Appendix VIII. Level of Traffic Stress

Level of Traffic Stress

A successful cycling network is one that makes it possible for people to get to where they want to go (connected) without significant detours (convenient) and without exposing cyclists to conditions that are beyond their tolerance for traffic stress (comfortable). Comfortable cycling routes are those with less interaction between bicycles and motor vehicles either due to slow traffic speeds and low volumes of traffic, or those that provide physical separation between cyclists and motor vehicle traffic on streets with higher traffic speeds and volumes.

Survey data from The Region of Peel and the City of Mississauga shows that feeling uncomfortable or unsafe is a significant deterrent to cycling in Mississauga. There is a strong preference among people who were surveyed to improve cycling comfort and safety through the provision of separated or protected cycling facilities.

Different people will tolerate different levels of traffic stress. To better understand the potential to increase cycling in Mississauga, a cycling survey was conducted and survey respondents were asked about their comfort level cycling on different kinds of bicycle facilities and different types of roadways. Based on the results, respondents were categorized as one of four types of cyclists.

- Strong and Fearless;
- Enthusiastic and Confident;
- Interested but Concerned; and
- No Way No How

For more information on these categories see **Figure 10** in the main report.

Results of the Mississauga Cycling Survey showed that the majority of respondents (61%) are "interested but concerned" cyclists, i.e., people who are curious about cycling and would like to cycle more often, but are afraid of sharing the roadway with motor vehicles. Survey results showed that 96% of cycling survey participants would either continue to cycle, cycle more often, or start cycling if facilities that were comfortable for "interested but concerned" cyclists were implemented.

A level of traffic stress analysis was undertaken for the existing and recommended cycling network to better understand the level of stress experienced by most cyclists or would-be cyclists who identify as interested but concerned.

Level of Traffic Stress Analysis

A traffic stress analysis is an objective evaluation based on data that assigns each bicycle facility segment a level of traffic stress score. Level of traffic stress analyses have been included in a number of recent cycling master plan updates in North American cities. Level of traffic stress classifications have been developed using available traffic data and have been based on a 2012 study, published through the University of San Jose, California, that developed a method to measure low-stress connectivity for the purpose of evaluating and guiding cycling network planning.[1] The researchers proposed a set of criteria to classify road segments as one of four levels of traffic stress (LTS) as shown in **Table VIII-1**. The LTS classifications were used to classify all the streets in the city's road network to identify the gaps in low-stress connectivity and prioritize comfortable bicycle facilities in locations that will connect "islands" of low stress streets within the network.

Table VIII-1: Levels of traffic stress (LTS)—definitions[2]

LTS 1	Low traffic stress and requiring less attention from cyclists. Suitable for almost all cyclists, including children (interested but concerned cyclists).
LTS 2	Low traffic stress but requiring attention and therefore suitable for most adult cyclists (interested but concerned cyclists).
LTS 3	More traffic stress than level 2, suitable for adults who are confident cyclists (enthusiastic and confident cyclists).
LTS 4	Highest level of stress, suitable for strong and fearless cyclists.

Applying a rigorous LTS classification to the entire road network was beyond the scope of the 2018 Cycling Master Plan update project. As a result, the focus for the LTS analysis was the existing and proposed cycling network. This provided the opportunity to visualize the before-and-after effects on levels of traffic stress that would result from the implementation of new, or upgrading of existing, cycling route facilities. This information was used to:

- Quantify the distribution of existing cycling network kilometres (centreline) by level of traffic stress;
- Identify cycling routes and the connectedness of existing cycling routes by level of traffic stress; and
- Identify locations where new routes and/or improvements to existing cycling routes are needed to connect a low stress network.

The maps in **Figures VIII-1 to VIII-3** help to illustrate the experience for the majority of cyclists or would-be cyclists who identify as interested but concerned.

Methodology

A set of criteria was developed based on the above-mentioned study, and subsequent research.[3] The criteria were used to classify the existing and proposed cycling network in Mississauga by level of traffic stress and are described further below.

Traffic Stress Criteria for Road and Trail Segments

All segments of the cycling network, both on- and off-road, were assigned a level of traffic stress (LTS).

Criteria were developed for three types of cycling facilities: physically separated facilities like separated bike lanes and shared multi-use trails, conventional bike lanes, and streets with mixed bicycle and motor vehicle traffic. The criteria aim to include factors that determine the stress or discomfort that cyclists feel when sharing the road with motor vehicles, factors for which data is readily available and easily measured. Data sources included:

- City of Mississauga traffic data, e.g., traffic counts, posted speeds and operating speeds for some segments;
- Region of Peel traffic data including volumes and operating speeds on regional roads; and
- GIS mapping of the road and trail networks including location of existing and proposed cycling facilities and pedestrian/bicycle-only bridges.

More details on these criteria are provided in **Table VIII-2**. These criteria are aligned with the research cited above with some small modifications to accommodate data availability.

Table VIII-2: LTS classification tables

FACILITY TYPE

Separated Cycling Facilities	LTS 1	LTS 2	LTS 3	LTS 4
Cycle Track (CT)/Separated Bike Lane (SBL)	All CTs/SBLs	NA	NA	NA
Multi-Use Trail (MUT)	All MUTs	NA	NA	NA

Conventional Bike Lanes	LTS 1	LTS 2	LTS 3	LTS 4
Posted Speed Limit or Operating Speed	0–49 km/h	50–59 km/h	60–69 km/h	70+ km/h
Width of Bike Lane	1.8 m or wider	Less than 1.8 m	NA	NA
Number of General Travel Lanes	1 per direction	1 per direction	2 or more per direction	NA
On-Street Parking	No parking	Parking	NA	NA

Shared Routes (residential, no centreline)	LTS 1	LTS 2	LTS 3	LTS 4
Posted Speed Limit or Operating Speed	0–49 km/h	50–59 km/h	NA	60+ km/h

Shared Routes (non-residential)	LTS 1	LTS 2	LTS 3	LTS 4
Posted Speed Limit or Operating Speed	NA	0–49 km/h	50–59 km/h	60+ km/h
General Travel Lanes	NA	1 per direction	1 per direction	2 or more per direction

Limitations of LTS

It should be noted that LTS is not a measure of safety. LTS considers cyclist stress as it relates to sharing space on the roadway with motor vehicles. LTS addresses perceived safety by users, and speaks to the likelihood that "interested but concerned" cyclists will feel comfortable cycling on a particular roadway or bike facility. Perceptions of safety affect cyclists' decisions on whether to cycle, and on which routes. However, research has shown a correlation between perceptions of safety and actual safety.[4] There is also evidence that bicycle route infrastructure can be designed to prevent injuries to cyclists. For example, cycle tracks or separated bike lanes (classified as LTS 1) have been shown to have higher safety performance and the lowest risk of bicycle collisions compared to other facility types or to no bicycle facilities on major roads.[5]

Separated Cycling Facilities

Separated cycling facilities including raised cycle tracks, separated bike lanes and multi-use trails have the lowest rating of LTS 1. However, an LTS analysis of intersections would likely show high levels of traffic stress at intersections where no dedicated crossings have been implemented, particularly where there are high volumes of turning vehicles or channelized right turn lanes. More details on intersections are provided starting on page 6.

There are several different types of physical separation that could be used including curbs, flexible bollards, raised medians, parking lanes, planters, etc. Although cyclists have provided feedback about some discomfort using multi-use trails when they are busy and many cyclists and pedestrians are present, this discomfort is not in the same category as stress due to motor vehicle traffic and does not typically discourage or prevent people from cycling.

Conventional Bike Lanes

Conventional bike lanes are painted lanes on the roadway adjacent to the curb and provide dedicated space for bicycles only. Depending on the design of the bike lane and the operating conditions of the roadway on which they are installed, conventional bike lanes can create a low to high stress environment. Wide bike lanes on streets with one travel lane in each direction and slow moving traffic can provide a very comfortable environment for cycling. However, bike lanes on multi-lane roadways with high traffic speeds or those adjacent to on-street parking with high turnover can create very uncomfortable conditions for cyclists.

Criteria that influence the LTS score for conventional bike lanes are shown in **Table VIII-2** and include operating speeds of adjacent traffic, operating space for cyclists (width of the bike lane), width of the roadway (number of through travel lanes) and the presence or absence of on-street parking. LTS criteria that have been developed in the available research have included the width of on-street parking stalls adjacent to bicycle lanes. This provides a better understanding of the space available for cyclists to operate outside of the door zone (area occupied by opening parked car doors) while remaining in the bicycle lane.

There are a small number of locations with parking adjacent to bike lanes in Mississauga (e.g., some sections of 10th line, Webb Drive and Bristol Road). On-street parking stall widths in these locations are not consistent and there is no data readily available on these widths. As a result, the width of parking stalls was assumed to be approximately 2.6 m. A comfortable (LTS 1) operating width for a bike lane and parking stall combined would allow 2.1m width for the parked vehicle, 1.0 m buffer zone for an opened vehicle door, and minimum 1.5 m clear operating space for the cyclist (minimum 4.6 m combined width).

Typically, if cars are illegally parked in the bike lane on a frequent basis, shared route criteria are used on these segments. However, this information was not readily available nor was it raised as a significant issue during stakeholder consultation, so it was not considered in this LTS evaluation.

Existing bike lanes show a variety of LTS ratings based on the operating conditions of the roadway, presence or absence of parking and width of the bike lane. Most existing bike lanes are 1.5 m wide, with some older ones being narrower (1.2 m), and those installed more recently being typically 1.8 to 2.0 m wide with some including a painted buffer. Examples of bike lane LTS scores are as follows:

- LTS 1—Bike lanes on 2-lane roads with 40 km/h posted speed limits (or operating speed when data is available), such as the northwest section of Mississauga Valley Boulevard.
- LTS 2—Most existing bike lanes on 2-lane roads such as Truscott Drive and Camilla Road.
- LTS 3—Existing bike lanes on 4-lane roads, such as Confederation Parkway and sections of Erin Centre Boulevard and Bristol Road West.
- LTS 4—Bike lanes on roads with high operating speeds (over 70 km/h), such as sections of Mississauga Road south of Dundas Street West.

Traffic Speed

Traffic speed is often cited by cyclists as affecting their level of comfort. Operating speeds are available for many of the streets in the cycling network and wherever data was available, 85th percentile operating speeds were used. Posted speed limit was used in all other cases.

Street Width

Street width is measured by the number of through travel lanes. This information is readily available, provides an indicator of the general amount of motor vehicle activity on the street and the relative distance between cyclists and left turning vehicles that will cross the path of cyclists at driveways and intersections.

Shared Routes

Cyclists do not have a designated lane on shared routes and the LTS analysis assumes that level of traffic stress is not affected by bike route signage, sharrow pavement markings or the width of the curb lane. Traffic volume has been used in some more recent traffic stress classifications, however this information was not available for most local and minor roads where shared routes are located.

When a centreline is present, research suggests that motorists and cyclists are guided into the same operating space increasing the opportunity for conflict, whereas when a centreline is absent traffic tends to operate more slowly and traffic is more likely to give priority to the space on the right to cyclists while sharing the middle of the roadway. As such, shared routes with no centreline typically have lower LTS. Where information was not available on the presence of a centreline, residential street classification was assumed to indicate no centreline and low traffic volumes.

Similar to conventional bike lanes, the LTS rating for existing shared routes also varied depending on the operating conditions of the roadway. LTS ratings for shared routes include:

- LTS 1—Signed routes on residential roads with posted speed limits (or operating speeds where available) of 40 km/h or less, such as Indian Grove and Ogden Avenue.

- LTS 2—Most signed routes on residential roads, with 50 km/h posted speed limits such as Indian Road and Fairview Road.
- LTS 3—Signed routes on non-residential 2-lane roads with 50 km/h or higher posted speed limits such as Cantay Road and Financial Drive.
- LTS 4—Signed routes on 4-lane roads, or those with operating speeds above 60 km/h, such as Ninth Line and City Centre Drive.

Intersections and Crossings

Intersections are typically analyzed separately from road segments in an LTS analysis. The geometry and operations of an intersection can significantly affect the level of traffic stress for cyclists. Auxiliary turn lanes and channelized right turn lanes that require motor vehicles to cross cycling lanes and vice versa can create very stressful conditions. Unsignalized crossings on busy roadways are also a barrier to cycling.

An inventory of all intersections was beyond the scope for the CMP update, but would be beneficial in the future to ensure that low levels of traffic stress apply equally to intersections/crossings and network segments, and to help prioritize intersection upgrades to improve cycling conditions. An LTS classification for intersections would need to be customized for Mississauga, due to its suburban form and road design and the prevalence of two-way boulevard multi-use trails in several locations. Some factors to be considered when developing LTS criteria for intersections in Mississauga are:

- The termination of bike lane pavement markings at the approach to intersections, where cyclists are expected to merge with traffic;
- The length of pocket bike lanes, sometimes painted green, to the left of dedicated right turn lanes;
- Intersection angle and curb radii effects on the speed of turning vehicles;
- Adjacent bus stops at intersection approaches with merging and stopping bus traffic;
- Bidirectional multi-use trails which may or may not have crossride pavement markings and/or bike signals;
- Bidirectional multi-use trails and one-way bike lanes that cross channelized right-turn lanes; and
- Bidirectional multi-use trails and/or bike lanes that cross roundabouts.

Classifying the Road Network

In order to classify the remaining road network where cycling facilities do not exist and are not proposed, the LTS metrics were simplified, due to data, technical and time limitations. The LTS of the remaining road network was assigned as follows:

- Assumes no cycling facility, therefore shared route criteria in **Table VIII-2** were used.
- Arterials and major collectors were assigned LTS 4. This is due to multi-lane conditions and/or having operating speeds above 60 km/h.
- Minor collectors and local roads with a posted speed limit of 40 km/h or less or were assigned LTS 1.
- Minor collectors and local roads with a posted speed limit of 50 km/h were assigned LTS 2.

Figure VIII-1 shows the level of traffic stress ratings for the full road network in Mississauga. Most minor, local roads are classified as LTS 2, while most arterial and major collectors

(which provide critical connections between neighbourhoods and across the city) are classified as LTS 4 when a bicycle facility is not present. **Figure VIII-2** shows the level of traffic stress of the existing cycling network only (as of March 2018) and **Figure VIII-3** shows the future LTS of the proposed cycling network after full implementation.

Higher LTS on Local Roads

LTS analyses in other cities often show local, residential roads as very comfortable, i.e., LTS 1. Because Mississauga has a suburban built-form, with wider, local, residential roads, and higher posted and operating speeds on local roads than more urban cities, most of Mississauga's local roads are classified as LTS 2. (Although LTS 2 is comfortable for most adult cyclists, it tends to be less comfortable for children and can be a deterrent to cycling for children and their parents). In some cases, very short, narrow, and/or dead-ending roads may have slower operating speeds, however operating speed data is not readily available in most of these instances. This means there is likely an overrepresentation of local roads rated at LTS 2.

LTS and Facility Upgrade Recommendations

The LTS analysis highlighted which segments of the existing cycling network were LTS 3 and 4, and thus flagged them for further investigation to determine if more comfortable (LTS 1 or 2) facility designs were feasible if there were no other comfortable routes close by. A closer examination of the operating conditions of these LTS 3 and 4 segments of the existing cycling network, was undertaken to identify where upgrades were needed and what types of facilities should be recommended. For more information on facility type selection see section 6.2.1 in the main report.

In some cases, existing cycling routes that scored LTS 3 and 4 were left as is, due to being rural routes, or having comfortable (low-LTS) alternative routes nearby. For example, a paved shoulder on Winston Churchill Boulevard south of Royal Windsor Drive is rated LTS 4. However there is low population and employment density in this area, very few destinations and nearby multi-use trails on Lakeshore Road West and Southdown Road provide a comfortable through route as an alternative.

Figure VIII-1: Level of traffic stress ratings for full road network in Mississauga

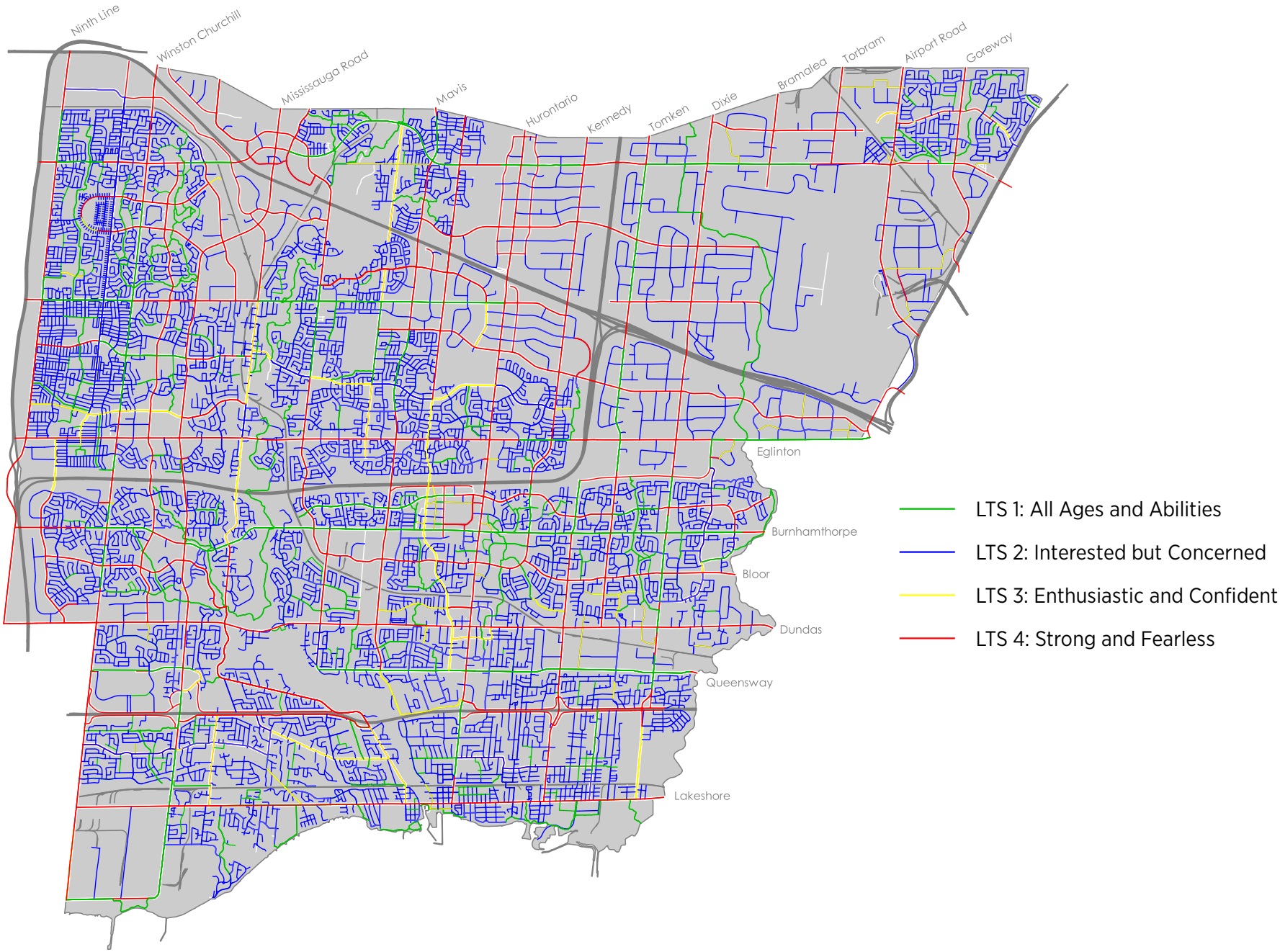


Figure VIII-2: Level of traffic stress of the existing cycling network only (as of March 2018)

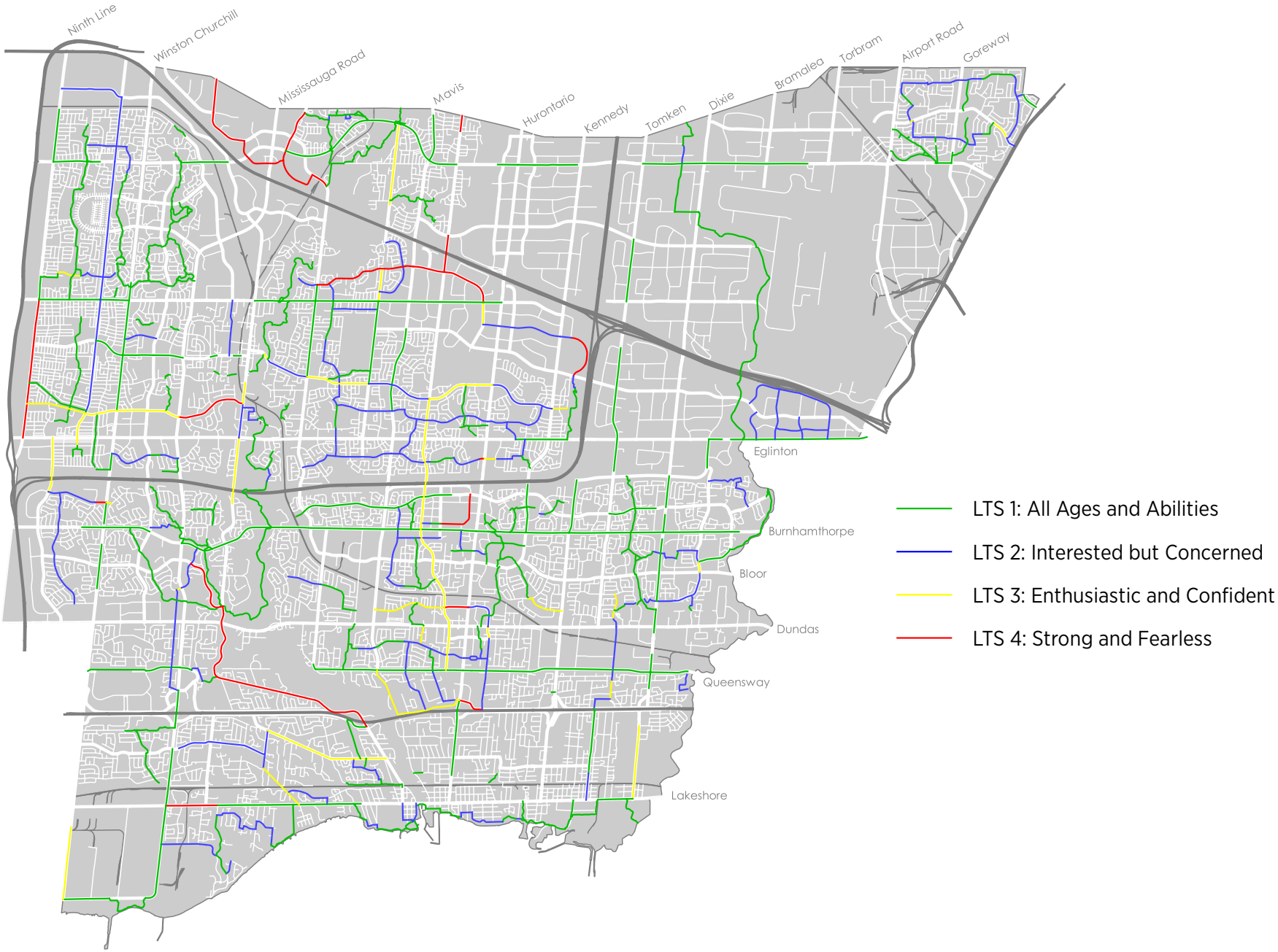
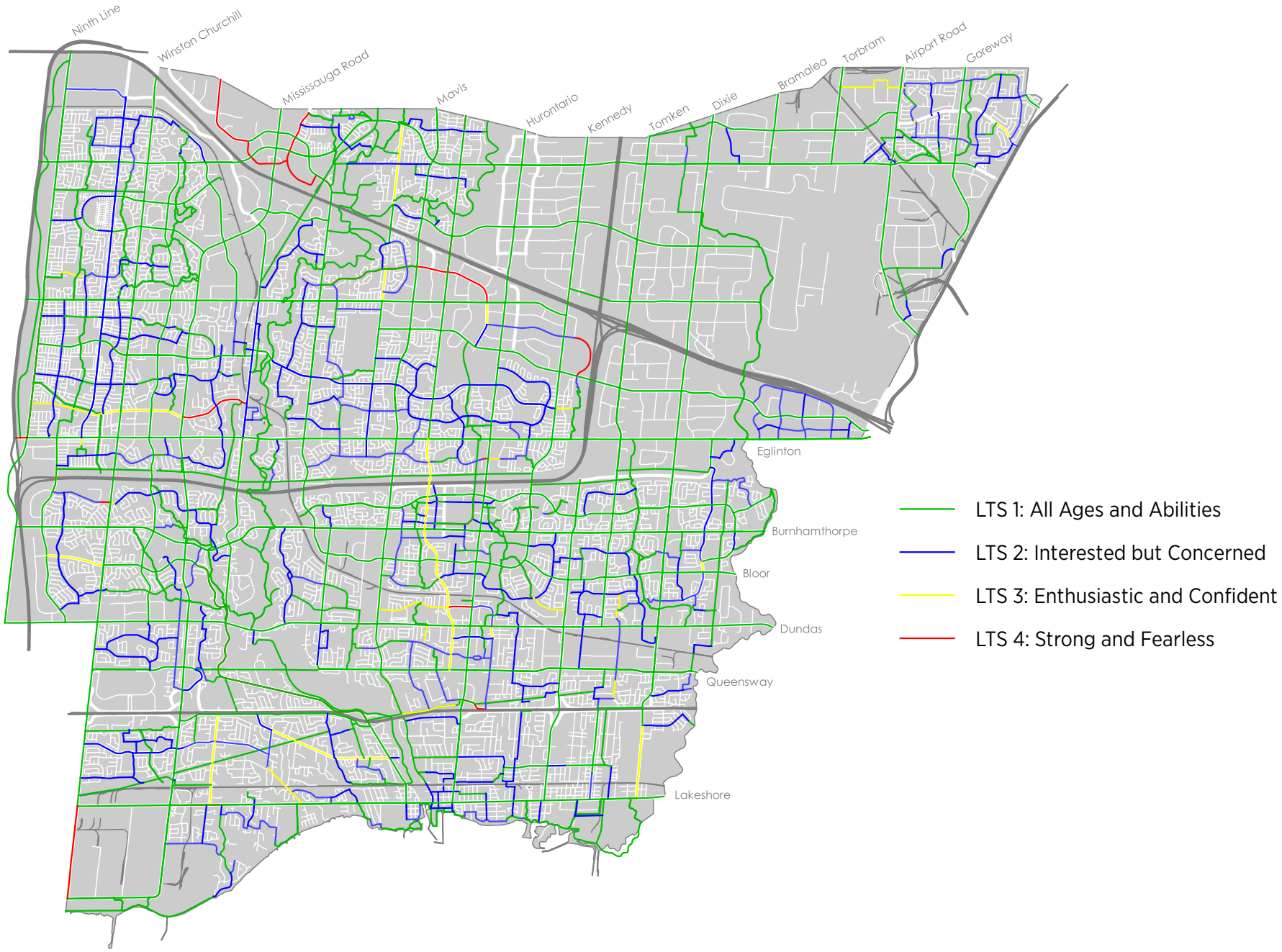


Figure VIII-3: Future level of traffic stress of the proposed cycling network after full implementation



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