City of Kitchener
Asset Management Plan
Engineering (Bridge and Culvert) Structures
2017
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1. Acknowledgements & Assumptions

This asset management plan for Engineering (Bridges & Culverts) Structures has been based on the template set by the City of Kitchener Parks and Open Spaces Asset Management Plan 2016. However due to the maturity of structural condition data collection through the City of Kitchener complying with Reg. 104/97 Public Transportation and Highway Improvement Act, which stipulates that

“the structural integrity, safety and condition of every bridge shall be determined through the performance of at least one inspection in every second calendar year under the direction of a professional engineer and in accordance with the Ontario Structure Inspection Manual. O. Reg. 472/10, s. 2.”

And inspecting the condition of structures using;

a) “the Canadian Highway Bridge Design Code” CAN/CSA-S6-14 ,
b) “the Ontario Structure Inspection Manual (OSIM)”, published by the Ministry and dated October 2000 (revised November 2003 and April 2008), and
c) using a professional engineer to verify the inspections

Then the asset management condition data used in this report is well defined, standardized with other structural data used in other Ontario Municipalities.

Asset valuation is also standardized as well as techniques for restoration/rehabilitation of condition states for structures, evaluation of effectiveness of rehabilitation and prolonging of service life, as the rehabilitation of a structure’s design, evaluation, construction or rehabilitation shall conform to,

(a) the standards set out in the Canadian Highway Bridge Design Code; and
(b) the most current accepted engineering standards, guidelines, procedures and practices. O. Reg. 472/10, s. 2.

Consequently, in this asset management plan we have been able to access many years of data, establish asset valuation techniques, establish measures of assessing asset deficiencies, service life, industry wide accepted restoration/rehabilitation techniques, and standard cost estimating techniques and industry accepted resources for data.

This results in the asset management plan for Engineering Structures being more advanced than the preceding Parks and Open Spaces Asset Management Plan 2016.
2. Executive Summary

The need for mobility requires that Kitchener’s roadway system be kept in good condition. Structures are a vital part of this system. The efficiency of the system is impaired and the public inconvenienced if a structure fails or its load-carrying capacity is reduced for any reason. To avoid such failings, an effective structure management system is required.

An essential component of a structure management system involves the systematic inspection, appropriate record keeping, rational decision making as to rehabilitation methodologies, the prioritization of competing needs and the eventual replacement of structures on the roadway network. The City has chosen to split ownership of structures between Engineering and Operation Divisions. This Asset management plan has a brief discussion on all structural assets but focuses upon the Engineering Division structures only.

In 2012, the Ministry of Infrastructure released their 10-year infrastructure plan “Building Together: Guide for Municipal Asset Management Plans”. In response to the Ministry’s document, and with a sincere desire to remain progressive and responsible asset owners, The City of Kitchener has produced this asset management plan for the City’s Engineering Structures which will be one of 12 City asset categories. This version of the asset management plan will serve as;

a) A means to predict future capital construction/maintenance cost, and costs related to engineering studies
b) A prioritization tool to optimize and reduce capital spending by maximizing residual life expectancy of structures
c) A tool to track emergent common asset defects, coping strategies, and replacement programs within certain types of structures (e.g. corrosion of spring lines in CSP culverts)

Ensuring that current asset inventories, data management and business processes align with the City’s corporate asset management strategy’s two guiding principles;

1. Balancing asset condition and level of service.
2. Allocate financial resources among priorities.

The Engineering Division is the asset owner responsible for the installation, disposal, operation, and maintenance of structural assets located within public Right of Way, excluding public parks, trails and open space assets. These assets include, but are not limited to bridges, culverts, retaining walls, head walls, wing walls, fences, electrical lighting, utility supports, sidewalks, and hand rails in close proximity to bridges and culverts. For the purposes of this plan, the existing asset inventory has been categorized into 5 asset groups:
Multi Modal (Roads, Pedestrians, Bicycles) Bridges
Concrete Culverts
Corrugated Steel Pipes (CSPs)
Pedestrian/ Bicycle Bridges
Railway Over/Underpasses

All railway over/underpasses tracked in the current structure asset database may not be solely owned by the City of Kitchener, with each individual site subject to conditions set in the grade separation agreement/Board Order signed at the time of construction. Ownership and responsibility for funding maintenance may be shared or directed to the Railway stakeholder. However, the impacts of these sites being in poor condition are far reaching and the City is well advised to track them for spalling concrete that may fall upon trail users, automobiles and/or pedestrians as a means of mitigating liability.

This document has reviewed the current practices for data collection of asset condition, life expectancy and project funding.

Our analysis includes a description of these asset inventories, defined service levels, service oriented and betterment expenditures, projected capital costs, on-going maintenance needs, and recommended future engineering studies.

Figures 7.3.2-3 to 7.3.2-7 show the “smoothed costs”, or the average cost per year over the charts’ 80 year assessment, and the related funding shortfalls or surpluses. The dollar amounts shown are in 2017 Canadian Dollars. It is assumed that no cost is accrued by the City of Kitchener for Railway Structure assets as they are owned by others and governed by individual board order agreements. Our estimation of an average capital expenditure expected for the 65 Engineering Structures is based on the addition of the four asset categories and is $2.6 m/year prorated 3% per annum for construction price index. Intuitively, the City of Kitchener should be prepared to replace or perform a major rehabilitation once every approximately 1.25 years.

With the province of Ontario moving towards standardization and consistency in municipal asset management, the first step is the requirement that any municipality seeking provincial capital funding prepares a detailed asset management plan and shows how its proposed project fits within this plan. As part of this process, municipalities will need to demonstrate how they themselves are assisting financially with the proposed project, including engaging with Infrastructure Ontario.

Future versions of this document will build on this plan and will provide a more comprehensive predictive capital cost over the specified time horizon. This will align with Bill 73 requirements to have an Asset Management Plan and to refer to this plan during the production of the Development Charge Background Study and subsequent by-law O.Reg. 82/97 as noted by the following:

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(2) The development charge background study shall include,
(c.2) an asset management plan prepared in accordance with subsection (3);

(3) The asset management plan shall,

(a) deal with all assets whose capital costs are proposed to be funded under the
development charge by-law;

(b) demonstrate that all the assets mentioned in clause (a) are financially
sustainable over their full life cycle;

(c) contain any other information that is prescribed; and

(d) be prepared in the prescribed manner. 2015, c. 26, s. 5 (2)
3. Introduction

3.1 Content

This Asset Management Plan (AMP) addresses the City of Kitchener’s Engineering Structure assets and conforms to the standards outlined in the Ministry of Infrastructure’s “Guide for Municipal Asset Management Plans”. For the purpose of analysis the asset types have been pooled into 5 asset groups. These groupings are based on how capital and operational budgets are presented, the work activities performed, and the type of services provided by each asset type. The asset groups covered by this plan are:

![Engineering Structures Diagram](image)

Figure 3.1-1 – Engineering Structural Assets Groups

This AMP looks at the estimated asset replacement costs in 2017 Canadian Dollars using the Ontario Ministry of Transportation 2017 algorithmic approach for bridge replacements/rehabilitations to produce a realistic capital need cash flow. The total replacement is estimated to be $118 million dollars for 65 City of Kitchener Engineering-owned sites and 10 additional railway-owned sites.

A follow-on version of this plan may discretize the assets further to differentiate between concrete and steel beam materials used for bridges and round versus multi-plate Corrugated Steel pipe (CSP) culverts.

Figure 3.1-2 provides a summary of the estimated replacement costs of Engineering Structures (excluding land value, engineering, utilities and environmental mitigation measures).
Typically recommended funding for a structural inventory would include sufficient capital expenditures to allow for full replacement of infrastructure as it ends its design life expectancy. A rule of thumb usually estimates that 1.5-2.0% of the value of the structural inventory be expended annually to ensure that the structure inventory can be maintained in perpetuity. With an asset value of $118m the City of Kitchener Engineering Division should be spending on average $1.77-2.36m per year.

### 3.2 Purpose of This Asset Management Plan

Engineering Structure assets are the most visible and utilized assets the City owns as they carry roads, sidewalks, and multi-use pathways over, under and around natural and man-made obstacles such as streams, rail lines, and other roads. The fast and efficient movement of goods and people is a key element directly impacting the way a municipality is shaped, the health and welfare of its citizens, general well-being of its economy, and vibrancy of its downtown area. This Asset Management Plan was created to help the City of Kitchener incorporate asset management principles in its efforts to meet corporate goals and the agreed-to levels of services its customers expect, and aid in the development of long term sustainable funding strategies that will address the needs of its aging infrastructure. These corporate goals have been documented in the City of Kitchener’s Growth Management Strategy and the Transportation Master Plan. By understanding the costs associated with providing existing levels of service and forecasting the renewal, replacement and future development of structural infrastructure, the City of Kitchener will become a more efficient and effective service provider and asset owner.
“Kitchener is challenged with meeting the demands of growth while also addressing infrastructure deficits with limited resources.”

The City of Kitchener’s population is predicted to grow from 244,030 to 304,655 residents, a growth rate of approximately 25%, over the next 15 years (source: Region of Waterloo, 2008). The City must develop and apply asset management principles to grow and maintain their structural infrastructure responsibly while providing a level of service that is agreed upon by council and accepted by the public.

![Figure 3.2-1 – Historic and Projected Population Growth of Kitchener](image)

There has been a number of site specific and general transportation network planning documents for roads, bridges, culverts, and multi-use pathways infrastructure that have been published prior to the creation of this asset management plan. Some of these strategic documents speak to the need of incorporating asset management and risk management to drive the development of asset inventories, inspection programs and to understand lifecycle costing related to maintenance and replacement to ensure sufficient budgeting from both a capital and operational perspective.

Because many of these planning documents (2014 Transportation Master Plan, Kitchener Growth Management Strategy, and the 2014 Development Charges Background Study) were published before the creation of this asset management plan, they have served as a partial blueprint for this document. It is understood that when aforementioned corporate strategic documents that deal with structural infrastructure are updated, they will look to this asset management plan as valuable source of information and a milestone in the execution of corporate strategies. The same reflection will also apply to annual operating and capital budget documents. With minimal asset management information historically available in the creation of capital and
operating budgets and project forecasts, this document will shape the way that business, as it relates to structures, is conducted in the future.

Figure 3.2-2 – Relationships to City Planning Documents

The City’s Structural management is led by the following organizational components found in the Operations, Environmental Services Division:

- Engineering Division tracks the condition of assets and plans and executes structure planning & design, construction of new sites and capital rehabilitation projects of existing assets.

- Maintenance and Operations is responsible for the day to day maintenance and operation of structures including emergency closures, bridge washing, and removal of debris.

The City’s Structural management is supported by the following organizational components:

- Corporate Services – Geographic Information Systems (GIS) provides a data management platform and maintains the infrastructure layers that represent the
geographical location and attribution of structural sites. Assists with the development of inventory and inspection programs.

- Infrastructure Services – City of Kitchener Asset Management Office assists in the development and implementation of asset management plans and strategies. Maintains and develops the City’s work management software (CityWorks) which plays a vital role in tracking operating cost for the various work management activities for structural assets. Assists with the development of inventory and inspection program data.

- Finance and Corporate Services – Annual budget reporting. Accounting and reporting on the historical costs and service life of all corporately owned assets.

4. State of Local Infrastructure

4.1 Asset Inventory

The City of Kitchener has a robust accessible corporate GIS. This GIS system is used to inventory and describe City owned assets across multiple Divisions including those assets related to structures. It is often left up to the asset owner, in this case the Engineering Division, with consultation from GIS, on how they would like their data represented. These decisions are typically based on how the data is to be used. The creation of many of the GIS layers specific to structures and different structure types requires a review so that the data can be utilized for data analysis along with a visual representation of the various assets within the overall inventory. The asset types have been pooled into 5 groups.

One of the challenges faced when identifying the true inventory of City owned bridge assets is discerning City owned assets from un-owned railway assets. Some of the sites inspected by the City are owned by railways and are located on city property through easements defined in railway board orders, and grade crossing agreements. In some cases the ownership confusion lies in the fact the data found in the corporate GIS has not been regularly updated to reflect any changes in ownership or boundaries over time. There are also some existing bridge-sites that are closed and are about to be demolished, which will have to be removed from the asset inventory. In other cases, a boundary road bridge may straddle the property limits of City of Kitchener and an adjacent municipality with the site being partially owned by both, and finally upper tier bridge owners (Region of Waterloo& MTO) cyclically download responsibilities of some sites to the City of Kitchener.

The City Engineering Division is currently undertaking several environmental assessment and development reviews of Subdivision Plans and Site Plans to justify the building of appropriately sized and located new bridge sites sufficient to meet growing connectivity needs of new growth
areas and to meet Transportation network needs to increase options for multi-modal transportation needs of existing road networks.

Another reason to create new structure assets is the functional obsolescence of existing bridges. Reviews of transportation modes (sidewalks, bicycle lanes, more vehicle lanes, bus-only, and LRT lanes) at bridge sites are assessed and either the existing site is altered or removed and replaced to meet current cross-sectional needs.

Finally, new structure assets are added to the inventory due to the need to replace existing assets based on existing condition being below the desired load carrying capacity for sites when it cannot be rehabilitated (technically), or economic analysis of rehabilitation suggests that replacement would produce a lower life cycle cost.

4.1.1 Bridges (Multi Modal)

In general a bridge is a structure including supports erected over a depression or an obstruction, such as water, natural area, highway, or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 3.0m between under-copings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes, where the clear distance between openings is less than half of the smaller contiguous opening. A bridge carries a passage that can be a roadway or railway across an obstruction utilizing direct bearing of its elements to carry its self-weight and loading from usage. The City of Kitchener has an inventory of 27 Multi Modal Bridges.

A bridge installation at a site often includes in-stream channel grading, small head walls, retaining walls, cut off walls, fences, spillways and energy attenuation devices that are grouped with the structure asset in the data base and are reviewed as part of the OSIM process, but are identified as a single asset in this Asset Management Plan. This leads to the opportunity to minimize the differing levels of service required to maintain the various sub-components of the overall structure’s site. The practice of grouping of sub-assets influences the rehabilitation and replacement of elements, design, the results of condition inspections and the reporting of disposals. Further discretization into sub-assets could be done as part of a follow-on exercise if asset valuation of the sub-elements is above threshold PSAB values for discretization. In general, revetments, long retaining walls and pedestrian pathways beneath the site could be further categorized.

4.1.2 Concrete Culverts

A culvert, on the other hand, is a structure that allows water to flow under a road, railroad, trail, or similar obstruction from one side to the other side. Typically embedded so as to be surrounded by soil, a culvert may be made from a steel pipe, reinforced concrete or other material. The soil placed above and around the culvert structure aids in the distribution of loading from usage. If
the amount of soil/fill is less than 300 mm in depth and the span of the site is more than 3m then the site is considered a bridge.

As shown in Figures 4.1 to 4.3, a culvert is a structure that forms an opening through soil and:

- Has a span of 3 meters or more (Figure 4.1.2-1), or;
- Has a sum of individual spans of 3 meters or more for adjacent multiple cell culverts (Figure 4.1.2-2), or;
- Has a sum of individual spans of 3 meters or more for adjacent multiple cell culverts (each with a span of 2 meters or more) separated by a width of soil that does not exceed the span of the smallest cell (Figure 4.1.2-3), or;
- Has been qualified by the owner to be a culvert.

Figure 4.1.2-1 – Single Cell Culverts
Figure 4.1.2-2 – Multiple Cell Culverts

Figure 4.1.2-3 – Multiple Cell Culverts with a Soil Separation

The City of Kitchener has an inventory of 34 culverts that have spans over 3 m or are in combination with other adjacent culverts as described above that the Kitchener Engineering Division maintains, 20 of which are concrete culverts. These sites are grouped as an asset grouping due to similar; function, load carrying characteristics, asset valuation, approval
purpose, life expectancy, typical defects, remedial measures to restore condition, inspection technique, and consumption.

A culvert installation at a site often includes instream channel grading, small head walls, retaining walls, cut off walls, fences, spillways and energy attenuation devices that are grouped with the pipe asset in the data base and are reviewed as part of the OSIM process, but are identified as a single asset in this Asset Management Plan. This leads to the opportunity to minimize the differing levels of service required to maintain the various sub-components of the overall structure’s site. The practice of grouping of sub-assets influences the rehabilitation and replacement of elements, design, the results of condition inspections and the reporting of disposals. However, further discretization into sub-assets is not recommended as it would add to complexity with very little benefit as the replacement, or rehabilitation of the prime asset (culvert pipe) often drives alterations of the secondary sub-assets.

4.1.3 Corrugated Steel Pipe Culverts

There are 14 Corrugated Steel Pipe culverts (CSPs) that the City of Kitchener Engineering Division maintains. They are separated from concrete culverts as they have different load carrying characteristics, life expectancy, typical defects, and remedial measures to restore condition.

Historically, Corrugated Steel Pipe culverts (CSPs) were first introduced to the construction industry in 1896, and they have had many revisions to the basic metal composition, corrugation patterns, and coatings since then. They became popular for wide spread usage during the post-war era as they are typically low cost solutions for small spans, and initially it was believed that their life expectancy would be similar to concrete culverts. As manufacturing technology through the 1960s improved larger single piece circular and oval spans were made available and new concepts for construction of the openings using multiple overlapping curved plates were introduced. These systems became very popular for their low cost and speed of construction that they almost eclipsed the concrete culvert. However, after a series of catastrophic failures brought about by large deformations, bolt hole cracking, and excessive corrosion, the usage of Corrugated Steel Pipe (CSP) came to an abrupt halt by many State Highway Departments and various engineering agencies.

Due to the large national inventory of Corrugated Steel Pipes (CSPs), a significant amount of research was conducted and numerous durability studies undertaken to determine the life expectancy of corrugated steel pipes. The general consensus of these studies is that corrugated steel pipes have a life expectancy of approximately 10-35 years, after which perforation of the metal occurs. This has caused the industry to seek a solution via coatings, both applied and bonded.
Remedial measures to restore pipe condition include partial concrete liners, full epoxy sock liners, grouting for plate separation and recoating for medium corrosion. It is the uncertainty related to a Corrugated Steel Pipe’s (CSP) corrosion, bolt hole cracking, and deformation that necessitates the separate tracking of this type of asset in the City of Kitchener Asset Management data base for structures.

4.1.4 Pedestrian Bridges/Boardwalks

The City of Kitchener Division has an inventory of 4 Pedestrian Bridges. There is a wide variety of multi-use trails and pedestrian bridges found throughout the City of Kitchener. A multi-use trail is defined as a paved surface of a range of styles and designs that forms a continuous off-road walking and cycling network. This Asset Management Plan looks at multi-use pathways and Trails that are located within the road right-of-way.

4.1.5 Railway Bridges

Railway grade separations are important facilities that allow the free flow of multi-modal traffic beneath or over railways, ensuring a city’s transportation network is unimpeded by long freight trains, medium speed intercity linkage trains, light rail and future high speed trains. These bridge assets range in age, and their ownership is often based on a case by case basis and set out in individual agreements signed at the time of construction in what is known as a “grade separation agreement/railway board order”. These legal documents stipulate cost sharing and responsibilities for maintenance, inspection and easement conditions. Irrespective of ownership, cities usually have concerns with the upkeep of these sites as they can on occasion become sources of spalling concrete falling on traffic and areas of criminal activity. Further, these assets can become functionally obsolete for vertical clearances, which results in frequent impacts by large trucks, resulting in a traffic flow bottleneck. The City of Kitchener reviews the condition of these sites in a manner consistent with that followed with their owned structural assets and similar to the approach followed by neighboring municipalities and the Ministry of Transportation to mitigate issues with crime, falling concrete, and frequent vehicle strikes.

There are 10 railway overhead/subway structures in the City of Kitchener. The fact that these assets may not be owned, be partially owned or fully owned by the City of Kitchener provides justification for the creation of this asset class, which may be treated separately from the rest of the asset population for funding needs.

4.2 Installation Profiles

Installation profiles display the total financial investment per installation year range of a particular asset class. For the purposes of this first phase asset management report, the total
number of assets or the assets installed over time will serve as the baseline for the installation profiles. As mentioned earlier in the report, there is limited information related to installation years for portions of the structure assets. By showing the count of assets as opposed to the monetary investment, we present an assessment of population that is free from the effects of inflation.

Figure 4.2-1 – Asset Installation Profile – Multi Modal Bridges (Engineering)

Figure 4.2-2 – Asset Installation Profile – Concrete Culverts (Engineering)
Figure 4.2-3 – Asset Installation Profile – Corrugated Steel Pipes (CSPs) (Engineering)

Figure 4.2-4 – Asset Installation Profile – Pedestrian Bridges (Engineering)
4.3 Asset Condition

The assessment of an asset’s condition is a valuable source of information to asset owners. The capturing of regularly scheduled condition data provides important insight into the performance of assets and what impact betterment activities are having on extending the serviceable life of infrastructure (i.e. improving or sustaining the overall health of the asset). Without this critical information, the condition of the assets will be evaluated solely on the degradation based on the initial installation date, thereby not taking into account the effect of use, environment factors or other condition specific data. This limits the ability of the asset owner to plan the rehabilitation or replacement for assets in the short and long terms from a financially strategic perspective.

The OSIM inspections require municipal bridges that meet selected criteria to be inspected every 2 years. The resulting scores from this inspection program range from 0 to 100, and for the purposes of representation, have been grouped into 5 categories that have been explained in Table 4.3-1.

The Condition score is calculated by subtracting the Ontario Ministry of Transportation Bridge Condition Index (BCI) from 100. It is noted that plans to start rehabilitation usually begin when the Condition Score is 25 or BCI is 75. Therefore, a good condition score structure could be showing the early signs of deficiencies needing future correction.
Table 4.3-1 – Asset Condition Categories

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<th>Condition Score</th>
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<tr>
<td>0 - 20</td>
<td>100-80</td>
<td>Very Good</td>
</tr>
<tr>
<td>21 - 40</td>
<td>79-60</td>
<td>Good</td>
</tr>
<tr>
<td>41 - 60</td>
<td>59-40</td>
<td>Fair</td>
</tr>
<tr>
<td>61 - 80</td>
<td>39-20</td>
<td>Poor</td>
</tr>
<tr>
<td>81 - 100</td>
<td>19-0</td>
<td>Very Poor</td>
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Figure 4.3-1 – 2016 Condition Assessment of Vehicular Bridges (Engineering)
Figure 4.3-2 – 2016 Condition Assessment of Concrete Culverts (Engineering)

Figure 4.3-3 – 2016 Condition Assessment of Corrugated Steel Pipes (CSPs) (Engineering)
Figure 4.3-4 – 2016 Condition Assessment of Pedestrian Bridges (Engineering)

Figure 4.3-5 – 2016 Condition Assessment of Railway Bridges (Engineering)
4.4 Asset Consumption by Asset Type

The following profiles illustrate the current lifecycle stages for each of the 5 asset groups. The profiles reflect on the most current condition scores for all the assets identified in this plan’s inventory. Asset consumption is defined by the Bridge Condition Index (BCI) which is a numerical weighted average of the OSIM data, and has been identified in the horizontal axis’ title.

Asset consumption values were estimated using BCI condition data. It is noted that in the previous Parks Asset Management Plan estimated service life was used in lieu of condition data.

The CHBDC and other sources estimate bridge life expectancy to be between 70 and 80 years, and that buried structure that are not exposed to deicing salts usually have a life expectancy of 100 years (similar to concrete sewers). Corrugated Steel Pipes (CSPs) that are not coated can have very low life expectancy dependent upon soil chemistry. In the Kitchener area, the life expectancy of Corrugated Steel Pipes (CSPs) is believed to be 10-35 years. If a Corrugated Steel Pipe (CSP) structure was installed correctly without bulges, missing bolts, and separation in plates and is coated, the service life could be increased to 100 years.

Replacement cost provided in the following figures are based on The City of Kitchener BCI calculation System which uses PSAB values that produce a non-dimensional BCI factor that should not be used for cost estimation. See Appendix I for current MTO cost estimation tool used later on for development of suggested funding needs.
Figure 4.4-2 – Asset Consumption Profile, Concrete Culverts (Engineering)

Figure 4.4-3 – Asset Consumption Profile, Corrugated Steel Pipes (CSPs) (Engineering)
Figure 4.4-4 – Asset Consumption Profile, Pedestrian Bridges (Engineering)

Figure 4.4-5 – Asset Consumption Profile, Railway Bridges (Engineering)
5. Levels of Service

The City of Kitchener does not have a complete catalogue of thoroughly documented, agreed upon service levels for all assets. Some of the more current service levels have been put into place as a response to legislated requirements for safety or accessibility.

A measure for the levels of service for structures could be established as the number of days a year they are open to their functional usage. OSIM and individual load evaluations for each site may limit the size of load crossing the structure. A poor condition may lead to a load posting and lead to a lowering of Level of Service as certain vehicles above quantized weights and wheel configurations may be precluded from using the structures.

By not having defined and reviewed agreed upon levels of service for users other than vehicles, the effects of outside influences are limited. For example, climate change is likely to have an influence on the required hydraulic opening for structures bridging over a water crossing. Current crossing may be inundated by spring run-off and be out of service for longer periods of time throughout the year, thereby not meeting the service level. Reviews of service levels will also assist in budgetary needs for maintenance and rehabilitation activities.

6. Asset Management Strategy

Many of the desired asset management strategies for transportation structure assets are yet to be defined in the Transportation Master Plan. Future funding opportunities will rely on documented asset management strategies to support additional resources necessary to maintain, rehabilitate and potentially replace aging assets. A new Transportation Master Plan should contain a Strategic Action plan that outlines five strategic themes for the creation and maintenance of the Transportation assets in the existing and future Transportation Network:

1. Conserving and Restoring existing assets
2. Expanding asset inventory to meet new TDM, active transportation needs, and incorporate the Accessibility for Ontarians with Disabilities Act, 2005
3. Strengthening and Expanding the Community connections and networks
4. Engaging and Activating the Community to reduce Single Occupancy Vehicle trips by expanding Transit and Ride-sharing
5. Reduction in Peak hour trips
The following sections will look at the City’s current processes including the work management system and how it addresses operational activities, rehabilitation activities, replacement, and disposal activities.

6.1 Operational Activities

For the purposes of this asset management plan, operational activities are those “service oriented” maintenance activities that are performed on an asset during the course of its lifecycle in an effort to maintain its level of service. These activities do not have a direct impact on the overall health of the asset, but simply maintain it at a defined service level, providing a certain aesthetic or user experience. Examples of this work activity at the City of Kitchener include the bridge inspection, washing, sweeping of winter sand, graffiti removal, and the picking up of litter.

The asset inventory housed in the corporate GIS is also used in the corporate work management software, CityWorks. CityWorks uses Kitchener specific business rules that allow the Engineering Division to capture labor, material, and equipment costs and charge them to a specific work activity code. CityWorks relies heavily on the completeness and accuracy of the corporate GIS data to help identify what asset(s) is being worked on. These work activity codes are each related to a specific SAP operating or capital account.

The work management system is continuously being improved upon from both a user interface and business process perspective. The current business rules include the use of ‘generic’ work activities relating to various assets across the city. This classification of activities makes it difficult to allocate workload and/or condition to a specific asset. An example of this is the removal of graffiti from any number of structural assets. Graffiti removal is captured under several work activity codes that are specific for each asset group. This definition of work activities is very helpful in assessing the City’s work efforts from an asset group perspective, but the cost of the work is not placed against the specific asset(s) it is servicing. This may in turn influence the scheduling of operational activities geographically.

6.2 Renewal/Betterment Activities

A renewal or betterment activity can be defined as a work task that when completed will provide added value to the asset that is being worked on. It is an investment in the betterment of that asset that will in turn extend its life. An example of this is the work activity is “Concrete Patching on a Barrier Wall Maintenance” where City forces may remove loose delaminated concrete on a section of barrier wall. This action will repair the barrier wall surface, maintaining the level of service for crash protection, while improving its condition and extending its serviceable life.
Much of the rehabilitation work performed by Engineering is identified through the regular visual inspections of asset groups and the scheduled condition inspection programs. Others may be called in by residents or result from vehicle collision damage reported by police.

As there is more work required to split service oriented and betterment activities, there is also additional effort in distinguishing between renewal activities and replacement activities. As mentioned earlier, the many components that can comprise a structural asset are identified as a single asset. The removal and replacement of a component, guide rail post for example, may currently be captured as rehabilitation to the structure. If the guide rail were to be captured as an individual asset in the structure asset inventory, it could be identified as a replacement, and potentially be a capital expenditure instead of an operational expenditure, and budgeted for accordingly. This is likely too fine of an aggregation of assets to make any practical usage of.

6.3 Replacement and Disposal Activities

Replacement and disposal activities of structural assets vary between asset groups. Some activities are documented while others are not. Budgets for asset replacement primarily come from capital budgets with many assets being replaced in a large transportation redesign project, such as widening a road from 2 to 4 lanes.

The replacement of a structural asset’s sub-components is generally conducted on a component by component basis for secondary elements such as (guide rails, fences, expansion joints, lighting, gabion retaining walls, etc.) in an effort to extend the serviceable life of the asset as a whole. The replacement of these primary load carrying asset components usually occurs through an independent structural design report that may include an in depth review of the structure’s condition, which goes beyond regular OSIM inspect. Specifically, an enhanced OSIM, Bridge Deck Condition Survey, timber survey, or a hydraulic review may lead to the replacement of a structural site. Individual cost estimates are prepared on a site by site basis.

6.4 Expansion Activities

The road network, trail pathways network, new LRT system, and configuration of subdivision and site plans play an important role in the expansion of the City’s structure asset inventory. Both vehicular and other modes of active corridors provide the necessary links that make the city connected, serviced and accessible to all individuals as per the AODA legislation.

The identification of new networks is critical for new development application. The following list considers factors that may influence the need for expanded services:

- Demand and Service
- Safety and Accessibility
- Cost Effectiveness and Efficiency
- Network Connectivity
6.5 Non-Infrastructure Solutions

The City of Kitchener, like other cities in North America, is undergoing several societal and demographical changes. These changes are leading to a shift in the way it lives, grows, travels, works and plays. The development of new transportation choices both inside, between adjacent cities and new “Smart Growth” design philosophies are changing patterns of development which in turn is challenging previous conceptions of traffic patterns and usage and need of different types of infrastructure.

It is our opinion that the installation/investment in rapid transit infrastructure and supporting infill/intensification development in transit nodes, the city is reducing two significant challenges

1) The reduction of Single Occupancy Vehicle trips and the

2) The reduction of average trip lengths

This will, in turn, reduce peak volume needs for roads and bridges.

7. Financial Strategy

This report has extracted the operational expenditures and betterment costs that have been entered into CityWorks from the years 2010 to 2017 summarized in Figure 7-1, and researched future draft budgets as shown in Figure 7-2. The data has been grouped as per asset type and expressed in Figures 7.1-1 to 7.1-5 showing comparisons between betterment activities (work that has a direct effect on the overall health of the asset) and service oriented work per year. It is noted that additional work may arise out of the recently proposed structural condition investigative work, including, but not limited to:

- Corrugated Steel Pipe (CSP) culvert condition below the spring lines on the barrels
- Concrete culverts with less than 2000 mm of cover that are not waterproofed
- Heritage arch bridges.
### Figure 7-1 – City of Kitchener Previous Spending on Bridge and Culvert Assets (Engineering)

<table>
<thead>
<tr>
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<td>Legislated Bridge Inspection Account No. 8004030002.CAP</td>
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<td>$13,272</td>
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<tr>
<td>Overland Drive Bridge</td>
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<td>Hayward Avenue Bridge</td>
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<tr>
<td>Stirling Avenue Railway Overpass</td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Shol Place Bridge</td>
<td>Total Spent</td>
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<td>Margaret Avenue</td>
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<tr>
<td>Pioneer Drive Bridge</td>
<td>Total Spent</td>
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</tbody>
</table>

Total Yearly expenditure: $768,564, 1,121,430, 1,175,110, 1,162,163, 1,226,243, 6,391,163, 319,751

### Figure 7-2 – City of Kitchener Pre-Asset Management Plan Predicted Spending on Bridge and Culvert Assets (Engineering)

<table>
<thead>
<tr>
<th>Project No</th>
<th>Project Name</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
<th>2026</th>
<th>Total</th>
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<tr>
<td>1</td>
<td>Road Bridge Repairs</td>
<td>$447,000</td>
<td>$465,000</td>
<td>$484,000</td>
<td>$503,000</td>
<td>$523,000</td>
<td>$543,000</td>
<td>$563,000</td>
<td>$583,000</td>
<td>$603,000</td>
<td>$623,000</td>
<td>$3,422,000</td>
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<tr>
<td>2</td>
<td>Legislated Bridge Inspection</td>
<td>$39,000</td>
<td>$39,000</td>
<td>$42,000</td>
<td>$41,000</td>
<td>$41,000</td>
<td>$42,000</td>
<td>$43,000</td>
<td>$44,000</td>
<td>$45,000</td>
<td>$46,000</td>
<td>$420,000</td>
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<tr>
<td>3</td>
<td>Old Mill Road Bridge</td>
<td>$350,000</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>$350,000</td>
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<tr>
<td>4</td>
<td>Stirling Ave Bridge</td>
<td>$286,000</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>$286,000</td>
</tr>
<tr>
<td>5</td>
<td>Dinason Cres Bridge</td>
<td>$340,000</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>$420,000</td>
</tr>
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</table>

Totals: $336,000, $337,000, $350,000, $41,000, $385,000, $420,000, $545,000, $446,000, $556,000, $450,000, $3,316,000

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7.1 Operating Expenditures

While operating expenditures do not return betterment on asset condition, they do reduce future costs and gather important asset condition data that is required to make wise choices. Typically, these costs are broken into two types: 1) minor washing and concrete sealing activities, and 2) collection of OSIM, enhanced OSIM and load posting/evaluation data.

The costs associated with the washing can be predicted on a per diem basis of $3000 per day and includes all necessary traffic protection with an average productivity per day of 6 sites. The data collection for condition data can be attributed as a percentage cost of the capital works program and typically is estimated at 1-5% of the capital construction cost depending upon the site’s complexity.
Figure 7.1-1 – Service Orientated vs. Betterment Expenditures with Future Predicted Funding, Multi-Modal Bridges
Figure 7.1-2 – Service Orientated vs. Betterment Expenditures with Future Predicted Funding. Concrete Culverts
Figure 7.1-3 – Service Orientated vs. Betterment Expenditures with Future Predicted Funding, Corrugated Steel Pipe (CSP) Culverts
Figure 7.1-4 – Service Orientated vs. Betterment Expenditures with Future Predicted Funding, Pedestrian Bridges
Figure 7.1-S – Service Orientated vs. Betterment Expenditures with Future Predicted Funding, Railway Bridges
7.2 Potential Capital Revenue Generation

Although the City of Kitchener does not currently collect revenue from structures, opportunities for advertisement banners exist and are currently being pursued by other cities as shown by the City of London example below.

Figure 7.2-1 – Typical Banner Advertising

7.3 Long Term Capital Funding Requirements

7.3.1 Basis for Future Cost Estimates for Structure Rehabilitation and Replacement

Figures 7.3.2-3 to 7.3.2-7 illustrate the theoretical projected long term capital investments needed to sustain the City’s existing structure (Engineering Owned) assets for the next 80 years. Estimates are based on a typical asset life of 80 years as mandated in the CHBDC and the typical rehabilitation cycle as per the Ontario Ministry of Transportation Structural Rehabilitation Manual (essentially once every 25 years).

The projected costs are based on the historic costs of the Ministry of Transportation database that is summarized as a three step algorithm contained in Appendix I, and presented through two
tables and a map. This data is from the rehabilitation of over 800 bridge sites over a period of 25 years.

7.3.2 Long Term Capital Funding and Timing Requirements

As mentioned in the Ontario Ministry of Infrastructure document Building together – Guide for Municipal Asset Management Plans Chart 1(below), prior under-investment in the maintenance and upkeep of public infrastructure in most municipalities in Ontario has developed an infrastructure deficit.

Figure 7.3.2-1 – Building Together – Guide for Municipal Asset Management Plans (Chart 1)

The City of Kitchener inventory of condition data was originally prioritized based on age of construction only. This produced a large “mud wave” of rehabilitation needs between 2019 and 2030 that was echoed with large successive waves at 2048, and 2069.

Geometric smoothening of the “needs” timing horizons was manually done based on current condition (BCI) and likely resilience of the type of structure. This resulted in spreading out and lowering of the funding needs over time.

This was performed in accordance with the Ontario Ministry of Infrastructure document Building together – Guide for Municipal Asset Management Plans Figure 1(below), and the desire for an
Asset Management Plan to allow structure needs to be prioritized over time. This, in turn, ensures that investments are made at the right time to minimize future repair and rehabilitation costs and maintain municipal assets. The original age-based distribution for rehabilitation needs can be perceived as “wants”, and the “smoothened distribution” represents the “needs”.

Figure 7.3.2-2 below considers an individual asset, and not an inventory of numerous assets. The superposition for all Engineering assets results in unsustainable capital costs and a reduced residual life.

Figure 7.3.2-2 – Building Together – Guide for Municipal Asset Management Plans (Figure 1)

The resulting rehabilitation schedules and predicted cash flows to repair the inventory do present some limitations and some degree of risks as the “theoretical wants” have been exceeded on some structures. However, it is noted that several structures in Ontario are over 100 years old and have exceeded the predicted service life estimated in The CHBDC.

Good asset management essentially makes informed and strategically sound decisions that optimize investments, and better manage risk. The risks can be mitigated through frequent OSIM Inspections, instigation of Enhanced OSIM inspections, Scour & Underwater/Probing/Diving Inspections, and Load Posting Evaluations.
Additionally, the frequent amendment (once every 5 years) of the asset management plan and review of environmental resilience – including the risk of infrastructure failure – taking into account the potential impact of other factors, such as climate change (e.g., damage due to extreme weather) will mitigate the City of Kitchener’s risks in this regard.

The suggested capital needs do have limitations that must be taken into account by City of Kitchener staff as noted below:

- It is assumed that a like-for-like replacement is undertaken at 80 years of structure life. These figures represent a theoretical “need”. Actual project costs and future funding needs will be determined by future inspections, load evaluation analyses, and Environmental Assessments.
- These figures are provided to set a funding target need, and actual budgets should also include additional engineering fees (+20%) and contingency fees (+30%). This approach does have limitations for accuracy as it is noted that some structural municipal assets in Ontario exceed the 100-year life expectancy.
- Savings could be achieved through new technologies such as epoxy liners for Corrugated Steel Pipe (CSP) culverts. However, further hydraulic and environmental work will be required to determine suitability for each site.
- Current existing needs that are to be determined by future follow-on evaluations and enhanced OSIM inspections are not included in the cash flow suggested in this report.
- The suggested funding amount does not include any provision for system expansion of new structures due to growth needs or widening for increased Level of Service needs (e.g. widening of site for the addition of a bicycle lane).

The aforementioned figures are presented below.
Figure 7.3.2-3 – Estimated Funding Requirements for Vehicle Bridges

Required Funding for Concrete Culverts per Year

$7,000,000
$6,000,000
$5,000,000
Figure 7.3.2-4 – Estimated Funding Requirements for Concrete Culverts

Figure 7.3.2-5 – Estimated Funding Requirements for Corrugated Steel Pipes (CSPs)
Figure 7.3.2-6 – Estimated Funding Requirements for Pedestrian Bridges

Figure 7.3.2-7 – Estimated Funding Requirements for Railway Bridges
Adding up all four City of Kitchener owned asset inventories (excluding Railway structures), the total funding requirements for the whole structure inventory is estimated to be approximately $2.6 million per year with adjustment for construction price index of 3% per year. A maintenance budget of $40,000, in addition to $30,000 for OSIM inspection per year is to be taken into account.

Comparing the above figures to Figures 7-1 and 7-2, it can be seen that an infrastructure deficit will likely grow if stable funding is not devoted for these assets. Table 7.3.2-1 presents suggested future funding for Engineering Structures in thousands of Canadian Dollars.
Table 7.3.2-1 – Suggested Funding for Engineering Structures (Thousands of CAD).

<table>
<thead>
<tr>
<th>Year</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
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<tbody>
<tr>
<td>Multi-Modal Bridges</td>
<td>$1800</td>
<td>$1854</td>
<td>$1909</td>
<td>$1967</td>
<td>$2025</td>
<td>$2086</td>
<td>$2149</td>
<td>$2213</td>
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<tr>
<td>Concrete Culverts</td>
<td>$500</td>
<td>$515</td>
<td>$530</td>
<td>$546</td>
<td>$562</td>
<td>$579</td>
<td>$597</td>
<td>$614</td>
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<tr>
<td>Corrugated Steel Pipes</td>
<td>$200</td>
<td>$206</td>
<td>$212</td>
<td>$218</td>
<td>$225</td>
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<td>$245</td>
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<tr>
<td>Pedestrian Bridges</td>
<td>$50</td>
<td>$52</td>
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<td>Bridge OSIM inspection</td>
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<td>$3040</td>
<td>$3134</td>
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Appendix I – MTO Estimation Algorithm

The projected costs are based on the historic costs of the Ministry of Transportation data base that is summarized as a three step algorithm. The algorithm consists of a table and two graphs (shown below), the information contained in which was derived taking into account over 800 bridge replacement and rehabilitation projects.

Table I1 – Selection of the Rehabilitation Methodology

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<thead>
<tr>
<th>Type of Betterment</th>
<th>Basic Cost $/m²</th>
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<td>Rehab Light</td>
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<td>Rehab</td>
<td>1,200</td>
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<tr>
<td>Rehab Extensive</td>
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<td>Superstructure Replacement</td>
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<tr>
<td>Complete Str. Replacement</td>
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Figure I2 – Application of County Location Factor

As per the above map, the Kitchener area is rated as a 1.0.

- Additional 25% for a bridge work over water
- Additional 40% for live railway work
- Additional engineering fees (+20%)
- Additional contingency fees (+30%)
- No property acquisition assumed
- No environmental mitigations assumed
- Like-for-like replacements, no grade raises assumed
- No utility relocations assumed
- 2017 costs with suggested prorating using Statistics Canada CPI index
Appendix II – List of City Bridges (2016)

Multi-modal Bridges (27 structures):

1. 801 – Old Mill Road Bridge
2. 802 – Doon Village Road Bridge #1
3. 803 – Doon Village Road Bridge #2
4. 804 – Pioneer Drive Bridge
5. 805 – Huron Road Bridge
6. 806 – Balzer Road Bridge #1
7. 807 – Hayward Avenue Bridge
8. 808 – Overland Drive Bridge
9. 809 – Sydney Street Bridge
10. 810 – Borden Avenue Bridge
11. 811 – Kent Avenue Culvert
12. 812 – Stirling Avenue Bridge #1 (near Courtland Ave)
13. 815 – Graber Place Bridge
14. 816 – West Avenue Bridge
15. 817 – Village Road Bridge
16. 822 – Belmont Avenue Bridge
17. 823 – Patricia Avenue Bridge
18. 824 – Lawrence Avenue Bridge
19. 826 – Wabanaki Drive Bridge
20. 827 – Shirk Place Bridge
21. 828 – Madison Avenue Bridge
22. 833 – David Street-Queen Street Bridge
23. 835 – Vanier Drive Bridge
24. 844 – Cherry Street Bridge
25. 858 – Shoemaker Greenway Bridge
26. 878 – Doon Mills Drive Bridge #2
27. 887 – Natchez Road Culvert

Concrete Culverts (20 structures):

1. 814 – Eckert Street Culvert
2. 818 – Homer Watson Boulevard Culvert
3. 825 – Queens Boulevard Culvert (over Sandrock Greenway)
4. 831 – Mill Street Culvert (over Shoemaker Creek)
5. 832 – Kehl Street Bridge
6. 840 – Greenbrook Drive Culvert
7. 841 – Stirling Avenue Bridge #3 (near Greenbrook)
8. 843 – West Avenue & Victoria Street Culvert
9. 845 – Doon Village Road Culvert (North of Tilt)
10. 849 – Eastforest Trail Culvert
11. 853 – Ruskview Road Bridge
12. 854 – Greenbrook Plaza Culvert
13. 856 – Highland Road Culvert
14. 857 – Courtland Ave - Borden Ave Culvert
15. 860 – Schneider Creek Trail Culvert #2
16. 869 – Daimler Dr Culvert
17. 873 – Balzer Road Culvert #2
18. 888 – Forest Creek Drive Culvert
19. 889 – Robert Ferrie Drive Culvert
20. 917 – Parkvale Dr Culvert

Corrugated Steel Pipe (CSP) Culverts (14 structures):

1. 834 – Country Hill Drive Arch Culvert
2. 836 – Dinison Crescent Culvert over Borden Greenway
3. 837 – Williamsburg Road Culvert
4. 839 – McGarry Drive Culvert
5. 842 – Stoke Drive Bridge
6. 846 – Westmeadow Drive Culvert
7. 847 – Westforest Trail Culvert
8. 855 – Voisin Greenway Trail Bridge
9. 864 – Reichert Drive Culvert
10. 865 – Doon Mills Drive Culvert #1
11. 866 – Biehn Drive Bridge
12. 868 – Idlewood Creek Trail Culvert #6
13. 879 – Dinison Crescent Bridge #2
14. 918 – Fallowfield Dr Culvert

Pedestrian Bridges (4 structures):

1. 872 – Highway 7/8 Pedestrian Bridge
2. 886 – Highway 401 Pedestrian Bridge
3. 921 – Huron Natural Park Trail Bridge #1
4. 922 – Huron Natural Park Trail Bridge #2

Railway Structures (10 structures):

1. 819 – Wilson Avenue Railway Bridge
2. 821 – Stirling Avenue Railway Overpass
3. 829 – Wellington Street Rail Underpass Bridge
4. 830 – Belmont Avenue Railway Underpass Bridge
5. 871 – River Road - Shirley Ave Rail Overpass Bridge
6. 874 – Iron Horse Trail Railway Overpass Bridge
7. 912 – Henry Sturm Greenway - Railway Overpass Bridge
8. 916 – Park St Rail Bridge
9. 1013 – Block Line Road Bridge
10. 1092 – Margaret Avenue Railway Overpass