City of Thunder Bay

TRANSPORTATION MASTER PLAN

Background Report I:

MULTIMODAL LEVEL OF SERVICE

April 2019

Superior by Nature

Prepared by IBI Group

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1 Introduction

1.1 Background

As the City of Thunder Bay moves forward with multimodal initiatives including the adoption of a Complete Streets policy, expanding the cycling network, improving transit services, and upgrading the pedestrian realm, it will be important to consider a performance measurement that weighs the experience of all road users.

Municipalities have traditionally focused on the performance of vehicular traffic when evaluating the level of service (LOS) of the road network. Recommended network modifications aimed at improving vehicle operations often degrade the operating condition of other modes that are not currently incorporated into the standard vehicular LOS indicator. In other words, the trade-offs between improving vehicular operations and the impacts on the level of service of other modes of transportation (transit, cycling, and pedestrian) are often overlooked. To measure the impacts and trade-offs to other modes, a formalized set of performance measures is needed.

Recently, there have been several initiatives aimed at developing a framework for evaluating a multimodal level of service (MMLOS), such as the National Cooperative Highway Research Program's (NCHRP) *Multimodal Level of Service Analysis for Urban Streets report (2008)* and the City of Ottawa's *Multi-Modal Level of Service (MMLOS) Guidelines (2015)*.

The MMLOS framework is a collection of level of service measures for road segments and signalized intersections intended to guide transportation planners in assessing level of service for all road users.

Adopting the use of MMLOS is an integral part of a Complete Streets approach, one that recognizes all modes are important. It acknowledges that trade-offs are often required between each mode due to physical or financial constraints. MMLOS gives cities the tools to quantify those trade-offs and the ability to evaluate alternatives in order to plan for quality networks for each mode.

1.2 Application of MMLOS

The framework outlined within this document is intended to be applied whenever a level of service analysis is required, such as a transportation environmental assessment or traffic impact analysis for a proposed development application. This document outlines the methodology and procedure for determining the levels of service for pedestrians, cyclists, transit riders, and motorists, as well as a series of target levels of service depending on the local contexts. These methods and targets have been customized for Thunder Bay.

The MMLOS framework is not intended to be the basis of design decisions nor is it intended replace professional judgement for safety and accessibility.

Using the MMLOS framework, transportation planners can identify a corridor or intersection's level of service for vehicles, pedestrians, transit, and cyclists to objectively compare the trade-offs of various network alternatives. The application of an MMLOS approach is not intended to require an immediate retrofit for all streets to meet specified targets, rather, it provides a framework that can be applied to the City's existing procedures to assess the transportation impacts and mobility needs of all road users.

1.3 MMLOS Overview

Different approaches to level of service are proposed for pedestrians, bicycles, transit, and drivers. Pedestrian and bicycle level of service are measured at both road segments and signalized intersections, while vehicular level of service is measured only at signalized intersections. Transit level of service does not specify intersection nor segment, but focuses on the overall experience through the perspective of the transit rider.

For the purposes of this document, any reference to intersections refers only to intersections that are signalized. Segments refer to the links between signalized intersections and in some cases may require separate evaluation for each direction.

Exhibit 1.1 summarizes the general approach to MMLOS evaluation for Thunder Bay. It requires a mix of quantitative and qualitative analysis, varying significantly by mode. The methodology for each mode is discussed in Chapter 2.

Exhibit 1.1: Summary of MMLOS approach

MODE	ELEMENT	LEVEL OF SERVICE	
		GOOD	POOR
Pedestrians (PLOS)	Segments	High level of comfort	Low level of comfort
	Intersections	Short delay, high level of comfort, low risk	Long delay, low level of comfort, high risk
Bicycles (BLOS)	Segments	Low level of traffic stress	High level of traffic stress
	Intersections	Low level of risk and stress	High level of risk and stress
Transit (TLOS)	Transit Stops	Easy access, many amenities	Difficult access, few amenities
Vehicles (VLOS)	Intersections	Short delay	Long delay

2 Recommended Approach

The methodology for each mode, Pedestrian, Bicycle, Transit and Vehicle, is described below. For the most part, the recommendations are in line with the City of Ottawa's MMLOS Guidelines, which were developed with significant review and analysis of level of service indicators.

2.1 Pedestrian LOS (PLOS)

2.1.1 Background

PLOS is predominantly impacted by the comfort, safety, and convenience experienced by pedestrians while travelling along a corridor. When evaluating PLOS for road segments, users are required to collect various road characteristic data such as sidewalk width, boulevard width, street width, and vehicular operating speed, and identify the appropriate PLOS using a look-up table. The signalized intersection methodology uses the Pedestrian Exposure to Traffic at Signalized Intersection (PETSI) approach which is originally based on the Charlotte (North Carolina) PLOS at Signalized Intersection methodology.

An alternative method for evaluating a signalized intersection's PLOS involves the calculation of the average delay experienced by pedestrians crossing the street. This process follows the methodology outlined by the Highway Capacity Manual:

$$Pedestrian\ Delay = 0.5 \times \frac{(Cycle\ Length - Pedestrian\ Walk\ Time)^2}{Cycle\ Length}$$

A look-up table is then used to determine the PLOS associated with the calculated pedestrian delay.

Note that there are many other factors that influence pedestrian comfort that are not included in this methodology, including snow removal, cleanliness, lighting, and streetscaping. While these factors are not part of this framework, appropriate consideration should be given to these factors when planning and designing roadways to accommodate pedestrian needs.

2.1.2 Methodology

The following data are required to evaluate PLOS along **road segments**:

- Sidewalk width
- Boulevard width
- Presence of on-street parking
- Vehicle traffic volume
- Vehicle operating speed

Where a multi-use path is provided instead of a sidewalk, the same methodology can be applied to the multi-use path.

Using the data above, the lookup table shown in Exhibit 2.1 is used to determine the PLOS for the road segment being analyzed.

Exhibit 2.1: PLOS Lookup Table for Road Segments

<table>
<tr><th rowspan="3">Sidewalk Width (m)</th><th rowspan="3">Boulevard Width (m)</th><th rowspan="3">Vehicle Traffic Volume (AADT)</th><th rowspan="3">Presence Of On-Street Parking</th><th colspan="4">SEGMENT PLOS</th></tr>
<tr><th colspan="4">Operating Speed (km/h)</th></tr>
<tr><th>0 – 30</th><th>31 – 50</th><th>51 – 60</th><th>>60</th></tr>
<tr><td rowspan="9">> 2.0</td><td rowspan="3">> 2.0</td><td>≤ 3000</td><td>-</td><td>A</td><td>A</td><td>A</td><td>B</td></tr>
<tr><td rowspan="2">> 3000</td><td>Yes</td><td>A</td><td>B</td><td>B</td><td>-</td></tr>
<tr><td>No</td><td>A</td><td>B</td><td>C</td><td>D</td></tr>
<tr><td rowspan="3">0.5 – 2.0</td><td>≤ 3000</td><td>-</td><td>A</td><td>A</td><td>A</td><td>B</td></tr>
<tr><td rowspan="2">> 3000</td><td>Yes</td><td>A</td><td>B</td><td>C</td><td>-</td></tr>
<tr><td>No</td><td>A</td><td>C</td><td>D</td><td>E</td></tr>
<tr><td rowspan="3">< 0.5</td><td>≤ 3000</td><td>-</td><td>A</td><td>B</td><td>C</td><td>D</td></tr>
<tr><td rowspan="2">> 3000</td><td>Yes</td><td>B</td><td>B</td><td>D</td><td>-</td></tr>
<tr><td>No</td><td>B</td><td>C</td><td>E</td><td>F</td></tr>
<tr><td rowspan="9">1.8 – 2.0</td><td rowspan="3">> 2.0</td><td>≤ 3000</td><td>-</td><td>A</td><td>A</td><td>A</td><td>B</td></tr>
<tr><td rowspan="2">> 3000</td><td>Yes</td><td>A</td><td>B</td><td>C</td><td>-</td></tr>
<tr><td>No</td><td>A</td><td>C</td><td>D</td><td>E</td></tr>
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<tr><td>No</td><td>C</td><td>D</td><td>F</td><td>F</td></tr>
<tr><td rowspan="7">1.5 – 1.8</td><td rowspan="3">> 2.0</td><td>≤ 3000</td><td>-</td><td>C</td><td>C</td><td>C</td><td>C</td></tr>
<tr><td rowspan="2">> 3000</td><td>Yes</td><td>C</td><td>C</td><td>D</td><td>-</td></tr>
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<tr><td>< 0.5</td><td>-</td><td>-</td><td>D</td><td>E</td><td>F</td><td>F</td></tr>
<tr><td>< 1.5</td><td>-</td><td>-</td><td>-</td><td>F</td><td>F</td><td>F</td><td>F</td></tr>
<tr><td>No Sidewalk</td><td>-</td><td>-</td><td>-</td><td>C</td><td>F</td><td>F</td><td>F</td></tr>
</table>

Source: City of Ottawa MMLOS Guidelines

The following data are required to evaluate PLOS at **intersections**:

- Intersection configuration
  - Number of lanes
  - Presence of a median
  - Presence of an island refuge
- Signal phasing and timing features
- Pedestrian walk time
- Corner radii
- Crosswalk treatment

PLOS at signalized intersections is evaluated using two separate approaches – a) Pedestrian Exposure to Traffic at Signalized Intersections (PETSI) and b) average pedestrian delay. The lower letter grade resulting from the two approaches determines the PLOS for the intersection.

Using the lookup table in Exhibit 2.3, a total PETSI score is calculated by evaluating four criteria: crossing distance and conditions, signal phasing and timing features, corner radius, and crosswalk treatment. The total score then corresponds to the PLOS letter grade in the lookup table shown in Exhibit 2.2.

Exhibit 2.2: Pedestrian Exposure to Traffic at Signalized Intersections (PETSI) Look-up Table

PETSI POINTS	PLOS
≥ 90	A
≥ 75	B
≥ 60	C
≥ 45	D
≥ 30	E
< 30	F

Exhibit 2.3: Pedestrian Exposure to Traffic at Signalized Intersections (PETSI) Evaluation Table

1. CROSSING DISTANCE & CONDITIONS		
	Points	
a. Total travel lanes crossed	**No median**	**With median (>2.4m)**
2	120	120
3	105	105
4	88	90
5	72	75
6	55	60
b. Island Refuge		
No	-4	
Yes	0	
Section 1 Total		

2. Signal Phasing & Timing Features		**3. Corner Radius**	
	Points		**Points**
a. Left turn conflict		Greater than 25m	-9
Permissive	-8	15m to 25m	-8
Protected/permissive	-8	10m to 15m	-6
Protected	0	5m to 10m	-5
No left turn/prohibited	0	3m to 5m	-4
b. Right turn conflict		Less than/equal to 3m	-3
Permissive or yield control	-5	No right turn	0
Protected/permissive	-5	Right turn channel with receiving	-3
Protected	0	Right turn “smart channel”	-2
No right turn	0	**Section 3 Total**	
c. Right turn on red			
Allowed	-3		
Prohibited at certain times	-2		
Prohibited	0		
d. Leading pedestrian interval			
No	-2		
Yes	0		
Section 2 Total			

4. Crosswalk Treatment	
Standard transverse markings	-7
Textured/coloured pavement	-4
Zebra stripe hi-vis markings	-4
Raised crosswalk	0
Section 4 Total	
TOTAL (Add total scores from sections 1 through 4):	

Source: City of Ottawa MMLOS Guidelines, September 2015

The second step in the process is to determine the average pedestrian crossing delay component, which can be calculated using the formula in Exhibit 2.4:

Exhibit 2.4: Average pedestrian delay PLOS lookup table

AVERAGE PEDESTRIAN CROSSING DELAY COMPONENT	
$Pedestrian\ Delay = 0.5 \times \frac{(Cycle\ Length - Pedestrian\ Walk\ Time)^2}{Cycle\ Length}$	
< 10 seconds per intersection leg	A
10 to 20 seconds	B
20 to 30 seconds	C
30 to 40 seconds	D
40 to 60 seconds	E
> 60 seconds	F

The final intersection PLOS is the lower letter grade between the PETSI evaluation and the average pedestrian crossing delay component.

2.1.3 Determining Overall PLOS

When the study area in question is longer than a single segment or intersection, the overall PLOS score can be determined by choosing the lowest score along the corridor.

For example, when studying a corridor with three segments and two signalized intersections, each must first be evaluated individually. Then, the intersection or segment with the lowest PLOS score represents the PLOS score for the entire study corridor.

2.1.4 Example – Arthur Street: Selkirk Street to Vickers Street

Note: The example calculation is provided for demonstration purposes only.

Segment 1: Selkirk Street to Franklin Street

Step 1: Collect required data:

- Sidewalk width: 1.5 m
- Boulevard width: 0.0 m
- Vehicle traffic volume: 19,000 AADT
- On-street parking: Not permitted
- Operating speed: 50 km/h

Step 2: Look up PLOS using the table in Exhibit 2.1:

- **PLOS E**

Intersection 1: Arthur Street and Franklin Street

Step 1: Collect required data and complete PETSI Scorecard in Exhibit 2.3

MEASURE	INPUT	SCORE	TOTAL
1a. Total travel lanes crossed	2 lanes	120	120
1b. Island refuge	No	-4	116
2a. Left turn conflict	Permissive	-8	108
2b. Right turn control	Permissive	-5	103
2c. Right turn on red	Allowed	-3	100
2d. Leading pedestrian interval	No	-2	98
3. Corner radius	3m to 5m	-4	94
4. Crosswalk treatment	Standard transverse markings	-7	87
Use Lookup Table	**Total PETSI score = 87**	**PLOS B**	

Step 2: Determine average pedestrian delay by using formula and lookup table found in Exhibit 2.4.

$Pedestrian\ Delay = 0.5\ \times\ \frac{(60-20)^2}{60}$ = 13.3 s

Where cycle length = 60 s and walk time = 20 s (estimates)

Using the lookup table for delay equals **PLOS B**.

Step 3: The lowest PLOS of the PETSI and delay methods determine the overall intersection PLOS. In this case, both are the same, so the overall intersection operates as **PLOS B**.

Segment 2: Franklin Street to Vickers Street

Step 1: Collect required data:

- Sidewalk width: 1.5 m
- Boulevard width: 0.8 m
- Vehicle traffic volume: 19,000 AADT
- On-street parking: Not permitted

- Operating speed: 50 km/h

Step 2: Look up PLOS using table in Exhibit 2.1:

- **PLOS E**

Combined Study Corridor:

Segment 1 = **PLOS E**

Intersection 1 = **PLOS B**

Segment 2 = **PLOS E**

Therefore, the entire study corridor is assigned the score of **PLOS E**.

2.2 Bicycle LOS (BLOS)

2.2.1 Background

While PLOS is tied to comfort, safety, and convenience experienced by pedestrians. BLOS is impacted by the level of traffic stress (LTS) experienced by cyclists when travelling along a corridor. This approach is based on the Mineta Transportation Institute[1] approach. Road segments are grouped into one of four LTS categories (LTS 1 – 4) based on the degree of comfort experienced by cyclists. LTS 1 corridors provide the lowest level of traffic stress and are suitable for cyclists of all ages and skill levels, while LTS 4 corridors are only suited for very confident and experienced cyclists.

A qualitative description of each level of traffic stress category is shown in Exhibit 2.5. These levels of traffic stress can then be translated to BLOS using various roadway characteristic such as: : number of travel lanes, bike lane width, and the manner in which cyclists complete left and right turn maneuvers at signalized intersections. Using the collected data and a look-up table, the appropriate BLOS can be identified.

[1] Low-Stress Bicycling and Network Connectivity (2012), MTI Report 11-19, Mineta Transportation Institute, San Jose State University

Exhibit 2.5: Qualitative Descriptions of Levels of Traffic Stress

Level of Traffic Stress (LTS)	
1	Presenting little traffic stress and demanding little attention from cyclists, and attractive enough for a relaxing bike ride. Suitable for almost all cyclists, including children trained to safely cross intersections. On links, cyclists are either physically separated from traffic, or are in an exclusive bicycling zone next to a slow traffic stream with no more than one lane per direction, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low speed differential. Where cyclists ride alongside a parking lane, they have ample operating space outside the zone into which car doors are opened. Intersections are easy to approach and cross
2	Presenting little traffic stress and therefore suitable to most adult cyclists but demanding more attention than might be expected from children. On links, cyclists are either physically separated from traffic, or are in an exclusive bicycling zone next to a well-confined traffic stream with adequate clearance from a parking lane, or are on a shared road where they interact with only occasional motor vehicles (as opposed to a stream of traffic) with a low speed differential. Where a bike lane lies between a through lane and a right turn lane, it is configured to give cyclists unambiguous priority where cars cross the bike lane and to keep car speed in the right-turn lane comparable to bicycling speeds. Crossings are not difficult for most adults.
3	More traffic stress than LTS 2, yet markedly less than the stress of integrating with multilane traffic, and therefore welcome to many people currently riding bikes in American cities. Offering cyclists either an exclusive riding zone (lane) next to moderate-speed traffic or shared lanes on streets that are not multilane and have moderately low speed. Crossings may be longer or across higher-speed roads than allowed by LTS 2, but are still considered acceptably safe to most adult pedestrians.
4	A level of stress beyond LTS3.

Source: Table 1 from Low-Stress Bicycling and Network Connectivity (2012), MTI Report 11-19, Mineta Transportation Institute, San Jose State University, adapted by IBI Group

2.2.2 Methodology

Similar to pedestrians, the bicycle level of service is also broken down to segments and signalized intersections. However, BLOS takes a broader weakest link approach. Depending on the type of cycling facility in place, users are asked to evaluate several different criteria using the lookup tables. Multiple BLOS scores will be returned, but the lowest criteria scored will determine the BLOS for the segment or the intersection in question.

For segments, one must take into account the type of cycling facility, the number of travel lanes, traffic speed, and the number and, if applicable, the configuration of any uncontrolled intersections along the segment.

For signalized intersections, the manner in which turns are made by both motorists and by cyclists are vital, as well as the treatment applied to the crossing. For cyclists, left turns can be the most difficult maneuver to perform, depending heavily on the number of lanes they must cross to reach the left turn lane and the speed of the adjacent traffic. The optimal configuration for left turning cyclists is a two-stage left turn bike box, which removes the element of risk of cutting across one or more lanes of traffic, typically moving at much higher speeds.

When evaluating study areas comprising of multiple segments and intersections, it is important to consider the conditions that provide the worst level of service. For example, a corridor that has a bike lane present only a portion of the length will not attract riders of all ages and abilities. It will only attract riders who are comfortable mixing with traffic. Similarly, terrific protected bike lanes that disappear on approaches to intersections are not as attractive to riders as would be a corridor with upgraded intersection treatments. Accordingly, the overall BLOS for a given corridor will be the lowest score assigned to the segments and intersections evaluated.

The City of Ottawa definitions of BLOS, as shown in Exhibit 2.6 for segments and Exhibit 2.7 for intersections, considers very specific configurations in determining BLOS. This level of detail is helpful in determining BLOS as it reduces the subjectiveness of measuring the perceived level of traffic stress. However, the lookup tables do not include every possible configuration of cycling facilities. It is also noted that with the upcoming release in 2019/2020 of a new Ontario Traffic Manual Book 18 – Cycling Facilities, new facility types and treatments may be introduced and refinements to facility type selection may require future adjustments to how BLOS is measured.

The following data are required to evaluate BLOS along **road segments**:

- Number of travel lanes
- Type of cycling facility
- Cycling facility width
- Vehicle operating speed
- Frequency of bike lane blockages
- Unsignalized crossings
  - Number of travel lanes crossed
  - Vehicle operating speed of street being crossed

The data above is applied to the lookup table in Exhibit 2.6 to determine the bicycle level of service for the road segment being analyzed.

Exhibit 2.6: BLOS Segment Lookup Table

Step 1: The segment BLOS is determined by the lowest scoring criteria for the facility type that is in place.		**LOS**
Physically separated	Cycle tracks, protected bike lanes, and multi-use paths. Physical separation refers to, but is not limited to, curbs, raised medians, bollards, and parking lanes located between the cycle lane and the traffic lane.	A
Painted bike lanes – Not adjacent to curbside parking lane.		
Number of travel lanes	1 travel lane in each direction	A
	2 travel lanes in each direction with a raised median	B
	2 travel lanes in each direction without a raised median	C
	More than 2 travel lanes in each direction	D
Bike lane width (including marked buffer and paved gutter width)	≥ 1.8 m	A
	≥ 1.5 m to < 1.8 m	B
	≥ 1.2 m to < 1.5 m	C
Operating speed	≤ 40 km/h	A
	> 40 km/h to ≤ 50 km/h	B
	> 50 km/h to ≤ 60 km/h	C
	> 60 km/h to ≤ 70 km/h	D
	> 70 km/h	E
Bike lane blockage	Rare	A
	Frequent	C
Painted bike lanes – Adjacent to curbside parking lane.		
Number of travel lanes	1 travel lane in each direction	A
	2 travel lanes in each direction	C
Bike lane and parking lane width (including marked buffer and paved gutter width)	≥ 4.5 m	A
	≥ 4.0 m to < 4.5	B
	< 4.0 m	C
Operating speed	≤ 40 km/h	A
	> 40 km/h to ≤ 50 km/h	B
	> 50 km/h to ≤ 60 km/h	D
	> 60 km/h to ≤ 70 km/h	E
	> 70 km/h	F
Bike lane blockage	Rare	A
	Frequent	C
MIXED TRAFFIC		
Number of travel lanes and operating speed	2 travel lanes, ≤ 40 km/h, no marked centreline	A
	2 to 3 travel lanes, ≤ 40 km/h	B
	2 travel lanes, 50 km/h, no marked centreline	B
	2 to 3 travel lanes, 50 km/h	D
	4 to 5 travel lanes, ≤ 40 km/h	D

	4 to 5 travel lanes, ≥ 50 km/h	E
	6 or more travel lanes, ≤ 40 km/h	E
	6 or more travel lanes, > 40 km/h	F
	≥ 60 km/h	F
Step 2: Only complete this step if the segment contains unsignalized intersections. The BLOS is determined by the lowest scoring criteria.		**LOS**
Unsignalized crossing – No median refuge in place.		
Number of travel lanes and operating speed on side street	3 or fewer lanes being crossed, ≤ 40 km/h	A
	4 to 5 lanes being crossed, ≤ 40 km/h	B
	3 or fewer lanes being crossed, 50 km/h	B
	4 to 5 lanes being crossed, 50 km/h	C
	3 or fewer lanes being crossed, 60 km/h	C
	4 to 5 lanes being crossed, 60 km/h	D
	6 or more lanes being crossed, ≤ 40 km/h	E
	3 or fewer lanes being crossed, > 60 km/h	E
	6 or more lanes being crossed, > 40 km/h	F
	4 to 5 lanes being crossed, > 60 km/h	F
Unsignalized crossing – Median refuge in place (≥ 1.8 m).		
Number of travel lanes and operating speed on side street	5 or fewer lanes being crossed, ≤ 40 km/h	A
	3 or fewer lanes being crossed, 50 km/h	A
	6 or more lanes being crossed, ≤ 40 km/h	B
	4 to 5 lanes being crossed, 50 km/h	B
	3 or fewer lanes being crossed, 60 km/h	B
	6 or more lanes being crossed, 50 km/h	C
	4 to 5 lanes being crossed, 60 km/h	C
	3 or fewer lanes being crossed, > 60 km/h	D
	6 or more lanes being crossed, 60 km/h	E
	4 to 5 lanes being crossed, > 60 km/h	E
	6 or more lanes being crossed, > 60 km/h	F
Step 3: The overall segment BLOS is determined by the lowest BLOS identified between Steps 1 and 2.		

Source: City of Ottawa MMLOS Guidelines, September 2015

The following data are required to evaluate BLOS at **intersections**:

- Intersection configuration
  - Turning lanes
  - Through lanes
  - Bike lane approach and crossing treatment
  - Presence of two-stage left turn bike box
- Vehicle operating speeds
- Vehicle right turning speeds
  - Curb radii
  - Approach angle

The data above is applied to the lookup table in Exhibit 2.7 to determine the bicycle level of service for the signalized intersection being analyzed.

Exhibit 2.7: BLOS Intersection Lookup Table

Determine the appropriate facility type, then choose the lowest scoring criteria to determine the overall intersection BLOS.		**LOS**
Bike lanes or higher order facility approaching a signalized intersection		
Cyclist making a left turn and operating speed of motorists	Two-stage left turn bike box, ≤ 50 km/h	A
	No lane crossed, ≤ 50 km/h	B
	1 lane crossed, ≤ 40 km/h	B
	No lane crossed, ≥ 60 km/h	C
	1 lane crossed, 50 km/h	C
	2 or more lanes crossed, ≤ 40 km/h	D
	1 lane crossed, ≥ 60 km/h	E
	2 or more lanes crossed, ≥ 50 km/h	F
	All other single left turn lane configurations	F
	Dual left turn lanes	F
Pocket bike lanes approaching a signalized intersection		
Right turn lane and turning speed of motorists	Right turn lane introduced to the right of the bike lane and ≤ 50 m long, with traffic turning speed ≤ 25 km/h	B
	Right turn lane introduced to the right of the bike lane and > 50 m long, with traffic turning speed ≤ 30 km/h	D
	Bike lane shifts to the left of the right turn lane, with traffic turning speed ≤ 25 km/h	D
	Right turn lane with any other configurations	F
	Dual right turn lanes	F
Cyclist making a left turn and operating speed of motorists	Two-stage left turn bike box, ≤ 50 km/h	A
	No lane crossed, ≤ 50 km/h	B
	1 lane crossed, ≤ 40 km/h	B
	No lane crossed, ≥ 60 km/h	C
	1 lane crossed, 50 km/h	C

	2 or more lanes crossed, ≤ 40 km/h	D
	1 lane crossed, ≥ 60 km/h	E
	2 or more lanes crossed, ≥ 50 km/h	F
	All other single left turn lane configurations	F
	Dual left turn lanes	F
Mixed traffic approaching a signalized intersection		
Right turn lane and turning speed of motorists	Right turn lane 25-50 m long with traffic turning speed ≤ 25 km/h	D
	Right turn lane 25-50 m long with traffic turning speed > 25 km/h	E
	Right-turn lane longer than 50 m	F
	Dual right turn lanes	F
Cyclist making a left turn and operating speed of motorists	Two-stage left turn bike box, ≤ 50 km/h	A
	No lane crossed, ≤ 50 km/h	B
	1 lane crossed, ≤ 40 km/h	B
	No lane crossed, ≥ 60 km/h	D
	1 lane crossed, 50 km/h	D
	2 or more lanes crossed, ≤ 40 km/h	D
	1 lane crossed, ≥ 60 km/h	F
	2 or more lanes crossed, ≥ 50 km/h	F
	All other single left turn lane configurations	F
	Dual left turn lanes	F

Source: City of Ottawa MMLOS Guidelines, September 2015

Note: **Pocket Bike Lane –** A “pocket” bike lane is a short section of bike lane that develops approaching an intersection in between vehicular right turn lanes and vehicular through or left turn lanes. With traffic on both sides of the bike lane, a pocket bike lane is considered to be more stressful for cyclists than a bicycle lane adjacent to the curb.

2.2.3 Determining Overall BLOS

Similar to the pedestrian experience, a cycling corridor is only as good as its weakest link. Thus, when corridors with several segments and intersections are being assessed, the lowest BLOS value should be taken to describe the entire corridor.

2.2.4 Example – Victoria Avenue: Edward Street to Lillie Street

Note: The example calculation is provided for demonstration purposes only.

Segment 1:

Step 1: Collect required data:

- Number of travel lanes: 1 lane each direction plus centre left turn lane
- Type of cycling facility: Painted bike lane (westbound), painted bike lane adjacent to curbside parking lane (eastbound)
- Cycling facility width: 1.5 m
- Cycling facility and adjacent parking lane width: 3.9 m
- Vehicle operating speed: Posted speed limit of 50 km/h

- Frequency of bike lane blockages: Rare
- Unsignalized intersections: Three crossings, all of which are 2-lane roads with stop signs and vehicle speeds of 40 to 50 km/h

Step 2: Determine BLOS

Westbound Painted Cycling Lane (not adjacent to curbside parking lane):

Criteria	Observed	LOS
Number of travel lanes	1 travel lane in each direction	A
Bike lane width	≥ 1.5 m to < 1.8 m	B
Operating speed	> 40 km/h to ≤ 50 km/h	B
Bike lane blockage	Rare	A

Eastbound Painted Cycling Lane (adjacent to curbside parking lane):

Criteria	Observed	LOS
Number of travel lanes	1 travel lane in each direction	A
Bike lane and parking lane width	< 4.0 m	C
Operating speed	> 40 km/h to ≤ 50 km/h	B
Bike lane blockage	Rare	A

Unsignalized Intersections (no median refuge in place):

Criteria	Observed	LOS
Number of travel lanes and operating speed on side street	3 or fewer lanes being crossed, ≤ 40 km/h	A

Step 3: Determine the segment BLOS:

The score for the segment is **BLOS C** as it is the lowest score from the results above.

Intersection 1: Victoria Avenue and Edward Street

Step 1: Collect required data:

- Intersection configuration: 1 approaching through lane, 1 left turn lane, 1 right turn lane, 2 lanes exiting the intersection eastbound, bike lanes do not exist along in the approach, exit, or through the intersection (cyclists must merge with traffic, sharrows are present eastbound)
- Vehicle operating speeds: Both streets have posted speed limits of 50 km/h
- Vehicle right turning speeds: Radii of approximately 8 m, assume vehicle turning speeds are ≤ 25 km/h

Step 2: Determine BLOS:

Mixed traffic approaching a signalized intersection:

CRITERIA	OBSERVED	LOS
Right turn lane and turning speed of motorists	Right-turn lane longer than 50 m	F
Cyclist making a left turn and operating speed of motorists	1 lane crossed, 50 km/h	D

Intersection is **BLOS F**.

Intersection 2: Victoria Avenue and Waterloo Street

Step 1: Collect required data:

- Intersection configuration on Victoria Avenue: 1 approaching through lanes, 1 left turn lane, 1 right-turn lane eastbound, bike lanes in both directions through the intersection.
- Intersection configuration on Waterloo Street: 2 approaching lanes
- Cyclist on Victoria Avenue making left turn: 1 lane crossed
- Westbound cyclist on Victoria Street: pocket bike lane with right turn lane < 50 m
- Cyclist on Waterloo Street making left turn: mixed traffic, 1 lane crossed
- Vehicle operating speeds: Both streets have posted speed limits of 50 km/h

- Vehicle right turning speeds: Southbound to westbound channelized right turn ramp, assume vehicle turning speeds are > 25 km/h

Step 2: Determine BLOS:

Painted bike lakes approaching a signalized intersection:

CRITERIA	OBSERVED	LOS
Cyclist making a left-turn on Victoria Avenue	Bike lane, 1 lane crossed, 50 km/h	C
Cyclist making a left-turn on Waterloo Street	Mixed traffic, 1 lane crossed, 50 km/h	D
Right turn lane and turning speed of motorists on Victoria Avenue	Westbound approach: Pocket bike lane with right-turn lane introduced to the right of the bike lane and ≤ 50 m long, with traffic turning speed ≤ 25 km/h	B

Intersection is **BLOS D**.

Overall Victoria Street Corridor:

Segment 1 = **BLOS C**

Intersection 1 = **BLOS F**

Intersection 2 = **BLOS D**

Since Intersection 1 (Victoria and Edward) scored BLOS F, the lowest score along the corridor, the overall corridor scores **BLOS F**. From this analysis, it is clear that if improvements to the corridor were desired, the intersections should be modified to provide safer and more comfortable cycling infrastructure.

2.3 Transit LOS (TLOS)

2.3.1 Background

TLOS measurements have traditionally focused on rapid transit operations. As Thunder Bay does not have rapid transit, this measure must be adapted to evaluate the conventional bus system.

TLOS can be measured from the perspective of how well transit operates in traffic – whether the transit vehicle experiences congestion and delays – or from the perspective of the transit rider – whether there are sidewalk connections, shelters and other amenities at bus stops.

In terms of how well transit operates in traffic, that level of service will be the same as, or very similar to, vehicular LOS. If there is significant congestion that impacts passenger vehicles, then those impacts are also felt by transit vehicles unless there are dedicated transit lanes or other transit priority measures. In

Thunder Bay, transit operates in mixed traffic and the vehicular LOS (discussed in Section 2.4) would apply to transit vehicles.

For Thunder Bay, the focus of TLOS, is from the perspective of the transit user to access/egress from transit. The important factors to consider for TLOS are the quality and quantity of amenities provided at the transit stop – benches, shelters, route maps, schedules, and so on, as well as the comfort and means of travel in the immediate vicinity of the stop. This includes the provision of sidewalks and the location of the nearest controlled crossing.

2.3.2 Methodology

The following data are required to evaluate TLOS at **transit stops** along a road corridor:

- Presence of amenities at the transit stop
  - Shelter
  - Bench
  - Mobility pad (or other accessible hard surface)
  - Information (real time countdown, schedules, route maps)
- Sidewalks (or multi-use trails)
- Proximity to controlled street crossing

Applying the data above, determine the TLOS for each transit stop using the look-up table in Exhibit 2.8.

Exhibit 2.8: TLOS Lookup Table

AMENITIES CHECKLIST:	LOS
☐ Shelter ☐ Seating ☐ Mobility Pad (or other accessible hard surface) ☐ Sidewalks (or multi-use path) ☐ Information (route map and/or schedule and/or real time information)	
All 5 amenities are present, and a controlled crossing <100 m away	A
Sidewalk, mobility pad, and shelter are present, and a controlled crossing <300 m away	B
Sidewalk and mobility pad are present, with a controlled crossing <300 m away.	C
Sidewalks and mobility pad are present with a controlled crossing >300 m away	D
No sidewalks and/or mobility pad are present.	F

2.3.3 Determining Overall TLOS

Similar to PLOS and BLOS, the TLOS score is determined by the weakest link along a corridor. The lowest scoring transit stop represents the TLOS for the study corridor as a whole.

2.3.4 Example – Victoria Avenue: Lillie Street to Waterloo Street

Note: The following provided for demonstration purposes only based on observations in 2018.

Step 1: Collect required data:

There are five bus stops located within this corridor, all with varying provisions of amenities:

- Stop 1: Westbound stop at Lillie Street – Located at a controlled crossing, with sidewalk connection and hard surface pad.
- Stop 2: Eastbound stop at Lillie Street – Located at a controlled crossing, with sidewalk, shelter, bench, and mobility pad provided.
- Stop 3: Westbound stop at Tarbutt Street – Located 200 m from a controlled crossing, with sidewalk connection. No shelter, bench, or hard surface provided.
- Stop 4: Westbound stop at Hyde Park Avenue – Located 210 m from a controlled crossing, with sidewalk connection, bench, and mobility pad.
- Stop 5: Eastbound stop at Hyde Park Avenue – located 180 m from a controlled crossing, with sidewalk connection, shelter, and mobility pad.

Step 2: Look up TLOS using the table in Exhibit 2.8.

Based on the above observations, the lookup table is used to determine the TLOS for each stop:

- Stop 1: **TLOS C**
- Stop 2: **TLOS B**
- Stop 3: **TLOS F**
- Stop 4: **TLOS C**
- Stop 5: **TLOS B**

Due to the score of TLOS F for Stop 3, the entire corridor rates as **TLOS F**. However, some relatively small modifications could bring the entire corridor up to TLOS C. Adding a hard surface and a bench or shelter to Stop 3 would improve its TLOS to C, increasing the entire corridor score to C along with it.

2.4 Vehicle LOS (VLOS)

2.4.1 Background

VLOS, or commonly referred to as just LOS, is the traditional measure of how well a transportation network operates. To determine VLOS, well-established existing practices can be followed. The Highway Capacity Manual (HCM) methodology for estimating intersection level of service is the accepted standard applied in North America. Various software programs are available to determine level of service using the HCM method. The Synchro analysis software is widely used for traffic analysis in the transportation planning industry.

2.4.2 Methodology

The City's existing methodology for determining VLOS is recommended to be carried forward at this time. Existing procedures for determining VLOS as part of Traffic Impact Studies can be found in the City's Engineering and Development Standards (2016).

The VLOS measure can be determined for the intersection as a whole, and for each approach and movement at a signalized and unsignalized intersections. Required data includes the intersection configuration, signal timing, and turning movement counts. The lowest VLOS measure is used for the overall study corridor score.

The following data are required to evaluate VLOS at **intersections**:

- Turning movement counts
- Intersection configuration – lanes, lane widths, turning bays, etc.
- Signal timing – cycle length, phasing, etc.

Using the Synchro software program, the average delay per vehicle for the intersection can be determined and the corresponding level of service. The look-up table for VLOS based on delay is shown in Exhibit 2.9.

Exhibit 2.9: VLOS Lookup Table

Average Delay at Signalized Intersection	Average Delay at Unsignalized Intersection[2]	LOS
≤10 s	≤10 s	A
10–20 s	10–15 s	B
20–35 s	15–25 s	C
35–55 s	25–35 s	D
55–80 s	35–50 s	E
>80 s	>50 s	F

Source: Highway Capacity Manual 2010

[2] At Two-Way Stop-Controlled intersections, LOS criteria applies to each minor street approach and is not calculated for the intersection as a whole.

2.5 Evaluating Trade-offs

The final step in the MMLOS assessment is the evaluation of trade-offs between various modes of transportation. Exhibit 2.10 presents an example MMLOS trade-off evaluation table comparing the LOS of all modes under existing conditions and three alternative solutions, to the targeted LOS.

Exhibit 2.10: Example MMLOS Trade-off Evaluation

SCENARIO	Pedestrian LOS	Bicycle LOS	Transit LOS	Vehicle LOS
Existing Conditions	C	E	D	D
Target LOS	B	B	C	D
Alternative Solution 1	A	A	D	E
Alternative Solution 2	B	B	C	D
Alternative Solution 3	C	D	B	B

Based on the example results presented above, Alternative Solution 2 would be the preferred solution since all LOS targets are met. Alternative Solution 1 favours pedestrians and cyclists to a point where transit and vehicle LOS is anticipated to exceed targets, while the opposite occurs under Alternative Solution 3.

In some situations it may not be possible to meet all MMLOS targets, in which case strategic trade-off decisions are required to achieve the best possible overall network performance. For these cases, the rationale behind the chosen alternative is recommended to be documented. Targets for Thunder Bay are presented in Section 3.2.

3 Proposed MMLOS Targets

3.1 Background

The previous sections provided an overview for determining the level of service of various modes of transportation. To customize the MMLOS application, each municipality can set unique MMLOS targets specifically tailored to the transportation characteristics and goals of their respective jurisdictions.

Achieving LOS A for all modes of transportation is neither realistic nor desirable due to limited funding and available land. LOS targets are set for each mode of transportation in order to prioritize more appropriate modes for the local context. It is recommended that different LOS targets are set for different policy areas or zones within a given municipality. For example: Downtown cores may prioritize pedestrian, bicycle, and transit level of service while main commuter corridors may prioritize transit and vehicle levels of service.

3.2 Proposed Targets

Exhibit 3.1 presents the minimum desirable level of service targets for Thunder Bay. It is important to note that the level of service scales of each mode are independent of one another. A vehicle experiencing LOS E or F will encounter congestion and delays, but a pedestrian experience LOS E or F represents a complete lack of comfort and high risk or stress. As such, targets may seem more generous to some modes than others.

These targets also cover a wide range of conditions, built forms and context. The minimum targets are intended to provide guidance rather than absolute minimums. Where targets cannot be achieved, documentation for the project or study should include rationale and feasibility of mitigating measures.

Exhibit 3.1: MMLOS Minimum Targets

DESIGNATED CORRIDOR OR POLICY AREA	PLOS	BLOS	TLOS	VLOS
Pedestrian Priority Corridor	B	C	B	C
Neighbourhood Greenway	C	C	C	C
Corridor in the Cycling Network	C	B	C	C
Corridor with Transit service	B	C	C	C
Strategic Core Areas	B	C	B	C
Rural Areas	n/a	D	n/a	C
Other Areas	C	D	n/a	C

Note: Where two policy areas overlap and the target LOS differs, the higher LOS minimum target should be selected.