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Shared-Use Path Level of Service Calculator

A USER'S GUIDE

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Pedestrian and Bicycle Safety

FOREWORD

Shared-use paths are paved, off-road facilities designed for travel by a variety of nonmotorized users, including bicyclists, pedestrians, skaters, runners, and others. Shared-use path planners and designers face a serious challenge in determining how wide paths should be and whether the various modes of travel should be separated from each other. Currently, very little substantive guidance is available to aid in those decisions.

This document describes how to use a new method to analyze the quality of service provided by shared-use paths of various widths that accommodate various travel mode splits. Given a count or an estimate of the overall path user volume in the design hour, the new method described here can provide the level of service (LOS) for path widths ranging from 2.4 to 6.1 meters (8.0 to 20.0 feet). The document describes in detail the input data needed to begin using the method, provides step-by-step instructions, and provides example applications of the new method. This document also describes how to use a spreadsheet calculation tool called SUPLOS that was also developed as part of the same effort and that is being circulated by the Federal Highway Administration.

The information in this document should be of interest to planners, engineers, park and recreation professionals, and others involved in the planning, design, operation, and/or maintenance of shared-use paths. In addition, this document will be of interest to researchers investigating how to analyze multiple modes of travelers in a finite space with minimal traffic control.

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Director, Office of Safety
Research and Development

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16. Abstract
17.

Shared-use paths are becoming increasingly busy in many places in the United States. Path designers and operators need guidance on how wide to make new or rebuilt paths and whether to separate the different types of users. The current guidance is not very specific, has not been calibrated to conditions in the United States, and does not accommodate the range of modes found on a typical U.S. path. The purpose of this project was to develop a level of service (LOS) estimation method for shared-use paths that overcomes these limitations. The research included the development of the theory of traffic flow on a path, an extensive effort to collect data on path operations, and a survey during which path users expressed their degree of satisfaction with the paths shown on a series of videos.

Based on the theory developed and the data collected, the researchers developed an LOS estimation method for bicyclists that requires minimal input and produces a simple and useful result. The method requires only four inputs from the user: One-way user volume in the design hour, mode split percentages, trail width, and presence or absence of a centerline. Factors involved in the estimation of an LOS for a path include the number of times a typical bicyclist meets or passes another path user and the number of those passes that are delayed. The method considers five types of path users when calculating adult bicyclists' LOS, including other adult bicyclists, child bicyclists, pedestrians, runners, and in-line skaters.

This report provides step-by-step instructions on how to use the LOS procedure and spreadsheet calculation tool, which can be downloaded from the Turner-Fairbank Highway Research Center Web site at www.tfhrc.org. Other products of the effort include FHWA-HRT-05-137 *Evaluation of Safety, Design, and Operation of Shared-Use Paths: Final Report,* which documents the research and the spreadsheet calculation tool and is the basis of FHWA-HRT-05-139 *Evaluation of Safety, Design, and Operation of Shared-Use Paths* TechBrief.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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1. INTRODUCTION

During the last 20 years, there has been an explosion in shared-use path construction across the United States and Canada. These new paths take many forms—rail-trails, greenway trails through linear parks, waterfront paths along beaches and oceans, and side-paths along road corridors.* These paths serve a wide variety of nonmotorized travelers—bicyclists, skaters, scooters, runners, walkers, people with disabilities, people pushing strollers, children, the elderly, and others. Many of these paths have become extremely popular and well used, especially in urban and suburban communities. Some shared-use paths are popular to the point of suffering from their success, i.e., periodic crowding and user conflicts begin to affect user enjoyment and safety.

In general, there are a variety of reasons why trail use is on the rise. Trail activities remain high on the list of most popular outdoor recreation activities, and U.S. participation levels in trail activities continue to trend upwards. † For example, between 1994 and 2000, participation in the following trail activities increased considerably: walking (35 percent increase); running (43 percent increase); bicycling (50 percent increase); and day hiking (52 percent increase).(1) As more trails are built in urban and suburban communities, they increase the population's access to close-to-home recreation and enable people to participate in trail use more often. Trail users and equipment continue to diversify, encouraging new constituencies. Finally, the purposes for trail use are expanding, as urban and suburban trails are used for utilitarian and commuting transportation, as well as for recreation.

In many communities, shared-use paths are an integral part of the multimodal transportation system. As transportation planners and decisionmakers have focused increased attention on trail development, concern about trail safety and the management of high user volumes has risen as well. However, trail and nonmotorized transportation planners have had few tools and little data to guide them in managing higher volumes and the increasingly diverse trail user modes. It remains unclear as to how many users are too many for any given trail width, or how user flow can be optimized using trail design or operational techniques. Research is needed to provide trail planners, designers, and managers with additional tools that can be used to make the best trails possible.

HOW TO USE THIS GUIDE

This guide is intended primarily for trail planners, designers, and managers, which include professionals from a wide variety of disciplines—planners, landscape architects, transportation engineers, bicycle and pedestrian transportation specialists, and park and recreation planners and managers. It may also be useful for trail, bicycle, and pedestrian advocates; elected officials; planning and park commissioners; and other members of the public—especially those who find themselves involved in trail planning efforts or in situations involving trail user conflicts that stem from high volumes and diverse mode mixes. These conditions are increasingly common on trails located in urban, suburban, and high-use recreational areas.

The purpose of this guide is to introduce practitioners and others to: 1) the findings of our study on the quality of service on trails; 2) a new analytical tool called the Shared-Use Path Level of

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* Throughout this document, the terms *shared-use path, path, pathway, and trail* will be used interchangeably. They should be understood to mean *a hard-surface treadway that is open to a variety of nonmotorized users, including bicyclists, pedestrians, runners, and skaters, and serves both transportation and recreational purposes.*

† Walking, bicycling, running or jogging, and day hiking rank 1st, 9th, 11th, and 12th, respectively, out of 35 outdoor recreation activities surveyed. *Outdoor Recreation in American Life: National Assessment of Demand and Supply Trends*, Ken Cordell, Sagamore Publishing, 1999.

Service (LOS) Calculator, and 3) potential implications for trail design. The tool can be used for a variety of trail planning tasks, where quantitative evaluation is needed to assist in solving design or management problems, as for example:

- To plan appropriate widths and cross sections for new trails.
- To evaluate LOS provided on existing trails.
- To guide the design of improvements for existing trails, where additional capacity is needed.
- To determine how many additional users a trail may be able to serve, given a minimum LOS threshold.
- To evaluate LOS for specific timeframes, when particular trip purposes need to be served, such as weekday morning and evening periods, when commuting trips are heaviest.
- To determine LOS at a particular location on a trail, such as a narrow pinch point in an unusually high use area or in an area with many reported user conflicts.

Other important findings of this research include the development of baseline data to which trail data from all parts of the country and from many different settings can be compared, including:

- Average user speeds for five major trail user groups.
- Documentation of diverse user volume ranges.
- Documentation of diverse ranges of user mix.
- Development of an average trail volume and mode split profile.

Readers of this guide may understand the term shared-use path (or multiuse trail) to be applicable to a very wide range of facility types and settings. It is important to note that the analytical tool introduced in this guide and the research behind it were not developed to apply to every type of shared-use path. The list below describes the limits of the study and the applicability of its findings.

FOR WHAT TYPES OF SHARED-USE PATHS IS THIS STUDY APPLICABLE?

- The tool presented in this guide is applicable only to paved hard-surface paths (asphalt or concrete). Paths surfaced with gravel, dirt, wood chips, or other materials were not evaluated in the research, and surface type and quality are not a component of this LOS evaluation.

- The tool evaluates path LOS for bicycle mobility. While the findings and recommendations will likely improve a trail's conditions for all users (pedestrians, runners, in-line skaters, etc.), the study was conducted from the point of view of the bicyclist.

- The tool does not accommodate use of specific mode split inputs for users outside the five user groups identified in this research—i.e., adult bicyclists, pedestrians, runners, in-line skaters, and child bicyclists. Moreover, it is not applicable to evaluating the unique impacts on LOS that other trail users may have, such as push scooters, wheelchair users, equestrians, cross-country skiers, electric vehicles, or others who may be a part of the mix on some trails.

- This tool is not applicable to trail segments with stop signs, signal controls, or road crossings placed more frequently than every 0.40 kilometers (km) (0.25 miles (mi)).

- The tool is structured to address two-way, shared-use path facilities. It was not created with bicycle-only or one-way paths in mind; however, it may be applicable to paths of this nature. It does not apply to on-street bicycle facilities.

CHAPTER SUMMARIES

This guide is divided into six chapters following this introduction.

Chapter 2 summarizes the purpose and objectives of the research, its approach, and its basic findings. It provides definitions for key terms used in the guide and a list of various factors studied during data analysis. Findings include a summary of characteristics found on the study trails, user perception survey results, and the development of a data profile for an average trail. Appendix A provides a full data profile for the 15 study trails.

Chapter 3 provides an introduction to the concept of LOS and describes how it has been applied to shared-use paths. It provides a brief description of the mathematical model used to create the Shared-Use Path LOS Calculator and describes how trail LOS grades should be interpreted. It concludes with a table of LOS scores and grades for the 15 trails examined in this study.

Chapter 4 describes how to apply the Shared-Use Path LOS Calculator to various trail planning and design issues. Data requirements are discussed, as well as model assumptions and default values. This chapter concludes with an introduction to the quick reference, “Look-Up Tables,” where a range of typical trail widths, volumes, and mode mixes are listed, with corresponding LOS scores and grades. The look-up tables are provided in appendix C.

Chapter 5 provides a step-by-step guide to using the Shared-Use Path LOS Calculator.

Chapter 6 discusses possible implications of research on trail design. Topics discussed include trail width, striping options, and use of separate treadways for select user types. Trail operation and management decisions may also be informed by analysis conducted with this tool.

Chapter 7 includes two fictional case studies that describe diverse applications of the calculator to real-life situations: first, to evaluate the performance of an existing trail to determine how much trail widening may be needed, and second, to determine the appropriate width when planning the cross section of a new trail.

OTHER REPORTS AND PRODUCTS GENERATED BY THIS STUDY

This Federal Highway Administration (FHWA) publication, FHWA-HRT-05-138, *Shared-Use Path LOS Calculator—A User’s Guide*, and the associated Shared-Use Path Level of Service Calculator are two of the products resulting from this research project. Other products include FHWA-HRT-05-137, *Evaluation of Safety, Design, and Operation of Shared-Use Paths—Final Report* and an accompanying TechBrief.

2. AN OVERVIEW OF THE RESEARCH

PROBLEM STATEMENT

During the design of every shared-use path, someone eventually asks, "How wide should this pathway be?" That question nearly always raises even more questions: "What types of users can we reasonably expect? When will we need to widen the path? Do we need to separate different types of users from each other?"

At the present time, conventional design manuals provide little guidance on these issues. The 1999 American Association of State Highway and Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* states, "Under most conditions, a recommended paved width for a two-directional shared-use path is 3.0 m (10.0 feet)…. Under certain conditions it may be necessary or desirable to increase the width of a shared-use path to 3.6 m (12.0 feet) or even 4.2 m (14.0 feet), due to substantial use by bicycles, joggers, skaters and pedestrians."[(2)] No further guidance is given to determine what specific levels of use—or mixture of uses—warrants a wider pathway or a separation of users. The purpose of this research is to fill this information gap and to give planners, designers, and managers the necessary tools to make more informed decisions regarding trail width and design.

Previous research efforts have laid the groundwork for the study of this problem. In order to provide some level of guidance in the year 2000 edition of the FHWA *Highway Capacity Manual* (HCM)[(3)], Rouphail, et al., recommended an analytical procedure to determine LOS for bicyclists on shared off-street paths.[(4)] Rouphail, et al., adapted a procedure originally developed by Hein Botma[(5)] in the Netherlands.[(4,5)]

Botma is considered an important pioneer in the development of early measures of user density (crowding), flow characteristics, and hindrance for bicyclists using shared-use paths. His procedure bases LOS on two factors: first, the number of trail users passed in the opposing direction (meetings), and second, the number of slower trail users that are traveling in the same direction that a bicyclist must overtake (active passes). A useful starting point, Botma's framework had a variety of limitations for application in the United States.[(5)]

The Botma method addressed only two trail user modes—bicycles and pedestrians. Runners, in-line skaters, and other common path users were not incorporated. The significant presence of these path users on U.S. trails suggested that a tool developed for application in the United States should attempt to address them.

Next, the LOS scores generated by the Botma method were developed based on his experience of shared-use paths in the Netherlands and were not calibrated to the opinions of actual trail users.[(5)] Harkey, et al., (1998) and Landis, et al., (1997) have developed LOS criteria for on-street bicycling conditions, which are validated against user perceptions of the quality of service.[(6,7)] The success of their work has shown that when quantitative measures are statistically calibrated with user perceptions, the resulting model has greater acceptance with stakeholders at all levels—technical staff, elected officials, facility users, and the general public.

Finally, Botma's work did not include investigation of any other factors to determine if they might have a significant influence on trail users' perceived LOS.[(5)] Factors such as delay, trail-striping patterns, the presence of usable shoulders, sight distance, or lateral clearance all might be important. Identification, analysis, and incorporation of other criteria that may contribute to actual users' opinion of LOS will ensure the development of a more effective predictive tool.

PURPOSE

The purpose of this study was to gather and analyze background data necessary to develop a model that professionals can use to evaluate the operational effectiveness of a shared-use path, create and test that model, and develop a user-friendly interface and guide for its use.

APPROACH

To accomplish this purpose, a three-step approach was developed:

1. Review prior research and develop a sound theoretical approach to solving the problem.
2. Gather the necessary operational and user perception data.
3. Analyze the data and develop and test a model that can be used by practitioners as a planning and design tool.

Step 1: Develop Theoretical Approach

Step one was accomplished through the completion of a literature review and the development of a technical dissertation that described the theoretical approach. The results of these interim products are summarized separately from this User's Guide, in the project's Final Report.(8)

Step 2: Data Collection

Step two involved gathering and analyzing two types of data, operational data and user perceptions. Operational data collection involved gathering volume, speed, and mode split data from test locations along 15 trails throughout the United States. It also included gathering sufficient information about the characteristics of each study trail to create a thorough path profile and also testing other factors that might prove influential to bicyclists' LOS. These data included path width, surface type, path setting, sight distance, lateral clearance, presence of a shoulder or adjacent unpaved treadway, and other factors. See appendix A for profiles of the 15 study trails.

User perception data were gathered by surveying over 100 typical trail users regarding their perceptions of four aspects of shared-use path operations:

- Lateral spacing.
- Longitudinal spacing.
- Ability to pass.
- Overall perception of comfort and freedom to maneuver.

Designing this aspect of the research posed a challenge: how to have a group of approximately 100 survey participants experience a wide variety of trail conditions. Because cost and logistics made the physical movement of groups of respondents to multiple trail survey sites impossible, it was decided to bring the study trail sites to the survey participants through the use of videotaped trail experiences.

A total of 105 survey participants were gathered in two metropolitan areas—Raleigh-Durham-Chapel Hill, NC, and Washington, DC. Each group of participants viewed 36 one-minute video clips of a test bicyclist traveling along a section of one of the study trails.[*] By viewing exactly the same video clips, two geographically distinct survey groups vicariously experienced the same variety of trails and trail conditions.

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[*] Five of the 15 study trails were not represented in the video clips used for the user perception survey: the W&OD, Grant's, Capital Crescent, Pinellas, and White Creek trails.

The video clips were created using a helmet-mounted video camera. A member of the research team (the test bicyclist) bicycled down a 0.8-km (0.5-mi) segment of each of the study trails while the camera taped the view of the trail ahead. Approximately 60 three-minute video clips were created for each of the study trails.[†] The 36 one-minute video clips used for the survey were selected from this footage.

Survey participants viewing the video clips could see the path ahead, the landscape on each side of the trail, the oncoming trail traffic, and slower moving traffic in the test bicyclist's lane. At times, the video clips included a tape of passing maneuvers, when the test bicyclist overtook slower moving traffic. The test bicyclist tried to remain at a constant speed for the duration of each video clip.

The participants in the survey were asked to score each video clip for the four aspects noted previously: lateral spacing, longitudinal spacing, ability to pass, and overall perception of comfort and freedom to maneuver.

Step 3: Data Analysis/Development of the Model

The raw operational data were analyzed for three purposes: to develop volume and mode split profiles for each study trail; to develop a variety of constants and other factors for use in the LOS model; and to validate the theoretical methods developed to predict meetings and passings. The constants gathered included average and standard deviation speeds for all trail-user types, a peak-hour factor, a propensity-to-pass factor, and passing-distance intervals.

The user perception survey results were expected to correlate with measurable events on each trail. Each trail was analyzed for the following four measurable events:

- Meetings: the number of trail users (by user type) that passed the test bicyclists going in the opposite direction.
- Active passes: the number of users traveling in the same direction (by user type) that were passed by the test bicyclists.
- Passive passes: the number of times the test bicyclist was passed by trail users traveling in the same direction.
- Delayed passes: the number of times that the test bicyclist needed to pass in order to maintain speed but was blocked by other users traveling in either direction.

A full discussion of model development and creation of the Shared-Use Path LOS Calculator is presented in chapter 3.

FINDINGS

The most important findings of this study can be organized into two groups: characteristics of study trails and perception survey results.

Characteristics of Study Trails

Typical 2-way trail user volumes were found to vary considerably from as low as 43 per hour on the W&OD Trail in Northern Virginia to 2,316 per hour on the North Beach Lakefront Path in

[†] Weather and technical problems prevented a full set of 60 three-minute clips from being created for four of the study trails. See tables 1–4 for the number of valid data collection trials that were completed for each study trail.

Chicago, IL. [‡] Per-hour volume data were created by averaging the counts from approximately 60 three-minute trials taken over the course of a peak usage day (from about 10 a.m. to 5 p.m.), typically Saturday or Sunday. Where commuter traffic was significant, some data were collected on weekday mornings. See table 1 for a summary of average per-hour volumes by study trail.

Table 1. Variations in trail user volume.

Path name	Location	Average two-way volume (per hour)	Trail width (ft)	Successful data collection trials (3 minutes each)
W&OD Trail	Arlington, VA	44	10.0	4
Honeymoon Island Trail	Dunedin, FL	110	12.0	48
Pinellas Trail	Pinellas County, FL	120	15.0	57
Grant's Trail	St. Louis County, MO	122	12.0	30
Capital Crescent Trail	Washington, DC	159	10.0	9
Lake Johnson Trail	Raleigh, NC	205	8.0	58
White Creek Trail	Dallas, TX	216	8.0	60
White Rock Lake Trail	Dallas, TX	252	14.0	60
Forest Park Trail	St. Louis, MO	299	10.0	57
Sammamish River Trail	Redmond, WA	418	10.0	58
Charles River Bike Path	Boston, MA	438	8.0	60
Minuteman Bikeway	Arlington, MA	442	12.0	60
South Bay Trail	Santa Monica, CA	616	14.0	60
Mill Valley—Sausalito Pathway	Marin County, CA	641	9.5	60
Lakefront Trail	Chicago, IL	2320	20.0	90

1 ft = 0.30 m

User mix also varied considerably on the 15 study trails. Users on five trails were observed to comprise more than 70 percent adult bicyclists. On six trails, more than 35 percent of users traveled on foot (pedestrians and runners). Observation of user types found few users outside of the five basic user groups presented in table 2. Wheelchair users and push scooters were observed on some trails, but not in sufficient quantity to develop a statistically valid average speed profile.

[‡] Due to adverse weather conditions, very few data collection trials could be executed on the W&OD and Capital Crescent trails in the Washington, DC, metropolitan area.

Table 2. Variations in trail user mix (mode split).

			Average percent of volume by trail user type (mode split)				
Path name	**Location**	**Trail width (ft)**	**Adult bicyclists**	**Pedes-trians**	**Runners**	**Skaters**	**Child bicyclists**
Pinellas Trail	Pinellas County, FL	15.0	81.4	4.6	2.3	11.6	0.0
Sammamish River Trail	Redmond, WA	10.0	78.9	3.4	3.4	6.0	8.4
W&OD Trail	Arlington, VA	10.0	73.7	5.3	15.8	5.3	0.0
Charles River Bike Path	Boston, MA	8.0	72.3	8.2	3.8	14.7	1.1
White Rock Lake Trail	Dallas, TX	14.0	71.6	13.6	8.0	3.4	3.4
White Creek Trail	Dallas, TX	8.0	64.8	9.9	6.6	14.3	4.4
Mill Valley—Sausalito Pathway	Marin County, CA	9.5	62.8	7.8	27.8	0.0	1.7
Grant's Trail	St. Louis County, MO	12.0	59.2	16.3	4.1	10.2	10.2
Capital Crescent Trail	Washington, DC	10.0	55.9	17.0	18.6	3.4	5.1
Minuteman Bikeway	Arlington, MA	12.0	51.9	6.2	15.6	18.1	8.1
Lakefront Trail	Chicago, IL	20.0	48.8	20.5	17.7	12.3	0.7
South Bay Trail	Santa Monica, CA	14.0	40.3	17.4	12.5	25.0	4.9
Forest Park Trail	St. Louis, MO	10.0	33.0	24.4	27.8	13.9	0.9
Honeymoon Island Trail	Dunedin, FL	12.0	22.9	54.2	12.5	8.3	2.1
Lake Johnson Trail	Raleigh, NC	8.0	14.1	63.3	21.9	0.0	0.8

1 ft = 0.30 m

Based on the width, centerline, volume, and mode split data collected on the study trails, an average trail profile was developed. To ensure that the outliers in the data set did not skew the average, the high- and low-volume trails (Lakefront and W&OD, respectively) were not used to calculate the data profile for the average trail in table 3. Mode split shares were rounded to the nearest five.

Table 3. Data profile for the average trail.

	Width	**Centerline**	**One-way volume per hour**	**Adult bicycles**	**Pedestrians**	**Runners**	**Skaters**	**Child bicycles**
Average trail	11 ft	Yes	105	55%	20%	10%	10%	5%

1 ft = 0.30 m

This research also yielded a large volume of data on average speeds for different types of trail users. Table 4 shows the average user speed for each mode and the typical range of variation (standard deviation).

Table 4. Average speed by mode.

Trail user type (mode)	Average speed (mi/h)	Standard deviation (mi/h)
Adult bicyclists	12.8	3.4
In-line skaters	10.1	2.7
Child bicyclists	7.9	1.9
Runners	6.5	1.2
Pedestrians	3.4	0.6

1 mi/h = 1.6 km/h

Perception Survey Results

As explained above, a survey of 105 trail users (primarily bicyclists) was used to determine what factors bicyclists found to be significant in their evaluation of comfort and freedom to maneuver on shared-use paths. Using standard statistical methods, a wide variety of factors were tested to determine their overall influence on survey responses. The following is a summary of these findings.

The primary factors found to affect bicyclists' perceived LOS were:

- Path width.
- Active passes (frequency of encountering and passing other users in the same direction).
- Meetings (frequency of encountering other users in the opposite direction).
- The presence of a striped centerline.

The frequency of active passes and meetings were determined by user mix (mode split) and the overall user volume on the trail.

As a result of the survey, bicyclists' LOS was shown to be most affected by sharing a trail with slower users. Pedestrians had the greatest negative impact, because they had the slowest average speed. For example, a bicyclist traveling at 19.3 kilometers per hour (km/h) (12.0 miles per hour (mi/h)) faced an impediment when encountering a pair of pedestrians traveling at 4.8 km/h (3.0 mi/h) or a runner traveling at 9.76 km/h (6.0 mi/h). During these encounters, the bicyclists executed passing maneuvers to maintain speed.

Encountering significant numbers of slow moving users in the same direction of travel increased the need to make passing maneuvers. Encountering significant numbers of slow moving users traveling in the opposite direction tended to block the space needed to make passing maneuvers. Width played a factor in determining how much space was available to make passing maneuvers, and the presence of a striped centerline was also found to affect the bicyclist's sense of freedom to maneuver.

In summary, bicyclists' LOS decreased when:

- The need to pass other users increases.
- The amount of space available to make a passing move decreases.
- The probability that a passing opportunity will be blocked by other users increases.

Factors found to have little or no effect on the bicyclist's operational comfort include the following:

- Trail setting.
- Lateral clearance.
- Sight distance.
- Presence of a shoulder.
- Presence of horizontal curves.

Each of the factors listed above was evaluated only within the range of variation extant among the 15 study trails (see appendix A for details). Within those ranges of variance, these factors were not found to be statistically correlated to the LOS ratings given by the participants in the user perception survey.

3. LOS FOR SHARED-USE PATHS

WHAT IS LOS?

For motor vehicles on roadways, HCM defines LOS as a "quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience."[(3)] HCM defines six levels of service for a particular facility type and uses letters A to F to represent them, from best to worst. Each LOS represents a range of operating conditions. Safety is not explicitly included in the measures that establish motor vehicle LOS.

The trail LOS model developed through this research is similar to that which is used for motor vehicle LOS. Listed below are some key similarities and differences.

Similarities include:

- The trail LOS model uses six levels of service categories and the letters A to F are used to represent them, from best to worst.
- Maintaining an optimum speed (for the bicyclist) is a key criterion.
- Service measures are primarily related to freedom to maneuver. These include meetings, active passes, delayed passes, and the perceived ability to pass.
- Safety is not included in the set of measures that establish service levels.

The key difference is:

- Trail LOS does not factor in travel time or traffic interruptions such as signals or stop signs at grade crossings.

It is important to note a host of other factors the reader may want to consider in a trail users' assessment of comfort and enjoyment of a trail, such as the following:

- Pavement/surface condition and materials.
- Weather.
- Frequency and design of curves.
- Presence and degree of grade changes (hills).
- Proximity to adjacent motor vehicle traffic.
- Quality of scenery.
- Physical setting.
- Quality of bicycling equipment in use.
- Perceived safety of the surrounding neighborhood.

Just as motor vehicle LOS measures a limited aspect of the experience of driving and does not take into account the quality of the vehicle in which a person travels, the scenery along the road, etc., the trail LOS model has similar limitations. While such factors of trail design are important to the user's experience, they will be left to further research.

THE SHARED-USE PATH LOS MODEL

The Shared-Use Path LOS (SUPLOS) model is a mathematical formula that uses select inputs describing conditions along a trail to calculate an LOS score. A key task in model development was to determine what inputs should be used and what mathematical relationships existed among them. The goal was to develop a formula that would yield scores consistent with the evaluation of similar conditions made by participants in the perception survey. A secondary objective was to use only those inputs that are truly necessary and most readily available.

Using a variety of statistical methods, the operational and user perception survey variables were examined to evaluate which variables had the most influence in determining the grades users gave to the different conditions represented in the video clips. A model (mathematical equation) was built that would use the most significant factors as inputs to generate LOS scores and grades. The model was tested and adjusted to ensure that it generated grades that closely correlated to the perception scores that trail users gave each video clip.

The equation in figure 1, below, is the basic SUPLOS model. Appendix B provides additional details about the factors used in the model. For a complete explanation of the derivation of the model see chapter 7 of the Final Report.[8]

$$\text{SUPLOS} = 5.446 - 0.00809(E) - 15.86(RW) - 0.287(CL) - (DPF)$$

Figure 1. Equation. Basic SUPLOS model.

Where:

E = Events = Meetings per minute + 10 (active passes per minute)
RW = Reciprocal of path width (i.e., 1/path width, in feet)
CL = 1 if trail has a centerline, 0 if trail has no centerline
DPF = Delayed pass factor

The SUPLOS model generates a LOS score between zero and five. Table 5 describes the SUPLOS scale, which shows how raw scores correspond to letter grades. An A is the highest score, excellent, and an F is the lowest score.

Table 5. SUPLOS scale.

LOS Score	LOS Grade	
$X \geq 4.0$	A	Best
$3.5 \leq X < 4.0$	B	↓
$3.0 \leq X < 3.5$	C	
$2.5 \leq X < 3.0$	D	
$2.0 \leq X < 2.5$	E	
$X < 2.0$	F	Worst

INTERPRETING SHARED-USE PATH LOS GRADES

In general, grades A–C can be considered acceptable levels of service and D–F can be considered degraded levels of service. The LOS descriptions in table 6 provide a more refined framework.

A benefit of this LOS model is that it provides a uniform quantitative measurement for use throughout the United States and North America. However, each political jurisdiction and trail managing agency certainly has latitude to adopt different policies covering acceptable levels of service for trails within their own communities, as is the case with roadway levels of service. To some degree, determining what scores and grades are acceptable can vary for each different application of the model. For example, a jurisdiction may elect to establish a policy to ensure that new trails meet a higher performance standard than the standard considered acceptable for existing trails.

Table 6. Interpreting SUPLOS grades.

A: Excellent. Trail has optimum conditions for individual bicyclists and retains ample space to absorb more users of all modes, while providing a high-quality user experience. Some newly built trails will provide grade-A service until they have been discovered or until their ridership builds up to projected levels.

B: Good. Trail has good bicycling conditions, and retains significant room to absorb more users, while maintaining an ability to provide a high-quality user experience.

C: Fair. Trail has at least minimum width to meet current demand and to provide basic service to bicyclists. A modest level of additional capacity is available for bicyclists and skaters; however more pedestrians, runners, or other slow-moving users will begin to diminish LOS for bicyclists.

D: Poor. Trail is nearing its functional capacity given its width, volume, and mode split. Peak-period travel speeds are likely to be reduced by levels of crowding. The addition of more users of any mode will result in significant service degradation. Some bicyclists and skaters are likely to adjust their experience expectations or to avoid peak-period use.

E: Very Poor. Given trail width, volume, and user mix, the trail has reached its functional capacity. Peak-period travel speeds are likely to be reduced by levels of crowding. The trail may enjoy strong community support because of its high usage rate; however, many bicyclists and skaters are likely to adjust their experience expectations, or to avoid peak-period use.

F: Failing. Trail significantly diminishes the experience for at least one, and most likely for all user groups. It does not effectively serve most bicyclists; significant user conflicts should be expected.

LOS SCORES FOR 15 STUDY TRAILS

Table 7 provides LOS scores and grades for 15 trails studied as part of this research. This table includes two-way and one-way user volumes, mode splits, trail widths, and presence of centerline variables. It also provides a data profile for the average trail and its corresponding LOS score and grade (3.15, C).

Table 7. Study trail level of service grades and characteristics.

							Trail User Type Mode Split Percentage				
Path Name	**LOS Score**	**LOS Grade**	**Total Two-Way Volume (per hour)**	**One-Way Volume (per hour)**	**Trail Width (ft)**	**Center-line**	**Adult Bikes**	**Pedestrians**	**Runners**	**Skaters**	**Child Bikes**
Pinellas Trail	4.05	A	120	60	15.0	Yes	81.4	4.6	2.3	11.6	0.0
Honeymoon Island Trail	3.78	B	110	55	12.0	No	22.9	54.2	12.5	8.3	2.1
White Rock Lake Trail	3.75	B	252	126	14.0	Yes	71.6	13.6	8.0	3.4	3.4
Grant's Trail	3.72	B	122	111	12.0	Yes	59.2	16.3	4.1	10.2	10.2
W&OD Trail	3.50	B	44	22	10.0	Yes	73.7	5.3	15.8	5.3	0.0
Sammamish River Trail	3.31	C	418	209	10.0	No	78.9	3.4	3.4	6.0	8.4
Minuteman Bikeway	3.30	C	442	221	12.0	Yes	51.9	6.2	15.6	18.1	8.1
Capital Crescent Trail	3.15	C	159	80	10.0	Yes	55.9	17.0	18.6	3.4	5.1
White Creek Trail	3.07	C	216	108	8.0	No	64.8	9.9	6.6	14.3	4.4
South Bay Trail	2.39	E	616	308	14.0	Yes	40.3	17.4	12.5	25.0	4.9
Charles River Bike Path	2.37	E	438	219	8.0	Yes	72.3	8.2	3.8	14.7	1.1
Forest Park Trail	2.17	E	299	150	10.0	Yes	33.0	24.4	27.8	13.9	0.9
Mill Valley—Sausalito Pathway	1.94	F	641	320	9.5	No	62.8	7.8	27.8	0.0	1.7
Lake Johnson Trail	1.61	F	205	102	8.0	No	14.1	63.3	21.9	0.0	0.8
Lakefront Trail	0.0	F	2320	1160	20.0	Yes	48.8	20.5	17.7	12.3	0.7
Average Trail†	3.15	C	311	105	11.0	Yes	55.0	20.0	10.0	10.0	5.0

1 ft = 0.3 m

† The profile of the Average Trail was created by averaging the data for 13 of the 15 study trails. The high and low volume trails (W&OD and Lakefront) were dropped from the mix and the data of the remaining trails was averaged. The mode splits were rounded to the nearest increment of five.

4. APPLYING THE MODEL TO YOUR TRAIL

The SUPLOS model is applicable to a variety of trail planning and design problems related to crowding and to accommodating diverse user groups. It is especially useful for trail planning and design tasks that need to augment qualitative criteria with quantitative measures to strengthen the basis for making trail design decisions. The following is a list of potential uses for the analysis tool:

- To plan appropriate widths and cross sections for new trails.
- To evaluate LOS provided on existing trails.
- To guide the design of improvements for existing trails, where additional capacity is needed.
- To determine how many additional users a trail may be able to serve, given a minimum LOS threshold.
- To evaluate LOS for specific timeframes when particular trip purposes need to be served, such as weekday morning and evening periods when commuting trips are heaviest.
- To determine LOS at a particular location on a trail, such as a narrow pinch point, an unusually high-use area, or an area with many reported user conflicts.

To enable the easy use of the model by practitioners, it has been programmed into a spreadsheet tool called the Shared-Use Path LOS Calculator. The spreadsheet tool provides the LOS for a path segment based on only four inputs from the user: estimated or counted one-way user volume in the design hour, mode split percentages, trail width, and presence or absence of a centerline. This chapter will help the reader understand how to apply this tool effectively and to generate results that are appropriate for the particular problem at hand. To make the best use of the calculator, it is important to understand the limits of its application and how contextual factors should be considered when collecting or structuring the input data.

LINK ANALYSIS

The SUPLOS model is a link analysis tool designed to provide an LOS evaluation for a particular link or segment of a linear trail. It is not designed to evaluate trail/roadway intersections, rest stops, or trailheads. It only provides LOS along a particular segment of pathway.

In general, segment length is not a limiting factor in selecting a link for analysis. The key to determining how much trail can be evaluated with one calculation is whether or not the trail conditions and use characteristics remain the same over the entire length that has been selected. However, because of the limits of the data used to calibrate the model, trail segments under a 0.40 km (0.25 mi) are not recommended for analysis. Moreover, because typical trip distances for some trail users are limited, and user turn-back rates will begin to undermine the accuracy of volume and mode split data on longer segments, 3.2–4.8 km (2.0–3.0 mi) is the recommended maximum segment length.

Each practitioner should exercise professional judgment in making these decisions. To aid that effort, the following list of conditions and characteristics should remain roughly the same over the entire distance of trail being considered as one link (segment):

- Trail width.
- Trail user volume.
- Trail user mix (mode split).
- Presence of a centerline stripe.

- An absence of significant flow interruptions such as stop signs, signalized road crossings, or other grade crossings (see box below).
- An absence of spur trails, trailheads, or other access points that may significantly affect user volumes or mix.

If any of these characteristics change significantly over the length of a trail segment, it is recommended that the segment be divided into one or more links using road crossings, access points, or other locations where characteristics change as endpoints for the smaller segments. Moreover, when considering establishing a trail volume and user mix profile for a single segment that is longer than 1.6 km (1.0 mi) based on counts taken in only one location, it is important to determine if turn-back rates for pedestrians or other users might be significant enough to affect the accuracy of this data for the sections of the segment that are farthest from the data collection point. In other words, if users often turn around partway through, a single count may not represent the whole segment very well.

As with any model, the quality and accuracy of the output can be no better than that of the inputs. It is understood that the quality and accuracy of input data will vary for each user of the tool. Moreover, each user and/or situation does not demand a uniform level of accuracy to produce a useful result. For these and other reasons, professional judgment is critical in determining what level of accuracy is required for the data to be used in any particular application. In most situations, slight variations in data may not affect LOS scores significantly, and the tool itself can be used to test variations in data and to determine what impact they have on LOS results.

Flow Interruptions

The SUPLOS model does not factor in potential delay and other impacts from stop signs, signalized road crossings, or other grade crossings that interrupt the flow of trail traffic. The model is designed to generate LOS scores for trail segments of 0.40 km (0.25 mi) or longer with no flow interruptions. If LOS is desired for a length of trail that includes these types of interruptions, the trail should be segmented at these locations, and if possible, separate volume and mode split data should be developed for each segment.

DATA REQUIREMENTS

Only four data inputs are needed for the model to generate an LOS score and grade-trail width, presence of a centerline, one-way user volume and mode split. The following discussion of data requirements is provided to help readers apply the tool correctly and effectively to their unique situation.

Trail Width

Trail widths should be measured in feet. Widths may be entered in half-foot increments, i.e., 8.0, 8.5, 9.0, etc. (1 ft = 0.305 m). The model is calibrated to address widths between 2.4 m and 6.1 m (8.0 ft and 20.0 ft). Widths greater or lesser than these amounts will produce score and grade outputs; however, the model is not designed to address widths outside a range of 2.4–6.1 m (8.0–20.0 ft).[*]

[*] The *Guide for the Development of Bicycle Facilities* (AASHTO, 1999) established 2.4 m (8.0 ft) as the minimum recommended width for shared use paths. The widest trail included in this study was the 6.1 m (20.0-ft) Lakefront Trail in Chicago, IL; the model is not designed to address widths outside these minimum and maximum boundaries.

Centerline

Centerline is a yes/no input, to be based on the existing striping pattern of each test segment or the proposed striping pattern for an unbuilt trail.

Trail User Volume

The volume data needed for the calculator can be provided in one of three ways, depending on how the tool is being applied:

- By using actual volume counts collected on an existing trail.
- By using estimated volume counts developed by extrapolating from actual volume data gathered on another trail that is determined to be similar to the test trail (this can be one of the trails addressed in this study).
- By developing projected user volumes such as for an unbuilt trail, where LOS calculations will be used to aid in the trail planning and design process.

Whether volume data are developed from estimates or actual counts, they should be structured, or restructured, in the following ways:

- One-way trail volume should be calculated for each separate segment (link) of trail for which an LOS score is desired. If counts are structured as total two-way volumes, an assumed 50/50 directional split is recommended for conversion to one-way volumes. Volume data should be expressed in users per hour.
- Volume data should include a total count of all user types (modes) that use the treadway being evaluated. If a separate parallel treadway such as a jogging track or equestrian trail exists in the same trail corridor, users on this treadway should not be included in the volume or user mix data used in the model.
- If new user counts are collected for use in this tool, it is recommended that a minimum of three two-way, hourly counts be taken on each trail segment for which an LOS score is desired. For each test trail segment, an average, one-way, per-hour volume can be created from the three, two-way hourly counts.

If actual user volume is not known and estimates need to be developed, options include:

1. Use the volume data collected on another trail in your community or region that is sufficiently similar to the one you wish to analyze.
2. The one-way trail volume for the average trail can be used. This can be accomplished by using the volume number provided in the SUPLOS model itself; also see the average trail in table 4.
3. Review the trail volumes of the 15 study trails (see appendix A and table 4), and use the volume from a study trail that seems to be similar to the trail you wish to analyze, i.e., if it is located in a similar community, has a similar setting, has a similar width, has a similar mode split, etc.

Trail User Mix (Mode Split)

Mode split is expressed as a percentage of one-way trail users per hour. The model provides the opportunity to input a mode split percentage for up to five different modes: adult bicyclists, pedestrians, runners, in-line skaters, and child bicyclists. Mode split inputs can be round numbers or precise numbers using one decimal place. They need to add up to 100 percent, exactly. Zero is an acceptable entry for any mode. Given the entire set of user types that are found on shared-use paths, these 5 categories were developed based on the actual users that were observed on the 15 study trails.

Other users, such as push scooters, electric scooters (used by disabled persons), wheelchairs, etc., may be present or expected on trails where this tool is applied. If the mode split data being used for the test trail segment include a breakout of user percentages in categories other than the five used by the calculator, those additional categories should be added to one of the five modes used by the calculator; use the mode that has the closest corresponding travel speed. [†] For average travel speeds, see table 4.

If actual mode splits are not known and estimates need to be developed, options include:

1. Use mode splits from data gathered on another trail in your community or region that are sufficiently similar to the one you wish to analyze.
2. Use the mode split for the average trail. This can be accomplished by clicking a special button in the calculator spreadsheet labeled default mode split.
3. Review the mode splits of the 15 study trails (see appendix A and table 2) and use a mode split from one of the study trails that you judge to be similar to the trail you wish to analyze, i.e., if it is located in a similar community, has a similar setting, has a similar width, etc.

Spatial and Behavioral Factors That Affect Volume and Mode Split Data

On many trails, user volumes and mix will vary considerably along different segments. When more accurate LOS scores are desired, trail segmenting should account for these variations. The following is a list of spatial and behavioral factors that can generate significant volume and mode split fluctuations and can be used to guide segmentation:

- Locations of trail access points, including junctions with other trails, spur trails, trailheads, park nodes along a trail, and access points between the trail and adjacent trip generators and destinations.

- Trip generators and destinations associated with points of access, such as housing developments, employment centers, schools, parks, university campuses, entertainment attractions, or other institutions or public properties.

- Typical trip lengths and turn back rates; these will vary by user type and from trail to trail, because they are influenced by a number of trail specific factors such as trail layout, trip purposes, landscape character, and the personal habits and needs of local trail users.

Additionally, when new user counts are planned, these factors may be used to inform the location, frequency, and timing of the counts. When volume and mode split estimates are being used for model inputs, the factors listed above may be used to make adjustments to the estimates to increase data accuracy.

[†] However, because the model does not address the unique characteristics of equestrians, cross-country skiers, snowmobiles, or motorized all-terrain vehicle (ATV) trail users, counts of these users should not be included in any of the five categories or in the user volume totals.

Temporal Factors That Affect Volume and Mode Split Data

Temporal factors such as season of the year, day of the week, and time of day may be the most significant factors affecting trail user volumes. Therefore, any LOS calculated by the model applies only to the timeframes in which the volume data counts were taken.

In most cases, trail analysts seek to understand trail operations under highest-use conditions. When this is the case, the volume data to use in the calculator should reflect those conditions. The volume data should be gathered during, or adjusted to reflect, the typical highest-use times. The exact number and duration of user counts needed to fully describe highest-use conditions may vary from case to case, depending on the level of detail desired for the volume profile and on how the resulting LOS score is to be used.

To make a decent accounting of the variation in user volumes one might expect on a trail, at least three one-hour counts are recommended for each trail segment evaluated. Assuming that the purpose of the LOS scores is to determine if and how to improve service during high-use periods, counts should be taken during the high-use season, on a high-use day(s), and at high-use times of the day.

In some cases, a trail manager’s problem may center as much on determining the duration or extent of high-use periods as on the decline of LOS during high-use times. Poor levels of service experienced during a few weekends a year or for an hour or two on a weekend day may be more tolerable than if a trail is crowded all day long throughout the spring, summer, and fall. The duration of time that certain levels of service exist may be as important to know as the LOS score itself. In these cases, the volume data used in the calculator should be more extensive and reflect greater temporal diversity.

Some users of this tool may seek an LOS evaluation for a more specific purpose such as determining the LOS for bicycle commuters during an afternoon peak. In such a case, the data would be gathered on weekdays during the season(s) that generates the highest commuting rates and would focus on the particular afternoon hours when bicyclists are present on the particular trail segments.

ASSUMPTIONS AND DEFAULTS

This section describes the key assumption and default values built into the Shared-Use Path LOS Calculator and look-up tables in appendix C. Any of these values may be changed in the detailed spreadsheets of the calculator if the user has more specific information on hand.

Directional Split

The SUPLOS model assumes a 50/50 directional split.

User Speed

The model uses the average speeds and standard deviations for each user as shown in table 7. The default speed for the test bicyclist is 20.6 km/h (12.8 mi/h), which is the same speed as the average bicyclist.

Peak-Hour Factor

The model uses a default peak-hour factor (PHF) of 0.85. This factor was calculated using the data collected on the study trails. PHF is based on the observed one-way volume for the peak 15 minutes within the 1-hour volume count. The model applies a PHF of 0.85 to the one-way, per-hour user volume, which results in a volume boost of 17.6 percent. This factor ensures that the model results are responsive to typical flow peaking conditions found on trails.

Operational Patterns and the Delayed Pass

This and other trail research has found that bicyclists on trails tend to operate in distinct lanes, whether or not lanes are indicated on the trail surface with striping. Typical operational patterns include two-lane, three-lane, and four-lane operations:

- In two-lane operations, passing maneuvers are made in the opposing lane.
- In three-lane operations, each direction of travel shares use of a middle lane for passing maneuvers.
- In four-lane operations, each direction of travel has its own passing lane.

Because no standards exist that correlate trail width with lane operations, this study assumed the correlations shown in table 8. The widths in table 8 roughly correlate with the AASHTO *Bicycle Facility Design Guide*'s recommended 1.2-m (4.0-ft) minimum allocation of space for safe bicycle operation.

Table 8. Correlation of trail widths and operational lanes.

Width (ft)	Lanes
8.0–10.5	2
11.0–14.5	3
15.0–20.0	4

1 ft = 0.3 m

Lane configuration matters only in the model's calculation of a delayed-pass factor. The model automatically determines the correct lane configuration to use based on trail width, as shown in table 8. The delayed pass factor is computed differently for each of the three possible lane configurations using the overall trail volume, mode split, and average travel speeds to calculate the probability of encountering delay in a passing maneuver:

- Two-lane operation has the greatest potential for creating delayed passes because the bicyclist must use the opposing lane to pass a slower user, and that lane may be occupied by users traveling in the opposite direction.

- Three-lane operations provide the bicyclist with better conditions for passing slower users because of the presence of a center, shared passing lane. Delay is determined primarily by the likelihood that a trail user traveling in the opposite direction is already using the center lane to make a passing maneuver; there is less likelihood of delay than in two-lane operation.

- Four-lane operations provide still better passing conditions because, unless overall user volume is extremely high, the probability of a delayed passing maneuver is greatly reduced.

SHARED-USE PATH LOS LOOK-UP TABLES

Appendix C includes a series of look-up tables that have been developed to provide readers a quick reference for LOS grades and volumes.

Tables 12 through 14 (see appendix C) provide LOS grades for a variety of volumes and trail widths using the average trail mode split, a high bicycle share mode split, and a high pedestrian share mode split, respectively. Tables 15 through 17 provide maximum service volumes for each LOS grade for a variety of trail widths. Service volumes are the volumes at the boundaries between levels of service. Again, three mode split examples are provided: average trail, high bicycle share, and high pedestrian share.

5. INSTRUCTIONS FOR USING THE SHARED-USE PATH LOS CALCULATOR

INTRODUCTION

The Shared-Use Path LOS Calculator is provided in the form of a spreadsheet. Programmed with the complete LOS model, it provides a one-page, user-friendly interface (worksheet) that allows the user to analyze up to five data sets. The calculator requires only four inputs to generate an LOS grade—trail width, presence of a centerline, trail user volume, and mode split for up to five user types (adult bicyclists, pedestrians, runners, in-line skaters, and child bicyclists).

The calculator is programmed in a Microsoft Excel ®™ spreadsheet file (filename: SUPLOS_Calculator_FHWA_2004) that can be acquired by downloading the file from the website of the U.S. Department of Transportation (USDOT) supported Pedestrian and Bicycle Information Center (www.bicyclinginfo.org or www.walkinginfo.org), or by ordering it on CD-ROM from the Information Center.

The calculator provides five data entry rows in which LOS can be tested on as many as five different trails or trail segments. Analysis scenarios can include different trails or diverse segments of the same trail. For details about the lengths of trail to which LOS calculations can be applied, see the box below.

Trail Length and LOS Calculations

Because the SUPLOS model is a *link analysis* tool, any single LOS score applies only to a trail segment having consistent width, striping, volume, and mode split characteristics throughout. A test segment must be at least 0.40 km (0.25 mi), but can be a number of kilometers (miles) long if the same input values are valid over the entire segment and there are no trail flow interruptions (stop signs, signals, or at-grade crossings) within the segment. The presence of flow interruptions, points of access (that significantly diminish or increase the volume, or change the mode split), or changes in trail width or surface will necessitate segmenting the trail for the purposes of LOS evaluation, and each segment will need its own unique set of input data.

STEP-BY-STEP INSTRUCTIONS

The Shared-Use Path LOS Calculator should be opened in Excel. Enable Macros should be selected in the first dialogue box. If not already selected, the Trail_LOS_Calculator tab at the bottom of the window should be selected. This will open the calculator worksheet.

The calculator provides five data entry rows in which LOS can be tested on as many as five different trails or trail segments at one time. The first row of the calculator includes example data for a typical trail, based on the average volumes and mode splits found on the 15 trails included in this study.

Entering Data

Before beginning the data entry process, review the previous chapter and the discussion about data requirements. Based on that discussion, assemble the data necessary to conduct your analysis.

1. The first column provides a cell to enter the trail or segment name. Type in a name or segment identifier.

2. The second column provides a cell for trail width. Enter a number representing the desired width in feet. Widths may be entered in 0.5-ft increments, i.e., 8.0, 8.5, 9.0, etc. (1 ft = 0.305 m).
3. The third column asks if the trail has (or will have) a centerline. Type in a 1 for yes or a 0 for no.
4. The fourth column provides a cell for one-way trail volume per hour. Enter a representative number.
5. Columns five through nine provide cells for mode split. Entries may or may not use decimal increments in tenths. (Decimal increments in hundredths should be rounded to tenths.) The sum of the 5 mode splits should total exactly 100, or an error message will appear above the data entry row.
6. Data entries cannot be made in any of the spreadsheet cells other than those described above.

Once all of the numeric inputs are entered, columns 11 and 12 will automatically calculate the LOS score and provide an LOS grade.

Interpreting Results

In the upper right-hand corner of the spreadsheet, a scale is provided that correlates the score with the appropriate grade. In general, grades A–C represent acceptable levels of service, whereas D–F are degraded levels of service. See chapter 3 for a full discussion on interpreting LOS grades.

Copying and Printing Results

The calculator worksheet provides five data entry rows to test LOS on as many as five different trails or trail segments at one time. Once five scenarios have been entered, the whole sheet may be copied or converted to a word processing or spreadsheet file to create a permanent record of these cases and results. Once the information has been pasted into a new file, revision of model calculations will not be possible in that new document.

Using the regular print commands, the results may be printed directly from Excel or by printing the file to which copies have been saved.

By copying and saving the results to another file, the calculator can be used multiple times without losing the results of previous scenarios.

Returning to the Default Mode Split

For convenience, the calculator worksheet has been designed with a separate one-click button to reset the default mode split for each row.

6. IMPLICATIONS OF THIS RESEARCH FOR TRAIL DESIGN

The central findings of this study have important implications for trail design. The following is a list of key findings that can be used to inform design choices:

1. Width is the key factor in determining LOS, and every additional foot of trail width has a positive impact on LOS.
2. Bicyclists' LOS on pathways is very sensitive to user mix; when the amount of foot traffic (runners and pedestrians) surpasses 15 percent of trail use, bicyclists' LOS is significantly impacted.
3. Bicyclists are affected by a centerline stripe dividing directional flows.

TRAIL WIDTH

The findings of this study provide strong support for the standard trail width guidance provided in the AASHTO *Guide for the Development of Bicycle Facilities*.(2) Trails having 2.4-m (8.0-ft) width, which AASHTO recommends only in "rare instances," were found to have poor LOS, except at very low volumes or with user mixes that included few pedestrians and runners. The findings of this research support AASHTO's minimum "recommended paved width for a two-directional shared-use path of [3.0 m] ten feet." [*]

The study found that widths of 3.4–4.6 m (11.0–15.0 ft) provide improved LOS for higher volumes and more balanced user mixes than narrower widths. This is consistent with AASHTO recommendations that "under certain conditions it may be necessary or desirable to increase the width of a shared-use path to 3.8 m (12.0 ft) or even to 4.3 m (14.0 ft), due to substantial use by bicycles, joggers, skaters and pedestrians, …."[†] Trails of 3.4–4.6 m (11.0–15.0 ft) are wide enough to operate as three-lane paths. The increased passing capacity provided by a trail that operates as three lanes improves LOS and increases the trail's ability to absorb higher volumes and more diverse mode splits without severely degrading service.

Design Implications—Width

- During design of new trails and widening of existing trails, designers may want to consider varying the trail width to achieve LOS goals in key locations but not overbuild in other locations. Adding width to improve LOS is valuable to trail users, even if it is provided only on selected segments.

- When considering wider trails, designers and decisionmakers may want to think in 0.3-m (1-ft), rather than 0.6-m (2.0-ft), increments. Typical practice has been to consider trail widths in 0.6-m (2.0-ft) increments. Using this approach may miss opportunities to provide measurable increases in LOS while at the same time containing costs and minimizing environmental impacts.

CENTERLINE STRIPING

A striped centerline was found to have strong impact on the bicyclist's perception of freedom to maneuver. This finding appears to support the intent of trail designers in providing a centerline, which is clear delineation of opposing travel lanes. A centerline reinforces the idea that, to pass a

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[*] *Guide for the Development of Bicycle Facilities*, AASHTO, 1999, p. 35.
[†] ibid, p. 36.

slower-moving user, the cyclist may need to use the travel lane of opposing trail users and should pass only when the opposing lane is open.

This research found that the presence of a centerline stripe results in a significant reduction in the LOS. It appears that bicyclists may feel less comfortable making a same-direction passing movement when a centerline stripe is present. While this finding might appear initially to mean that a centerline stripe degrades pathway LOS and should not be used, it is important to note that there may be other valid safety reasons for providing a centerline stripe, particularly on crowded trails, on curves with limited sight distance, and in other appropriate circumstances.

MULTILANE STRIPING

Only two trails in this study were striped with more than two travel lanes. The Pinellas Trail was striped as a three-lane trail, with one lane in each direction for bicycles and skaters and one lane for pedestrians. The Lakefront Trail was striped as four lanes, with two lanes in each direction. These two examples did not represent a sufficient number of study trails to fully assess the impact of multilane striping patterns on LOS. However, it is likely that having sufficient trail width for a four-lane operation (a minimum of 4.6 m (15.0 ft)) increases the ability of bicyclists to pass slower-moving users without encountering blockage from trail users in the opposing lanes.

MULTIPLE TREADWAYS

A number of shared-use trails have been designed with two treadways in the same trail corridor. Often, one is paved and the other is a soft surface. Frequently, one of the treadways is provided for exclusive use by one or two trail user groups, or user restrictions are imposed on both paths in an effort to segregate users.

Given this study's findings about the impact of user mix on bicyclist LOS, a multiple treadway design that effectively reduces the number of pedestrians and runners mixing with bicyclists will have significant LOS benefits for the treadway used by bicyclists. This study did not address compliance with use restrictions, an issue that is often raised by trail managers as a problem when separate treadways are provided.

TRAIL OPERATIONS AND MANAGEMENT

While this study did not examine issues related to trail operations and management, the framework of the tool may lend itself to applications in this area. Such possibilities might include the use of LOS grades in warrants for trail etiquette or warning signs. Trail etiquette signs address the sharing of treadways or the use of designated passing protocols. LOS may also be useful in setting trail speed limits or other advisory or regulatory protocols that will increase user safety and moderate user conflicts.

7. EXAMPLE APPLICATIONS: FICTIONAL CASE STUDIES

CASE STUDY 1: TESTING DESIGN OPTIONS FOR THE STONE CREEK TRAIL UPGRADE

Stone Creek Trail is located in the heart of Rockton, an old, eastern industrial city of about 200,000 residents. The 25-year-old trail is located in a linear park that was developed along a large stream, Stone Creek. Downtown Rockton grew at the confluence of Stone Creek and the Rocky River. The trail is 8.8 km (5.5 mi) long and connects a number of the city's finest neighborhoods with downtown. Along it are located an elementary and junior high school, a major playground, a small hospital, and a small liberal arts college. When it was last repaved 15 years ago, it was widened from the previous 1.8-m or 2.1-m (6.0-ft or 7.0-ft) width to 2.4 m (8.0 ft) throughout.

In recent years, the city council and managing agency, Rockton Department of Public Works and Parks (DPW&P), have been receiving pressure to widen the trail even further. That pressure was coming from a number of community interests:

- The Tourism Council and Historic Preservation League, which have been successful in boosting the city's economy through historic preservation efforts focused on the old milling industry, the reuse of warehouses as small-scale breweries, and the town's access to outdoor recreation activities in the nearby mountains. They wanted more and better outdoor recreation activities to be offered in town to keep tourist dollars coming into the city.

- A group of parents who felt that the trail was unsafe because of its age, rough surface, and narrow width. In recent years, there have been a couple of bad crashes between trail users; these involved youths. Skaters, skateboarders, push scooters, strollers, and dog walkers are all common on the trail, in addition to bicycles and pedestrians.

- A local environmental organization that recently joined with the local bicycle club to promote in-line skate and bicycle commuting to reduce downtown parking demand and keep the air clean. The trail seemed too narrow to accommodate more nonmotorized wheels, however, along with all of the pedestrians, kids, and a growing crowd of fitness walkers organized by the hospital.

The Stone Creek Park Committee, a longstanding advisory committee for DPW&P, favors some widening but is wary of making the trail so wide that too many trees are lost and the 100-year-old park will become a speedway for wheels. There is concern that too many wheeled users will make the park and trail too scary for senior citizens and others (mostly walkers) who have cared for it for many years. Segregation of users is one possibility they are considering, but they are not sure users will comply.

The question is this: How much more width is enough to satisfy the demand and how much is too much? An initial staff survey determined that, in most parts of the park, enough space exists to accommodate a trail of up to 4.3 m (14.0 ft) wide. The DPW&P staff and the committee would like to know what other communities in similar situations have done. However, even on the Internet, they had difficulty finding another community with enough similar characteristics that had already encountered and solved a similar trail problem. Then, in response to a call to the State, the Bicycle and Pedestrian Coordinator at the State department of transportation recommended the Shared-Use Path LOS Calculator, a new FHWA resource.

Because the community had no existing trail counts, nor were any useful volume counts available from other multiuse trails in the State, it was necessary to gather fresh trail user counts to develop inputs for use of the tool. Volunteers from all of the interested stakeholder groups were organized, and they followed the trail count guidelines provided in the SUPLOS User's Guide. To meet the data needs necessary for the results they wanted, the following data collection scope was adopted:

- Collect data on three warm-weather Spring days in different weeks of May and early June (Friday, Saturday, and Sunday).
- Take counts to cover the following time periods—three 2-hour periods on Friday (7–9 a.m., 12–2 p.m., and 4–6 p.m.) and 10 a.m.–4 p.m. on Saturday and Sunday.
- Take counts at five locations along the trail, at midpoints between major access points.
- Count children on skateboards, push scooters, and skates as pedestrians, the user type with the most similar speed profile.

Figure 2, a screen capture from the Shared-Use Path LOS Calculator for this case, shows the results of the average weekend, one-way, per-hour, volume counts, and mode splits. Friday volumes were found to be about 50 percent lower and so were not used for the LOS calculations. As noted above, for data collection and analysis purposes, the trail was divided into five segments. Trail segments 1 and 2 scored F and E levels of service, respectively, while the other segments scored D, confirming suspicions that peak-hour conditions were deteriorating. It was easy for the staff and committee to imagine even worse conditions on summer weekends when more tourists were in town.

Before various widths were tested, participants agreed that if the trail were widened, it should be done not only to improve conditions for existing users, but also to secure some additional capacity for future growth in trail use.

ROW #1

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	Volume	Mode Split (%)*							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
Stone Creek 1	13.0	1	152.0	53.0%	24.5%	13.0%	7.5%	2.0%	100.0%	3.27	C

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

ROW #2

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	Volume	Mode Split (%)*							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
SC 2	11.0	0	137.0	64.5%	19.5%	9.5%	5.0%	1.5%	100.0%	3.57	B

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

ROW #3

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	Volume	Mode Split (%)*							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
SC 3	10.0	1	94.0	55.5%	13.5%	12.0%	9.0%	10.0%	100.0%	3.13	C

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

ROW #4

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	Volume	Mode Split (%)*							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
SC 4	11.0	1	117.0	62.0%	11.5%	13.5%	9.5%	3.5%	100.0%	3.47	C

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

ROW #5

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	Volume	Mode Split (%)*							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
SC 5	12.0	1	145.0	61.5%	8.0%	15.5%	13.0%	2.0%	100.0%	3.55	B

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

1 ft = 0.3 m

Figure 2. Screen capture. Existing conditions LOS analysis.

The following general LOS goal and design policy was adopted:

- The LOS goal should be a high C or low B to ensure space for additional users.
- A flexible design approach should be used to meet the needs of the users that are attracted to each segment. For example:
  - Segment 1 near downtown should have room to attract more users and provide a trail experience that tourists will want to repeat.
  - Part of segment 3 near the school and a popular playground attracts more youth and should be designed to support trail etiquette education.
  - Segment 5, which runs along the college campus, attracts more skaters and runners.

Using these guidelines, a variety of widths was tested in the calculator to see which achieved the desired levels of service. Figure 3, a screen capture from the Shared-Use Path LOS Calculator for this case, shows the widths and resulting LOS scores that were finally selected.

ROW #1

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
Stone Creek 1	8.0	1	152.0	53.0%	24.5%	13.0%	7.5%	2.0%	100.0%	1.95	F

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

ROW #2

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
SC 2	8.0	1	137.0	64.5%	19.5%	9.5%	5.0%	1.5%	100.0%	2.33	E

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

ROW #3

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
SC 3	8.0	1	103.0	55.5%	13.5%	12.0%	9.0%	10.0%	100.0%	2.67	D

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

ROW #4

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
SC 4	8.0	1	117.0	62.0%	11.5%	13.5%	9.5%	3.5%	100.0%	2.65	D

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

ROW #5

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerline	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
SC 5	8.0	1	145.0	61.5%	8.0%	15.5%	13.0%	2.0%	100.0%	2.58	D

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicylists.

Click Here for Default Mode Split

1 ft = 0.3 m

Figure 3. Screen capture. LOS for selected design widths.

Working with a trail design consultant, the widths in figure 3 and the general guidelines were used to develop five different cross-sections. Designs for segments 2 and 4 varied only in the centerline treatment, as a means to further test users' response. Table 9 describes the final segment designs selected.

Table 9. Selected cross sections.

Segment Number/Distance	Width	Shoulder	Rationale
1 / 0.75 mi	13 ft, centerline	Grass	The downtown section serves a heavy mix of pedestrians, tourists, and bicycle commuters.
2 / 1.75 mi	11 ft, centerline only on curves	Grass	This section weaves through an especially cherished part of the park with many old trees and scenic settings along the stream; trail expansion needs to be kept to a minimum.
3 / 0.75 mi	10 ft, centerline	2 ft of rolled stone dust on each side	Because of its proximity to the schools, playground, and adjacent neighborhoods, this section should include a centerline and shoulders to facilitate youth education about trail-sharing etiquette.
4 / 1.00 mi	11 ft, centerline	Grass	This requires a transition design between segments; a separate soft surface jogging path could be added in the future.
5 / 1.25 mi	12 ft, centerline	Grass	Width could be added to serve in-line skaters and higher overall user volumes from the college; segments 4 and 5 can be promoted as ideal for skating as a way to draw skaters to this section of trail. A separate soft-surface jogging path could be added in the future.

1 mi = 1.6 km; 1 ft = 0.3 m

CASE STUDY 2: TESTING DESIGN OPTIONS FOR THE DE SOTO RIVER WATERFRONT TRAIL

The De Soto River Trail is a 7.2-km (4.5-mi) segment of multi-use trail proposed for the downtown waterfront in the city of New Metropolis. It will extend the existing De Soto River Trail, a 24.2-km (15.0-mi) trail system, from a nearby suburb into the heart of the city. New Metropolis is a city of 500,000 people in a metropolitan area of approximately 1.5 million.

The Waterfront Trail has been an idea in the city's comprehensive plan for many years; however, no action was taken until a waterfront revitalization effort brought the idea to prominence. Currently, a detailed waterfront redevelopment plan is underway and the city's Office of Planning wants to ensure that the trail component of this plan establishes appropriate path design guidelines. Because it is the first major shared-use path to be built in the city for 25 years, the city's transportation and park departments have no pre-existing guidelines and little trail experience. An advisory committee has been formed to assist the Office of Planning and revitalization consultants with the trail plan.

The major question facing the Waterfront Trail Advisory Committee (WTAC) is this: How wide must the trail be to serve the volumes and diverse user groups expected? A WTAC member suggested using a new resource developed by USDOT-funded research called the Shared-Use Path LOS Calculator. The following discussion describes how WTAC used the calculator to inform their design process.

After reading in the User's Guide how the LOS concept should be applied to a trail with various access points, WTAC recognized that a LOS evaluation should be performed for three separate segments:

- Segment A—3.2 km (2.0 mi) of path in newly acquired public lands that pass through a natural area slated to become an urban conservation area, with limited park development. This segment has no access points between the existing trailhead in Jefferson County and Reed Mill Park.

- Segment B—a 2.4-km (1.5-mi) segment that passes through Reed Mill Park, the oldest park in the city, which is slated for revitalization and will serve as a major trailhead area.

- Segment C—a 1.6-km (1.0-mi) segment that will be located in a new waterfront park to be built as an extension of Reed Mill Park. The new park is very close to downtown New Metropolis, which is expanding toward the river, now that upgraded flood control infrastructure is in place. From downtown to Water Street, the old warehouse district is being redeveloped with commercial and residential uses. The park will be about 0.40 km (0.25 mi) wide along the shoreline. Future expansion of the path 4.8 km (3.0 mi) down-river may be feasible if and when an old railroad line is abandoned.

Given the history of the De Soto River Trail in neighboring Jefferson County, it seemed logical to employ trail usage data from that trail, at least as a starting point for volumes and user mixes that might be expected on the city's section of the trail.

The existing De Soto River Trail is a 3.0-m (10.0-ft) wide asphalt path. Counts taken the previous year show that the trail is averaging about 250 users per hour (total 2-way volume). The mode split for various trail user types was as follows:

- Bicycles—51 percent.
- Pedestrians—16 percent.
- Joggers—19 percent.
- Skaters—10 percent.
- Other—4 percent.

The volume data provided by Jefferson County were generated by taking counts every hour between 12:00 p.m. and 4:00 p.m. on one nice-weather weekend in both the spring and fall. The location where these counts were taken is just outside the city, along a 2.4 km (1.5-m) segment between a large trailhead near the city limits and a Jefferson County regional park facility in Jeffersonville (a suburb of 85,000 people). Based on this volume and mode split data, the calculator gave the existing De Soto River Trail in Jefferson County a LOS score of 2.81, which is a high D.

Because the Waterfront Trail will be located in the city, which has higher population density and fewer trail opportunities than suburban Jefferson County, WTAC wants a plan to accommodate higher future-use levels. As a result, WTAC developed the following adjustments to the Jefferson County baseline counts, upon which to base assumptions for LOS analysis of segments A–C:

- Each trail segment should be developed to meet a low-C LOS for projected 10-year volumes and mode splits as defined below.
- Each trail segment has a different character and context; therefore, the 10-year projections and mode splits should vary accordingly:
    - Segment A, plus 20 percent of baseline, with fewer pedestrians and more bicycles.
    - Segment B, plus 50 percent of baseline, at the same mode split.
    - Segment C, plus 100 percent of baseline, with more pedestrians and fewer bicycles.
- To accommodate additional increases in usage beyond these estimates, the trail should be designed with right-of-way reserved for expansion.
- It is assumed that, in the first few years after a trail segment is built, the trail will experience user volumes lower than the baselines, and thus levels of service during those periods will be above C.
- If the new trail is very popular from the start, it may need to exist at an LOS D for a period of years until expansion can be funded.

Using these assumptions, the Office of Planning staff developed a series of volume and mode split estimates to use as inputs into the Shared-Use Path LOS Calculator to develop potential trail design cross sections for segments A–C of the Waterfront Trail, as shown in table 10.

Table 10. Volume and mode split estimates to test in the calculator.

Segment	Assumptions (conditions)	One-way volume per hour	Bikes	Peds	Runners	Skaters	Child Bikes
Existing trail in Jefferson County	Experiencing some user conflicts	125.0	51%	16%	19%	10%	4%
Segment A	Same as above	150.0	56%	11%	19%	10%	4%
Segment B	Same as above	187.5	51%	1%	19%	10%	4%
Segment C	Same as above	250.0	40%	25%	20%	13%	2%

Various widths were tested in 0.2-m (0.5-ft) increments, starting at 2.9 m (9.5 ft). With each width change, the LOS score was observed to determine when a low-C (3.0-3.2) was achieved. It took 6.1 m (20.0 ft) width to get a low-C for segment C. Because 6.1 m (20.0 ft) was considered too wide a footprint, a multiple treadway design was considered that would provide pedestrians and runners with their own dedicated treadways. An 80 percent compliance rate was used for pedestrians and runners, and the user volume and mode splits were reduced accordingly. Figure 4, a screen capture from the Shared-Use Path LOS Calculator for this case, shows the results from the calculator after revising segment C for multiple-treadway options.

Based on these results, WTAC adopted the following width design guidelines for each trail segment:

- Segment A: Build a 3.4-m (11.0-ft) asphalt path, with AASHTO-recommended 0.6-m (2.0-ft) shoulders to be planted in grass. In natural areas, boardwalk sections may be reduced to a total clearance between railings of 3.7 m (12.0 ft).

- Segment B: Build a 3.7-m (12.0-ft) asphalt path, with AASHTO-recommended 0.6-m (2.0-ft) shoulders to be planted in grass.

- Segment C: For environmental and aesthetic reasons, building a path 6.1 m (20.0 ft) wide was not considered optimal or desirable. However, given the 0.40-km (0.25-mi) width of the waterfront park and the high volume that is expected in this segment near downtown, at least 6.1 m (20.0 ft) of width was determined to be desirable if it was provided in separate treadways, using space, landscaping, and elevation as buffers:

  - Closest to the river, a 1.8–2.4-m-wide (6.0–8.0-ft-wide) concrete promenade for pedestrians to stroll and observe the river (3.0–3.7 m (10.0–12.0 ft) wide for the expected highest-use segment).

  - Located away from the river, a 3.4-m (11-ft) asphalt path for bicyclists and skaters, with 0.4-m (1.0-ft) concrete shoulders and 0.6-m (2.0-ft) grass shoulders on each side (4.0 m (13.0 ft) of usable treadway) and a minimum 10.7-m (35.0-ft) buffer between path and promenade.

  - Located adjacent to the path (on the riverside), a 1.2-m (4.0-ft) soft surface trail for runners, with a minimum 1.5-m (5.0-ft) grass buffer.

  - Assuming an 80 percent compliance rate for pedestrians and runners using their separate treadways, the bicycle/skate path will provide a high LOS C (see segment C, revised, in figure 4).

ROW #1

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerlin	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
Jeff. County	10.0	1	125.0	51.0%	16.0%	19.0%	10.0%	4.0%	100.0%	**2.81**	**D**

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicyclists.

Click Here for Default Mode Split

ROW #2

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerlin	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
Segment A	11.0	1	150.0	56.0%	11.0%	19.0%	10.0%	4.0%	100.0%	**3.33**	**C**

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicyclists.

Click Here for Default Mode Split

ROW #3

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerlin	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
Segment B	12.0	1	187.5	51.0%	16.0%	19.0%	10.0%	4.0%	100.0%	**3.13**	**C**

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicyclists.

Click Here for Default Mode Split

ROW #4

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerlin	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
Segment C	20.0	1	250.0	40.0%	25.0%	20.0%	13.0%	2.0%	100.0%	**3.01**	**C**

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicyclists.

Click Here for Default Mode Split

ROW #5

Segment Name	Path Width	Centerline	Volume (users per hour in 1 direction) and Mode Split							Trail LOS	
	Closest 0.5 ft.	0=No Centerlin	*Volume*	*Mode Split (%)**							
Name	Width (ft)	1=Centerline	One-Way (per hour)	Adult Bicyclists	Pedestrians	Runners	In-Line Skaters	Child Bicyclists	All Modes	LOS Score	LOS Grade
C Revised	11.0	1	160.0	62.5%	8.0%	6.5%	20.0%	3.0%	100.0%	**3.42**	**C**

*Default mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicyclists.

Click Here for Default Mode Split

1 ft = 0.3 m

Figure 4. Screen capture. LOS for 10-year projected volumes and selected design widths.

To ensure the potential to serve higher than expected volumes of trail users in the future, the following recommendations were included in the design guidelines:

- For segment A: Identify a separate alignment for a 1.2–1.5-m (4.0–5.0-ft) hiker/runner path with a soft surface, to be developed if demand warrants. Because this is a natural area, if more capacity is ever needed, a natural surface pedestrian track should be created rather than expanding the paved treadway. To minimize the path footprint and visual impact in the natural area, the pedestrian track could be located away from the paved trail.

- For segment B: Reserve sufficient right-of-way on the waterside of the main path to allow the development of a 1.8-m (6.0-ft) stone-dust pedestrian and runner path with a minimum 1.5-m (5.0-ft) buffer between the two paths. The second path can be added if and when additional capacity is needed. It could also be paved if a hard surface will better meet users' needs and if environmental impacts are acceptable.

APPENDIX A. STUDY TRAIL PROFILES

Lake Johnson Trail
Raleigh, NC

Trail Profile

Trail length:	8.8 kilometers (km) (5.5 miles (mi))
Community context:	Suburban SE Raleigh, NC
Trail endpoints:	Loop in Lake Johnson Park
Trail type:	Park loop
Part of a trail system:	Part of the Capital Area Greenway
Managing agency:	Raleigh Department of Parks and Recreation

Study Location Characteristics

Study location:	0.40 km (0.25 mi) to 1.21 km (0.75 mi)
Landscape setting at study location:	Wooded park, lake
Surface material:	Asphalt (in poor condition)
Path width:	2.4–2.6 meters (m) (8.0–8.5 feet (ft))
Improved shoulder:	No
Centerline:	No
Lane striping pattern:	None
Other treadways in the corridor:	None
Clear zone:	0.3–1.2 m (1.0–4.0 ft)
Landscape adjacent to clear zone:	Wooded park, lake
Sight distance	Poor
Curves:	Medium
Slopes:	Low

Sammamish River Trail
Redmond, WA

Trail Profile

Trail length:	16.1 km (10.0 mi)
Community context:	Suburban Seattle, WA
Trail endpoints:	Blyth Park in Bothell, WA, and Marymoor Park in Redmond, WA
Trail type:	Linear riverside greenway
Part of a trail system:	Connects directly with the Burke Gilman Trail in Bothell, WA
Managing agency:	King County Park and Recreation Division

Study Location Characteristics

Study location:	In Sixty Acre Park, about 0.8 km (0.5 m) from NE 116th St. in Redmond, WA
Landscape setting at study location:	Linear park, grass, and ballfields, adjacent to Sammamish River
Surface material:	Asphalt
Path width:	3.0 m (10.0 ft)
Improved shoulder:	No
Centerline:	No
Lane striping pattern:	None
Other treadways in the corridor:	Horse trail
Clear zone:	1.8–3.0 m (6.0–10.0 ft) of short, mowed grass
Landscape adjacent to clear zone:	Linear park, grass, and ballfields, adjacent to Sammamish River
Sight distance	Good
Curves:	Low
Slopes:	Low

Mill Valley—Sausalito Pathway
Marin County, CA

<u>Trail Profile</u>

Trail length:	4.8 km (3.0 mi)
Community context:	Suburban San Francisco
Trail endpoints:	Harbor Drive in Sausalito, CA, and Alto Tunnel in Mill Valley, CA
Trail type:	Rail-trail
Part of a trail system:	A small component of the Bicentennial Bike Path and San Francisco Bay Trail; connects to popular on-street routes at each end
Managing agency:	Marin County Department of Parks, Open Space and Cultural Services

<u>Study Location Characteristics</u>

Study location:	At Bothin Marsh, north of the U.S. 101 bridge
Landscape setting at study location:	Marsh, adjacent highway, bay
Surface material:	Asphalt
Path width:	2.9–3.2 m (9.5–10.5 ft)
Improved shoulder:	Yes; 5.0–7.0 ft of gravel
Centerline:	No
Lane striping pattern:	None
Other treadways in the corridor:	None
Clear zone:	1.5–2.1 m (5.0–7.0 ft) gravel
Landscape adjacent to clear zone:	Marsh, adjacent highway, bay
Sight distance	Unlimited
Curves:	Low
Slopes:	No

White Rock Lake Trail
Dallas, TX

Trail Profile

Trail length:	15.0 km (9.3 mi)
Community context:	Urban NE Dallas, TX
Trail endpoints:	Loop in White Rock Lake Park
Trail type:	Park loop
Part of a trail system:	Connects to the White Creek Trail on the north lakeside.
Managing agency:	Dallas Department of Parks and Recreation

Study Location Characteristics

Study location:	Just south of the E. Lawther/Emerald Isle park access, near Winfrey Point
Landscape setting at study location:	Open parkland, lake, park road
Surface material:	3.7 m (12.0 ft) of asphalt with 0.30-m (1.0-ft) concrete edges
Path width:	4.3 m (14.0 ft)
Improved shoulder:	No
Centerline:	Yes
Lane striping pattern:	Solid striped centerline; two 2.1-m (7.0-ft) lanes
Other treadways in the corridor:	Some bicyclists use park road
Clear zone:	3.0–6.1 m (10.0–20.0 ft) grass, with some trees
Landscape adjacent to clear zone:	Open parkland, lake, park road
Sight distance	Unlimited
Curves:	Low
Slopes:	No

Lakefront Trail
Chicago, IL

Trail Profile

Trail length:	39.4 km (24.5 mi)
Community context:	Urban north Chicago, IL
Trail endpoints:	Southside Chicago, IL, and Evanston, IL
Trail type:	Lakefront beach trail
Part of a trail system:	Connects to lakefront trail in Evanston, IL
Managing agency:	Chicago Parks District

Study Location Characteristics

Study location:	Near trail intersection with North Avenue
Landscape setting at study location:	Public park and beach
Surface material:	Concrete
Path width:	6.1 m (20.0 ft)
Improved shoulder:	No
Centerline:	Yes
Lane striping pattern:	Solid centerline and lane striping forming two interior 1.8-m (6.0-ft) lanes bounded by two 1.2-m (4.0-ft) lanes
Other treadways in the corridor:	None
Clear zone:	Unlimited
Landscape adjacent to clear zone:	Public park and beach
Sight distance	Poor, due to heavy user volumes
Curves:	No
Slopes:	No

South Bay Trail
Santa Monica, CA

Trail Profile

Trail length:	35.4 km (22.0 mi)
Community context:	Suburban W. Los Angeles, CA
Trail endpoints:	Santa Monica, CA, and Torrance, CA
Trail type:	Oceanfront beach trail
Part of a trail system:	Many connections
Managing agency:	City of Santa Monica

Study Location Characteristics

Study location:	About 1.6 km (1.0 mi) north of the Santa Monica Pier
Landscape setting at study location:	Public beach
Surface material:	Concrete
Path width:	4.37 m (14.0 ft)
Improved shoulder:	No
Centerline:	Yes
Lane striping pattern:	Dashed centerline
Other treadways in the corridor:	None
Clear zone:	Unlimited
Landscape adjacent to clear zone:	Public beach
Sight distance	Unlimited
Curves:	Low
Slopes:	No

Forest Park Trail
St. Louis, MO

Trail Profile

Trail length:	12.1 km (7.5 mi)
Community context:	Urban St. Louis, MO
Trail endpoints:	Loop in Forest Park, MO
Trail type:	Park loop
Part of a trail system:	Connects to many trails within park
Managing agency:	St. Louis Department of Parks, Recreation and Forestry

Study Location Characteristics

Study location:	On the north edge of the park, along Lindell Blvd., between mileposts 5.25 and 5.75 (8.4 km–9.3 km), close to the History Museum
Landscape setting at study location:	Open parkland, adjacent roadway
Surface material:	Asphalt
Path width:	3.0 m (10.0 ft)
Improved shoulder:	Yes; 1.2 m (4.0 ft) of dirt on one side
Centerline:	Yes
Lane striping pattern:	Solid centerline
Other treadways in the corridor:	1.2-m (4.0-ft) dirt jogging path on one side
Clear zone:	1.2 m (4.0 ft)
Landscape adjacent to clear zone:	Open parkland, adjacent roadway
Sight distance	Good
Curves:	No
Slopes:	No

Honeymoon Island Trail (Dunedin Causeway)
Dunedin, FL

Trail Profile

Trail length:	4.9 km (2.5 mi)
Community context:	Suburban Tampa/St. Petersburg, FL
Trail endpoints:	Pinellas Trail in Dunedin, FL, and Honeymoon Island State Park
Trail type:	Highway sidepaths, greenway
Part of a trail system:	Connects to the Pinellas Trail in Dunedin, FL
Managing agency:	Florida Department of Transportation

Study Location Characteristics

Study location:	West of the draw bridge
Landscape setting at study location:	Marsh, beach, adjacent roadway
Surface material:	Asphalt
Path width:	2.2 m (12.0 ft)
Improved shoulder:	No
Centerline:	No
Lane striping pattern:	None
Other treadways in the corridor:	None
Clear zone:	None on one side, 1.2–1.5 m (4.0–6.0 ft) of grass on the other side
Landscape adjacent to clear zone:	Marsh, beach, guardrail, roadway
Sight distance	Unlimited
Curves:	Low
Slopes:	No

Minuteman Bikeway
Arlington, MA

Trail Profile

Trail length:	16.9 km (10.5 mi)
Community context:	Suburban Boston, MA
Trail endpoints:	Town of Bedford, MA, and Alewife "T" Station in Cambridge, MA
Trail type:	Rail-trail
Part of a trail system:	Connects to Alewife Linear Park and other trails
Managing agency:	Town of Arlington, MA

Study Location Characteristics

Study location:	Mile marker 7.5 (12.1 km) in Arlington, MA, near the Bike Shop
Landscape setting at study location:	Wooded railroad corridor
Surface material:	Asphalt
Path width:	3.7 m (12.0 ft)
Improved shoulder:	No
Centerline:	Yes
Lane striping pattern:	Dashed centerline; dashes are each 1.8 m (6.0 ft) long and 4.3 m (14.0 ft) apart
Other treadways in the corridor:	None
Clear zone:	0.6–1.4 m (2.0–4.0 ft)
Landscape adjacent to clear zone:	Wooded railroad corridor
Sight distance	Okay
Curves:	No
Slopes:	No

Charles River Bike Path (Dr. Paul Dudley White Bike Path)
Boston, MA

Trail Profile

Trail length:	29.0 km (18.0 mi)
Community context:	Urban Boston, MA
Trail endpoints:	O'Brien Bridge in Boston, MA, and Watertown, MA
Trail type:	Linear riverside greenway
Part of a trail system:	Circles the tidal Charles River on both shorelines from Science Park in Boston to Watertown Square
Managing agency:	Metropolitan District Commission

Study Location Characteristics

Study location:	South side of the Charles River, east of the Harvard Bridge (Massachusetts Ave.)
Landscape setting at study location:	Narrow linear park, river, adjacent highway
Surface material:	Asphalt
Path width:	2.4 m (8.0 ft)
Improved shoulder:	No
Centerline:	Yes
Lane striping pattern:	Dashed centerline; dashes are each 1.8 m (6.0 ft) long and 3.7 m (12.0 ft) apart
Other treadways in the corridor:	Separate pedestrian paths are present along much of the trail corridor
Clear zone:	None
Landscape adjacent to clear zone:	Narrow linear park, river, adjacent highway
Sight distance	Poor
Curves:	Medium
Slopes:	No

W&OD Trail
Northern Virginia

Trail Profile

Trail length:	72.4 km (45.0 mi)
Community context:	Suburban northern Virginia
Trail endpoints:	I-395 at Shirlington in Arlington, VA, and Purcellville, VA
Trail type:	Rail-trail
Part of a trail system:	Serves as the east-west spine of a system of trails in northern Virginia
Managing agency:	Northern Virginia Regional Park Authority

Study Location Characteristics

Study location:	Vienna, VA
Landscape setting at study location:	Narrow linear park
Surface material:	Asphalt
Path width:	3.0 m (10.0 ft)
Improved shoulder:	No
Centerline:	Yes
Lane striping pattern:	Solid
Other treadways in the corridor:	None
Clear zone:	Unlimited
Landscape adjacent to clear zone:	Narrow linear park
Sight distance	Excellent
Curves:	Gentle
Slopes:	None

Capital Crescent Trail
Washington, DC

Trail Profile

Trail length:	14.4 km (12.0 mi)
Community context:	Urban Washington, DC
Trail endpoints:	Silver Spring, MD and Georgetown in Washington, DC
Trail Type:	Rail-trail
Part of a trail system:	Connects to the Rock Creek Park Trail and C&O Canal Towpath at the south end
Managing agency:	Maryland National Capital Park and Planning Commission and the U.S. National Park Service (DC)

Study Location Characteristics

Study location:	Between K St. and Fletcher's Boathouse at the southern end of the trail in DC
Landscape setting at study location:	Wooded railroad corridor
Surface material:	Asphalt
Path width:	3.0 m (10.0 ft)
Improved shoulder:	No
Centerline:	Yes
Lane striping pattern:	Dashed centerline
Other treadways in the corridor:	C&O Canal Towpath parallels this section of trail
Clear zone:	0.6–1.2 m (2.0–4.0 ft)
Landscape adjacent to clear zone:	Wooded railroad corridor
Sight distance	No
Curves:	Unlimited
Slopes:	No

Grant's Trail
St. Louis County, MO

Trail Profile

Trail length:	10.9 km (8.0 mi)
Community context:	Suburban southwest St. Louis, MO
Trail endpoints:	I–55 at Hoffmeister in Orlando Gardens, MO, and Highway 44 in Kirkwood, MO
Trail Type:	Rail-trail
Part of a trail system:	No
Managing agency:	St. Louis County Department of Parks and Recreation

Study Location Characteristics

Study location:	Near trail crossing of Union Road
Landscape setting at study location:	Wooded railroad corridor, suburban homes
Surface material:	Asphalt
Path width:	3.7 m (12.0 ft)
Improved shoulder:	No
Centerline:	Yes
Lane striping pattern:	Solid yellow stripe
Other treadways in the corridor:	None
Clear zone:	0.6–1.2 m (2.0–4.0 ft)
Landscape adjacent to clear zone:	Wooded railroad corridor, suburban homes
Sight distance	Good
Curves:	Gentle
Slopes:	None

Pinellas Trail
Dunedin, FL

Trail Profile

Trail length:	75.7 km (47.0 mi)
Community context:	Suburban Tampa/St. Petersburg, FL
Trail endpoints:	Tarpon Springs, FL, and St. Petersburg, FL
Trail type:	Rail-trail
Part of a trail system:	Serves as the north-south spine for a system of trails and on-street bikeways in Pinellas County, FL
Managing agency:	Pinellas County Park Department

Study Location Characteristics

Study location:	North of Curlew Road in Dunedin, FL
Landscape setting at study location:	Narrow linear park
Surface material:	Asphalt
Path width:	4.6 m (15.0 ft)
Improved shoulder:	None
Centerline:	Yes
Lane striping pattern:	Solid white stripe divides bicycle/skate path (3.0 m (10.0 ft)) from pedestrian path (1.5 m (5.0 ft)), which is periodically marked with a white pedestrian symbol
Other treadways in the corridor:	Along some segments of the trail, the bicycle and pedestrian paths are separated by a grass buffer
Clear zone:	1.8–3.0 m (6.0–10.0 ft)
Landscape adjacent to clear zone:	Narrow Linear Park
Sight distance	Unlimited
Curves:	None
Slopes:	None

White Creek Trail
Dallas, TX

Trail Profile

Trail length:	12.1 km (7.5 mi)
Community context:	Suburban northern Dallas, TX
Trail endpoints:	Valley View Park (Hilcrest Road) in north Dallas, TX, and White Rock Lake Park in northeast Dallas, TX
Trail Type:	Linear streamside greenway
Part of a trail system:	Connects to the White Rock Lake Trail on the south end
Managing agency:	Dallas Department of Parks and Recreation

Study Location Characteristics

Study location:	North of the Fair Oaks Tennis Center, on both sides of the Walnut Hill Lane overpass
Landscape setting at study location:	Open parkland, stream
Surface material:	Asphalt
Path width:	2.4 m (8.0 ft)
Improved shoulder:	No
Centerline:	No
Other treadways in the corridor:	None
Clear zone:	9.2–22.9 m (30.0–75.0 ft) of grass with sparse tree cover.
Landscape adjacent to clear zone:	Open parkland, stream
Sight distance:	Unlimited
Curves:	None
Slopes:	None

APPENDIX B. FACTORS USED IN THE LOS MODEL

Table 11 provides a summary list of the key factors used in the Shared-Use Path LOS model. It also provides the shorthand name for each factor and a general description of how it functions in the model.

Table 11. Factors used in the shared-use path LOS model.

Factors found to affect bicyclists' LOS	Shorthand name	How the factor functions in the model
Overall user volume	One-way volume per hour	Used in the calculations of meetings, active passes, and delayed passes
Peak-hour factor	PHF	Accounts for flow peaking that was found to be common within hourly counts. Boosts base volume by 17.6 percent
Percentage of volume assigned to each of the five user types	Mode split	Used in the calculations of active passes, number of meetings, and number of delayed passes
User speed	Speed: average and standard deviation	Used in the calculations of meetings, active passes, and probability of delayed passes
Passing users traveling in the same direction	Active pass	Multiplied by 10 and added to meetings to create total events
Test bicyclist speed	Test bicyclist speed	Used in the calculations of meetings, active passes, and probability of delayed passes
Meeting users traveling in opposite direction	Meetings	Added to 10 x active passes to create total events
Meetings and active passes	Events	Total number of events and width determine LOS; calibrated to user perception survey grades
Path width	Width	Limits or enables passes, determines impact of potential blockages, defines operational characteristics, and is calibrated to user perception survey grades
Other users block active passing event	Delayed pass	Total number of delayed passes, from 0 to 180, correlates to a reduction of baseline LOS score of 0 to 1.5
Presence of a striped centerline	Centerline	Correlates to a .28 reduction in baseline LOS score

APPENDIX C. LOS LOOK-UP TABLES

Table 12. Shared-use path level of service look-up table, typical mode split.

		Trail Width (feet)						
		8	10	12	14	16	18	20
Trail Volume (One Direction per Hour)	25	B	B	B	B	A	A	A
	50	D	C	B	B	A	A	A
	75	D	C	B	B	B	A	A
	100	D	D	B	B	B	A	A
	150	E	D	C	C	B	B	B
	200	F	E	D	C	C	B	B
	250	F	F	D	D	C	C	C
	300	F	F	E	E	D	C	C
	400	F	F	F	F	E	E	E
	500	F	F	F	F	F	F	F
	600	F	F	F	F	F	F	F
	800	F	F	F	F	F	F	F
	1000	F	F	F	F	F	F	F

1 ft = 0.3 m

Table Assumptions

Mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicyclists.

An equal number of trail users travel in each direction (the model uses a 50%/50% directional split).

Trail volume represents the actual number of users counted in the field (the model adjusts this volume based on a peak hour factor of 0.85).

Trail has a centerline.

Table 13. Shared-use path level of service look-up table, high bicycle mode split.

		Trail Width (feet)						
		8	10	12	14	16	18	20
Trail Volume (One Direction per Hour)	25	A	A	A	A	A	A	A
	50	B	B	B	B	A	A	A
	75	B	B	B	B	A	A	A
	100	D	C	B	B	A	A	A
	150	D	C	B	B	B	A	A
	200	E	D	C	B	B	B	A
	250	E	D	C	C	B	B	B
	300	F	E	C	C	B	B	B
	400	F	F	D	D	C	C	B
	500	F	F	E	E	C	C	C
	600	F	F	F	F	D	D	D
	800	F	F	F	F	E	E	E
	1000	F	F	F	F	F	F	F

1 ft = 0.3 m

Table Assumptions

Mode split is 75% adult bicyclists, 7.5% pedestrians, 7.5% runners, 5% in-line skaters, and 5% child bicyclists.

An equal number of trail users travel in each direction (the model uses a 50%/50% directional split).

Trail volume represents the actual number of users counted in the field (the model adjusts this volume based on a peak hour factor of 0.85).

Trail has a centerline.

Table 14. Shared-use path level of service look-up table, high pedestrian mode split.

		Trail Width (feet)						
		8	10	12	14	16	18	20
Trail Volume (One Direction per Hour)	25	B	B	B	B	A	A	A
	50	D	C	B	B	B	A	A
	75	E	D	C	B	B	B	B
	100	F	E	C	C	C	B	B
	150	F	F	E	D	D	D	C
	200	F	F	F	F	E	E	E
	250	F	F	F	F	F	F	F
	300	F	F	F	F	F	F	F
	400	F	F	F	F	F	F	F
	500	F	F	F	F	F	F	F
	600	F	F	F	F	F	F	F
	800	F	F	F	F	F	F	F
	1000	F	F	F	F	F	F	F

1 ft = 0.3 m

Table Assumptions

Mode split is 25% adult bicyclists, 50% pedestrians, 15% runners, 7.5% in-line skaters, and 2.5% child bicyclists.

An equal number of trail users travel in each direction (the model uses a 50%/50% directional split).

Trail volume represents the actual number of users counted in the field (the model adjusts this volume based on a peak hour factor of 0.85).

Trail has a centerline.

Table 15. Shared-use path service volume look-up table, typical mode split.

		Trail Width (feet)						
		8	10	12	14	16	18	20
Level of Service	A	24	24	24	24	70	102	125
	B	49	49	110	147	191	213	229
	C	49	97	198	226	282	300	315
	D	109	155	267	290	362	379	392
	E	167	212	328	349	436	452	464
	F	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table shows maximum trail volume (one direction per hour) in each LOS category

1 ft = 0.3 m

Table Assumptions

Mode split is 55% adult bicyclists, 20% pedestrians, 10% runners, 10% in-line skaters, and 5% child bicyclists.

An equal number of trail users travel in each direction (the model uses a 50%/50% directional split).

Trail volume represents the actual number of users counted in the field (the model adjusts this volume based on a peak hour factor of 0.85).

Trail has a centerline.

Table 16. Shared-use path service volume look-up table, high bicycle mode split.

		Trail Width (feet)						
		8	10	12	14	16	18	20
Level of Service	A	40	40	40	40	123	182	224
	B	81	81	185	246	348	388	419
	C	81	162	330	376	519	554	581
	D	184	267	446	487	671	703	728
	E	289	373	551	590	812	842	866
	F	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table shows maximum trail volume (one direction per hour) in each LOS category

1 ft = 0.3 m

Table Assumptions

Mode split is 75% adult bicyclists, 7.5% pedestrians, 7.5% runners, 5% in-line skaters, and 5% child bicyclists.

An equal number of trail users travel in each direction (the model uses a 50%/50% directional split).

Trail volume represents the actual number of users counted in the field (the model adjusts this volume based on a peak hour factor of 0.85).

Trail has a centerline.

Table 17. Shared-use path service volume look-up table, high pedestrian mode split.

		Trail Width (feet)						
		8	10	12	14	16	18	20
Level of Service	A	13	13	13	13	35	51	62
	B	26	26	57	77	95	105	114
	C	26	52	105	120	140	149	156
	D	58	82	143	156	179	187	194
	E	87	110	177	189	215	223	229
	F	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table shows maximum trail volume (one direction per hour) in each LOS category

1 ft = 0.3 m

Table Assumptions

Mode split is 25% adult bicyclists, 50% pedestrians, 15% runners, 7.5% in-line skaters, and 2.5% child bicyclists.

An equal number of trail users travel in each direction (the model uses a 50%/50% directional split).

Trail volume represents the actual number of users counted in the field (the model adjusts this volume based on a peak hour factor of 0.85).

Trail has a centerline.

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