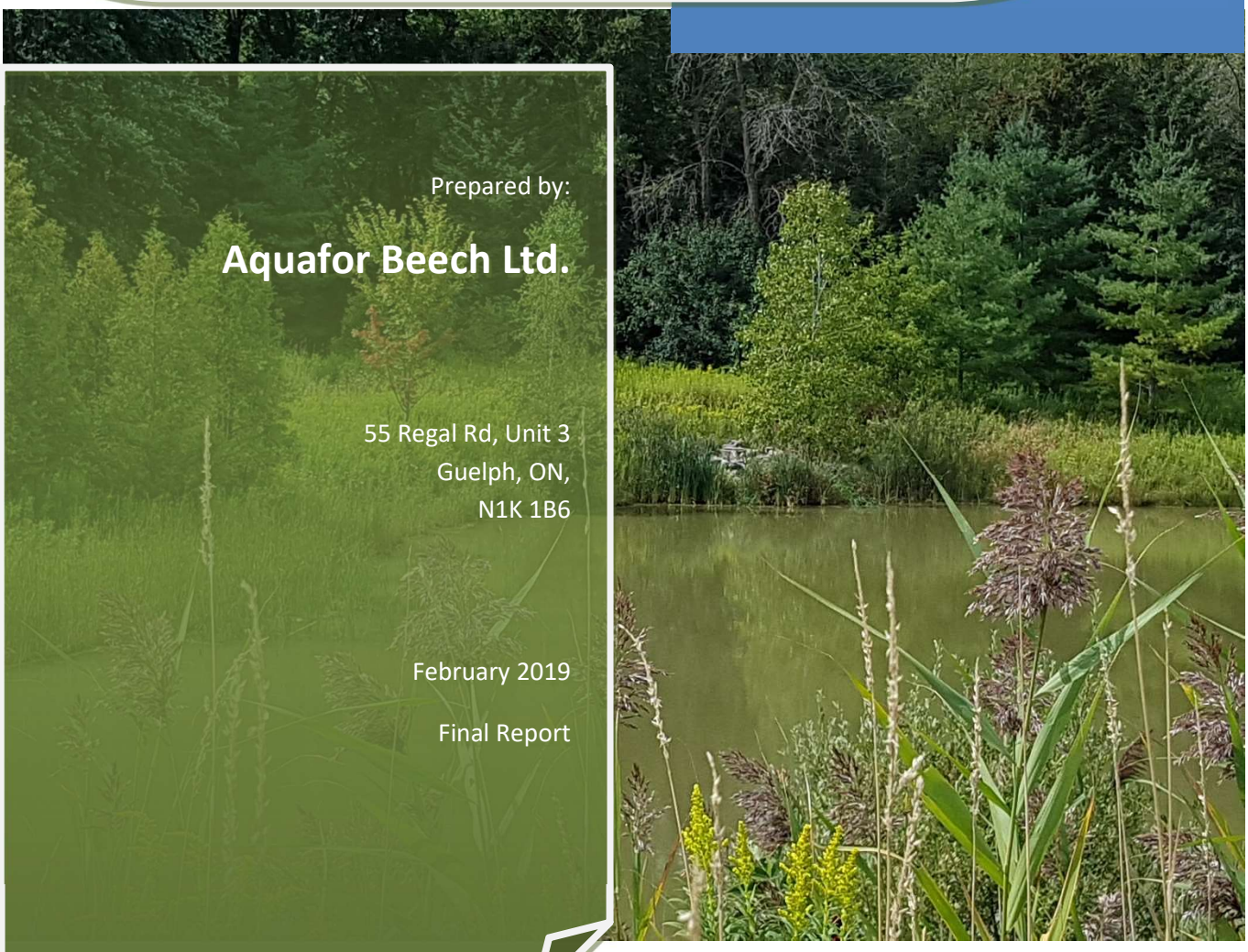
Prepared for:

City of Waterloo

STORMWATER MANAGEMENT MASTER PLAN (SWM-MP)

MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT

SUBWATERSHED HEALTH ANALYSIS



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February 2019

Final Report

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1.0 Introduction

At the implementation phase of the City of Waterloo's Stormwater Management (SWM) Master Plan, individual projects will be prioritized and scheduled. Project recommendations will include stream restoration works to mitigate erosion issues, improvements to SWM facilities to improve water quality, new SWM facilities where there are opportunities to increase areas controlled for quality and quantity, as well as road retrofits to provide conveyance controls within the municipal right-of-way in catchments where there are no end-of-pipe controls. Although many factors including budgeting, planning, and integration with other programs and projects will contribute to prioritization of these projects, a way of prioritizing candidate projects based on the subwatersheds that would benefit most from improvements to water quality and a more natural runoff regime is valuable for implementation. To prioritize project in this manner, the City's 23 subwatersheds were ranked based on existing conditions. To do this a decision matrix that considers the state of the following subwatershed health metrics was used:

1. Terrestrial Subwatershed Health
2. Stormwater Management
3. Water Quality
4. Stream Channel and Riparian Health
5. Aquatic Ecology

While the implementation of SWM control will not directly influence all of the subwatershed health metrics, a primary goal of an SWM strategy focusing on providing natural hydrologic function via source, conveyance and end-of-pipe SWM features is to mitigate the impacts of urbanization on local aquatic ecosystems. Through this approach, hydrologic functions such as infiltration, depression storage, filtration and evapotranspiration that were once provided by wetlands, forests and other natural features are reintegrated into the urban environment by a landscape-based SWM strategy.

2.0 Terrestrial Subwatershed Health

The Southwestern Ontario landscape has experienced significant, possibly irreversible, ecological change following European settlement. Lands which were once covered in forest, wetland, savannah, and grasslands as well as watercourses have been removed or altered in favor of widespread agricultural and urban development. Many of the ecological processes the aforementioned natural heritage features provide have also been altered or eliminated. Accordingly, it is of vital importance to the natural heritage system as a whole to restore, conserve, and protect the form and function of natural areas.

In recognition of the significant landscape scale change in the country, Environment Canada has published an updated science-based guide which addresses common terrestrial vegetation community types and their roles in subwatershed health. The *How Much Habitat is Enough?* (2013) guideline is widely used by governments, NGOs, and citizen's groups as an ecology reference, and is especially valuable for watershed planning. Aquafor Beech Limited chose to use the subwatershed health criteria in the guideline in the development of terrestrial subwatershed health metrics for the City of Waterloo's Subwatershed Health Analysis because of the guideline's science-based holistic approach to land use planning and management. Terrestrial subwatershed health metrics are not only interrelated, they often correspond

with metrics from other disciplines such as stormwater and aquatic ecology. As such, it is recommended that the metrics are interpreted and applied in a holistic manner.

Discussion regarding the development of terrestrial subwatershed health parameters for this project is found in **Sections 2.1 to 2.4**. The calculation of subwatershed Terrestrial Health Metrics are assessed in **Section 2.5**.

Four of the five terrestrial subwatershed health metric parameters described below were adapted from the 3rd Edition of Environment Canada's *How Much Habitat is Enough?* (2013). The Environment Canada document provides general guidelines based on an aggregation and review of science-based literature, and encourages adaptation of the general guidelines and principles to suit local ecological contexts and priorities. Many of the criteria of the 2nd edition of the *How Much Habitat is Enough?* document remain applicable in the 3rd edition. The parameters detailed below are high-level and are easily assessed using GIS technologies. Finer scale analysis of parameters related to terrestrial subwatershed health, such as the amount of suitable habitat available to target species or species-at-risk, is not included in the scope of this report.

The vegetation coverage guidelines within the How Much Habitat is Enough? (HMHE) document are intended to be viewed as minimums, and are not intended to justify reduction of habitat types that are present in excess of the guideline minimums. In the case of a highly urbanized landscape like the City of Waterloo, it may not be possible to meet the guideline minimums. However, as mentioned above, the guidelines can be adapted to the context in which they are applied.

The natural heritage resources within the City of Waterloo are largely situated within an urban matrix. Disjunct habitat patches are generally less valuable to wildlife than connected patches; a connected matrix of natural heritage features will exhibit greater ecological function than a fragmented system and will likely be more adaptable to stressors such as climate change. Accordingly, two parameters in addition to applicable parameters of the HMHE guideline, natural cover and connectivity, have been included in the list of metrics detailed below.

2.1 Wetland Habitat

Wetlands are valuable components of a natural heritage system, often supporting a greater diversity of species than temperate upland forests and grassland on a per area basis (Cromer et al. 2005; Gibbons et al. 2006; Meyer et al. 2003). They also provide valuable hydrological functions, including but not limited to improving and maintaining water quality, flood attenuation, contributing to groundwater recharge, and reducing sediment delivery to water bodies.

Figure 2.1: Deciduous treed swamp in spring. (Aquafor Beech Ltd.)

Wetlands are defined as:

> lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens.

One of the six habitat guidelines for wetlands in the HMHE is *percent cover of wetland area*. According to the guideline, "at a minimum, the greater of (a) 10% of each major watershed and 6% of each subwatershed, or (b) 40% of the historic watershed wetland coverage, should be protected and restored". Given the spatial scale of this project (i.e. the subwatershed scale), the target of **6% subwatershed wetland coverage** was chosen as the most appropriate wetland criteria for this project.

The GIS data set used to calculate the percentage of wetland coverage within each subwatershed included: "locally significant wetlands", "provincially significant wetlands", and "unevaluated/other wetlands".

2.2 Forest Habitat

Prior to European settlement, forest was the predominant vegetation type across the Mixedwood Plains (Environment Canada, 2013). Forests provide many hydrologic benefits in terms of water quality, flood attenuation, stream hydrology as well as other benefits such as oxygen production, carbon sequestration, erosion reduction, nutrient cycling, wildlife habitat, and more. For these reasons, the presence of forest habitat is a significant indicator of subwatershed health. Many species of flora and fauna are obligate forest habitat users, and as such the preservation of forested habitats are essential to their survival. There is increasing evidence that total forest cover in a given area is a major predictor of the persistence and size of bird populations, and the HMHE minimum forest cover guideline is largely based upon scientific studies that were focused on this taxon (Environmental Canada 2013). In addition to percent cover, other factors such as size, geometry, and diversity are also important to consider when evaluating forest habitat. However, given the data available for this study, only percent cover in areas greater than 1500 m^2 have been included in the analysis.

For the purpose of this study, the definition of forested habitat follows the HMHE guideline where the term forest shall include: all treed communities (where trees are generally 6 metres or more in height) with a canopy cover of at least 35%, and more typically 60% or greater. This includes both upland forests and swamps as well as plantations. It generally does not include orchards or tree farms.

Figure 2.2: Upland maple-beech forest (Aquafor Beech Ltd.)

The HMHE guideline recommends that a minimum of 30% forest cover at the watershed scale is the minimum forest cover threshold, which represents a high-risk approach which may only support less than half of the potential species richness and marginally healthy aquatic ecosystems (Environment Canada 2013). Medium and low-risk approaches equate to 40% and 50% forest cover, respectively. For the purposes of this study, the high-risk threshold of a **minimum of 30% forest cover** per subwatershed was selected as the preferred parameter given the highly urbanized nature of the lands within the City's boundary.

The GIS data set used in the analysis of forest habitat includes the City of Waterloo's urban forest layer, which includes forested areas greater than 1500 m^2.

2.3 Natural Cover

The City of Waterloo recognises the importance of the natural heritage system for maintaining biodiversity and supporting ecological functions and is committed to the restoration and enhancement of natural features within publicly-

owned land by prohibited development. In addition to their inherent value; wetlands, forests, grasslands, and riparian areas provide many important ecological services to people and wildlife. As such, the parameter of "natural cover" was included in the analysis.

The GIS data set used in the analysis of natural cover includes wetlands, woodlands, and watercourses, and waterbodies.

2.4 Connectivity

As mentioned above, the natural heritage resources within the City of Waterloo are largely situated within an urban matrix. Urban infrastructure such as roads and buildings often bisect or surround natural areas, separating them from other natural areas. Without connection to other habitats or the greater natural heritage system, isolated habitat patches exhibit limited potential for movement and propagation of flora and fauna, genetic exchange, species interaction, etc. Connections between and amongst components of the natural heritage system contribute to the ecological function of connected habitat patches and the natural heritage system as a whole, and habitat fragmentation is commonly cited as a threat to species extinction and loss of biodiversity (D'Eon et al. 2002).

The City of Waterloo recognises that natural linkages and corridors are an essential component of the natural heritage system. Connectivity is a functional relationship between physical habitat features and the flora and fauna that use them. For example: two forested habitats connected by an unvegetated stream will be used differently by aquatic or semi-aquatic organisms (functionally connected) compared to the way in which small terrestrial mammals are able to use the stream (not functionally connected). Furthermore, proximity (and organisms' dispersal abilities) also influences the ways in which flora and fauna travel between discrete habitat patches. Such nuances were not taken into consideration in this study due to the scope of such an undertaking and the limitations of the GIS-based analysis used for this study.

For this study, connectivity was calculated as the percentage of natural and semi-natural patches within each subwatershed that were directly connected physically/geographically to at least one other habitat patch either within the same subwatershed or areas outside the subwatershed by a terrestrial or aquatic linkage. The GIS data set used in the analysis of connectivity includes: woodlands, wetlands, valleylands, restoration areas, streams, restoration streams, creeks, rivers, watercourses, surface water, and core natural heritage features. In this terrestrial subwatershed health metric, wetlands, ponds, woodlands, valleylands, restoration areas, and core natural heritage features are considered habitat patches. Streams, restoration streams, creeks, rivers, and watercourses are treated as potential habitat "connectors", or linkages. Habitat patches were considered "connected" if terrestrial habitat patches are physically connected to other habitat patches either by each other or by an aquatic linkage type, or, if through air photo interpretation it was determined that unmapped natural and/or semi-natural vegetation connected habitat patches.

Minimum targets for habitat connectivity are currently not explored in the scientific literature; however the general consensus is that greater connectivity is more desirable than less connectivity. As such, subwatershed connectivity for each subwatershed was given a score relative to the percentage of number of connected habitat patches located within the boundaries of each subwatershed, regardless of whether the habitat patches were connected to other patches within or outside of the subwatershed. Similar to the minimum recommended threshold for riparian cover, 75% was selected as the minimum recommended percentage for connectivity.

2.5 Scoring of Terrestrial Subwatershed Health Metric

The scoring system used for the Terrestrial Subwatershed Health Metric follows that of other subwatershed health metrics in that each parameter (e.g. water quality, terrestrial, aquatic, etc.) is given a score from one (1) to five (5), with 1 representing a "very good" score and 5 representing a "poor" score.

A summary of the scoring methodology for each of the metrics for terrestrial subwatershed health is presented below in **Table 2.1**. Values in the same row as "1 (Excellent)" represent the suggested minimum described in **Section 1** under each parameter. For terrestrial subwatershed health, each parameter was given a score between one (1) and five (5) according to **Table 2.1**. In recognition of the interrelationship between all parameters, the average score is considered the overall terrestrial health score for each of the subwatershed included in the analysis.

Table 2.1: Terrestrial Subwatershed Health Thresholds and Scoring Scheme

Score	Terrestrial Subwatershed Health Parameter Thresholds				
	Wetland Habitat	Riparian Habitat	Forest Habitat	Natural Cover	Connectivity
1 (Excellent)	≥ 6%	≥ 75%	≥ 30%	≥ 50%	≥ 75%
2 (Good)	4.4% - 5.9%	60% - 74.9%	21.5% - 29%	37.4% - 49.9%	60% - 74.9%
3 (Fair)	2.9% - 4.3%	45% - 59.9%	14% - 21.4%	24.9% - 37.3%	45% - 59.9%
4 (Marginal)	1.4% - 2.8%	30% - 44.9%	6.5% - 13.9%	12.4% - 24.8%	30% - 44.9%
5 (Poor)	<1.4%	< 30%	< 6.5%	> 12.4%	< 30%

Table 2.2 presents an assessment of existing conditions for each subwatershed within the City of Waterloo as it relates to the terrestrial health parameters described above. As mentioned above, in recognition of the interrelationship between the terrestrial subwatershed health metrics, it is recommended that the metrics are interpreted and applied in a holistic manner. The information contained in **Table 2.2** can be used as a guideline prioritizing for restoration initiatives in the City of Waterloo as a whole and in each of the subwatersheds listed.

The City of Waterloo is encouraged to consider prioritizing the restoration of vegetation types which may address multiple parameters. For example, treed swamp vegetation community types address both forest and wetland coverage targets and depending on their location, could also address riparian habitat targets. The City is also encouraged to look within and beyond their urban and geographical boundaries to neighbouring lands and consider how increasing landscape connectivity and representation of a diversity of ecological communities can provide an overall benefit for the ecology of the City of Waterloo. Furthermore, it is recommended that metrics from other disciplines (e.g. aquatic ecology, water quality, etc.) also be considered when evaluating priorities for overall subwatershed improvement.

Overall, **Table 2.2** shows subwatersheds that have not yet been subject to development scored better than those that were fully developed. Terrestrial Health scores, which represent a combined average of the scores for individual parameters, varied from 1.6 (very good – good) to 4.2 (marginal), and are generally in line with the overall scores for each subwatershed. **Figure 2.3** illustrates the results obtained for the Terrestrial Subwatershed Health Assessment.

Table 2.2: Summary of Analysis of Terrestrial Health Metrics

Subwatershed	Terrestrial Health Metrics and Associated Scores								Subwatershed Terrestrial Health Score
	Wetland Habitat(ha)	Score	Forest Habitat(ha)	Score	Natural Cover(ha)	Score	Connectivity(ha)	Score	
Alder Creek	1.67	3	7.99	3	8.77	4	8.12	1	2.75
Beaver Creek	15.50	1	22.00	2	23.92	3	23.72	1	1.75
Cedar Creek	4.31	5	25.05	4	25.75	5	23.17	1	3.75
Clair Creek	25.52	4	93.24	4	113.91	5	99.87	1	3.5
Colonial Creek	6.04	5	22.59	5	24.70	5	15.16	2	4.25
Conestogo River - Lower	-	5	0.02	5	1.04	5	0.02	5	5
Cooper's Creek	5.13	2	17.50	3	17.73	4	16.84	1	2.5
Critter Creek	6.08	2	13.05	4	17.41	4	15.57	1	2.75
Cuckoo Creek	0.28	2	1.83	2	1.88	3	1.89	1	2
Forwell Creek	5.94	5	26.42	5	32.52	5	24.37	2	4.25
Grand River Tributaries South	2.15	4	16.06	3	18.40	4	12.91	2	3.25
Horst Creek	34.84	1	63.05	2	72.62	3	61.79	1	1.75
Laurel Creek Reservoir	96.74	1	63.88	3	140.51	2	135.49	1	1.75
Lower Laurel Creek	12.18	5	55.93	5	66.30	5	56.5	1	4
Maple Hill Creek	0.85	5	26.69	4	27.08	5	16.78	2	4
Martin Creek East	0.36	5	-	5	1.27	5	-	5	5
Martin Creek West	1.46	4	13.30	3	14.95	4	13.98	1	3
Melitzer Creek	18.29	1	19.63	3	25.37	4	24.74	1	2.25
Middle Laurel Creek	21.45	3	65.44	4	91.50	4	80.69	1	3
Minnow Creek	20.25	1	23.51	1	27.05	1	26.74	1	1
Monastery Creek	118.93	1	215.35	1	234.57	2	228.99	1	1.25
Schneider Creek	-	5	-	5	0.45	5	-	5	5
Willow Creek	0.70	1	1.37	1	1.75	2	1.75	1	1.25

THE CITY OF Waterloo

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FIGURE 2.3:
SUBWATERSHED HEALTH - TERRESTRIAL RANK

- Single Line Road Network
- Water Bodies
- Study Area

Terrestrial Ranking

- Excellent
- Good
- Fair
- Marginal
- Poor

0 1 2
Kilometers

N

Aquafor Beech Limited

Base data provided by The City of Waterloo, 2017.

Date: November 2018

3.0 Stormwater Management Metric

The stormwater management (SWM) practices in the City of Waterloo generally reflect the age of development of neighbourhoods within the City. As a result, areas of older development may lack stormwater quality and/or stormwater quantity infrastructure. To provide an existing conditions evaluation score for the SWM metric on a subwatershed basis, three (3) paraments were used. SWM parameters used for this analysis are:

1. Stormwater Quality Control
2. Stormwater Quantity Control
3. Impervious Percentage

3.1 Stormwater Quality Control

A combination of wet SWM facilities, constructed wetlands and OGS units provide stormwater quality control for development within the City of Waterloo. To provide a comparative parameter, the total area draining to stormwater quality facilities was calculated for each subwatershed. This analysis included all levels of stormwater quality protection (i.e. enhanced, normal and basic). In order to normalize the stormwater quality control metric, the area draining to stormwater quality facilities was divided by the total area of each subwatershed to provide a percent control indicator. Open space areas such as conservation lands, undeveloped lands, and agricultural areas are not typically provided with SWM quality controls and are not included in the calculation of this metric. The percent of the urban subwatershed areas provided with stormwater quality control ranges from 12% to 98%. The scoring system for the stormwater quality control parameter is presented in **Table 3.1**.

Table 3.1: Stormwater Quality Scoring System

% Quality Control	Quality Control Rating	Evaluation Score
% Control ≥ 60	Excellent	1
40 ≤ **% Control** < 60	Good	2
20 ≤ **% Control** < 40	Fair	3
10 ≤ **% Control** < 20	Marginal	4
0 ≤ **% Control** < 10	Poor	5

Table 3.4 provides a summary of stormwater quality control within the City by subwatershed.

3.2 Stormwater Quantity Control

A combination wet and dry SWM facilities as well as subsurface detention systems (e.g. superpipe storage) provide stormwater quantity control for development within the City of Waterloo. Like the stormwater Quality Control metric described above in **Section 3.1**,to provide a comparative parameter, the total area draining to stormwater quantity facilities was calculated for each subwatershed. In order to normalize the stormwater quality control metric, the area draining to stormwater quality facilities was divided by the total area of each subwatershed to provide a percent control indicator. Open space areas such as conservation lands, undeveloped lands, and agricultural areas are not typically provided with SWM quantity controls and are not included in the calculation of this metric. The percent of subwatershed area provided with stormwater quantity control ranges from 13% to 98%. The scoring system for the stormwater quantity control parameter is presented in **Table 3.2**.

Table 3.2: Stormwater Quantity Scoring System

% Quantity Control	Quantity Control Rating	Evaluation Score
% Control ≥ 60	Excellent	1
40 ≤ **% Control** < 60	Good	2
20 ≤ **% Control** < 40	Fair	3
10 ≤ **% Control** < 20	Marginal	4
0 ≤ **% Control** < 10	Poor	5

Table 3.5 provides a summary of stormwater quantity control within the City of Waterloo by subwatershed.

3.3 Impervious Percentage

Impervious surfaces are the main source of excess stormwater runoff volume and pollutant loading when catchments are compared to pre-urbanized conditions. To provide a comparative metric, the percent of impervious area for each subwatershed was calculated. Impervious areas used in this calculation include buildings, parking areas, roads and sidewalks. The subwatershed percent impervious ranged from 0% to 78%. The scoring system for impervious parameter is presented in **Table 3.3**.

Table 3.3: Impervious Percentage Scoring System

% Quality Control	Quality Control Rating	Evaluation Score
0 ≤ **Impervious %** < 10	Excellent	1
10 ≤ **Impervious %** < 20	Good	2
20 ≤ **Impervious %** < 30	Fair	3
30 ≤ **Impervious %** < 40	Marginal	4
Impervious % ≥ 40	Poor	5

Table 3.76 provides a summary of impervious percentage within the City by subwatershed.

Table 3.4 Stormwater Quality Control Analysis

Subwatershed	Analysis Area (ha)*	Area with Quality Control (ha)	% of Area with Quality Control	Quality Control Rating	Evaluation Score
Alder Creek	46.06	8.49	18.43	Marginal	4
Beaver Creek	85.81	60.18	70.13	Excellent	1
Cedar Creek	356.88	45.7	12.8	Marginal	4
Clair Creek	1033.22	577.02	55.85	Good	2
Colonial Creek	436.7	123.96	28.38	Fair	3
Conestogo River - Lower	35.13	34.33	97.71	Excellent	1
Cooper's Creek	116.45	110.61	94.99	Excellent	1
Critter Creek	113.98	108.96	95.59	Excellent	1
Cuckoo Creek	6.22	5.12	82.33	Excellent	1
Forwell Creek	508.49	72.59	14.28	Marginal	4
Grand River Tributaries South	82.7	56.29	68.06	Excellent	1
Horst Creek	256.94	195.62	76.13	Excellent	1
Lower Laurel Creek	1211.81	180.66	14.91	Marginal	4
Maple Hill Creek	326.6	117.71	36.04	Fair	3
Martin Creek East	142	82.28	57.94	Good	2
Martin Creek West	74.25	56.57	76.19	Excellent	1
Melitzer Creek	134.54	121.15	90.04	Excellent	1
Middle Laurel Creek	609.7	309.39	50.74	Good	2
Minnow Creek	43.31	41.45	95.7	Excellent	1
Monastery Creek	488.78	400.92	82.02	Excellent	1
Schneider Creek	51.1	16.64	32.56	Fair	3
Willow Creek	3.99	2.87	71.91	Excellent	1

*Undeveloped areas (valley lands, wetlands, woodlots, and agricultural lands) were excluded from the area controlled/uncontrolled analysis because they are not expected to be provided with engineered stormwater controls.

Table 3.5 Stormwater Quantity Control Analysis

Subwatershed	Analysis Area (ha)*	Area with Quantity Control (ha)	% of Area with Quantity Control	Quantity Control Rating	Evaluation Score
Alder Creek	46.06	8.49	18.43	Marginal	4
Beaver Creek	85.81	60.18	70.13	Excellent	1
Cedar Creek	356.88	50.98	14.28	Marginal	4
Clair Creek	1033.22	607.72	58.82	Good	2
Colonial Creek	436.7	198.97	45.56	Good	2
Conestogo River - Lower	35.13	34.33	97.71	Excellent	1
Cooper's Creek	116.45	109.35	93.9	Excellent	1
Critter Creek	113.98	107.77	94.55	Excellent	1
Cuckoo Creek	6.22	2.07	33.34	Fair	3
Forwell Creek	508.49	145.02	28.52	Fair	3
Grand River Tributaries South	82.7	54.77	66.23	Excellent	1
Horst Creek	256.94	195.62	76.13	Excellent	1
Lower Laurel Creek	1211.81	162.81	13.44	Marginal	4
Maple Hill Creek	326.6	173.84	53.23	Good	2
Martin Creek East	142	126.84	89.32	Excellent	1
Martin Creek West	74.25	70.53	94.98	Excellent	1
Melitzer Creek	134.54	121.84	90.56	Excellent	1
Middle Laurel Creek	609.7	296.26	48.59	Good	2
Minnow Creek	43.31	41.45	95.7	Excellent	1
Monastery Creek	488.78	407.23	83.32	Excellent	1
Schneider Creek	51.1	23.34	45.67	Good	2
Willow Creek	3.99	2.87	71.91	Excellent	1

*Undeveloped areas (valley lands, wetlands, woodlots, and agricultural lands) were excluded from the area controlled/uncontrolled analysis because they are not expected to be provided with engineered stormwater controls.

Table 3.6 Impervious Scoring Analysis

Subwatershed	Analysis Area (ha)*	Impervious Area (ha)	% Impervious (ha)	Impervious Rating	Evaluation Score
Alder Creek	46.06	0.07	0.15	Excellent	1
Beaver Creek	85.81	0.74	0.86	Excellent	1
Cedar Creek	356.88	201.33	56.41	Poor	5
Clair Creek	1033.22	429.87	41.61	Poor	5
Colonial Creek	436.7	243.71	55.81	Poor	5
Conestogo River - Lower	35.13	20.35	57.93	Poor	5
Cooper's Creek	116.45	59.47	51.07	Poor	5
Critter Creek	113.98	21.87	19.19	Good	2
Cuckoo Creek	6.22	2.47	39.75	Marginal	4
Forwell Creek	508.49	346.98	68.24	Poor	5
Grand River Tributaries South	82.7	26.39	31.91	Marginal	4
Horst Creek	256.94	83.05	32.32	Marginal	4
Lower Laurel Creek	1211.81	686.67	56.66	Poor	5
Maple Hill Creek	326.6	166.6	51.01	Poor	5
Martin Creek East	142	111.44	78.48	Poor	5
Martin Creek West	74.25	33.17	44.67	Poor	5
Melitzer Creek	134.54	61.48	45.7	Poor	5
Middle Laurel Creek	609.7	355.41	58.29	Poor	5
Minnow Creek	43.31	2.67	6.17	Excellent	1
Monastery Creek	488.78	74.12	15.16	Good	2
Schneider Creek	51.1	24.74	48.41	Poor	5
Willow Creek	3.99	0.46	11.5	Good	2

*Undeveloped areas (valley lands, wetlands, woodlots, and agricultural lands) were excluded from the impervious % analysis because this parameter meant to corollate with intensity of urban development in the subwatershed.

3.4 Scoring of Stormwater Management Metric

An overall stormwater evaluation score was calculated for each subwatershed by averaging the stormwater quality control, stormwater quantity control and impervious percentage scores. Overall SWM scores ranged from 1 to 4.3. SWM ratings form “poor” through “excellent” were assigned based on this scoring system.

Table 3.7 provides a summary of SWM evaluation scores and SWM ratings for each subwatershed. **Figure 3.1** summarizes the Subwatershed SWM Ranking Analysis in geographical context.

Table 3.7: Overall SWM Scores by Subwatershed

Subwatershed	Quality Control Evaluation Score	Quantity Control Evaluation Score	Impervious Percentage Evaluation Score	Stormwater Management Rating	Overall SWM Score
Alder Creek	4	4	1	Fair	3
Beaver Creek	1	1	1	Excellent	1
Cedar Creek	4	4	5	Poor	4.33
Clair Creek	2	2	5	Fair	3
Colonial Creek	3	2	5	Marginal	3.33
Conestogo River - Lower	1	1	5	Fair	2.33
Cooper's Creek	1	1	5	Fair	2.33
Critter Creek	1	1	2	Good	1.33
Cuckoo Creek	1	3	4	Fair	2.67
Forwell Creek	4	3	5	Marginal	4
Grand River Tributaries South	1	1	4	Good	2
Horst Creek	1	1	4	Good	2
Laurel Creek Reservoir	1	1	2	Good	1.33
Lower Laurel Creek	4	4	5	Poor	4.33
Maple Hill Creek	3	2	5	Marginal	3.33
Martin Creek East	2	1	5	Fair	2.67
Martin Creek West	1	1	5	Fair	2.33
Melitzer Creek	1	1	5	Fair	2.33
Middle Laurel Creek	2	2	5	Fair	3
Minnow Creek	1	1	1	Excellent	1
Monastery Creek	1	1	2	Good	1.33
Schneider Creek	3	2	5	Marginal	3.33
Willow Creek	1	1	2	Good	1.33

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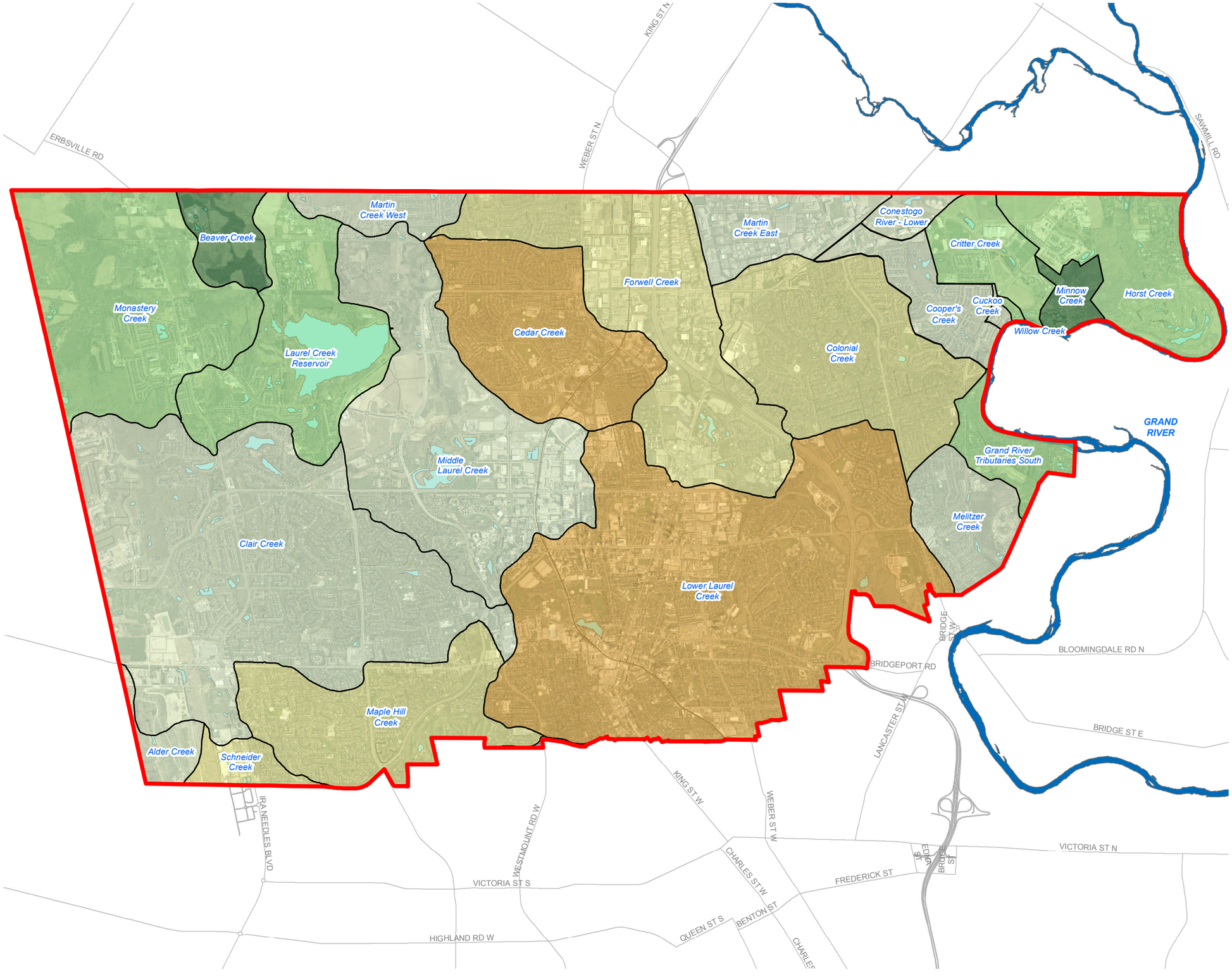
FIGURE 3.1:
SUBWATERSHED HEALTH - STORMWATER RANK



Single Line Road Network
Water Bodies
Study Area

Stormwater Management Ranking

- Excellent
- Good
- Fair
- Marginal
- Poor

0 1 2
Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: November 2018

4.0 Water Quality Metric

Water Quality is a critical indicator of subwatershed health. Poor water quality can result in a loss of biodiversity and impact the way Waterloo residents interact with local streams and rivers. By monitoring long-term trends and changes to the concentration of pollutants in local watercourses, it is possible to assess the impact of land use and SWM measures implemented within subwatershed areas. Stormwater pollutants of note may include: chloride from road salting; dissolved metals from vehicle wear; nutrients from yard waste and agricultural practices; pathogens from animal waste; and sediment from erosion and road sanding.

The most comprehensive source of water quality data within the City is a long-term water quality study of Laurel Creek spanning a period of 1996 through 2015 undertaken by the University of Waterloo Department of Geography and Resource Management (Stone, 2016). The program was implemented to measure the effects of urban development on water quality and water quantity. Standard methods were used to measure total phosphorus, suspended solids, pH, dissolved oxygen and water temperature at ten sites reflecting a range of land uses. Also included in this program is the monitoring and assessment of benthic macroinvertebrate communities, of which can help identify trends in water quality and aquatic habitat. Each monitoring site was sampled from the beginning of May through to the end of August consecutively for 20 years (1996 to 2015).

The location of water quality monitoring sites is shown in **Figure 4.1**. The ten (10) water quality monitoring sites are within only five of the subwatersheds. These are Cedar Creek (1 site), Middle Laurel Creek (2), Beaver Creek (1), Clair Creek (3) and Monastery Creek (2).

4.1 Water Quality Parameters

For this analysis, three (3) key water quality parameters were used as a reference for watershed health. These three (3) parameters are:

- Total Phosphorus;
- Suspended Sediment; and
- Dissolved Oxygen.

Phosphorus is a nutrient that is essential for plant growth in aquatic environments. Excess phosphorus can lead to eutrophication and anoxia. The Provincial Water Quality Objective (PWQO) for phosphorus is 0.03 mg/L. The percent of samples at each monitoring site that exceed the PWQO was used as an indicator to establish water quality. For subwatersheds that have more than one (1) monitoring site, the average percent exceedance was used.

Suspended sediment is a primary water quality parameter of concern for urban catchments. Sediment is washed off of paved surfaces during rainfall events. The erosion of unvegetated landscapes, channel banks and beds also contribute to suspended sediment in runoff. Large volumes of sediment deposited in watercourses can destroy aquatic habitat and can reduce the flow capacity of hydraulic structures. Other contaminants of concern including metals and pathogens may become attached to suspended sediments resulting in further risk to aquatic life and human water users. For this analysis the PWQO of 25mg/L was used. The percent of samples at each monitoring site that exceed the PWQO was used as an indicator to establish water quality. For subwatersheds that have more than one (1) monitoring site, the average percent exceedance was used.

Dissolved oxygen (DO) refers to the concentration of oxygen dissolved in water. Oxygen enters water by absorption from the atmosphere and is also generated through photosynthesis by aquatic plants and algae. Fast flowing turbulent waters generally have more DO than stagnant water due to mixing at the surface. Sufficient DO is essential to growth and reproduction of aerobic aquatic life. Average DO concentrations were used as a water quality parameter. For subwatersheds that have more than one (1) monitoring site, overall average DO concentration was used.

4.2 Scoring of Water Quality Metric

Scoring for each water quality paraments was assigned based on the distribution of water quality results at each the water quality stations. The scoring for each parameter is outlined in **Table 4.2**.

Table 4.1 Water Quality Scoring System

Evaluation Score	Description
Total Phosphorus	
1	Water quality samples were not within these categories
2	
3	Greater than 65% through 75% sample exceedance of 0.03 mg/L objective
4	Greater than 75% through 85% sample exceedance of 0.03 mg/L objective
5	Greater than 85% sample exceedance of 0.03 mg/L objective
Suspended Solids	
1	Less than 20% exceedance of 25 mg/L objective
2	Greater than 20% through 30% sample exceedance of 25 mg/L objective
3	Greater than 30% through 40% sample exceedance of 25 mg/L objective
4	Greater than 40% through 50% sample exceedance of 25 mg/L objective
5	Water quality samples were not within this category
Dissolved Oxygen	
1	Water quality samples were not within this category
2	DO averages from 7.5 mg/L but less than 8.0 mg/L
3	DO averages from 7.0 mg/L but less than 7.5 mg/L
4	DO averages from 6.5 mg/L but less than 7.0 mg/L
5	Water quality samples were not within this category

Table 4.2 provides a summary of water quality evaluation scores for subwatersheds in which water quality samples were taken. **Figure 4.2** illustrates water quality scores for each subwatershed. Eighteen (18) subwatersheds did not have sufficient water quality data to assign a water quality classification. Because there is a strong correlation between the other subwatershed metrics indicating subwatershed urbanization and water quality, the average subwatershed metric score was used for subwatersheds were there are no water quality data. This was preferable to neutral scores which would result in clustering of overall subwatershed health scores. The eighteen (18) subwatersheds that do not have sufficient data to assign a water quality score are:

- Alder Creek
- Colonial Creek
- Conestogo River - Lower
- Cooper's Creek

- Critter Creek
- Cuckoo Creek
- Forwell Creek
- Grand River Tributaries South
- Horst Creek
- Laurel Creek Reservoir
- Lower Laurel Creek
- Maple Hill Creek
- Martin Creek East
- Martin Creek West
- Melitzer Creek
- Minnow Creek
- Schneider Creek
- Willow Creek

Table 4.2 Water Quality Evaluation Scoring

	Cedar Creek	Middle Laurel Creek			Beaver Creek	Clair Creek				Monastery Creek			
	Site 3	Site 10	Site 7	Average	Site 17	Site 14	Site 8	Site 5	Average	Site 21	Site 23	Site 20	Average
Total Phosphorus (% Exceedance)	88.5	54.6	78.6	66.6	78.3	73.9	79.3	88.8	80.7	30.7	91.4	78.2	66.8
Score	5			3	4				4				3
Suspended Sediment (% Exceedance)	46.6	9.4	57.0	33.2	25.1	40.1	33.1	34.0	35.7	13.1	38.0	7.9	19.7
Score	4			3	2				3				2
Dissolved Oxygen (mg/L)	6.7	7.3	7	7.2	7.8	7.9	6.4	7.2	7.2	8.2	7.3	7.1	7.5
Score	4			3	2				3				2
Average Water Quality Score	4.3			3.0	2.7				3.3				2.3

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.1: WATER QUALITY MONITORING LOCATIONS

- WQ
- Regional Road Centerline
- Watercourse
- Waterloo Boundary
- Water Bodies
- Rivers

Subwatershed

- Alder Creek
- Beaver Creek
- Cedar Creek
- Clair Creek
- Colonial Creek
- Conestogo River - Lower
- Critter Creek
- Cuckoo Creek
- Forwell Creek
- Grand River Tributaries North
- Grand River Tributaries South
- Horst Creek
- Laurel Creek Reservoir
- Lower Laurel Creek
- Maple Hill Creek
- Martin Creek East
- Martin Creek West
- Melitzer Creek
- Middle Laurel Creek
- Minnow Creek
- Monastery Creek
- Schneider Creek
- Willow Creek

0 1 2
Kilometers

N

Aquafor Beech Limited

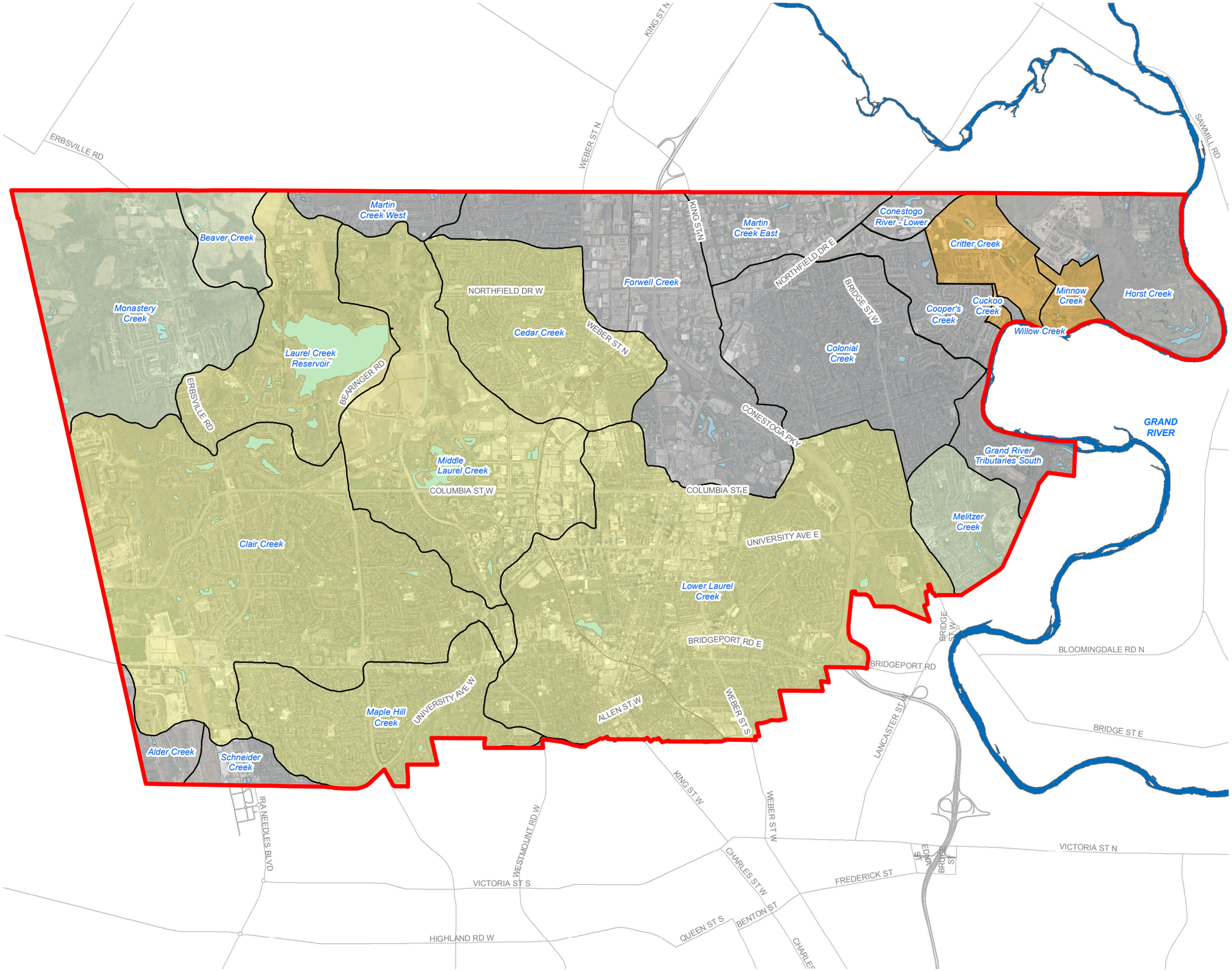
Base data provided by The City of Waterloo, 2017.

Date:

THE CITY OF Waterloo

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 4.2: SUBWATERSHED HEALTH - WATER QUALITY RANK



- Single Line Road Network
- Water Bodies
- Study Area

AQUATICRANK

- Fair
- Marginal
- Poor
- Insufficient Data

0 1 2 Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: November 2018

5.0 Stream Channel and Riparian Health

Healthy watercourses contain abundant riparian vegetation which provides habitat and shade for aquatic and terrestrial species and protects streambanks from erosive forces. Mature trees and wetland vegetation in riparian areas are the primary indicators of good riparian stream health. Additionally, channels with natural substrate and sediment depositions patterns minimally influenced by urbanization are also indication of good stream health. As catchments urbanize, changes to the fluvial system may include excessive bank erosion and channel deepening caused by an increased frequency and intensity of flows above the erosive threshold. Urbanization may also encroach on valley lands, forcing engineers to constrict the lateral migration of the channel with concrete, armorstone or other hard surfaces.

The following scores were determined based on field assessment completed as part of the City of Waterloo Erosion Master Plan (under separate cover).

5.1 Riparian Condition

During channel assessments, riparian conditions were assessed for each subwatershed. Mature trees and wetland vegetation in riparian areas were the primary indicators of good riparian stream health while the inverse is indicative of poor riparian stream health. The scoring system for the riparian health control parameter is presented in **Table 5.1**

Table 5.1: Riparian Condition Scoring System

Evaluation Score	Description
1	Excellent riparian habitat conditions for most watercourses, including mature trees and/or wetland vegetation; no significant erosion issues for most watercourses
2	Good riparian habitat conditions for most watercourses, including mature trees and/or wetland vegetation; low to moderate natural erosion rates and/or minor erosion issues
3	Moderate natural erosion rates, erosion issues, and/or degradation of engineered structures; fair riparian habitat conditions for most watercourses, and/or only locally poor habitat
4	Marginal riparian habitat conditions for most watercourses, and/or only locally fair to good habitat; significant erosion issues including degradation of engineered structures
5	Poor riparian habitat conditions for most watercourses; significant erosion issues on most watercourses, including degradation of engineered structures

5.2 Erosion Condition

A comprehensive inventory of erosion was documented at both the site and reach level within each of the subwatersheds. For this analysis, general subwatershed scores were assigned based on the average condition of the subwatershed and the severity of identified erosion issues. Scoring for this metric is presented in **Table 5.2**

Table 5.2: Erosion Condition Scoring System

Evaluation Score	Description
1	No significant erosion issues for most watercourses
2	Low to moderate natural erosion rates and/or minor erosion issues
3	Moderate natural erosion rates, erosion issues, and/or degradation of engineered structures

Evaluation Score	Description
4	Significant erosion issues on about 50% of the watercourses, including degradation of engineered structures
5	Significant erosion issues on most watercourses, including degradation of engineered structures

5.3 Aquatic Condition

During channel assessments, physical aquatic conditions were assessed for each subwatershed. Those channels with natural substrate and sediment depositions patterns minimally influenced by urbanization were given lower evaluation scores. Evaluation scores were increased for reaches with concrete channelization, piped sections, fish barriers and sediment deposition regimes heavily influenced by subwatershed urbanization. For this analysis, general subwatershed scores were assigned based on the average condition of the subwatershed and the severity of identified aquatic issues. Scoring for this metric is presented in **Table 5.3**.

Table 5.3: Aquatic Condition Scoring System

Evaluation Score	Description
1	Excellent physical aquatic habitat conditions for most watercourses, and/or contributing habitat
2	Good physical aquatic habitat conditions for most watercourses, and/or contributing habitat
3	Fair physical aquatic habitat conditions for most watercourses, and/or only locally poor habitat
4	Marginal physical aquatic habitat conditions for most watercourses, and/or only locally fair to good habitat
5	Poor physical aquatic habitat conditions for most watercourses

5.4 Scoring of Stream Health Metric

An overall stream health evaluation score was calculated for each subwatershed by averaging the channel condition and riparian condition parameters. Each subwatershed was assigned a score between one (1) and five (5). A score of one (1) given to a watercourse indicates that the riparian zone has not been altered and there is no evidence of erosion or sedimentation beyond what can be expected within a natural system. A score of five (5) given to a watercourse indicates excessive erosion resulting in channel widening to the extent that property or infrastructure is at risk of failure. Encroachment, erosion or sedimentation that are not visibly resulting in immediate risk to property or infrastructure will fall between one (1) and five (5) depending on severity. **Table 5.4** provides a summary of stream health evaluation scores for each subwatershed, which is also illustrated in **Figure 5.1**

Table 5.4: Stream Health Score by Subwatershed

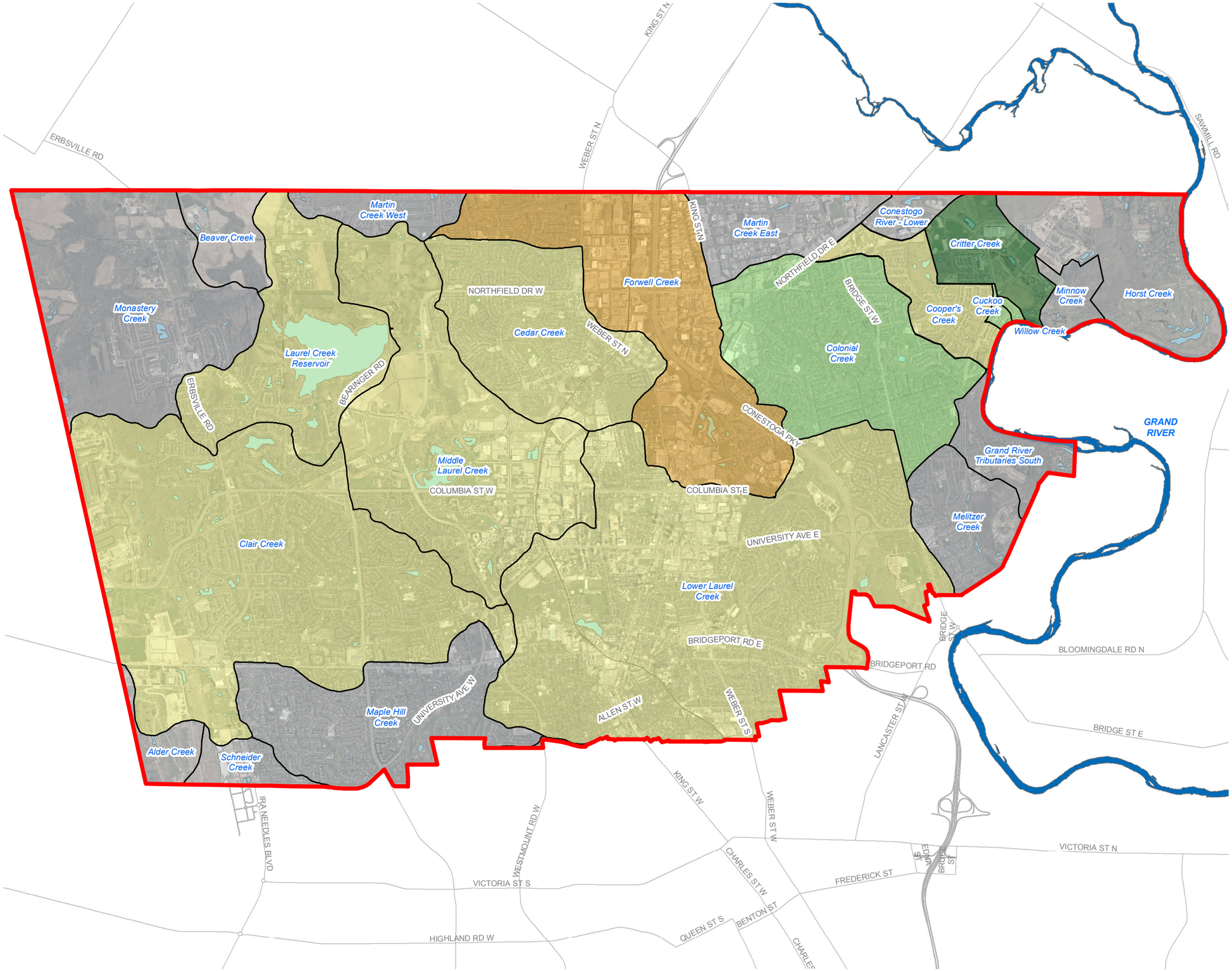
Subwatershed	Riparian Score	Erosion Score	Aquatic Score	Stream Health Ranking	Overall Stream Health Score
Cedar Creek	4	3	3	Marginal	3
Clair Creek	3	4	3	Marginal	3.33
Colonial Creek	3	3	3	Fair	2.33
Cooper's Creek	2	4	4	Marginal	2.33
Critter Creek	2	2	2	Good	4
Cuckoo Creek	1	4	4	Fair	2
Forwell Creek	5	4	4	Poor	2
Laurel Creek Reservoir	3	4	3	Marginal	2.67
Lower Laurel Creek	3	4	3	Marginal	2.33
Middle Laurel Creek	3	4	3	Marginal	3.33
Willow Creek	1	3	4	Fair	1.33

Because there is a strong correlation between the other subwatershed metrics indicating subwatershed urbanization and stream health, the average subwatershed metric score was used for subwatersheds were there are no stream health data. This was preferable to neutral scores which would result in clustering of overall subwatershed health scores. The twelve (12) subwatersheds that lack stream health data are:

- Alder Creek
- Beaver Creek
- Conestogo River - Lower
- Grand River Tributaries South
- Horst Creek
- Maple Hill Creek
- Martin Creek East
- Martin Creek West
- Melitzer Creek
- Minnow Creek
- Monastery Creek
- Schneider Creek

MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 5.1:
SUBWATERSHED HEALTH - STREAM HEALTH RANK



Single Line Road Network
Water Bodies
Study Area

Stream Health Ranking

- Good
- Fair
- Marginal
- Poor
- Insufficient Data

0 1 2
Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: November 2018

6.0 Aquatic Ecology Metric

Healthy watercourses generally support a variety of aquatic life including fish, benthic invertebrates, aquatic insects, amphibians, reptiles and water foul. In general, higher species richness is indicative of a higher quality habitat. The presence of species intolerant of disturbance are particularly good bioindicators of subwatershed health. The following three (3) parameters were used for each subwatershed to determine an overall aquatics evaluation score:

- Species Richness
- Species Intolerant of Disturbance
- Habitat Sensitivity

6.1 Species Richness

In general, a diverse, high quality habitat is able to support a variety of species. Therefore, higher species richness is indicative of a higher quality habitat. Scores of 0-20 were divided among the five categories as shown in **Table 6.1** to develop the ranges used in the evaluation score.

6.2 Species Intolerant of Disturbance

The presence of species that are intolerant to disturbance is indicative of higher quality habitat. Therefore, habitats with a greater number of intolerant species are higher quality than habitats with fewer intolerant species. Scoring ranges are presented in **Table 6.1**.

6.3 Species Intolerant of Disturbance

In general, coldwater habitat and the species which reside in them are more sensitive to disturbance than warmwater habitat and warmwater species. Scores were applied so that coldwater habitats are the most sensitive, followed by coolwater and then warmwater. Scoring ranges are presented in **Table 6.1**.

6.4 Scoring of Aquatic Ecology Metric

An overall aquatic ecology score was calculated for each subwatershed by averaging the species richness, species intolerant of disturbance and species tolerant of disturbance scores. A score of one (1) given to a watercourse would indicate that the watercourse is expected to currently support a wide diversity of aquatic life consistent with natural conditions. A score of 5 (five) given to a watercourse would indicate that biodiversity within the watercourse is expected to be severely degraded. Watercourses that have historically supported coldwater species but are at risk of diminished coldwater habitat due to thermal pollution or lack of baseflow received a score of one (1). **Table 6.1** provides a summary of biotic community health evaluation scores for each subwatershed, which is also illustrated in **Figure 5.1**

Table 6.1: Aquatic Ecology Score by Subwatershed

Subwatershed	Species Richness	Species Richness Score	Species Intolerant of Disturbance	Species Intolerant of Disturbance Score	Aquatic Ranking	Overall Aquatic Score
Beaver Creek	15	2	0	0	Fair	2.67
Cedar Creek	7	4	0	0	Marginal	4
Clair Creek	6	4	0	0	Marginal	4
Critter Creek	4	5	0	0	Poor	4.33
Cuckoo Creek	4	5	0	0	Poor	4.33
Laurel Creek Reservoir	14	3	0	0	Marginal	3.67
Lower Laurel Creek	14	3	0	0	Marginal	3.67
Maple Hill Creek	6	4	0	0	Marginal	4
Melitzer Creek	8	4	1	1	Fair	3
Middle Laurel Creek	14	3	0	0	Marginal	3.67
Minnow Creek	4	5	0	0	Poor	4.33
Monastery Creek	10	3	0	0	Fair	3

Because there is a strong correlation between the other subwatershed metrics and the presence and health of aquatic species, the average subwatershed metric score was used for subwatersheds were there are aquatic species data. This was preferable to neutral scores which would result in clustering of overall subwatershed health scores. The eleven (11) subwatersheds did not have sufficient aquatic species data to assign an overall aquatics score are:

- Alder Creek
- Colonial Creek
- Conestogo River - Lower
- Cooper's Creek
- Forwell Creek
- Grand River Tributaries South
- Horst Creek
- Martin Creek East
- Martin Creek West
- Schneider Creek
- Willow Creek

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MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE: 6.1
SUBWATERSHED HEALTH - AQUATIC RANK

- Single Line Road Network
- Water Bodies
- Study Area

Aquatic Ranking

- Fair
- Marginal
- Poor
- Insufficient Data

0 1 2
Kilometers

N

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Base data provided by The City of Waterloo, 2017.

Date: November 2018

7.0 Subwatershed Scores

Existing conditions subwatershed scores were calculated by adding evaluation scores for each of the subwatershed health metrics:

1. Terrestrial Subwatershed Health
2. Stormwater Management
3. Water Quality
4. Stream Channel and Riparian Health
5. Aquatic Ecology

A maximum score of five (5) was achievable for each of the subwatershed health metrics. The maximum total subwatershed score achievable, indicting the worst possible existing conditions for any subwatershed was 25. The minimum score achievable, indicting the best possible existing conditions for any subwatershed was 5.

Upon evaluating the existing conditions subwatershed scores, Forwell Creek and Schneider Creek subwatersheds were determined to have the highest score, indicating the worst subwatershed conditions in the City. The existing conditions subwatershed scores of 21 resulted from scores of 4.0 (marginal) or higher in all evaluation categories where data was available. Cedar Creek, Lower Laurel Creek, Martin Creek East, Forwell Creek also received scores of 20.

Willow Creek subwatershed was determined to have the lowest score, indicating the best subwatershed conditions in the City. Within this creek, the existing conditions subwatershed score of 9 resulted from scores between 2.0 (good) and 3.0 (fair) in three (3) of the metrics.

On average, subwatersheds within the City of Waterloo received an existing conditions subwatershed score of 15.5.. Individual evaluation scores and overall existing conditions subwatershed scores are shown for each subwatershed in

Table 7.1**,** while **Figure 7.1** shows this scoring graphically**. Figure 7.2** geographically shows the distribution on priority subwatersheds across the City.

7.1 Subwatershed Prioritization

Existing conditions subwatershed scores are used to establish a hierarchy of prioritization for the City to initiate subwatershed improvement projects including LID road retrofits. Four (4) levels of subwatershed priority were established.

Those subwatersheds with scores greater than 20 are classified as **Priority 1 Subwatersheds**. In order to improve the environmental conditions in these subwatersheds, municipal stormwater projects including conveyance control works should receive high priority. The nine (9) Priority 1 subwatersheds are:

- Cedar Creek (Score = 20)
- Lower Laurel Creek (Score = 20)
- Martin Creek East (Score = 20)
- Forwell Creek (Score = 21)
- Schneider Creek (Score = 21)

Those subwatersheds with scores greater than 15 and less than or equal to 19 are classified as **Priority 2 Subwatersheds**. In order to improve the environmental conditions in these subwatersheds, municipal stormwater projects including conveyance control works should receive moderate priority. The Priority 2 subwatersheds are:

- Middle Laurel Creek (Score = 17)
- Clair Creek (Score = 18)
- Colonial Creek (Score = 18)
- Conestogo River – Lower (Score = 19)
- Maple Hill Creek (Score = 19)

Those subwatersheds with scores greater than 11 but less than or equal to 15 are classified as **Priority 3 Subwatersheds**. In order to improve the environmental conditions in these subwatersheds, municipal stormwater projects including conveyance control works should receive low priority. The Priority 3 subwatersheds are:

- Laurel Creek Reservoir (Score = 13)
- Melitzer Creek (Score = 13)
- Cooper's Creek (Score = 14)
- Critter Creek (Score = 14)
- Grand River Tributaries South (Score = 14)
- Martin Creek West (Score = 14)
- Alder Creek (Score = 15)
- Cuckoo Creek (Score = 15)

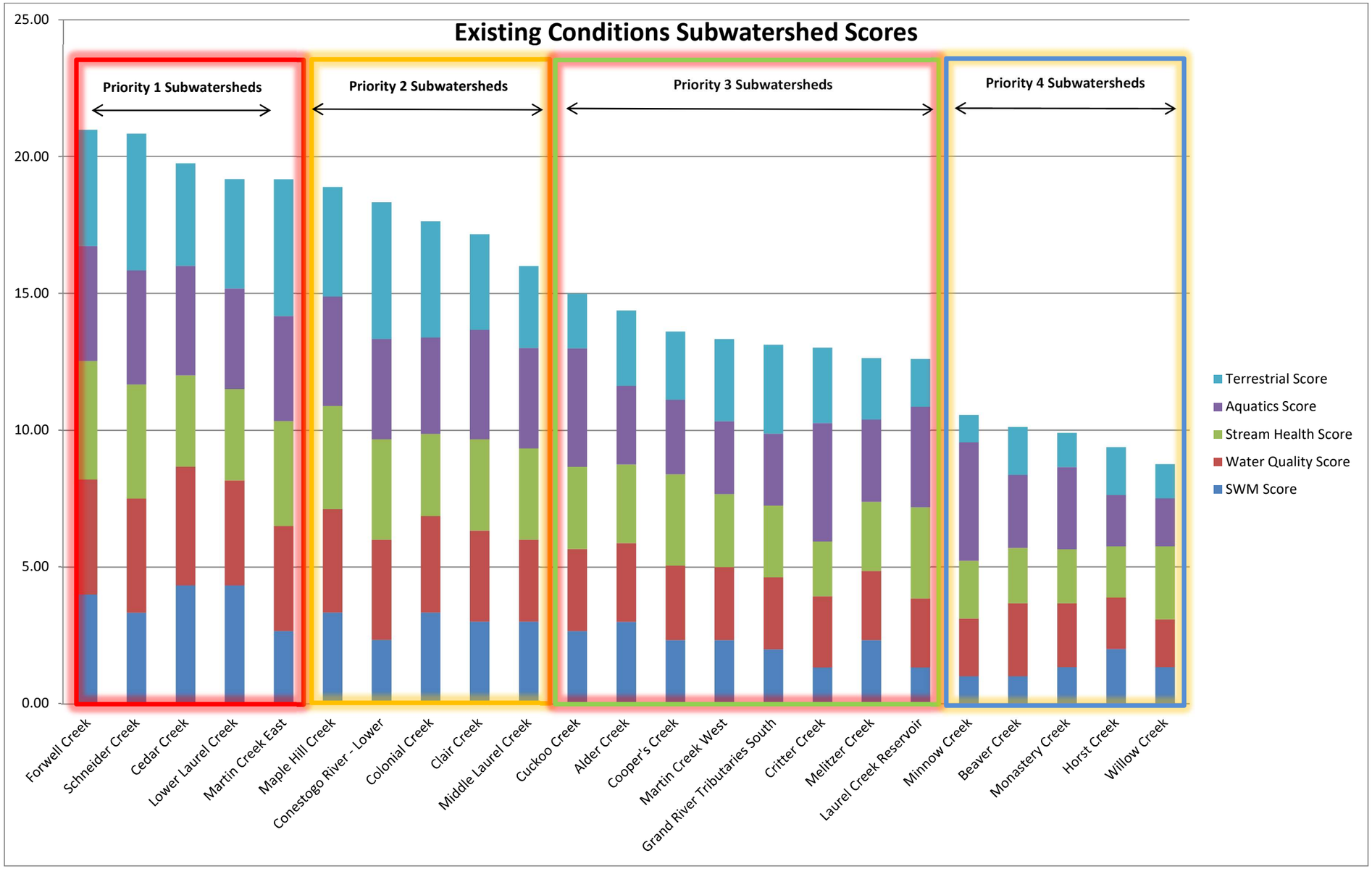
Those subwatersheds with scores less than less than or equal to 11 are classified as **Priority 4 Subwatersheds**. These subwatersheds are the closest to natural environmental conditions of the subwatersheds in the City of Waterloo. In order to sustain the environmental conditions in these subwatersheds, development and intensification should focus on providing sufficient buffers and maintaining the natural hydrologic cycle through source control initiatives and conveyance control works, and end-of-pipe facilities. The Priority 4 subwatersheds are:

- Willow Creek (Score = 9)
- Horst Creek (Score = 10)
- Monastery Creek (Score = 10)
- Beaver Creek (Score = 11)
- Minnow Creek (Score = 11)

Table 7.1: Evaluation of Existing Conditions Priority Rating

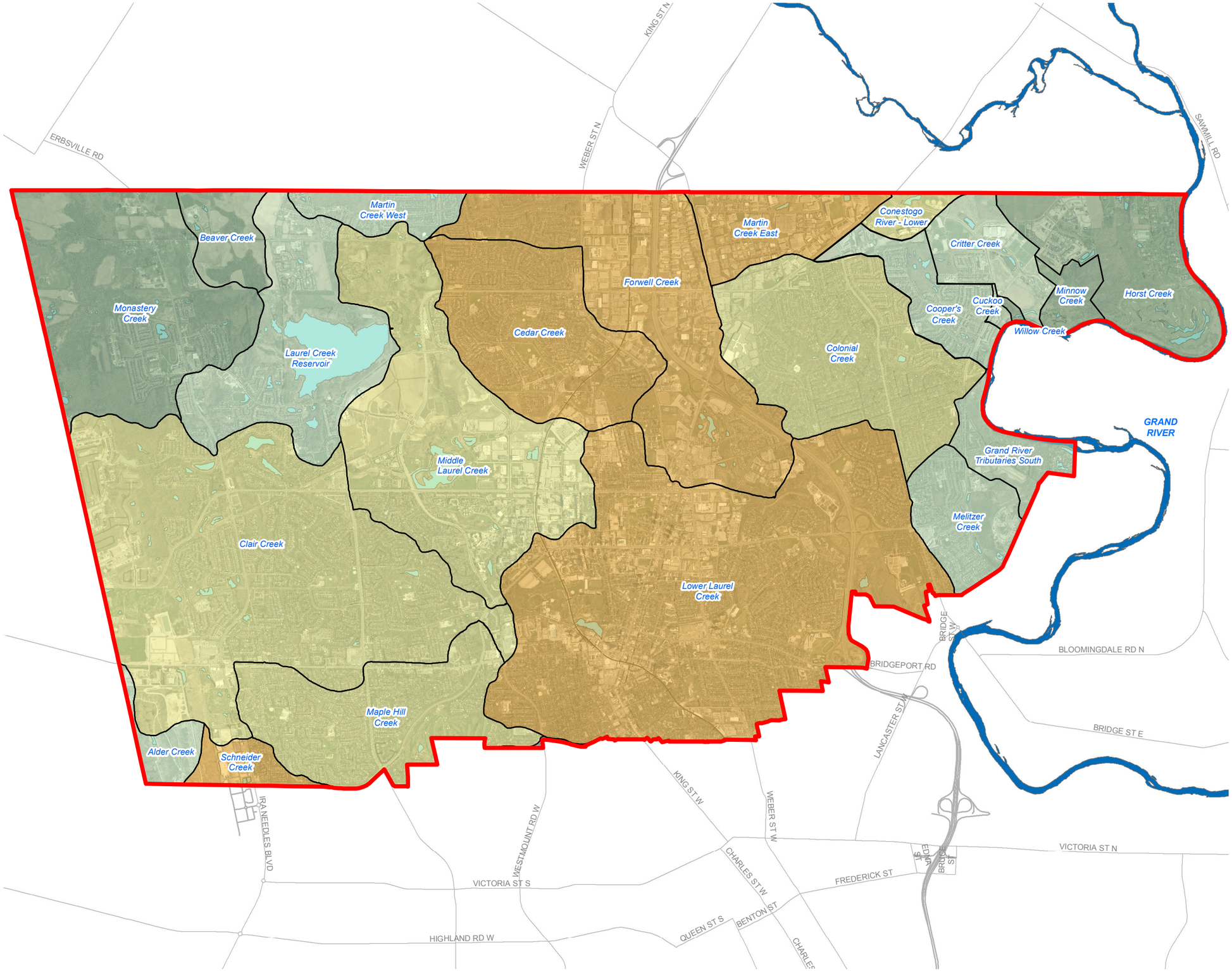
Subwatershed	SWM Score	Water Quality Score	Stream Health Score	Aquatics Score	Terrestrial Score	Total Score	Existing Conditions Priority Rating
Alder Creek	3.00	-	-	-	2.75	15	2
Beaver Creek	1.00	2.66	-	2.67	1.75	11	1
Cedar Creek	4.33	4.33	3.33	4	3.75	20	4
Clair Creek	3.00	3.33	3.33	4	3.5	18	3
Colonial Creek	3.33	-	3.33	-	4.25	18	3
Conestogo River - Lower	2.33	-	-	-	5	19	3
Cooper's Creek	2.33	-	3.33	-	2.5	14	2
Critter Creek	1.33	-	2	4.33	2.75	14	2
Cuckoo Creek	2.67	-	3	4.33	2	15	2
Forwell Creek	4.00	-	4.33	-	4.25	21	4
Grand River Tributaries South	2.00	-	-	-	3.25	14	2
Horst Creek	2.00	-	-	-	1.75	10	1
Laurel Creek Reservoir	1.33	-	3.33	3.67	1.75	13	2
Lower Laurel Creek	4.33	-	3.33	3.67	4	20	4
Maple Hill Creek	3.33	-	-	4	4	19	3
Martin Creek East	2.67	-	-	-	5	20	4
Martin Creek West	2.33	-	-	-	3	14	2
Melitzer Creek	2.33	-	-	3	2.25	13	2
Middle Laurel Creek	3.00	3	3.33	3.67	3	17	3
Minnow Creek	1.00	-	-	4.33	1	11	1
Monastery Creek	1.33	2.33	-	3	1.25	10	1
Schneider Creek	3.33	-	-	-	5	21	4
Willow Creek	1.33	-	2.66	-	1.25	9	1

Figure 7.2: Evaluation of Existing Conditions Priority Rating



MUNICIPAL CLASS EA INTEGRATED STORMWATER MANAGMENT MASTER PLAN

FIGURE 7.2:
SUBWATERSHED HEALTH - PRIORITY RANKING



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Base data provided by The City of Waterloo, 2017.

Date: November 2018

8.0 Recommendations to Address Data Gaps

To address existing data gaps as identified in this assessment, the following recommendations have been put forward for consideration by the City of Waterloo:

- It is recommended that the City develop and initiate a program comprehensive City-wide water quality and aquatic resources monitoring program. This program is recommended to include flor proportionate sampling in order to develop Event Mean Concentrations (EMCs) for water quality contaminants, as well as benthic macroinvertebrate and fisheries sampling programs.

- It is recommended that once the City has collected sufficient data to fill the identified gaps, that the Subwatershed Health Assessment be repeated to recategorize the subwatershed health of the various subwatersheds.

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