised of 195 service panels	Appendix A
8	**Signs**	Comprised of 5,439 signs.	Appendix A
9	**Signal and Traffic Controllers**	Comprised of 97 signal and traffic controllers.	Appendix A
10	**Streetlights**	Comprised of 3,812 streetlights.	Appendix A

Further details on the inventories and asset hierarchies for each of the in-scope transportation asset classes is included in Appendix A.

1.3 Asset Valuation

The transportation assets are collectively valued at approximately **$458 Million (2019)**. The breakdown by asset class is provided in Figure 1 below.

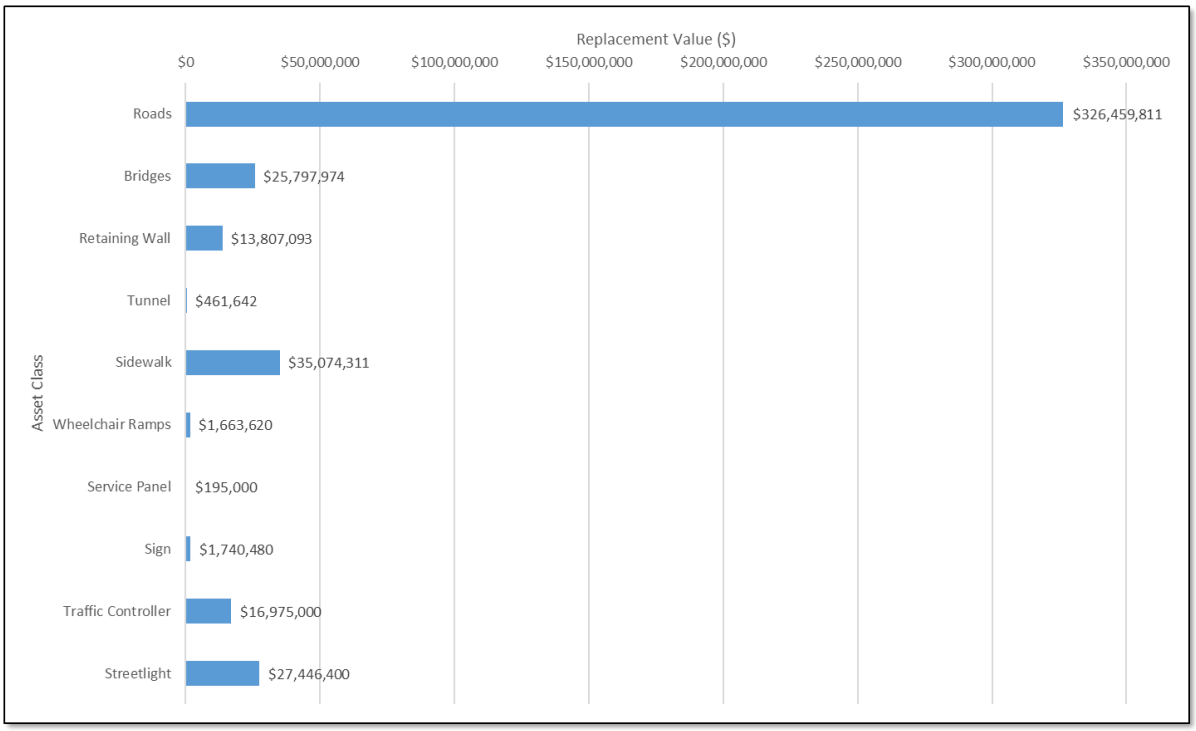


Figure 1 – Asset Valuation by Asset Class

The pavement/roads asset class represents approximately 70% of the transportation portfolio asset replacement value. Further details on the methodology used to determine the values is included in Section 7 and details on the valuations of the individual asset classes are provided in Appendix A.

1.4 Asset Condition

The asset condition model in the AMP contemplates a hybrid of: (a) age-based condition (for those assets that have not yet been subject to empirical condition analysis); and (b) evidence-based condition (for those assets where data has been validated in the field).

Based on the City's source data, Figure 2 below provides a summary of the age profiles of the respective asset classes as of early-2019. For some of the asset classes there is currently no age-based data and this is represented as "n/a" on the chart.

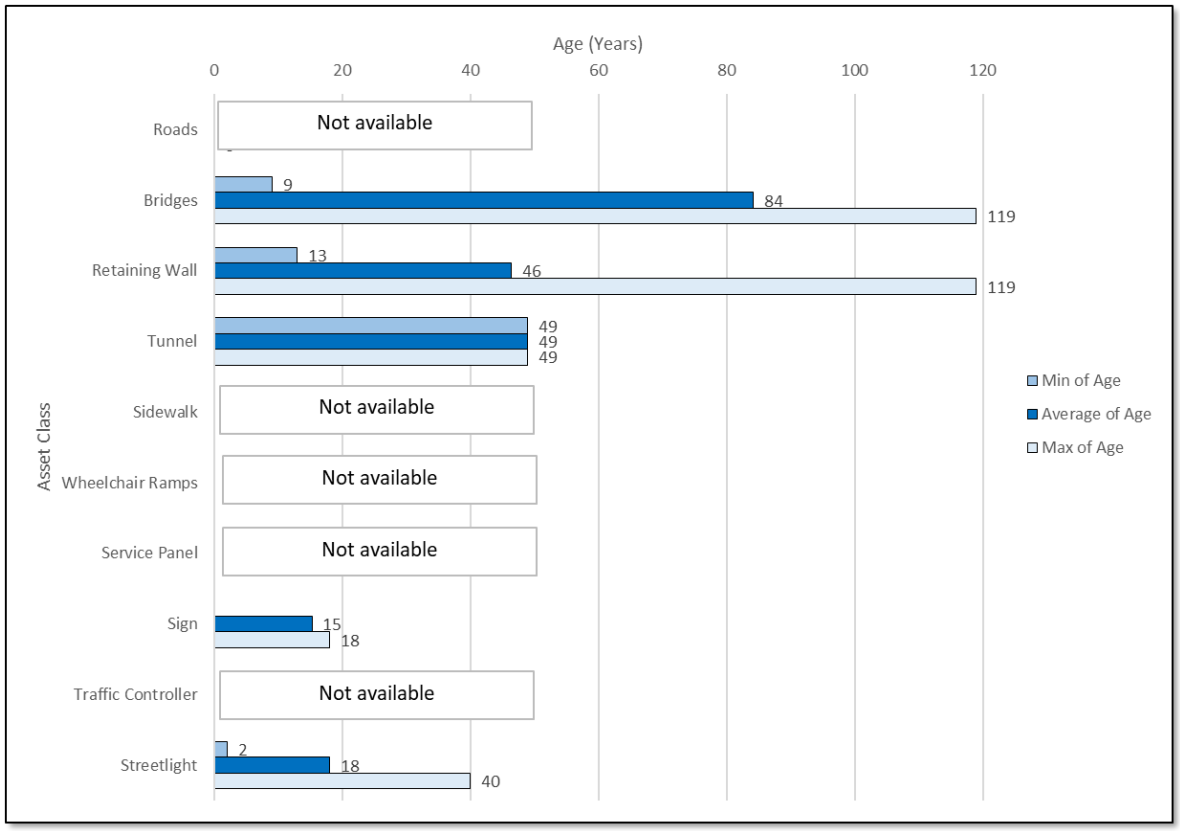


Figure 2 – Asset Age Profiles by Asset Class

Figure 3 shows the condition profile of the City's transportation assets arranged by asset class derived from a hybrid of the asset age profiles and evidence-based condition, where data is available.. Condition is graded on a 5-point scale in conformity with the qualitative descriptions in the Canadian Infrastructure Report Card (CIRC).

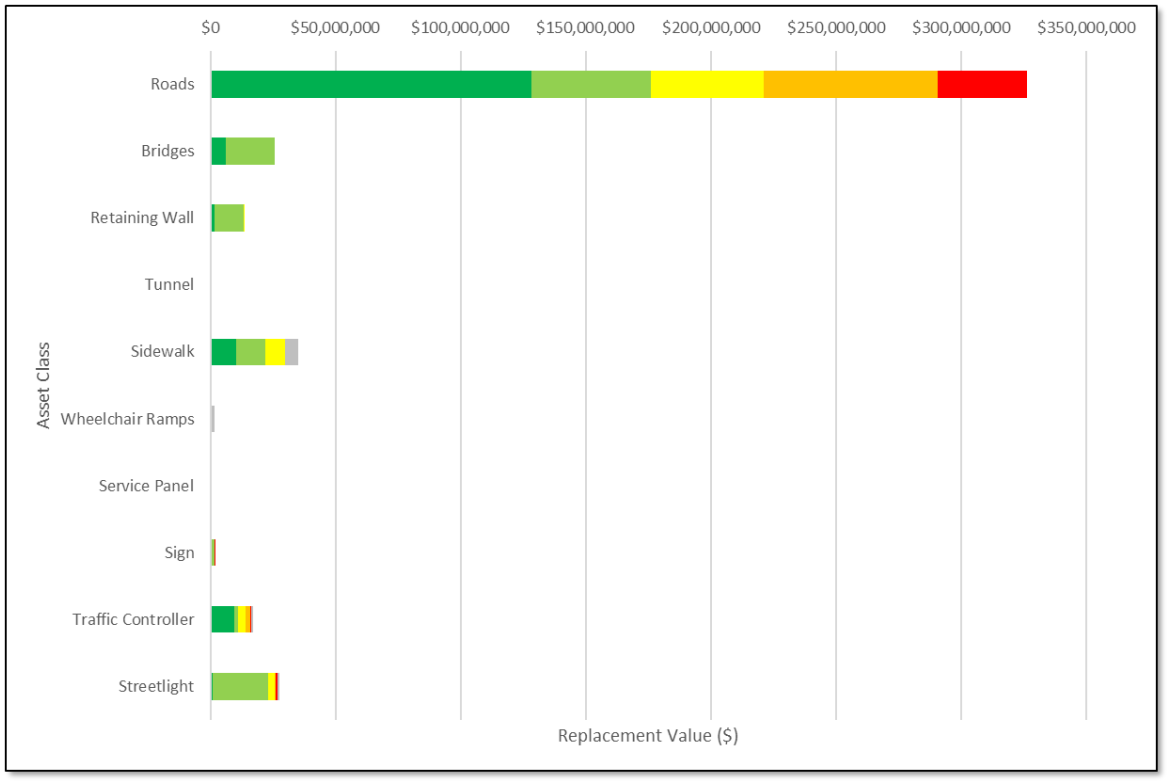


Figure 3 – Asset Condition by Asset Class

Approximately $37 Million (8%) of the transportation asset portfolio is in “very poor” condition, of which the vast majority is in the pavement (road class) category. The condition grading methodology is outlined in Sections 3 and 5 of the report and further details on the condition of the assets at lower levels of the asset hierarchy are included in Appendix A.

1.5 Asset Risk

An asset risk model has been integrated into the asset condition profiles in order to develop a more robust forecast of future asset needs. In this regard, assets of deemed higher criticality take priority in the investment timetable, particularly in a constrained funding context.

The asset risk model derives three scores for each asset: (a) the Probability of Failure (PoF); (b) the Consequences of Failure (CoF); and, (c) the product of the PoF and CoF scores. The PoF scores are directly translated from asset condition and are represented along the y-axis of the Risk Exposure Matrix (see below). The CoF scores, represented along the x-axis of the Risk Exposure Matrix are derived from the results of a criticality ranking of the assets.

Figure 4 provides a rolled-up scatter plot of the average risk scores for each of the ten in-scope transportation asset classes. The size of the bubbles represents the relative replacement value of the asset class.

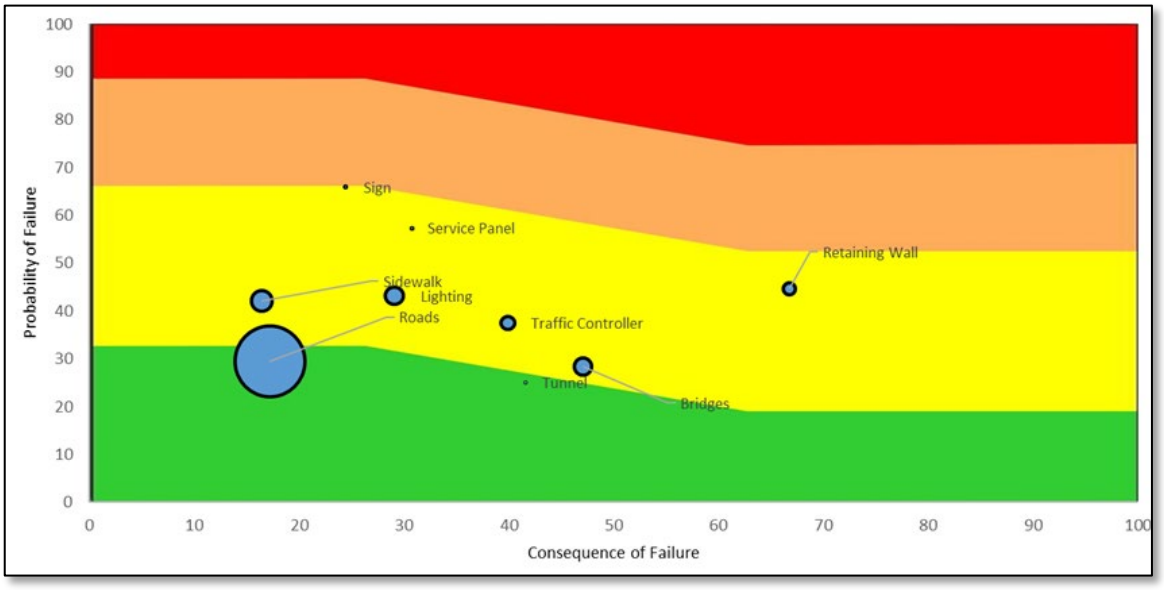


Figure 4 – Risk Exposure Matrix

In order to establish the relative criticality rankings along the x-axis of the Risk Exposure Matrix, the City's transportation group has embarked upon a journey of developing a weighting schema. Although the weightings have not yet been fully vetted, formally approved by City council and operationalized into a decision-making framework across all the City's assets, the following table provides an interim summary of the dialogue amongst the subject matter experts (SMEs) within each asset class.

Table 4 – Weightings for the Risk Model

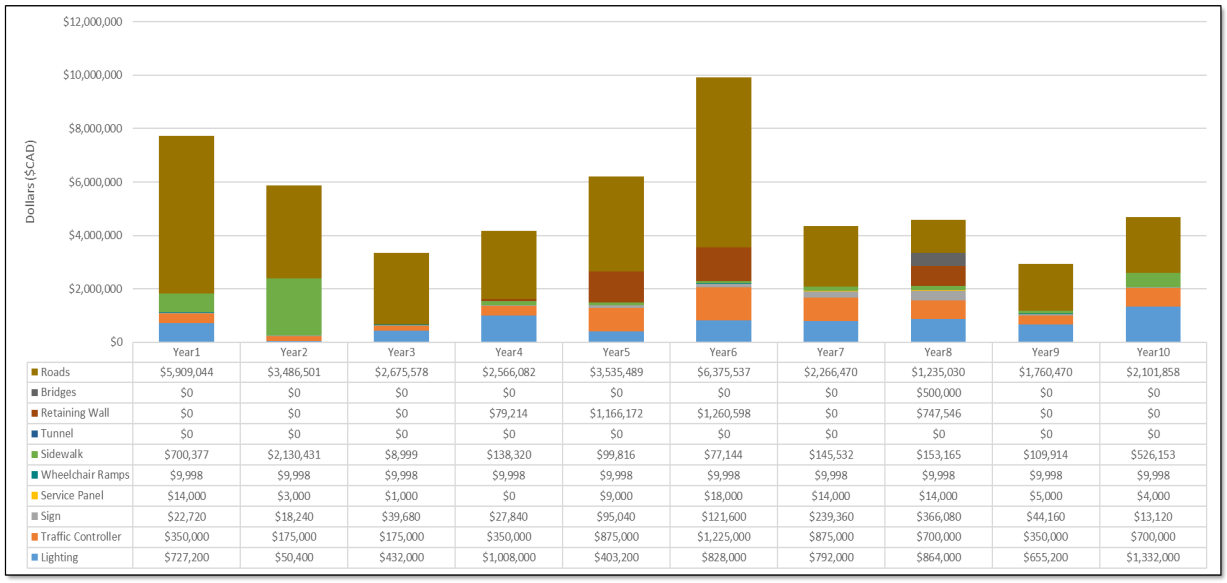
Model Criteria		Economic 18%	Social 12%	Environmental 38%	Operational 32%	
1	AADT	28%	20%			13%
2	Truck Route	20%		50%		17%
3	Road Class	32%			30%	22%
4	Land Use	20%	33%			17%
5	Transit Rout				27%	9%
6	Rail Crossing				15%	5%
7	Disaster Response Route				28%	9%
8	Sustainable Trans		27%			3%
9	Ambulance Route		20%			2%
10	Flood Plan			50%		9%
	Totals	100%	100%	100%	100%	100%

The methodology for development of the risk exposure matrix is included in Section 5 of the report and more detailed risk matrices that reveal the risk scores for assets at lower levels of the transportation asset hierarchy are included in Appendix A.

1.6 Asset Needs Forecast

It has been estimated that the transportation group will require an infrastructure reinvestment of approximately **$6.5 Million per year** to address the base life cycle needs of the in-scope transportation assets over the ensuing 10 years (2019-2028). This translates into approximately **1.4%** of the transportation's portfolio's current replacement value.

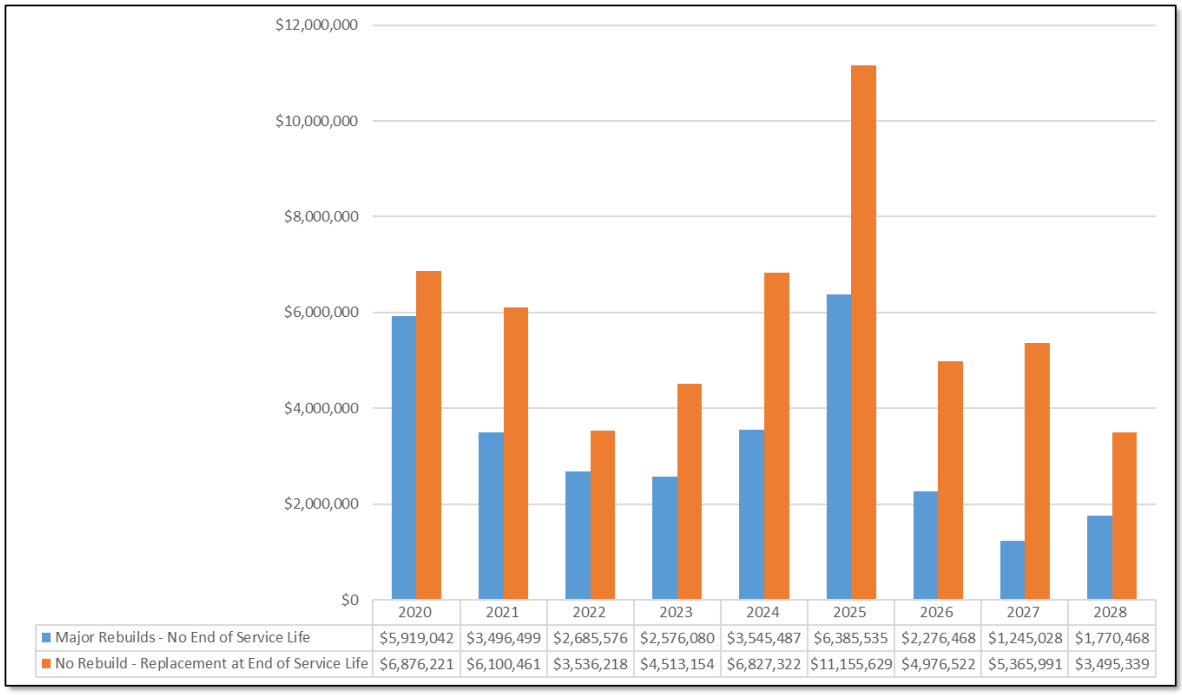
The capital projects have been identified through a combination of asset condition (to establish the general schedule for the projects) and asset criticality (to refine the relative sequence of the projects). Figures 5 through 7 provide a summary of the capital needs forecast for the City's transportation asset classes over a 10-year and 20-year planning horizon.



	Year1	Year2	Year3	Year4	Year5	Year6	Year7	Year8	Year9	Year10
Roads	$5,909,044	$3,486,501	$2,675,578	$2,566,082	$3,535,489	$6,375,537	$2,266,470	$1,235,030	$1,760,470	$2,101,858
Bridges	$0	$0	$0	$0	$0	$0	$0	$500,000	$0	$0
Retaining Wall	$0	$0	$0	$79,214	$1,166,172	$1,260,598	$0	$747,546	$0	$0
Tunnel	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sidewalk	$700,377	$2,130,431	$8,999	$138,320	$99,816	$77,144	$145,532	$153,165	$109,914	$526,153
Wheelchair Ramps	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998
Service Panel	$14,000	$3,000	$1,000	$0	$9,000	$18,000	$14,000	$14,000	$5,000	$4,000
Sign	$22,720	$18,240	$39,680	$27,840	$95,040	$121,600	$239,360	$366,080	$44,160	$13,120
Traffic Controller	$350,000	$175,000	$175,000	$350,000	$875,000	$1,225,000	$875,000	$700,000	$350,000	$700,000
Lighting	$727,200	$50,400	$432,000	$1,008,000	$403,200	$828,000	$792,000	$864,000	$655,200	$1,332,000

Figure 5 – Capital Needs Forecast, 10-year Planning Horizon

Recognizing that the capital projects vary in their scope, where some are classified as (a) full asset replacement projects; and others as (b) major rebuild projects, the following chart (Figure 6) summarizes the distribution of costs across these reinvestment categories.



	2020	2021	2022	2023	2024	2025	2026	2027	2028
Major Rebuilds - No End of Service Life	$5,919,042	$3,496,499	$2,685,576	$2,576,080	$3,545,487	$6,385,535	$2,276,468	$1,245,028	$1,770,468
No Rebuild - Replacement at End of Service Life	$6,876,221	$6,100,461	$3,536,218	$4,513,154	$6,827,322	$11,155,629	$4,976,522	$5,365,991	$3,495,339

Figure 6 – Capital Needs Forecast - Rebuilds vs. Replacements

Figure 7 shows an extended analysis of a 20-year planning horizon in order to provide a longer-range view of the transportation funding needs.



	2019	2020	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Roads	$5.9 M	$3.5 M	$2.7 M	$2.6 M	$3.5 M	$6.4 M	$2.3 M	$1.2 M	$1.8 M	$2.1 M	$0.2 M	$0.4 M	$0.3 M	$0.8 M	$1.9 M	$3.2 M	$6.6 M	$5.6 M	$7.3 M	$12.9 M
Bridges	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.5 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$2.1 M	$0.0 M	$0.5 M	$0.0 M
Retaining Wall	$0.0 M	$0.0 M	$0.0 M	$0.1 M	$1.2 M	$1.3 M	$0.0 M	$0.7 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.8 M	$0.0 M	$0.7 M	$0.0 M	$0.0 M	$0.0 M	$0.2 M	$0.0 M
Tunnel	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Sidewalk	$0.7 M	$2.1 M	$0.0 M	$0.1 M	$0.1 M	$0.1 M	$0.1 M	$0.2 M	$0.1 M	$0.5 M	$0.1 M	$0.4 M	$0.2 M	$0.4 M	$0.3 M	$0.3 M	$1.2 M	$0.7 M	$0.5 M	$1.2 M
Wheelchair Ramps	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Service Panel	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Sign	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.1 M	$0.1 M	$0.2 M	$0.4 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Traffic Controller	$0.4 M	$0.2 M	$0.2 M	$0.4 M	$0.9 M	$1.2 M	$0.9 M	$0.7 M	$0.4 M	$0.7 M	$1.1 M	$1.1 M	$0.5 M	$1.4 M	$0.2 M	$1.1 M	$0.7 M	$1.2 M	$0.7 M	$0.7 M
Lighting	$0.7 M	$0.1 M	$0.4 M	$1.0 M	$0.4 M	$0.8 M	$0.8 M	$0.9 M	$0.7 M	$1.3 M	$2.0 M	$1.3 M	$1.4 M	$2.9 M	$2.1 M	$3.6 M	$1.9 M	$4.5 M	$0.1 M	$0.2 M

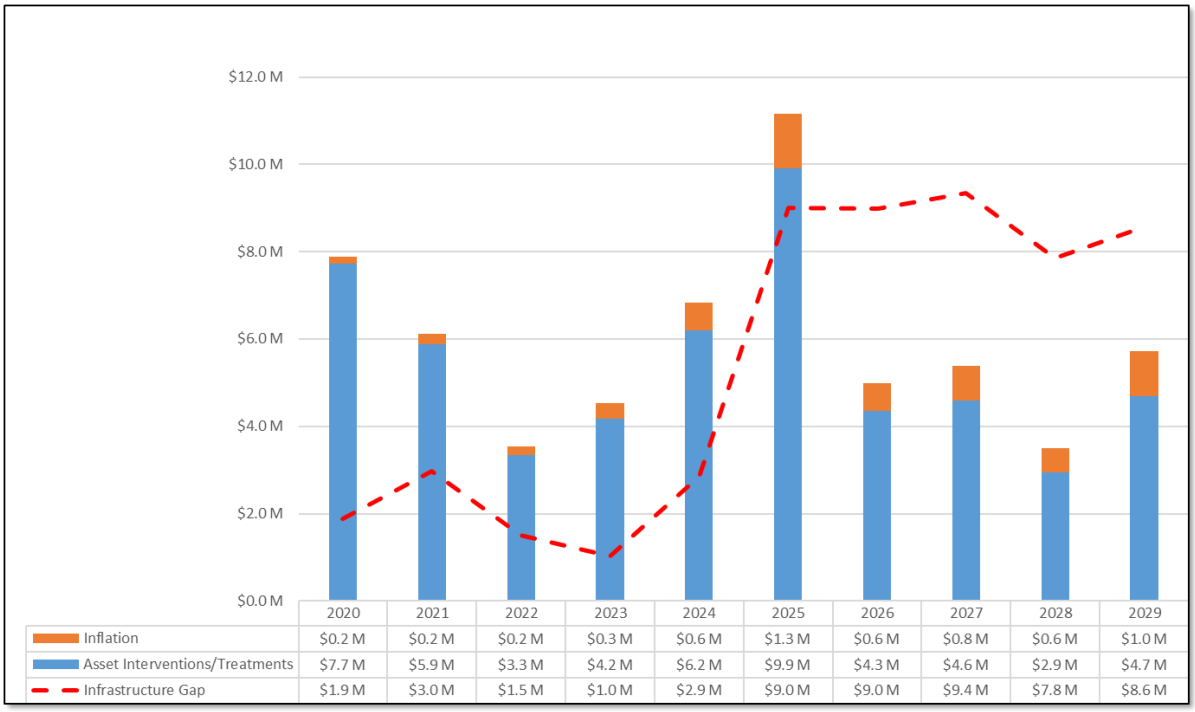
Figure 7 – Capital Needs Forecast over a 20-Year Planning Horizon

The methodology for development of the forecasting model is included in Section 7 of the report and more detailed forecasts at lower levels of the asset hierarchy are included in Appendix A.

1.7 Infrastructure Gap

The infrastructure gap, in simplest terms, reveals the potential mismatch between how much money the City will need over the planning horizon relative to how much funding it will have on hand. A series of alternative funding scenarios are included as a sensitivity analysis in Section 7 to test the impact of different funding levels.

As an illustration of one of these scenarios, Figure 8 shows the cumulative infrastructure gap resulting from a fixed annual reinvestment of **$5 Million** in the ongoing sustainment of the current portfolio of transportation assets, which represents the average historical funding level for the City's transportation assets.



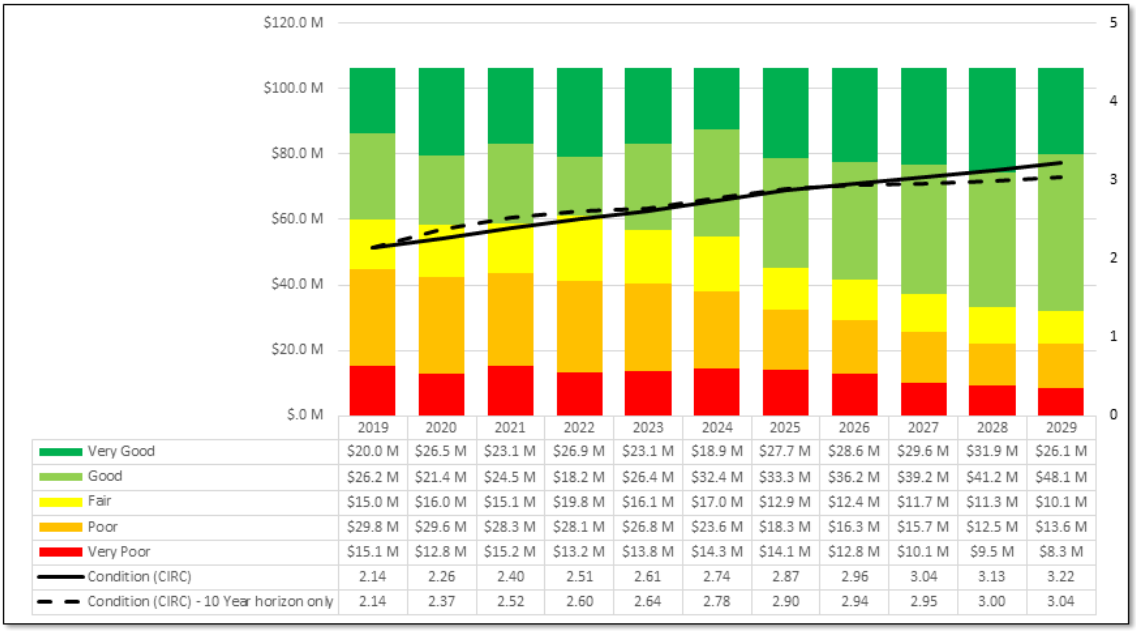
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Inflation	$0.2 M	$0.2 M	$0.2 M	$0.3 M	$0.6 M	$1.3 M	$0.6 M	$0.8 M	$0.6 M	$1.0 M
Asset Interventions/Treatments	$7.7 M	$5.9 M	$3.3 M	$4.2 M	$6.2 M	$9.9 M	$4.3 M	$4.6 M	$2.9 M	$4.7 M
Infrastructure Gap	$1.9 M	$3.0 M	$1.5 M	$1.0 M	$2.9 M	$9.0 M	$9.0 M	$9.4 M	$7.8 M	$8.6 M

Figure 8 – Infrastructure Gap at $5M Annual Investment

In the preceding figure:

- The vertical "blue" bars represent the forecast capital projects
- The solid "yellow" line represents the annual available investment (under the current scenario)
- The dashed "red" line represents the infrastructure gap

Recognizing that the funding levels will have an impact on overall portfolio condition, Figure 9 illustrates the evolving condition of the asset portfolio under the $5 Million per annum reinvestment rate.



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Very Good	$20.0 M	$26.5 M	$23.1 M	$26.9 M	$23.1 M	$18.9 M	$27.7 M	$28.6 M	$29.6 M	$31.9 M	$26.1 M
Good	$26.2 M	$21.4 M	$24.5 M	$18.2 M	$26.4 M	$32.4 M	$33.3 M	$36.2 M	$39.2 M	$41.2 M	$48.1 M
Fair	$15.0 M	$16.0 M	$15.1 M	$19.8 M	$16.1 M	$17.0 M	$12.9 M	$12.4 M	$11.7 M	$11.3 M	$10.1 M
Poor	$29.8 M	$29.6 M	$28.3 M	$28.1 M	$26.8 M	$23.6 M	$18.3 M	$16.3 M	$15.7 M	$12.5 M	$13.6 M
Very Poor	$15.1 M	$12.8 M	$15.2 M	$13.2 M	$13.8 M	$14.3 M	$14.1 M	$12.8 M	$10.1 M	$9.5 M	$8.3 M
Condition (CIRC)	2.14	2.26	2.40	2.51	2.61	2.74	2.87	2.96	3.04	3.13	3.22
Condition (CIRC) - 10 Year horizon only	2.14	2.37	2.52	2.60	2.64	2.78	2.90	2.94	2.95	3.00	3.04

Figure 9 – Portfolio Condition under a $5 Million per year Funding Scenario

Section 7 of the report includes three alternative scenarios: (a) Run to Failure; (b) Unconstrained Investment; and (c) a historical comparison.

1.8 Priority Projects

Recognizing the challenges of managing a 10-year forecast of projects, the following chart (Figure 10) provides an itemized list of the assets with the top-40 risk scores and their corresponding replacement values. This is intended to help the City embark upon a journey of pursuing cross-functional optimization by making defensible trade-offs when allocating the limited available funds across the ten asset classes.

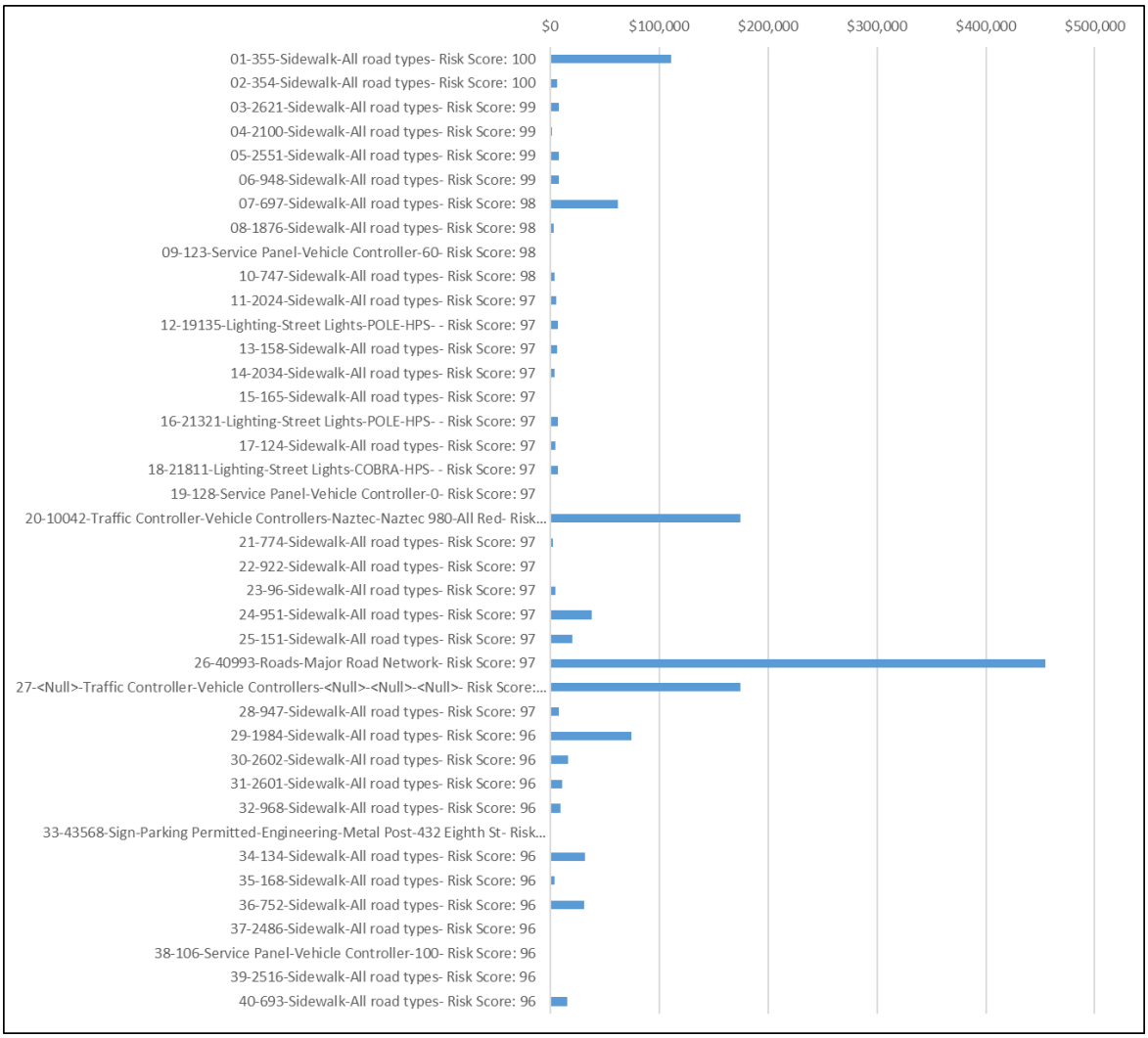


Figure 10 – Top-40 Projects by Risk Score (and corresponding project value)

The data suggests that some relatively small projects are deemed highly critical and completion of these projects would improve the overall risk score

1.9 Recommendations

As part of a journey of continuous improvement, Table 5 provides an itemized summary of the initiatives identified in the AMP, which are arranged primarily by asset class.

Table 5 – Recommendations

Asset Classes		ID	Description	Level of Effort	Level of Benefit
1	**Pavement/ Roads**	P.1	Develop LOS measures and targets	Med.	High
		P.2	Confirm the installation years and last treatment years of the pavement segments to improve the deterioration modelling	Med.	Med.

Asset Classes		ID	Description	Level of Effort	Level of Benefit
2	**Bridges**	B.1	Import the 2019 updated bridge condition data into the risk model and AMP forecasts	Low	High
		B.2	Develop LOS measures and targets	Med.	High
3	**Tunnel**	T.1	Update the AMP source data once the 2019 structures assessment is complete	Low	Med.
4	**Retaining Walls**	RW.1	Refine the asset hierarchy to enable analysis of the different types of retaining walls	Low	Med.
		RW.2	Import the 2019 updated RW condition data into the risk model and AMP forecasts	Med.	High.
5	**Sidewalks**	SW.1	Reconcile GIS coordinates for sidewalks with engineering data	Low	Med.
		SW.2	Develop LOS measures and targets	Low	High
6	**Wheelchair Ramps**	WR.1	Reconcile GIS	Low	High
		WR.2	Develop LOS measures and targets	Med.	High
7	**Lighting**	L.1	Enhance the asset hierarchy by confirming light fixtures that are located along parks walkways	Low	Med.
		L.2	Develop LOS measures and targets	Med.	Med.
8	**Traffic Controllers**	TC.1	Develop LOS measures and targets	Med.	Med.
		TC.2	Refine the asset hierarchy to clearly differentiate between vehicular and pedestrian controllers	Low	Med.
9	**Service Panels**	SP.1	Refine the asset hierarchy for the service panels into sustainable transportation categories	Low	Med.
10	**Signs**	S.1	Refine the asset hierarchy for the traffic signs to help distinguish the sustainable transportation asset class	Low	Med.

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Appendix A Analysis by Asset Class

Definitions

Included below are definitions of some key concepts that are used in the AMP.

Term	Definition
Asset	Anything that has potential or actual value to the City. Currently this is limited to Tangible Capital Assets.
Average Annual Lifecycle Investment	The annual investment needed to sustain existing infrastructure over its service life (over the next 20 years and beyond). AALCI must be considered in conjunction with infrastructure renewal deficit (backlog) as this is forward looking parameter that does not consider historical expenditures.
Asset Management	Coordinated activity of an organization to realize value from assets.
Capital Load	The total capital cost of an asset over the planning horizon.
Continual Improvement	Recurring activity to enhance performance.
Critical Asset	An asset having potential to significantly impact on the achievement of the City's objectives.
Infrastructure Renewal Deficit	A measure of the amount of infrastructure that has passed its theoretical service life but is still providing service to the community. This infrastructure should be inspected to determine if replacement is necessary for not.
ISO 31000	International Standard for Risk Management.
ISO 55000	International Standard for Asset Management.
Objective	A result to be achieved. Note: Objectives can relate to different disciplines (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process). "Risk" can therefore include positive possibilities (opportunities) as well as negative possibilities (risks).
Pairwise Analysis	A method for comparing criteria in pairs in order to judge which entity is preferred and by what degree. The pairwise analysis results in a series of weightings to be applied across the selected criteria.
Reinvestment Rate	The annual funding level for future renewal of the assets within an asset class, which is expressed as percentage of the costs to replace the entire asset class. The percentage is used for benchmarking against industry standards (such as RIC) and monitoring changes across fiscal cycles.
Risk	The effect of uncertainty on the City's objectives.
Risk Exposure Matrix	A plot of the composite scores of the risk hazards relative to their probability of failure (POF) and consequences of failure (COF).
Risk Management	A coordinated set of activities and methods that is used to direct an organization and control the many risks that can affect its ability to achieve its objectives.
Stakeholder	Any person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or an activity.
Structural Condition Index (SCI)	A measure of the condition of a transportation structure, such as a bridge, tunnel or retaining wall.

Term	Definition
Sustainable Transportation	Any means of transportation that is 'green' and has low impact on the environment. Examples include walking, cycling, transit, carpooling, car sharing, and green vehicles.
Tangible Capital Asset	Assets inventoried under PSAB 3150.
Weighting	The level of importance of something compared to something else.

Acronyms

Included below are some acronyms used in the Transportation AMP.

Acronym	Definition
AADT	Average Annual Daily Traffic
AAI	Average Annual Investment
AALCI	Average Annual Lifecycle Investment
ACA	Average Crack Area
AHP	Analytic Hierarchy Process
AMP	Asset Management Plan
AMS	Asset Management System (not to be confused with EAMS)
CAPEX	Capital Expenditure
CoF	Consequences of Failure
CMMS	Computerized Maintenance Management System
CIRC	Canadian Infrastructure Report Card
EAMS	Enterprise Asset Management System
GIS	Geographical Information System
IIMM	International Infrastructure Management Manual
IRI	International Roughness Index
ISO	International Organization of Standardization
KPI	Key Performance Indicator
MEAV	Modern Equivalent Asset Value
MTP	Master Transportation Plan
MRN	Major Road Network
OCP	Official Community Plan
OPEX	Operating Expenditure
PAS	Publicly Accessible Specification
PCI	Pavement Condition Index
PoF	Probability of Failure
PQI	Pavement Quality Index
PSAB	Public Sector Accounting Board
RACI	Responsible, Accountable, Consulted, Informed
REM	Risk Exposure Matrix

Acronym	Definition
RTF	Run to Failure
SAMP	Strategic Asset Management Plan
SCI	Structural Condition Index
SCR	Structural Condition Rating
SDM	Structured Decision Making
SME	Subject Matter Expert
SOI	State of Infrastructure
TCA	Tangible Capital Asset
TBL	Triple Bottom Line
UOM	Unit of Measure (e.g. Square Metres)

2. Introduction

GHD Limited (GHD) was retained by the City of New Westminster (the City) to assist in the development of an Asset Management Plan (AMP) for the City's in-scope transportation assets.

2.1 Background

In 2018 the City originally started preparing the AMP in-house and city staff developed the state of infrastructure chapter.

2.2 Purpose

The purpose of the AMP is to address a series of key questions that will assist the City in the responsible stewardship of the tangible capital assets in the transportation asset class.

Table 6 – Questions Addressed by the AMP

Questions		Measures, metrics & KPIs	Chapter(s) of the AMP
1	**What do we own?**	Inventory and hierarchy	Section 3
2	**What are our assets worth?**	Valuation	Section 4
3	**How long will our assets last?**	Asset Service Life	Section 3
4	**Which assets are beyond their theoretical service life and need to be inspected for condition?**	Infrastructure Renewal Deficit (backlog)	Section 3
5	**What is the relative importance of our assets?**	Risk Scores	Section 5
6	**When do the assets need to be replaced?**	Remaining Life	Section 6
7	**How much will it cost to replace the assets?**	Replacement Value	Section 6
8	**How much money will we need?**	Capital load; Reinvestment Rate	Section 6
9	**What assets do we fix first?**	Ranked Projects	Section 7
10	**How much money will we have?**	Average Annual Life Cycle Investment (AALCI)	Section 8
11	**What are the next steps on our journey?**	Recommendations	Section 9

2.3 Scope

The City provides a wide range of services to the community and stewards a portfolio of transportation assets for present and future generations. The Transportation AMP sits in a context of two broad asset categories.

Table 7 – Two Primary Asset Categories

Categories	Samples of Asset Types	In Scope of AMP
Natural Assets	Also referred to as "eco-assets" or "natural resources", includes natural capital such as trees, ditches, water bodies and other natural features within the City's boundaries.	No
Engineered Assets	Also referred to as "built assets", includes physical assets such as transportation, water distribution, sewer and drainage systems, vehicle fleets, parks, and facilities.	Yes - Transportation

Within this context, the City's transportation assets form a multi-modal transportation system, which serves the movement of regional goods, as well as local and regional travel for cyclists, motorists, and pedestrians alike. Table 8 provides a summary of the transportation assets that are included in the first iteration of the Transportation AMP.

Table 8 – Inventory of Transportation Assets

Asset Categories		Quantity	Unit of Measure
1	**Pavement/Roads**	252	Km
2	**Bridges**	11	Ea.
3	**Retaining Walls**	27	Ea.
4	**Tunnel**	1	Ea.
5	**Sidewalks**	475,000	m^2
6	**Wheelchair Ramps**	3262	Ea.
7	**Service Panels**	195	Ea.
8	**Signs**	5,439	Ea.
9	**Signal and Traffic Controller**	97	Ea.
10	**Streetlights**	3,812	Ea.

The inventory used in this AMP conforms to the data within the City's Geographic Information System (GIS), primarily collected by City staff. Human error in data entry is minimized through routine inspection and maintenance. The inventory is not 100% accurate due to data entry lag, especially for new or replaced assets. Detailed breakdowns of the inventories within each asset class is included in Appendix A.

2.4 Methodology

The methodology for development and integration of the asset condition model and the asset risk model is outlined in Table 9.

Table 9 – Condition and Risk Integration Methodology

Steps		Description	AMP Section
1	**Data Quality Assessment**	Review the existing asset data in order to ascertain the quality of the asset inventories, hierarchical structures and attributes. Identify data quality gaps against best practice and recommend opportunities for continual improvement.	Section 2 & 3
2	**Age Profiles**	Prepare a series of charts to illustrate the asset age profiles, including the minimum, maximum and average age for each asset class.	Section 3
3	**Age-based Condition Profiles**	Prepare a series of charts to indicate the existing age-based condition for each asset class.	Section 3
4	**Criticality Analysis**	Determine criticality criteria (i.e. Consequence of Failure) and assign triple-bottom-line (TBL) weightings.	Appendix A
5	**Risk Plot**	Assign composite risk scores to assets based on the probability of failure (i.e. physical condition in step 3) and the consequence of failure (criticality in step 4), taking into consideration the TBL factors. Plot the assets on a risk exposure matrix for each asset class.	Appendix A
6	**Risk-based Condition Profile**	Develop a risk-based condition profile that takes into consideration asset criticality in addition to the age-based and evidence-based condition of the assets.	Appendix A
7	**Risk-based Capital Needs Forecast**	Prepare a 10-year capital needs forecast that reconciles asset condition and asset criticality.	Section 7 & Appendix A

2.5 Structure

The AMP is arranged into eight sections, each of which is summarized in Table 10.

Table 10 – AMP Framework

	Title		Content
Body	1	**Executive summary**	Provides a succinct overview of the assets, highlighting major points.
	2	**Introduction**	Sets the overall context and expectations for the report.
	3	**State of Infrastructure (SOI)**	Presents insight into the asset portfolio including inventory, age and condition, accompanied by information on the quality of the supporting data.
	4	**Level of Service (LOS)**	Describes how service is linked to infrastructure investment. Defines how service is measured and how performance goals and expectations are identified and set.

	Title		Content
	5	**Risk Analysis**	Determines asset needs by identifying hazard events, evaluating risks, identifying treatments and controls, and establishing procedures for ongoing monitoring and review.
	6	**Life Cycle Strategies**	Sets planned actions that will enable the assets to provide the desired levels of service in a sustainable way, while managing risk and growth, at the lowest lifecycle cost.
	7	**Financial Strategies**	Describes the OPEX and CAPEX costs over the planning horizon and compares these to available funding. Identifies funding shortfall in relation to financial requirements and determines how the impact will be managed.
	8	**Implementation & Improvement plan**	Provides the initiatives for an asset management journey of continual improvement.
Appendices	**A**	**Analysis by Asset Class**	Detailed reports for each of the ten in-scope asset classes within the transportation group.

2.6 Data Confidence

The City had previously developed a State of Infrastructure chapter and requested that this analysis serve as the baseline for the 1st iteration of the Transportation AMP. Table 11 provides a summary of the scope of services regarding the manipulation of the source data for the AMP.

Table 11 – Data Management Roles

Data Management	Description	Example	In Scope
Data Collection/ Generation	Performing condition assessments and other field activities	Pavement & structures inspections	No
Data Compilation	Assembling data from multiple sources	Merging the risk model with the pavement condition mode	Yes
Data Cleansing	Correcting errors in the source data, such as gaps and inconsistencies	Removal of the “strata roads” category from the source data	Partial
Data Validation	Confirming the accuracy of the source data	Checking the unit rates for asset treatment	Partial
Data Modeling	Writing formulas to generate data analysis	Converting the risk model into a needs forecast along a planning timeline	Yes
Data Analysis	Interpretation of the data outputs		Yes

This AMP represents the first step on the City’s asset management journey. The AMP has differentiated between the following three types of data analysis.

Sources		Description	Corresponding Data confidence
1	**Age-based**	All that is known is the age of the asset. The “calendar age” drives the analysis.	Lowest
2	**Proxy-based**	Factors are used to adjust the “calendar age” so that an “effective age” is applied to the data.	Moderate
3	**Evidence-based**	The remaining useful life is used to establish the “effective age’.	Highest

Figure 11 provides a visual representation of the volume of data that has been modelled from each of the three data sources.

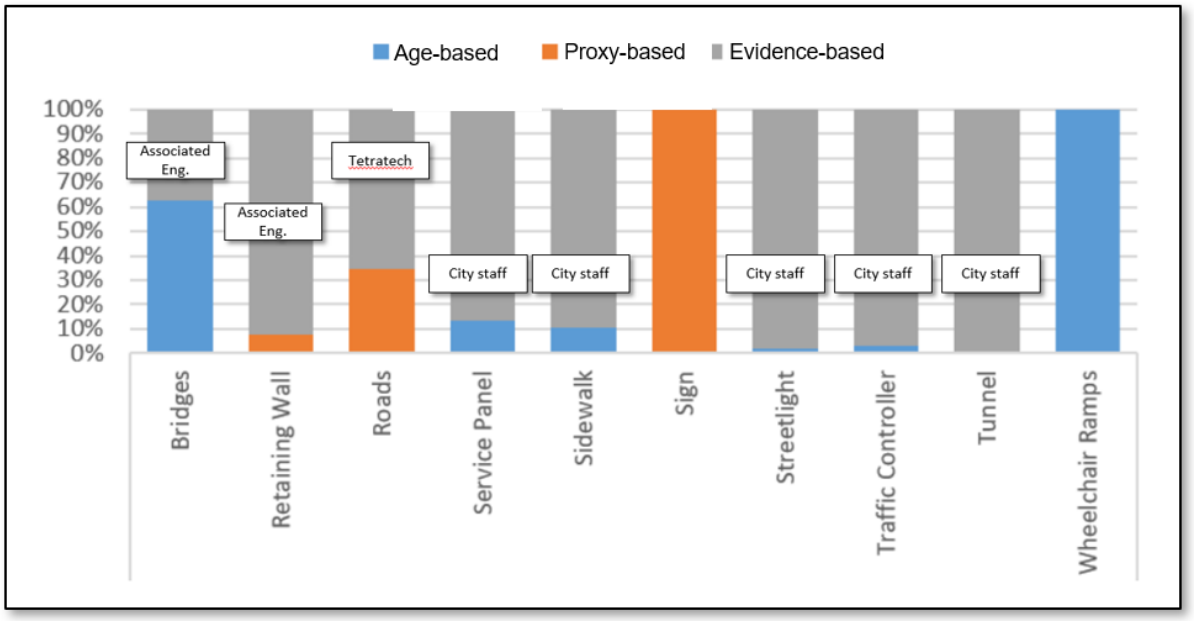


Figure 11 – Data Sources for each Asset Class

The data confidence analysis in the preceding figure suggests that the data sources vary dramatically across the asset classes. Table 12 provides a breakdown of the distribution of data sources for each asset class which allows for a benchmark comparison to be made between the asset classes and against the average scores.

Table 12 – Data Sources by Asset Class

Asset Classes		Age-based	Evidence-based	Proxy-based	Totals
1	**Pavement /Roads**	0.00%	65.36%	34.64%	100%
2	**Bridges**	62.96%	37.04%	0.00%	100%
3	**Retaining Walls**	0.00%	92.59%	7.41%	100%
4	**Tunnel**	0.00%	100.00%	0.00%	100%
5	**Sidewalks**	10.41%	89.59%	0.00%	100%

6	Wheelchair Ramps	100.00%	0.00%	0.00%	100%
7	Service Panels	13.33%	86.67%	0.00%	100%
8	Signs	0.00%	0.00%	100.00%	100%
9	Signs & Traffic Controllers	3.09%	96.91%	0.00%	100%
10	Street Lighting	1.97%	98.03%	0.00%	100%
	Averages	**21.31%**	**11.93%**	**66.76%**	**100%**

Table 13 below outlines the number of assets in the AMP source data that do not have a calculated installation year.

Table 13 – Number of Assets without Known install years

	Asset Classes	Assets Count	Install Year provided	Per Cent
1	Roads	2594	0	0%
2	Bridges	27	27	100%
3	Retaining Wall	27	27	100%
4	Tunnel	1	1	100%
5	Sidewalk	2631	0	0%
6	Wheelchair Ramps	1	0	0%
7	Service Panels	195	0	0%
8	Sign	5439	5439	100%
9	Traffic Controller	97	0	0%
10	Lighting	3812	2501	65%

The following pie chart (Figure 12) illustrates the distribution of across the three data sources, age-based, proxy-based and evidence-based.

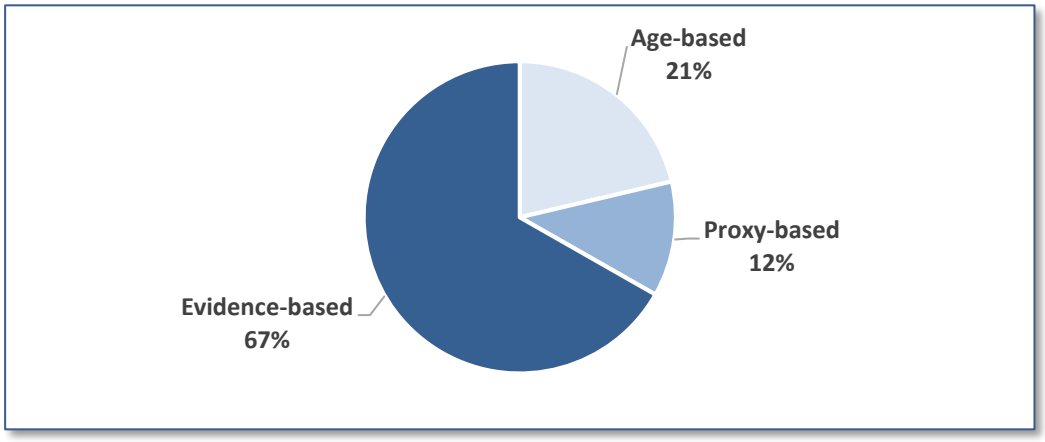


Figure 12 – Distribution of Data Sources

Data confidence in the AMP is classified on a 5-level scale in accordance with Table 14 below.

Table 14 – Data Confidence Grades

Grade	Reliability	Description	Accuracy
1	**Highly reliable**	Data based on sound records, procedures, investigations and analysis, documented properly and agreed as the best method of assessment.	Dataset is complete and estimated to be accurate ± 2%.
2	**Reliable**	Data based on sound records, procedures, investigations and analysis, documented properly but has minor shortcomings, for example some of the data is old, some documentation is missing and/or reliance is placed on unconfirmed reports or some extrapolation.	Dataset is complete and estimated to be accurate ± 10%.
3	**Uncertain**	Data based on sound records, procedures, investigations and analysis which is incomplete or unsupported, or extrapolated from a limited sample for which grade 1 or 2 data are available.	Dataset is substantially complete but up to 50% is extrapolated data and accuracy estimated ± 25%.
4	**Very uncertain**	Data is based on unconfirmed verbal reports and/or cursory inspections and analysis.	Dataset may not be fully complete and most data is estimated or extrapolated. Accuracy ± 40%.
5	**Unknown**	None or very little data held.	

While most of the transportation data is evidence based (approximately 67%), the City should consider making further refinements as part of its ongoing journey of continuous improvement. This will improve the defensibility of the funding forecasts and lend further credibility to the business cases for funding requests.

3. State of Infrastructure

The Transportation AMP recognizes that there are three facets of condition associated with the City's transportation infrastructure at different stages in its lifecycle. Table 15 provides a summary description of each type of condition, a few examples to illustrate and indication of which assets are susceptible to each of the condition factors.

Table 15 – Three Facets of Asset Condition

Types of Condition	Description	Distress Indicators (examples)	Susceptible Assets
Physical Condition	An asset's degradation and deterioration in terms of the individual physical elements in the overall assembly.	• Alligator cracking, potholes, corrosion, cracking, peeling, delamination, spalling, blistering, etc.	All assets
Demand Condition	An asset's capacity to meet the service needs of existing customers and future customers.	• Overloading • Under-utilization, etc.	Pavement Bridges, tunnel Service panels
Functional Condition	An asset's ability to meet the program and service delivery needs in an efficient and effective manner.	• Technological obsolescence (e.g. Spares availability) • Economic obsolescence (e.g. energy efficiency) • Legal obsolescence (e.g. code changes) • Functional obsolescence	Traffic controllers Service panels Streetlights

This first iteration of the Transportation AMP focuses primarily on the physical condition of the assets, primarily due to insufficient quantitative data being available to model functional condition. Demand condition and functional condition should be given addition consideration in future updates to the AMP and operationalized in the City's journey of continuous improvement.

With reference to the physical condition of the transportation assets, the following table provides a summary explanation for the two types of physical condition data that are contemplated in the AMP, including an estimation of the percentage of assets that fall into each condition category.

Table 16 – Age-Based Condition vs. Evidence-Based Condition

Types of Physical Condition Modeling	Description	Formula
Age-based condition	An estimate of the condition of an asset derived entirely from its calendar age relative to its expected useful life (based on statistical averages).	Calendar Age/Useful life
Evidence-based condition	An estimate of the condition of an asset from empirical data derived from observed conditions, which translates into a statement of the effective age. The effective age may be higher or lower than the calendar age depending on loadings and exposure conditions..	Effective Age / Useful life

Both age-based condition and evidence-based condition have been normalized to a standardized condition grading scheme. In this regard, the following table provides a comparative summary of the

5-point qualitative condition grading scheme contemplated in the Canadian Infrastructure Report Card (CIRC).

Table 17 – CIRC Condition Grading Scheme

Grade	Rating	Description (Qualitative)
1	**"Very Good"**	The infrastructure in the system or network is generally in very good condition, typically new or recently rehabilitated. A few elements show general signs of deterioration that require attention.
2	**"Good"**	The infrastructure in the system or network is in good condition; some elements show general signs of deterioration that require attention. A few elements exhibit significant deficiencies.
3	**"Fair"**	The infrastructure in the system or network is in fair condition; it shows general signs of deterioration and requires attention. Some elements exhibit significant deficiencies.
4	**"Poor"**	The infrastructure in the system or network is in poor condition and mostly below standard, with many elements approaching the end of their service life. A large portion of the system exhibits significant deterioration.
5	**"Very Poor"**	The infrastructure in the system or network is in unacceptable condition with widespread signs of advanced deterioration. Many components in the system exhibit signs of imminent failure, which is affecting service.

The condition degradation model in the AMP includes a hybrid of age-based condition (for those assets that have not been subject to empirical condition analysis) and evidence-based condition (for those assets where data has been validated in the field).

3.1 Asset Age Profiles

Figure 13 provides a summary of the age profiles, as of early-2019, across the various transportation asset classes. This information is used to support the age-based condition model (where necessary). For some of the asset classes there is currently no age data and this is represented as "n/a" on the chart.

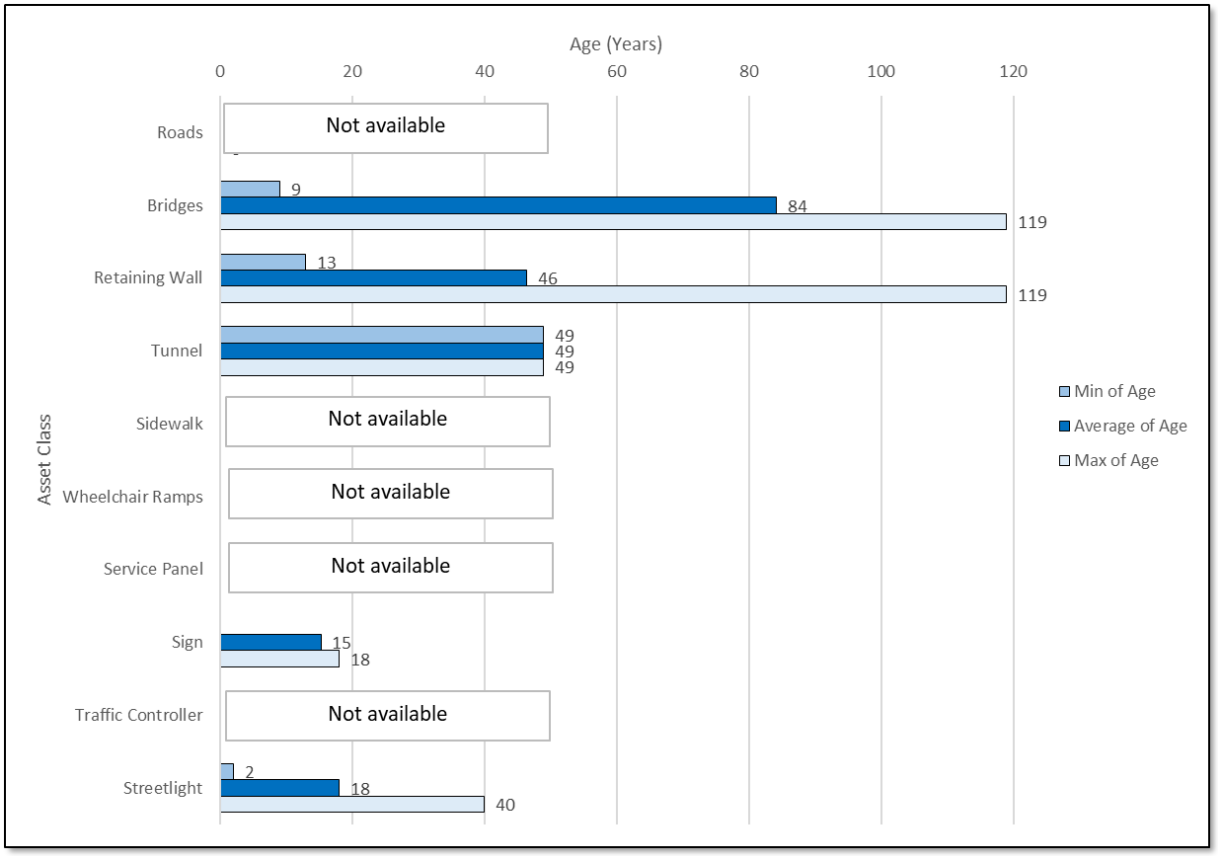


Figure 13 – Asset Age Profiles

Based on current (incomplete) data, the transportation assets are statistically averaged at approximately 42 years old. This is not an accurate reflection of overall asset age as it does not include the age profiles of the pavement segments, sidewalk segments, service panels, traffic controllers and wheelchair ramps.

The data on asset age is currently incomplete and the impact on data confidence and data modelling has been addressed in Section 1. A more detailed breakdown of asset age distributions by individual asset class and at lower levels of the asset hierarchy can be found in Appendix A.

3.2 Asset Useful Lives

Theoretical useful lives were developed by the City in 2009 to meet Tangible Capital Asset (TCA) reporting requirements under PSAB-3150. Actual useful lives are based on the professional judgement of experienced staff from the administration, design, and operations divisions within the Engineering Department.

The asset useful lives shown in Table 17 below approximate the time between the installation and failure of an asset; however, this time will vary with maintenance programs, and new standards or technology. The following table provides a summary of the asset useful lives that were developed by City staff and used in the 1st iteration of the transportation AMP.

Table 18 – Theoretical Useful Lives

ID	Asset Classes	Useful Lives (years)		Factors that may affect useful life
		TCA	Engineering	
1	**Roads – base layer**	100	100	
	Roads – surface layer	15-25	Arterial, MRN: 10	New public bus routes or increased frequencies introduce additional stress to base and surface material.
			Collector: 20	
			Local/Narrow, Lane, Recreation: 30+	
2	**Bridges**	75	75	Bridge design standards change.
3	**Retaining Walls**	75	75	Changing slope conditions affect the soil being retained.
4	**Tunnel**	75	75	Significant storms strain drainage systems.
5	**Sidewalks**	50	50	Tree roots cause cracking
6	**Wheelchair Ramps**	50	40	Vehicles that drive over ramp damage its underlying structure.
7	**Signs**	10	7 - 10	Vandalism inhibits sign visibility.
8	**Service Panels**	30	40	Dog urine deteriorates service bases.
9	**Traffic Signals**	30	30+	New traffic control systems
10	**Streetlights**	30	30+	Public complains about light brightness

Useful life can differ drastically in response to various factors, including shifting demand conditions and climate change. While actual useful life in this section serves as a helpful baseline, there is a need for the City to track age and develop a methodology to determine the “Remaining Useful Life” of individual assets, providing a more accurate representation of useful life for transportation infrastructure.

To place the useful lives of the transportation assets in the context of other assets classes, the following table is excerpted from the City’s TCA policy.

Table 19 – Asset Useful Lives Established by TCA for PSAB 3150 Reporting

Asset Category	Asset Segment	Useful Life
Buildings	Electrical	15-70 (building type)
	Envelope	20-25 (building type)
	Finishing	10-24 (building type)
	Mechanical	15-25 (building type)
	Structure	20-70 (building type)
	Wharf	50
	Columbaria	70
	Parking Lots	20

Asset Category	Asset Segment	Useful Life
Electrical Distribution System	Substation	5-100 (component type)
	Electrical Meters	40
	Manholes	100
	Overhead Underground Span	40-100 (type)
	Poles	40
	Pull Box	100
	Junction Box	50
	Switching Kiosk	50
	Transformers	50-100 (type)
	Switches	50
Land	Parcels	Not Amortized
	Land Under Roads	Not Amortized
Park Improvements	Infrastructure	5-75 (infrastructure type)
	Park Amenity	5-80 (amenity type)
	Sport Amenity	10-30 (asset type)
	Support to Amenity	7-50 (asset type)
Roads	Base Layer	100
	Surface Layer	15-25 (road type)
Sewer System	Outfall	50-75 (material)
	Sewer Pump Stations - Building	20-50 (type of building)
	Sewer Pump Stations - Chamber	50
	Sewer Pump Stations - Electrical	20
	Sewer Pump Stations - Hydraulics	20-50 (type)
	Sewer Pump Stations - Mechanical	20
	Sewer Pump Stations - Site Works	50
	Sewer mains - Combined	50-100 (material)
	Sewer mains - Force	75-80 (material)
	Sewer mains - Sanitary	50-100 (material)
	Sewer mains - Storm	50-100 (material)
Transportation - Other	Bridges	75
	Rail Crossings	50
	Retaining Walls	30-75 (type)
	Sidewalks	50
	Sidewalks – Wheelchair Ramps	50
	Bus Bays	25
	Signage	30
	Streetlights	30
	Traffic Circle	25
	Traffic Lights – Major Intersection	30
	Traffic Lights – Pedestrian Crossing	30
	Tunnels	75

It is strongly recommended that these useful lives be revisited over time and refined for the various sub-categories within each asset class.

3.3 Evidence-Based Condition

The City has commissioned reports from various engineering consulting firms to confirm the evidence-based condition of certain asset classes.

	Asset Class	Consultant	Scope	Year(s)
1	**Roads / pavement**	Tetratech	conduct condition assessments on certain road classes and to develop a management plan for the road network	2016
		AECOM	Risk framework	2018
2	**Bridges**	Associated Engineering	Condition assessment of transportation structures	2016 and 2019
3	**Tunnel**	Associated Engineering	Condition assessment of transportation structures	2016 and 2019
4	**Retaining walls**	Associated	Condition assessment of transportation structures	2016 and 2019

Other asset types were evaluated by City Staff.

Each asset was assigned a grade from 1-5 (with 1 being “Fit for purpose”, and 5 being “Unfit for sustained service”). The City uses the five-point rating scale as a standard for all AM-related condition assessments, to promote future benchmarking within the City and against other municipalities. This scale also aligns with the Canadian Infrastructure Report Card (CIRC) developed by the Canadian Construction Association (CCA), Canadian Public Works Association (CPWA), Canadian Society for Civil Engineers (CSCE), and the Federation of Canadian Municipalities (FCM).

The following table provides a comparative summary of the 5-point qualitative condition grading scheme contemplated in the Canadian Infrastructure Report Card (CIRC) and the City’s quantitative grading scheme.

Table 20 – CIRC Condition Grading Scheme

CIRC, Qualitative			City, Quantitative	
Grade	Rating	Description	PQI Pavement Quality Index	ACA Average Crack Area
1	**“Very Good”**	The infrastructure in the system or network is generally in very good condition, typically new or recently rehabilitated. A few elements show general signs of deterioration that require attention.	PCI 100-80	0
2	**“Good”**	The infrastructure in the system or network is in good condition; some elements show general signs of deterioration that require attention. A few elements exhibit significant deficiencies.	PCI 66-79	1-5

CIRC, Qualitative			City, Quantitative	
Grade	Rating	Description	PQI Pavement Quality Index	ACA Average Crack Area
3	**"Fair"**	The infrastructure in the system or network is in fair condition; it shows general signs of deterioration and requires attention. Some elements exhibit significant deficiencies.	PCI 55-66	5-10
4	**"Poor"**	The infrastructure in the system or network is in poor condition and mostly below standard, with many elements approaching the end of their service life. A large portion of the system exhibits significant deterioration.	PCI 35-54	10-30
5	**"Very Poor"**	The infrastructure in the system or network is in unacceptable condition with widespread signs of advanced deterioration. Many components in the system exhibit signs of imminent failure, which is affecting service.	PCI 0-34	30-100

Figure 14 provides a summary of the condition of the City's in-scope transportation asset classes distributed across the 5-point CIRC condition scale and displayed by asset value.

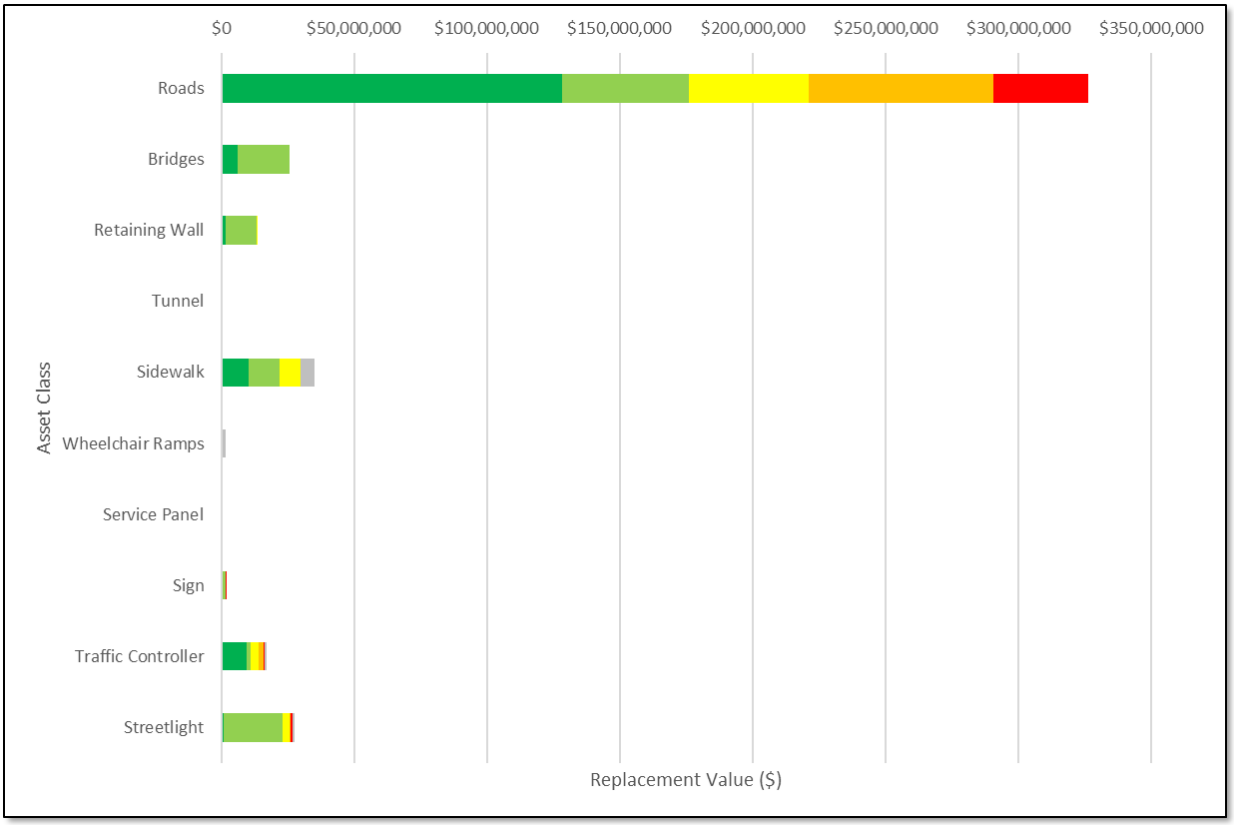


Figure 14 – Condition Grades for all Asset Classes, by Asset Value

Approximately $37 Million (or 8%) of the transportation asset portfolio is deemed to be in “very poor” condition, of which the vast majority is in the pavement (roads class) category. Further details on the condition of the assets at lower levels of the asset hierarchy are included in Appendix A.

Roads represent the largest asset class and exhibit segments in all five condition grades. The next graph represents the condition distributions as a percentage of the overall asset class.

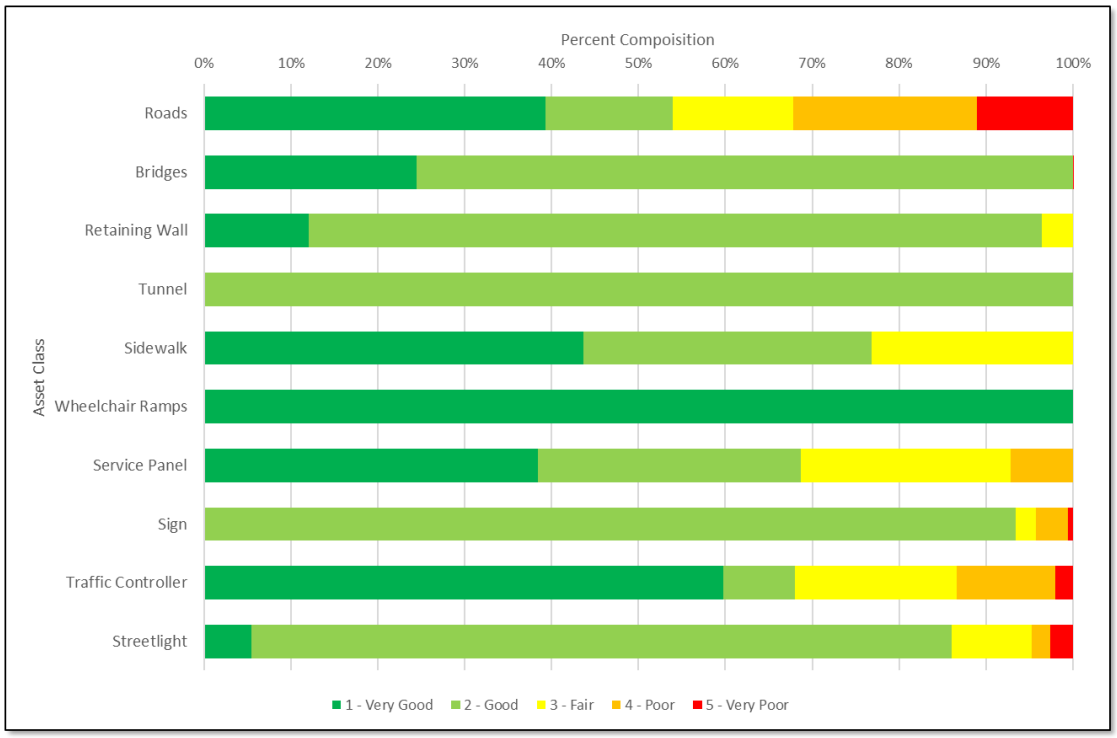
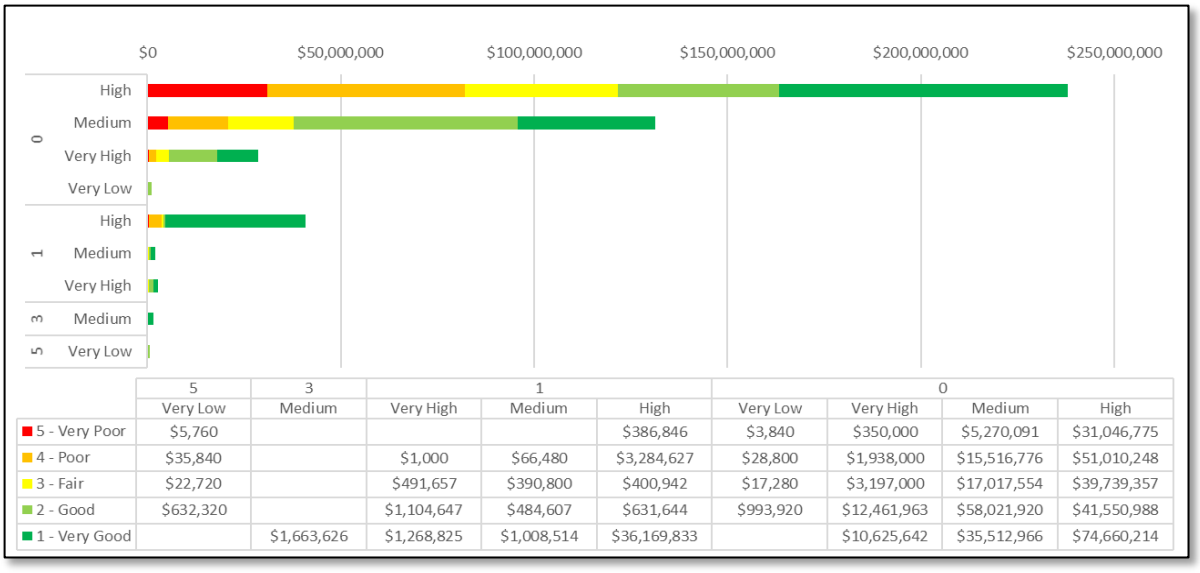


Figure 15 – Condition for All Assets Classes, as Percentage

Detailed breakdowns of the condition grades by individual asset classes and at lower levels of the asset hierarchy can be found in Appendix A.

Figure 15 provides a visual summary of the distribution of asset condition across the different asset criticality rankings (grade from 1 to 5). The criticality scale is based on the following ranking: 5 – Very Low Criticality, 4 – Low Criticality, 3 – Medium Criticality, 2 – High Criticality and 1 – Very High Criticality.



	5	3	1			0			
	Very Low	Medium	Very High	Medium	High	Very Low	Very High	Medium	High
5 - Very Poor	$5,760				$386,846	$3,840	$350,000	$5,270,091	$31,046,775
4 - Poor	$35,840		$1,000	$66,480	$3,284,627	$28,800	$1,938,000	$15,516,776	$51,010,248
3 - Fair	$22,720		$491,657	$390,800	$400,942	$17,280	$3,197,000	$17,017,554	$39,739,357
2 - Good	$632,320		$1,104,647	$484,607	$631,644	$993,920	$12,461,963	$58,021,920	$41,550,988
1 - Very Good		$1,663,626	$1,268,825	$1,008,514	$36,169,833		$10,625,642	$35,512,966	$74,660,214

Figure 16 – Condition Grades by Criticality Ranking

Approximately $35 Million of highly critical assets are deemed to be in very poor condition, which translates into 7% of total portfolio value. Information on the asset criticality model is in section 5 of the

report and detailed breakdowns of the condition grades by individual asset classes and at lower levels of the asset hierarchy can be found in Appendix A.

4. Levels of Service (LOS)

This section of the AMP describes how service is linked to transportation infrastructure investment. Where data is available, it also defines how service is measured and how performance goals and expectations are identified and set. The section of the report is arranged into four parts, as follows:

- Alignment with City Objectives
- Stakeholder Analysis
- Performance Metrics
- Demand Analysis

Some key definitions related to LOS are included at the beginning to this report.

4.1 Alignment with the City's Organizational Objectives

A level of service framework helps to translate the City's overarching organizational aspirations (that set the context and direction for the organization's activities) into concrete asset management work plans and activities within each department (or service area). The translation of qualitative statements into quantitative measures is shown conceptually in Figure 17 below.



Figure 17 – Level of Service hierarchy

Table 21 provides a summary of the seven layers of the hierarchy from core values to measurements within each department.

Table 21 – Aspirational-Transactional Hierarchy

	Hierarchy	Description
1	**Values**	The City's guiding principles
2	**Vision**	The community's view of the future
3	**Mission**	Why the City exists
4	**Goals**	Broad long-range outcomes
5	**Objectives**	The results to be achieved
6	**Strategies**	Steps that deliver on goals and objectives
7	**Measurements**	Department work plans and reports

4.1.1 The City's Aspirational Artifacts

The City's aspirational documents serve as the guiding principles for the development of the asset management objectives. The conversion of the City's organizational objectives into asset management objectives is addressed in the City's Strategic Asset Management Plan (SAMP). Included below in Table 22 for reference are some excerpts from some of the primary artifacts.

Table 22 – The City's Aspirational Artifacts

	Aspirations	Description
1	**Community Vision**	"A vibrant, compassionate, sustainable city that includes everyone".
2	**Envision 32 Guiding Sustainability Principles, 2013**	• Apply long-term thinking to all decision making • Achieve lasting economic security and social well-being, with vibrant arts and culture • Recognize the intrinsic value of nature and work to enhance it • Minimize our ecological footprint, which is the total impact of our production and consumption activities on the earth, whether this takes place within or outside of the City • Strive to maintain harmony with natural systems when developing within the community • Recognize and build on New Westminster's distinctive characteristics, including our history, human and cultural values, and built and natural heritage • Support people with the resources they need to live more sustainable lifestyles and foster active participation in achieving the community's future vision together • Engage and enable community partners, including organizations, business, institutions and other levels of government, to work towards a common, sustainable future • Strive towards continuous measurable improvement in meeting sustainable objectives • Institutionalize accountability and transparency in governance practices
3	**OCP, 2017**	**Values:** • Grounded in the Past and Forward Thinking • A Riverfront City • Socially Minded

	Aspirations	Description
		• Socially Connected • Physically Connected • Our City, Our Future
		Themes: • Housing choice • Neighbourhood hearts • Strengthened Connections • Supporting Innovation • Heritage • Community Health • Resilience

4.1.2 The City's OCP Goals

The Official Community Plan provides direction to realize the City's opportunities and manage assets and issues to ensure that the city remains one of the most livable communities in Metro Vancouver. It describes the kind of community that the municipality wishes to evolve into and acknowledges the importance of shaping growth in a way that is responsive to the city's distinct circumstances. The OCP provides a vision, goals and policies for New Westminster to the year 2041. Table 23 includes examples of the 12 OCP goals.

Table 23 – OCP Goals Mapped to Asset Classes

ID	OCP Goals	Description	Example of Policy
1	**Community & Individual Well-Being**	To be an equitable, inclusive, and safe community where members have opportunities to contribute, while feeling connected and accepted.	1.2 Create a safe community for residents, students, visitors, and workers.
2	**Culture**	To encourage the generation and opportunity to encounter diverse features of the City.	2.3 Enhance the City's cultural facilities and creative community spaces.
3	**Economy & Employment**	To be a diverse and adaptive economy that is a desirable place to work, live, shop and invest.	3.4 Promote a diverse range of retail and services for all residents.
4	**Energy, Emissions & Climate Change**	To be an energy-efficient and low-carbon community that takes action to reduce greenhouse gas emissions and is resilient to the impacts of climate change.	4.1 Reduce transportation energy use and related greenhouse gas emissions.
5	**Environment & Natural Areas**	To be a community that values natural habitat areas that support biodiversity and healthy communities.	5.2 Enhance and celebrate waterway corridors as a place of ecology, leisure and work.
6	**Hazard Management**	To protect against land use related hazards and manage associated risks.	6.3 Use emergency management programs to protect critical City infrastructure from hazard events.

ID	OCP Goals	Description	Example of Policy
7	**Heritage**	To be a community that has a strong sense of historic identity and promotes and protects its heritage assets.	7.1 Retain and protect physical heritage assets city-wide.
8	**Housing**	To provide the community with neighborhoods that are great places to live and have diverse housing choices.	8.1 Facilitate access to affordable and non-market housing for low-to-moderate-income households.
9	**Parks & Recreation**	To provide excellent programs, events and recreation opportunities for all within a high-quality, comprehensive network of parks, open spaces and facilities.	9.1 Maintain and develop a network of trails and greenways to ensure a high-quality recreational experience.
10	**Public Realm & Urban Design**	To be a livable city, with an attractive, dynamic urban character demonstrating innovation and leadership in the design of the built environment.	10.1 Require a high standard of urban design to facilitate attractive and well-integrated development throughout the City.
11	**Transportation & Accessibility**	To provide an accessible transportation system to people of all ages and abilities; supporting a compact, sustainable and prosperous community.	11.6 Manage the road network for the safety and reliability of all road users.
12	**Utilities & Service Infrastructure**	To provide reliable and innovative servicing that efficiently and effectively meets the needs of the community and reduces impacts on the environment.	12.4 Provide the infrastructure that enables a digital economy.

4.1.3 The City's Sustainability Charter

"Sustainability" is meeting the needs of the present generation in terms of social and cultural systems, the economy and the environment while promoting quality of life but without compromising the ability of future generations to meet their own needs.

This has also been described as "Triple Bottom Line" thinking, where in addition to thinking about the financial bottom line (the Economy), the impacts of our decisions on Society (Socially and culturally) and the Environment are equally important interests.

The City has taken the standard three-pillar concept further by establishing "Social and Cultural" as a distinct sustainability pillar. Illustrated below (See Figure 18) is an excerpt from Envision 2032 of the City's sustainability framework which include four overlapping spheres.



Figure 18 – The City' Sustainability Framework

The City's long-term financial performance can be considered sustainable only when the planned long-term service standards and associated infrastructure investment levels can be met without resorting to unplanned increases in property taxes/rates or disruptive cuts to/reductions in services. More specifically, the City is considered financially sustainable when the following conditions are met:

- A reasonable degree of stability and predictability exists for property taxes/rates.
- Future generations will not face massive decreases in services or unreasonable property tax/rate increases to deal with items deferred from this generation.
- The current generation does not bear all the burden of funding items that will benefit future generations.
- The City Council's highest priority programs (both capital and operating) can be maintained.

In recognition of the need to establish an appropriate balance between developing new assets and maintaining its existing asset base, the City is committed to managing its assets in accordance with sound, industry-recognized financial Asset Management practices.

Future service planning will increasingly need to balance the social, environmental, and economic interests of the community with their capacity and preparedness to pay for these services, both now and into the future.

4.2 Stakeholder Analysis

Identification of stakeholders, their requirements, and conversion of those requirements into value, is contemplated in the Strategic Asset Management Plan (SAMP). A stakeholder -- from the perspective of the transportation asset class -- is any person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or an activity related to the 10 in-scope transportation assets categories. There is a myriad of transportation stakeholder groups, which includes cyclists, pedestrians, transit users, persons with disabilities, truck drivers, commuters, safety regulators, ICBC, TransLink, Ministry of Transportation and Infrastructure

Stakeholder analysis is the process of identifying the myriad stakeholder groups and understanding the needs, expectations and perceptions relative to each stakeholders' respective level-of-interest and level-of-influence over the City.. Detailed stakeholder mapping is beyond the scope of the AMP and the

following table is provides as a reference to different levels of stakeholder engagement to be considered in a larger stakeholder communication strategy.

Table 24 – Levels of Stakeholder Engagement

ID	Levels of Engagement	Goal of Engagement	Promise	Level of Effort
1	**Inform**	To obtain balanced and objective information in a timely manner	"We will keep you informed"	Low
2	**Consult**	To obtain feedback on analysis, issues, alternatives and decisions	"We will listen to and acknowledge your concerns"	Low
3	**Involve**	To work with public to make sure that concerns and aspirations are considered and understood	"We will work with you to ensure your concerns and aspirations are directly reflected in the decisions we make"	Med
4	**Collaborate**	To partner with the public in each aspect of decision making	"We will look to you for advice and innovation and incorporate this in decisions as much as possible"	High
5	**Empower**	To place the final decision making in the hands of the public	"We will implement what you decide"	High

More detailed stakeholder analysis is included in the SAMP and further refinement of the analysis, relative to the transportation assets, forms part of the City's ongoing journey of continuous improvement.

4.3 Performance Metrics

4.3.1 Technical Levels of Service (TLOS)

Different types of technical level of service (TLOS) measures were developed in consultation with the City's transportation subject matter experts (SME's) at a Level of Service workshop. Table 25 combines performance measures that the City is currently tracking and analyzing and some that the City would like to analyze in the future as well. The measures span across a variety of the universal customer values including, reliability; safety; accessibility; sustainability; quality and availability.

Table 25 – Technical LOS Measures

Universal Customer Values		Performance Measures		Link to Sustainable Transportation?	Analyzed at Workshop	Target
1	**Reliability**	R.T.1	Ratio of planned vs. reactive maintenance per year	--	--	80:20
		R.T.2	Total quantity of permeable pavement	--	--	--
		R.T.3	No. of days of traffic detours due to road closures per year	--	--	0
		R.T.4	Average age of road network	--	--	--
		R.T.5	Average age of road when replaced	--	--	--
		R.T.6	% of roads in "good" and "very good" condition	--	--	>80%
		R.T.7	% pavement renewal per year	--	--	--
		R.T.8	% of sidewalks in "good" or "very good" condition	Yes	--	>80%

Universal Customer Values		Performance Measures		Link to Sustainable Transportation?	Analyzed at Workshop	Target
		R.T.9	% of pavement meeting ACA targets	--	Yes	--
		R.T.10	% streets swept per year	--	--	--
2	**Safety**	H.T.1	No. of reportable H&S incidents affecting staff	--	--	0
		H.T.2	No. of snow clearing operator training hours	--	--	--
		H.T.3	No. of pedestrian trip, slip, or falls	Yes	--	0
3	**Accessibility**	A.T.1	Proportion of people in the public right of way that have a disability relative to total population	Yes	--	--
		A.T.2	No. of barrier-free amenities in the public right of way	Yes	--	--
		A.T.3	No. of intersections missing wheelchair ramps	Yes	--	--
		A.T.4	No. of wheelchair let downs	Yes	Yes	--
		A.T.5	No. of sidewalks (km's) across transportation network	Yes	--	--
		A.T.6	No. of bike lanes (km's) across transportation network	Yes	Yes	--
4	**Sustainability**	S.T.1	GHG emissions produced as a result of inefficient signal coordination	Yes	--	--
5	**Cost Effectiveness**	C.T.1	Financial reinvestment rate ($ / asset value)	--	--	--
		C.T.2	Unit cost of asset rehabilitation / replacement	--	--	--
		C.T.3	Accepted infrastructure backlog threshold	--	--	--
		C.T.4	Cost ($) / km of roads for snow clearing per year	--	Yes	--
		C.T.5	Cost ($) / km of sidewalks for snow clearing per year	Yes	Yes	--
		C.T.6	Ratio of snow clearing costs of sidewalks vs. roads	Yes	--	--
		C.T.7	% LED retrofits completed per year	Yes	--	--
	Count	**27**	**--**	**12**	**5**	**--**

A total of twenty-seven (27) diverse TLOS measures were identified by the City, of which twelve (12) are connected in some way to sustainable transportation and five (5) were analyzed in more detail. The preceding table is to be populated in more detail as the City continues to collect and analyze actual performance data and pursues its journey of continuous improvement.

4.3.2 Customer Levels of Service (CLOS)

The following table includes a summary of the different types of customer level of service (CLOS) measures developed in consultation with the City's SME's at a Level of Service Workshop. Where the "Target" columns are populated, the target has been included for the purpose of best practice. It should be noted that Table 26 combines performance measures the City is currently tracking and analyzing and those that may be considered in the future as well. The measures have been grouped by universal customer value including: reliability; safety; quality, availability and sustainability.

Table 26 – Customer LOS Measures

Universal Customer Values		Performance Measures		Link to Sustainable Transportation?	Analyzed at Workshop	Target
1	**Reliability**	R.C.1	No. of complaints regarding snow/ice	Yes	--	0
		R.C.2	Ratio of snow clearing complaints regarding sidewalks vs. roads	Yes	--	--
		R.C.3	No. of complaints regarding poor road markings	--	--	0
		R.C.4	No. of complaints regarding potholes	--	Yes	0
		R.C.5	No. of complaints regarding tree branch encroachment on sidewalks	Yes	Yes	0
		R.C.6	No. of complaints from motorists regarding obscured vision due to vegetation encroachment	--	Yes	0
		R.C.7	No. of customer requests for new streetlights	Yes	--	--
		R.C.8	Average response time to traffic signal failure	--	yes	--
		R.C.9	Average response time to resume traffic flow	--	Yes	<24hrs
		R.C.10	Average response time to clear fallen tree from road	--	--	<48hrs
		R.C11	No. of customer complaints regarding poor street lighting	Yes	--	0
2	**Health & Safety**	H.C.1	No. of injury insurance claims	--	--	0
3	**Accessibility**	A.C.1	No. of complaints regarding wheelchair ramps	Yes	Yes	0
		A.C.2	% of total population within walking distance to a car share parking lot	Yes	--	--
	Count	**14**	**--**	**7**	**6**	**--**

A total of fourteen (14) CLOS measures were identified by the City at the Level of Service workshop, of which seven (7) have a connection to sustainable transportation and six (6) were analyzed in more detail. The preceding table is to be populated in more detail as the City continues to collect and analyze actual performance data.

4.3.3 Performance Matrix

4.3.3.1 Technical Level of Service

Since the City does not yet have enough quantitative data to accurately measure and report on level of service performance, qualitative data was generated at a workshop with staff.

During this process, twenty-seven (27) TLOS measures were identified by staff, of which five (5) were plotted on an Importance-Satisfaction Matrix (see Figure 19). The top left-hand quadrant identifies those measures that are considered important to stakeholders and the City is on target, whereas the top right-hand quadrant identifies the measures that are off target (i.e. there is a variance between the current score and the target score).

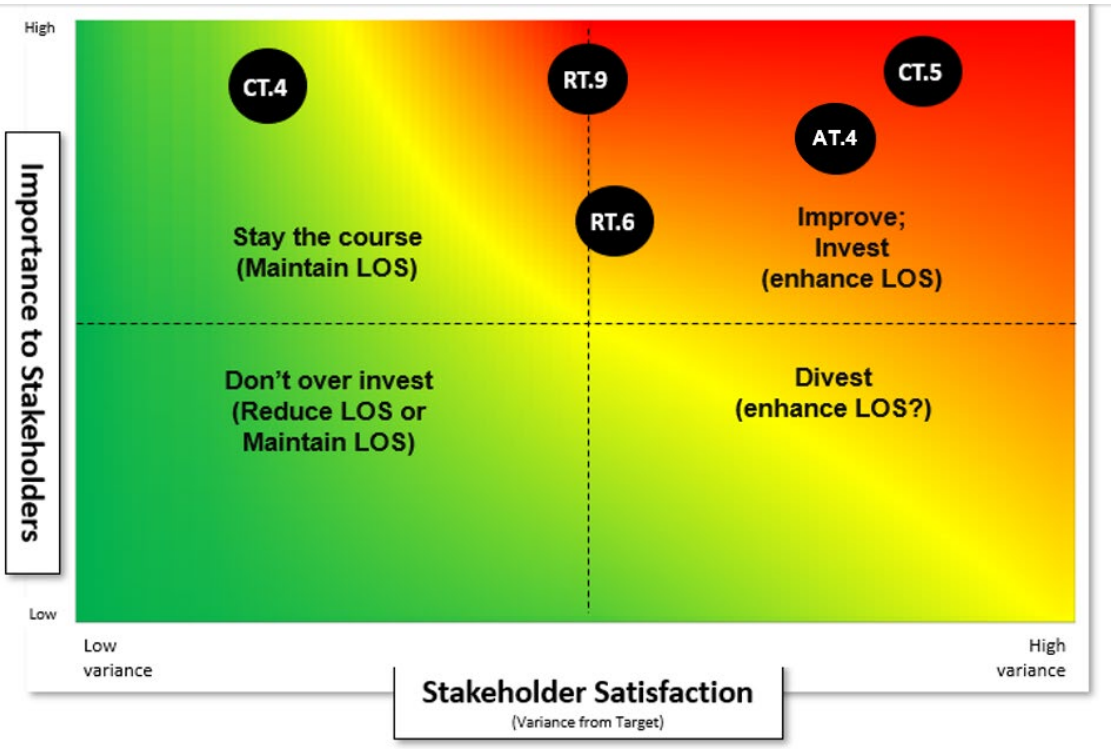


Figure 19 – TLOS Performance Matrix

- CT.4 - Cost ($) / km of roads for snow clearing
- CT.5 - Cost ($) / km of sidewalks for snow clearing
- RT.9 - % of pavement meeting the City's ACA targets
- AT.4 - Quantity of wheelchair letdowns across the City

4.3.3.2 Customer Level of Service

In collaboration at the Level of Service workshop, fourteen (14) CLOS measures were identified by the City's SMEs, of which six (6) were analyzed and plotted on the Importance-Satisfaction Matrix (see Figure 20).

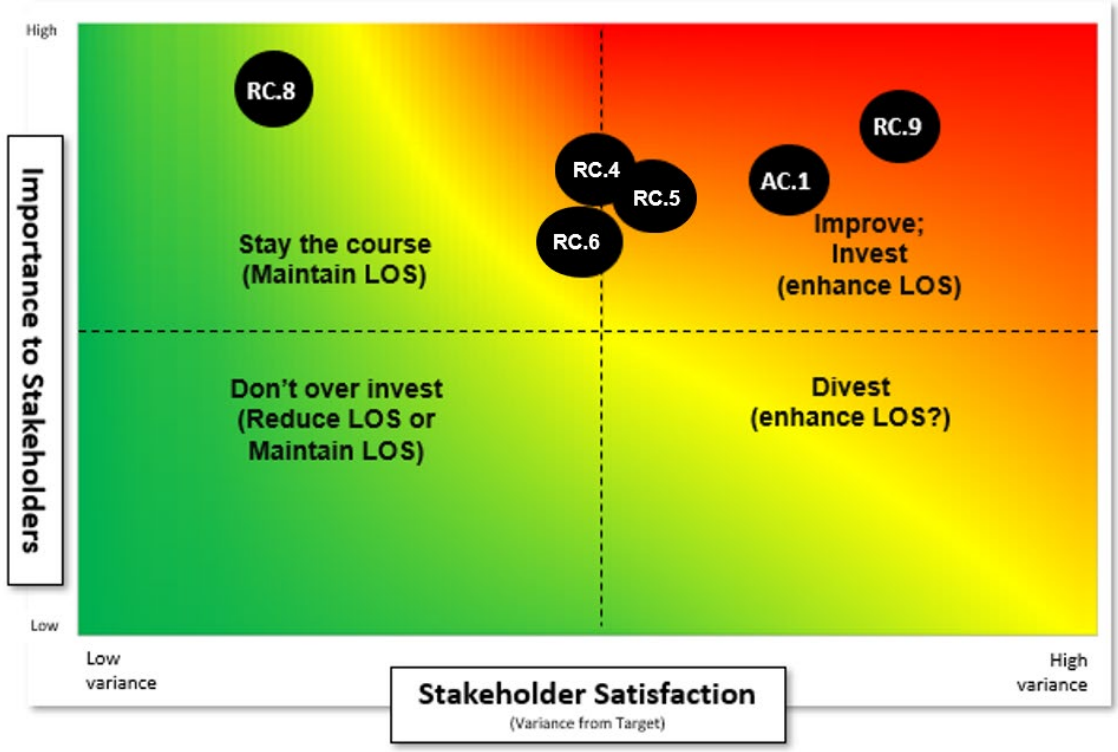


Figure 20 – CLOS Performance Matrix

- RC.8 - Average response time to traffic signal failure
- RC.9 - Average response time to resume traffic flow
- AC.1 - No. of customer complaints regarding wheelchair ramps
- RC.4 - No. of customer complaints regarding potholes
- RC.5 - No. of customer complaints regarding tree branch encroachment on sidewalks
- RC.6 - No. of motorist complaints regarding obscured vision due to vegetation encroachment

4.4 Demand Analysis

The International Infrastructure Management Manual defines demand management as: Actions taken to influence demand for service and assets, often undertaken as part of sustainability initiatives and/or to avoid or defer required asset

The goals of demand management within transportation are as follows:

- To understand the general trends (past, current and future) in the utilization of the transportation assets.
- To determine the current relationship between “capacity” of the transportation assets/network and “demands” placed on the assets/network.
- To ascertain the potential changes in the demand-capacity relationships.

Detailed growth forecasts are included in the City’s OCP and Transportation Master Plan. For general reference purposes in the 1st iteration of the Transportation AMP, the following table includes a summary of some of the key growth statistics.

Table 27 – City Growth Statistics

Growth Statistic	2016	2041
Population	70,996	103,871
Total housing units	32,705	48,088
Total jobs	n/a	46,030

The next table provides an excerpt of traffic volume data.

Table 28 – Traffic Volumes

Count Location	Trucks per Day (2014)
Stewardson Way at 4th Avenue	5,500
Royal Avenue at 3rd Street	2,150
McBride Boulevard at Memorial Drive	2,400
Brunette Avenue at Sherbrooke Street	6,100

4.4.1 Correlation of Condition and demand

The following scatter plot (Figure 21) provides analysis on the correlation between asset condition (ranked as CIRC scores 1 through 5) and AADT ranging from 0 to 60,000

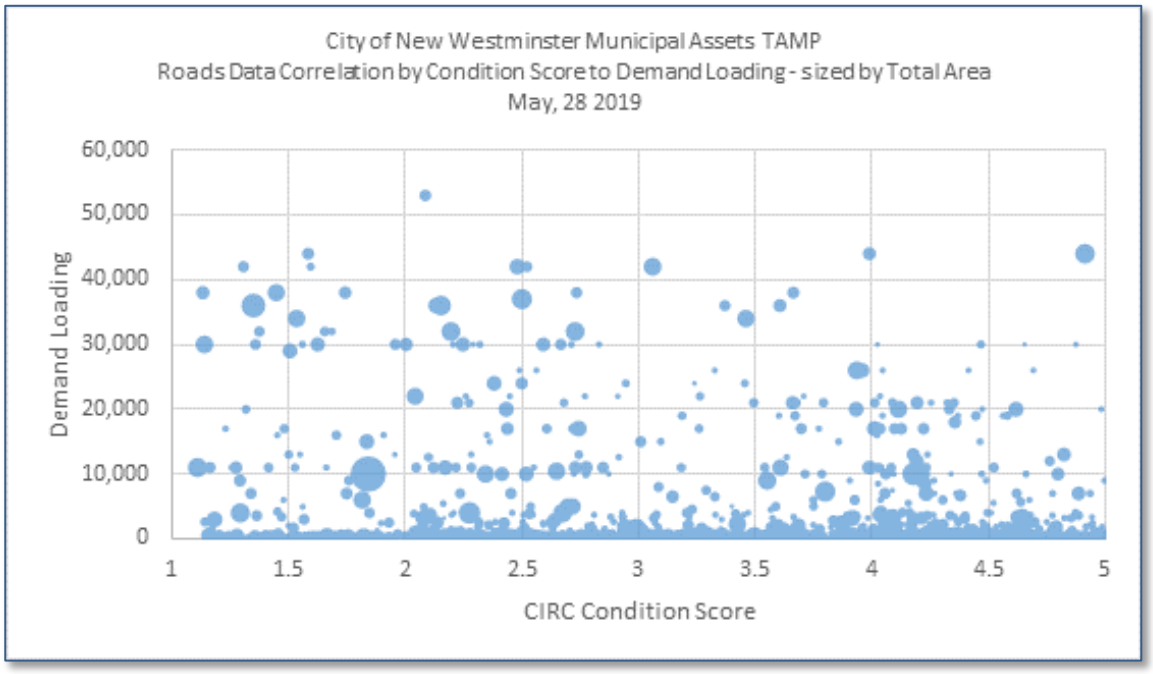


Figure 21 – Condition Correlated to AADT

Figure 22 shows the CIRC condition distributions across the different AADT cohorts.

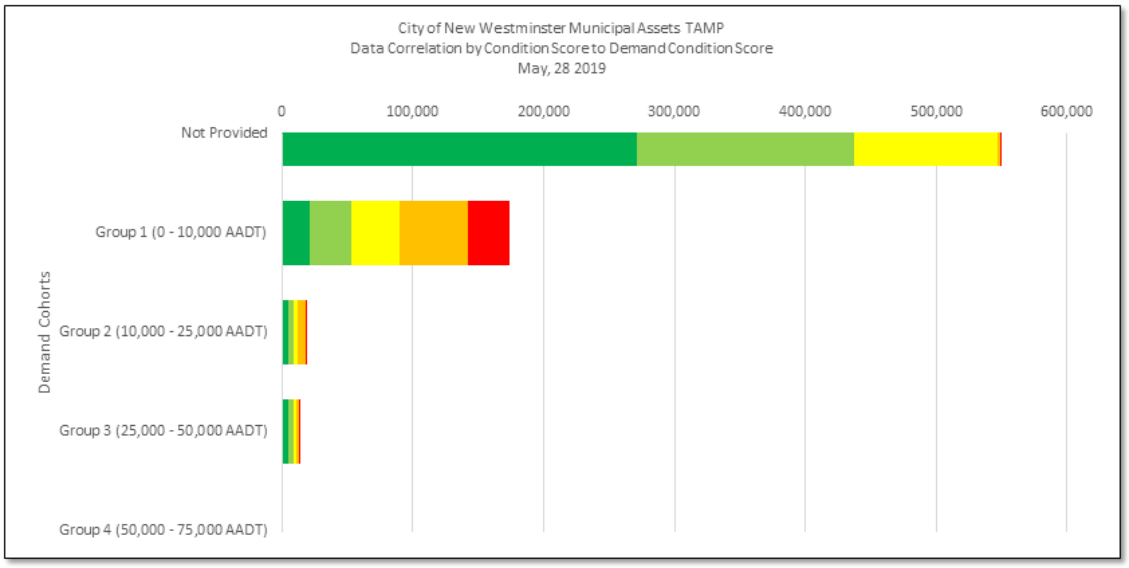


Figure 22 – Condition Across AADT Cohorts

5. Risk Analysis

Risk is an integral part of managing the life cycle of infrastructure assets and is defined by ISO 55000 as “the effect of uncertainty on the City’s objectives”.

5.1 Risk Management Process

The AMP contemplates a six step risk management process that conforms with the ISO 31000 Risk Management standard.

Table 29 – Risk Management Process

Risk Process		Description
1	**Risk Context**	The process of scanning the City's internal and external context in order to articulate the requirements and expectations of various transportation stakeholder groups. These requirements translate into the City's tolerance for risk and appetite for risk.
2	**Risk identification**	The procedures by which the City finds and describes its risks within the context of the organization. This include a scan of the City's internal and external parameters that must be considered when managing the City's transportation risk. Risks are arranged into the following two types of risk management: • Enterprise risk (such as seismic events, pandemics, strikes, acts of war, dissatisfied stakeholders, reputational damage, etc.) • Asset risk (such as equipment failures, warranty failures, deferred maintenance backlogs, vandalism, injuries, inclement weather, service interruptions)
3	**Risk Analysis**	The procedures that the City uses to understand the nature, sources and causes of risks that have been identified. Here we focus on: • Risk equations (PoF x CoF) • Consequences matrix • Likelihood matrix • Causal chains (root causes, proximal causes, fishbone diagrams, etc.)
4	**Risk Evaluation**	The procedures that the City uses to compare risk analysis results with its risk criteria in order to determine whether a specified level of risk is acceptable or tolerable to the City. Here the focus on things like: • Risk appetite and tolerance • Identification of critical assets • Risk scoring systems and ranking schemes • Risk matrix correlations (High-probability-high-impact; low-probability-low-impact, etc.)
5	**Risk Treatment**	The procedures the City uses to modify its transportation risks by selecting one or more treatment and/or control options, such as: avoid the risk, reduce the risk, remove the source of the risk, and transfer the risk. Treatments are grouped into two broad categories: • Modifying the likelihood of the risk through measures such as: asset renewal, asset rehabilitation, standard operating procedures (SOPs); rigorous maintenance program, enhanced monitoring regime • Modifying the consequences of the risk through measures such as new redundant assets, contingency planning, and staff training Residual risk left over after treatment/control

Risk Process		Description
6	**Risk Monitoring & Risk**	The procedures the City uses to supervise and continually check and critically observe the transportation risk register and risk plan. Review activities are carried out in order to determine whether something is suitable, adequate and effective way of achieving objectives.

5.2 Risk Context

Effective risk management programs are characterized by clear objectives that the City is trying to meet. In development of the Strategic Asset Management Plan for the City, Table 30 was included in the SAMP to capture the City's current state with regards to the risk framework initiative.

Table 30 – The City's Risk Context

Scenario	Change Model	Description
The "Problem"	Current State	• Individual departments do not currently document asset specific risks • Asset risks are addressed intuitively/subjectively by each department • Residual risk has not been quantified • There is no formal risk register • There is no formal risk treatment plan
The "Solution"	Transition State	• Pilot test the risk framework within one of the service areas
	Future State	• A fully developed and operationalized risk framework consistent across service areas that is used to make risk-based decisions • Criticality scores are assigned to all assets and consistently recorded in GIS
The "Outcome"	Benefits	• To mitigate risk • To improve operational efficiencies • To treat/control and monitor risk

Setting the context of a risk assessment serves to scope the risk assessment process. Industry leading practice suggests this is done best by aligning strategic objectives and goals to specific customer and technical levels of service.

The organization should manage risk at several levels including:

- **Corporate:** High level risks that affect the whole organization, including corporate reputation, emergencies, business continuity, health and safety, political, legal and financial risk, and are undertaken by senior decision makers.
- **Strategic and Tactical:** Risks that affect the management of the infrastructure.
- **Operational:** Risks that affect operational activities.

5.3 Risk Identification

Risk identification is the process of finding and describing risks within the context of the organization. Table 31 provides a small sample of risk events that may be contemplated as part of a larger risk register. The risk register is a work in progress and will need to be updated as part of the City's ongoing asset management journey.

Table 31 – Asset Risk Examples

Asset Class	ID	Type of Risk Events	Cause (due to…)	Sustainable Transportation Link?
Pavement / roads	**PA.1**	Motor vehicle accident	Sinkhole collapse due to poor soil conditions	--
	PA.2	Motor vehicle accident	Pothole	--
	PA.3	Traffic congestion	Increased network demand due to population growth	Yes
Bridges	**BR.1**	Bridge closure	Suicide jumper	--
	BR.2	Bridge collapse	Seismic event / structural design flaw	--
Sidewalks	**SW.1**	Slip and Fall	Inadequate winter control measures	--
	SW.2	Trip and Fall	Pavement heaving	--
Retaining Walls	**RW.1**	Graffiti	Inadequate maintenance	--
	RW.2	Retaining wall collapse	Landslide due to extreme weather event	--
Tunnel	**TU.1**	Tunnel roof fall / cave-in	Deterioration / structural design flaw	--
	TU.2	Vehicle fire	Vehicle collision	--
	TU.3	Poor air quality	Inadequate ventilation	--
Service Panels	**SP.1**	Power outage	Vehicle collides with service panel	--
	SP.2	Worker electrical injury	Improper safety procedures	--
Wheelchair Ramps	**WC.1**	Injury or fall	Wheelchair tips due to poor ramp condition (e.g. heaving)	--
	WC.2	Injury or fall	Inadequate winter control measures	--
Signs	**SI.1**	Vehicle over height impact	Inadequate signage	--
	SI.2	Cyclist accident	Poor sign visibility	Yes
Streetlights	**SL.1**	Bicycle theft	Inadequate street lighting	Yes
	SL.2	Vehicle vandalism (break and enters)	Inadequate street lighting	--
Signal & Traffic Controller	**TC.1**	Disruption of traffic	Power outage causes traffic signal to fail	--
	TC.2	Accident, vehicle-vehicle	Power outage causes traffic signal to fail	--
Totals	**22**	--	--	**3**

5.4 Risk Analysis

Risk analysis allows the identified risks to be analyzed in a systematic manner to identify which risks are unacceptably high. This enables the City to determine its level of exposure to certain risks and develop a treatment plan to mitigate those risks.

Most asset failures can be classified under one of the following four failure modes:

- **Capacity / Utilization:** the demand exceeds the capacity of the existing asset or network of assets.
- **Physical End-of-Life:** the structural condition of the asset is such that it has reached the end of its effective life.
- **Financial Efficiency:** the cost of the asset exceeds the economic return necessary to justify retention of the asset, including obsolescence.
- **Functional:** the asset no longer meets functional requirements or performance targets due to a variety of reasons including changes in regulatory requirements or customer preference.

The key components used to evaluate risk exposure is explained further in the sub-sections below.

5.4.1 Risk Equations

In simplest terms, risk can be calculated as the product of the likelihood of an "event" occurring and the consequence when it does happen. Table 32 includes some examples of risk equations of different degrees of sophistication.

Table 32 – Sample Risk Equations

Levels of Complexity	Formula
Level 1	$Risk = Likelihood \times Consequences$ This formula utilizes the consequence with the maximum value
Level 2	$Risk = Likelihood \times \sum Consequences$ This formula sums up the value of all the consequences
Level 3	$Risk = Likelihood \times \sum (Probability \times Consequences)$
Level 4	$Risk = Likelihood \times \sum (Probability \times Severity \times Scale)$

This report applies the level 2 formula.

5.4.2 Likelihood Matrix

The table included below provides a likelihood matrix, which represents one of the elements of the overall risk equation. A five (5) point scale was established to evaluate the likelihood of a threat occurrence.

Table 33 – Likelihood Matrix

Likelihood	Score	Description
Almost Certain ≥90%	5	Very high probability that risk will occur in the next 36 months
Likely ≥70% to <90%	4	High probability that risk will occur in the next 36 months
Possible ≥25% to <70%	3	Moderate probability that risk will occur in the next 36 months
Unlikely >1% to <25%	2	Low probability that risk will occur in the next 36 months
Rare ≤1%	1	Very low probability that risk will occur in the next 36 months

The likelihood scale in the table above is calibrated specifically for the City. The likelihood frequency was developed in collaboration with the City at previous workshops.

5.4.3 Consequence Matrices

A consequences matrix represents the second key element of the overall risk equation. In this regard, the City has identified four (4) types of consequences, as follows: reputational; financial; health & safety; and environmental.

The 2018 AECOM Risk Report identified the following consequence categories: Economic, Social, Operational, and Environmental. AECOM's operational category has been absorbed into the Financial consequence category applied in this report.

For reference, Table 34 below references the three-point consequence matrix utilized in AECOM's 2018 Risk Report.

Table 34 – Consequence Categories

Consequence categories	Low	Medium	High
Service Implication	Negligible impact to service delivery	Noticeable to significant impact to service	Catastrophic impact to service and/or public safety
Operational Impact	Failure can be addressed through normal operations	Failure can be accommodated by strains operations	Failure cannot be handled in an effective manner
Management Strategy	Run-to-Failure	Manage failure	Avoid failure

This report proposes a five-point scale which has been established to evaluate the consequence of a threat occurrence based on the triple bottom line considerations (financial, health & safety, and

environment) as shown below. The overall consequence rating was calculated by taking the sum of the evaluation criteria to allow for the development of targeted mitigation strategies.

5.4.3.1 Risk Consequence: Strategic, Political, and Reputational

The following table includes a summary of the strategic, political and reputational consequences and corresponding severity bands, with scores ranging from 1-5 points. This consequence impacts the City's reputation and stakeholder engagement.

Table 35 –Reputational Consequences Matrix

1. Negligible	2. Minor	3. Moderate	4. Severe	5. Catastrophic
Adverse internal communications	Adverse corporate communications	Sustained local media reports.	Negative reports on national media.	Protracted adverse local and national media coverage.

5.4.3.2 Risk Consequence: Financial

The following table includes a summary of the financial consequences and corresponding severity bands, with scores ranging from 1-5 points. This consequence impacts the City's ability to fund transportation operations.

Table 36 –Financial Consequences Matrix

1. Negligible	2. Minor	3. Moderate	4. Severe	5. Catastrophic
<$10k	$10k to <$100k	$100k to <$500k	$500k to <$1m	>$1m

5.4.3.3 Risk Consequences: Health & Safety

The following table includes a summary of the safety consequences and corresponding severity bands, with scores ranging from 1-5 points. This consequence impacts the City's ability to provide a safe environment for its stakeholders.

Table 37 –Health & Safety Consequences Matrix

1. Negligible	2. Minor	3. Moderate	4. Severe	5. Catastrophic
No impact to health and safety	Minor injury or illness without lost time	Illness/injury resulting in lost time	Illness/injury resulting in permanent or long-term disability	Multiple fatalities

5.4.3.4 Risk Consequences: Environmental

The following table includes a summary of the environmental consequences and corresponding severity bands, with scores ranging from 1-5 points. This impact's the City's ability to achieve environmental stewardship.

Table 38 – Environmental Consequences

1. Negligible	2. Minor	3. Moderate	4. Severe	5. Catastrophic
Very insignificant impact or can be restored within 1 week	Minor short term (up to 1 month) local damage	Significant short term (up to 2 months) local damage	Significant long term (up to 1 year) widespread damage	Significant long term (greater than 1 year) or permanent widespread damage

The consequence matrix were developed in collaboration with staff at workshops but will require further calibration once the City has developed a formal risk framework to be applied consistently across all the asset classes.

5.4.4 Risk Matrix

A risk matrix shows likelihood plotted against consequence and reflects the organization's risk threshold limits or appetite. As part of the City's continual journey to build out the risk register at the corporate, strategic, and operational level, each risk should be analyzed, utilizing the risk formula (likelihood x ∑ consequence) and plotted on a risk matrix.

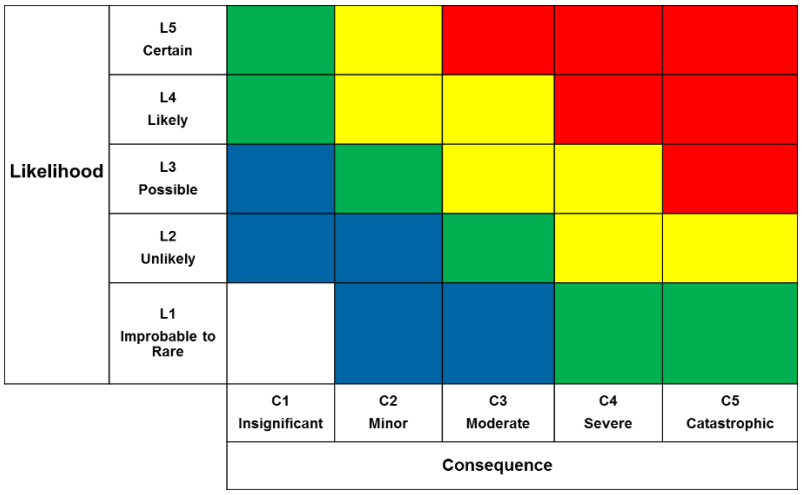


Figure 23 – Risk Exposure Matrix

Insignificant Risk: Do Nothing. Risk controls not needed to reduce risk to the organization.

Low Risk: Status Quo. Risk controls not needed to reduce risk to the organization.

Moderate Risk: Monitor threat events. Review mitigation strategies and plans. Risk controls or management strategies may be needed to reduce risk to the organization.

High Risk: Respond to threat events. Review and update mitigation strategies and plans. Risk controls needed to reduce risk to the organization.

Extreme Risk: Respond to threat events. Review and update mitigation strategies and plans. Risk controls needed to reduce risk to the organization.

The weightings for each of the four (4) consequence categories for the pavement asset class from the City's 2018 risk report is shown in Table 39. The weightings are derived from a pairwise analysis that compares each of the four criteria with one another.

Table 39 – Primary Weightings

	Social	Economic	Environmental	Operational	Weighting
Social	3	2	2	1	12%
Economic	4	3	2	2	18%
Environmental	4	4	3	4	38%
Operational	5	4	2	3	32%

Within each of the four primary categories, a series of sub-categories are assigned weightings and these form the secondary weightings. Table 40 is provided for reference from the 2018 risk report.

Table 40 – Secondary Weightings

Inputs	Economic 38%	Operational 32%	Social 12%	Environmental 18%	Combined 100%
Annual Average Daily Traffic	28%		20%		13%
Truck Route	20%			50%	17%
Road Class	32%	30%			22%
Land Use	20%		33%		17%
Transit Route		27%			9%
Rail Crossing		15%			5%
Disaster Response Route		28%			9%
Sustainable Transportation			27%		3%
Ambulance Route			20%		2%
Flood Plain				50%	9%
TOTAL	100%	100%	100%	100%	100%

5.5 Risk Evaluation

Risk evaluation is the process of comparing risk analysis results in order to determine whether a specified level of risk is acceptable or tolerable. In the sub-sections below, a risk matrix has been provided for eight (8) transportation asset categories based on AECOM's 2018 risk report.

The 2018 risk evaluation was based purely on the impact of failure of each of the transportation assets and therefore, strategic and corporate risks (such as a bridge closure caused by a suicide jumper or an increase in vehicle theft due to poor street lighting) have yet to be analyzed and plotted onto the risk matrix.

The following risk matrix (Figure 24) plots the aggregated scores for the probability of failure and consequence of failure for each of the in-scope transportation asset classes. This analysis is intended to serve only a high-level benchmarking function and the reader is cautioned that the criticality scores vary dramatically within each asset class.

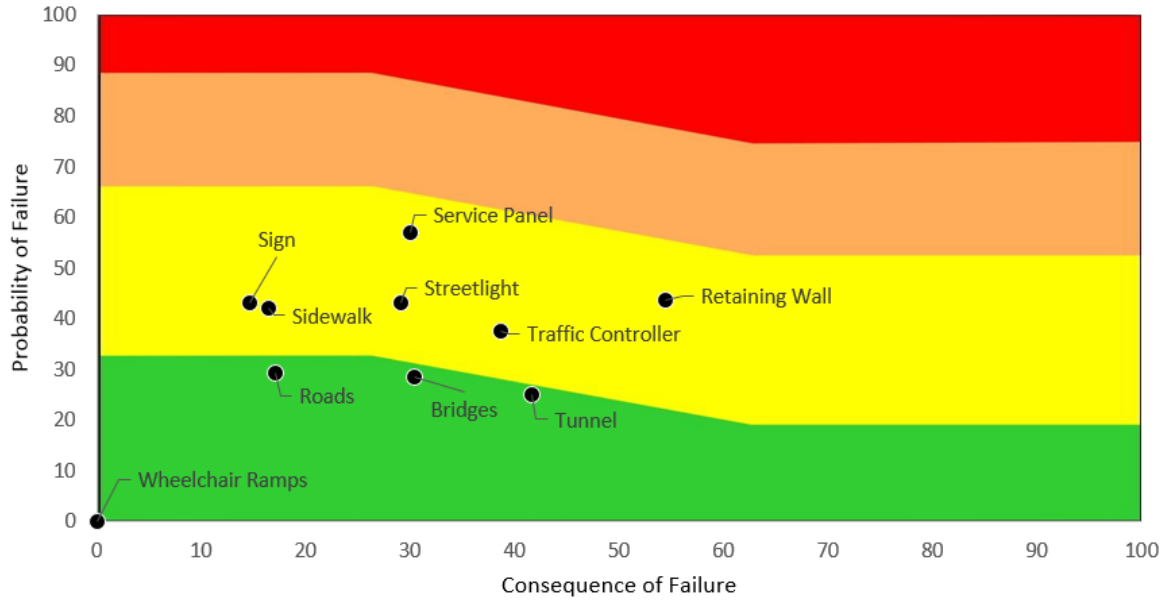


Figure 24 – Risk Exposure Matrix for All Asset Classes, Aggregated Scores

At this high aggregated level, the retaining walls are deemed to have the highest consequence of failure, followed next by the tunnel and traffic controllers. The data for the wheelchair ramps is not currently sufficiently developed to assign risk scores to each ramp. More detailed risk matrices for each asset class are included in Appendix A.

5.6 Risk Treatment & Control

Risk treatment is the process of modifying the risks. The resilience of critical infrastructure is vital to the City's customers and the services provided. To adapt to changing conditions and grow over time, the City needs to understand its capacity to respond to possible disruptions and be positioned to absorb disturbance and act effectively in a crisis to ensure continuity of service. Resilience is built on aspects such as response and recovery planning, financial capacity and crisis leadership.

Table 41 provides a summary of generic risk reduction options, which is provided for reference to the City's ongoing journey of continual improvement.

Table 41 – Generic Risk Reduction Options

Categories	Risk Reduction Options		Reduce Likelihood	Reduce Consequences	Count
Capital Investment	T.1	Asset Renewal	●	--	1
	T.2	Asset rehabilitation	●	--	1
	T. 3	New redundant asset	--	●	1
	T.4	Site Design	●	--	1
O&M Protocols	T.5	Enact Policy	●	--	1
	T.6	Develop SOPs	●	--	1
	T.7	Rigorous maintenance program	●	--	1
	T.8	Enhanced monitoring regime	●	--	1
	T.9	Contingency planning	●	--	1
	T.10	Staff training	●	--	1
	T.11	Signage	●	--	1
	T.12	Critical spares	●	●	2
		Totals	**11**	**2**	

5.7 Risk Monitoring & Review

Risk monitoring and review is beyond the scope of the AMP, however, below are some considerations for the City's ongoing journey of continual improvement.

- Establish a risk committee
- Develop a risk register of risk hazard events
- Develop a risk treatment plan
- Develop documented procedures, including RACI charts and workflow diagrams to detail the sequence of steps and pertinent roles for periodic updating of the risk register

Risk monitoring and review programs are characterized by updating risk profiles on an annual basis and updating risk scores following implementation of mitigation strategies.

6. Lifecycle Management

6.1 Program Descriptions

Table 42 provides a summary of the different lifecycle management programs relative to the different types of transportation assets. Each program has been provided a unique alphanumeric identification number in order that the programs can be cross-referenced with the Level of Service Measures. The LOS measures in red are the measures that are currently being analyzed by the City. The remaining measures have been identified as LOS measures that the City would like to analyze in the future. It should be noted that the following table is to be developed as part of the City's ongoing continual improvement.

Table 42 - Lifecycle Programs Linked to LOS Measures

Assets	Program ID	Lifecycle Programs	Description	Triggers	Stakeholders	Link to Sustainable Transp.?	LOS ID	LOS Measures
Pavement	PA.1	Inspection program	• MRN and arterial roads are inspected by engineering consultants every 3 years	• Calendar year	• Consultants • City staff	--	R.T.4	Average age of road network
							R.T.6	% of roads in "good" and "very good" condition
							R.T.9	% of pavement meeting ACA targets
	PA.2	Street sweeping program	--	--	--	--	R.T.10	% streets swept per year
	PA.3	Winter control program	--	--	--	--	H.T.2	No. of snow clearing operator training hours
							C.T.4	Cost ($) / km of roads for snow clearing per year
	PA.4	Run to Failure Program	• Local/collector roads are left to run to failure for as long as possible due to lack of funding	• Politics - fiscal year (budget) • Coordinated underground utility replacement	• City Council • Staff	--	R.T.4	Average age of road network;
							R.T.6	% of roads in "good" and "very good" condition;
							R.T.9	% of pavement meeting ACA targets
	PA.5	Resurfacing program	• Roads replaced as per needs studies and available funding	• ACA condition triggers resurfacing of MRN and arterial roads.	• TransLink provides funding for MRN; maintenance performed by City staff. • Consultants	--	R.T.4	Average age of road network;
							R.T.6	% of roads in "good" and "very good" condition;
							R.T.9	% of pavement meeting ACA targets
Sidewalks	SW.1	Inspection program	• Drive-by visual inspections performed by sidewalk crew (main walkways only). • City staff perform GPS inspections which is uploaded into GIS. • Maintenance gets dispatched and prioritized after inspections. • Inspections are purely based on physical condition (not functional condition).	• Physical condition	• Parks O&M staff • Transportation O&M staff	Yes	R.T.8	% of sidewalks in "good" or "very good" condition
	SW.2	Trip hazard maintenance	• Sidewalk surface measured with a gage. • Prioritized – level 1 high priority	• Calendar year	• City staff	Yes	H.T.3	No. of pedestrian trip, slip, or falls
	SW.3	Winter control program	--	--	--	Yes	H.T.2	No. of snow clearing operator training hours
							C.T.5	Cost ($) / km of sidewalks for snow clearing per year
	SW.4	New Sidewalk program	• City has outstanding obligations to improvement areas to add new sidewalks • New sidewalks are also coordinated with installing/replacement of wheelchair curb ramps	• Coordinated activity (e.g. wheelchair curb ramps)	• Developers • City staff	Yes	A.T.5	No. of sidewalks (km's) across transportation network

Assets	Program ID	Lifecycle Programs	Description	Triggers	Stakeholders	Link to Sustainable Transp.?	LOS ID	LOS Measures
	SW.5	Accessibility retrofit program	--	--	--	Yes	A.T.5	No. of sidewalks (km's) across transportation network
							A.T.2	No. of barrier-free amenities in the public right of way
Wheelchair Ramps	WC.1	Inspection program	• Inspections contracted out / maintenance depends on the City	• Calendar based	• Contractors • City staff	Yes	A.T.3	No. of intersections missing wheelchair ramps
							A.T.4	No. of wheelchair let downs;
							A.C.1	No. of complaints regarding wheelchair ramps
Lighting	LI.1	Inspection Program	• Annual visual inspections • The City is lacking funds to improve the condition of streetlights; therefore, maintenance is done as needed (reactive)	• Maintaining LOS • Calendar year – annual automatic trigger in the Maintenance Management Program	• City staff	--	R.C.11	No. of customer complaints regarding poor street lighting
							R.C.7	No. of customer requests for new streetlights
	LI.2	Safety program	• The City reviews intersection collisions every 5 years and try to determine root cause and whether it is lighting related.	• Safety improvements based on historical collision data • Calendar-based	• Consultant • City Staff	--	--	--
	LI.3	CPTED Program	• Crime prevention through environmental design	•	• City	--	--	--
	LI.4	Illumination Program	• The City will infill street lighting or replace heads if there are dark sky complaints	• Enhancing LOS - customer complaints; public safety; comfort	• City staff	--	R.C.11	No. of customer complaints regarding poor street lighting
							R.C.7	No. of customer requests for new streetlights
	LI.5	LED retrofit program	• The target is to retrofit 100% of the City's street lights to reduce labour costs (each LED light will last 10-15 years) • The majority of streetlight failures are underground; therefore, tearing up the whole street is required to replace a streetlight due to the age of the infrastructure. • Some streetlights were installed 60 years ago, so these lights are being retrofitted first; however, there is no schedule that is being adhered	• Efficiency – reduce labour costs • Enhancement – improve lighting for customers • Customer complaints / safety reasons • Coordinated construction, or if the whole streetlight requires replacing • Physical condition (age) • Demand (higher growth areas)	• City staff	Yes	C.T.7	% LED retrofits completed per year
	LI.6	Pedestrian/ Cycle Sustainable Lighting	• City thinks this should be separate from road safety	• Customer feedback based • Political – corporate sustainability objectives	• City Council • City staff	Yes	--	--
Traffic Controllers & Signals	TC.1	Accessible Pedestrian Signal Program	--	--	--	Yes	R.C.8	Average response time to traffic signal failure
							R.C.9	Average response time to resume traffic flow
Traffic Signs	TS.1	Inspection Program	• City staff goes to each of the seven (7) regulatory signs to visually inspect on an annual basis. Staff member will dispatch maintenance as needed.	• Calendar year (annual)	• City staff	--	R.C.6	No. of complaints from motorists regarding obscured vision due to vegetation encroachment
	TS.2	Stop sign replacement program	• Previously upgraded all the stop signs as part of an old initiative by ICBC • Now stop sign replacement is done on an "as needed" basis.	• Maintain LOS	• City staff	--	--	--

Assets	Program ID	Lifecycle Programs	Description	Triggers	Stakeholders	Link to Sustainable Transp.?	LOS ID	LOS Measures
Service Panels	SP.1	N/A	• There is no formalized program in place • Vegetation does severe damage to a service panel	• Maintain LOS	• City staff	--	--	--
Bridges (vehicles and pedestrians)	BR.1	Inspection program	• City is currently updating the 2015 bridge inspection report from Associated with a new report by Parsons. The new report will be including functional condition as well as physical condition • Engineered inspections every 3 to 5 years • Pedestrian bridges are less critical (consequence of failure is lower)	• Calendar based (every 3 to 5 years) • Physical condition	• City staff • Engineering consultants	--	R.T.1	--
	BR.2	Asphalt decks	• See pavement inspection program (PA.1) above	--	--	--		--
Retaining walls	RW.1	Inspection Program (Structures)	• See bridge inspection (BR.1) comments above • Every 3-5 years there is an engineering inspection which will assess physical condition – the City will then go out and conduct work based on consultant recommendations • The City will create a budget and plan a maintenance program for structures (e.g. bridges, retaining walls, tunnels, etc.)	• Calendar-based (every 3 to 5 years) • Physical condition	• City staff • Engineering consultants	--		--
	RW.2	Graffiti Program - Structures	• Applies to all structures (bridges, tunnels, retaining walls)	• Maintain LOS (reactive)	• City staff	--		Ratio of planned vs. reactive maintenance per year
Tunnels	TU.1	Clean-up - Structures	• Program to clean-up litter is conducted by Parks & Recreation; a staff member will dispatch a maintenance work order if a tunnel requires maintenance • Vegetation clearing is part of this program • Applies to all structures (bridges, tunnels, retaining walls)	• Maintain LOS (reactive)	City Staff	Yes		Ratio of planned vs. reactive maintenance per year
Multi-modal transportation	MM.1	Pedestrian crossing improvement program	--	--	--	Yes		--
Staff	SF.1	Staff Training Program	--	--	--	--	H.T.2	No. of snow clearing operator training hours
Count	**28**	**--**	**--**	**--**	**--**	**10 (33%)**	**--**	**--**

Table 43 below summarizes the number of lifecycle programs associated with each Level of Service measure. The Program ID corresponds with the Program ID identified in the Table 44. The City should prioritize collecting and analyzing performance data for LOS measures (KPI's) that have the strongest correlation with existing lifecycle programs. For instance, collecting data to analyze the average age of the road network correlates to three lifecycle programs at the City and should have a higher priority than collecting data for a performance measure that links to only one program.

Table 43 – LOS Measures Linked to Lifecycle Programs

LOS ID	Level of Service Measures	No. of Programs	Program ID
R.T.4	Average age of road network	3	PA.1
			PA.4
			PA.5
R.T.6	% of roads in "good" and "very good" condition	3	PA.1
			PA.4
			PA.5
R.T.9	% of pavement meeting ACA targets	3	PA.1
			PA.4
			PA.5
H.T.2	No. of snow clearing operator training hours	3	PA.3
			SW.3
			SF.1
R.C.11	No. of customer complaints regarding poor street lighting	2	LI.1
			LI.4
R.C.7	No. of customer requests for new streetlights	2	LI.1
			LI.4
A.T.5	No. of sidewalks (km's) across transportation network	2	SW.4
			SW.5
R.T.1	Ratio of planned vs. reactive maintenance per year	2	RW.2
			TU.1
R.T.10	% streets swept per year	1	PA.2
C.T.4	Cost ($) / km of roads for snow clearing per year	1	PA.3
R.T.8	% of sidewalks in "good" or "very good" condition	1	SW.1
H.T.3	No. of pedestrian trip, slip, or falls	1	SW.2
C.T.5	Cost ($) / km of sidewalks for snow clearing per year	1	SW.3
A.T.2	No. of barrier-free amenities in the public right of way	1	SW.5

LOS ID	Level of Service Measures	No. of Programs	Program ID
A.T.3	No. of intersections missing wheelchair ramps	1	WC.1
A.T.4	No. of wheelchair letdowns;	1	WC.1
A.C.1	No. of complaints regarding wheelchair ramps	1	WC.1
C.T.7	% LED retrofits completed per year	1	LI.5
R.C.8	Average response time to traffic signal failure	1	TC.1
R.C.9	Average response time to resume traffic flow	1	TC.1
R.C.6	No. of complaints from motorists regarding obscured vision due to vegetation encroachment	1	TS.1
Count	**21**		

6.2 Programs by Investment Drivers

The following table provide an itemized summary of the transportation stewardship program correlated to the four primary investment drivers (Maintain LOS, Enhance LSO, Growth and Legislative). The LOS measures in red are the measures that are currently being analyzed by the City. The remaining measures have been identified as LOS measures that the City would like to analyze in the future. It should be noted that the following table is to be developed as part of the City's ongoing continual improvement.

Table 44 - Lifecycle Programs by Investment Drivers

Assets	Program ID	Lifecycle Programs	LOS ID	LOS Measures	Analyzed at staff workshops	Investment Drivers (%)			
						Maintain LOS	Enhance LOS	Growth	Legislative
Pavement	PA.1	Inspection program	R.T.4	Average age of road network	--	●			
			R.T.6	% of roads in "good" and "very good" condition	--	●			
			R.T.9	% of pavement meeting ACA targets	Yes	●			
	PA.2	Street sweeping program	R.T.10	% streets swept per year	--	●			
	PA.3	Winter control program	H.T.2	No. of snow clearing operator training hours	--	●			
			C.T.4	Cost ($) / km of roads for snow clearing per year	Yes	●			
	PA.4	Run to Failure Program	R.T.4	Average age of road network;	--	●			
			R.T.6	% of roads in "good" and "very good" condition;	--	●			
			R.T.9	% of pavement meeting ACA targets	Yes	●			
	PA.5	Resurfacing program	R.T.4	Average age of road network;	--	●			
			R.T.6	% of roads in "good" and "very good" condition;	--	●			
			R.T.9	% of pavement meeting ACA targets	yes	●			
Sidewalks	SW.1	Inspection program	R.T.8	% of sidewalks in "good" or "very good" condition	--	●			
	SW.2	Trip hazard maintenance	H.T.3	No. of pedestrian trip, slip, or falls	--	●			
	SW.3	Winter control program	C.T.5	Cost ($) / km of sidewalks for snow clearing per year	Yes	●			
	SW.4	New Sidewalk program	A.T.5	No. of sidewalks (km's) across transportation network	--		●		
	SW.5	Accessibility retrofit program	A.T.5	No. of sidewalks (km's) across transportation network	--	●			
			A.T.2	No. of barrier-free amenities in the public right of way	--		●		
Wheelchair Ramps	WC.1	Inspection program	A.T.3	No. of intersections missing wheelchair ramps	--		●		
			A.T.4	No. of wheelchair let downs;	Yes		●		
			A.C.1	No. of complaints regarding wheelchair ramps	Yes		●		
Lighting	LI.1	Inspection Program	R.C.11	No. of customer complaints regarding poor street lighting	--		●		
			R.C.7	No. of customer requests for new streetlights	--		●		

Assets	Program ID	Lifecycle Programs	LOS ID	LOS Measures	Analyzed at staff workshops	Investment Drivers (%)			
						Maintain LOS	Enhance LOS	Growth	Legislative
	LI.2	Safety program	--	--	--				
	LI.3	CPTED Program	--	--	--				
	LI.4	Illumination Program	R.C.11	No. of customer complaints regarding poor street lighting	--		●		
			R.C.7	No. of customer requests for new streetlights	--		●		
	LI.5	LED retrofit program	C.T.7	% LED retrofits completed per year	--		●		
	LI.6	Pedestrian/ Cycle Sustainable Lighting	--	--	---				
Traffic Controllers & Signals	TC.1	Accessible Pedestrian Signal Program	R.C.8	Average response time to traffic signal failure	Yes	●			
			R.C.9	Average response time to resume traffic flow	Yes	●			
Traffic Signs	TS.1	Inspection Program	R.C.6	No. of complaints from motorists regarding obscured vision due to vegetation encroachment	Yes	●			
	TS.2	Stop sign replacement program	--	--	--	●			
Service Panels	SP.1	N/A	--	--	--				
Bridges	BR.1	Inspection program	R.T.1	Ratio of planned vs. reactive maintenance per year	--	●			
	BR.2	Asphalt decks	--	--	--	●			
Retaining walls	RW.1	Inspection Program (Structures)	--	--	--	●			
	RW.2	Graffiti Program - Structures	--	--	--	●			
Tunnels	TU.1	Clean-up - Structures	--	--	--	●			
Multi-modal transportation	MM.1	Pedestrian crossing improvement program	--	--	--		●		
Staff	SF.1	Staff Training Program	H.T.2	No. of snow clearing operator training hours	--	●			
				Count	**10**	**26**	**11**	--	--

7. Financial Strategies

This section of the AMP describes the CAPEX costs (and available OPEX costs) for the transportation assets over the 10-year planning horizon and compares these to available funding. Where information is available, this section also identifies funding shortfalls in relation to financial requirements and determines how the impact will be managed. The section is arranged into seven parts as follows:

- Asset Valuation
- Operating Budget
- Historical Expenses
- Capital Needs Forecast
- Infrastructure Gap
- Reinvestment Scenarios
- Strategies to Address the Infrastructure Gap

General accounting guidelines state that a purchase will be considered a capital expenditure if it has physical substance and meets the following criteria:

- has been acquired, constructed or developed to be used on a continuing basis
- has a useful economic life extending beyond one year
- is not intended for sale in the ordinary course of business
- it is of enough monetary value to warrant capitalization

Typically, it is helpful to provide historic expenditure levels classified by expenditure type as outlined in the breakdown below, with two predominant categories; base-service provision or renewal (i.e., to maintain the current service level); and enhancement (i.e., to provide some change or improvement from the current service level).

The two predominant categories for capital expenditure classification are:

- Base-Service Provision (or Renewal) – This relates to capital expenditures that are required to maintain the current LOS to customers. Base maintenance expenditure is not just for assets that are beginning to fail but can also be used where there is a demonstrable savings in OPEX arising from the project (that is, automation or replacing the asset with a modern equivalent). This form of funding is classified as “spend to save” but is still base maintenance.
- Enhancement – This relates to capital expenditures that cause a permanent increase in the current LOS to a new base level. Enhancement is further divided as follows.
  - **Legislative:** This relates to expenditures that are required for compliance with new legally enforceable obligations (e.g., new acts or regulations).

- **Enhanced LOS:** This relates to expenditures that provide an identifiable, measurable, and permanent step change in overall LOS to existing customers above the standard previously provided (e.g., extending the hours of bus service).
- **Supply/Demand Balance or Growth:** This relates to expenditures that provide services for new customers with no net deterioration from the current LOS provided to existing customers, as well as expenditure that accommodates the increased use of services by existing customers at the current LOS (e.g., providing additional capacity).

This type of analysis can provide an understanding of what proportion of the actual expenditure has been focused on maintaining the current asset base, as opposed to being used for purposes such as growth driven projects or projects focused on providing an enhanced LOS.

7.1 Asset Valuation

The AMP recognizes that there are different ways to measure and report on the replacement value of assets. Data sources for financial information presented in this AMP are derived predominantly from 2009 TCA data, and engineering reports and evaluations supplied by the City. With this in mind, Table 45 provides a summary of the approaches to asset valuation that are applied to the AMP.

Table 45 – Types of Asset Valuation

	Types of Value	Professional Domains	Description	Use in the AMP
1	**Historical/ Opening Cost**	Accountants	The value of the asset at the time of acquisition	Partial
2	**Book Value/ Depreciation Value**	Accountants	The current amount carried on the City's balance sheet after accounting for depreciation and impairment at the last fiscal year end	Partial
3	**Modern Equivalent Asset Value (MEAV)**	Asset Managers	The cost to replace the asset today (2019), including all "directly attributable" costs	Yes
4	**Inflated Value**	Accountants Asset Managers	The cost to replace the asset at a point in the future with corresponding inflation factors up the forecast year	Partial

Depending on the quality of available financial data, the AMP has utilized a hybrid of Book Value and MEAV.

The City has an extensive capital asset inventory with an estimated 2016 replacement value of **$1.2 billion** (excluding land), equivalent to approximately $36,000 per household. Within this context, the value of the transportation infrastructure is estimated (as of 2018) at approximately **$458 Million** or **38%** of all City asset. The following pie chart (Figure 25) provides an illustration of the transportation assets relative to all asset classes across the City's portfolio.

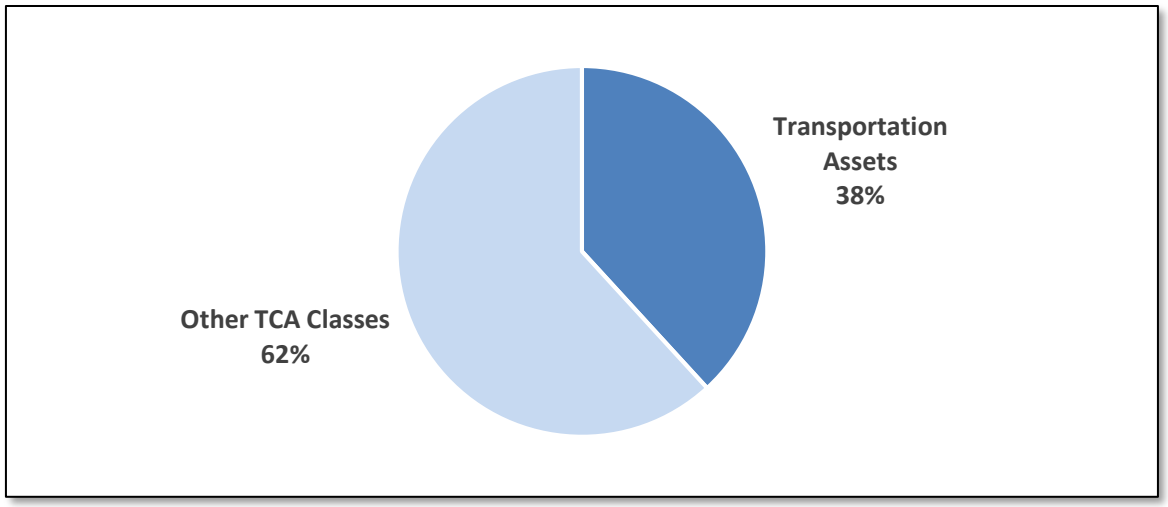


Figure 25 – Transportation Assets relative to Other City Assets

Figure 26 provides the distribution of estimated asset replacement values (2019) across the ten in-scope transportation asset classes.

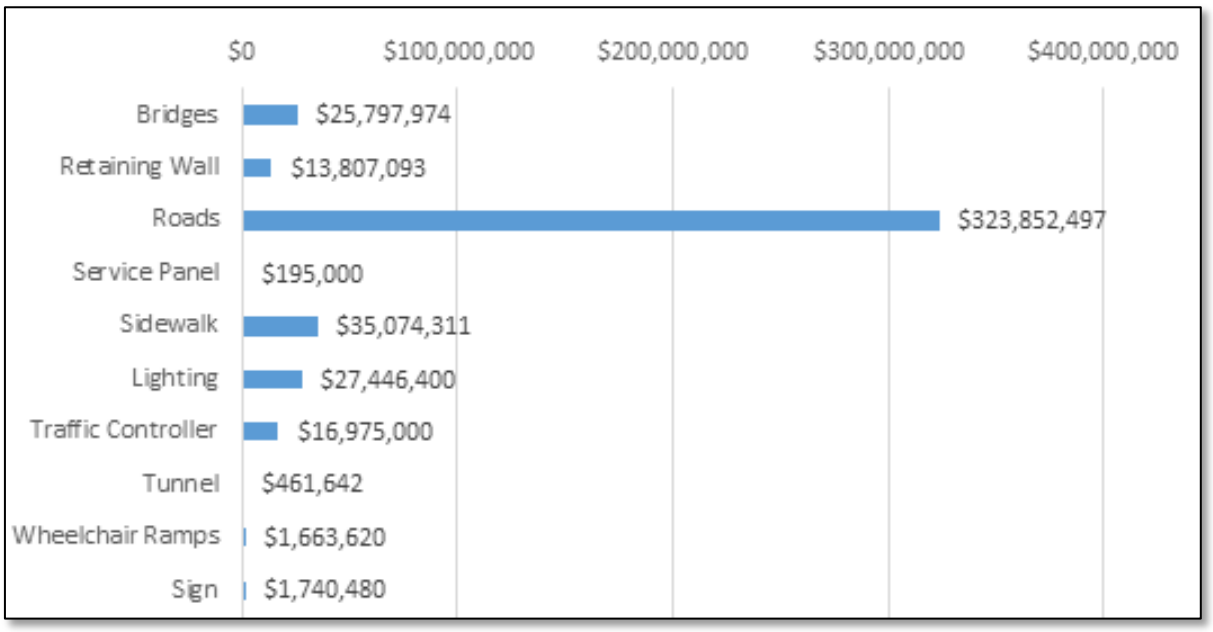


Figure 26 – Distribution of Replacement Value of Transportation Assets

The following table includes summary of the units of measure and unit rates utilized in this Transportation AMP.

Table 46 – Unit Replacement Costs

Category	Road Class	Cost $	Unit of Measure
Linear assets	**Arterial**	$1,300.00	Ln M

	MRN	$2,300.00 $140	Ln M M2
	City Collector	$1,950.00	Ln M
	Neighbourhood Collector	$1,700.00	Ln M
	Local/Narrow	$1,050.00 $110	Ln M M2
	Lane	$450.00	Ln M
	Recreation	$650.00	Ln M
	Sidewalk	$74.00	M2
Non-linear assets	**Service Panels**	$1,000.00	Ea.
	Signs	$320.00	Ea.
	Streetlights	$7,200.00	Ea.
	Traffic Signals	$175,000.00	Ea.
	Wheelchair Ramps	$510.00	Ea.

Asset valuation is subject to market and regulatory forces, which may affect the labour, material, and other costs of future capital projects.

7.2 Historical Funding

As shown in Table 47 below, progress has been made since 2010 to reduce the funding gaps identified at that time. However, as new assets are added to the inventory, setting aside funds for eventual rehabilitation/replacement of those assets also increases the demand of fiscal resources.

A summary of historical capital spends by department and corresponding asset classes, with the transportation assets identified at row 4 is shown in Table 47 below.

Table 47 – Historical Capex by Department

Departments	Asset Classes		Notes	Funding, in Millions	
				2010	2016
Parks	**1**	**Parks & Recreation**		$1.5	$2.5
Finance & IT	**2**	**IT**	Included in asset class #9	--	--
Engineering	**3**	**Facilities**		$2.3	$2.7
	4	**Transportation**	*Incl. roads and other trans.*	**$3.3**	**$5.8**
	5	**Storm Water**	Included in asset class #6	--	--
	6	**Wastewater**	combined sewer system)	$2.1	$4.0

Departments	Asset Classes		Notes	Funding, in Millions	
				2010	2016
	7	**Solid Waste**	Included in asset class #9	--	--
	8	**Water Supply**		$1.1	$3.0
	9	**Fleet**	Incl. vehicles & equipment	$3.1	$3.2
Electrical	10	**Electrical Utility**		$1.1	$2.4
			Total, Approx.	**$14.5**	**$23.6**

The average historical spend of approximately **$5 Million** is utilized in this AMP as one of the reinvestment scenarios. This represents approximately **25%** of all capital expenses across all city departments (See Figure 27).

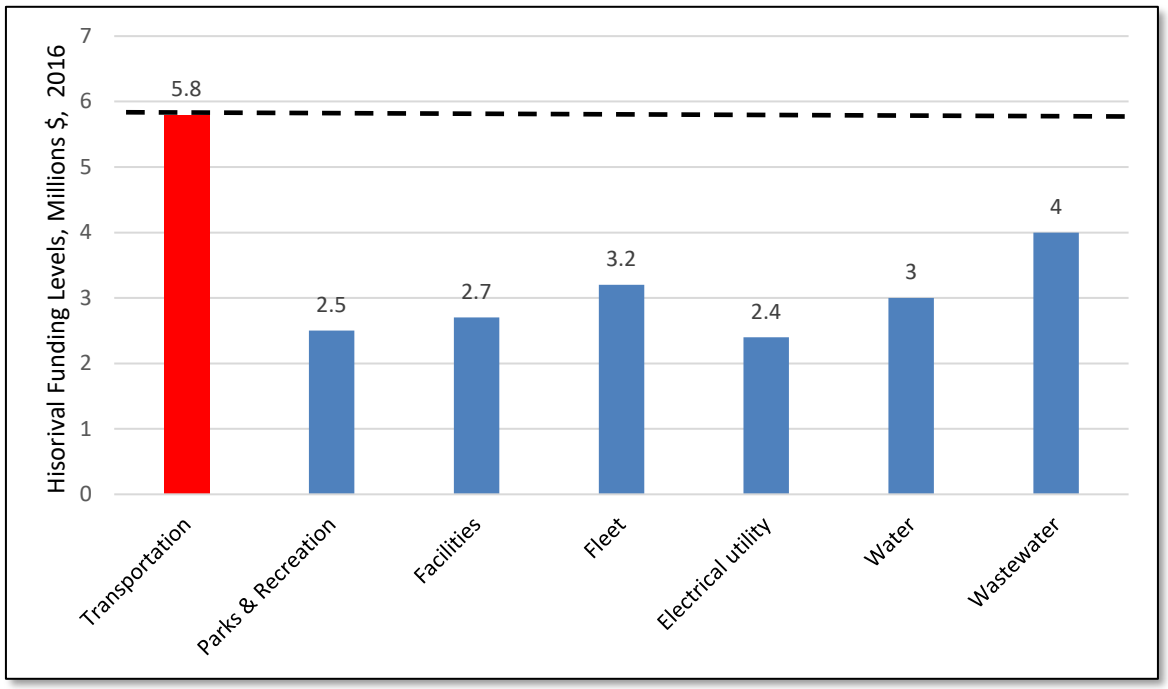


Figure 27 – Benchmarking of Historical Funding Levels, Millions, 2016

7.3 Forecast Expenses

As of early-2019, the estimated value of the transportation capital needs projects forecast over the 10-year planning horizon is estimated at approximately **$59 Million**. Relative to the replacement value of the pavement asset portfolio of **$458 Million,** the projects are in comparison approximately **13%** of the overall asset value. The following pie chart provides a visual representation of the 10-year capital needs forecast relative to the replacement value of the overall asset portfolio.

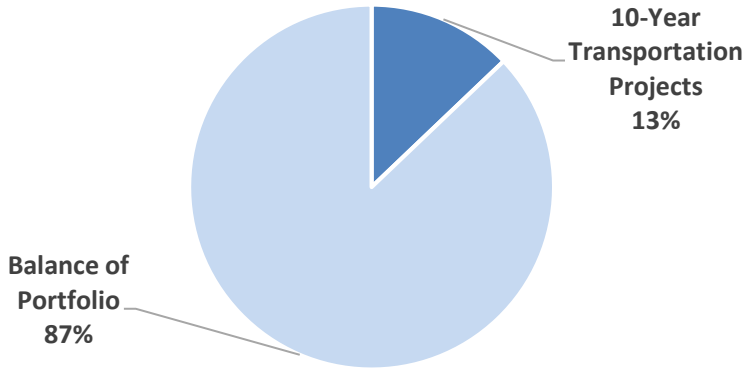


Figure 28 – 10-year Capital Needs Relative to Asset Portfolio Value

Within the $59 Million capital needs forecast over the 10-year planning horizon, the next table provides the estimated annual reinvestment rates for each of the in-scope asset classes. This enables a high-level benchmarking comparison between asset classes and relative to the average values.

The replacement backlog, sometimes referred to as the infrastructure deficit, is the current replacement cost of assets that are still in-service but have exceeded their designated lifespan. The annual funding gap is the difference between current funding level and recommended spending for asset renewal and replacement. The transportation, facilities and park & rec asset classes have a higher replacement backlog and will require the most attention. The electrical distribution, water and sewer systems have smaller funding gaps indicated at this time. Timely maintenance, replacement and upgrading of City capital assets are essential for the continued and effective provision of services. Funding sources are limited and include reserves, grants from higher levels of government and debt borrowing. Reserves are funded from the tax base and utility levies.

As of 2016, the City had identified a replacement backlog of approximately $105 million and an annual funding gap in the range of $12.1 million. The following figure visually represents the 2016 replacement backlog distributed across the service areas.

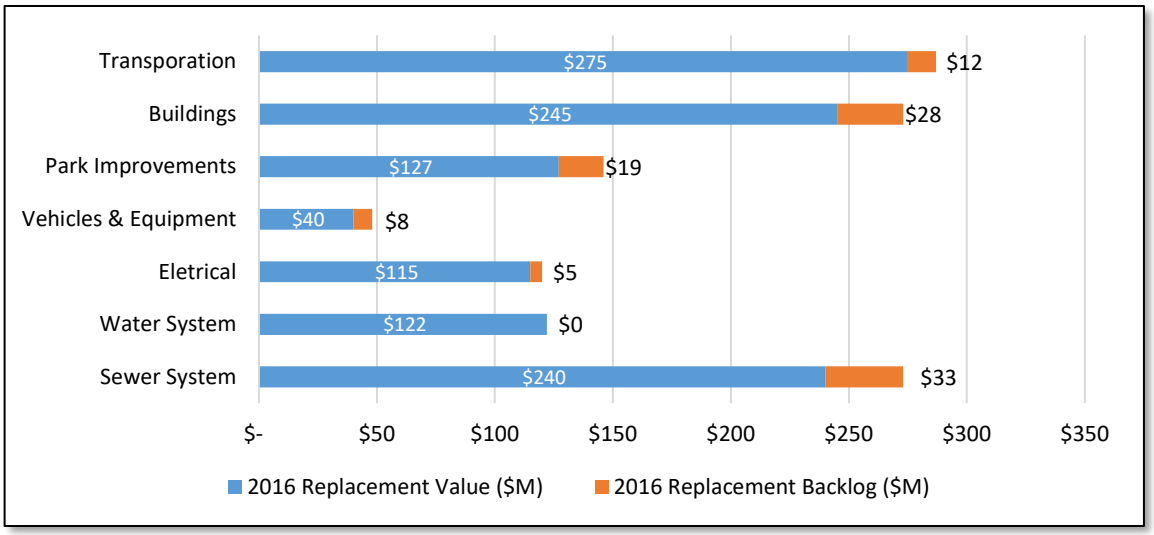


Figure 29 – City's Replacement Backlog, 2016

Table 48 provides a high-level summary of the City's capital assets based on analysis of information contained in the Tangible Capital Assets (TCA) database. The analysis has limitations given some of the assumptions and estimates around capital asset in-service dates, useful service life, and replacement value. It does however provide an indication of the magnitude of the asset deficit faced by the City. The figures in the table will require review and updating, as the City moves forward with its Asset Management journey.

Table 48 – Asset Backlog and Funding Gaps

Departments	Asset Classes		Replacement Value, 2016	Replacement Backlog, 2016	% of 2016 Replacement Value	Annual Funding Gap, 2016
Parks	1	Parks & Rec/	$127 million	$19 million	15.0%	$2.7 million
Engineering	2	Facilities	$245 million	$28 million	11.4%	$6.0 million
	3	**Transportation**	**$275 million**	**$12 million**	**4.3%**	**$2.1 million**
	4	Storm Water	Included in asset class #6			
	5	Wastewater	$240 million	$33 million	13.8%	--
	6	Solid Waste	Included in asset class #9			
	7	Water Supply	$122 million	--	--	--
	8	Fleet	$40 million	$8 million	20.0%	$1.3 million
Electrical	9	Electrical Utility	$115 million	$5 million	4.3%	--
Total - Approx.			**$1.2 billion**	**$105 million**	**--**	**$12.1 M**

The City of New Westminster, like most other Canadian municipalities, faces the challenge of funding the replacement of aging infrastructure and buildings while at the same time financing new capital assets to meet the needs of its growing community. Asset Management has been identified in Corporate Strategic Plan as one of the priorities for 2016 to 2018.

Table 49 provides a summary of the key parameters that are incorporated into the capital needs forecast.

Table 49 – Key Parameters of the Capital Needs Forecasts

Parameters		Description	Notes
Planning horizon	**Strategic**	30 years	--
	Tactical	10 years, 2019 to 2028	--
	Sub-tactical	3 years	--
	Operational	1 year	--
Capital reserves	**Opening balance**	Zero	The model currently assumes that there is no replacement reserve. Balance to be confirmed by the City (if any)
	Annual contribution	Zero	To be confirmed by the City (if any)
Variables	**Inflation factor**	2%	The model currently assumes 2% inflation/escalation compounded annually. The preferred inflation factor is to be confirmed by the City
	Taxation Rate	0%	The model currently assumes that there is no taxation rate. To be confirmed
	Discount rate	None	The model has not yet activated any discount rates for comparing alternatives as all projects are currently considered of like kind
	Interest income	None	The model does not currently calculate interest earned on the capital reserve (if any). To be confirmed
Capital project budgets	**Type/scope of projects**	Like-for-like	The model currently assumes that all pavement renewal projects are of like kind.
	Project "hard" costs	Included	All costs are currently consolidated into a unit rate per square metre.
	Project "soft" costs	Partially included	Any additional soft costs that are not in the unit rate are to be confirmed by the City
Total capital forecast ***(over 10-year horizon)***	**Uninflated**	59 Million (approx.)	--
	Inflated at 2%	$84 Million (approx.)	--
	As a % of the asset base	18% (approx.)	--
Annualized spend	**Historical**	$5 Million p.a.	Over 3-year period
		$1 Million p.a.	Over 50+ year period
	Forecast	$8 Million p.a.	Annualized forecast exceeds historical annual spend by approximately $3 Million p.a.

The 1st iteration of the City's transportation AMP has tested three alternative models for deriving capital needs forecasts for the in-scope assets. These are described in Table 50, together with commentary on their relative merits and limitations.

Table 50 – Alternative Models for Needs Forecasting

Model name		Description	Data Confidence	10-year forecast for all assets, millions	Average annual forecast for all assets, millions	Annual reinvestment rate
1	**Age-based**	The capital needs are derived solely from the age of the asset relative to useful life. This is the least sophisticated model.	Low	$12.50	$1.25	3%
2	**Condition-based (& age-based)**	The capital needs are derived from a combination of the age-based model and actual asset condition derived from Tetratech ACA scores and Associated SSI scores	Med	$61.68	$6.17	14%
3	**Risk-based**	The capital needs are derived from the risk scores, which is the composite of the POF and COF scores of each asset. Assets with a higher consequence of failure are prioritized on the planning horizon.	Med-high	$76.21	$7.62	17%
		Average		**$50.13**	**$5.01**	**11%**

The purpose of the age-based model is not to make capital decisions but to facilitate benchmarking and to justify the value of the condition-based inspections.

The risk model, on the other hand, is more nuanced and endeavors to capture the evidence-based condition of the assets (where empirical data is available) and recognizes that the assets have different criticality rankings and therefore some lower priority projects could either be postponed or the assets allowed to potentially run to failure.

Table 51 shows the estimated annual reinvestment rates for each of the in-scope transportation asset classes over the 10-year planning horizon. This enables a quick benchmarking comparison between asset classes and relative to the average values.

Table 51 – 10-year Reinvestment Forecasts by Asset Class

	Asset Classes	10-year forecast	Annual reinvestment rate
1	**Pavement / Roads**	$35,071,464	1.08%
2	**Bridges**	$585,829	0.17%
3	**Retaining walls**	$3,668,798	2.66%
4	**Tunnel**	--	--
5	**Sidewalks**	$4,406,600	1.26%
6	**Wheelchair Ramps**	$111,665	0.67%
7	**Signs**	$1,128,907	6.49%
8	**Traffic controllers**	$6,546,092	3.86%
9	**Service panels**	$92,006	4.72%
10	**Streetlights**	$8,050,139	2.93%
	Totals	**$59,661,503**	**1.30%**

The traffic signs have the highest annual reinvestment rate of **6.49%**, which reflects their shorter useful lives. The bridges, on the other hand, have the lowest annual reinvestment rate of **0.17%** primarily due to the long lives of these structures. The breakdown of costs within each asset class is included in the sections below.

The following bar chart helps to benchmark the reinvestment rates across the different transportation assets.

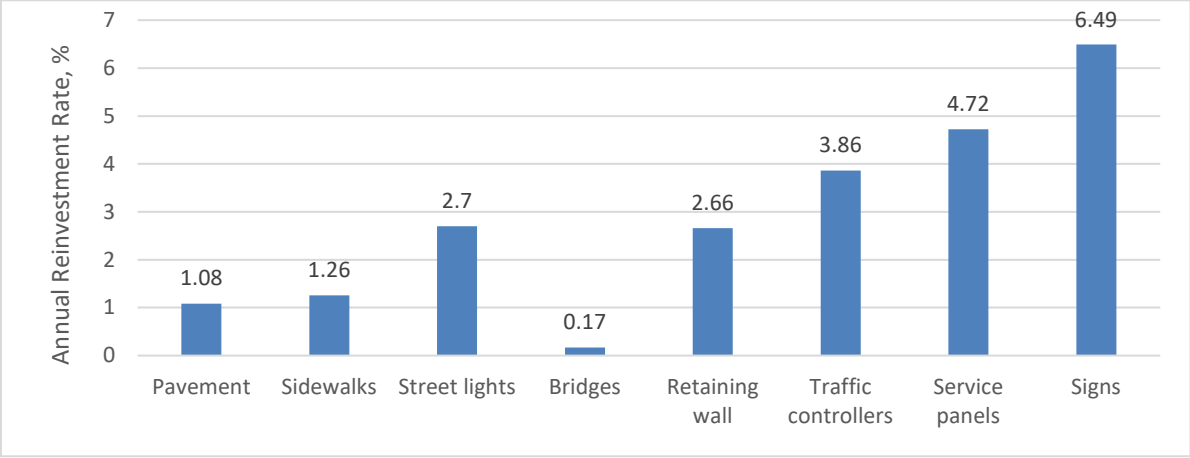
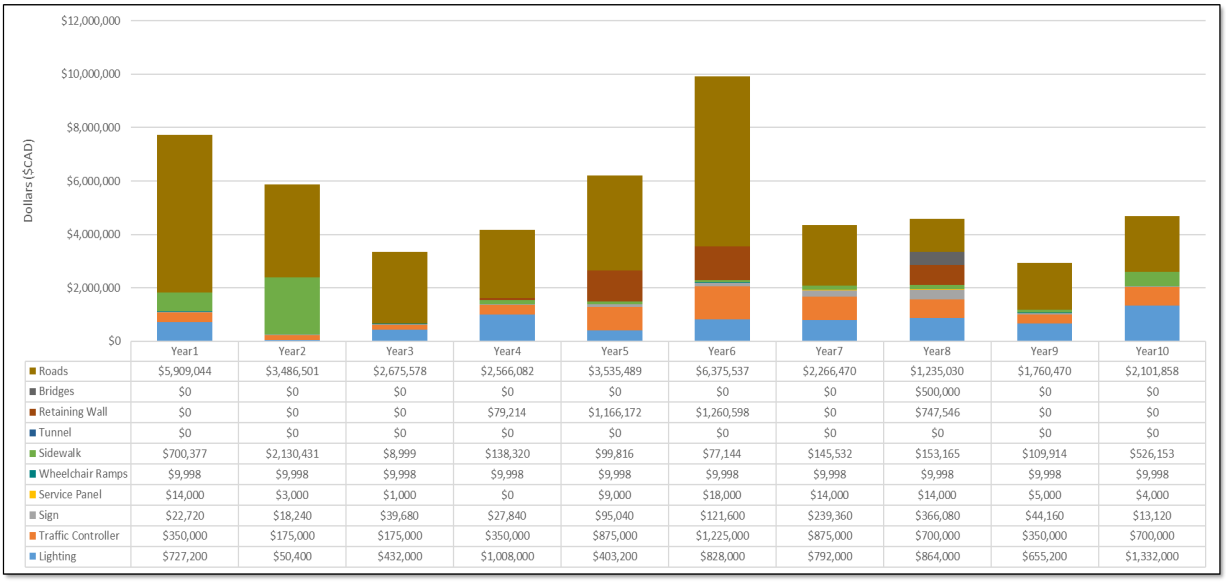


Figure 30 – Benchmarking of Annual Reinvestment Rates

The following graph provides the 10-year capital needs forecast derived from the risk-based model across the ten in-scope asset classes.

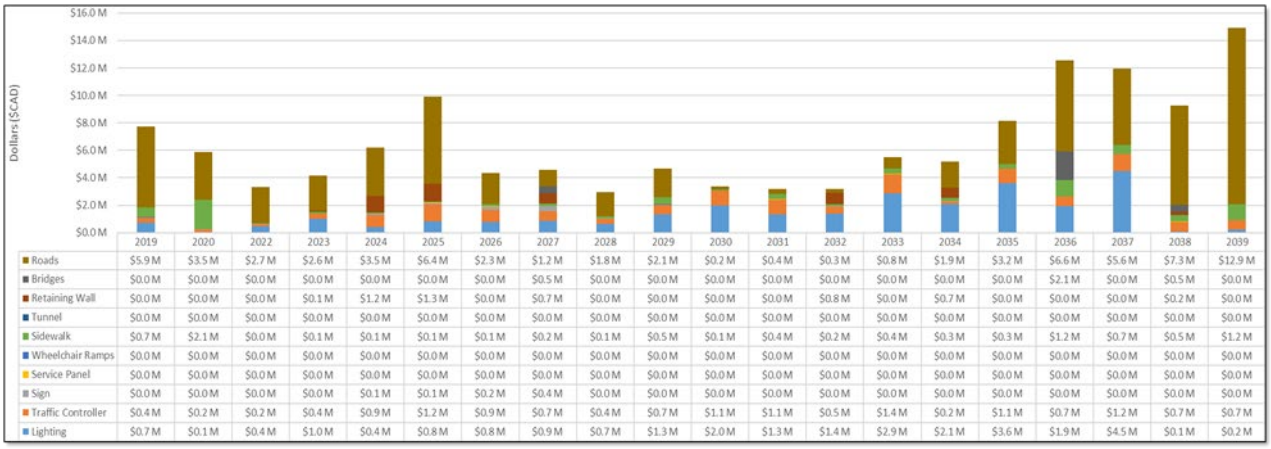
Figure 31 – 10-Year Needs Forecast Relative to Asset Portfolio Value



	Year1	Year2	Year3	Year4	Year5	Year6	Year7	Year8	Year9	Year10
Roads	$5,909,044	$3,486,501	$2,675,578	$2,566,082	$3,535,489	$6,375,537	$2,266,470	$1,235,030	$1,760,470	$2,101,858
Bridges	$0	$0	$0	$0	$0	$0	$0	$500,000	$0	$0
Retaining Wall	$0	$0	$0	$79,214	$1,166,172	$1,260,598	$0	$747,546	$0	$0
Tunnel	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Sidewalk	$700,377	$2,130,431	$8,999	$138,320	$99,816	$77,144	$145,532	$153,165	$109,914	$526,153
Wheelchair Ramps	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998	$9,998
Service Panel	$14,000	$3,000	$1,000	$0	$9,000	$18,000	$14,000	$14,000	$5,000	$4,000
Sign	$22,720	$18,240	$39,680	$27,840	$95,040	$121,600	$239,360	$366,080	$44,160	$13,120
Traffic Controller	$350,000	$175,000	$175,000	$350,000	$875,000	$1,225,000	$875,000	$700,000	$350,000	$700,000
Lighting	$727,200	$50,400	$432,000	$1,008,000	$403,200	$828,000	$792,000	$864,000	$655,200	$1,332,000

Figure 32 – Capital Needs Forecast over 10-Year Planning Horizon

The next figure provides a 20-year capital needs forecast arranged into two 10-year planning horizons.



	2019	2020	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Roads	$5.9 M	$3.5 M	$2.7 M	$2.6 M	$3.5 M	$6.4 M	$2.3 M	$1.2 M	$1.8 M	$2.1 M	$0.2 M	$0.4 M	$0.3 M	$0.8 M	$1.9 M	$3.2 M	$6.6 M	$5.6 M	$7.3 M	$12.9 M
Bridges	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.5 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$2.1 M	$0.0 M	$0.5 M	$0.0 M
Retaining Wall	$0.0 M	$0.0 M	$0.0 M	$0.1 M	$1.2 M	$1.3 M	$0.0 M	$0.7 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.8 M	$0.0 M	$0.7 M	$0.0 M	$0.0 M	$0.0 M	$0.2 M	$0.0 M
Tunnel	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Sidewalk	$0.7 M	$2.1 M	$0.0 M	$0.1 M	$0.1 M	$0.1 M	$0.1 M	$0.2 M	$0.1 M	$0.5 M	$0.1 M	$0.4 M	$0.2 M	$0.4 M	$0.3 M	$0.3 M	$1.2 M	$0.7 M	$0.5 M	$1.2 M
Wheelchair Ramps	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Service Panel	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Sign	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.1 M	$0.1 M	$0.2 M	$0.4 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M
Traffic Controller	$0.4 M	$0.2 M	$0.2 M	$0.4 M	$0.9 M	$1.2 M	$0.9 M	$0.7 M	$0.4 M	$0.7 M	$1.1 M	$1.1 M	$0.5 M	$1.4 M	$0.2 M	$1.1 M	$0.7 M	$1.2 M	$0.7 M	$0.7 M
Lighting	$0.7 M	$0.1 M	$0.4 M	$1.0 M	$0.4 M	$0.8 M	$0.8 M	$0.9 M	$0.7 M	$1.3 M	$2.0 M	$1.3 M	$1.4 M	$2.9 M	$2.1 M	$3.6 M	$1.9 M	$4.5 M	$0.1 M	$0.2 M

Figure 33 – Capital Needs Forecast over 20-Year Planning Horizon

More detailed forecasts at lower levels of the asset hierarchy are included in Appendix A.

7.4 Revenue Sources

The asset renewal program is understood to be funded, either directly or indirectly, from a wide range of revenue sources. At this juncture, information on the different revenue sources in not included in this first iteration of the AMP.

Future iterations of the AMP report should identify the specific funding sources that are available for the pavement assets. In this regard, the following table provides a conceptual illustration of how the revenue sources can be plotted against the different types of asset stewardship programs.

	Funding Sources	Infrastructure Renewal	Growth	Strategic Priorities	Other	Totals
1	Funding source 1	--	●	●	--	**2**
2	Funding source 2	●	--	--	--	**1**
3	Funding source 3	●	●	●	--	**3**
4	Funding Source 4	--	--	--	●	**1**
	Totals	**2**	**2**	**2**	**1**	--

7.5 Infrastructure Gap

The infrastructure gap is the difference between the amount of funding needed to maintain the transportation assets to support the existing level of service (LOS) being delivered by the operating group and the amount of funding currently available to do so over the plan period. The infrastructure gap is usually focused on renewal funding, the funding allocated as base maintenance, as opposed to funding allocated to growth, new legislation, enhanced LOS, or "spend to save" (i.e., spending capital specifically to reduce operating costs).

There are different approaches to estimating the infrastructure gap. Table 52 includes a summary of some of the methods and identifies the method utilized in this AMP.

Table 52 – Methods for Calculating the Infrastructure Gap

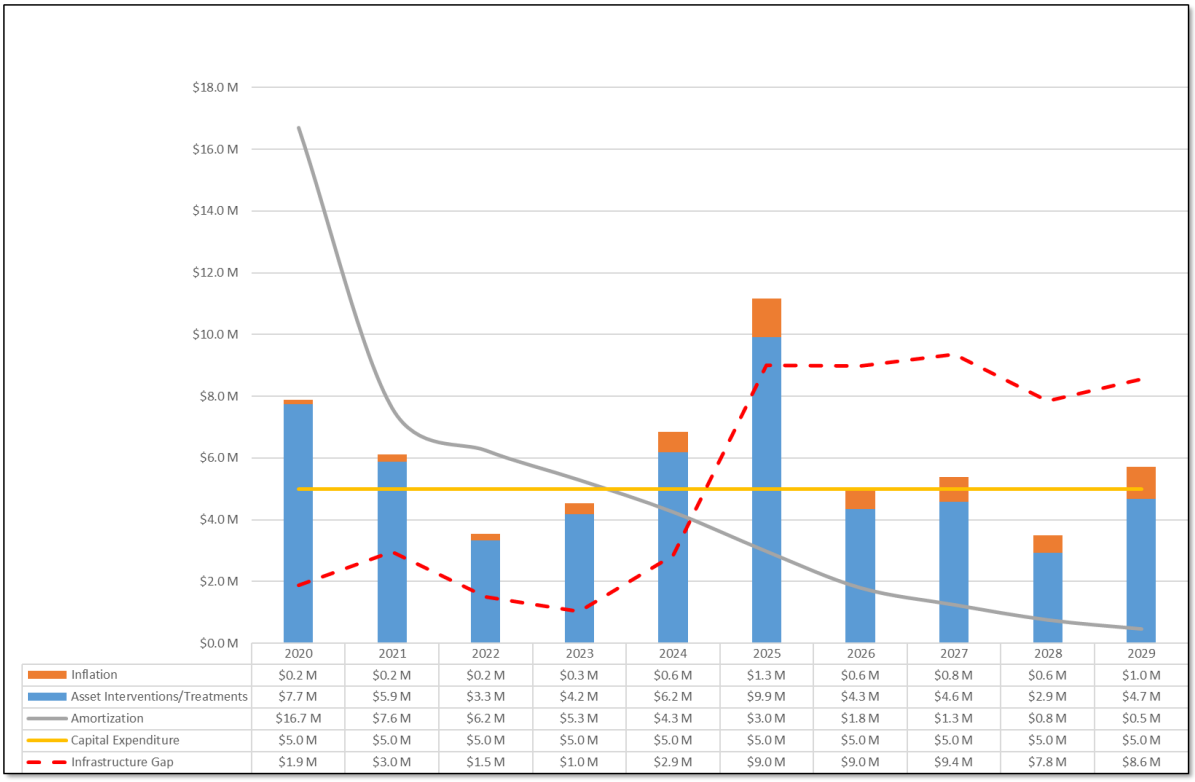
Methods		Description	Evaluation	Used in AMP
1	**Asset in "Very Poor" Condition**	Estimate the current replacement value of all those assets that have been categorized as "Very Poor". The value for the required funding over the total plan period is then the current replacement value of all those assets that have been categorized as "Very Poor" in 2019 plus what is anticipated to become "Very Poor" by the end of 2029.	This approach tends to over-estimate the infrastructure gap. This approach does not contemplate asset criticality and therefore treats every assets as having the same criticality ranking.	No
2	**Assets in "Very Poor" and "Poor Condition"**	This approach considers all those assets that have been categorized as both "Poor" and "Very Poor". The value for the required funding over the total plan period is then the current replacement value of all those	This approach would further over-estimate the infrastructure gap than approach 1. This approach does not contemplate asset criticality	No

		assets that have been categorized as either “Poor” or “Very Poor” in 2019 plus what is anticipated to become “Poor” or “Very Poor” by the end of 2029.		
3	**Degradation Model**	The value of all projects identified over the 10-year planning horizon is compared to the available funding over the same period. The cumulative funding difference between the Needs Forecast and Expenditure Limit is calculated and results in a cumulative infrastructure gap.	This method introduces asset criticality as a trigger point for treatment, whereby highly critical assets are not permitted to degrade to a “very poor” condition as the consequences of failure are deemed to be too significant.	Yes

As of late-2018, it has been estimated that the transportation group will require an infrastructure investment of approximately **$6.5 Million** per year to address the base life cycle needs of the core assets over the ensuing 10 years (2019-2028).

However, the operating group has currently identified available funding of approximately **$5 Million per year**, which will result in the steady growth of an infrastructure gap of roughly **$8.6 Million** at the end of the 10-year period. The analysis does not consider expenditures required to address growth, service improvements, or inflation.

The funding shortfall between the capital needs forecast and the assumed available funding (approximately **$5 Million** per year) is reflected in the figure below.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Inflation	$0.2 M	$0.2 M	$0.2 M	$0.3 M	$0.6 M	$1.3 M	$0.6 M	$0.8 M	$0.6 M	$1.0 M
Asset Interventions/Treatments	$7.7 M	$5.9 M	$3.3 M	$4.2 M	$6.2 M	$9.9 M	$4.3 M	$4.6 M	$2.9 M	$4.7 M
Amortization	$16.7 M	$7.6 M	$6.2 M	$5.3 M	$4.3 M	$3.0 M	$1.8 M	$1.3 M	$0.8 M	$0.5 M
Capital Expenditure	$5.0 M	$5.0 M	$5.0 M	$5.0 M	$5.0 M	$5.0 M	$5.0 M	$5.0 M	$5.0 M	$5.0 M
Infrastructure Gap	$1.9 M	$3.0 M	$1.5 M	$1.0 M	$2.9 M	$9.0 M	$9.0 M	$9.4 M	$7.8 M	$8.6 M

Figure 34 - Infrastructure Gap resulting from $5M Investment per year

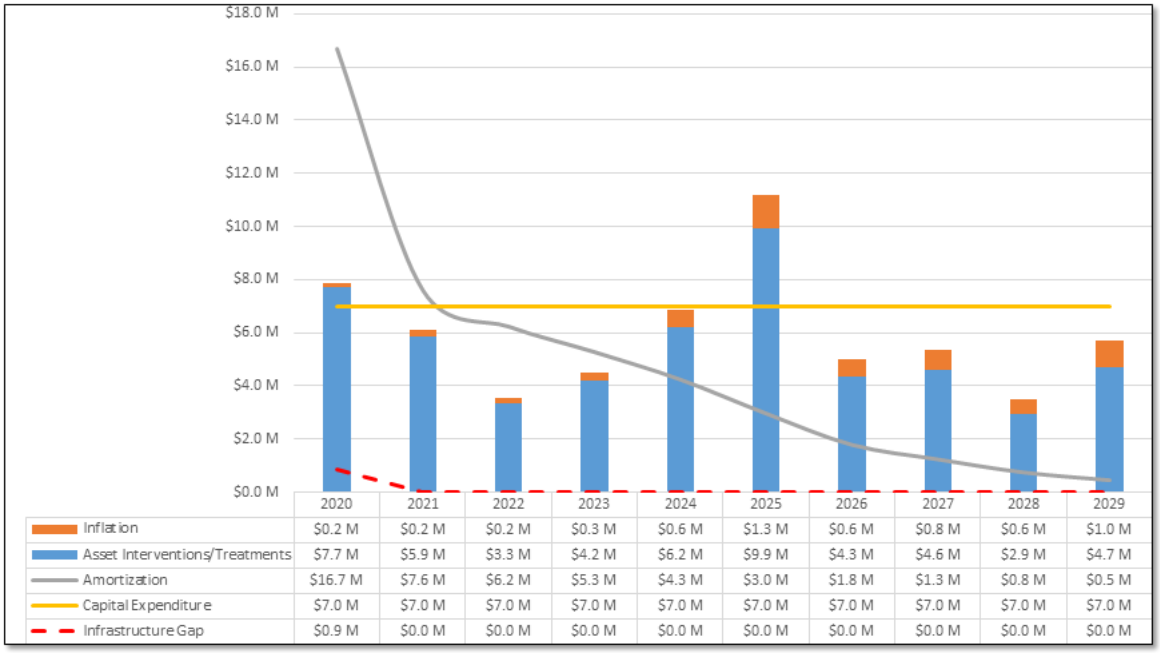
In the preceding figure the **Asset Interventions/Treatments** (“blue” bars) are the investments required to maintain the existing assets in serviceable condition. The initial value for the required funding is the current replacement value of all those assets that have been categorized as ‘Very Poor’ in 2019, in addition to what is anticipated to become ‘Very Poor’ by the end of 2019.

The **Available Capital Funding** (“yellow” line) is the amount of investment in the transportation operating group currently forecasts spending on infrastructure renewal.

The **Cumulative Infrastructure Gap** (dashed “red” line) is the sum of the differences between the Total Treatments and the Total Planned Budget (blue bar minus yellow line). The current infrastructure gap represents the amount of investment today that would be required to address the risk represented by assets nearing the end of their estimated useful lives. These needs do not include allowances for growth, inflation, or service improvements.

The preceding graphs reveals that the deficit at the 10th year (2028) is estimated at approximately **$8.6 Million** if the reinvestment rate continues at **$5 Million** annually.

To illustrate the sensitivity of the model, the next graph illustrates the infrastructure gap resulting from a **$7 Million** investment per year.



	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Inflation	$0.2 M	$0.2 M	$0.2 M	$0.3 M	$0.6 M	$1.3 M	$0.6 M	$0.8 M	$0.6 M	$1.0 M
Asset Interventions/Treatments	$7.7 M	$5.9 M	$3.3 M	$4.2 M	$6.2 M	$9.9 M	$4.3 M	$4.6 M	$2.9 M	$4.7 M
Amortization	$16.7 M	$7.6 M	$6.2 M	$5.3 M	$4.3 M	$3.0 M	$1.8 M	$1.3 M	$0.8 M	$0.5 M
Capital Expenditure	$7.0 M	$7.0 M	$7.0 M	$7.0 M	$7.0 M	$7.0 M	$7.0 M	$7.0 M	$7.0 M	$7.0 M
Infrastructure Gap	$0.9 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M	$0.0 M

Figure 35 – Infrastructure Gap Resulting from $7M Investment per year

In the preceding chart the infrastructure gap is reduced to zero at the end of the 10-year planning horizon

7.6 Reinvestment Scenarios

Table 53 provides a summary of the two broad classes of reinvestment scenarios that are typically contemplated in planning for the stewardship of unfunded liabilities

Table 53 – Two Types of Reinvestment Scenarios

	Types of Scenarios	Description	Attributes	Included in AMP
1	**Changing State – Budget Scenarios**	These types of scenarios ask the question: "What happens to the condition of my asset portfolio at funding level x?"	Level funding	Yes
2	**Steady State – Performance Target Scenarios**	These types of scenarios as the question: "What funding level should we use to keep the portfolio condition steady at level y?"	Lumpy funding	No

There are many variations for 'x" and "y" in the preceding table and this AMP contains a small set of scenarios.

This section of the AMP report identifies and evaluates three alternative "changing state" (budget) scenarios and their impact on the overall condition of the transportation portfolio over the course of the 10-year planning horizon (2018-2027).

The following graph provides a visual representation of the changing-state of the CIRC condition scores under the three alternative reinvestment scenarios.

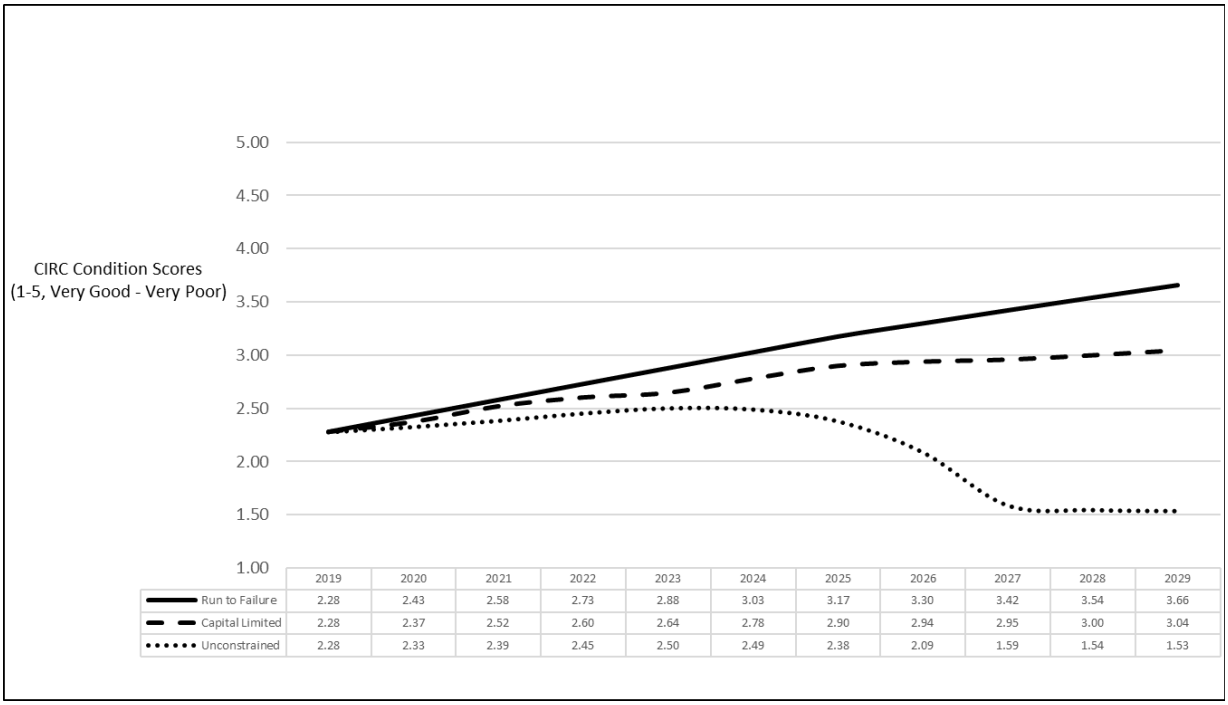


Figure 36 – Evolving CIRC Scores within each Reinvestment Scenario

7.6.1 Benchmarking

The City's proposed reinvestment rates are primarily in line with CIRC target reinvestment rates as illustrated in Table 54.

Table 54 – Current & Proposed Reinvestment Rates by Asset Class

Asset Classes		Current		Proposed			
		2016 Annual Replacement Budget	2016 Reinvestment Rate	Proposed Annual Replacement Budget	Proposed Reinvestment Rate	2016 National Reinvestment Rate	CIRC Target Reinvestment Rate
1	Parks & Recreation	$2.5 M	2.0%	$5.2 M	4.1%	1.3%	1.7-2.5%
2	Facilities	$2.7 M	1.1%	$8.7 M	3.6%	1.7%	1.7-2.5%
3	Transportation	$5.8 M	4.1%	$7.9 M	5.5%	1.1%	2.0-3.0%
4	Wastewater	$4.0 M	1.7%	$4.0 M	1.7%	0.7% sanitary linear; 0.3% storm linear; 1.3% non-linear	1.0-1.5% linear; 1.7-2.5% non-linear
5	Water Supply	$3.0 M	2.5%	$3.0 M	2.5%	0.9% linear; 1.1% non-linear	1.0-1.5% linear; 1.7-2.5% non-linear
6	Fleet	$3.2 M	8.0%	$4.5 M	11.3%	n/a	n/a
7	Electrical Utility	$2.4 M	2.1%	$2.4 M	2.1%	n/a	n/a
Averages					**4.40%**		

The following figure provides a graphical illustration of the proposed annual reinvestment rate for transportation relative to other asset classes.

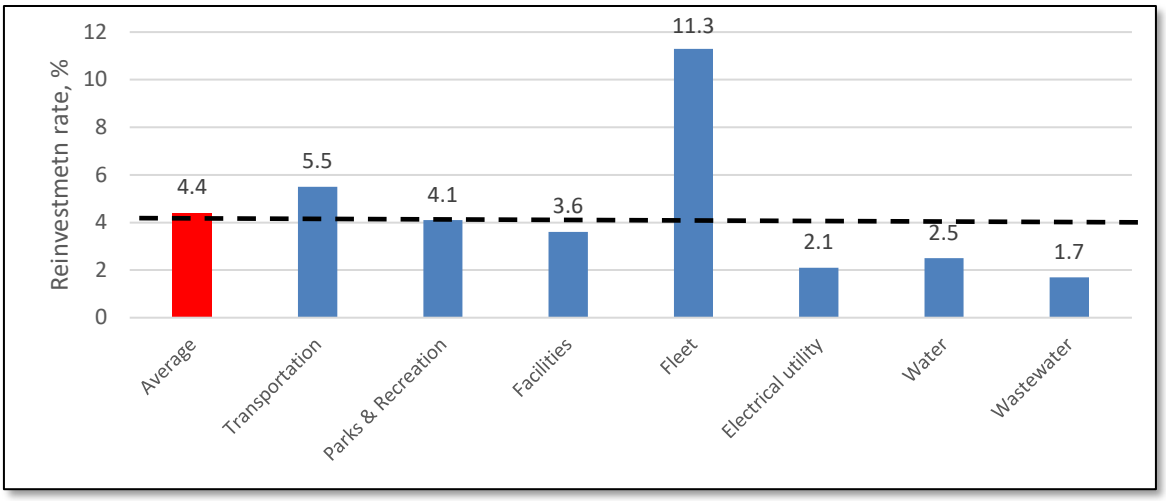


Figure 37 – Benchmarking of Proposed Reinvestment Rates across all TCA City Assets

The next figure provides the absolute dollar values for the proposed reinvestment rates across the City's TCA asset classes.

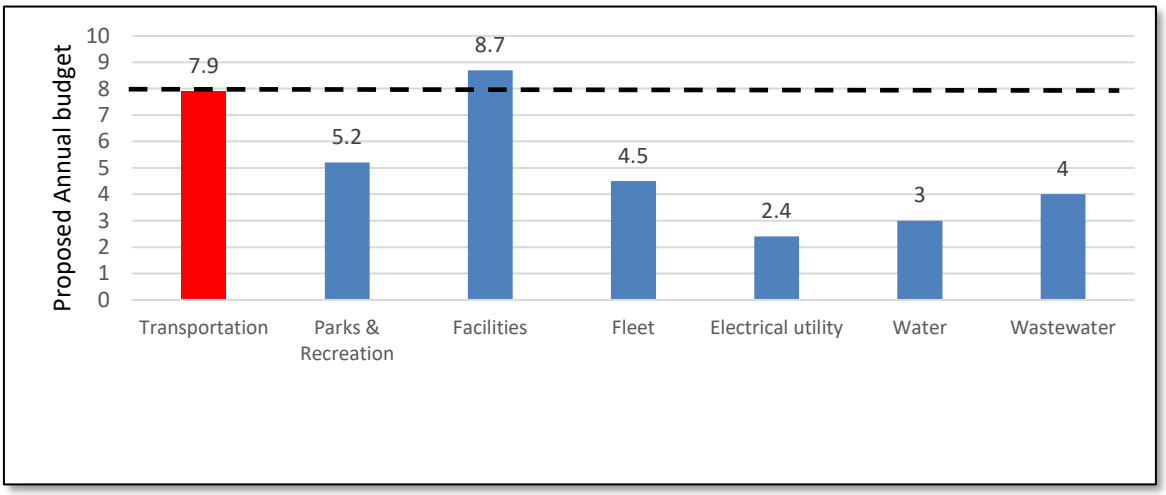


Figure 38 – Benchmarking of Proposed Annual Budgets across TCA Assets, $M

Included in the figure below are the 2016 replacement backlog estimates for all TCA assets classes. The values are benchmarked to the transportation assets.

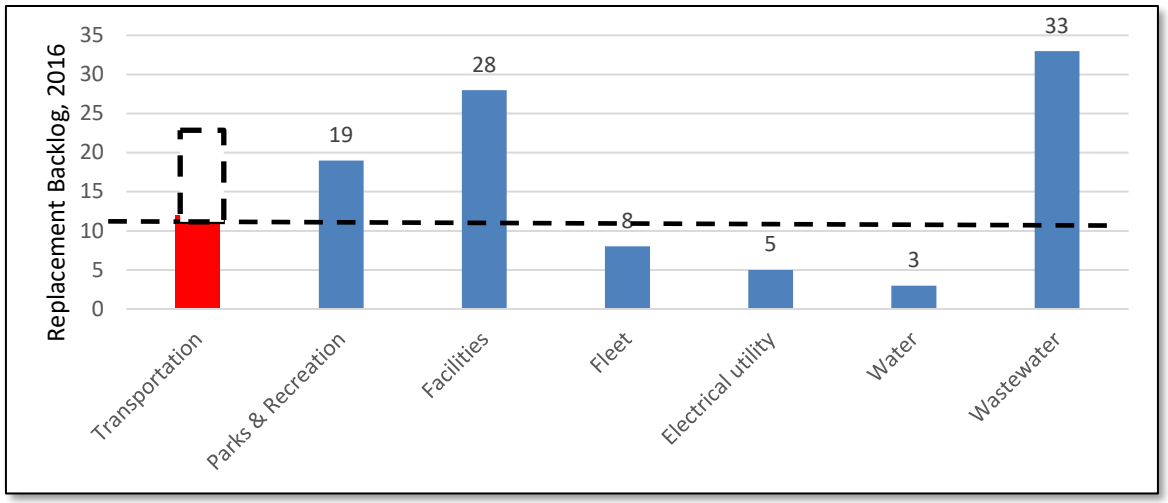
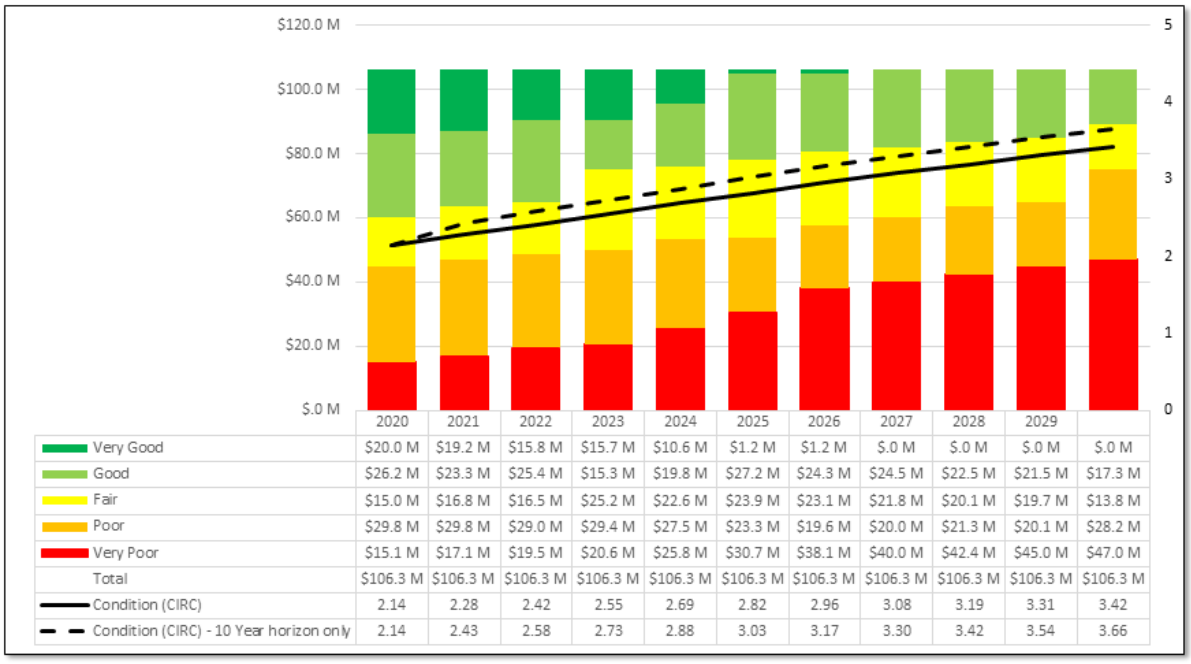


Figure 39 – Benchmarking of Backlog values, %, 2016

7.6.2 Scenario "A" – Run to Failure

The following graph indicates the deteriorating condition of the portfolio of in-scope transportation assets at a zero reinvestment rate over the 10-year planning horizon. The supporting data, and corresponding pivot table, is included in an Excel Workbook that accompanies the AMP report.



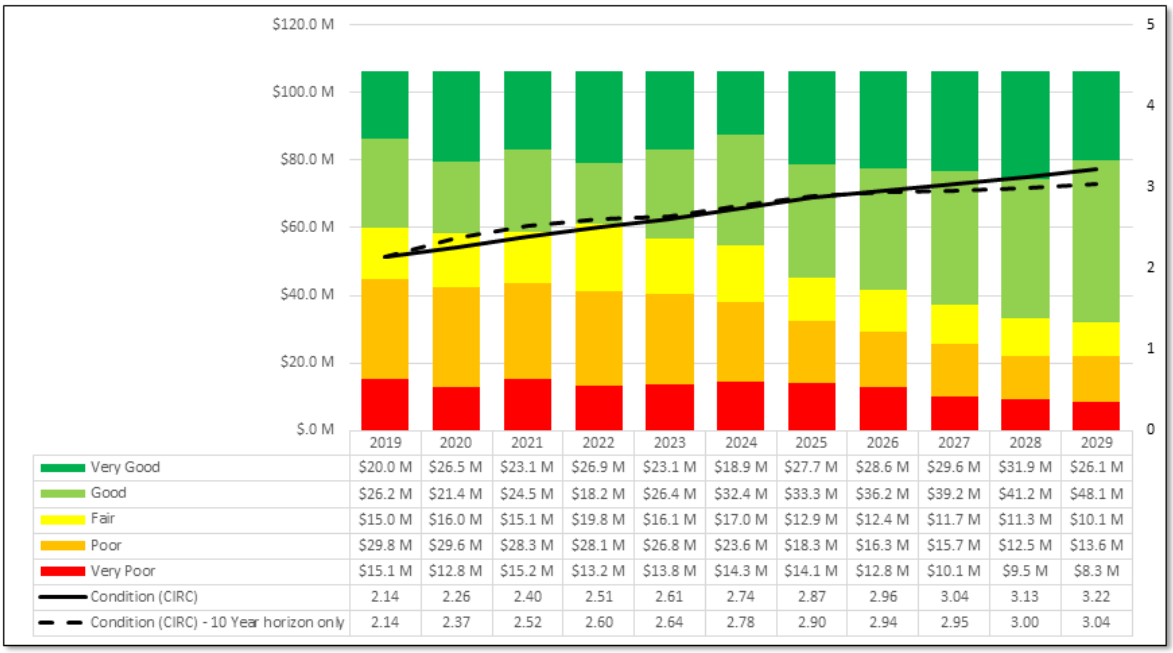
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	
Very Good	$20.0 M	$19.2 M	$15.8 M	$15.7 M	$10.6 M	$1.2 M	$1.2 M	$.0 M	$.0 M	$.0 M	$.0 M
Good	$26.2 M	$23.3 M	$25.4 M	$15.3 M	$19.8 M	$27.2 M	$24.3 M	$24.5 M	$22.5 M	$21.5 M	$17.3 M
Fair	$15.0 M	$16.8 M	$16.5 M	$25.2 M	$22.6 M	$23.9 M	$23.1 M	$21.8 M	$20.1 M	$19.7 M	$13.8 M
Poor	$29.8 M	$29.8 M	$29.0 M	$29.4 M	$27.5 M	$23.3 M	$19.6 M	$20.0 M	$21.3 M	$20.1 M	$28.2 M
Very Poor	$15.1 M	$17.1 M	$19.5 M	$20.6 M	$25.8 M	$30.7 M	$38.1 M	$40.0 M	$42.4 M	$45.0 M	$47.0 M
Total	$106.3 M	$106.3 M	$106.3 M	$106.3 M	$106.3 M	$106.3 M	$106.3 M	$106.3 M	$106.3 M	$106.3 M	$106.3 M
Condition (CIRC)	2.14	2.28	2.42	2.55	2.69	2.82	2.96	3.08	3.19	3.31	3.42
Condition (CIRC) - 10 Year horizon only	2.14	2.43	2.58	2.73	2.88	3.03	3.17	3.30	3.42	3.54	3.66

Figure 40 – Scenario "A" – Run to Failure

At a zero reinvestment rate, the asset portfolio is forecast to degrade to a backlog of approximately **$47M Million** of the transportation assets in "very poor" condition in the last year of the 10-year planning horizon (i.e. 2029).

7.6.3 Scenario "B" – Constrained at $5M Per Annum ("Status Quo")

Based on average annual historical capital expenditures of approximately $5 Million per year, the following graph indicates the changing condition of the portfolio of in-scope transportation assets at an annual reinvestment rate of **$5 Million** over the 10-year planning horizon. This is referred to a as the "status quo" reinvestment rate.



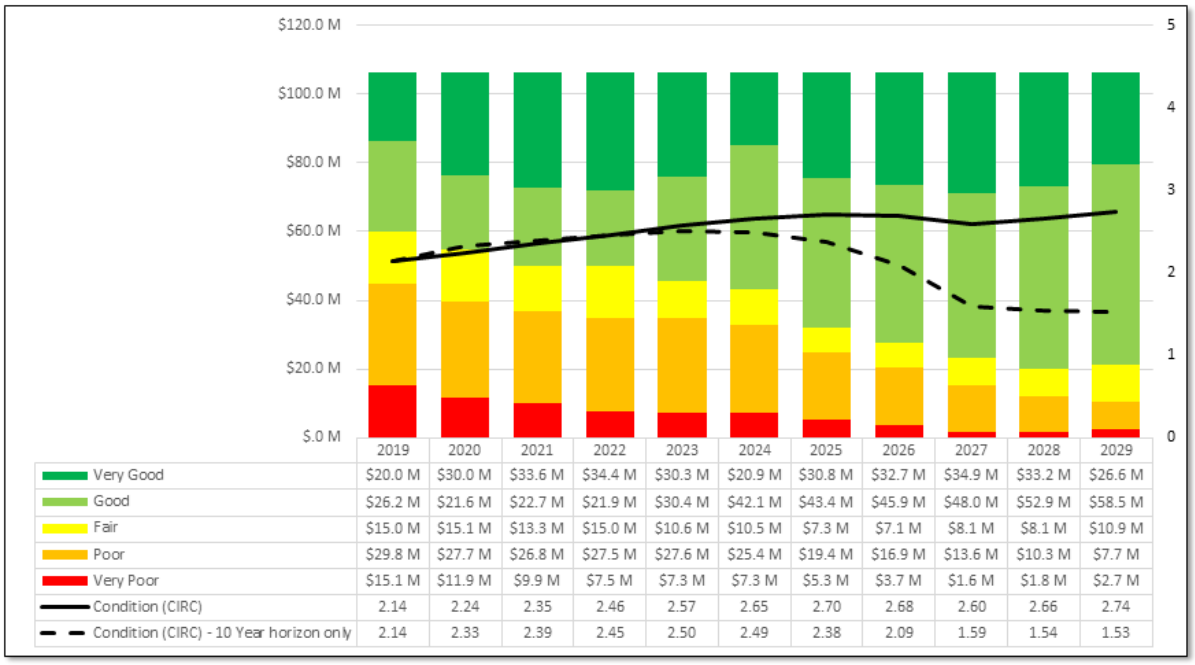
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Very Good	$20.0 M	$26.5 M	$23.1 M	$26.9 M	$23.1 M	$18.9 M	$27.7 M	$28.6 M	$29.6 M	$31.9 M	$26.1 M
Good	$26.2 M	$21.4 M	$24.5 M	$18.2 M	$26.4 M	$32.4 M	$33.3 M	$36.2 M	$39.2 M	$41.2 M	$48.1 M
Fair	$15.0 M	$16.0 M	$15.1 M	$19.8 M	$16.1 M	$17.0 M	$12.9 M	$12.4 M	$11.7 M	$11.3 M	$10.1 M
Poor	$29.8 M	$29.6 M	$28.3 M	$28.1 M	$26.8 M	$23.6 M	$18.3 M	$16.3 M	$15.7 M	$12.5 M	$13.6 M
Very Poor	$15.1 M	$12.8 M	$15.2 M	$13.2 M	$13.8 M	$14.3 M	$14.1 M	$12.8 M	$10.1 M	$9.5 M	$8.3 M
Condition (CIRC)	2.14	2.26	2.40	2.51	2.61	2.74	2.87	2.96	3.04	3.13	3.22
Condition (CIRC) - 10 Year horizon only	2.14	2.37	2.52	2.60	2.64	2.78	2.90	2.94	2.95	3.00	3.04

Figure 41 – Scenario "B" – Constrained Reinvestment at $5Million

At this reinvestment rate, the overall condition of the transportation portfolio is forecast to gradually improve with a portfolio of approximately **$8 Million** of the transportation assets in "very poor" condition at the end of the 10-year planning horizon (i.e. 2029).

7.6.4 Scenario "C" – Unconstrained Reinvestment

The following graph indicates the changing condition of the portfolio of transportation assets at an unconstrained (and lumpy) reinvestment over the 10-year planning horizon (2019-2029). The supporting data is included in an Excel Workbook that accompanies the AMP.



	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Very Good	$20.0 M	$30.0 M	$33.6 M	$34.4 M	$30.3 M	$20.9 M	$30.8 M	$32.7 M	$34.9 M	$33.2 M	$26.6 M
Good	$26.2 M	$21.6 M	$22.7 M	$21.9 M	$30.4 M	$42.1 M	$43.4 M	$45.9 M	$48.0 M	$52.9 M	$58.5 M
Fair	$15.0 M	$15.1 M	$13.3 M	$15.0 M	$10.6 M	$10.5 M	$7.3 M	$7.1 M	$8.1 M	$8.1 M	$10.9 M
Poor	$29.8 M	$27.7 M	$26.8 M	$27.5 M	$27.6 M	$25.4 M	$19.4 M	$16.9 M	$13.6 M	$10.3 M	$7.7 M
Very Poor	$15.1 M	$11.9 M	$9.9 M	$7.5 M	$7.3 M	$7.3 M	$5.3 M	$3.7 M	$1.6 M	$1.8 M	$2.7 M
Condition (CIRC)	2.14	2.24	2.35	2.46	2.57	2.65	2.70	2.68	2.60	2.66	2.74
Condition (CIRC) - 10 Year horizon only	2.14	2.33	2.39	2.45	2.50	2.49	2.38	2.09	1.59	1.54	1.53

Figure 42 – Scenario "C" – Unconstrained Reinvestment

At this reinvestment rate, the overall condition of the transportation portfolio is forecast to continue to gradually improve with approximately **$2 Million** of the asset base in "very poor" condition at the end of the 10-year planning horizon (2029).

7.7 Strategies to Address the Infrastructure Gap

This section provides details of what the transportation department has been doing and what it plans to do, in order to:

- Better understand the size of the backlog
- Minimize the infrastructure backlog
- Manage the assets so that the correct level of rehabilitation is carried out with the aim of slowing the deterioration of assets.

Mitigation strategies can be arranged into two broad categories: (a) asset management strategies and (b) financial strategies.

7.7.1 Asset Management Strategies

This section provides details of what the transportation group has been doing and what it plans to do, in order to:

- Better understand the size of the backlog
- Minimize any infrastructure backlog

- Manage the assets so that the correct level of rehabilitation is carried out with the aim of slowing the deterioration of assets.

By adopting the asset management practices and programs any future infrastructure backlog can be partially mitigated. Table 55 provides an outline of some of the strategies/approaches that may be available to mitigate the transportation infrastructure deficit.

Table 55 – Financial Mitigation Strategies

Strategies		Description
1	**Lower the LOS** (for certain asset classes)	Review the current LOS across the different classes of assets and accept a lower LOS for certain asset classes or for sub-sets (i.e., less critical) within an asset class. In this example, some of the assets currently graded as 'Very Poor', which equated to a certain LOS, could be reassessed as 'Poor', or 'Fair' as the definition of what constitutes 'Very Poor' is amended. Therefore, by being more granular when setting LOS, the actual funding gap may be reduced. However, any potential changes to LOS would only be considered as part of a thorough review of service levels across Service Areas.
2	**Asset rationalization**	There may be cases where there are two assets in 'Very Poor' condition which could be replaced by one, thereby significantly reducing the total replacement cost. This would mean certain bus loops or park and ride facilities are taken out of service.
3	**Improve data confidence**	Obtain better condition and performance data on assets and to gather this data at a more granular level. This would enable a better estimate of which elements within the asset are actually in 'Very Poor' condition. By doing this, future estimates of the infrastructure deficit would only include those parts of the assets classified as 'Very Poor'. This contrasts with assessing the asset at too high a level in the asset hierarchy, which may result in the complete asset being graded 'Very Poor'.
4	**Implement a maintenance optimization program**	This strategy includes activities to extend the life of certain assets. Regarding the further deterioration of assets, there are a few maintenance approaches available that the operating group has been adopting. If applied at the correct point in an asset's life cycle, these approaches can slow down the deterioration process and lessen the growth of any infrastructure deficit. These maintenance activities are normally funded from a combination of the capital and operational budgets and may, in the short term, require enhanced funding for a period of time. The operating group will also need to continue its reactive work, while enhancing its proactive maintenance approach. However, decisions on the selection of optimum maintenance activities should be made on a lowest whole life cost basis. By adopting a more proactive approach to the management of its assets, the operating group could realize significant cost savings over the useful life of these assets.

The transportation group has a large infrastructure gap and asset management strategies alone cannot close the gap. In order to maintain and, in some cases, restore LOS, the department will have to consider increased levels of funding.

7.7.2 Funding Strategies

The table below provides an outline of some of the strategies/approaches that may be available to mitigate the transportation group's infrastructure deficit.

Table 56 – Financial Mitigation Strategies

Strategy		Description
1	**Implement debt management measures**	Reduce debt load and interest charges; etc. A variety of strategies, including: Reduction of debt levels by exceeding annual debt repayment limits to lower interest charges; cancellation of authorized but unused debt. Increase PAYG financing in lieu of debenture financing. Maintain liquidity of investments to temporarily finance projects. Disposal of existing assets to use proceeds to reduce debt.
2	**Optimize the mix of funding sources**	Seek out appropriate balances between the different sources of funding (taxation, capital reserves, capital levies, etc.)
3	**Seek out new funding sources**	Consider what funding sources are available to the Service Area to close the infrastructure gap, both internal and external (where applicable) and include a discussion on which funding sources are applicable, along with the future plans for considering alternative funding sources.

Revenue sources are not within the scope of this AMP and should potentially be considered with the next iteration of the report.

Appendices

Appendix A
Analysis by Asset Class



Transportation Asset Management Plan: Appendices – By Asset Class

City of New Westminster

Iteration No. 1

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1. A - By Individual Asset Class

1.1 Pavement / Roads

1.1.1 Key Performance Indicators

The following matrix provides a high level "heat map" of the eight (8) key performance indicators for the pavement asset class. Definitions for each of the KPIs is included in the body of the report.

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10 years	Annual Reinvestment Rate
Recreation	19%	--	1.39	22	23	2.45	$578,387	0.2%
Local	68%	--	2.58	28	11	2.34	$5,498,361	1.7%
Local, Narrow	92%	--	3.29	32	15	2.57	--	--
Collector	75%	--	2.73	35	34	3.10	$7,574,213	2.3%
Major Road Network	66%	--	1.77	45	65	3.87	$5,852,792	1.8%
Arterial	70%	--	2.65	42	72	4.04	$1,114,537	0.3%
Lane	76%	--	2.50	25	8	2.15	$531,451	0.2%
Collector	69%	--	2.41	43	35	3.30	$13,842,098	4.3%
Highway, Provincial	2%	--	1.00	0	0	1.00	--	--
Restricted	11%	--	1.19	20	19	2.27	$79,620	--
Total	**67%**	**--**	**2.45**	**29**	**17**	**2.50**	**$35,071,464**	**1.08%**

A more comprehensive "heat map" that places the pavement assets in a broader context with the other asset classes is included in the Executive Summary.

1.1.1 Data Confidence

As of early-2019, approximately 65% of the pavement assets have been subject to evidence-based condition assessment. The following chart provides a visual representation of the volume of pavement data that has been subject to empirical condition validation.

Asset Classes	Empirical	Anecdotal
Roads	65.36%	34.64%
Arterial	70.00%	30.00%
Collector	68.80%	31.20%
Highway, Provincial	1.64%	98.36%
Lane	75.60%	24.40%
Local	68.39%	31.61%
Local, Narrow	91.67%	8.33%
Major Road Network	65.99%	34.01%

Neighbourhood Collector	74.76%	25.24%
Recreation	19.44%	80.56%
Restricted	11.11%	88.89%

The following chart indicates the distribution of data sources for each of the road classes. Description of the three types of data sources are included in the body of the report.

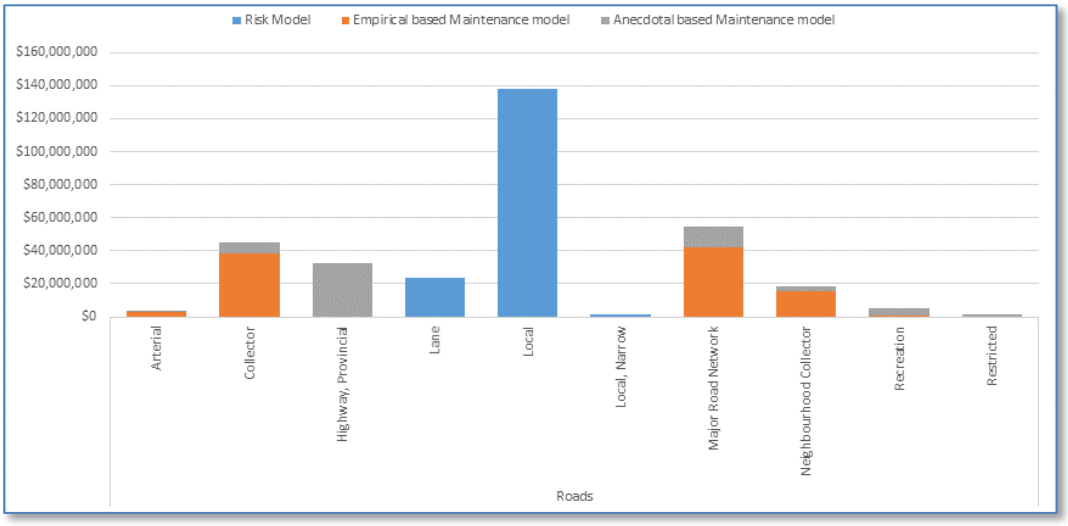


Figure 1 Distribution Data Sources for All Road Classes

1.1.2 Inventory

The City's roads network is comprised of 252 km of roads, including 23.8 km of MRN, 2.7 km arterial roads, and 133.3 km of local roads. Included below are some sample photographs for reference.



Figure 2 Sample Photograph (City Road)

1.1.3 Valuation

The following table provides a summary of the unit rates used in the AMP to derive the asset replacement costs. The following chart provides the valuation summary for the transportation assets.

Roads Asset Hierarchy	Unit of Measure	Average Unit Rates, Average (2019)	Major Rebuild Unit Rates. Average
Recreation	m	$1,060	$795
Local	m	$1,060	$553
Local, Narrow	m	$470	$0
Neighbourhood Collector	m	$1,700	$1,164
Major Road Network	m	$2,300	$906
Arterial	m	$1,300	$837
Lane	m	$450	$185
Collector	m	$1,939	$1,247
Highway, Provincial	m	$2,300	$1,725
Restricted	m	$450	$338
Strata	m	$450	$1,050

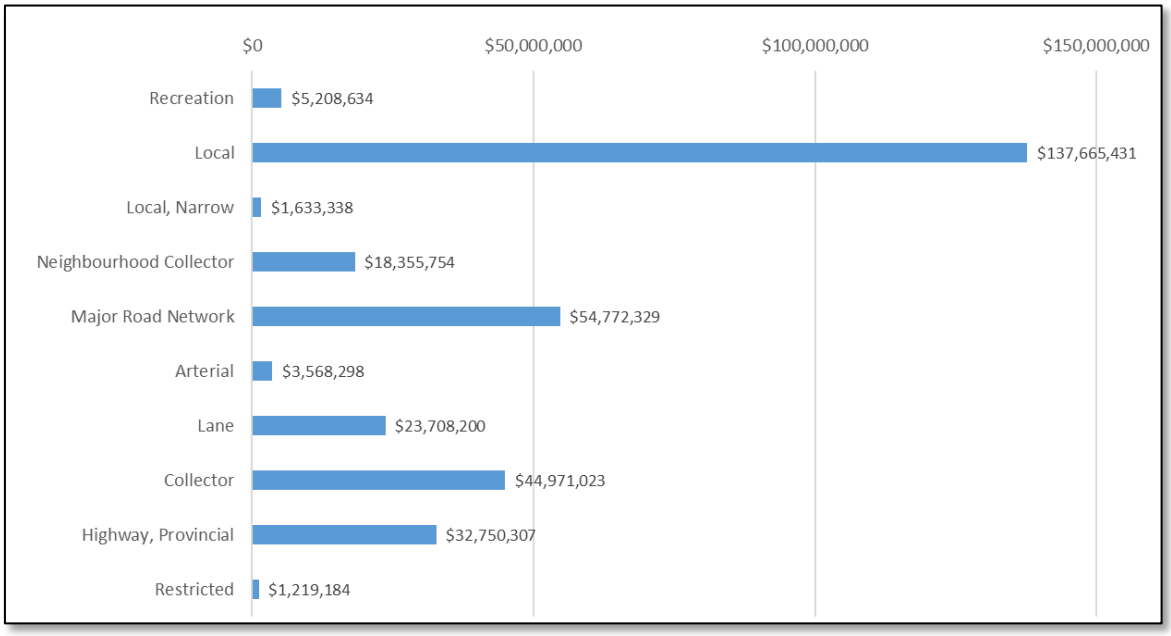


Figure 3 Valuation Summary by Road Type

The figure below provides the road network classifications as per the Master Transportation Plan (MTP 2015): Arterial, Major Road Network (MRN), City Collector, Neighbourhood Collector, Local/Narrow Street, Lane, and Recreation.

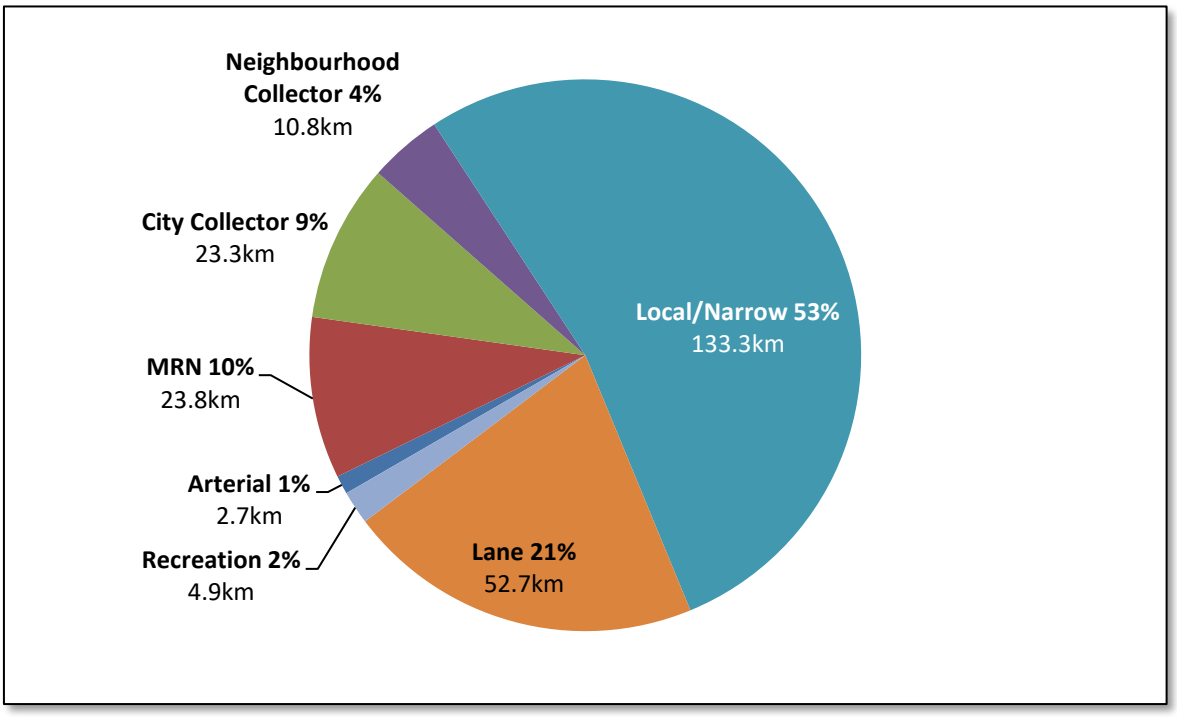
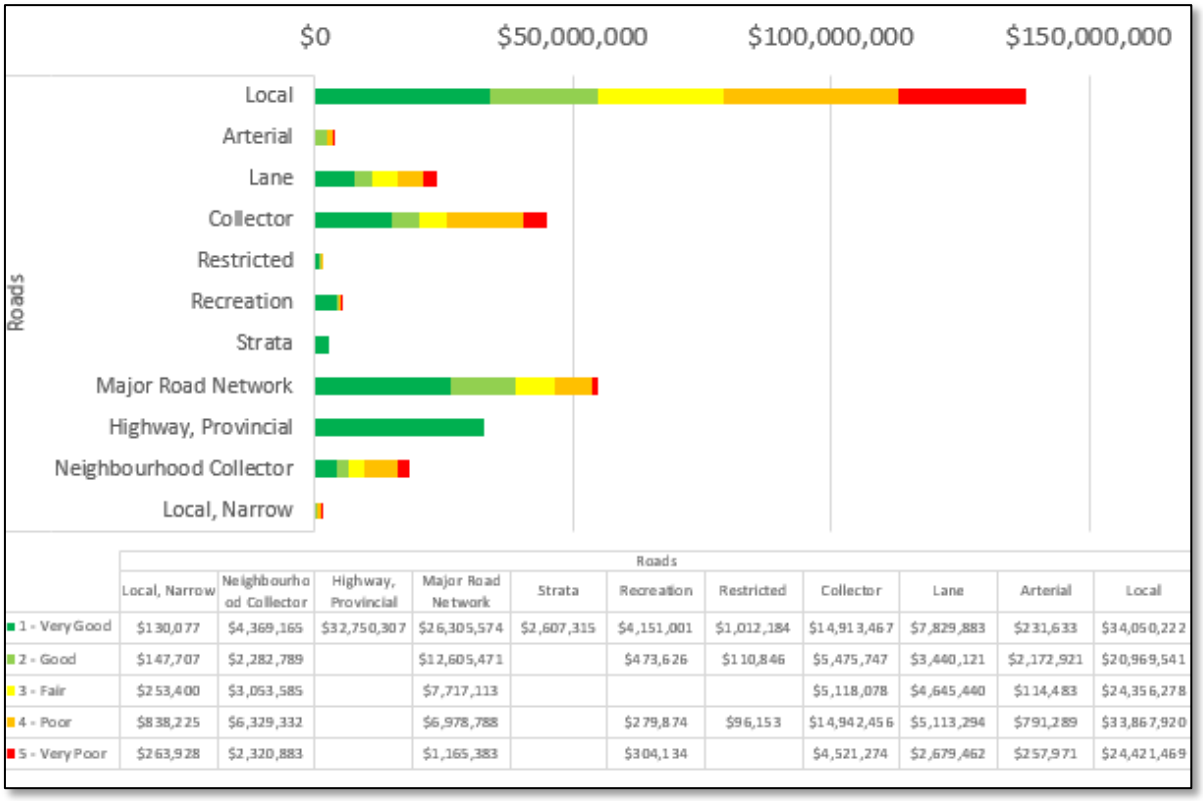


Figure 4 Road Network Classifications

1.1.4 Condition

Based on a composite of the Tetratech condition data and the AECOM risk model, the following bar chart provides a visual summary of the condition of the City's pavement across the different road classes. Condition is graded on a 5-point scale in conformity with the Canadian Infrastructure Report Card (CIRC). The supporting data is included in an MSExcel workbook that accompanies the AMP.



	Roads										
	Local, Narrow	Neighbourhood Collector	Highway, Provincial	Major Road Network	Strata	Recreation	Restricted	Collector	Lane	Arterial	Local
1 - Very Good	$130,077	$4,369,165	$32,750,307	$26,305,574	$2,607,315	$4,151,001	$1,012,184	$14,913,467	$7,829,883	$231,633	$34,050,222
2 - Good	$147,707	$2,282,789		$12,605,471		$473,626	$110,846	$5,475,747	$3,440,121	$2,172,921	$20,969,541
3 - Fair	$253,400	$3,053,585		$7,717,113				$5,118,078	$4,645,440	$114,483	$24,356,278
4 - Poor	$838,225	$6,329,332		$6,978,788		$279,874	$96,153	$14,942,456	$5,113,294	$791,289	$33,867,920
5 - Very Poor	$263,928	$2,320,883		$1,165,383		$304,134		$4,521,274	$2,679,462	$257,971	$24,421,469

Figure 5 Condition Summary by Valuation per Road Type

The next graph provides the condition distributions as a percentage of each asset class.

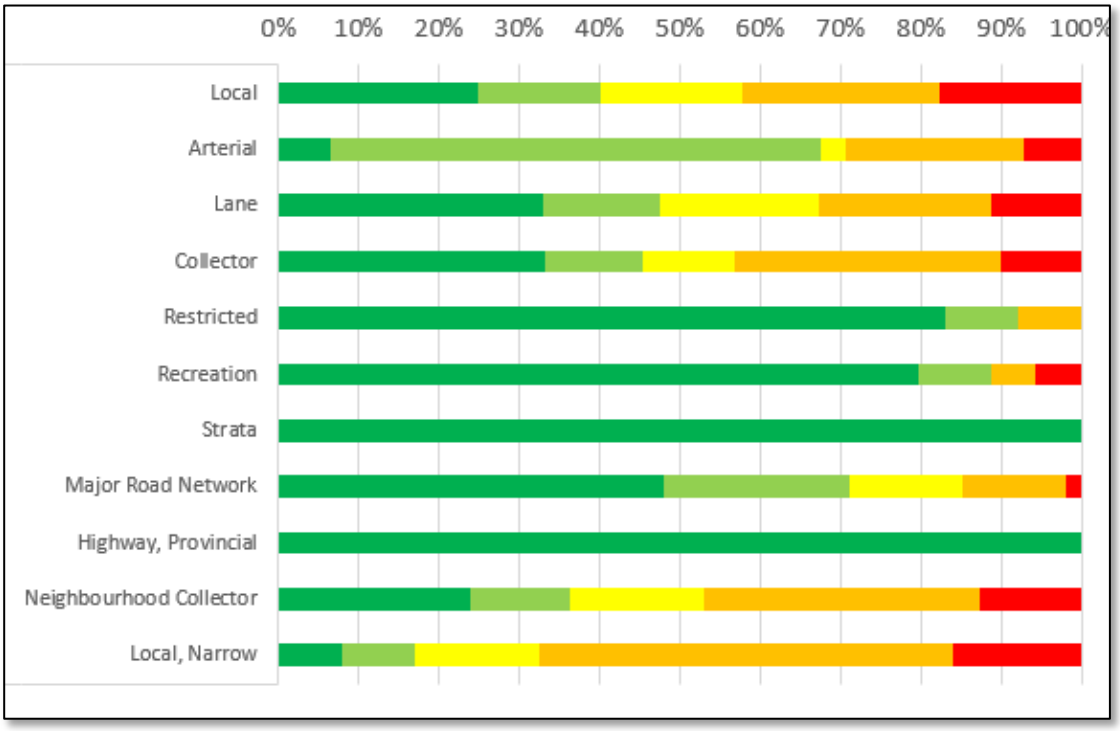


Figure 6 Condition Summary by Percentage by Road Type

Benchmarking of the condition of the pavement relative to the condition of the other asset classes is necessary for achieving cross-asset optimization. The condition distributions across all the City's various transportation asset classes is included in Section 3.

1.1.5 Risk

The following risk matrix plots the probability of failure and consequence of failure for the pavement assets by road type.

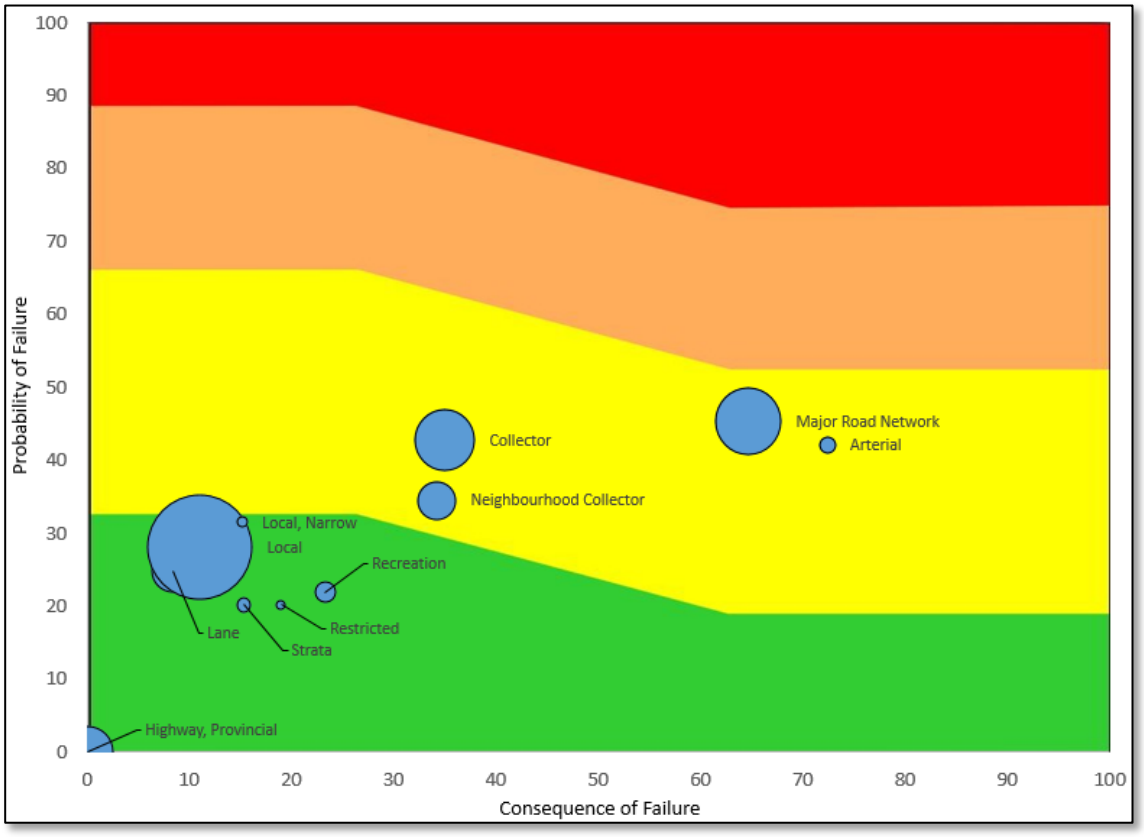


Figure 7 Risk Summary for Different Road Types

The MRN and Arterial roads occupy the highest consequence of failure band on the horizontal “x” axis. The next figure provides the risk matrix for the collector roads

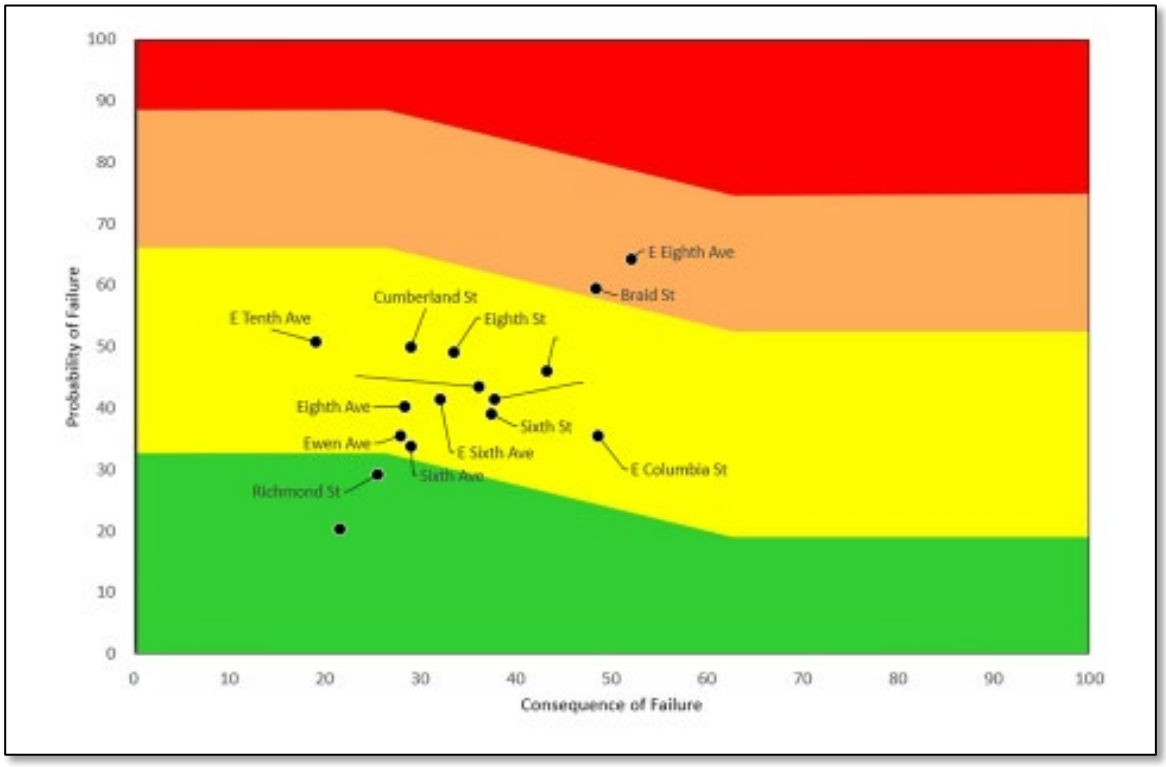


Figure 8 MRN and Arterial Roads Risk Map

It is evident that the collector roads have varying conditions and a wide range of consequence scores.

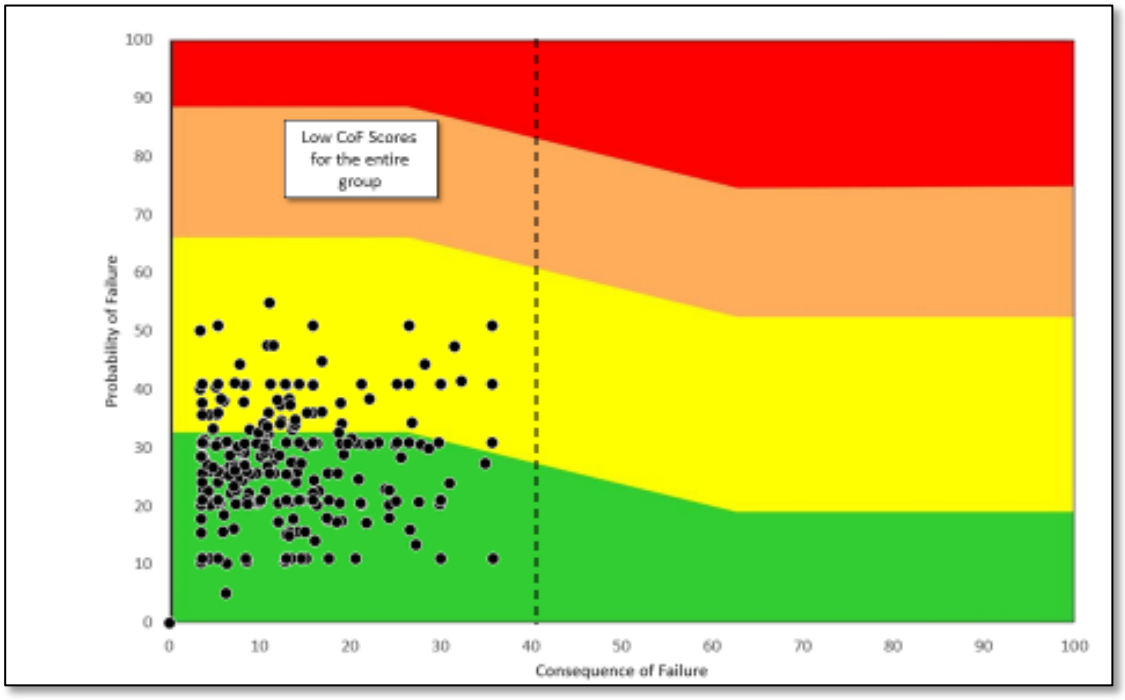


Figure 9 Collector Roads Risk Map

The majority of the local roads are deemed to have a lower consequence of failure than the MRN and Arterial roads classes.

The criticality of the pavement assets relative to the City's other asset classes can be found in Section 5 of the report. This comparison is necessary for achieving cross-asset optimization. Furthermore, the risk scores are a key element in the model that forecasts the timing of capital projects across the 10-year planning horizon.

1.1.6 Lifecycle Management

The following table provides a summary of the treatment types and unit costs suggested by Tetra Tech (2015):

Category	Treatment	Unit Cost
Preventative Maintenance	Crack Sealing	$2/m
Reactive Maintenance	Patching (pothole filling)	$15/$m^2$
Minor Rehabilitation	Overlay (50 mm)	$18/$m^2$ +70/m^2 cracked area repair
	Mill and Fill (50 mm)	$25/$m^2$ +70/m^2 cracked area repair
	Edge Mill and Overlay (50 mm)	$25/$m^2$ +70/m^2 cracked area repair
Major Rehabilitation / Reconstruction	Full Depth Mill	$45/$m^2$ (minor roads); $65/$m^2$ (major roads) + $0.3 per mm of structural deficiency

	Reclaim (pulverize)	$45/m^2 (minor roads), $61.60 /m^2 in Queensborough; $65/m^2 (major roads) + $0.3 per mm of structural deficiency
	Reconstruct	$110/m^2 (minor roads) $140/m^2 (major roads)

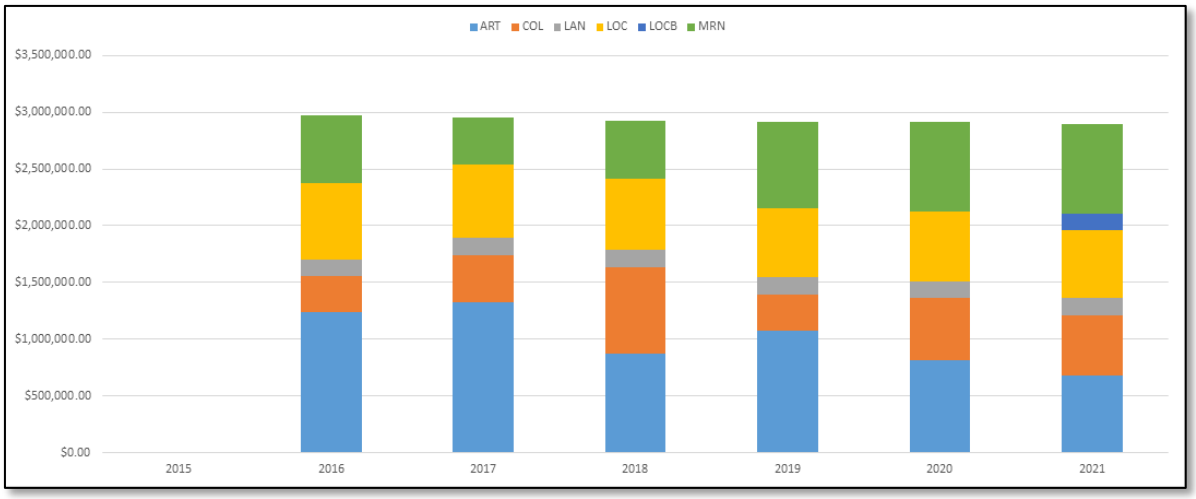


Figure 10 Treatments by Year for Roads

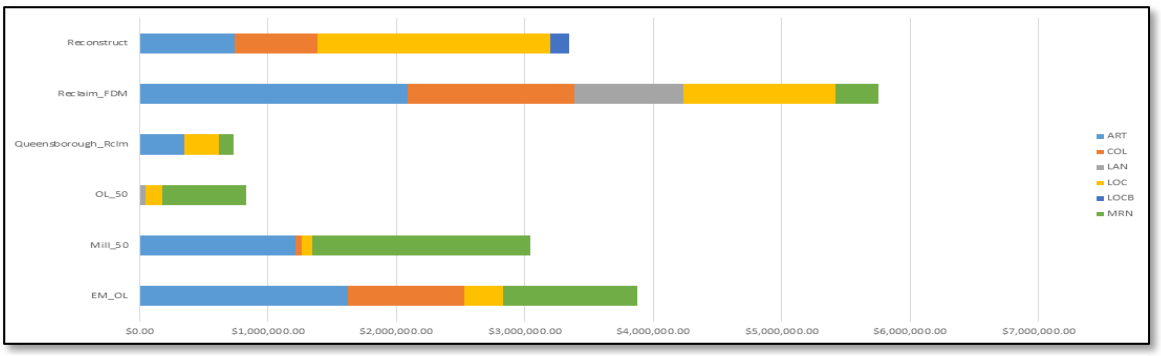


Figure 11 Treatments by Type (over 10-year Planning Horizon)

1.1.7 Capital Needs Forecast

The following graph provides a risk-based capital needs forecast for the City's in-scope pavement assets over a 10-year planning horizon. The supporting data is captured in an MSExcel workbook that accompanies the AMP report.

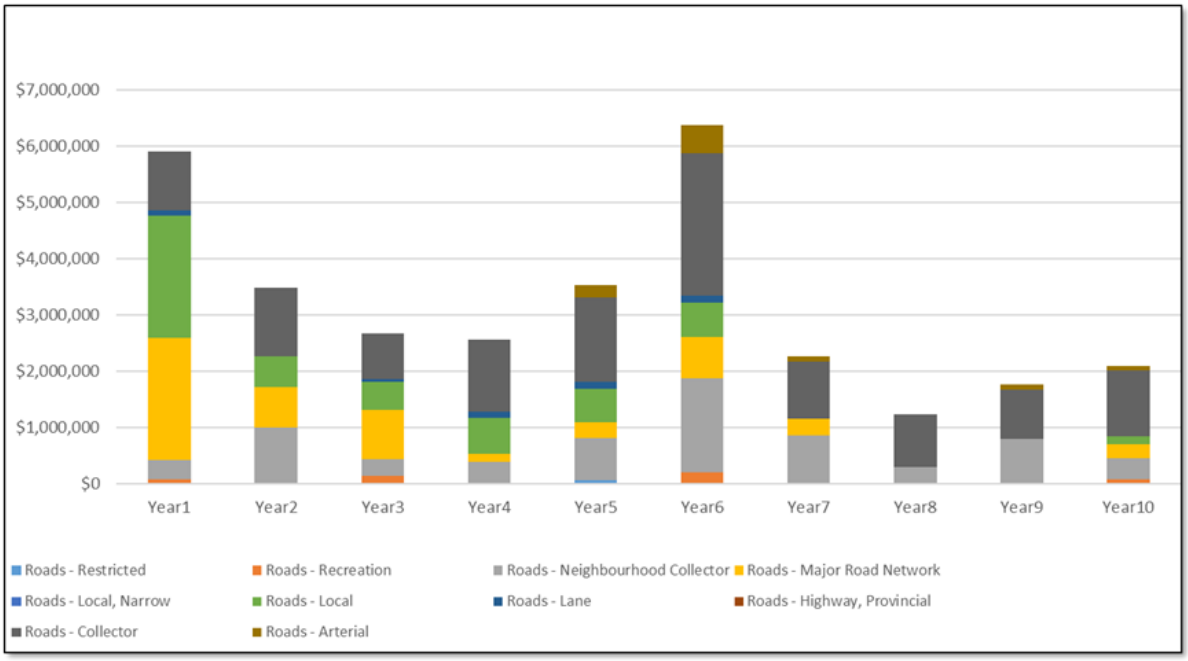


Figure 12 10-Year Capital Needs Forecast for Roads (by Road Type)

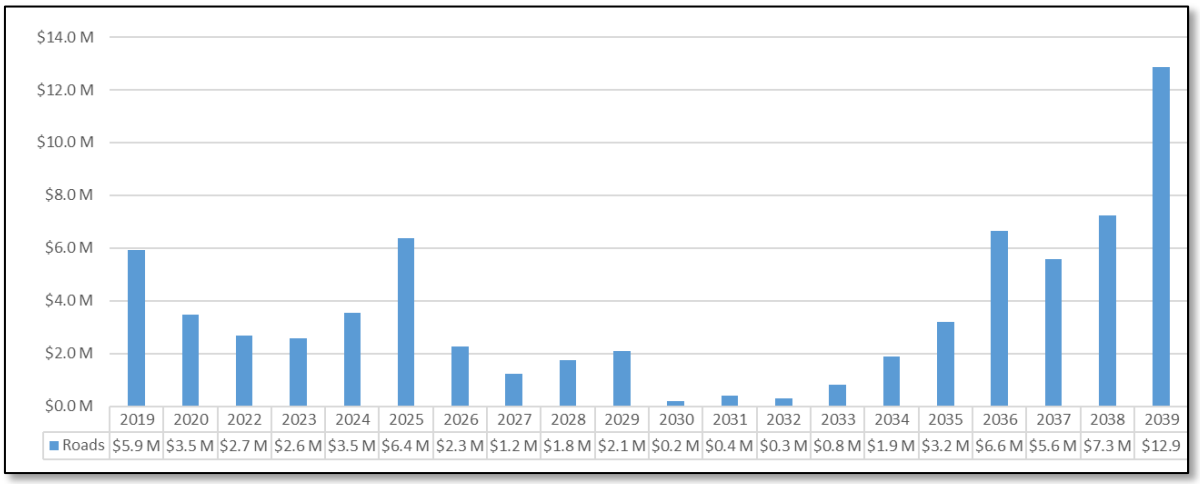


Figure 13 20-Year Capital Needs Forecast for Roads

A variety of reinvestment scenarios have been developed to test the impact of different funding levels on the cumulative infrastructure gap and overall asset condition. This sensitivity analysis is included in Section 7 of the report.

1.1.8 Priority Projects

The following chart provides a summary list of the top-20 risk scoring assets within the pavement asset class.

Table 1 – Top-20 Risk Scoring Road Segments

Risk Rank	Street Properties				CoF x PoF = Risk		
	Road ID (from GIS)	Street Name	Length (m)	Replacement Cost	CoF	PoF	Risk
1	40993	E Columbia St	198	$454,629.12	97.5	89	87
2	40527	Columbia St	363	$472,422.68	94.1	89	84
3	40562	Stewardson Way	365	$840,187.61	94.1	89	84
4	40994	E Columbia St	442	$1,016,449.42	77.7	100	78
5	40956	E Columbia St	468	$1,077,011.29	97.5	78	76
6	40950	Royal Ave	40	$93,088.91	75.2	100	75
7	40953	Royal Ave	85	$195,841.03	75.2	100	75
8	41910	Brunette Ave	159	$364,884.37	96.5	78	75
9	40531	Royal Ave	222	$511,301.19	95.1	78	74
10	40548	Stewardson Way	138	$317,956.69	94.1	78	73
11	41116	Braid St	253	$417,806.33	80	89	72
12	40970	McBride Blvd	199	$457,359.29	80	89	71
13	41145	Brunette Ave	171	$392,595.23	75	89	67
14	40483	Stewardson Way	84	$193,782.60	100	67	67
15	39329	Tenth Ave	174	$400,952.11	85	76	64
16	40973	McBride Blvd	410	$942,288.11	82	78	64
17	40974	McBride Blvd	408	$938,423.56	82	78	64
18	40954	Royal Ave	24	$55,844.52	63	100	63
19	40551	Royal Ave	68	$156,382.52	94	67	63
20	39253	Royal Ave	237	$545,780.21	80	78	62

For benchmarking and cross-asset optimization purposes, a list of the top 5 projects by asset class and the top 40 projects across all asset classes is included in the Executive Summary.

1.1.9 Improvement Journey

Included below is a summary of the key improvement initiatives to be considered for enhancement of the AMP for the pavement assets.

ID	Recommendations	Level of Effort	Level of Benefit
P.1	Develop level of service (LOS) measures and targets for each of the roads classes	High.	High
P.2	Confirm the installation years of the pavement segments to improve the deterioration modelling	Med.	Med.

P.3	Develop a register of risk “events/hazards” for the different road classes, analyze the events and development treatment plans	High	High
P.4	Correlate the AADT data with road condition data to further refine the analysis	Med	High

The full suite of recommendations across all asset classes is included in Section 8.

1.2 Sidewalks

1.2.1 Key Performance Indicators

The following matrix provides a high level “heat map” of the eight (8) key performance indicators for the sidewalk asset class. Definitions for each of the KPIs is included in the body of the report.

Table 2 – KPI Matrix for Sidewalks

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10-years	Annual Reinvestment Rate
Sidewalks	90%	--	1.89	42	16	2.94	$4,406,600	1.26%
Total	**90%**	**--**	**1.89**	**42**	**16**	**2.94**	$4,406,600	1.26%

A more comprehensive “heat map” that places the sidewalk assets in a broader context with the other asset classes is included in the Executive Summary.

1.2.2 Risk

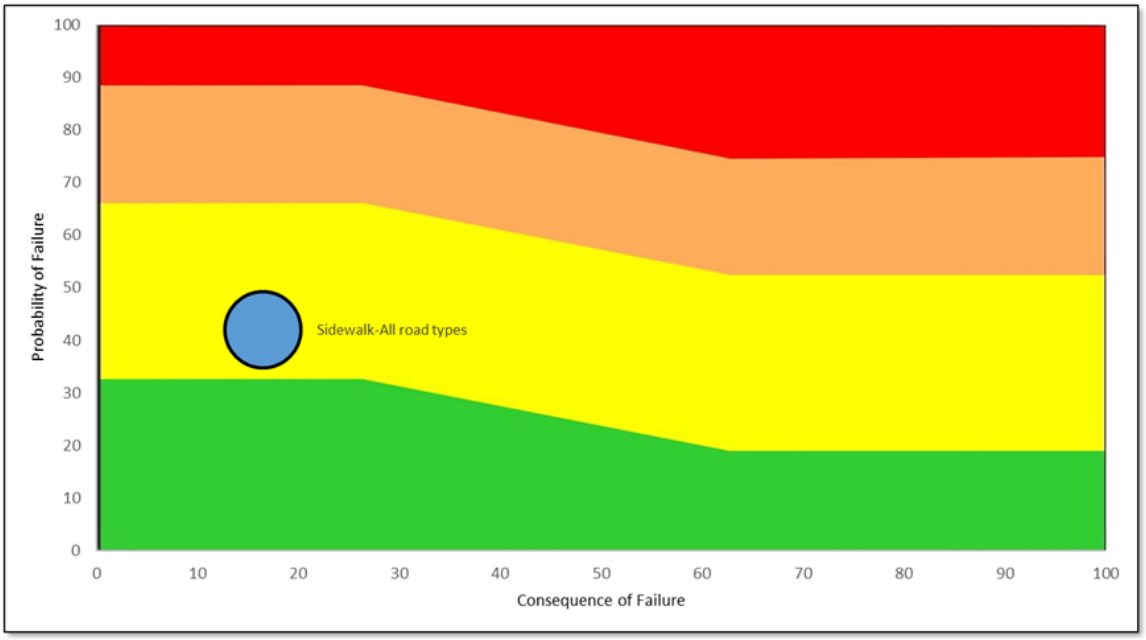


Figure 14 Risk Summary for Sidewalks

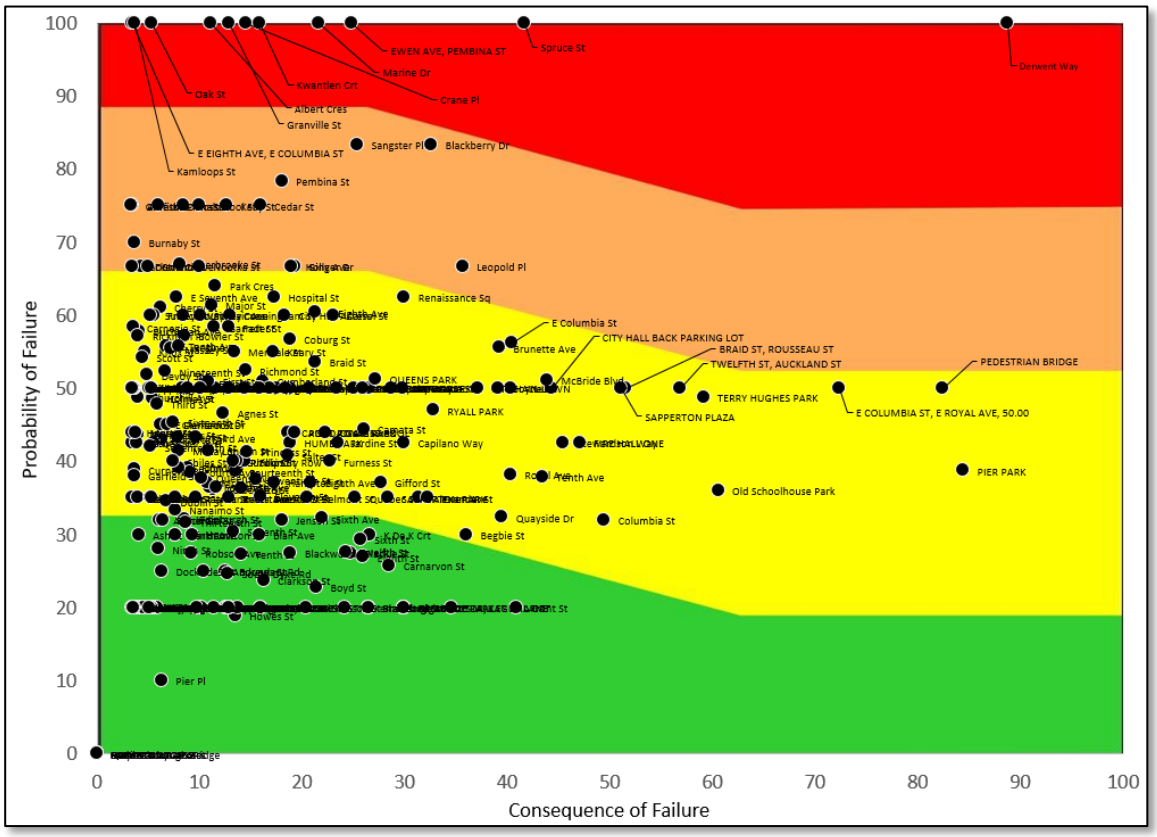


Figure 15 Risk Map for Sidewalks

The criticality of the sidewalks relative to the City's other transportation asset classes can be found in Section 5 of the report. This comparison is necessary for achieving cross-asset optimization. Furthermore, the risk scores are a key element in the model that forecasts the timing of capital projects across the 10-year planning horizon.

1.2.3 Capital Needs Forecast

The following graph provides a risk-based capital needs forecast for the City's sidewalks over a 10-year planning horizon derived from the transportation risk model and the available condition report

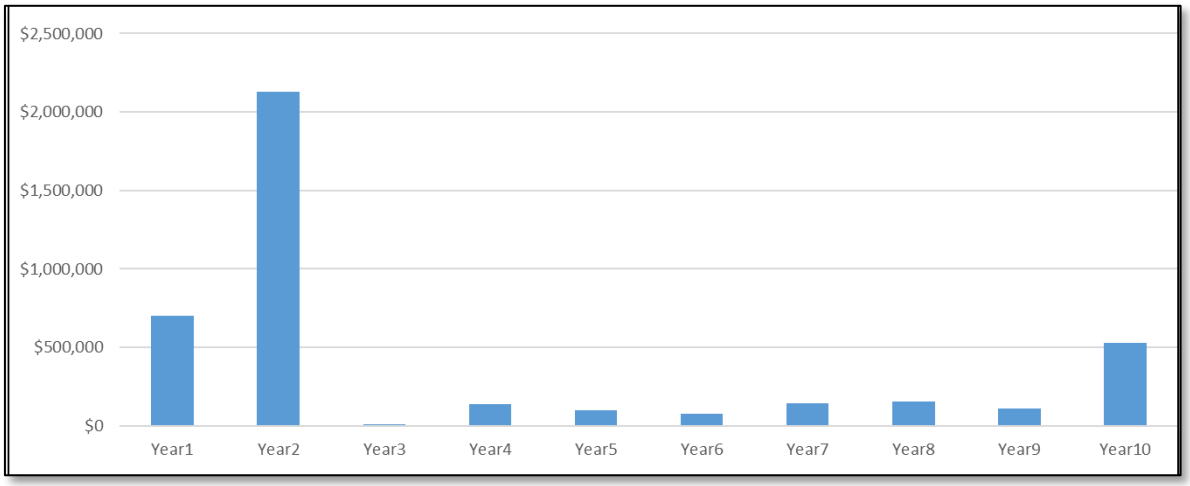


Figure 16 10-Year Capital Needs Forecast for Sidewalks

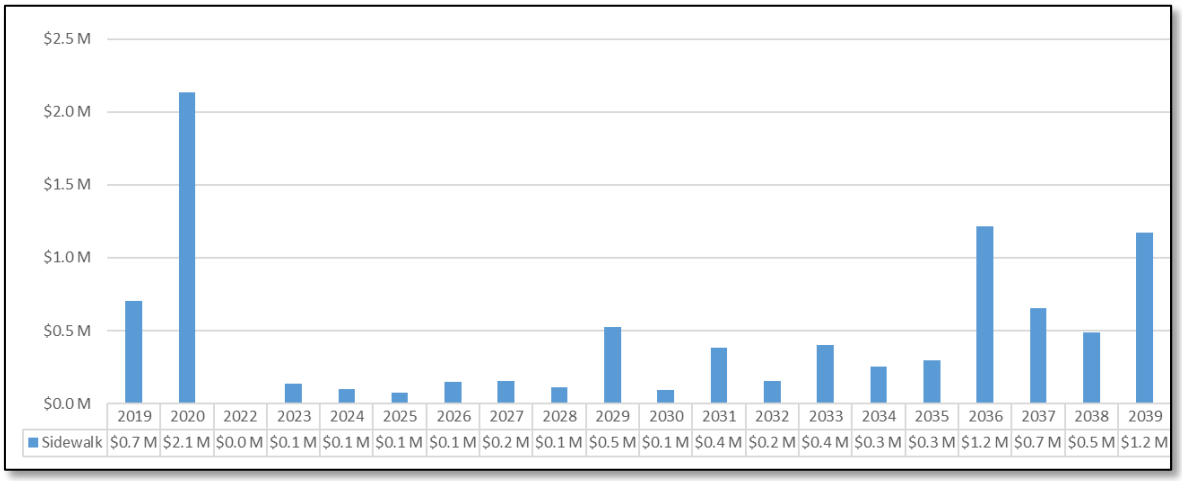


Figure 17 20-Year Capital Needs Forecast for Sidewalks

A variety of reinvestment scenarios have been developed to test the impact of different funding levels on the cumulative infrastructure gap and overall asset condition. This sensitivity analysis is included in Section 7 of the report.

1.2.4 Priority Projects

The following chart provides a summary list of the top-20 risk scoring assets within the sidewalks asset class.

Risk Rank	Sidewalk Properties					CoF x PoF = Risk		
	Sidewalk ID (from GIS)	Adjacent Road ID	Street Name	Length (m)	Replacement Cost	CoF	PoF	Risk
1	354	40993	E Columbia St	73	$6,117.58	98	100	98
2	355	40956	E Columbia St	964	$110,863.84	98	100	98
3	2100	40816	Derwent Way	28	$1,366.78	89	100	89
4	2609	40816	Derwent Way	114	$7,536.90	89	100	89
5	2663	40973	McBride Blvd	74	$8,131.86	82	100	82
6	948	40175	Royal Ave	125	$7,681.94	75	100	75
7	697	41323	McBride Blvd	892	$61,964.64	65	100	65
8	1876	40556	Twelfth St	84	$3,606.02	57	100	57
9	747	41326	Tenth Ave	83	$4,301.62	52	100	52
10	1923	40483	Stewardson Way	138	$8,999.14	100	50	50
11	2024	40474	Fourteenth St	91	$5,685.42	50	100	50
12	351	40956	E Columbia St	214	$16,459.08	98	50	49
13	352	40956	E Columbia St	1277	$101,092.88	98	50	49
14	353	40993	E Columbia St	63	$6,354.38	98	50	49
15	374	40956	E Columbia St	102	$7,306.02	98	50	49
16	392	40956	E Columbia St	73	$7,107.70	98	50	49
17	1320	40527	Columbia St	78	$4,441.48	94	50	47
18	1321	40527	Columbia St	77	$4,477.00	94	50	47
19	1387	40527	Columbia St	103	$9,908.60	94	50	47
20	1388	40527	Columbia St	333	$31,676.44	94	50	47

For benchmarking and cross-asset optimization purposes, a list of the top 5 projects by asset class and the top 40 projects across all asset classes is included in the Executive Summary.

1.2.5 Improvement Journey

Included below is a summary of the key initiatives to be considered for enhancement of the AMP for the sidewalk assets.

ID	Recommendations	Level of Effort	Level of Benefit
SW.1	Reconcile GIS coordinates for sidewalks with engineering data	Low	Med
SW.2	Develop LOS measures and targets for the sidewalks adjoining the different road classes	Low	High

SW.3	Develop a register of risk “events/hazards for the sidewalks and identify treatment strategies	Med	High

The full suite of recommendations across all asset classes is included in Section 8 of the report.

1.3 Bridges

1.3.1 Key Performance indicators

The following matrix provides a high level “heat map” of the eight (8) key performance indicators for the bridge asset class. Definitions for each of the KPIs is included in the body of the report.

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10-years	Annual Reinvestment Rate
Unknown	50%	70.0	3.40	28	56	3.47	--	--
Vehicle	38%	84.8	3.88	30	49	3.34	$585,829	0.20%
Pedestrian	67%	52.5	2.76	26	53	3.36	--	--
Railroad	0%	119.0	5.00	28	34	2.92	--	--
Total	**37%**	**84.1**	**3.84**	**28**	**47**	**3.26**	**$585,829**	**0.15%**

A more comprehensive “heat map” that places the bridge assets in a broader context with the other asset classes is included in the Executive Summary.

1.3.2 Valuation

The following figure provides a summary of the distribution of replacement costs (2019) across the different types of bridges.

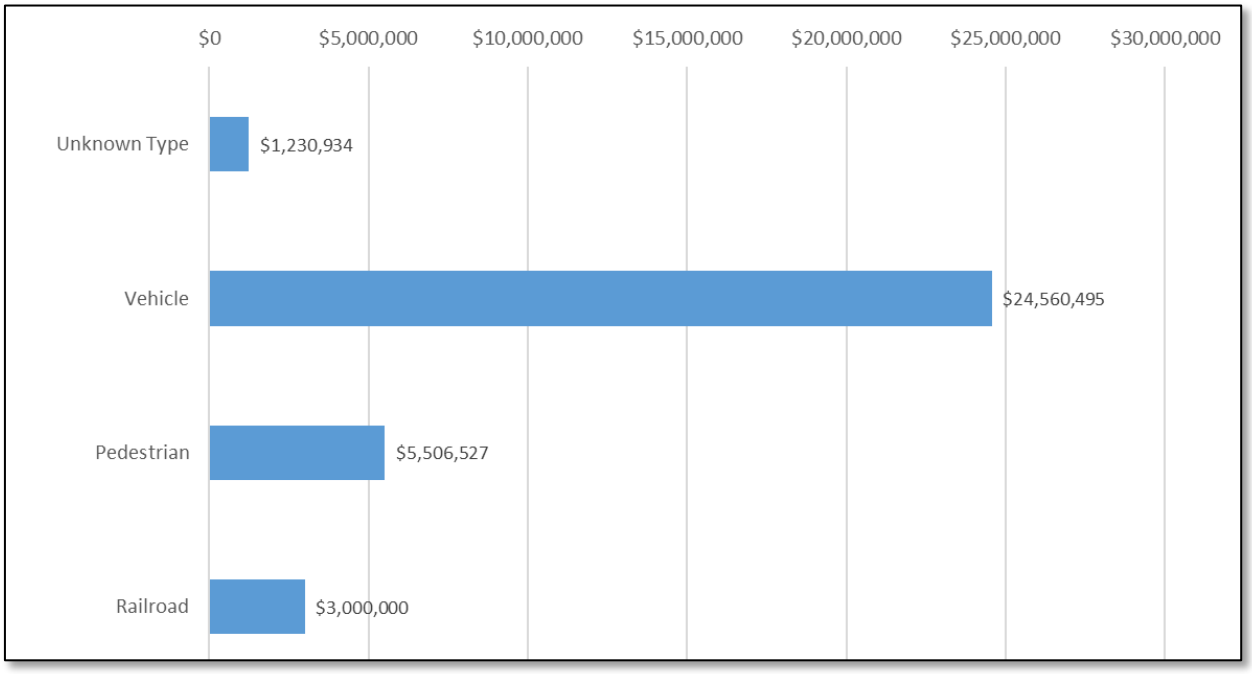


Figure 18 Replacement Cost Valuation by Bridge Type

1.3.3 Condition

Bridge condition has been determined empirically by the Associated Engineering Bridge Inspection Report originally conducted in 2016 and being updated in 2019. It should be noted however that only 60% of the bridges were included in the Associated scope. The following graph provided the distribution of condition grades across the bridge asset classes.

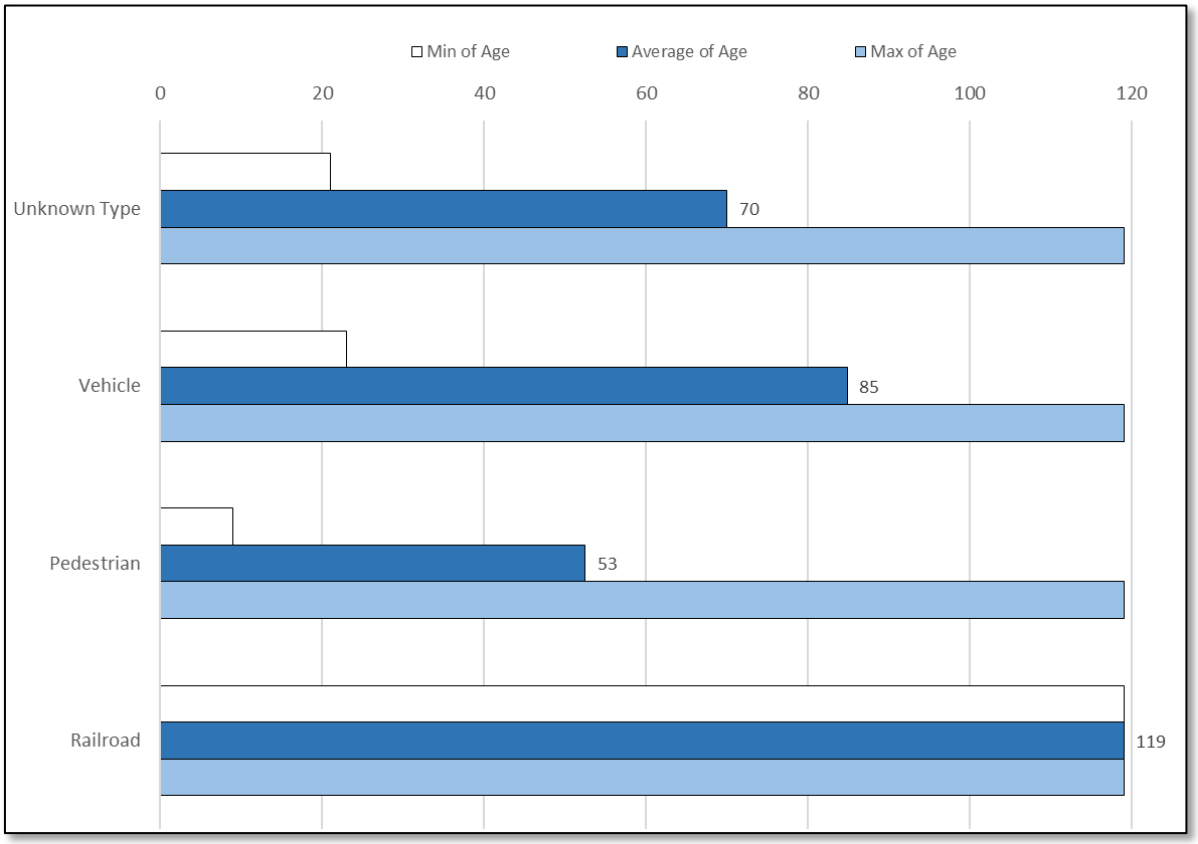


Figure 19 Age Evaluation by Bridge Type

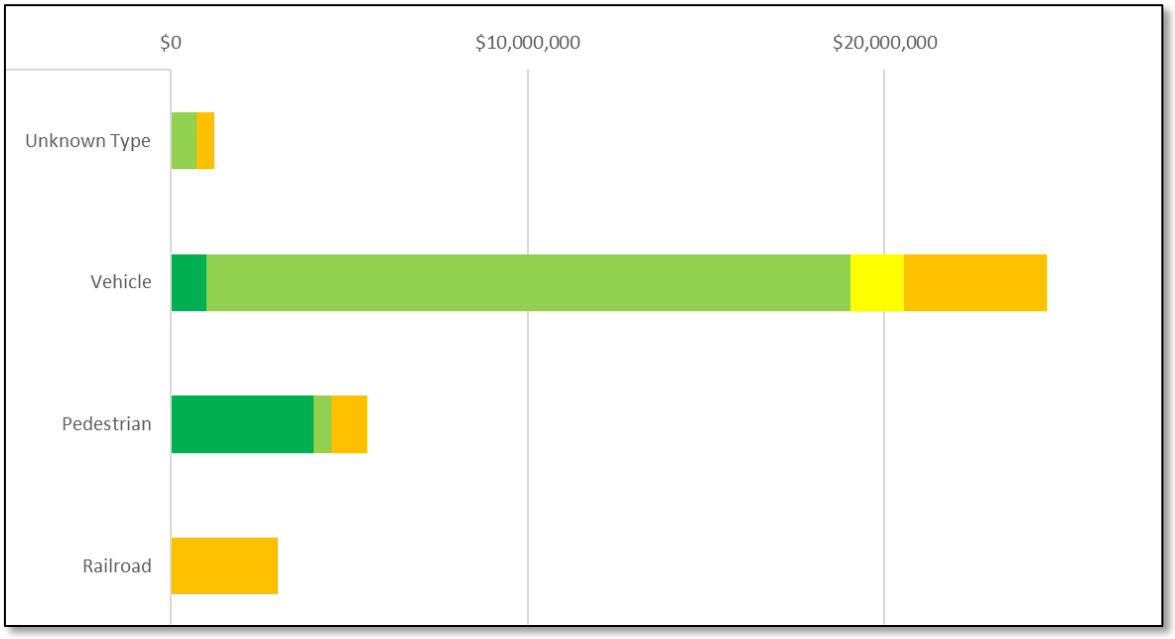


Figure 20 Condition Evaluation by Replacement Cost for Bridge Types

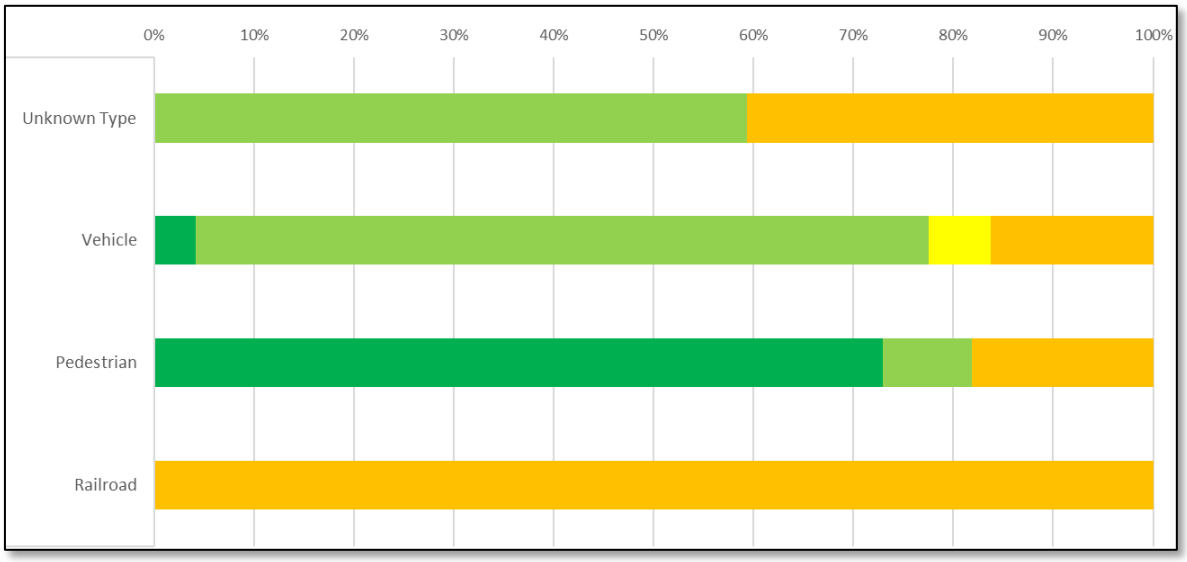


Figure 21 Condition Evaluation by Percentage for Bridge Types

Included in the table below is a summary of the SCR (Structural Condition Rating) scores from the 2016 bridge report. Data from the 2019 bridge condition assessment has not yet been made available for the AMP.

Number	Structure	Age	SCR	Estimated Remaining Life (Years)
BR 01	Royal Avenue Underpass	57	55.6	10
BR 02	Spruce Street Bridge	15	72.2	>25
BR 03	Canfor Diversion Bridge	27	72.2	23
BR 04	Braid Street Bridge	18	55.6	<2
BR 05	Canfor Street Bridge	17	77.8	>25
BR 06	3rd Avenue Overpass	24	61.1	>25
BR 07	Quayside Overpass	31	66.7	19
BR 08	Quayside Market Pedestrian Bridge	--	61.1	10
BR 09	Front Street Parkade Pedestrian Bridge	--	83.3	10
BR 10	Canfor Diversion Pedestrian Bridge	10	72.2	>25
BR 11	McBride Boulevard (7th Avenue) Pedestrian Bridge	12	77.8	>25
BR 12	McBride Boulevard Pedestrian Bridge	3	88.9	>25

Benchmarking of the condition of the retaining walls relative to the condition of the other asset classes is necessary for achieving cross-asset optimization. The condition distributions across all the City's various transportation asset classes is included in Section 3.

1.3.4 Risk

The following risk matrix plots the probability of failure and consequence of failure for the bridge assets by bridge type.

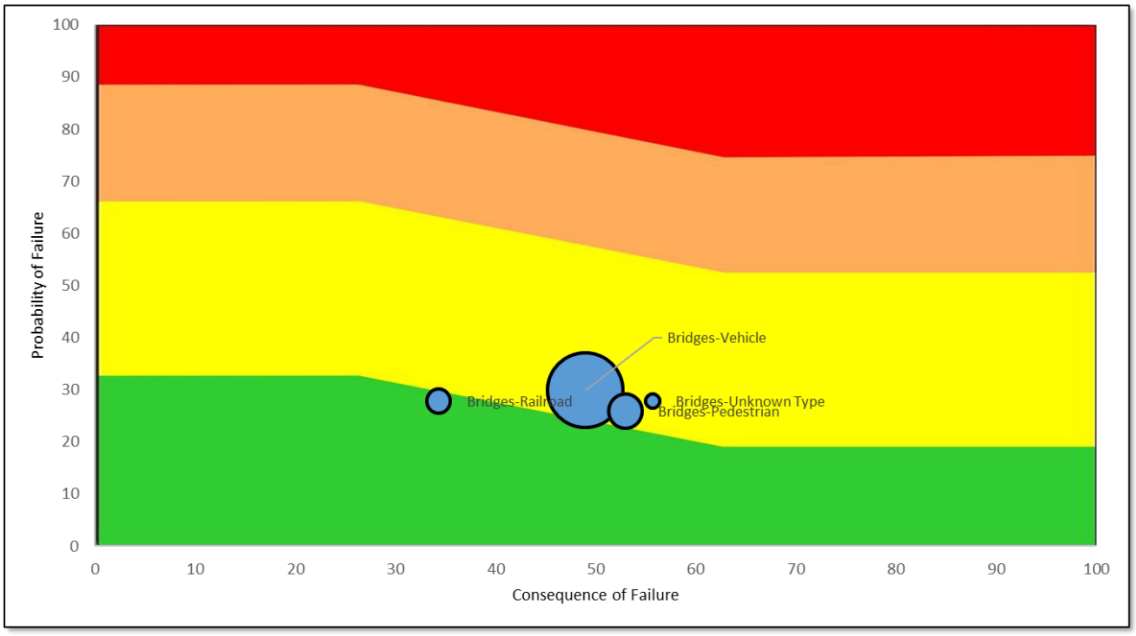


Figure 22 Risk Summary for Bridges

The criticality of the bridge structures relative to the City's other asset classes can be found in Section 5 of the report. This comparison is necessary for achieving cross-asset optimization. Furthermore, the risk scores are a key element in the model that forecasts the timing of capital projects across the 10-year planning horizon.

1.3.5 Improvement Journey

Included below is a summary of the key improvement initiatives to be considered for enhancement of the AMP for the bridge assets.

ID	Recommendations	Level of Effort	Level of Benefit
B.1	Import the 2019 updated bridge condition data into the risk model and AMP forecasts	Low	High
B.2	Develop LOS measures and targets for the different types of bridges	Med.	High
B.3	Develop a register events/hazards for the different types of bridges	Med	High

The full suite of recommendations across all asset classes is included in Section 8.

1.4 Tunnel

1.4.1 Key Performance indicators

The following matrix provides a high level “heat map” of the eight (8) key performance indicators for the tunnel asset class. Definitions for each of the KPIs is included in the body of the report.

Table 3 – KPIs Matrix for Tunnel

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	**Data Quality Score**	**Asset Avg. Age**	**Asset Condition Score**	**PoF Score**	**CoF Score**	**Risk Score**	**Capital Needs, 10 Years**	**Annual Reinvestment Rate**
Pedestrian	100%	49.0	1.87	25	42	3.04	--	--
Grand Total	**100%**	**49.0**	**1.87**	**25**	**42**	**3.04**	**--**	**--**

A more comprehensive “heat map” that places the tunnel assets in a broader context with the other asset classes is included in the Executive Summary. The City’s asset portfolio includes one pedestrian tunnel. Included below are some sample photographs.





1.4.2 Risk Profile



Figure 23 Risk Summary for Tunnels

1.5 Retaining Walls

1.5.1 Key Performance Indicators

The following matrix provides a high level "heat map" of the eight (8) key performance indicators for the retaining wall asset class. Definitions for each of the KPIs is included in the body of the report.

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10-years	Annual Reinvestment Rate
Retaining Walls	93%	46.4	1.71	45	67	3.86	$3,668,798	2.66%
Total	**93%**	**46.4**	**1.71**	**45**	**67**	**3.86**	**$3,668,798**	**2.66%**

A more comprehensive "heat map" that places the retaining wall assets in a broader context with the other asset classes is included in the Executive Summary.

1.5.2 Inventory

There are 27 retaining walls in the City's asset portfolio. These have not yet been classified into types. Included below are some samples of asset photos to illustrate scale and variability.





1.5.3 Condition

The table below is excerpted from the Associated Engineering Report (2016) and provides a summary of the condition scores for some of the retaining walls

ID	Structure	Age	SCI (2016)	Estimated Remaining Life (Years)
RW 06	Front Street – Wall 5	*	1.96	10
RW 07	Front Street – Wall 6	*	1.55	5
RW 08	Front Street – Wall 7	*	1.85	10
RW 09	Front Street – Wall 8	*	1.67	10
RW 10	Front Street – Wall 9	*	1.61	10
RW 11	Front Street – Wall 10	*	1.34	10
RW 12	Columbia Street – Wall at 4th Street	*	1.65	10
RW 13	Columbia Street Brooklyn Pub to Albert Crescent Park	64	1.95	10
RW 14	Columbia Street off-Ramp to CN Property	*	1.61	10
RW 15	Ramp to CN Property – Front Street Side	*	2.2	10

Benchmarking of the condition of the retaining walls relative to the condition of the other asset classes is necessary for achieving cross-asset optimization. The condition distributions across all the City's various transportation asset classes is included in Section 3.

1.5.4 Risk

The following risk matrix plots the probability of failure and consequence of failure for the retaining wall assets.

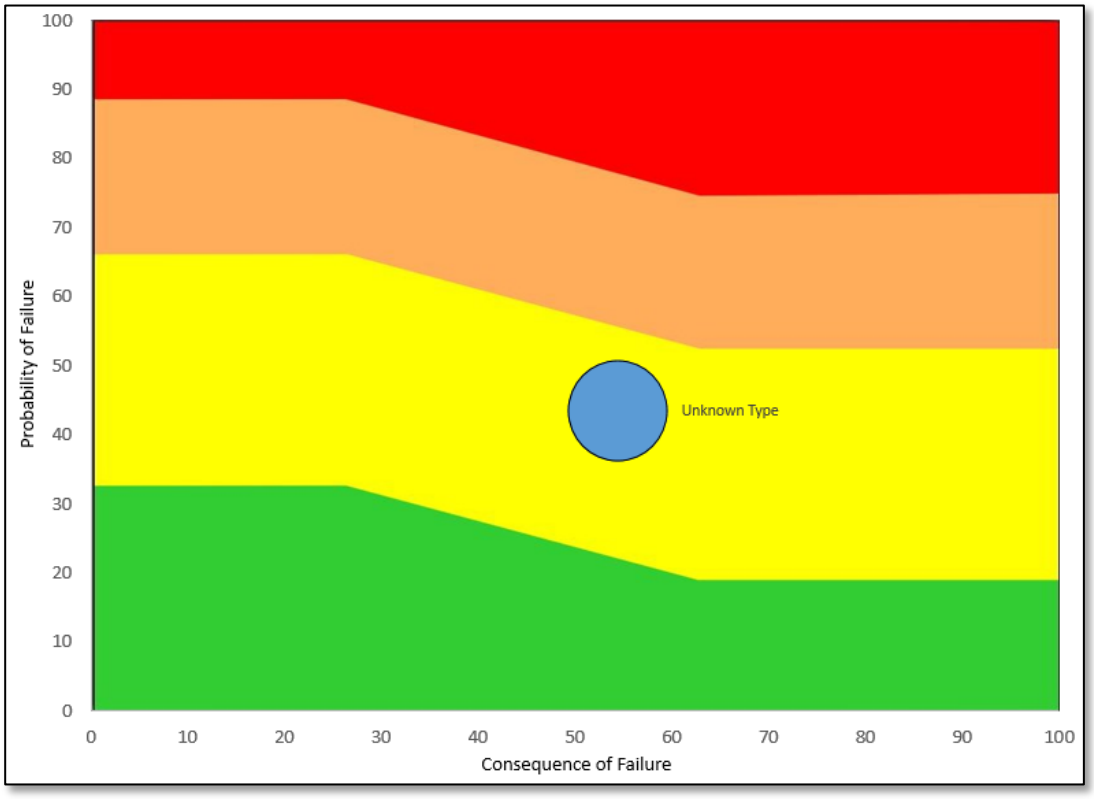


Figure 24 Risk Summary for Retaining Walls

The criticality of the retaining walls relative to the City's other asset classes can be found in Section 5 of the report. This comparison is necessary for achieving cross-asset optimization. Furthermore, the risk scores are a key element in the model that forecasts the timing of capital projects across the 10-year planning horizon.

1.5.5 Capital Needs Forecast

The following graph provides a risk-based capital needs forecast for the City's retaining walls over a 10-year planning horizon derived from the transportation risk model and the structures condition report

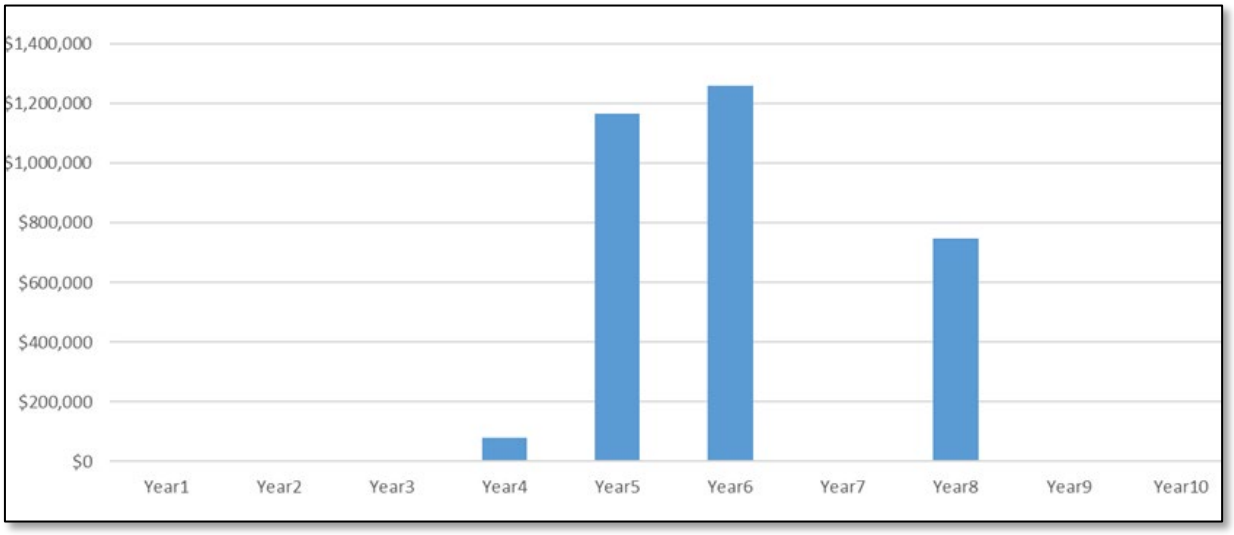


Figure 25 10-Year Capital Needs Forecast for Retaining Walls

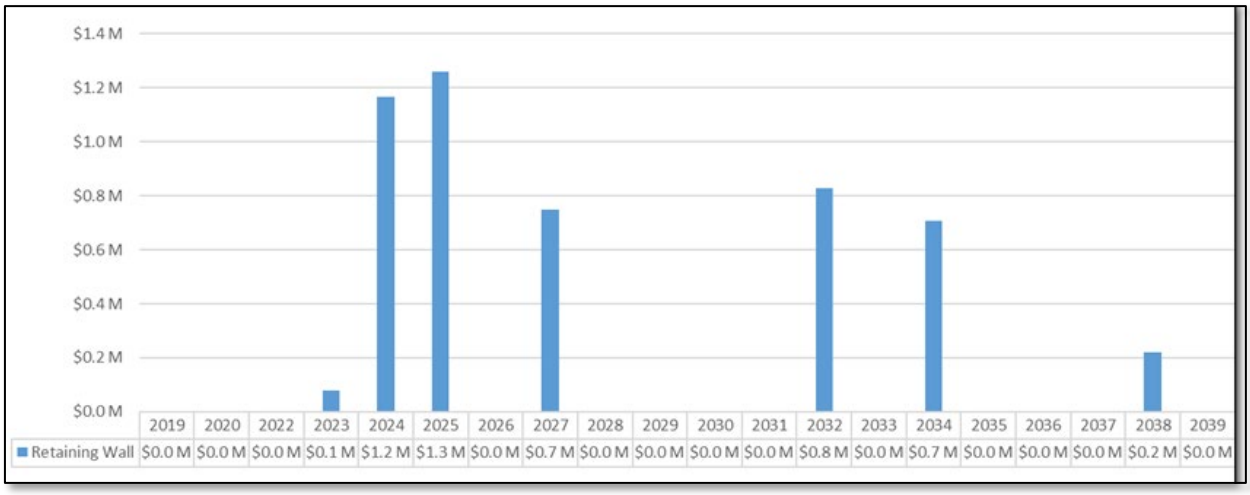


Figure 26 20-Year Capital Needs Forecast for Retaining Walls

A variety of reinvestment scenarios have been developed to test the impact of different funding levels on the cumulative infrastructure gap and overall asset condition. This sensitivity analysis is included in Section 7 of the report.

1.5.6 Improvement Journey

Included below is a summary of the key improvement initiatives to be considered for enhancement of the AMP for the retaining walls.

ID	Recommendations	Level of Effort	Level of Benefit
RW.1	Refine the asset hierarchy to enable analysis of the different types of retaining walls	Low	Med

RW.2	Import the 2019 updated retaining wall condition data into the risk model and AMP forecasts	Med.	High
RW.3	Develop LOS measures and targets for the retaining walls	Low	Low
RW.4	Develop a risk register for the different types of retaining walls	Low	Med.,

The full suite of recommendations across all asset classes is included in Section 8.

1.6 Wheelchair Ramps

1.6.1 Key Performance Indicators

The following matrix provides a high level "heat map" of the eight (8) key performance indicators for the wheelchair ramp asset class. Definitions for each of the KPIs is included in the body of the report.

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10-years	Annual Reinvestment Rate
Wheelchair ramps							$111,665	0.67%

A more comprehensive "heat map" that places the wheelchair ramp assets in a broader context with the other asset classes is included in the Executive Summary.

1.6.2 Improvement Plan

Included below is a summary of the key improvement initiatives to be considered for enhancement of the AMP for the wheelchair ramps.

ID	Recommendations	Level of Effort	Level of Benefit
WR.1	Reconcile GIS data with condition data	Med.	High
WR.2	Develop LOS measures and targets for the wheelchair ramps	Med.	High

The full suite of recommendations across all asset classes is included in Section 8.

1.7 Streetlights

1.7.1 Key Performance Indicators

The following matrix provides a high level "heat map" of the eight (8) key performance indicators for the streetlight asset class. Definitions for each of the KPIs is included in the body of the report.

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10-yrs	Annual Reinvestment Rate

Streetlights	98%	18.3	2.18	43	29	3.24	$7,893,815	2.88%
Walkway Lights	98%	6.8	2.28	41	31	3.20	$156,323	0.06%
Total	**98%**	**18.0**	**2.18**	**43**	**29**	**3.24**	**$8,050,139**	**2.93%**

A more comprehensive “heat map” that places the streetlights in a broader context with the other asset classes is included in the Executive Summary.

1.7.2 Valuation

The following figure provides a summary of the distribution of replacement costs (2019) across the two types of transportation lighting – namely streetlights and walkway lights.

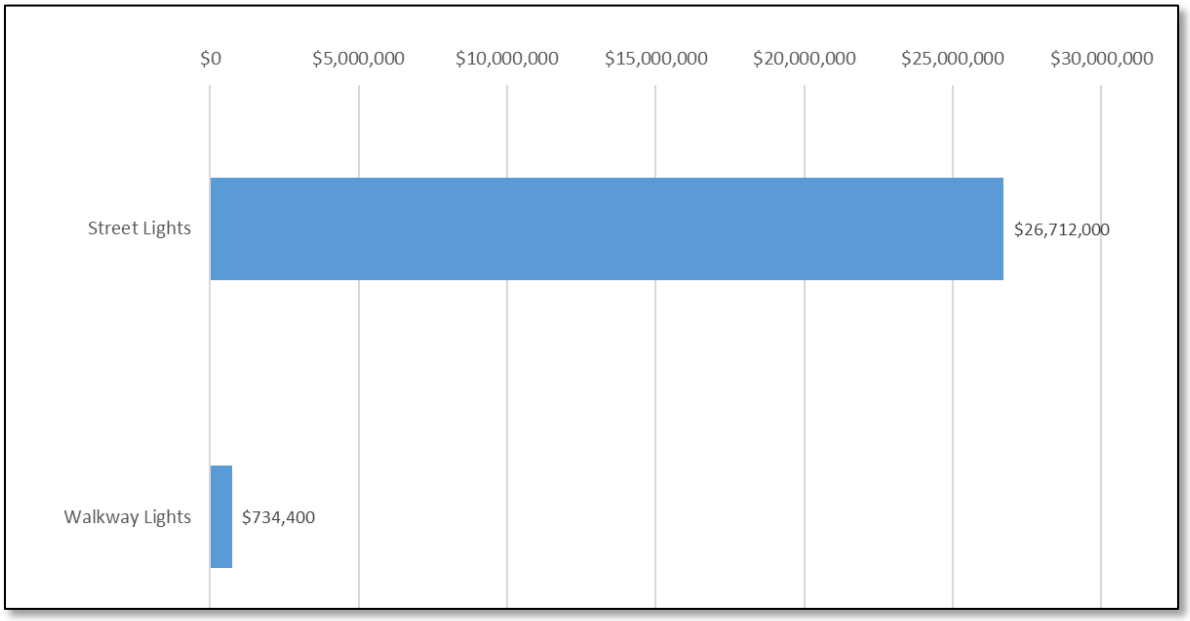


Figure 27 Valuation Summary for Lighting

The walkway lighting has not yet been fully identified in the source data and this one area for data quality improvement.

1.7.3 Condition

The following chart provides a summary of the age profiles of the streetlights and walkway lights.

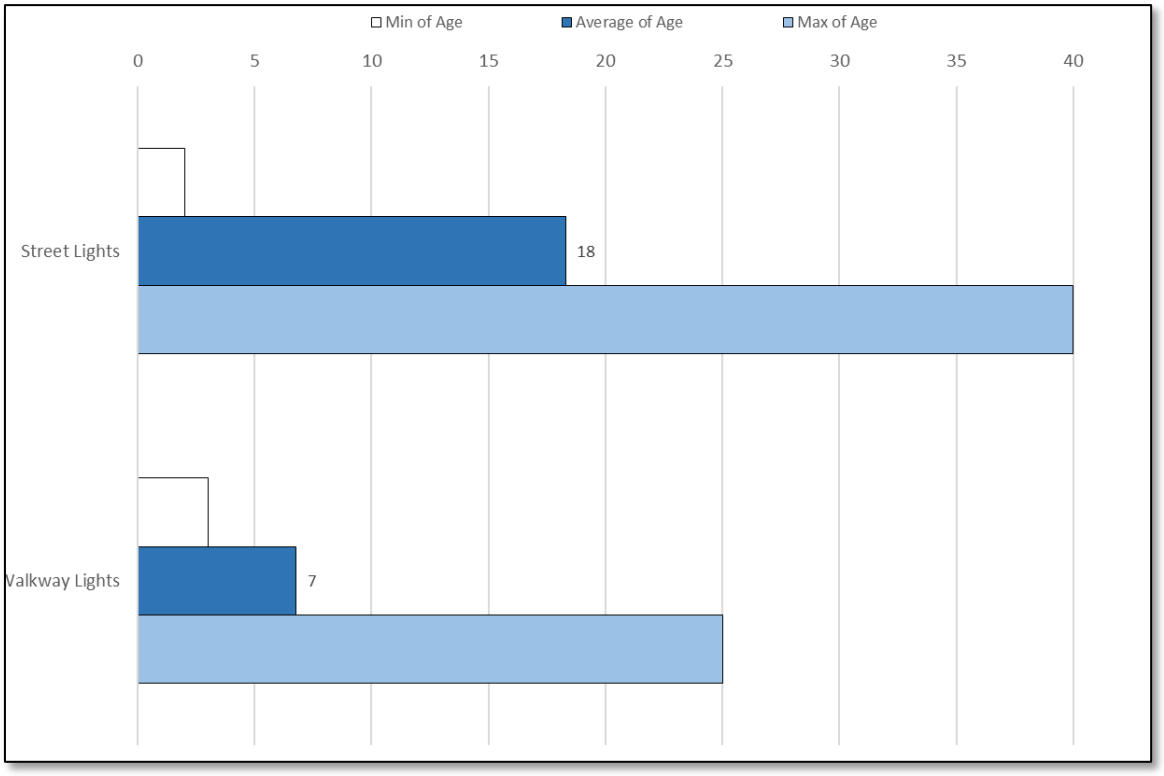


Figure 28 Age Profile Summary for Lighting

The following bar chart provides a visual summary of the condition of the City's streetlights distributed across the 5-point CIRC condition scale.

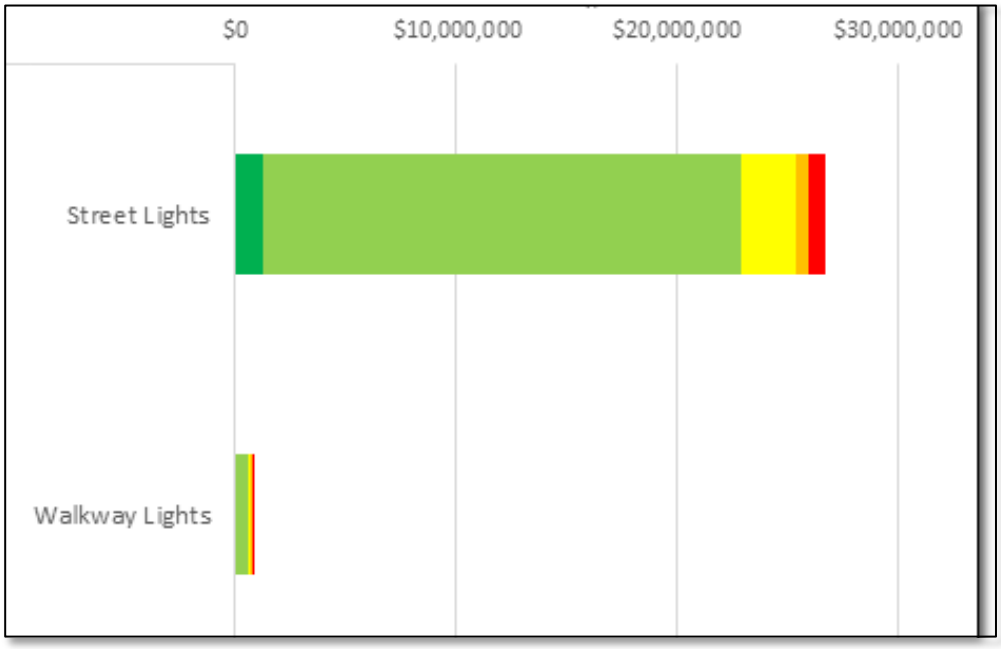


Figure 29 Condition Summary for Lighting

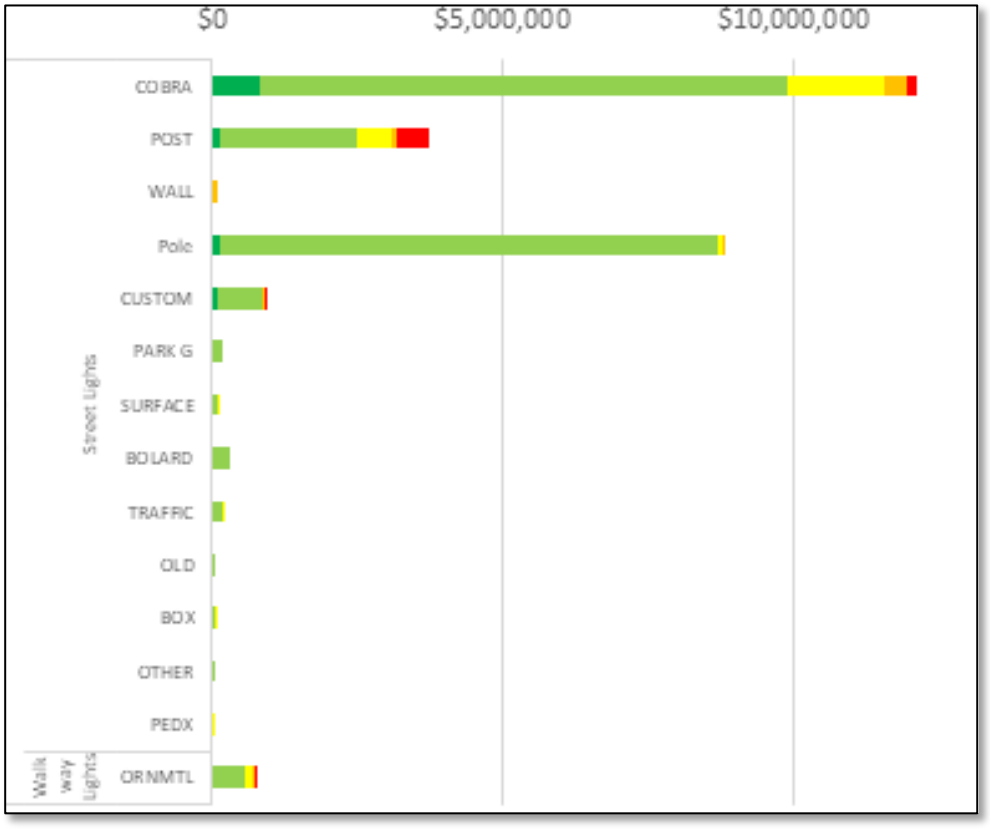


Figure 30 Condition Summary for Lighting by Lighting Type

Benchmarking of the condition of the streetlights relative to the condition of the other asset classes is necessary for achieving cross-asset optimization. The condition distributions across all the City's various transportation asset classes is included in Section 3.

1.7.4 Risk

The following risk matrix plots the probability of failure and consequence of failure for the streetlight assets by type.

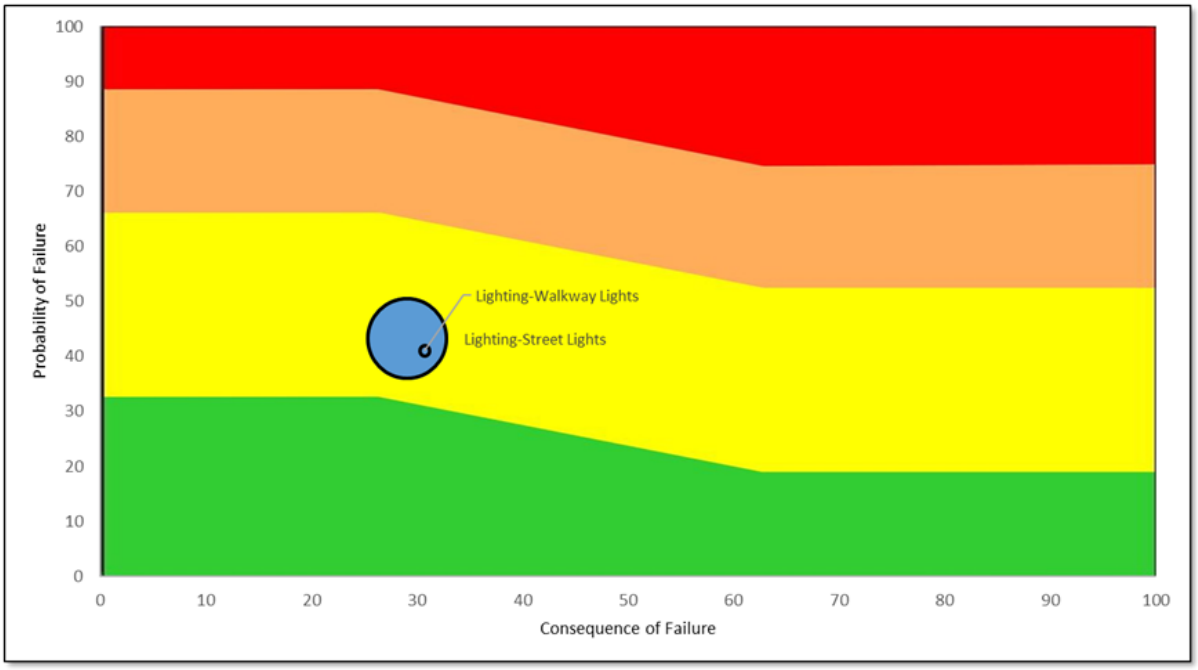


Figure 31 Risk Summary for Lighting

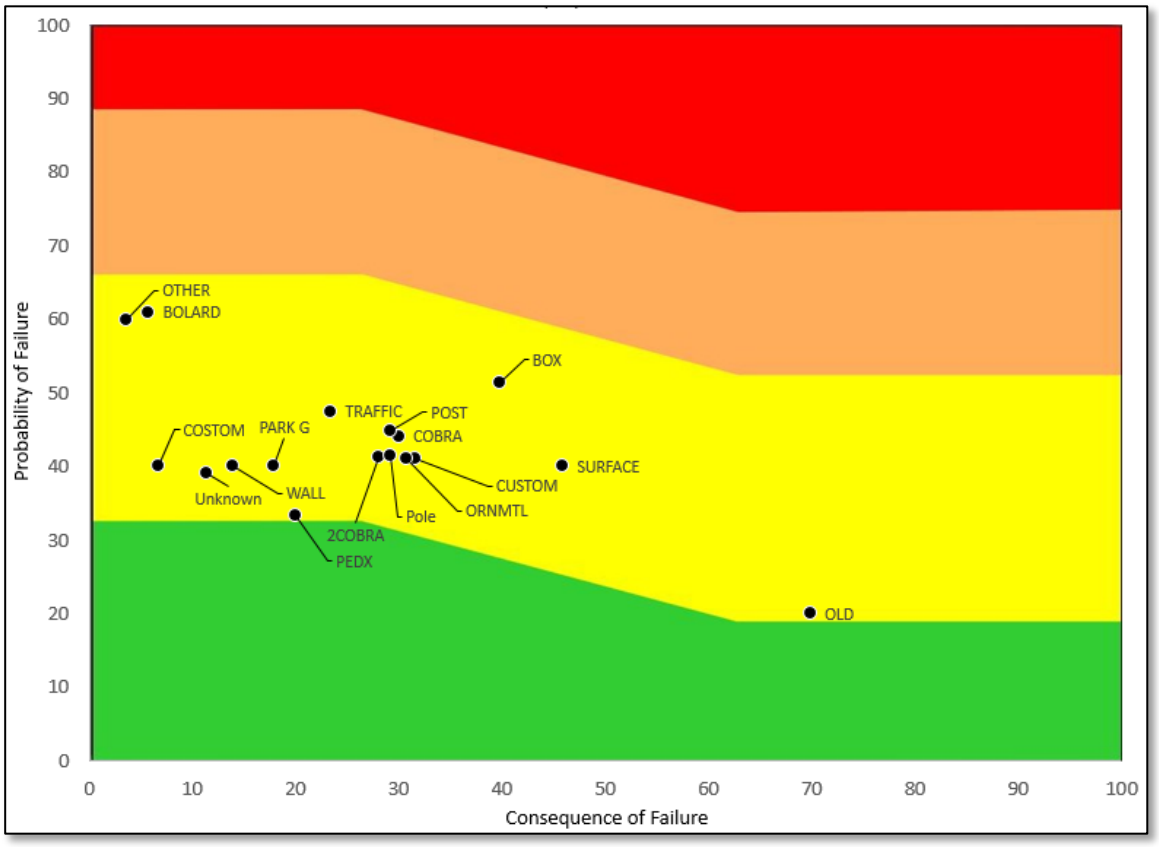


Figure 32 Risk Profile for Lighting Types

The criticality of the streetlights relative to the City's other transportation asset classes can be found in Section 5 of the report. This comparison is necessary for achieving cross-asset optimization. Furthermore, the risk scores are a key element in the model that forecasts the timing of capital projects across the 10-year planning horizon.

1.7.5 Capital Needs Forecast

The following graph provides a risk-based capital needs forecast for the City's streetlights derived from the transportation risk model and the available condition data.

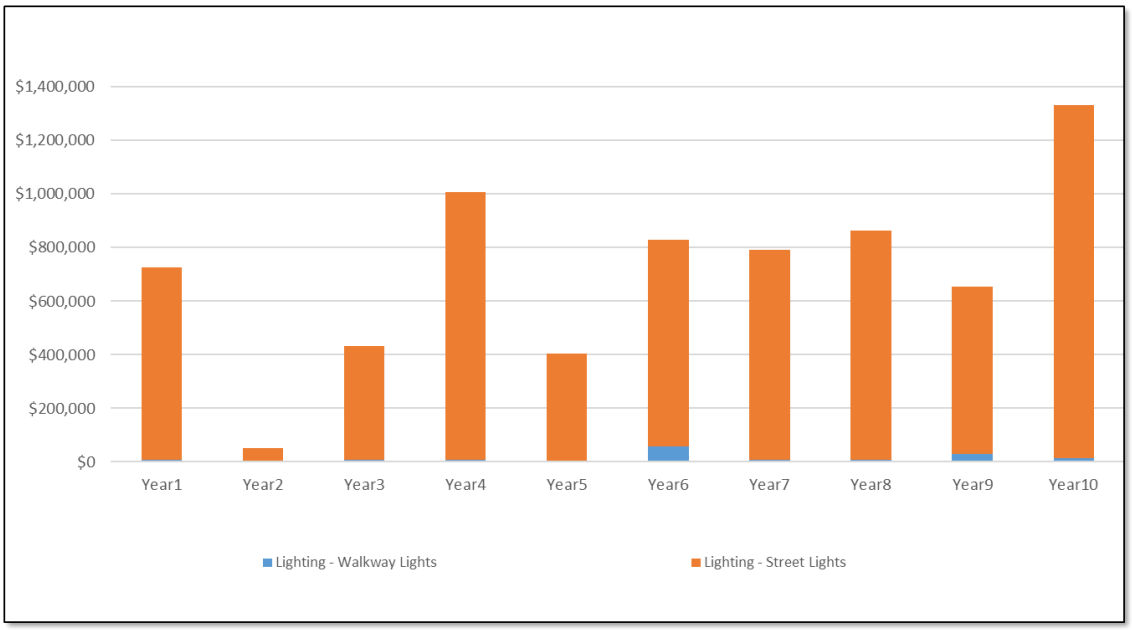


Figure 33 10-Year Capital Needs Forecast for Lighting

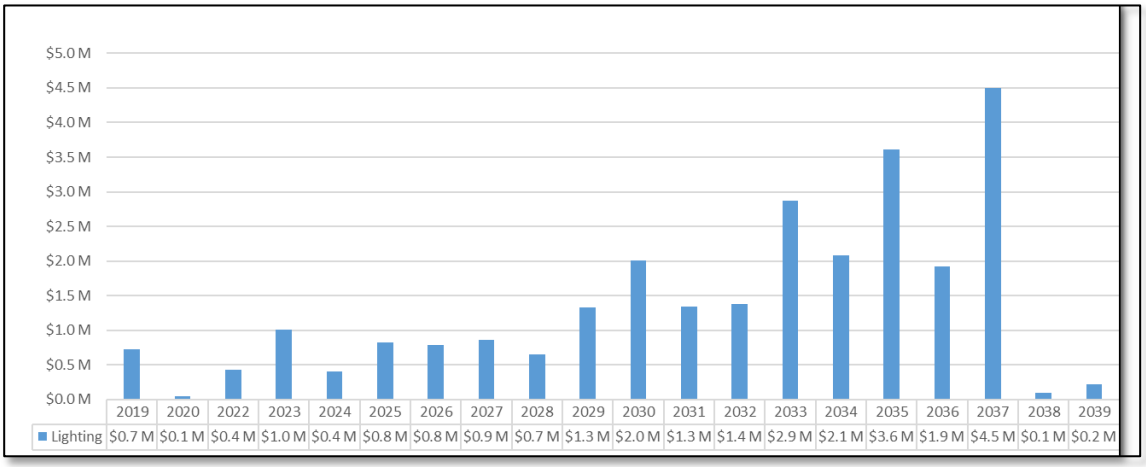


Figure 34 20-Year Capital Needs Forecast for Lighting

A variety of reinvestment scenarios have been developed to test the impact of different funding levels on the cumulative infrastructure gap and overall asset condition. This sensitivity analysis is included in Section 7 of the report.

1.7.6 Improvement Journey

Included below is a summary of the key initiatives to be considered for enhancement of the AMP for the lighting assets.

ID	Recommendations	Level of Effort	Level of Benefit
L.1	Enhance the asset hierarchy by confirming lighting that is located along park walkways	Low	Med.
L.2	Develop LOS measures and targets for the street lights and park walkway lights	Med.	Med.

The full suite of recommendations across all asset classes is included in Section 8.

1.8 Traffic Controllers

1.8.1 Key Performance Indicators

The following matrix provides a high level "heat map" of the eight (8) key performance indicators for the traffic controller asset class at hierarchy level 2. Definitions for each of the KPIs is included in the body of the report.

	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10 Years	Annual Reinvestment Rate
Vehicle Controllers	96%	--	1.95	40	40	3.41	$6,345,072.35	37.4%
Pedestrian Controllers	100%	-	1.43	24	39	2.95	$201,019.99	1.2%
Grand Total	**97%**	**-**	**1.88**	**38**	**40**	**3.35**	**$6,546,092.34**	**38.6%**

Table 4 - KPI Matrix for Traffic Controllers (L3)

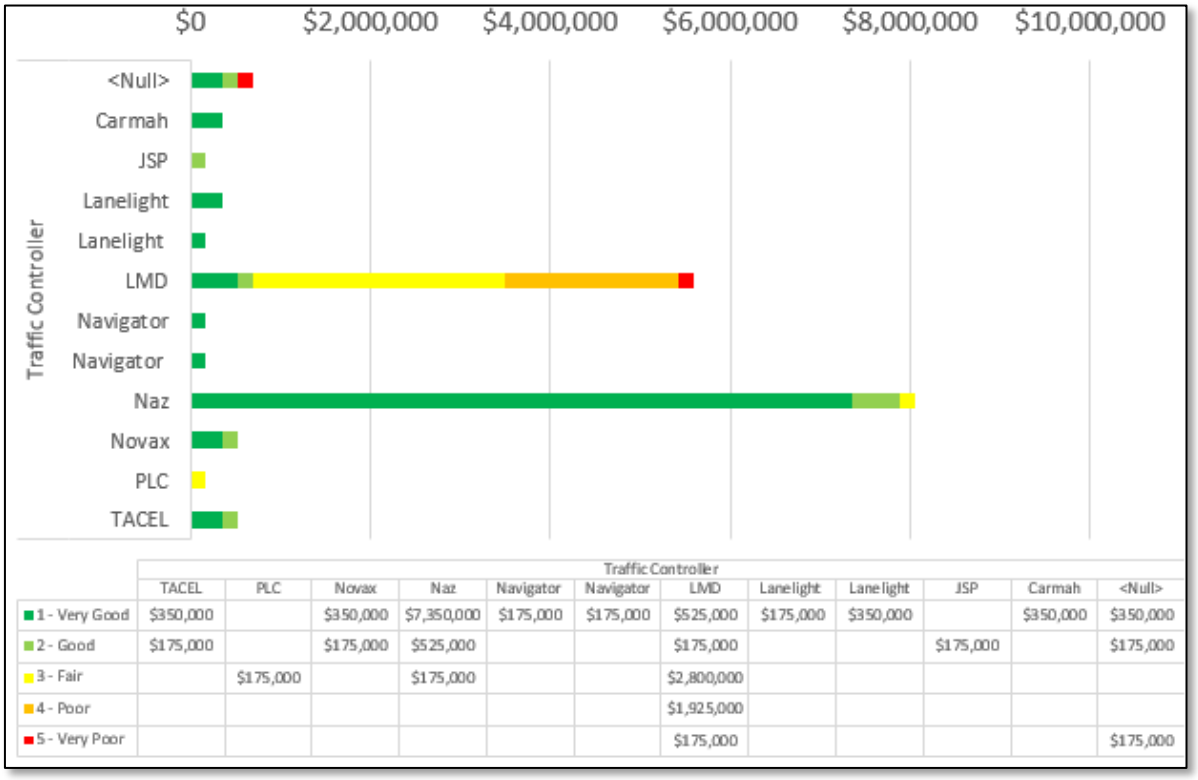
		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10-yrs	Annual Reinvestment Rate
Vehicle Controllers	96%	0.0	1.95	40	40	3.36	$5,775,000	3.98%
LMD	90%	0.0	3.16	52	36	3.58	$2,800,000	5.16%
Naztec	100%	0.0	1.11	32	43	3.23	$2,800,000	3.48%
PLC	100%	0.0	3.00	20	46	2.96	$0	0.00%
Novax	100%	0.0	1.00	20	16	2.18	$0	0.00%

<Null>	100%	0.0	2.25	45	34	3.57	$175,000	2.50%
Pedestrian Controllers	100%	0.0	1.43	24	39	2.89	$175,000	0.71%
LMD	100%	0.0	4.00	20	42	2.85	$0	0.00%
JSP	100%	0.0	2.00	40	25	3.02	$0	0.00%
Novax	100%	0.0	1.50	30	48	3.27	$0	0.00%
Carmah	100%	0.0	1.00	20	32	2.60	$0	0.00%
Tacel	100%	0.0	1.33	27	49	3.19	$175,000	3.33%
Navigator	100%	0.0	1.00	20	53	3.14	$0	0.00%
Navigator	100%	0.0	1.00	20	53	3.14	$0	0.00%
Lanelight	100%	0.0	1.00	20	31	2.57	$0	0.00%
Lanelight	100%	0.0	1.00	20	24	2.37	$0	0.00%

A more comprehensive “heat map” that places the traffic controller assets in a broader context with the other asset classes is included in the Executive Summary.

1.8.2 Condition

The following bar chart provides a visual summary of the condition of the City’s different types of traffic controllers (both vehicle and pedestrian) distributed across the 5-point condition scale.



	Traffic Controller											
	TACEL	PLC	Novax	Naz	Navigator	Navigator	LMD	Lanelight	Lanelight	JSP	Carmah	<Null>
1 - Very Good	$350,000		$350,000	$7,350,000	$175,000	$175,000	$525,000	$175,000	$350,000		$350,000	$350,000
2 - Good	$175,000		$175,000	$525,000			$175,000			$175,000		$175,000
3 - Fair		$175,000		$175,000			$2,800,000					
4 - Poor							$1,925,000					
5 - Very Poor							$175,000					$175,000

Figure 35 Condition Summary for Traffic Controllers

The next chart indicates the condition of the vehicle controllers and the pedestrian controllers.

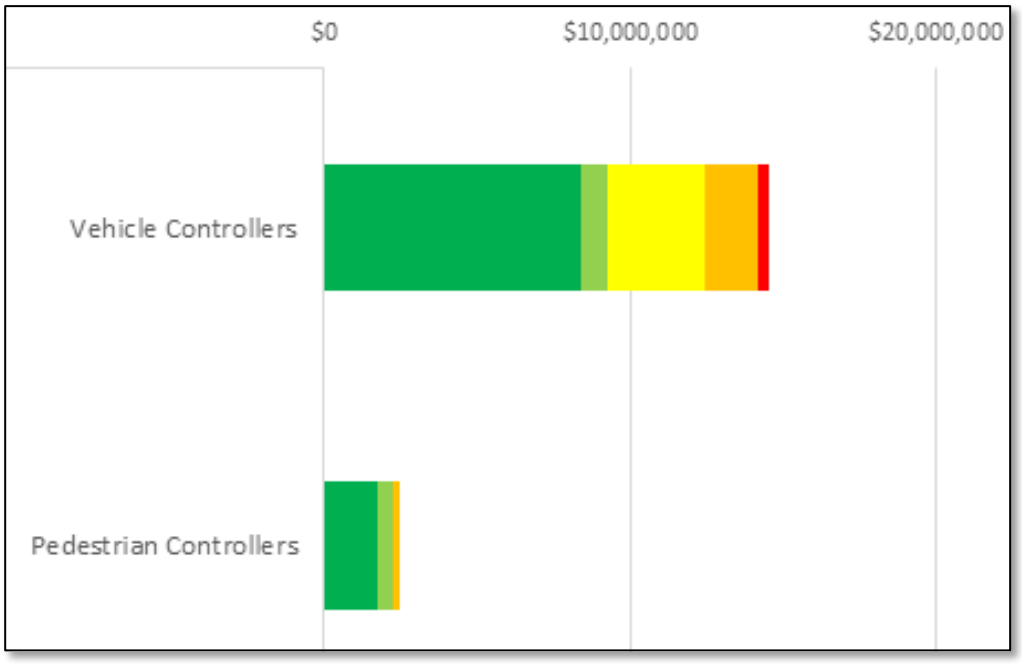


Figure 36 Condition Summary by Traffic Controller Type

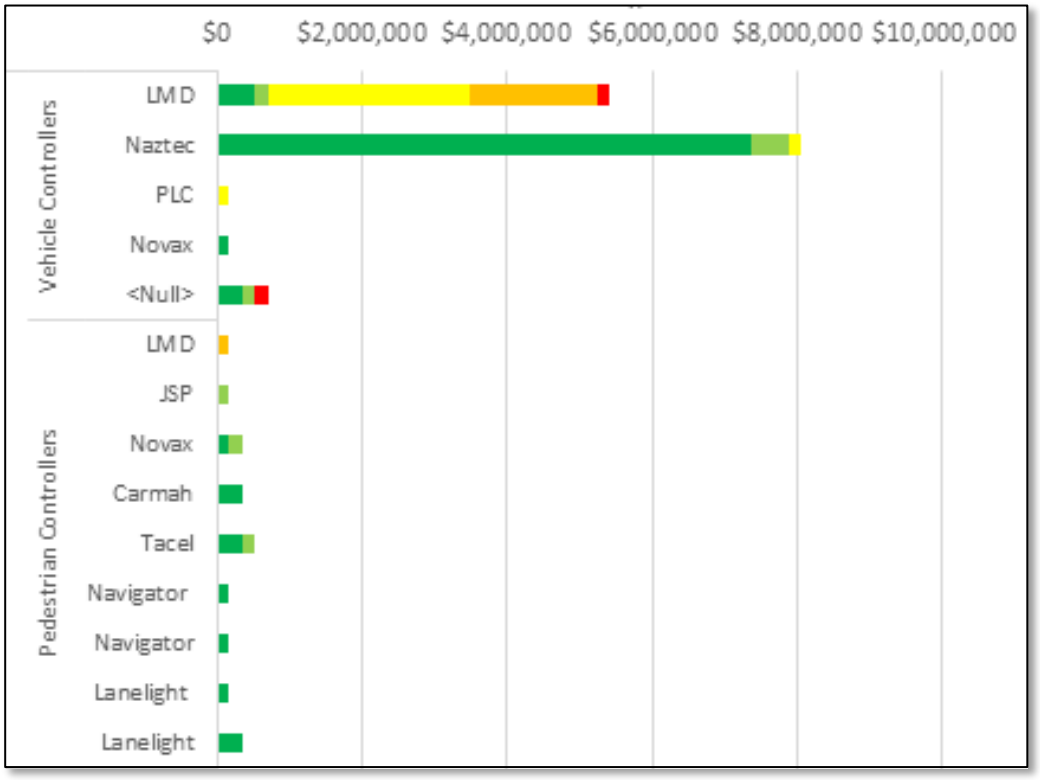


Figure 37 – Condition Summary for Traffic Controllers at HL2

Benchmarking of the condition of the traffic controllers relative to the condition of the other asset classes is necessary for achieving cross-asset optimization. The condition distributions across all the City's various transportation asset classes is included in Section 3.

1.8.3 Risk

The following risk matrix plots the probability of failure and consequence of failure for the traffic controller assets by type.

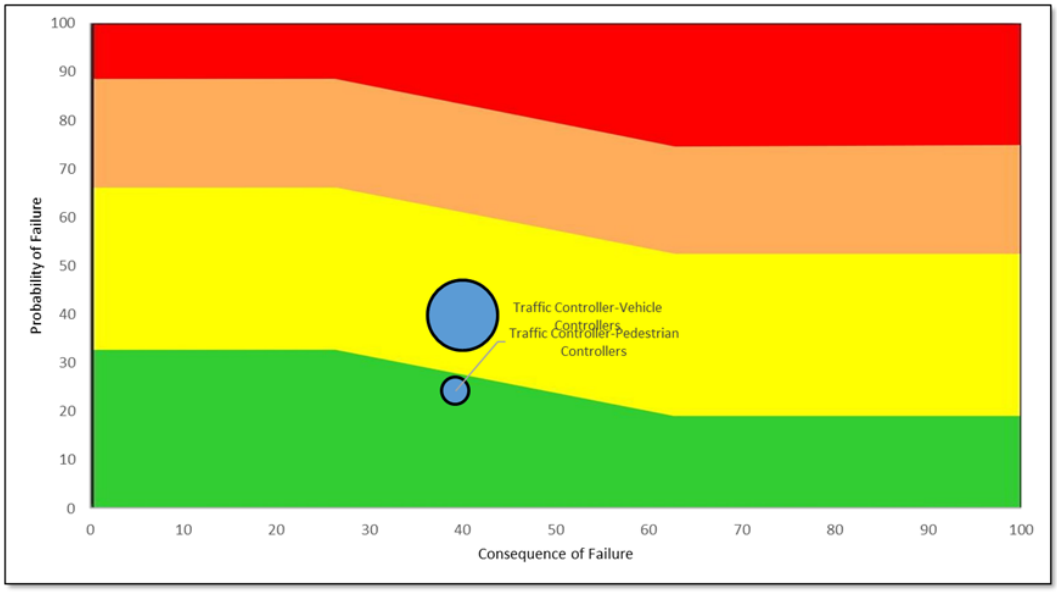


Figure 38 Risk Summary for Traffic Controllers

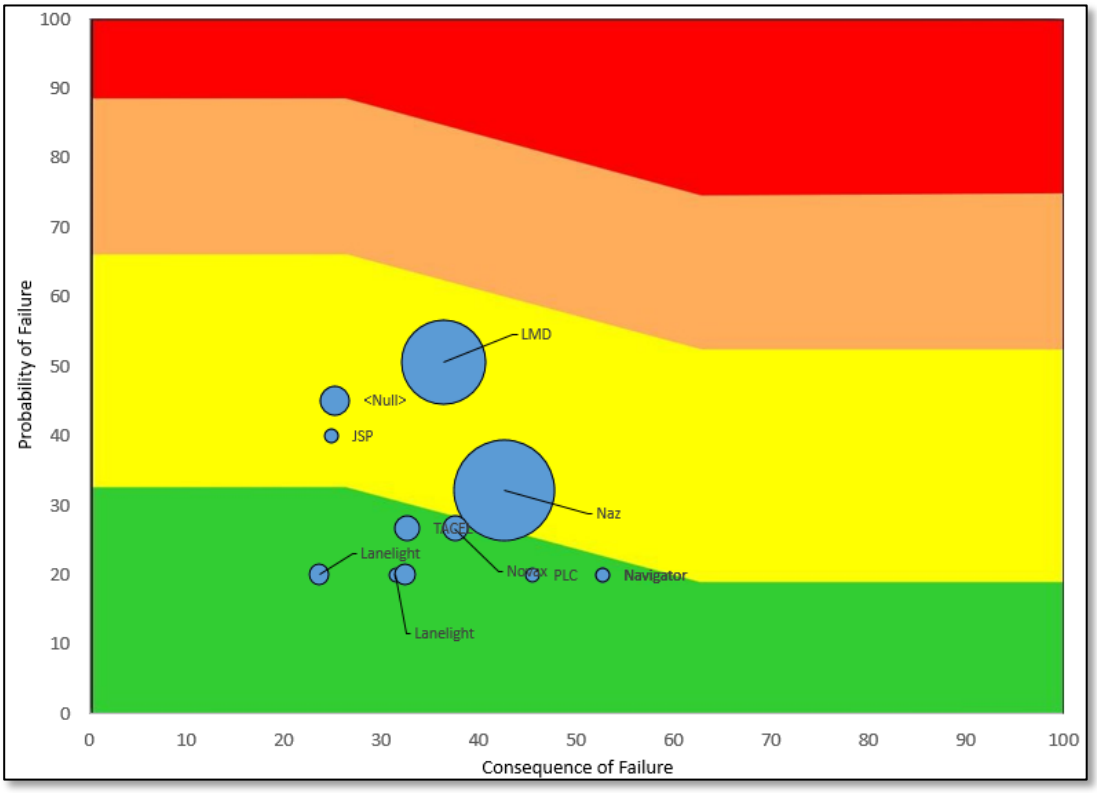


Figure 39 Risk Profile for Traffic Controller Types

The criticality of the traffic controllers relative to the City's other transportation asset classes can be found in Section 5 of the report. This comparison is necessary for achieving cross-asset optimization. Furthermore, the risk scores are a key element in the model that forecasts the timing of capital projects across the 10-year planning horizon.

1.8.4 Capital Needs Forecast

The following graph provides a risk-based capital needs forecast for the City's traffic controllers derived from the transportation risk model and the structures condition report

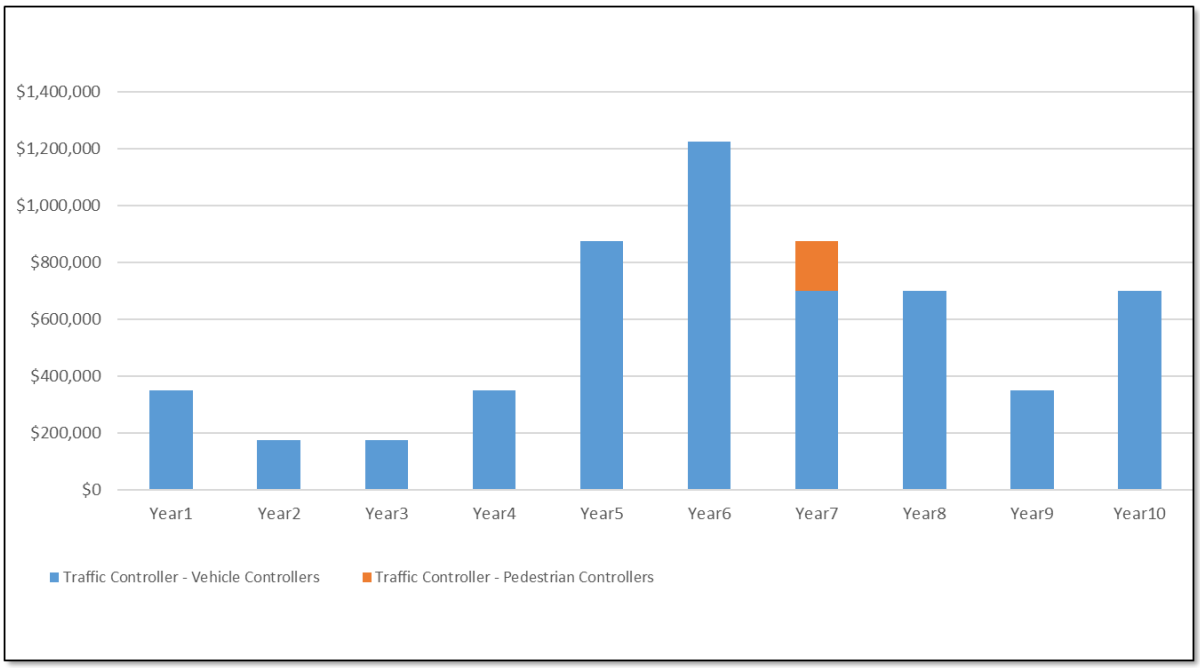


Figure 40 10-Year Capital Needs Forecast for Traffic Controllers

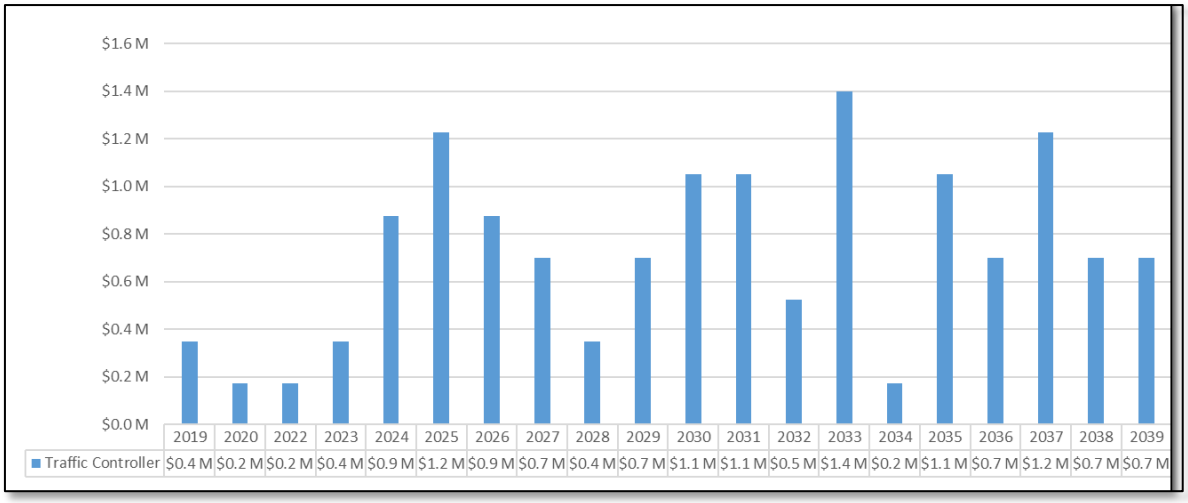


Figure 41 20-Year Capital Needs Forecast for Traffic Controllers

A variety of reinvestment scenarios have been developed to test the impact of different funding levels on the cumulative infrastructure gap and overall asset condition. This sensitivity analysis is included in Section 7 of the report.

1.8.5 Improvement Journey

Included below is a summary of the key initiatives to be considered for enhancement of the AMP for the traffic controllers.

ID	Recommendations	Level of Effort	Level of Benefit
TC.1	Develop LOS measures and targets for the traffic controllers	Med.	Med.
TC.2	Refine the asset hierarchy to clearly differentiate between vehicular and pedestrian controllers	Low	Med
TC.3	Confirm the age of the traffic controllers	Med	Med

The full suite of recommendations across all asset classes is included in Section 8.

1.9 Service Panels

1.9.1 Key Performance Indicators

The following matrix provides a high level "heat map" of the eight (8) key performance indicators for the service panel asset class. Definitions for each of the KPIs is included in the body of the report.

		Pre-Risk		Risk			Financial	
	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition Score	PoF Score	CoF Score	Risk Score	Capital Needs, 10-yrs	Annual Reinvestment Rate
Parks	75%	0.0	1.45	49	41	3.69	$8,993	4.68%
Vehicle Controller	88%	0.0	2.06	58	30	3.67	$83,012	4.26%
Total	**87%**	**0.0**	**2.00**	**57**	**31**	**3.67**	**$92,005**	**4.72%**

A more comprehensive "heat map" that places the service panel assets in a broader context with the other asset classes is included in the Executive Summary.

1.9.2 Condition

The following bar chart provides a visual summary of the condition of the City's service panels distributed across the 5-point condition scale.

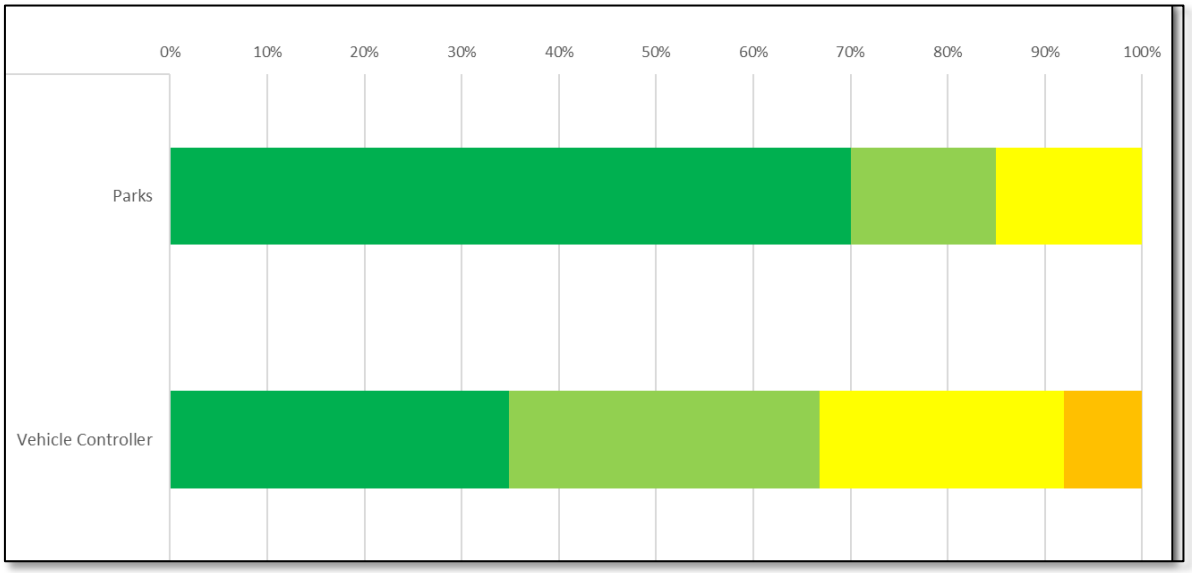
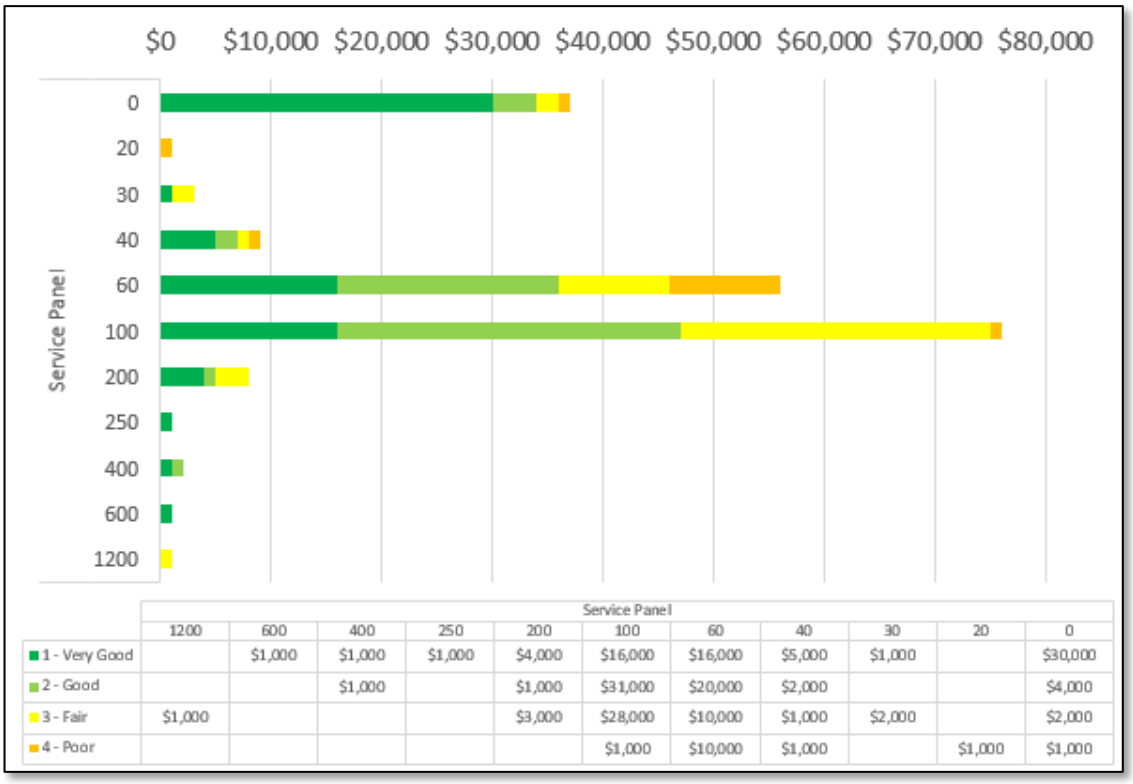


Figure 42 Condition Summary for Service Panels



	Service Panel										
	1200	600	400	250	200	100	60	40	30	20	0
1 - Very Good		$1,000	$1,000	$1,000	$4,000	$16,000	$16,000	$5,000	$1,000		$30,000
2 - Good			$1,000		$1,000	$31,000	$20,000	$2,000			$4,000
3 - Fair	$1,000				$3,000	$28,000	$10,000	$1,000	$2,000		$2,000
4 - Poor						$1,000	$10,000	$1,000		$1,000	$1,000

Figure 43 Condition Summary by Service Panel Types

1.9.3 Risk

The following risk matrix plots the probability of failure and consequence of failure for the service panel assets by amperage.

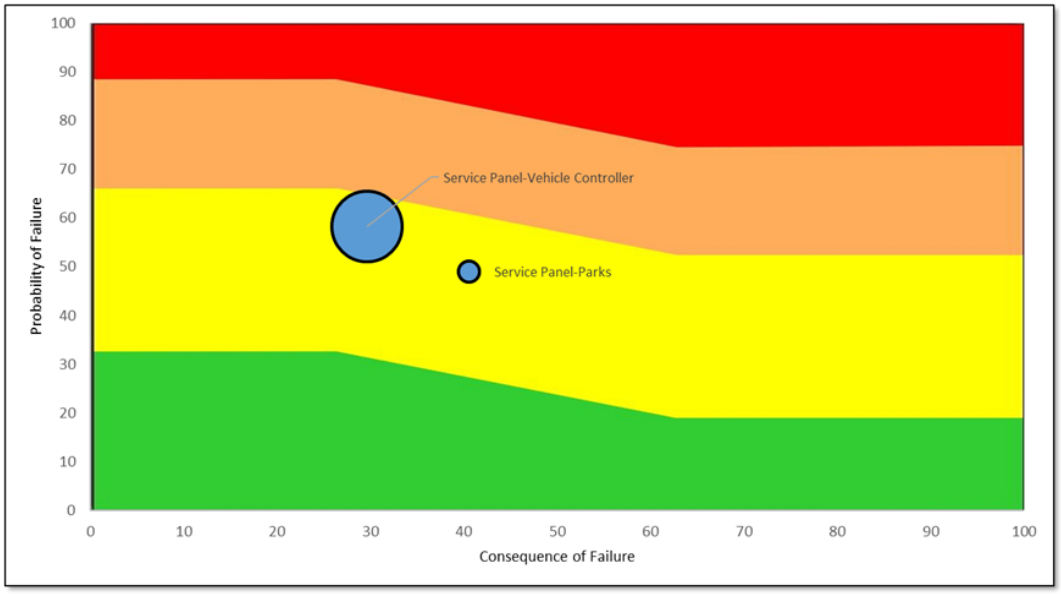


Figure 44 Risk Summary for Service Panels

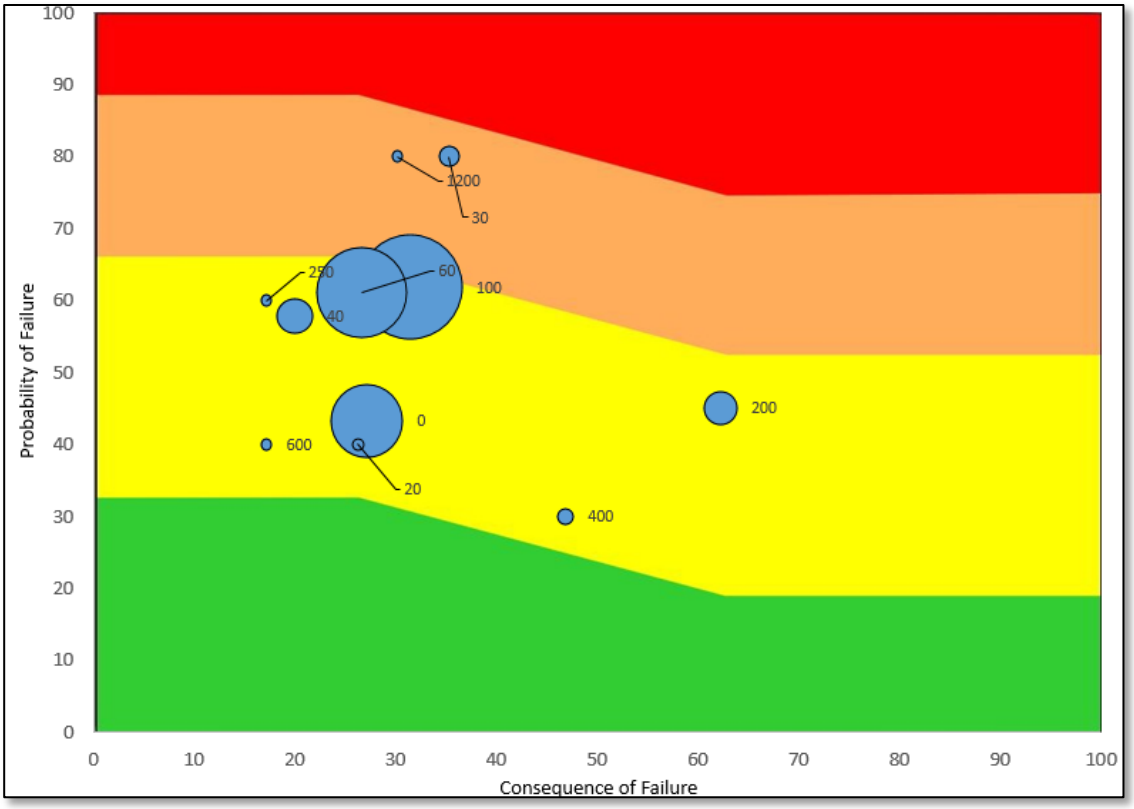


Figure 45 Risk Profile for Service Panel Types

The criticality of the service panels relative to the City's other transportation asset classes can be found in Section 5 of the report. This comparison is necessary for achieving cross-asset

optimization. Furthermore, the risk scores are a key element in the model that forecasts the timing of capital projects across the 10-year planning horizon.

1.9.4 Capital Needs Forecast

The following graph provides a risk-based capital needs forecast for the City's service panels derived from the transportation risk model and the available condition data.

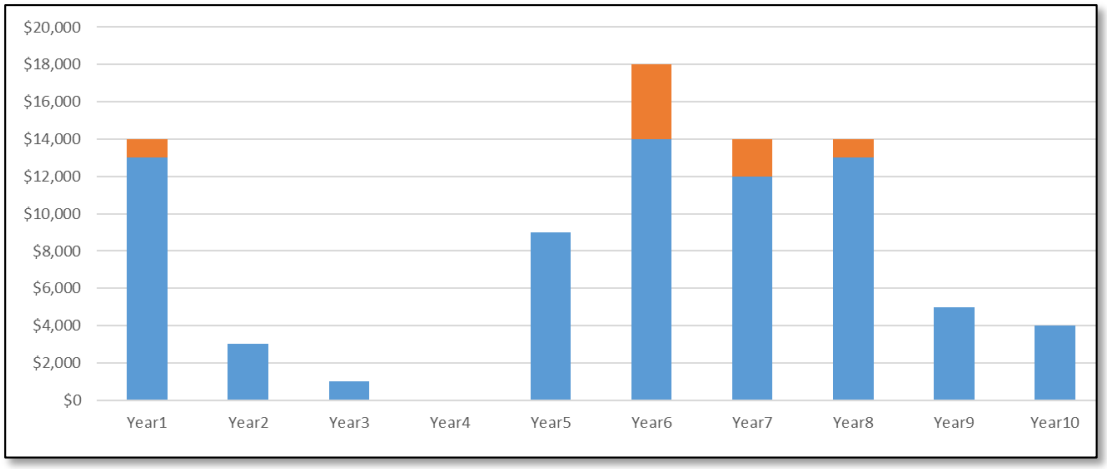


Figure 46 10-Year Capital Needs Forecast for Service Panels

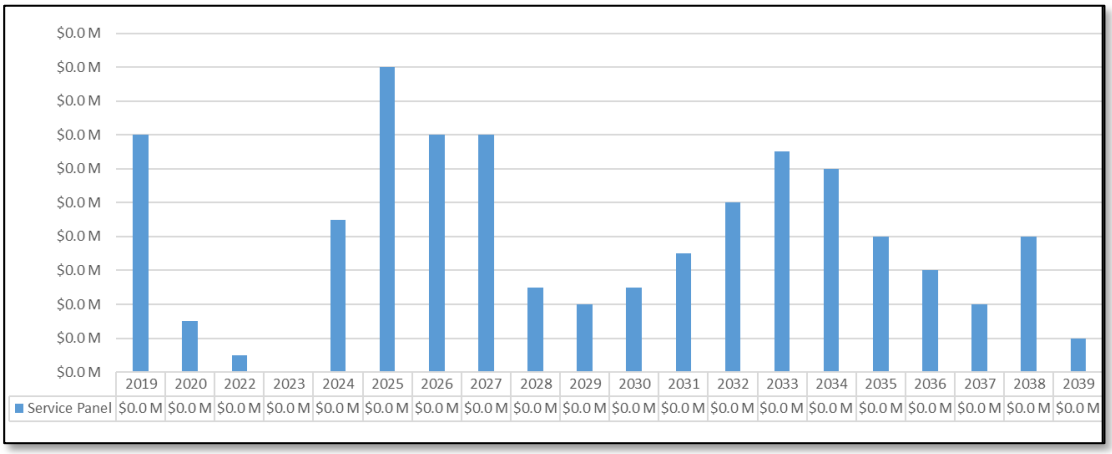


Figure 47 20-Year Capital Needs Forecast for Traffic Controllers

A variety of reinvestment scenarios have been developed to test the impact of different funding levels on the cumulative infrastructure gap and overall asset condition. This sensitivity analysis is included in Section 7 of the report.

1.9.5 Improvement Journey

Included below is a summary of the key initiatives to be considered for enhancement of the AMP for the service panels.

ID	Recommendations	Level of Effort	Level of Benefit
TC.1	Develop LOS measures and targets for the service panels	Low	Med.
TC.2	Refine the asset hierarchy for the service panels	Low	Med.

The full suite of recommendations across all asset classes is included in Section 8.

1.10 Signs

1.10.1 Key Performance Indicators

The following matrix provides a high level "heat map" of the eight (8) key performance indicators for the sign asset class. Definitions for each of the KPIs is included in the body of the report.

	1	2	3	4	5	6	7	8
Asset Hierarchy Levels	Data Quality Score	Asset Avg. Age	Asset Condition	PoF Score	CoF Score	Risk Score	Capital Needs, 10 Years	Annual Reinvestment Rate
Unknown		15.0	2.12	62	30	4.08	$17,735	0.10%
No Parking		14.3	2.04	65	19	3.82	$194,349	1.12%
Reg_Road_Use		16.2	2.19	70	41	4.23	$227,305	1.31%
Warning		14.7	2.29	57	20	4.04	$90,271	5.2%
Parking Permitted		14.9	2.00	67	14	3.83	$97,306	5.6%
Misc.		15.0	2.00	67	34	4.07	$1,797	0.1%
Reg_Right-of-Way		16.1	2.06	71	22	4.05	$376,638	2.16%
No Stopping		13.9	2.04	63	31	3.92	$39,582	2.3%
Tabs		16.4	2.07	72	17	4.01	$83,538	4.8%
Special New West Signs and Tabs		15.7	2.20	56	0	0.00	$382.	0.0%
Grand Total		**15.3**	**2.11**	**66**	**24**	**4.00**	**$1,128,907**	**6.49%**

Table 5 – KPI Matrix for Signs

A more comprehensive "heat map" that places the sign assets in a broader context with the other asset classes is included in the Executive Summary.

1.10.2 Valuation

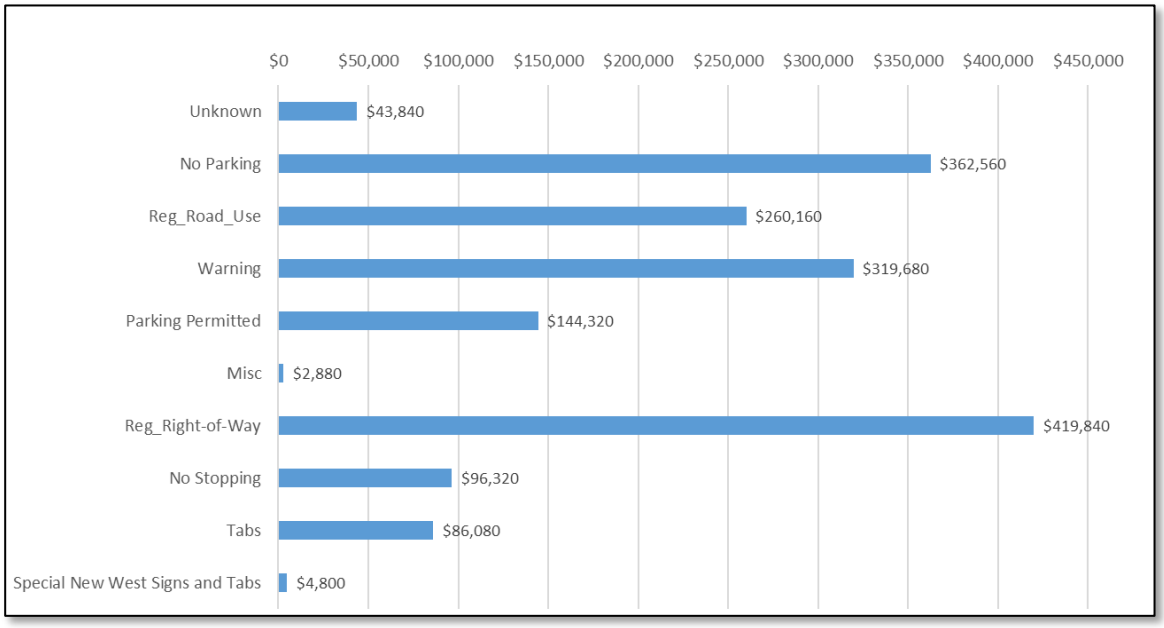


Figure 48 Valuation Summary by Sign Type

1.10.3 Condition

The following bar chart provides a visual summary of the condition of the City's street signs distributed across the 5-point condition scale.

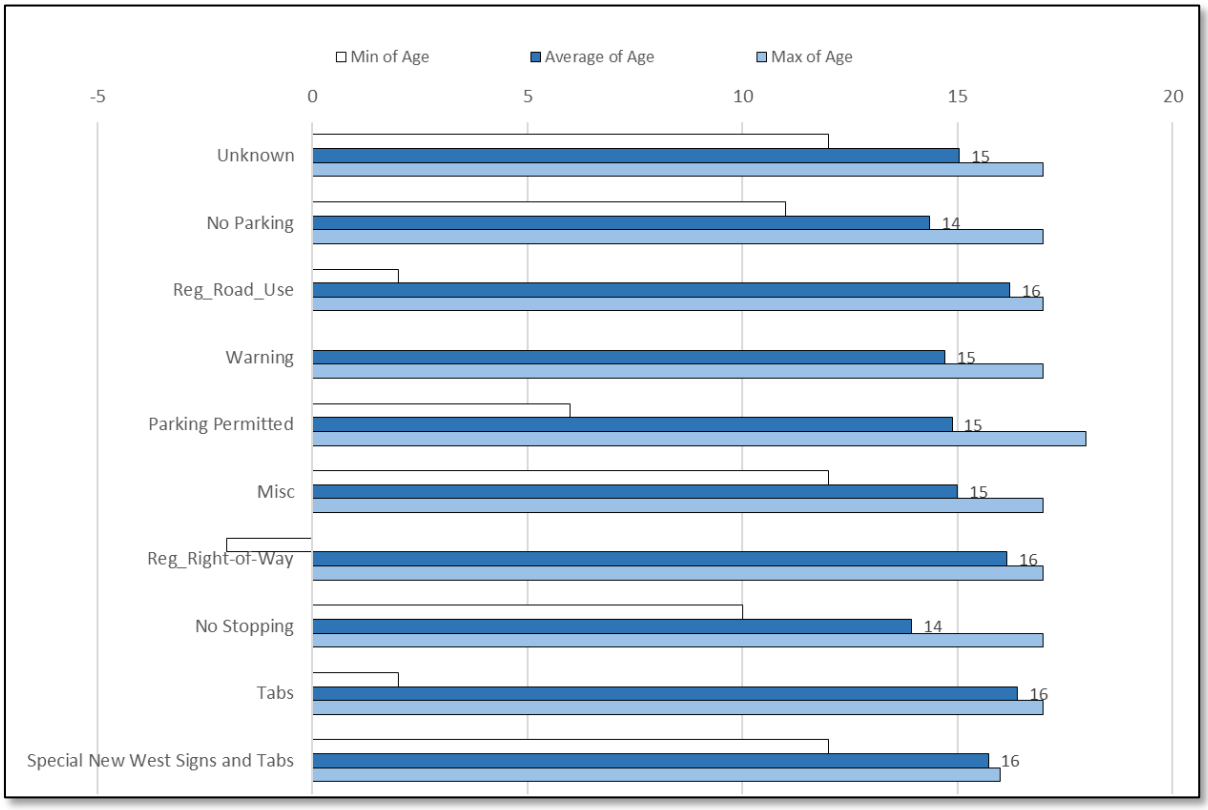
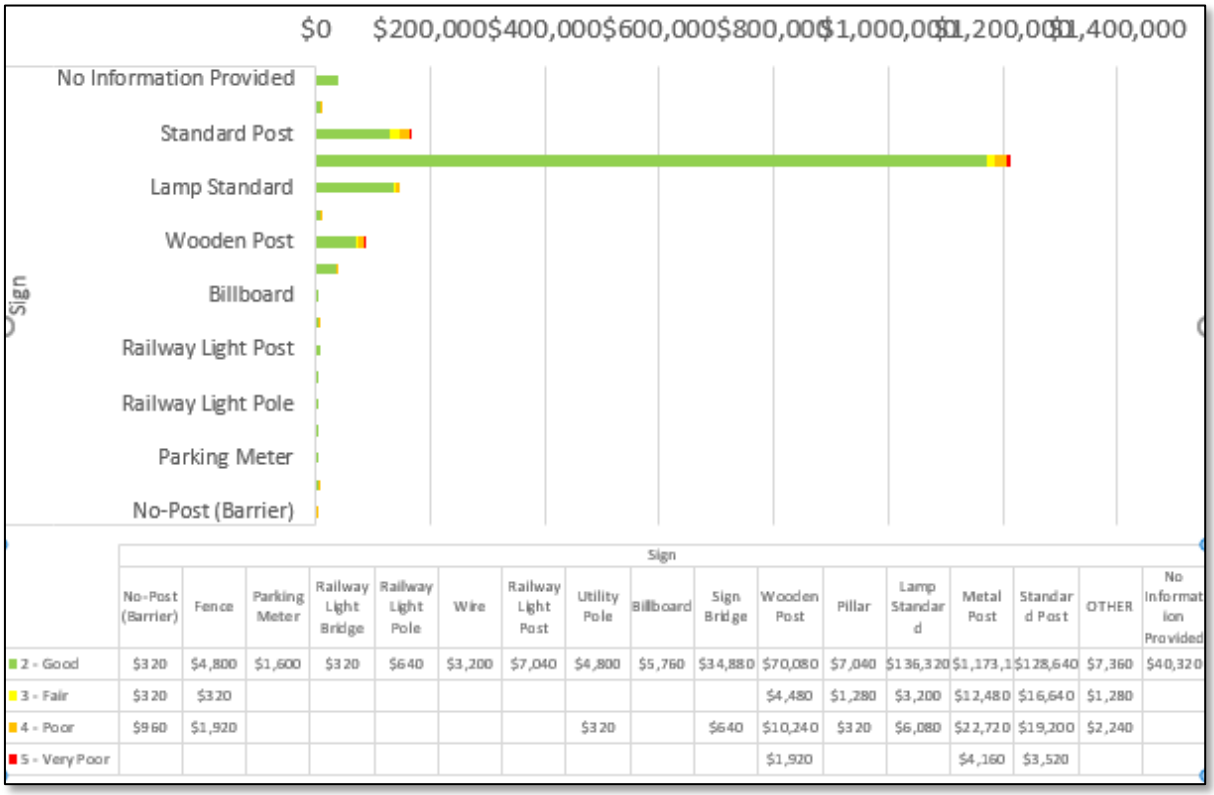


Figure 49 Age Profile Summary by Sign Type



	Sign																
	No-Post (Barrier)	Fence	Parking Meter	Railway Light Bridge	Railway Light Pole	Wire	Railway Light Post	Utility Pole	Billboard	Sign Bridge	Wooden Post	Pillar	Lamp Standard	Metal Post	Standard Post	OTHER	No Information Provided
2 - Good	$320	$4,800	$1,600	$320	$640	$3,200	$7,040	$4,800	$5,760	$34,880	$70,080	$7,040	$136,320	$1,173,1	$128,640	$7,360	$40,320
3 - Fair	$320	$320									$4,480	$1,280	$3,200	$12,480	$16,640	$1,280	
4 - Poor	$960	$1,920						$320		$640	$10,240	$320	$6,080	$22,720	$19,200	$2,240	
5 - Very Poor											$1,920			$4,160	$3,520		

Figure 50 Condition Summary by Sign Type

Benchmarking of the condition of the signs relative to the condition of the other asset classes is necessary for achieving cross-asset optimization. The condition distributions across all the City's various transportation asset classes is included in Section 3.

1.10.4 Risk

The following risk matrix plots the probability of failure and consequence of failure for the sign assets by type.

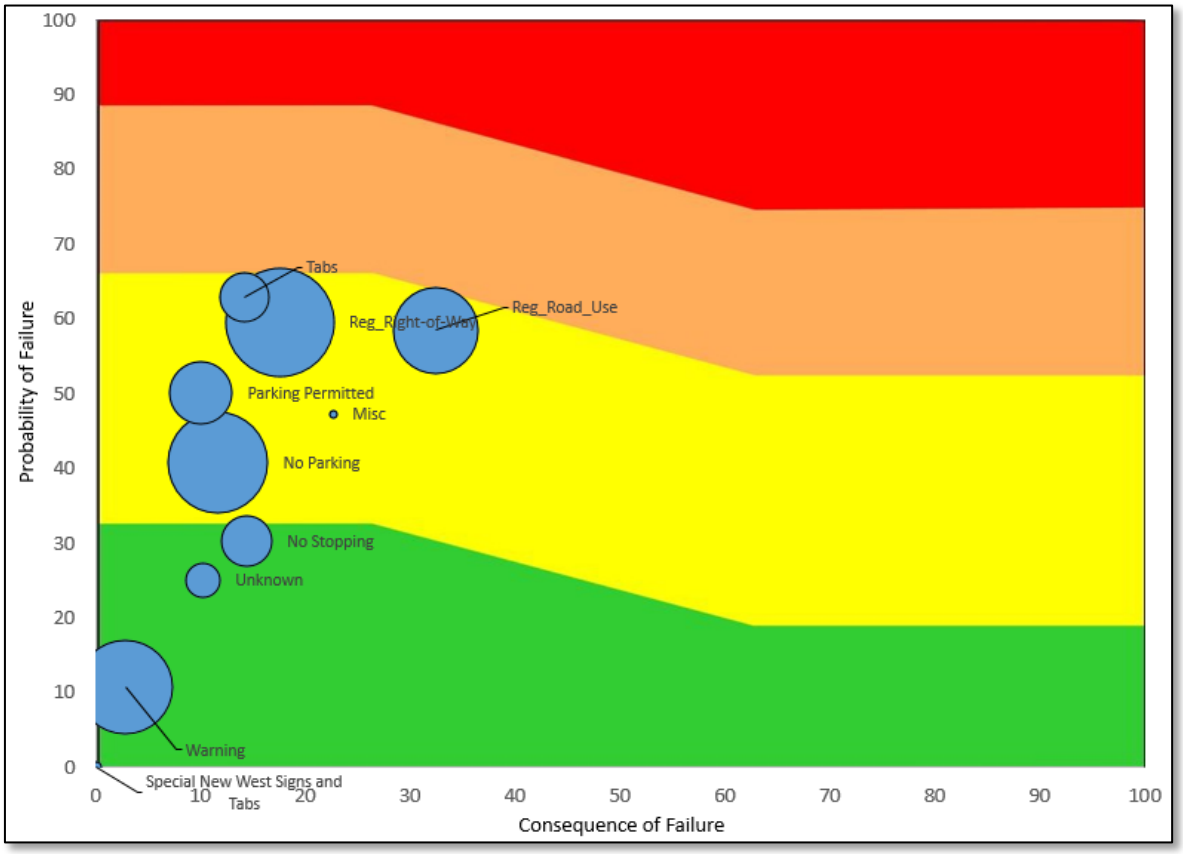


Figure 51 Risk Profile for Sign Types

The criticality of the traffic signs relative to the City's other transportation asset classes can be found in Section 5 of the report. This comparison is necessary for achieving cross-asset optimization. Furthermore, the risk scores are a key element in the model that forecasts the timing of capital projects across the 10-year planning horizon.

1.10.5 Capital Needs Forecast

The following graph provides a risk-based, capital needs forecast for the City's street signs derived from the transportation risk model and the available condition data.

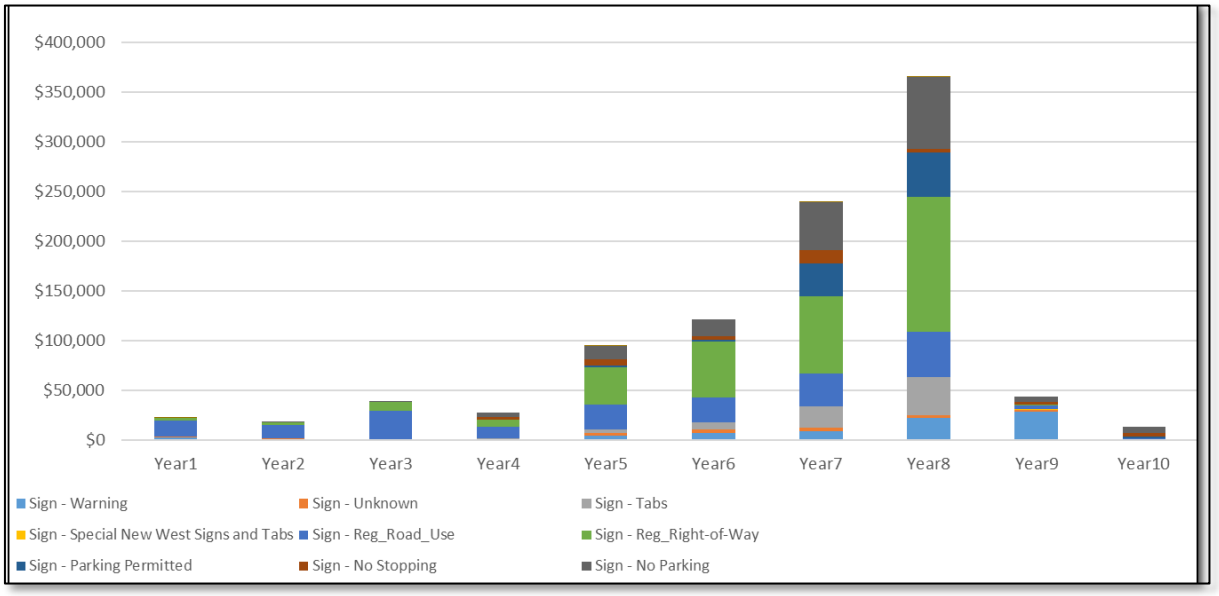


Figure 52 10-Year Capital Needs Forecast for Signs

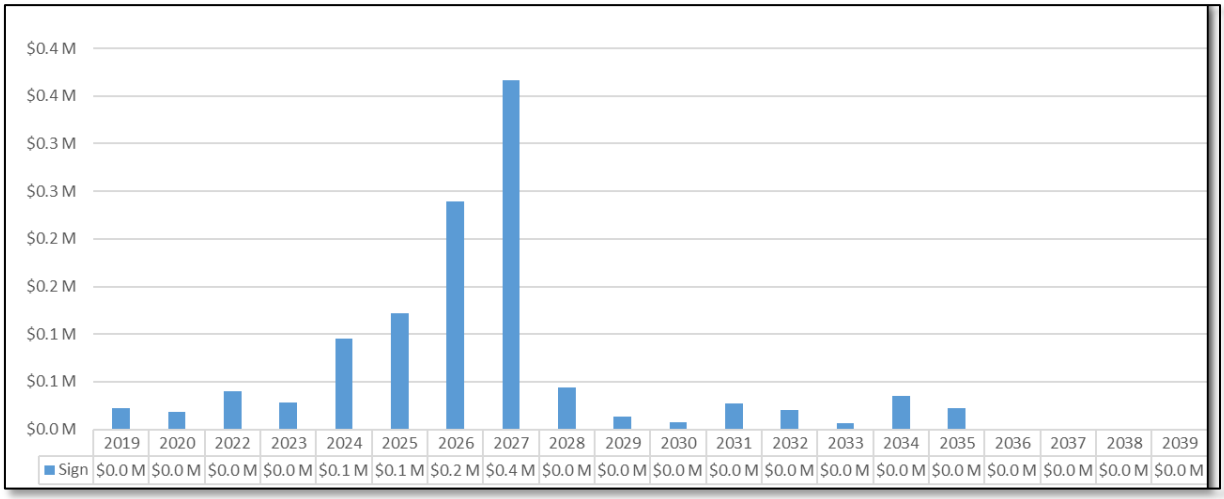


Figure 53 20-Year Capital Needs Forecast for Signs

A variety of reinvestment scenarios have been developed to test the impact of different funding levels on the cumulative infrastructure gap and overall asset condition. This sensitivity analysis is included in Section 7 of the report.



about GHD

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