



appendix b

BLOS: Bicycle Level of Service

B.1 Background

Level of Service (LOS) is a framework that transportation professionals use to describe existing conditions (or suitability) for a mode of travel in a transportation system. The traffic planning and engineering discipline has used LOS models for motor vehicles for several decades. Motor vehicle LOS is based on average speed and travel time for motorists traveling in a particular roadway corridor. In the 1990s, new thinking and research contributed to the development of methodologies for assessing levels of service for other travel modes, including bicycling, walking, and transit. Specific methodologies for bicycle level of service have been developed and used by a number of cities, counties, and states around the U.S. since the mid-1990s. This Plan adopts the Bicycle Level of Service (Bicycle LOS) Model assessment method.

When considering level of service in a multi-modal context, it is important to note that LOS measures for motor vehicles and bicycles are based on different criteria and are calculated on different inputs. Motor vehicle LOS is primarily a measure of speed, travel time, and intersection delay. Bicycle LOS is a more complex calculation, which represents the level of comfort a bicyclist experiences in relation to motor vehicle traffic.

B.2 Bicycle Level of Service Model

The *Bicycle Level of Service Model (Bicycle LOS Model)* is an evaluation of bicyclist-perceived safety and comfort with respect to motor vehicle traffic while traveling in a roadway corridor. It identifies the quality of service for bicyclists or pedestrians that currently exists within the roadway environment.



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The statistically calibrated mathematical equation entitled the *Bicycle LOS Model*¹ (*Version 2.0*) is used for the evaluation of bicycling conditions in shared roadway environments. It uses the same measurable traffic and roadway factors that transportation planners and engineers use for other travel modes. With statistical precision, the *Model* clearly reflects the effect on bicycling suitability or “compatibility” due to factors such as roadway width, bike lane widths and striping combinations, traffic volume, pavement surface condition, motor vehicle speed and type, and on-street parking.

The *Bicycle Level of Service Model* is based on the proven research documented in *Transportation Research Record 1578* published by the Transportation Research Board of the National Academy of Sciences. It was developed with a background of over 150,000 miles of evaluated urban, suburban, and rural roads and streets across North America. Many urban planning agencies and state highway departments are using this established method of evaluating their roadway networks. The Virginia Department of Transportation is using the *Bicycle LOS Model* in both the Richmond and Northern Virginia regions. The model has also been applied in Anchorage AK, Baltimore MD, Birmingham AL, Buffalo NY, Gainesville FL, Houston TX, Lexington KY, Philadelphia PA, Sacramento CA, Springfield MA, Tampa FL, Washington, DC, and by the Delaware Department of Transportation (DelDOT), Florida Department of Transportation (FDOT), New York State Department of Transportation (NYDOT), Maryland Department of Transportation (MDOT) and many others.

Widespread application of the original form of the *Bicycle LOS Model* has provided several refinements. Application of the *Bicycle LOS Model* in the metropolitan area of Philadelphia resulted in the final definition of the three effective width cases for evaluating roadways with on-street parking. Application of the *Bicycle LOS Model* in the rural areas surrounding the greater Buffalo region resulted in refinements to the “low traffic volume roadway

width adjustment”. A 1997 statistical enhancement to the *Model* (during statewide application in Delaware) resulted in better quantification of the effects of high speed truck traffic [see the $SP_t(1+10.38HV)^2$ term]. As a result, *Version 2.0* has the highest correlation coefficient ($R^2 = 0.77$) of any form of the *Bicycle LOS Model*.

Notes

¹Version 2.0 of the *Bicycle Level of Service Model (Bicycle LOS Model)* has been employed to evaluate collector and arterial roadways in the Winston-Salem Urban Area. Its form is shown on the next page.



$$\text{Bicycle LOS} = a_1 \ln (\text{Vol}_{15}/L_n) + a_2 SP_t (1+10.38HV)^2 + a_3 (1/PR_5)^2 + a_4 (W_e)^2 + C$$

Where:

Vol_{15} = Volume of directional traffic in 15 minute time period

$$\text{Vol}_{15} = (\text{ADT} \times D \times K_d) / (4 \times \text{PHF})$$

where:

- ADT = Average Daily Traffic on the segment or link
- D = Directional Factor (assumed = 0.565)
- K_d = Peak to Daily Factor (assumed = 0.1)
- PHF = Peak Hour Factor (assumed = 1.0)

L_n = Total number of directional *through* lanes

SP_t = Effective speed limit

$$SP_t = 1.1199 \ln(SP_p - 20) + 0.8103$$

where:

SP_p = Posted speed limit (a surrogate for average running speed)

HV = percentage of heavy vehicles (as defined in the 1994 Highway Capacity Manual)

PR_5 = FHWA's five point pavement surface condition rating

W_e = Average effective width of outside through lane:

where:

- $W_e = W_v - (10 \text{ ft} \times \% \text{ OSPA})$ and $W_1 = 0$
- $W_e = W_v + W_1(1 - 2 \times \% \text{ OSPA})$ and $W_1 > 0$ & $W_{ps} = 0$
- $W_e = W_v + W_1 - 2(10 \times \% \text{ OSPA})$ and $W_1 > 0$ & $W_{ps} > 0$
- and a bikelane exists

where:

- W_t = total width of outside lane (and shoulder) pavement
- OSPA = percentage of segment with occupied on-street parking
- W_1 = width of paving between the outside lane stripe and the edge of pavement
- W_{ps} = width of pavement striped for on-street parking
- W_v = Effective width as a function of traffic volume

and:

- $W_v = W_t$ if $\text{ADT} > 4,000 \text{ veh/day}$
- $W_v = W_t (2 - 0.00025 \times \text{ADT})$ if $\text{ADT} \leq 4,000 \text{ veh/day}$,

and if the street/ road is undivided and unstriped

a_1 : 0.507 a_2 : 0.199 a_3 : 7.066 a_4 : - 0.005 C: 0.760

($a_1 - a_4$) are coefficients established by the multi-variate regression analysis.



B.3 Bicycle Level-of-Service Categories

The Bicycle LOS score resulting from the final equation is pre-stratified into service categories “A”, “B”, “C”, “D”, “E”, and “F” (“A” is best, and “F” is worst), according to the ranges shown in Table 1. These ranges reflect users’ perception of the road segments level of service for bicycle travel. This stratification is in accordance with the linear scale established during the referenced research (i.e., the research project bicycle participants’ aggregate response to roadway and traffic stimuli). The *Model* is particularly responsive to the factors that are statistically significant. An example of its sensitivity to various roadway and traffic conditions is shown on the following page.

The Model represents the comfort level of a hypothetical “typical” bicyclist. Some bicyclists may feel more comfortable and others may feel less comfortable than the Bicycle LOS grade for a roadway. A poor Bicycle LOS grade does not mean that bikes should be prohibited on a roadway. Rather, it suggests to a transportation planner that the road may need other improvements (in addition to shoulders) to help more bicyclists feel comfortable using the corridor.

B.4 Application

The *Bicycle LOS Model* is used by planners, engineers, and designers throughout the US and Canada in a variety of planning and design applications.

Applications include:

- 1) Conducting a benefits comparison among proposed bikeway/roadway cross-sections
- 2) Identifying roadway restriping or reconfiguration opportunities to improve bicycling conditions
- 3) Prioritizing and programming roadway corridors for bicycle improvements
- 4) Creating bicycle suitability maps
- 5) Documenting improvements in corridor or system-wide bicycling conditions over time

Table 1. BLOS Grades and Corresponding Scores

LEVEL-OF-SERVICE	Bicycle LOS Score
A	≤ 1.5
B	> 1.5 and ≤ 2.5
C	> 2.5 and ≤ 3.5
D	> 3.5 and ≤ 4.5
E	> 4.5 and ≤ 5.5
F	> 5.5



Bicycle LOS Model Sensitivity Analysis

$$\text{Bicycle LOS} = a_1 \ln(\text{Vol}_{15}/\text{Ln}) + a_2 \text{SP}_t(1+10.38\text{HV})^2 + a_3 (1/\text{PR}_5)^2 + a_4 (W_e)^2 + C$$

where: a_1 : 0.507 a_2 : 0.199 a_3 : 7.066 a_4 : -0.005 C: 0.760
 T-statistics: (5.689) (3.844) (4.902) (-9.844)

Baseline inputs:

ADT = 12,000 vpd % HV = 1 L = 2 lanes
 SP_p = 40 mph W_e = 12 ft PR₅ = 4 (good pavement)

	<u>BLOS</u>	<u>% Change</u>
Baseline BLOS Score (Bicycle LOS)	3.98	N/A

Lane Width and Lane striping changes

W _t = 10 ft	4.20	6% increase
W _t = 11 ft	4.09	3% increase
W _t = 12 ft -- (baseline average) -----	3.98 - - - -	no change
W _t = 13 ft	3.85	3% reduction
W _t = 14 ft	3.72	7% reduction
W _t = 15 ft (W ₁ = 3 ft)	3.57 (3.08)	10%(23%) reduction
W _t = 16 ft (W ₁ = 4 ft)	3.42 (2.70)	14%(32%) reduction
W _t = 17 ft (W ₁ = 5 ft)	3.25 (2.28)	18%(43%) reduction

Traffic Volume (ADT) variations

ADT = 1,000 Very Low	2.75	31% decrease
ADT = 5,000 Low	3.54	11% decrease
ADT = 12,000 Average - (baseline average) --	3.98 - - - -	no change
ADT = 15,000 High	4.09	3% increase
ADT = 25,000 Very High	4.35	9% increase

Pavement Surface conditions

PR ₅ = 2 Poor	5.30	33% increase
PR ₅ = 3 Fair	4.32	9% reduction
PR ₅ = 4 -- Good - (baseline average) - - -	3.98 - - - -	no change
PR ₅ = 5 Very Good	3.82	4% reduction

Heavy Vehicles in percentages

HV = 0 No Volume	3.80	5% decrease
HV = 1 --- Very Low - (baseline average) --	3.98 - - - -	no change
HV = 2 Low	4.18	5% increase
HV = 5 Moderate	4.88	23% increase ^a
HV = 10 High	6.42	61% increase ^a
HV = 15 Very High	8.39	111% increase ^a

^aOutside the variable's range (see Reference (1))

(Footnotes)

¹Landis, Bruce W. et.al. "Real-Time Human Perceptions: Toward a Bicycle Level of Service" *Transportation Research Record 1578*, Transportation Research Board, Washington, DC 1997.

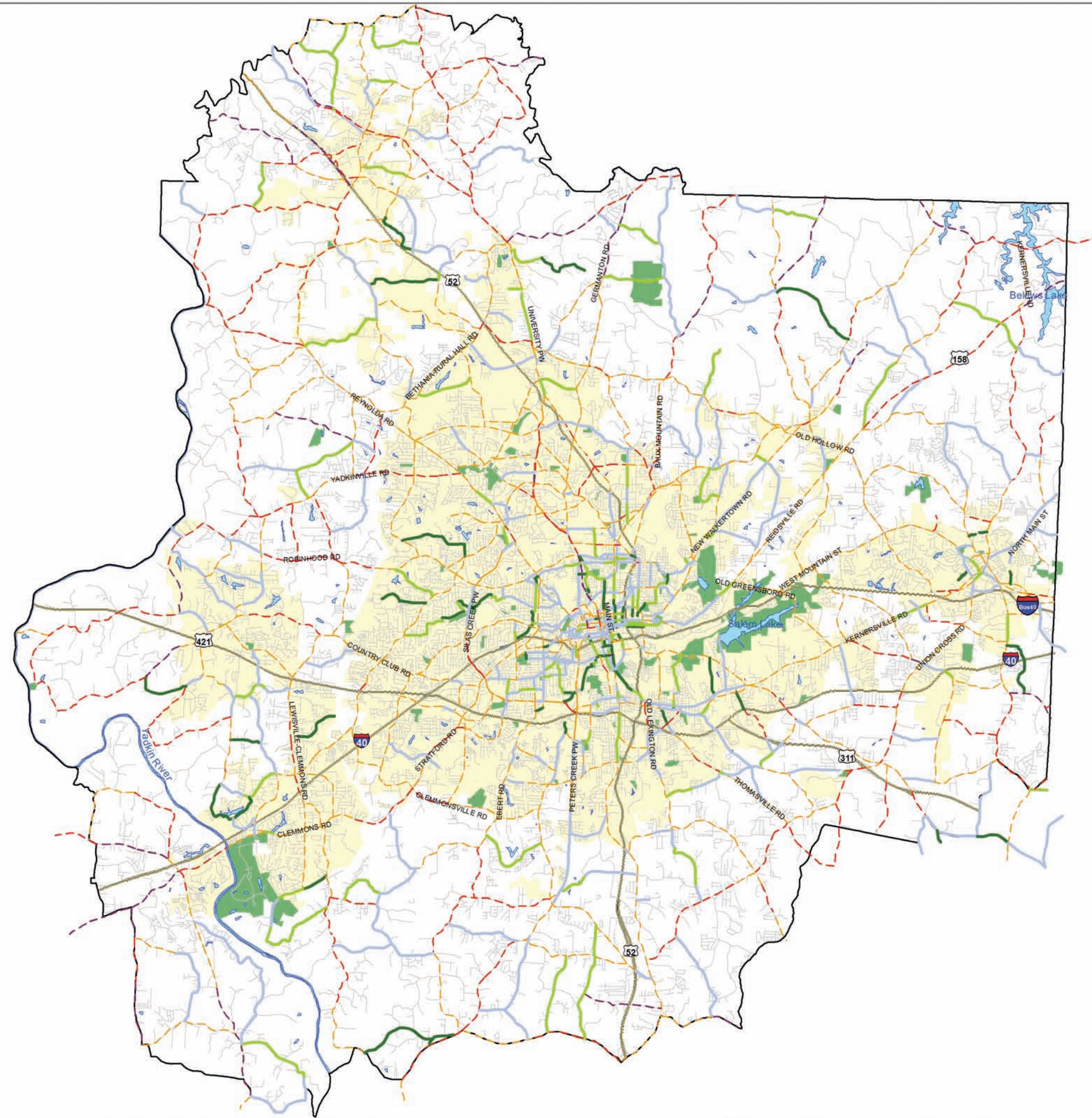




Winston-Salem Urban Area

Comprehensive Bicycle Master Plan

Bicycle Level Of Service



Legend

BLOS Grade	— Major Roads
— A	— Streets
— B	▭ Study Area
— C	▭ Water Bodies
— D	▭ Parks
— E	▭ Towns
— F	



Data Sources: City of Winston-Salem