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Bridge Maintenance Audit

January 30, 2018

The Office of the City Auditor conducted this
project in accordance with the
*International Standards for the
Professional Practice of Internal Auditing*

Bridge Maintenance Audit

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Executive Summary

Maintaining Edmonton’s bridge inventory to acceptable standards is essential for public safety and economic sustainability. City bridges represent a significant financial investment for the City which must be effectively managed to ensure optimal life cycle and value are achieved. The City Operations Department is responsible for ongoing inspection and maintenance of the City’s 305 bridges.

The objective for this audit was to determine if the City’s bridge maintenance program is compliant with existing processes and effectively managed. We also assessed the program governance including ownership and responsibility of City and non-City owned bridges.

Based on our audit findings we have identified four recommendations which include:

1. Development of a process for quality assurance and control to ensure completeness, accuracy, and quality of City’s bridge inspections and maintenance program.
2. Development of a system to ensure that all maintenance deficiencies for City owned bridges are documented and tracked effectively.
3. A review of the governance structure of City’s bridges to address any gaps in responsibilities.
4. A review of the City’s role and liability in regards to non-City owned bridges.

Bridge Maintenance Audit

1 Introduction

Maintaining Edmonton’s bridge inventory to acceptable standards is essential for public safety and economic sustainability. City bridges represent a significant financial investment for the City, which must be effectively managed to ensure optimal life cycle and value are achieved. The Office of the City Auditor (OCA) included a review of the City of Edmonton’s bridge maintenance program in its 2017 Annual Work Plan.

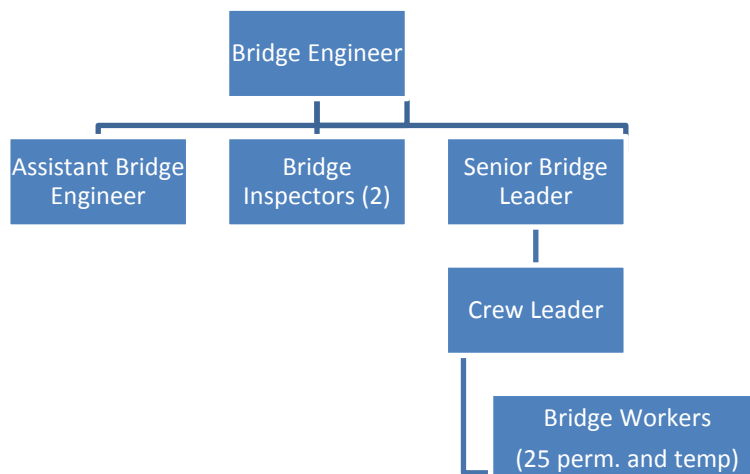
2 Background

2.1 Bridge Responsibilities

2.1.1 Operations

The City Operations Department is responsible for ongoing operations of the City’s bridge inventory. This Bridge Inspection and Maintenance unit is part of the Parks and Roads, Infrastructure Maintenance Section. Figure 1 below illustrates the labour resources dedicated to this business unit, which includes a total of 31 employees.

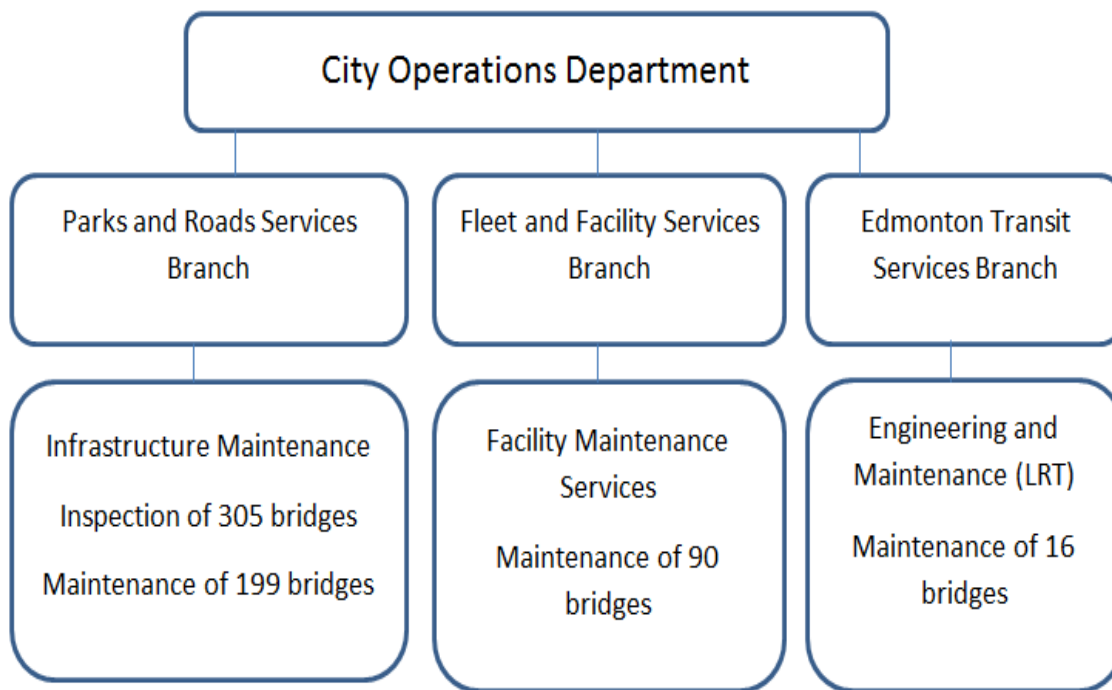
Figure 1 – Bridge Inspection and Maintenance Unit



The Bridge Inspection and Maintenance Unit conducts bridge inspections for all 305 City bridges, and conducts maintenance for 199 bridges under its responsibility.

The ownership of City owned bridges is shared by three different branches within the City Operations Department. Figure 2 below illustrates the functional responsibilities for the inspection and maintenance of the 305 City bridges within City Operations Department.

Figure 2 – Operations of City Owned Bridges



2.2 City Bridge Inventory

The City bridge inventory includes four main types of bridges including pedestrian, vehicle, culverts, and railway. Table 1 on the following page provides a summary of the 305 City owned bridges, with an estimated 2016 replacement cost of \$2.275 billion.

Table 1– City Bridge Inventory

Bridge Owner	Type of Bridge				Total	Estimated Replacement Cost (\$ in Millions)
	Pedestrian	Vehicular	Culverts	Railway		
Parks & Roads	57	93	30	19	199	1,697
Fleet & Facilities	85	3	2	0	90	23
Edmonton Transit Services (LRT)	2	0	0	14	16	555
Total City Bridges	144	96	32	33	305	2,275

2.3 Annual Bridge Expenditures

2.3.1 Annual Operating Costs

The annual operating expenditures for the inspection and maintenance of City bridges is highlighted in Table 2 below. As shown, annual expenditures have increased from \$1.860 million in 2012 to \$2.753 million 2016. Current 2017 expenditures are expected to decline to approximately \$2.304 million.

Table 2 – City Bridge Operating Expenditures (\$-thousands)

Year	2012 (actual)	2013 (actual)	2014 (actual)	2015 (actual)	2016 (actual)	2017 (YTD)
Parks & Roads	\$1,696	\$2,478	\$1,809	\$2,161	\$2,522	\$1,984
Fleet & Facilities	144	179	357	127	218	289
Edmonton Transit Services (est.)	20	24	3	23	13	31
Total	\$1,860	\$2,681	\$2,169	\$2,311	\$2,753	\$2,304

2.3.2 Capital Costs

The annual capital expenditure for refurbishment and replacement of City bridges is highlighted in Table 3 on the following page. Refurbishment expenditures include performing major structural repairs to existing bridge structures in order to extend their useful asset life. A refurbishment example is repairs to 53 Avenue over Whitemud Bridge which occurred from 2016-2017. Replacement expenditures include building new or replacing existing bridges structures. Example of replacement bridges include Walterdale Bridge and 102Avenue Bridge (over Groat Road).

The total planned capital expenditures are based on life cycle needs for the City’s entire bridge inventory and therefore the level of funding will vary from year to year. As shown in Table 3, total annual capital expenditures increased from \$23.9 million in 2012 to \$66.0 million in 2016. Planned capital expenditures from 2017 to 2019 are expected to decline from \$48.6 million down to \$17.5 million.

Table 3 – City Bridge Capital Expenditures (\$-millions)

Year	2012 (actual)	2013 (actual)	2014 (actual)	2015 (actual)	2016 (actual)	2017 (budget)	2018 (budget)	2019 Beyond (budget)
Refurbishment	\$17.5	\$6.6	\$3.2	\$1.6	\$15.4	\$20.8	\$34.7	\$17.5
Replace or New	\$6.4	\$35.9	\$45.7	\$45.4	\$50.6	\$27.8	-	-
Total Capital	\$23.9	\$42.5	\$48.9	\$47.0	\$66.0	\$48.6	\$34.7	\$17.5

3 Audit Objective and Criteria

Our audit objective was to determine if the City’s bridge maintenance program is effectively managed. This audit objective was tested against the following criteria:

1. The inspection and maintenance of bridges is in compliance with defined processes.
2. The bridge inspection and maintenance program is monitored for effectiveness.
3. Governance, including ownership and responsibility of bridges within the City of Edmonton, is clearly defined.

4 Observations and Recommendations

4.1 Inspections

4.1.1 Bridge Inspection Legislation

The ongoing inspection of a bridge is needed to identify any required maintenance work to ensure that the bridge is in safe operating condition. This inspection must be completed by a qualified individual with proper training and experience.

Alberta Transportation maintains a comprehensive bridge inspector certification process that must be successfully completed by a candidate prior to being certified. There are two classes of bridge inspectors, Class A and Class B. Class B is the first level and the requirements include training, certification examination, and supervisory review by a Class A Inspector. Class A or the advanced level inspector requirements include training, certification examination, and a mentorship period with a Class A inspector that has been certified for at least 6 years. Both classes require re-certification through Alberta Transportation every 3 years.

The City's bridge maintenance program includes two Class A certified bridge inspectors. As part of our audit testing, we verified the validity of the certification of the City's two bridge inspectors. We also confirmed that ongoing re-certification requirement (every three years) was in fact occurring.

From 2012 to 2016 the City conducted 718 bridge inspections. We reviewed a representative sample of 250 bridge inspections and confirmed that these inspections were completed by a certified bridge inspector.

4.1.2 Bridge Washing

Bridge washing to vehicular bridges is an important preventative maintenance activity as it helps preserve the condition of the bridge and helps extend the life of the asset. Bridge washing is conducted prior to the official bridge inspections such that maintenance deficiencies can be more easily identified.

We tested 100 scheduled bridge washings between 2012 and 2016 to determine whether they were being washed annually as per schedule. We found that 96 percent (96/100) of bridges were washed in accordance with defined schedules during this five year period. The remaining 4 bridges were not washed due to weather conditions.

Management communicated that bridge washing is conducted annually on all bridges that carry vehicles. The primary purpose of bridge washing is to wash away chloride and salt laden sand, to preserve the condition of the bridge deck and structure.

After bridges are washed, the Crew Leader is responsible for completing a bridge washing report. The report identifies any potential deficiencies associated with the bridge such as the deck, curbs, medians, sidewalk, and drains. This report is forwarded to the Bridge Inspector prior to the official bridge inspection so that the inspector has an understanding of the risk areas before conducting the inspection.

We found that there were a total of 31 missing wash reports for the 100 bridge washings we tested. We confirmed that the City bridges were in fact washed as per schedule, however, management could not locate all completed bridge wash reports (See Recommendation 1).

4.1.3 City Bridge Inspection Program

Although the province mandates certification requirements for bridge inspectors, each municipality is responsible for setting its own standards for inspection, maintenance, and rehabilitation program.

The City's bridge inspectors complete Level 1 visual inspections for all the bridges within the City. Level 1 bridge inspections are conducted to identify visual defects such as deck surface cracks, potholes, concrete cracks, paint condition, drainage issues, and accident damage.

If potential major repairs are identified such as structural issues, then a Level 2 inspection is conducted by external consultants. This Level 2 inspection is conducted to obtain more information prior to initiating rehabilitation or replacement work on a bridge.

The City’s Level 1 bridge inspection standards are shown in Table 4.

Table 4 – Level 1 Bridge Inspection Standards by Bridge Type

Type of Bridge	Minimum Inspection Frequency	Number of City Bridges
River crossing and dangerous good routes	Annually	48
Grade separation, park bridges	3 years	224
Culverts	5 years	33

We reviewed a representative sample of 250 scheduled Level 1 bridge inspections (years 2012-2016) to determine whether bridges were inspected as often as required. We found that 98 percent (246/250) of bridge inspection reports were reviewed in accordance with the City’s inspection standards. The bridge inspection staff indicated that the four incomplete inspections could not be completed because of the bridge physical location.

A review of the bridge inspection report by a supervisor is not provincially legislated, however, it would provide assurance over completeness and quality of inspections. Under the current process, after a bridge inspection report is prepared, the report is to be reviewed and then initialed to confirm review. Management reinforced that bridge inspection report with a significant issue is always reviewed immediately by one of the City bridge supervisors.

In our review we found 53 percent (133/250) of bridge inspection reports were initialed by a supervisor upon the completion of the inspection. Management indicated that many bridge inspection reports in the auditor’s sample were reviewed but may have failed to be initialed. However, without adequate documentation it is not possible to confirm whether inspection reports were in fact reviewed.

Based on these observations regarding the review of bridge inspection reports and missing bridge washing reports, we have provided the following recommendation.

Recommendation 1 – Quality Assurance and Control Process
We recommend that the Director of Infrastructure Maintenance, Parks and Roads Services Branch, develop a process to improve quality assurance and control for the City’s bridge inspections and maintenance program.
Management Response
Accepted Action Plan: Administration will provide a quality assurance and control process for the City’s bridge inspection and maintenance programs which will include: <ol style="list-style-type: none">1. A document management process to ensure all documents and records are kept according to corporate needs.2. A procedure outlining the review process of inspection reports Planned Implementation Date: September 30, 2018 Responsible Party: Director of Infrastructure Maintenance, Parks and Roads Services Branch

4.2 Maintenance

The City of Edmonton Bridge Maintenance program includes activities such as minor maintenance, washing, deck repairs, sealing, joint repairs, and graffiti removal. We reviewed the City Bridge Maintenance program and tested two activities in detail; bridge washing and bridge sealing. Shown on the following page are photos of some Bridge Maintenance activities.

Figure 3 – Bridge Washing



Source: Office of the City Auditor

Figure 4 – Bridge Deck Repairs



Source: Office of the City Auditor

4.2.1 Bridge Deck Sealing

Bridge deck sealing helps extend the life of the bridge and protects the City’s investment. If bridges are not sealed as often as required the deterioration of bridges will accelerate and they will require rehabilitation or replacement sooner than necessary. The bridge deck sealing program is designed to protect the bridge deck from salt, sand, moisture, and other contaminants.

We tested 36 bridges scheduled between 2012 and 2016 to determine whether sealing work is completed in adherence to a three year cycle. We found that 89 percent (32/36) of bridges were sealed in accordance to the schedule.

Management indicated that they evaluate and balance the need to seal a bridge versus the disruption to the City’s traffic system. The four bridges identified by the auditor were not sealed due to traffic concerns based on such an evaluation.

4.2.2 Tracking of maintenance deficiencies

Maintenance deficiencies identified through inspection reports should be addressed in a timely manner and monitored. Maintenance deficiencies identified through the bridge inspection process are to be tracked through Infrastructure Maintenance’s database tracking system.

We tested whether maintenance deficiencies from the 250 bridge inspections (years 2012 and 2016) were being tracked. We found that 78% of the inspections were being tracked through the bridge maintenance database, however, a total of 56 out of 250 (22%) of the bridge inspection reports were missing and not tracked through the Bridge Maintenance database. Many of these missing records occurred during the first years that the Bridge Maintenance database was implemented and the consistency of tracking has improved since then. Hence, this is not considered a systemic problem in the City’s bridge maintenance program.

It should be noted that since bridge inspections are completed on a cyclical basis, a bridge deficiency not addressed through maintenance will be re-documented on the next bridge inspection. However, without proper tracking of maintenance deficiencies there is no assurance that they are addressed in a timely manner. We therefore have recommended the following.

Recommendation 2 – Tracking of Maintenance Deficiencies
We recommend that the Director of Infrastructure Maintenance, Parks and Roads Services Branch develop a system to ensure that all maintenance deficiencies for City owned bridges are documented and tracked effectively.
Management Response
Accepted
Action Plan: Develop a quality assurance and control procedure to ensure that the process of recording recommended bridge repair and maintenance activities tracks all recommendations identified during bridge inspections.

Planned Implementation Date: September 30, 2018

Responsible Party: Director of Infrastructure Maintenance, Parks and Roads Services Branch

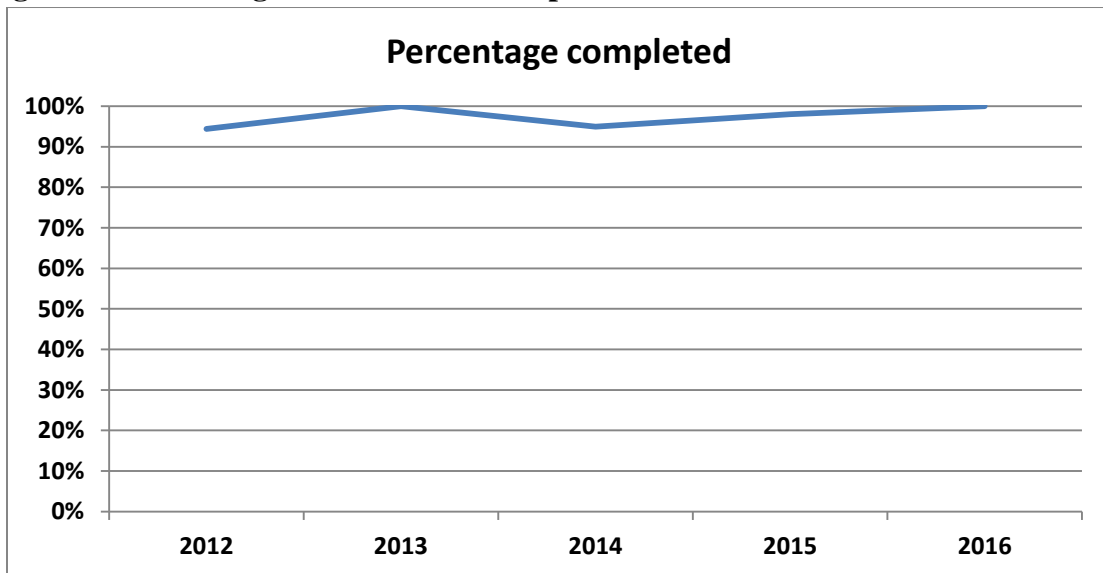
4.3 Performance Monitoring

Performance monitoring of a program is necessary to ensure overall effectiveness and efficiency. We reviewed several performance measures by Infrastructure Maintenance and determined that performance monitoring of City bridges is demonstrated for effectiveness, however, there are opportunities for improvement of efficiency measures.

4.3.1 Percentage of inspections completed

The City tracks the percentage of completed inspections on a weekly basis. This tool is designed to help monitor the performance of the planned bridge inspections. We examined the percentage of completed bridge inspections for each year between 2012 and 2016, with the results shown in Figure 5 below.

Figure 5 – Percentage of Documented Inspections



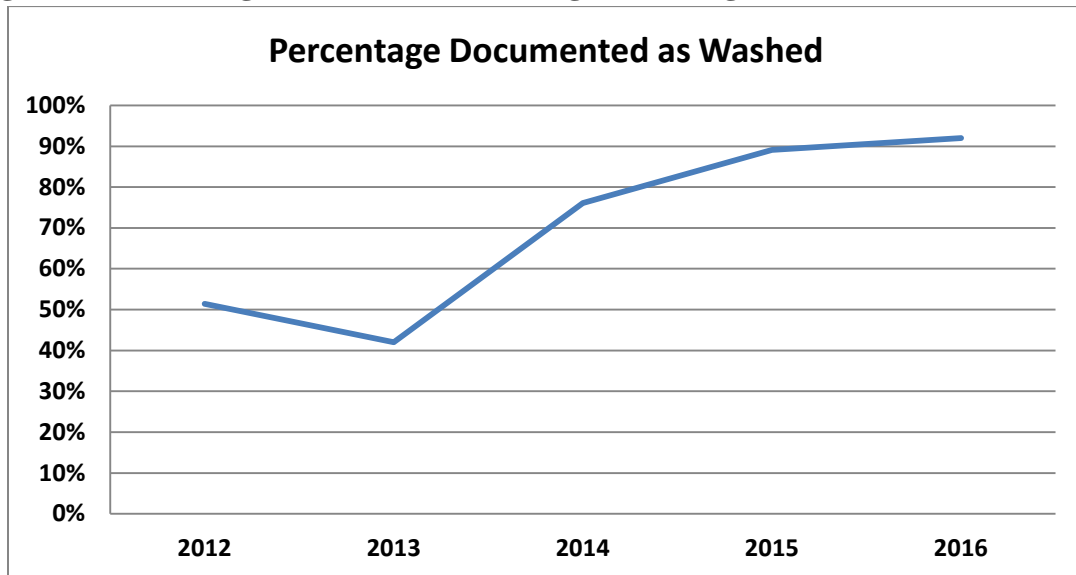
We found that the City completed a minimum 94% of bridge inspections that were scheduled within the last 5 years. In years, where 100% of the bridge inspections were not completed, those inspections were carried over to the following year. City staff

indicated that the reasons for not inspecting certain bridges were due to weather constraints and limited allocated resources.

4.3.2 Percentage of Bridges Washed

The City also uses the percentage of bridges washed as a performance measure. This is tracked on a weekly basis during the spring and summer months when bridge washing is conducted. We examined the percentage of completed bridge washings for each year between 2012 and 2016, with results shown in Figure 6 below.

Figure 6 – Percentages of Documented Bridges Washings



From 2012 to 2016, we found that the City has significantly improved the performance and documentation of bridge washing. Since 2012, the City along with other municipalities has recognized the importance of bridge washing programs in order to increase the life cycle of bridges and added resources towards this activity.

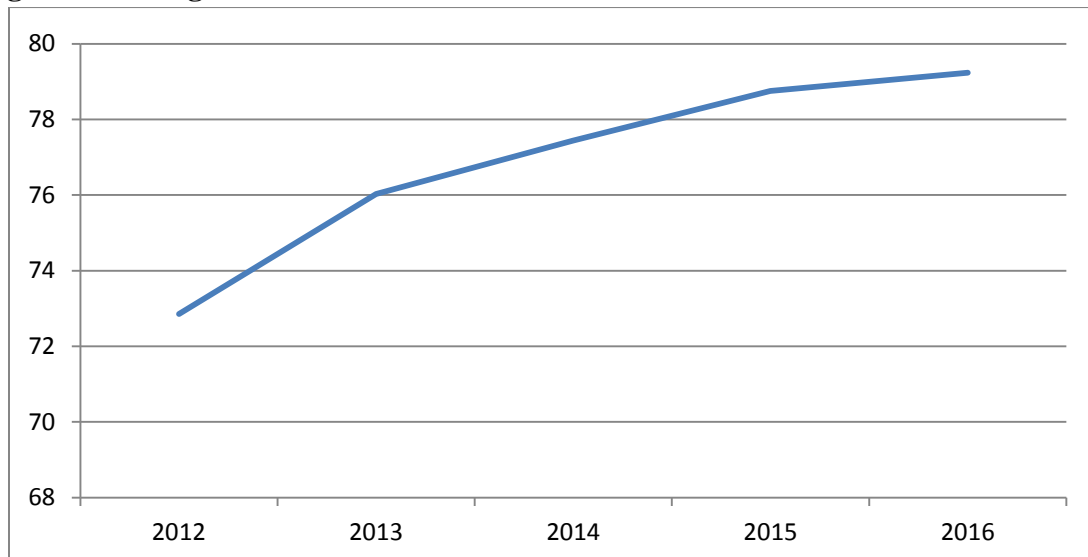
4.3.3 Bridge Condition Index (BCI)

Parks and Roads Services Branch use a Bridge Condition Index (BCI) to determine the overall condition of the bridges that are owned by the City. During an inspection assessment information is collected on bridge components to generate a bridge condition index. This BCI helps the City to understand the condition of the bridge inventory and is

one of the methods used to determine what structures need repairs, maintenance or replacement. Through discussion with management they have communicated that a BCI of 70 means that the bridge is in sufficient (good) condition.

Figure 7 below illustrates the average BCI of bridges currently in the City’s electronic bridge management system.

Figure 7 – Bridge Condition Index



There are currently 111 out of 305 City bridges included in this index. The 111 bridges included in the index are the City’s larger bridges so the presented BCI is representative of the City’s bridge inventory. Each year the City continues to evaluate more bridges and add more bridges the City’s BCI index. As shown, the City’s average BCI for these bridges has increased from 73 in 2012 to 79 in 2016 which corresponds to the City significant capital investment from 2012 to 2017.

We are satisfied that the program area demonstrates effective use of resources through performance monitoring. We also observed that there are no performance measures to demonstrate program efficiency. Management indicated that this is an industry challenge, however, they are continuing to explore opportunities to identify potential efficiency measures.

4.4 Governance

We found that there are gaps associated with the governance of City-owned bridges and issues relating to the City’s inspection role of non-City bridges.

4.4.1 City-Owned Bridges

As shown in Table 5 below, ownership and maintenance responsibility for all 305 City-owned bridges exist with the City Operations Department. Both Fleet and Facilities and Edmonton Transit Services branches rely on the resources within the Parks and Roads to conduct Level 1 bridge inspections. However, each Branch is responsible to conduct their own Level 2 inspections (due to potential serious structural issues) and also to review all inspection reports.

Table 5 – Bridge Responsibilities Chart

Responsibility	City Operations Department		
	Parks & Roads Branch	Fleet and Facilities Branch	Edmonton Transit Services (LRT) Branch
Level 1 inspections	✓	Conducted by Parks and Roads	Conducted by Parks and Roads
Level 2 inspections	✓	✓	✓
Review inspection reports	✓	✓	✓
Perform maintenance	✓	✓	Conducted by Fleet and Facilities
Tracking of maintenance	✓	✓	Conducted by Fleet and Facilities
Capital planning in coordination with Life Cycle Management, Integrated Infrastructure Services Dept.	✓	✓	✓
Performance reporting	✓	X	X

X – Not being completed

Each City Branch is also responsible for performing their own bridge maintenance activities. Parks and Roads and Fleet and Facilities branches complete their own maintenance. Edmonton Transit Services contracts with Fleet and Facilities to complete and track all maintenance deficiencies for LRT bridges.

On an annual basis, Park and Roads and Fleets and Facilities meet to communicate the status of maintenance deficiencies. Communicating when maintenance is completed is important as it helps provide a better understanding of the condition of bridges within the City.

We confirmed that each City Branch is individually coordinating their own capital planning efforts for bridge refurbishment and replacement. We observed that performance monitoring is being conducted by Parks and Roads for its bridges. However, performance monitoring is not occurring for the other City bridges in Fleet and Facilities and Edmonton Transit Services.

Based on these observations we have provided the following recommendation.

Recommendation 3 – Governance of City Bridges
We recommend that the Deputy City Manager, City Operations Department review the governance structure of City bridges to address the identified gaps in responsibilities.
Management Response
<p>Accepted</p> <p>Action Plan:</p> <p>The DCM, City Operations will review and revise the departmental governance structure of City bridges to clarify and simplify both responsibility and accountability.</p> <p>Planned Implementation Date: September 30, 2018</p> <p>Responsible Party: Deputy City Manager, City Operations Department</p>

4.4.2 Non-City Bridges

As shown in Table 6, there are 73 bridges owned by private corporations, which the City has identified as part of their inventory.

Table 6 – Non-City Owned Bridges Inspected by City

Bridge Owner	Type of Bridge				Total
	Pedestrian	Vehicular	Culverts	Railway	
EPCOR (Drainage)	1	0	6	0	7
Railway Companies	0	0	0	23	23
Developers	41	2	0	0	43
Total	42	2	6	23	73

The City conducts Level 1 bridge inspections at no cost to privately owned bridges within the City. These services are conducted to ensure safety of bridges used by Edmontonians. Following the City inspections, EPCOR and Developers are provided the inspection reports which detail any maintenance deficiencies. Bridge inspections conducted by the City on Railways bridges are not forwarded but retained for City use. The estimated annual costs to the City of providing inspections services for privately owned bridges are \$22,000.

We also confirmed that there is no follow-up communications between these private companies and the City confirming completion of maintenance deficiencies identified through City bridge inspections.

We contacted the City of Calgary staff to determine if they are also conducting bridge inspections for non-city bridges. The staff indicated that similar to Edmonton they also conduct bridge inspections for non-city bridges including Railway and Developers. However, inspections are completed only for developers bridges that are under a service agreement and will ultimately become the ownership of the city. In contrast, the City of Edmonton is conducting inspections on Developer bridges that will not become the property of the city. Based on these observations, potential liabilities may exist and therefore recommend the following:

Recommendation 4 – Non-City Owned Bridges
<p>We recommend that the Deputy City Manager, City Operations Department in consultation with the City Law Branch review the City’s current role of conducting Level 1 inspections for privately owned bridges to address any potential liability.</p>
Management Response
<p>Accepted</p> <p>Action Plan:</p> <p>The DCM, City Operations will consult with the Law Branch to review the City’s current role of conducting Level 1 inspections of non-City owned bridges in order to address any potential liability.</p> <p>Planned Implementation Date: September 30, 2018</p> <p>Responsible Party: Deputy City Manager, City Operations Department</p>

5 Conclusions

Based on our review, we conclude that the City is managing an effective bridge and inspection program. However, we have made four recommendations to improve program effectiveness and governance.

We tested and confirmed that scheduled bridge inspections were conducted as often as required. We confirmed that bridge washing of City bridges was conducted in accordance with schedules, however, we observed that not all bridge washing reports were available. We also observed not all bridge inspection reports were documented as being reviewed. We have recommended the City develop a process to improve quality assurance and control for the City's bridge inspections and maintenance program.

We also observed that some maintenance deficiencies related to City bridges were missing and not being tracked. We have recommended that the City develop a system to ensure all maintenance deficiencies are tracked and addressed.

We reviewed that the City has performance measures such as percentage of inspections and maintenance completed and bridge condition index that demonstrate program effectiveness.

We observed that there are gaps within the governance of City-owned bridges. We have recommended that City Operations Department review the current governance structure and address identified gaps in responsibilities for City bridges.

We also observed that potential liability may exist given that the City is currently conducting inspections on non-City owned bridges. We have recommended that the City Operations Department review this practice in collaboration with the City Law Branch.

The Office of the City Auditor would like to thank the management and staff of the City Operations Department for their cooperation and assistance during this audit.

6 Appendix: Scope and Methodology

Scope

The audit reviewed the current City of Edmonton guidance and processes to address bridge maintenance. Our detailed testing included records over the past five years which aligns to the City's inspection process associated with bridges. Our primary contact was City Operations. We also contacted other business areas responsible for the management of bridges. This audit did not review the installation of new bridges or the rehabilitation of bridges.

Methodology

In order to achieve our audit objectives, we performed the following:

- Reviewed BIM Certification Process administered by Alberta Transportation
- Verified that the City's Bridge Inspectors are certified
- Performed walkthroughs on inspection and maintenance activities
- Interviewed staff responsible for inspection, maintenance, lifecycle management, monitoring, and reporting of bridges
- Reviewed the City's existing bridge inspection and maintenance processes
- Identified bridge inspection and maintenance standards determined by the City
- Evaluated the City's compliance to inspection and preventative maintenance standards
- Reviewed program objectives
- Identified and assessed performance measures
- Conducted an analysis to determine if there were any gaps in responsibilities within the management of City bridges
- Reviewed the City's Lifecycle Management processes associated with bridges
- Worked with Lifecycle Management to conduct a scenario analysis for the capital investment towards bridges