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Item No. 15.1.5
Halifax Regional Council
January 25, 2022

TO: Mayor Savage and Members of Halifax Regional Council

SUBMITTED BY: Original Signed by
Jacques Dubé, Chief Administrative Officer

DATE: January 4, 2022

SUBJECT: Recommendation on Level of Service (LOS) for the HRM Street Network

ORIGIN

This report originates from The Strategic Priorities Plan 2021-25 and the Transportation and Public Works 2021/22 Budget and Business Plan. Both documents state: Municipal staff will work with Regional Council to articulate what a "Well-Maintained Transportation Network" means for the municipality. This includes defining levels of service for transportation related assets (e.g., streets, sidewalks, walkways, etc.) and will help identify funding requirements to maintain assets at an acceptable level.

LEGISLATIVE AUTHORITY

Halifax Regional Municipality Charter, R.S.N.S. 2008, c. 39:

Purposes of Municipality
7A The purposes of the Municipality are to
(a) provide good government;
(b) provide services, facilities, and other things that, in the opinion of the Council, are necessary or desirable for all or part of the Municipality; and
(c) develop and maintain safe and viable communities.

Municipal expenditures
79A (1) Subject to subsections (2) to (4), the Municipality may only spend money for municipal purposes if
(a) the expenditure is included in the Municipality's operating budget or capital budget or is otherwise authorized by the Municipality.

Street related powers
322 (1) The Council may design, lay out, open, expand, construct, maintain, improve, alter, repair, light, water, clean, and clear streets in the Municipality.

RECOMMENDAITONS ON PAGE 2

RECOMMENDATION

It is recommended that Halifax Regional Council:

1) Approve the Pavement Quality Index (PQI) Condition Categories as described in Table 4 of this report;

2) Approve a target Level of Service (LOS) for the HRM road pavement network as outlined in the Discussion section of this report to maintain a minimum of 67% of the network in "Good" condition with PQI for each functional class of road greater or equal to the number shown in Table 4 for the "Good" category";

3) Approve the proposed Budget Based Funding Scenario described in Table 10 of this report as the target funding level for the Street Recapitalization Account in future capital plans; and refer to the 2022/23 Budget process for the initial 22/23 funding level;

4) Approve the continued use of District allocation for Capital program selection as described in the Discussion section of this report; and

5) Approve a biennial reporting period, whereby staff will conduct similar analyses and report back to Council every two years with pavement condition, as described in the Discussion section of this report.

EXECUTIVE SUMMARY

Transportation and Public Works (TPW) manages the maintenance and rehabilitation of 3897 lane kilometers of roads throughout HRM. Pavement management has been a core function of TPW, with ongoing investments in pavement engineering, and management tools and processes. In 2020, staff acknowledged the importance of defining Council approved levels of service (LOS) for transportation infrastructure and included an initiative in both the Strategic Priorities Plan 2021-25 and the Transportation and Public Works 2021/22 Budget and Business Plan to work with Council on defining LOS. As part of this initiative, given that pavements are HRM's highest valued asset, the focus was to establish LOS for the road network first.

In 2021, HRM Staff worked with Stantec Consulting Ltd. (Stantec) to review and update many of the core data and parameters utilized in the pavement management software, assess network condition based on the 2016, 2018 and 2020 data collections, conduct jurisdictional scans, develop new PQI triggers and condition categories, and recommend a Level of Service (LOS) for the HRM roadway network as it relates to condition. Several budget and performance LOS analyses were completed to ultimately recommend an LOS for the network that helps stabilize the condition over the 10-year analysis period. The LOS recommended by both staff and Stantec is to maintain a minimum of 67% of the network in good condition with PQI for each functional class greater or equal to the number shown in Table 4 of this report for the "Good" category. However, due to the historical backlog, significant funding is required immediately to rapidly improve network condition. With potential concerns on the ability for HRM staff and the industry to deliver a more robust capital program, staff conducted a budget-based scenario, where funding would gradually increase over the 10-year analysis period. The proposed funding scenario, displayed in Table 7, would result in continued short-term decline in condition, but by year 2030 would align with the recommended LOS.

The Street Recapitalization Account funds street rehabilitation but also funds elements such as concrete curb and gutter, integrated traffic calming, accessibility improvements, staff resources, etc. As part of this report, staff assessed funding impacts of these elements. It was observed that on average roughly 40% of Street Recapitalization funding is currently attributed to other elements. One of the measures that can be

implemented to help maintain pavement condition but reduce potential Street Recapitalization costs is to implement more timely surface treatments and light rehabilitation activities without adding all complete streets elements (until a more aggressive rehabilitation treatment is required). Therefore, staff is recommending that not every street selected as part of the Capital Program be immediately considered for complete streets aspects. The decision to hold on rehabilitating or adding additional assets will continue to be discussed as part of the overall integration process with the Integration Committee. If the complete streets elements are not necessarily a priority, or require multiple years of planning, they will be added in a future year when the paving strategy is more intrusive. Like this, the costs of rehabilitating or adding adjacent assets can be distributed over many years, while pavement condition can potentially be stabilized.

Another aspect reviewed in this report was the selection criteria for the street rehabilitation program, including District allocation. Staff conducted an analysis where they compared optimization based on allocated funds and optimizing by District individually versus optimizing the entire network simultaneously. The analysis resulted in similar performance for both methodologies; therefore, staff are recommending that District allocation continue to be utilized at this time as part of program selection.

As part of the next steps, staff will continue to collect pavement condition data, conduct further refinement of the core data and parameters utilized in the pavement management software and conduct further budget and performance analyses as parameters are refined and adjust funding requirements as necessary. This will be completed biennially.

BACKGROUND

Transportation and Public Works (TPW) is responsible for the maintenance and rehabilitation of HRM's road network. It is comprised of 3897 lane kilometers of arterial, collector and local roads and is likely HRM's highest valued asset, valued over $1.6 billion. Pavement Management has been a core function of TPW, with both an on-going pavement condition data collection program and Pavement Management System (PMS). The information is used to monitor pavement condition, identify deficiencies, and develop annual/long term capital investment plans. Over time, HRM has continued to invest in the development of pavement engineering and management tools and processes.

Between 1996 and 2015, HRM collected pavement condition data for its road sections on a three-year cycle via visual windshield surveys performed by a field technician. The collected data was then uploaded into the PMS software Road Analytics, which was used primarily as the repository for pavement inventory and condition data, and had few analytical capabilities. The condition data uploaded to Road Analytics was used to compute the performance index reported at that time, the Surface Distress Index (SDI). The SDI was based on a scale from zero to 10, where 10 was best condition and zero worst condition.

In 2014 HRM engaged a third-party consultant to conduct an analysis of the current surface condition of the pavement network, assess current PMS processes, evaluate long term rehabilitation investment strategies based on alternative budget scenarios, and provide recommendations and next steps.

In 2016 HRM developed a Pavement Condition Rating Guide, procured a new PMS (Highway Pavement Management Application (HPMA)), and adopted a new pavement condition data collection methodology. The new data collection methodology involves collecting condition data biennially using a multi-function data collection vehicle. The vehicle includes a Laser Crack Measurement System (LCMS) for crack detection, laser profiler for rut and roughness measurements, a Distance Measuring Instrument (DMI), GPS and Right of Way (ROW) camera. Data collection is completed by a third-party consultant, and data for the entire network is captured over a two-month period. The intent of the new data collection methodology was to accelerate the collection period and to eliminate possible subjectivity involved with manual windshield surveys.

Like Road Analytics, HPMA serves as a repository for pavement inventory and condition data, and computes the performance indices; however, the software also has many analytical capabilities including the tools to evaluate various funding or condition-based constraints to help in decision making as it relates to the management of the road network. The software can also predict long term performance using deterioration models to predict condition over time.

As part of the new PMS implementation, HRM also adopted new performance indices related to roadway condition: The Pavement Condition Index (PCI), Ride Condition Index (RCI), and Pavement Quality Index (PQI). Unlike the SDI, the PCI, RCI, and PQI range from zero (worst condition) to 100 (best condition). The PCI is based on pavement surface distresses that include, alligator cracking, edge cracking, longitudinal / transverse cracking, bleeding, potholes, patching and utility cut patching and rutting. As part of the new data collection methodology and PMS, HRM started collecting roughness, which is a measure of the pavement longitudinal profile. It is used to describe the ride quality of a road, and is defined in HPMA as the RCI. The PQI is a composite performance index composed of both surface distresses and roughness, and is therefore based on the PCI and RCI. Given that roughness was an added parameter, it was decided that HRM would begin using PCI as the performance index until staff were able to review roughness datasets, with the intent to eventually transition to PQI as the overall index.
Since 2016, HRM staff have also worked to refine the PMS to align with HRM's requirements, capture and review condition data and conduct analyses using the PMS software. Table 1 summarizes HRM's pavement asset management activities since 2014.

Table 1. HRM Pavement Asset Management Activities Since 2014

Timeline	Pavement Asset Management Activities
2014	• Pavement Condition Report (current network condition, investment strategies, recommendations, and next steps)
2016	• Pavement Condition Rating Guide Development (New Data Collection Methodology) • Linear Referencing System Standards Development • Completed High Speed Pavement Condition Data Collection (Surface Distress and Roughness) • Procured New Pavement Management System – Highway Pavement Management Application (HPMA)
2017	• Completed Initial Implementation of HPMA
2018	• Completed High Speed Pavement Condition Data Collection (Surface Distress and Roughness)
2019	• Capital Budgeting and Programming Analysis Using HPMA • Pavement Condition Data Update
2019 – 2020	• Pavement Condition Indices and Performance Prediction Models Review/Update
2020	• HPMA Construction History Update • HPMA Traffic Data Update • Capital Budgeting and Programming Analysis Using Updates and Enhanced HPMA Models • Completed High Speed Pavement Condition Data Collection (Surface Distress and Roughness)

2021	• HPMA Construction History and Pavement Condition Data Update • HPMA Models and Decision Trees Review/Update • RCI Equation Update • Transition to PQI as Performance Index Related to Pavement Condition • Maintenance & Rehabilitation (M&R) Treatments Service Lives Update • Updated M&R Treatments List • Unit Costs Update – Based on 2020 Unit Rates • PQI Triggers and Performance Targets/Level of Service (LOS) Review

The 2014 Pavement Condition Report provided a budget scenario for maintaining the current network average condition at that time. The recommendation indicated a funding need for pavements of $313M between 2015 and 2024. As shown in Figure 1, the funding attributed solely to pavements between 2015 and 2021 indicates a shortfall of approximately $83.8M over those seven years.

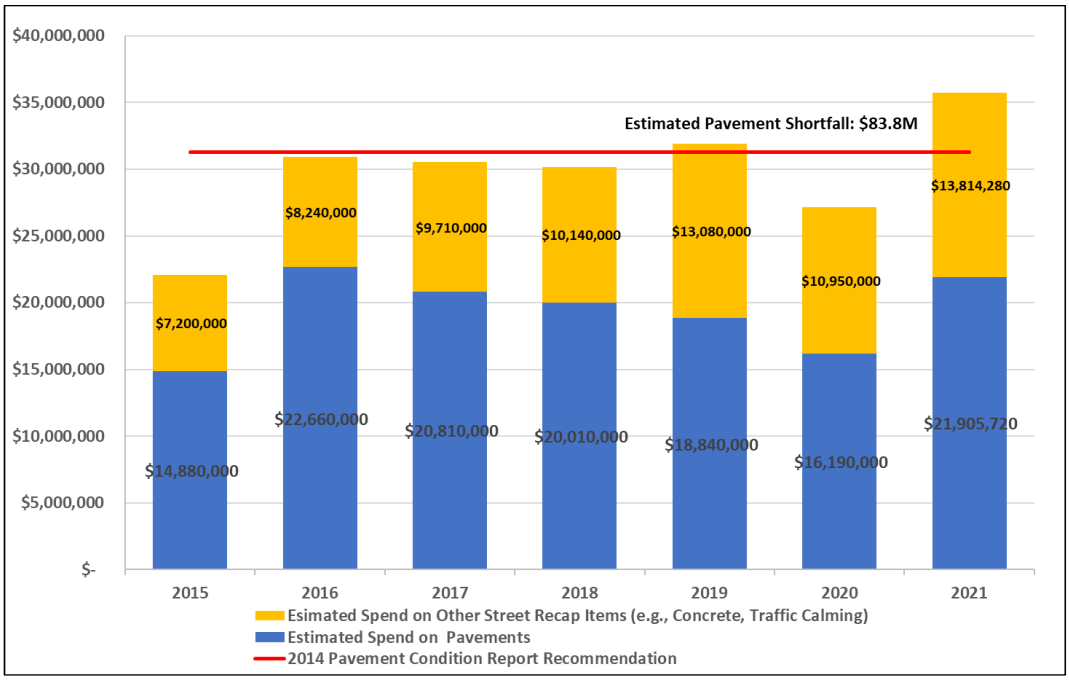

Figure 1. Estimated Versus 2014 Recommended Budget Spend on Pavements

As noted in Table 1, pavement condition data collection was completed in 2016, 2018 and 2020. As shown in Figure 2, the Pavement Condition Index (PCI) for the network and across all functional classes has steadily decreased.

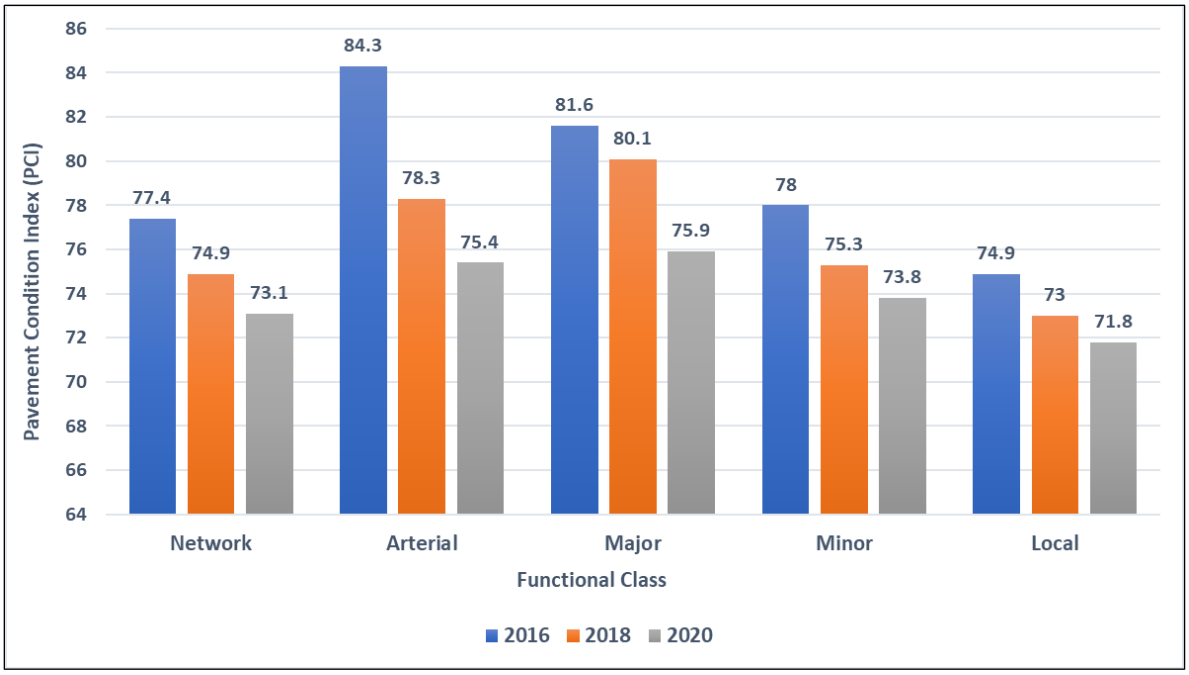

Figure 2. Pavement Condition Index (PCI) for Network and by Functional Class Since 2016

Given the estimated shortfall in pavement spending, the average network condition has decreased, and the rehabilitation backlog has increased. Historically staff have presented to Council the rehabilitation backlog required to bring all streets above a PCI of 75 (or SDI of 7.5). As shown in Figure 3, backlog has increased significantly between 2015 and 2018. Note that backlog was not computed with the 2020 condition data using this methodology. Needs backlog is further discussed in the Discussion section of the report, and includes the 2020 data.

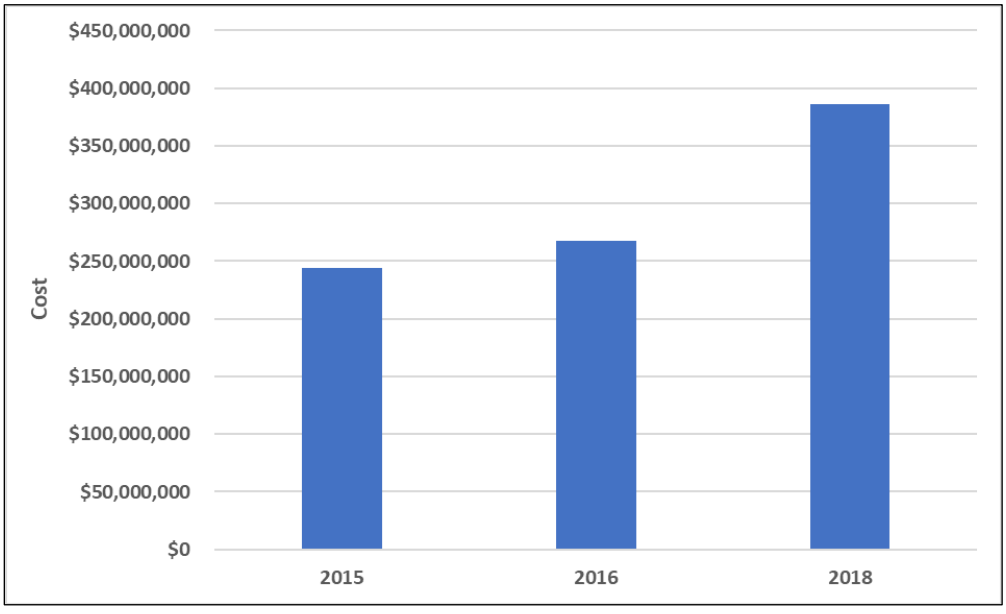

Figure 3. Rehabilitation Backlog Between 2015 and 2018

Historically, the development of HRM's annual street rehabilitation capital program has been largely based on the following criteria:

- SDI/PCI/PQI (street condition rating).
- Street classification (e.g., arterial, collector, local).
- Type of existing street surface material.
- Synergies, conflicts, and integration with both internal and external stakeholders (Integration Committee) (i.e., engage in integration opportunities with utilities such as Halifax Water or with internal stakeholders such as Active Transportation or Transit; avoid conflicts with large development projects).
- Rehabilitation backlog in each District (i.e., funding is allocated by District based on the percentage of the overall backlog in each District. Therefore, a District with a higher percentage of rehabilitation backlog receives a higher percentage of funding allocation to help reduce the backlog).
- Budget levels.

DISCUSSION

Like HRM, annual investments in transportation infrastructure throughout many agencies in North America continue to fall short of needs, resulting in a persistent and growing backlog of maintenance and rehabilitation (also referred to as infrastructure deficit). This has become a critical challenge for agencies as they struggle with constrained budgets and increased demands for infrastructure use. As a result, agencies are increasingly completing data-driven analysis and adopting performance-based management and decision-making approaches to help develop and prioritize investments and policies.

In a recent Transportation Association of Canada (TAC) study on performance-based decision making conducted by Montufar, Regehr and Haas[1], several agencies were surveyed on the level of impact that various performance objectives have on their asset management decisions and on the optimization techniques that the respondents use for managing assets. The performance objective that was identified by respondents as having the highest level of impact was asset condition, followed by safety and then financial resources. The survey identified engineering judgement as the most used optimization technique for asset management, followed by level of service targets and risk exposure analysis.

In 2021, HRM staff worked with Stantec Consulting Ltd. (Stantec) to review and update many of the core data and parameters utilized in HPMA to better refine the analytical capabilities of the software. In addition, HRM reviewed and updated many of the models utilized in HPMA, and transitioned to the Pavement Quality Index (PQI) to measure the functional performance of the pavement assets related to the condition (i.e., Performance Index). In 2021, Stantec was also retained to conduct jurisdictional scans, work with HRM staff to develop new PQI triggers and condition categories, and recommend a Level of Service (LOS) for the HRM roadway network as it relates to condition.

One of the key objectives of HRM's pavement management program is to manage the assets to the level of service (LOS) that meets the expectations of customers (i.e., public users), and to provide a safe and functional road network, while applying cost-effective solutions. LOS targets are used by some agencies to set an annual maintenance and rehabilitation standard that aligns with the public's expectations and available funding. For some agencies, the LOS may be striving to maintain the current network average condition. For others, they may wish to maintain a targeted percentage of the network in good or poor condition, where good and/or poor is defined by the overall asset condition. This is often characterized by indices, such as the PQI. The jurisdictional scans conducted by Stantec suggested that some municipalities strive to maintain a particular network average condition; however, there are larger jurisdictions such as provincial/state level agencies in Canada and the United States and larger municipalities/cities that use

[1] Montufar, J., Regehr, J., Chapman, S. and Haas, R. 2021. Performance-Based Decision Making for Asset Management: Lessons Learned and Practitioner Toolkit. Ottawa, ON: Transportation Association of Canada.

overall percent good or percent poor as targets for their network. In general, the LOS selected by an agency may relate to the level of sophistication regarding their pavement management processes.

With HRM's roadway network condition steadily declining and the rehabilitation backlog (infrastructure deficit) continuing to increase, HRM staff believe it is now imperative to establish a Council approved Level of Service (LOS) that stabilizes the network condition while determining funding requirements over the next ten years that align with the newly established LOS. With the optimizations made to HPMA, staff now have a greater comfort level with the analytical capabilities of the software.

Establishing PQI Triggers and Condition Categories

HPMA uses pavement condition data and analysis models to forecast maintenance and rehabilitation needs across the road network, and can develop maintenance program budgets and priorities. HPMA uses cost-effectiveness and marginal cost-effectiveness approaches to select an optimized program. In other words, performing the right fix at the right time. Rehabilitation needs generally increase when roads are not maintained or rehabilitated within a timeframe when the work would be effective (i.e., missed opportunities to resurface a road may result in more costly rehabilitation work, including partial or full reconstruction being required much earlier in the overall life of the pavement).

The optimization function provides a methodology for determining feasible maintenance and rehabilitation (M&R) strategies for each street section (cost-effectiveness), and can perform network optimization of the strategies based on performance and/or funding constraints (marginal cost-effectiveness). Performance constraints can be used to determine funding requirements while funding constraints can be used to develop a work program or determine resulting network performance.

The M&R strategy analysis process is based on user-defined decision trees that vary by functional class and pavement type. The decision trees define the feasible strategies under various conditions. Each treatment alternative selected, based on the decision tree, is analyzed in terms of life-cycle costs and performance (performance index and/or individual distresses predicted). The decision trees utilized in HPMA were defined by HRM staff in consultation with Stantec, and align with typical HRM construction practices.

The cost-effectiveness analysis and evaluation methodology is extensively used in pavement management. The study conducted by Montufar, Regehr and Haas[1] suggests that the methodology provides a relatively simple calculation where costs and benefits are clearly outlined, is successful in evaluating the cost-effectiveness of individual system interventions, and is perceived to be a reliable, objective, and consistent technique for prioritizing investments. However, while the analysis has the ability to select a cost-effective program, it does not have the ability to assess intangible factors such as disruption/congestion, integration opportunities / conflicts with other stakeholders, or issues such as environmental impacts (i.e., street flooding/icing problems) which are also key factors in developing a comprehensive rehabilitation program. Another factor is the implementation of complete streets. In certain instances, the inclusion of complete streets elements requires the paving strategy to be more intrusive than required in terms of pavement cost-effectiveness, or can result in delays to the rehabilitation year due to planning requirements. This results in a sub-optimal treatment selection and influences overall budget. However, the benefits of applying the complete streets elements in some instances may outweigh the cost-effectiveness of the pavement treatment selection/timing when assessing the entire roadway corridor. As a result, engineering judgement is also important in the overall development of the program.

As mentioned in the Background section, historical backlogs were calculated using a PCI of 75 (or SDI of 7.5), and represented the funds required to bring all streets above this value. In this scenario, the intent was to eliminate all potential rehabilitation needs for the network. With HPMA, the software has the capability to set differing rehabilitation triggers based on functional class. Rehabilitation triggers are commonly used by agencies to aid in rehabilitation needs analysis. They represent the condition level where an asset requires needs or intervention by means of maintenance or rehabilitation, and generally differ by

road functional class (i.e., Arterial, Collector, Local). In many cases throughout the industry, the condition rehabilitation triggers represent the condition level where the asset would be considered in poor condition. It can also be considered the critical value you would not want a particular asset to fall below. For HRM, the condition triggers are based on PQI.

The needs analysis performed using HPMA utilizes M&R optimization analysis described above and ultimately calculates the cost required to bring all streets above the trigger values for each functional class. Need is defined as the level where a street segment falls below the trigger, and therefore the objective of the M&R analysis is to identify the feasible M&R treatments (i.e.,, microsurfacing, overlay, mill and overlay, reconstruction, etc.) for each section in need based on the current PQI during the analysis period. The costs identified are for pavement M&R only, and do not include any additional assets. The year in which a street's PQI falls below the defined PQI trigger is the pavement need year.

During the initial implementation of HPMA, HRM staff selected PQI triggers which they considered were aligned with industry standards. However, as part of the analyses performed by HRM staff and Stantec in 2021, Stantec conducted jurisdictional scans of comparable agencies to confirm if HRM's triggers aligned with industry. In addition, Stantec conducted an analysis to evaluate the existing PQI triggers and assess the need for establishing new PQI triggers. The analysis involved conducting a needs sensitivity analysis using the following scenarios:

- Initial PQI Triggers (established during initial implementation of HPMA)
- Initial PQI Triggers Minus Five PQI Points
- Initial PQI Triggers Plus Five PQI Points
- Initial PQI Triggers for Arterial and Major Collector and Minus Five PQI Points for Minor Collector and Local

The first sensitivity analysis that was performed included the plus and minus five PQI points scenarios. The plus/minus five PQI points were somewhat arbitrary selections, but still aligned with industry standards, and provided enough differentiation in PQI to observe the needs impacts from altering the trigger values. Once this analysis was completed, HRM staff decided to add a fourth scenario which would maintain the initial values for arterials and major collectors but reduce the thresholds for minor collectors and locals. The intent of this decision was to keep higher traffic volume streets (i.e., arterials and major collectors) in better condition but reduce overall funding needs by reducing the threshold on lower traffic volume streets (i.e., minor collectors and locals). PQI trigger values corresponding to each scenario are shown in Table 2. Based on the jurisdictional scans, all scenarios align with the ranges identified from other jurisdictions.

Table 2. PQI Trigger Scenarios

Functional Class	PQI Trigger Scan Ranges	Initial PQI Triggers	Initial PQI Minus 5	Initial PQI Plus 5	Initial PQI Minus 5 (Minor and Local Only)
Arterial	50 to 70	60	55	65	60
Major Collector	40 to 65	55	50	60	55
Minor Collector	40 to 65	55	50	60	50
Local	40 to 55	50	45	55	45

Using the various triggers identified above, Stantec performed an M&R optimization analysis using HPMA for all roads in the network. Ten years was selected as the analysis period. The results of the needs analysis for each trigger scenario are displayed in Table 3

Table 3. Results of Need Budget Scenarios Related to PQI Triggers

Budget Scenario	Average Annual Needs ($M)	Year-1 Needs ($M)
Initial PQI Triggers	$53 M	$192 M
Initial PQI Minus 5	$52 M	$152 M
Initial PQI Plus 5	$60 M	$235 M
Initial PQI Minus 5 (Minor and Local Only)	$50 M	$163 M

Reviewing the results, the "Initial PQI Triggers for Arterial and Major Collector and Minus Five PQI Points for Minor Collector and Local" scenario has the lowest average annual needs among all other scenarios with the second lowest Year-1 needs. As a result, Stantec recommended reducing the existing PQI triggers for minor collectors and locals to align with this scenario. Given the current financial pressures faced by HRM, HRM staff agreed with the recommendation and lowered the PQI triggers for minor collectors and locals given that they are still within the ranges identified in the jurisdictional scans. These PQI triggers were then used for the LOS analysis described in the next section of the report. As a note, the needs identified in Table 3 would be the funds required to bring all streets above poor condition. It does not represent the funds required to eliminate all M&R requirements.

In addition to the PQI triggers used in the needs analysis described above, the PQI of a road section can then be classified as Good, Fair, or Poor, where the Good/Fair/Poor thresholds would also vary by functional class. HRM staff, through consultation with Stantec and review of the jurisdictional scans, established new condition categories for each functional class as part of the work completed in 2021. Three condition categories (Good/Fair/Poor) were selected for each functional class as outlined in Table 4. Similar to the PQI triggers, the condition categories have higher thresholds depending on functional class, i.e., higher traffic volume streets have higher thresholds. It should be noted that three to five condition states are typical throughout the industry.

Table 4. PQI Condition Category Thresholds for Each Functional Class

Functional Class	Good	Fair	Poor
Arterial	≥ 75	60-75	≤60
Major Collector	≥ 70	55-70	≤55
Minor Collector	≥ 65	50-65	≤50
Local	≥ 60	45-60	≤45

Once the transition to PQI was completed and the new PQI triggers and condition categories were established, HRM staff assessed network condition using the 2016, 2018 and 2020 condition data. Figure 4 displays the PQI for the network and for each individual functional class. Figure 5 indicates the needs backlog or cost required to bring all streets above the newly established trigger values. Figure 6 shows the distribution of Good/Fair/Poor. Like the PCI trend and backlog identified in the Background section of the report, the condition analyses conducted in 2021 show significant deterioration over the three most recent

data collections and further reinforce the pavement funding shortfall estimated since 2015. In addition, the percentage of the network considered in good condition dropped significantly from 2016 to 2020, and the backlog nearly doubled.

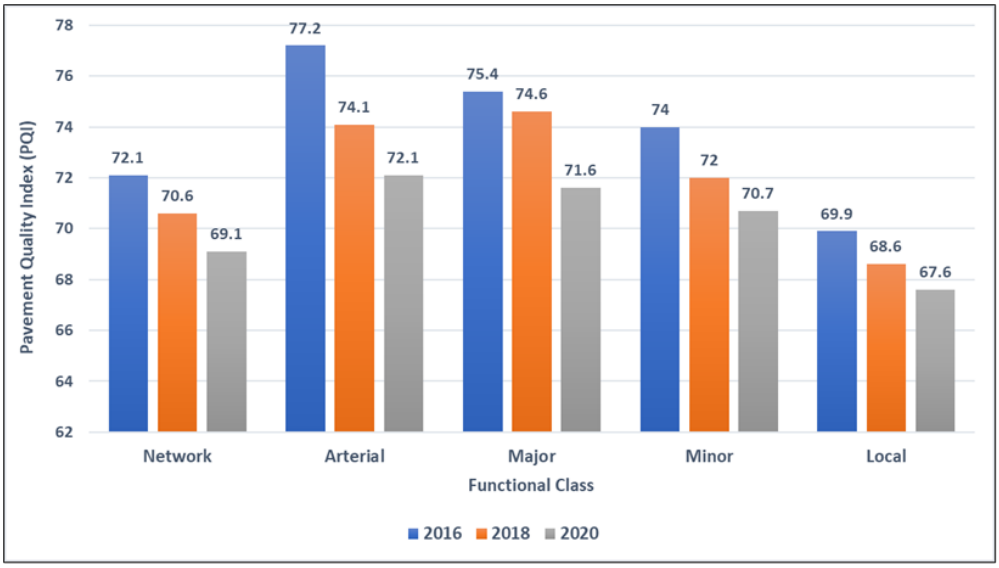

Figure 4. Pavement Quality Index (PQI) for Network and by Functional Class Since 2016

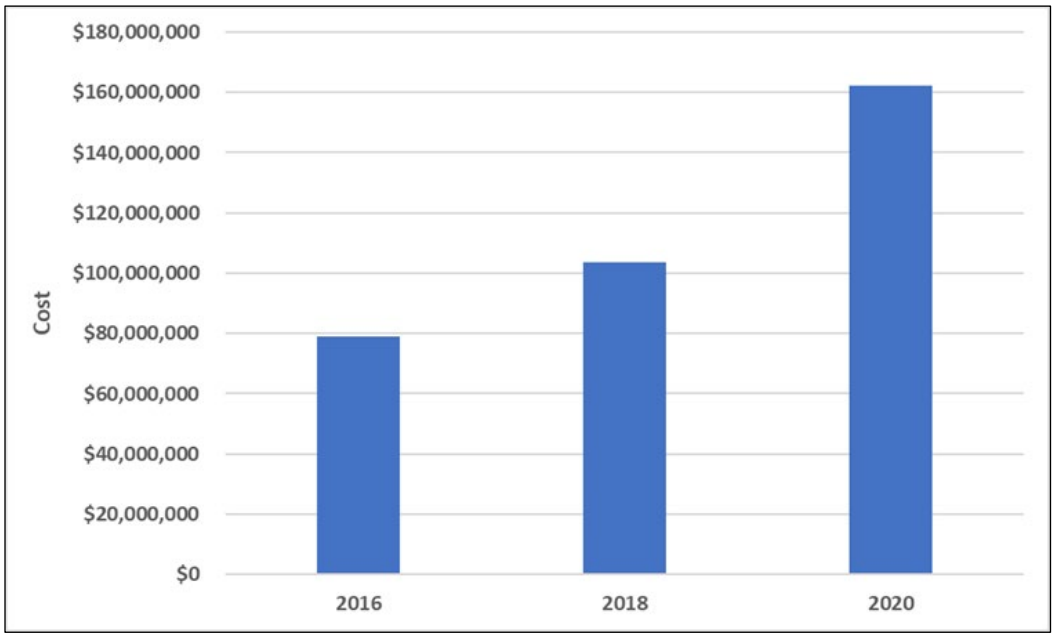

Figure 5. Rehabilitation Needs Backlog (Funds Required to Bring all Streets Above Poor Threshold)

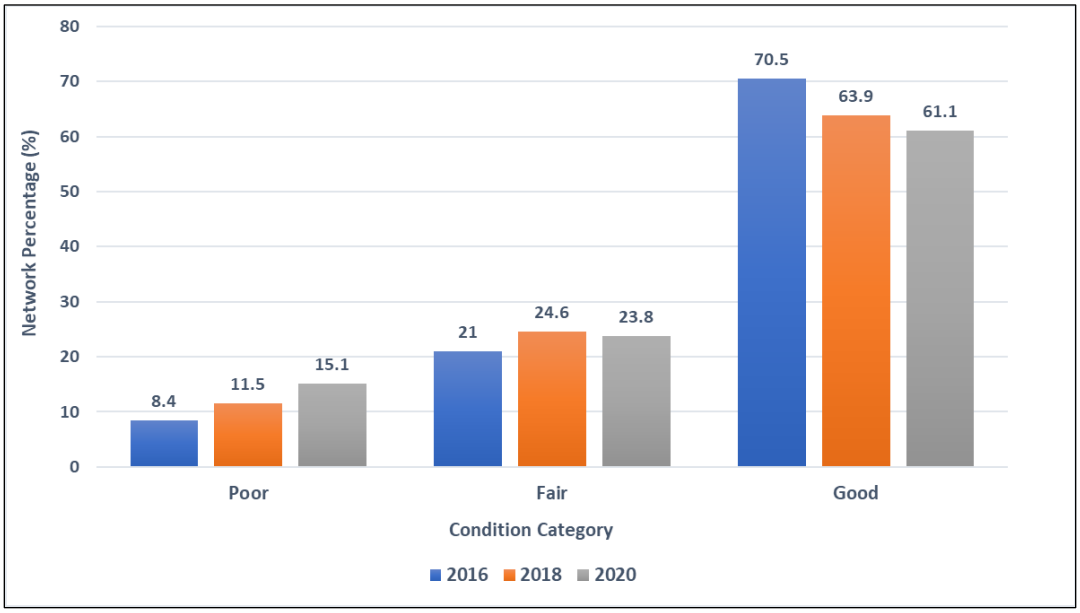

Figure 6. Network Condition in Terms of Good / Fair / Poor Distribution

Budget and Performance Analysis

In general, jurisdictions should strive to have manageable needs backlogs and should try to avoid growing the needs backlog as future attempts to stabilize the network condition will be even more cost prohibitive. In addition, delaying necessary state of good repair work also increases road rehabilitation backlogs which generally relate to the following risks:

- Increased operational reactive maintenance requirements (i.e., increased need for pothole repairs).
- Lower customer satisfaction.
- Increased vehicle maintenance costs (frames, suspensions, tires, etc.) of private as well as transit and commercial vehicles.
- Reduced network safety (friction and drainage issues) and reduced accessibility.
- Potential for increased claims and greater liability.
- Potential for health and safety impacts.
- Likelihood that missed opportunities to perform minor maintenance and rehabilitation will result in a greater volume of major rehabilitation needs along with higher cost repairs.
- Likelihood that more intrusive rehabilitation requirements increase road disruption.

With historical backlogs continuing to increase and Year-1 needs already unfeasible to address, HRM Staff believe the newly selected LOS should help stabilize the network over the 10-year analysis period (i.e., funding requirements should maintain the network average PQI and needs backlog near the 2020 condition levels (i.e., network average PQI = 69.1, needs backlog 15.1% of network lane-kilometers). In addition, increasing the percentage of streets in good condition should also be considered a target.

Using the newly established PQI triggers and condition categories, Stantec then completed budget and performance LOS analyses using a variety of scenarios. The following analysis parameters were used:

- Programming and Economic Analysis Period: 10 years (base year is 2021)
- Inflation Rate: 0% (i.e., analysis based on present day costs)
- Discount Rate: 0% (i.e., constant dollars approach used for the M&R analysis, therefore, the

interest rate used to estimate the present worth of future costs and benefits is zero.)
- M&R costs provided by HRM (2020/21 Unit Rates)
- Engineering Factor of 1 (i.e., no increase in funding due to additional assets or engineering costs)

The scenarios considered in the study included the following:

- Budget based scenario (base-level funding).
- Maintain current network average PQI (PQI = 69.1).
- Maintain the current network average PQI plus 3 (PQI = 72.1).
- Maintain the current network average PQI minus 3 (PQI = 66.1).
- Maintain a minimum of 67% of the network in good condition with PQI for each functional class greater or equal to the number shown in Table 4 for the Good category.
- Maintain a minimum of 64% of the network in good condition with PQI for each functional class greater or equal to the number shown in Table 4 for the Good category.
- Maintain a minimum of 70% of the network in good condition with PQI for each functional class greater or equal to the number shown in Table 4 for the Good category.
- Maintain a maximum of 5% of the network in poor condition with PQI for each functional class less or equal to the number shown in Table 4 for the Poor category.
- Maintain a maximum of 10% of the network in poor condition with PQI for each functional class less or equal to the number shown in Table 4 for the Poor category.
- Maintain a maximum of 15% of the network in poor condition with PQI for each functional class less or equal to the number shown in Table 4 for the Poor category.

The base-level funding budget scenario utilized the funding parameters identified in Table 5 (see below). These values were the base levels provided for the Street Recapitalization Account in the 2022/23 Draft four-year budget and conveyed to 2030 as a baseline. As shown in Table 5, the funds attributed to pavement M&R are 60% of the total spend, given that 40% of the funds are spent on other items such as curb, traffic calming etc. (as noted above and discussed later in this report). Funding displayed for 2021 is the actual pavement spend given that the construction season is nearly completed.

Table 5. Budget Based Scenario (Base-Level Funding)

Year	Street Recap Funding Proposed	Funds Attributed to Pavement (60%)
2021		$21,905,720*
2022	$32,000,000	$19,200,000
2023	$33,000,000	$19,800,000
2024	$33,000,000	$19,800,000
2025	$33,000,000	$19,800,000
2026	$33,000,000	$19,800,000
2027	$33,000,000	$19,800,000
2028	$33,000,000	$19,800,000
2029	$33,000,000	$19,800,000
2030	$33,000,000	$19,800,000

*Estimated funds spent on Pavement in 2021

The Maintain current PQI scenario was selected considering some municipal agencies as identified in the jurisdictional scans select this as their LOS. From there, it was decided to select plus/minus three as a sensitivity analysis to determine the impacts of raising and lowering the network average. As opposed to the sensitivity analysis performed for the PQI triggers where plus/minus five was selected, plus/minus three

was selected for reviewing impacts to the overall network average. In the case of the network average, a three percent change in condition can significantly impact funding requirements and seemed reasonable as a starting point for the sensitivity analysis.

The Maintain % Good scenarios were established based on the jurisdictional reviews. Some agencies strive to maintain two thirds or 67% of their network in good condition. Therefore 67% was selected as a starting point and plus/minus three was selected for sensitivity analysis. For the % Poor scenarios, the intent was to determine the effect of maintaining minimal backlog throughout the network. It is important to note that maintaining a percentage of the network in good condition does not control the LOS percentage for the other two condition categories (i.e., fair and poor), and similarly maintaining a percentage of the network in poor condition does not control the fair and good categories.

Table 6 and Figure 7 summarize the results of all 10 budget scenarios. As mentioned above, note the following for comparison purposes:

- Network average PQI in 2020 was 69.1.
- Needs backlog in 2020 was estimated at 15.1% of the network lane-kilometers (i.e., the PQI of approximately 588 lane-kilometers (15.1% of 3897) of street were below the PQI triggers).
- 61% of the network was in good condition in 2020 (70% in 2016).

Table 6. LOS Scenarios Results Comparisons

Budget Scenario	Average Annual Budget Needs ($M)*	Year-1 Needs ($M)*	Needs Backlog at Year 10 (% Lane-Kms)	PQI at Year 10	Average % Good	% Good at Year 10
Base Level Funding	20	22	40	56.0	-	-
Maintain Current PQI	42	61	16	69.1	-	-
Maintain Current PQI Minus 3	36	-**	22	66.1	-	-
Maintain Current PQI Plus 3	48	103	11	72.1	-	-
67% Good	38	69	15	67.5	67	65.4
64% Good	36	51	18	66.6	64	62.7
70% Good	41	90	13	68.7	70	67.4
5% Poor	45	114	5	71.4	65	66.9
10% Poor	39	57	10	69.1	60	62.9
15% Poor	34	20	15	66.7	55	58.4

*Funds are for Pavement M&R only
**Year-1 funds not required as PQI below actual value

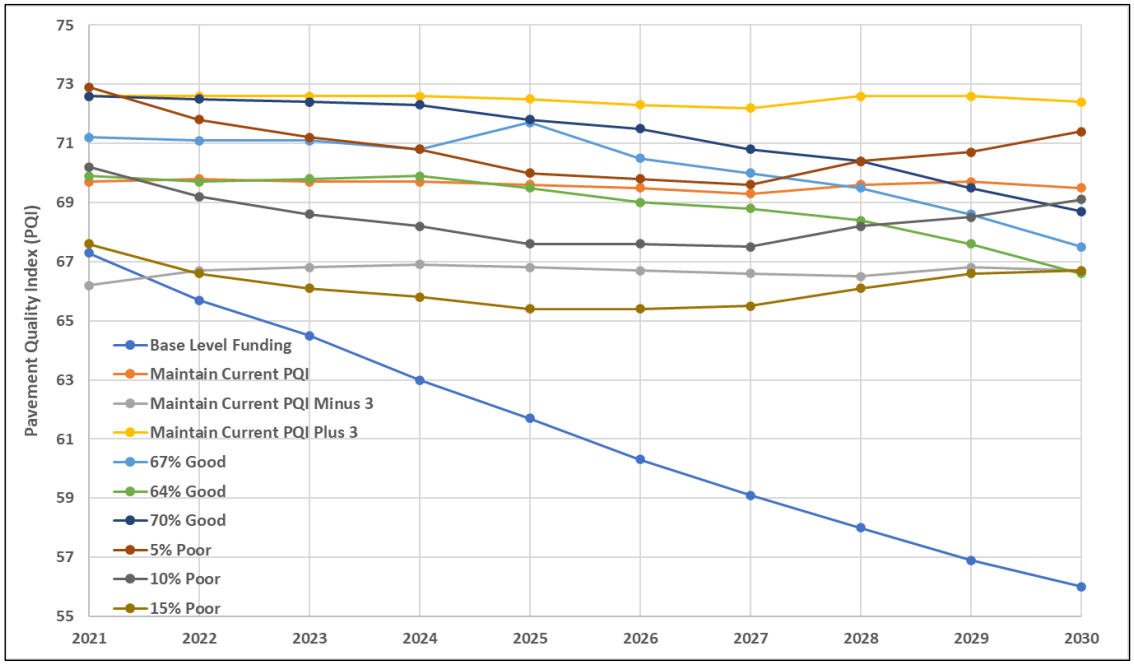

Figure 7. LOS Scenarios PQI Summary Comparisons

As shown in the results comparisons, the base level funding scenario results in a significant decline to the network average PQI (69.1 in 2020 to 56 in 2030) and significant increase to the needs backlog (15.1% in 2020 to 40% in 2030) over the 10-year analysis period. As a result, HRM staff would not recommend the current baseline funding scenario.

Two of the proposed LOS scenarios that maintain or reduce the needs backlog, maintain the network average PQI near the 2020 level, maintain a larger percentage of the network in good condition, and have both Year-1 and average funding needs that appear reasonable include:

- Maintain current network average PQI (69.1).
- Maintain 67% of the network in good condition.

As mentioned earlier, these LOS scenarios align with LOS used by other jurisdictions. However, selecting an LOS based on performance of the various functional classes (e.g., % Good or % Poor) allows for maintaining differing conditions for the various functional classes. As a result, streets such as arterials with higher traffic volumes can be maintained at a higher threshold than lower volume locals. A budget scenario based on maintaining a network average PQI does not allow for the differentiation by functional class.

Based on Stantec's observations and discussions with HRM staff, they provided the following key recommendations regarding LOS:

- Reduce the PQI Triggers as outlined in Table 2.
- Use 67% Good as an annual LOS target for M&R analysis.
- Invest a minimum of $40M annually on pavement rehabilitation as soon as feasible.
- Detailed constrained funding and cash flow analysis should be performed in the future to practically align the new LOS target against HRM budget, resources, and other organizational constraints, and recommend changes to existing business processes and recommend new business processes.

- Long term investment planning effects of different funding constraints needs to be analyzed using a 25-year analysis period.

HRM Staff LOS Recommendation and Proposed Funding Scenario

HRM staff agree with Stantec's recommendation that maintaining 67% Good as an annual LOS target for M&R analysis will help stabilize the network long term.

However, due to the historical backlog, the resulting Year-1 needs for all LOS scenarios including 67% Good, are significantly higher than the actual HRM budget spending for pavements in 2021 and the proposed spending for 2022. It is also important to note that the proposed Year-1 needs are significantly more than what HRM staff could currently design, tender and manage in a given year, and that the construction industry would likely be required to prepare in advance to construct such a program. HRM would have to increase staffing resources to plan, design and deliver such a large program. The construction industry would also likely have to increase resources or would be required to prepare in advance. In addition, with many other budget pressures, HRM Finance will require time to potentially align available funding to the proposed LOS need.

As a result, HRM staff performed a second Budget Based Scenario with the actual 2021 budget spend on pavement, proposed 2022 Workplan, and future budgets that allow both HRM and the construction industry to gradually increase resources, plan funding strategies, and over the course of the 10-year period aligns with the recommended LOS. In accordance with the other scenarios described previously, the funding requirements proposed below are for Pavement M&R only, and do not include inflation. They are based on present day costs. The funding scenario is displayed in Table 7 with results provided in Table 8 and Figure 8. Figure 8 also includes the measured values for 2016, 2018 and 2020 for comparison with the predicted outer year values. Note that the results for the funding scenario are also based on the condition categories described in Table 4.

Table 7. Proposed Budget Based Scenario

Year	Funds Attributed to Pavement M&R
2021	$21,905,720*
2022	$22,770,000**
2023	$35,000,000
2024	$40,000,000
2025	$45,000,000
2026	$45,000,000
2027	$45,000,000
2028	$50,000,000
2029	$50,000,000
2030	$55,000,000

*Estimated funds spent on Pavement in 2021
**Estimated funds to be spent on Pavement in 2022 based on current workplan

Table 8. Recommended Proposed Funding Scenario Performance Results

Budget Scenario	Average Annual Budget Needs ($M)*	Year-1 Needs ($M)*	Needs Backlog at Year 10 (% Lane-Kms)	PQI at Year 10	Average % Good	% Good at Year 10
Recommended Funding	41	22 (Current)	15.4	69.9	56.9	66.9

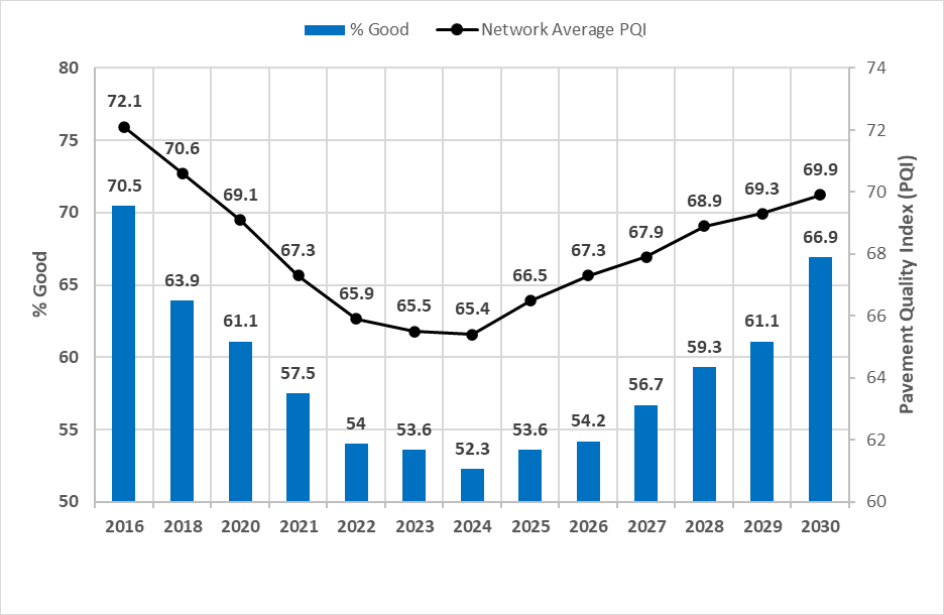

Figure 8. % Good and PQI Trend for Proposed Funding Scenario
Based on this scenario, due to the historical backlog and under funding in 2021 and 2022, the PQI continues to decrease, and backlog increases in the short term, however as funding ramps up in future years, the PQI returns to 2020 levels and the backlog also decreases to 2020 levels by 2030.

Therefore, HRM staff recommend the selection of maintain a minimum of 67% of the network in good condition with PQI for each functional class greater or equal to the number shown in Table 4 for the Good category as an LOS, with understanding that due to historical backlog, this may not be achieved until 2030. At that time, HRM may wish to alter the LOS. In the interim, the pavement funding scenario outlined in Table 7 will potentially achieve the LOS by 2030. It is important to note that due to the continued short-term decline in network condition, the need for operational reactive maintenance may also increase in the short term.

Historically, HRM's pavement management strategy included trying to prevent good and fair streets from declining into the poor category, while also selecting poor streets (blended strategy), especially as part of integration projects with partners such as Halifax Water. In line with the new proposed LOS (67% Good), it is likely that the focus will be on improving the number of good streets in the network. Therefore, similar to historical practice, project selection may include addressing more fair and good streets and maintaining them or bringing them into the good category using lower cost rehabilitation treatments, while reconstructing some poor streets, particularly where there is an opportunity for integration. For example, there are roads in poor condition that may require reconstruction, however, in the interim, they will continue to deteriorate and be maintained through reactive activities such as critical interim repairs, localized pothole filling, crack sealing and patching.

As discussed above, the optimization analysis conducted using HPMA develops a cost-effective rehabilitation program, however it does not have the ability to assess intangible factors such as disruption/congestion, integration opportunities/conflicts, flooding/icing problems, potential complete streets impacts or as mentioned in the Background, funding allocation based on District backlog. In terms of rehabilitation program selection, given that engineering judgement is still considered one of the most used optimization techniques, HRM staff believe that utilizing HPMA as a tool to establish a baseline optimized program, followed by the implementation of engineering judgement to refine the program based on additional factors is the best approach. It will allow for HRM staff to integrate with both internal and external stakeholders which produces many intangible benefits and can result in multi-asset optimization. HRM staff are planning to work with Stantec on developing a manual intervention module in HPMA to incorporate ground truth and engineering judgement to the HPMA recommended capital program to align and coordinate it with multi-asset multi-year capital programs. As part of this work, HRM staff are also looking to conduct a comprehensive budget and performance LOS analysis for comparing the impacts of program selection including intangible factors versus not including them. This analysis will be completed over the next two years.

In regard to District allocation, HRM staff conducted an M&R analysis where they utilized proposed District allocated funds, set budget constraints for each district, and ran optimization scenarios for each district individually. The results from each District were then summed to determine percent good and percent poor for the overall network. These results were then compared to the analysis conducted for the budget-based scenario described above, where the optimization analysis was conducted by allocating funds on the overall network and not by individual District. The results provided in Figure 9 indicate that optimizing by District with allocated funds provides similar results to optimizing the entire network when comparing %Good and %Poor for years 2021 and 2022. The District allocated analysis results in slightly lower %Good, but also slightly lower %Poor.

Therefore, staff recommend Council approve the use of District allocation based on District backlog as part of the rehabilitation program selection procedure at this time. As additional data is collected, staff will monitor measured versus predicted performance, conduct further analysis on the use of manual intervention and reassess optimization techniques over the next two years.

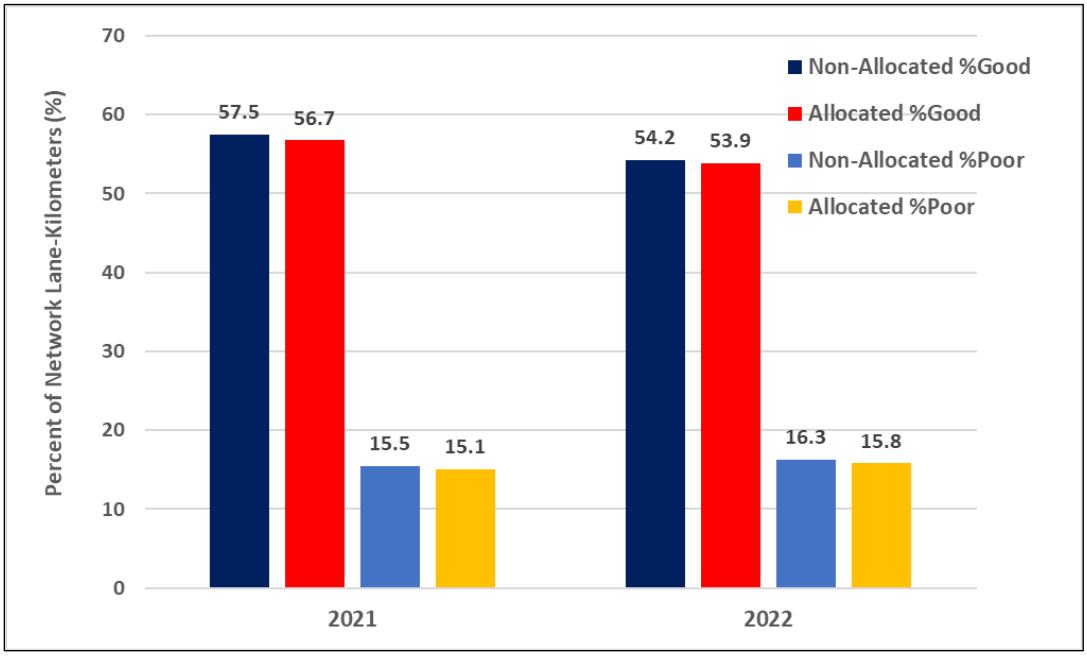

Figure 9. %Good / %Poor Comparison for Full Network vs Individual District Optimization

Additional Funding Impacts on the Street Recapitalization Account

The Street Recapitalization Account is the account that funds HRM capital street rehabilitation projects. In addition to street rehabilitation, the account also funds complete streets elements such as curb, integrated traffic calming measures (bump outs or speed humps/tables), sidewalk spot repairs, pedestrian ramps, tactile plates, landscaping elements, etc. The account also funds preventative maintenance initiatives such as crack sealing and street planer patching along with items such as staff resources tied to capital, studies, designs, investigations, surveys, and pavement condition data collection.

HRM staff reviewed the Street Recapitalization Account in detail for 2014/2015 (pre-IMP) and for 2019/2020 (post-IMP), and calculated the percentage of funds not attributed directly to pavement rehabilitation activities. The average percentage from 2014/2015 was determined to be approximately 32% and increased to an average of 41% for 2019/2020. Based on initial review of the 2022 proposed Capital Program, this value may increase to 44%.

As described above, the analyses performed using HPMA are based solely on associated pavement needs, and do not include any additional assets or items described above. The associated costs in HPMA are for pavement maintenance and rehabilitation (M&R) only. Pavement M&R treatments currently utilized in HPMA include surface treatments (e.g., microsurfacing, thin overlay), overlay, mill and overlay, partial depth recycling, full depth recycling and partial/full depth reconstruction. Crack sealing and street planer patching are critical preventative maintenance initiatives but are currently not included in the HPMA decision trees; however, all deterioration models within HPMA have been refined using street condition data where these activities have generally occurred. Note that operational maintenance requirements such as reactive pothole repair and surface patching are not funded by the Street Recapitalization Account.

The HPMA analyses and network funding requirements reviewed above are therefore based solely on pavement M&R costs for treatments incorporated in the decision trees and do not reflect all other items currently covered by the Street Recapitalization Account.

One of the measures that can be implemented to help maintain pavement condition but reduce potential Street Recapitalization costs is to implement more surface treatments and light rehabilitation activities without adding all complete streets elements (holding strategy). For example, in certain instances, a street may receive a microsurfacing or mill and overlay, but no curb renewal if flooding is not a concern. The curb renewal would be implemented at a later date when the pavement is receiving a more intrusive rehabilitation strategy (e.g., partial reconstruction). As a result, more lane kilometers of pavement can be rehabilitated at a lower cost. Based on this, the intent would be to perform more surface treatments and light rehabilitations without renewing adjacent assets in certain cases, which could potentially reduce the impact from the 41% or more currently observed. As part of the engineering judgement optimization and work with stakeholders, the decision to hold on rehabilitating or adding additional assets will continue to be discussed as part of the overall integration process with the Integration Committee. If additional assets are considered a priority, they will be added to the program even when the paving strategy is minimal. However, if the complete streets elements are not necessarily a priority, or require multiple years of planning, they will be added in a future year when the paving strategy is more intrusive. Like this, the costs of rehabilitating or adding adjacent assets can be distributed over many years, while pavement condition can potentially be stabilized.

For financial planning purposes, Table 9 and 10 below outline the potential Street Recapitalization Account Funding required based on the recommended LOS funding scenario for pavement rehabilitation and impacts due to the additional items outlined above. For years 2021 and 2022, the funds are based on estimated pavement spend for actual projects. For years 2023 to 2030, Table 9 utilizes an impact of 41% while Table 10 displays the impacts for 30% spending on additional assets. 30% was selected as this aligns closely to historical impacts. Like Table 7, these values are based on present day costs. Based on the recommended funding for pavement M&R, the yearly investment in Street Recapitalization can be reduced by $10 to 15 million by reducing impacts of adjacent assets.

Table 9. Potential Street Recapitalization Account Funding Required to Achieve Pavement LOS with 41% Funds Attributed to Other Assets

Year	Funds Attributed to Pavement (59%)	Street Recap Funding Proposed
2021	$21,905,720*	
2022	$22,770,000**	
2023	$35,000,000	$59,322,034
2024	$40,000,000	$67,796,610
2025	$45,000,000	$76,271,186
2026	$45,000,000	$76,271,186
2027	$45,000,000	$76,271,186
2028	$50,000,000	$84,745,763
2029	$50,000,000	$84,745,763
2030	$55,000,000	$93,220,339

*Estimated funds spent on Pavement in 2021
**Estimated funds to be spent on Pavement in 2022 based on current workplan

Table 10. Potential Street Recapitalization Account Funding Required to Achieve Pavement LOS with 30% Funds Attributed to Other Assets

Year	Funds Attributed to Pavement (70%)	Street Recap Funding Proposed
2021	$21,905,720*	
2022	$22,770,000**	
2023	$35,000,000	$50,000,000
2024	$40,000,000	$57,142,857
2025	$45,000,000	$64,285,714
2026	$45,000,000	$64,285,714
2027	$45,000,000	$64,285,714
2028	$50,000,000	$71,428,571
2029	$50,000,000	$71,428,571
2030	$55,000,000	$78,571,429

*Estimated funds spent on Pavement in 2021
**Estimated funds to be spent on Pavement in 2022 based on current workplan

2022 Road Transfer and Development

It is important to note that the analyses completed in 2021 do not include the proposed increase in roadway network size due to the 2022 Road Transfer or new developments. At this time, the roads/streets in HPMA are only considered to be HRM owned. The 2022 high speed pavement condition data collection will include streets transferred as part of the Road Transfer. Once these streets, along with their condition are included in HPMA, further analyses will be required to determine needs for the larger network. Currently, the estimated increase in network size as part of the Road Transfer is eight percent. In addition, HRM typically

accepts 10 to 20 lane-kilometers of new streets on average yearly through development. One key difference between roads obtained through development as opposed to Road Transfer, is that the newly developed streets should be designed to the latest edition of the Municipal Design Guidelines. Therefore, many or all complete streets elements should already be in place. In the case of Road Transfer streets, funds will be required to maintain the pavement, but near-term investments will likely also be required to include some complete streets elements.

Next Steps

HRM staff are continuously working to improve HRM's pavement management processes. Some of the next steps required to continue this improvement and monitor LOS include:

- Develop cash flow analysis to align with the proposed LOS and apply reasonable inflation rates to the various analyses.
- Should Council decide to increase funding allocation for Street Recapitalization, an assessment on staff resourcing will have to be completed with requirements to potentially increase TPW staff for planning, design, and construction.
- Work with industry partners to ensure industry has the capacity to construct more robust capital programs.
- Revisit the analysis once the 2022 Road Transfer is complete and include a 25-year analysis period.
- Continue to work with integration partners both internal and external to find synergies and optimizations with competing programs.
- Look to define LOS targets for other assets such as curb, sidewalk, etc. This will also help establish overall funding requirements for Street Recapitalization.
- Work with industry partners and conduct more research and development to look for innovative methodologies that could help extend pavement life at a minimal cost increase.
- Develop a manual intervention module in HPMA to incorporate ground truth and engineering judgement to the HPMA recommended capital program to align and coordinate it with multi-asset multi-year capital programs and conduct a comprehensive budget and performance LOS analysis for comparing the impacts of program selection.
- Continue to collect pavement condition data and as more data is collected, conduct further refinement of the core data and parameters utilized in HPMA to better refine the analytical capabilities of the software. This will be completed biennially.
- Conduct further budget and performance analyses as parameters are refined, and adjust funding requirements as necessary. This will be completed biennially.
- Where feasible align pavement management planning with climate change mitigation approaches.

FINANCIAL IMPLICATIONS

The financial implications associated with the recommended level of service for maintaining an average of 67% of HRM roads at "good" condition impacts not only the Street Recapitalization capital project account, but also staff compensation for estimated increased program delivery capacity, and a short-term increase likely to be experienced in the road operating repairs and maintenance budget while the network further deteriorates before stabilizing as per Figure 8. An accurate estimate for the required staffing complement increase will be assessed once Regional Council sets the level of service direction and will be incorporated into the 2023/24 operating budget recommendation. The roads state of good repair, which is budgeted at approximately $3M (cost centres R715, R719, R735, R743) in Transportation & Public Works operating budget for 2022/23, will be assessed as part of the annual business planning process as street condition is only one driver.

The recommended level of service to stabilize the road condition and continue to implement complete streets at a slower progress to minimize cost escalation will require an estimated additional $72,428,571 over the next four years, as reflected in the table below.

Street Recapitalization #CR200006	2022/23	2023/24	2024/25	2025/26	Total 4Yr
Current 2022/23 Capital Plan	32,000,000	33,000,000	33,000,000	33,000,000	131,000,000
Proposed Capital Plan (Table 10)	32,000,000	50,000,000	57,142,857	64,285,714	203,428,571
Additional Funding Required	**$ -**	**$ 17,000,000**	**$ 24,142,857**	**$ 31,285,714**	**$ 72,428,571**

The $72.4M increase is not currently funded in the 2022/23 multi-year capital plan which was approved December 17, 2021. The November 28, 2021 Budget Committee Fiscal Framework report indicated that there is $11.5M capital from operating funds presently unallocated to capital projects in anticipation of additional priorities being raised throughout the budget deliberations, including this report. Attributing $9M annually from those funds would cover half of the $72.4M variance required. These funds are contingent on Council approving the recommended 5.9% tax increase.

Possible funding options for the first four years of the ten-year stabilization plan include higher capital from operating, increased federal funding from the Canada Community-Building Fund (previously Gas Tax) or other cost sharing, reprioritizing projects within the capital plan, additional debt funding or additional tax increases in 2023/24 and future years.

It is noted that the projected annual budget required for the Street Recapitalization project account in Table 10 is stated in present-day dollars and therefore does not reflect inflationary increases, which is additionally volatile and unpredictable right now due to the pandemic. There is also risk due to the 2022/23 Road Transfer from the Province since the condition data for these roads was not available for this analysis. These two potentially large factors will be assessed and updated biennially to iteratively reflect the accurate investment required to reach the condition target within the ten-year plan.

RISK CONSIDERATION

Research suggests that poorly maintained pavements can result in:

- Increased operational reactive maintenance requirements (e.g., increased need for pothole repairs).
- Lower customer satisfaction.
- Increased vehicle maintenance costs (frames, suspensions, tires, etc.) of private as well as transit and commercial vehicles.
- Reduced network safety (friction and drainage issues) and reduced accessibility.
- Potential for increased claims and greater liability.
- Potential for health and safety impacts.
- Likelihood that missed opportunities to perform minor maintenance and rehabilitation will result in a greater volume of major rehabilitation needs along with higher cost repairs.
- Likelihood that more intrusive rehabilitation requirements increase road disruption.

As a result, further deterioration of the pavement network could result in risks associated with the items listed above. These risks could be related to service delivery, health and safety, reputation and legal.

Another risk that has been identified is industry capacity. The industry is currently experiencing labor shortages in many jurisdictions nationwide. As a result, even with the ability to gradually ramp up resources, the market may have difficulty delivering such a robust program.

COMMUNITY ENGAGEMENT

No direct community engagement has been completed as part of this report. However, historical along with the latest citizen survey results indicate some dissatisfaction with the current condition of the HRM roadway network.

ENVIRONMENTAL IMPLICATIONS

Research suggests that poorly maintained pavements can result in:

- Environmental impacts such as increased fuel consumption, GHG emissions, and energy use.
- Increased noise which impacts short term welfare (e.g., sleep disturbance) and may also have long term health consequences (e.g., cardiovascular diseases).
- Increased resource consumption (construction materials); associated increased quarrying.

ALTERNATIVES

Regional Council could select one of the other budget and performance LOS scenarios identified in this report as a recommended LOS for the HRM street network or could direct the Chief Administrative Officer to conduct additional analyses and provide further LOS recommendations and funding scenarios, including changes to the proposed condition categories.

In regard to program selection, Council could elect to remove District allocation based on District backlog as a selection criterion. This is not recommended at this time as initial analysis suggests that optimizing by individual district has little influence on performance. Further analyses will be conducted to assess the influence of manual intervention on program selection.
Council could elect that staff include complete streets elements for all streets, no matter what rehabilitation strategy is required. However, this is not recommended as this will likely lead to increased budget pressures and further deterioration of the network condition.

At present, Staff are looking to provide updates to Regional Council biennially (every two years) to align with the current data collection frequency. Council could elect to increase or reduce the frequency of updates. Increasing the frequency is not recommended as it would not provide Staff sufficient time to review collected data and perform the necessary analyses.

ATTACHMENTS

No attachments.

A copy of this report can be obtained online at halifax.ca or by contacting the Office of the Municipal Clerk at 902.490.4210.

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