

**UPDATING THE AASHTO GUIDE FOR THE DEVELOPMENT OF  
BICYCLE FACILITIES**

FINAL REPORT

Prepared for  
National Cooperative Highway Research Program  
Transportation Research Board  
National Research Council

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## **ABSTRACT**

This report documents a project to develop an outline of the scope and content of the next edition of the AASHTO *Guide for the Development of Bicycle Facilities* (herein referenced for convenience as the *Bike Guide*).

Since the current AASHTO *Bike Guide* was published in 1999, numerous Federal, state and local agencies have published their own design guides. Generally, these documents have built upon the AASHTO *Bike Guide* and providing additional guidance to their users. Additionally, National manuals such as the MUTCD and the AASHTO Green Book have been revised and have more current information on bicycle facilities design. New research reports have also been released which may impact the information that should be included in the next update to the AASHTO *Bike Guide*.

The purpose of this project was to explore the most appropriate role for the development and scope of the AASHTO *Bike Guide*. This project included a survey of nearly 500 users of the existing AASHTO *Bike Guide* to determine what additional information or document revisions they feel are necessary for the next edition of the *Bike Guide*. Additionally, a literature review was performed to identify additional content that should be in the next update. In addition to the

proposed outline and scope presented in this report, there are several subject areas identified as needing additional research.

## CHAPTER 1: INTRODUCTION

Since the current AASHTO *Guide for the Development of Bicycle Facilities* (herein referenced for convenience as the *Bike Guide*) was published in 1999, and reflects the state of practice from 1996 – 1997, numerous federal, state and local agencies have published their own design guides. Generally, these documents have built upon the AASHTO *Bike Guide* and provide additional guidance to their users. Additionally, national manuals such as the *Manual on Uniform Traffic Control Devices (MUTCD)* and the AASHTO *Policy on Geometric Design of Streets and Highways (Green Book)* have been revised and have more current guidance on bicycle facilities design.

The proponents / sponsors of this project had informal feedback from users of the AASHTO *Bike Guide* that indicated the current edition may not adequately address all the issues that bicycle facility designers need to consider today. At the recent meeting of the AASHTO Technical Committee on Nonmotorized Transportation, State DOT bicycle and pedestrian coordinators identified issues such as bike lane design at intersections, facility selection criteria, accommodating bicyclists at roundabouts, liability, and more as needing expanded coverage in the next edition of the AASHTO *Bike Guide*. Also under consideration for inclusion in the new *Guide* are issues related to planning, structural and material design, and construction of bicycle facilities. The provisions of the new *Guide* should also account for the fact that bicycle facilities will be shared by other users such as pedestrians, joggers, and inline skaters. This reality has a significant bearing on how facilities are to be designed; recent FHWA research has revealed that in virtually all design components of both on- and off-road facilities, bicyclists would not be the “critical user,” and therefore not the “design user.”<sup>1</sup>

## Chapter 1: Introduction

In addition to providing state DOTs with technical design fundamentals, the AASHTO *Bike Guide* is used by many local agencies as their guideline or standard for bicycle facilities. The *Bike Guide* is also used as a reference or text for bicycle facilities design courses which are taught to planners, engineers, landscape architects and university students all over the country. Therefore, the proponents / sponsors of this project felt there was a need to explore the most appropriate role for the development and overall scope of the AASHTO *Bike Guide*. This project will establish the direction, scope and overall content of the next edition of the AASHTO *Bike Guide*.

### ENDNOTES

<sup>1</sup> Bruce W. Landis, Theodore A. Petritsch, and Herman F. Huang. *Characteristics of Emerging Road and Trail Users and Their Safety*. Report No. FHWA-HRT-04-103. Federal Highway Administration, McLean, VA, July 2004.

## **CHAPTER 2: RESEARCH APPROACH**

### **Task 1. Survey of Users**

As stated above, informal feedback from users of the AASHTO *Bike Guide* led the proponents and sponsors of this project to hypothesize that the current edition does not adequately address all the issues that bicycle facility designers need to consider. Feedback obtained by the researchers while teaching the National Highway Institute's course Bicycle Facilities Design (NHI Course No. 142046) over the past two years strongly support this hypothesis. The vast majority of the NHI Course attendees are design professionals; their day-to-day use of the AASHTO *Bike Guide* substantiated the need for this update.

For this project, formal feedback from users and stakeholders in the AASHTO *Bike Guide* was obtained by the researchers using an interactive web based survey. To this end, they developed a comprehensive survey to distribute to AASHTO *Bike Guide* stakeholders. It addressed every subject area covered by the current AASHTO *Bike Guide*. After extensive in-house pilot testing, the survey was sent to the NCHRP 20-7 Task 187 Panel for review. Their comments were incorporated into the final survey and the survey was posted to the web for public access.

#### *Survey Format*

The researchers developed the survey questionnaire into a four-section format:

1. Introductory questions on the type of individuals and their design experience level responding to the survey. These included questions concerning the occupation and workplace of the respondents and how often they used the AASHTO *Bike Guide*.

## Chapter 2: Research Approach

2. Questions about subjects covered in the current AASHTO *Bike Guide*. Each of these questions addresses a specific item in the *Bike Guide*'s Table of Contents and asked about the *Bike Guide*'s treatment of the subject. Respondents were given the following choices:
  - Adequately addressed
  - Needs to be more thoroughly addressed or revised
  - No opinion
  - Not appropriate for the *Bike Guide*

Respondents who stated the subject “needs be more thoroughly addressed or revised” were prompted by the survey to provide additional information. Those who responded that a subject was “not appropriate for the *Bike Guide*” were prompted to state what document should address the subject.

3. Questions concerning how individuals use the AASHTO *Bike Guide*.
4. Questions about additional subjects that should be included in the AASHTO *Bike Guide*.

The researchers used an online survey service called *SurveyMonkey.com* to develop and conduct the survey.

### *Survey Distribution*

Once the researchers completed the survey development and posted it to the website, the URL to access the survey was emailed to nationally prominent groups. Specifically the survey URL was sent to the following groups:

- State Pedestrian and Bicycle Coordinators
- National Committee on Uniform Traffic Control Devices Bicycle Technical Committee

## Chapter 2: Research Approach

- AASHTO Committee on Geometric Design
- AASHTO Committee on Planning
- AASHTO Committee on Traffic Engineering
- State Highway Engineers
- Association of Pedestrian and Bicycle Professionals
- MPO Pedestrian and Bicycle Coordinators
- League of American Bicyclists
- State Transportation Enhancement Coordinators
- State Recreational Trails Coordinators
- Members of the Greenways and Trails email listserve
- Attendees of the NHI Bicycle Facilities Design Course
- American Society of Civil Engineers Committees on Transportation and Urban Planning
- National Association of County Engineers
- American Planning Association
- American Association of Landscape Architects

To ensure that the maximum number of interested individuals could provide input into the scope and outline of the next AASHTO *Bike Guide*, initial respondents to the survey were asked to provide the email addresses of individuals who might also be interested in completing the survey. As a result, emails were sent to an additional 113 individuals requesting their participation in the survey.

## Chapter 2: Research Approach

### *Survey Respondents*

In all, there were a total of 468 respondents to the final survey. The majority of individuals responding to the survey were transportation professionals. Of those reporting their occupation, nearly 60% were engineers, planners, landscape architects or professors. Responses were obtained from five individuals who listed their job titles as State Pedestrian and Bicycle Coordinators, more than 30 pedestrian / bicycle coordinators or planners. Complete list of the titles of the respondents is included in the “Findings” section of this report.

Of those who individuals who responded to the survey, most (57%) were members of a professional organization related to engineering or planning. Of those who stated their primary purpose for using *AASHTO Bike Guide*, 73% said they used it primarily for planning, design, or design review.

### *Follow-Up Correspondence*

As mentioned previously, respondents who stated the subject “needs be more thoroughly addressed or revised” were prompted by the survey to provide additional information. This resulted in 3620 specific comments on the content of the current *AASHTO Bike Guide*. On occasion, as the research staff was reviewing these specific comments, there were responses that were either unclear or failed to provide complete information. These respondents were contacted via email and phone calls for clarification on their responses.

In addition to providing information on what subjects need to be addressed in the next update of the *Bike Guide*, respondents made numerous comments concerning the actual text and criteria contained within the *Bike Guide*. A working document was created to summarize just those comments that concerned the scope and subject content of the *Guide*. This working document has been incorporated into the “Findings” section of this report.



## **Task 2. Literature Review**

While this comprehensive survey was being developed and administered, the researchers performed a literature search. This was done for two reasons: first, to identify what additional planning, design, operational and maintenance guidance has become available since the current *Guide* was developed; and secondly, to identify new practices and knowledge. The researchers thoroughly reviewed guidance and “best practices” documents, as well as compendiums of innovative analysis and facility design treatments. They reviewed state and local bicycle facility planning and design documents that have been developed or updated since 1999. They reviewed documents to determine if, and where, they differ from the AASHTO *Bike Guide*.

The literature review was a continuing and interactive effort throughout this project. Several survey respondents suggested additional documents for the researchers to review. Many of these were reviewed and added to the literature search. In addition to standards and published research, however, we were referred to many documents which were essentially position papers. While we reviewed these documents, most were not included in the literature review because they did not contain actual studies of the effectiveness of the treatments.

The results of the literature review are included in Chapter 3.

## **Task 3. Identification of Gaps and Needs**

While performing the survey and conducting the literature search, we identified numerous areas to be newly addressed or more thoroughly covered in the upcoming AASHTO *Bike Guide* update. These items have been included within the proposed *Bike Guide* scope and outline as underlined text in the “Conclusions” section of this report.

Additional subject areas were identified for which additional research is needed. These subjects are discussed in the section titled *Areas Identified for Future Research*.

## **CHAPTER 3: LITERATURE SEARCH**

### **Introduction**

This literature review comprises Task 2 of NCHRP Project 20-07, Task 187. As stated in the Scope of Work, the components of this task are the following:

1. Compile and briefly analyze state and local bicycle facility and street design guidance published since 1999 to identify new knowledge and treatments. (See “State and Local Design Guidance.”)
2. Review relevant guidance of AASHTO, FHWA, ITE and other national organizations published since 1999 to identify new knowledge and practices. (See the sections on “National Guidance” and “Synthesis of Practice.”)
3. Determine when subsequent editions of these other national manuals are due to be updated to maximize opportunities to cross-fertilize information and guidance. (See below.)
4. Review published research on bicycle facilities and users. (See the section on “Research on Bicycle Facilities and Users.” This section covers both peer-reviewed and other published research.)

### Chapter 3: Literature Search

Table 1 below lists the current and previous editions of national manuals. Of these, the current edition of AASHTO's Highway Drainage Guidelines came out in 2004 and the 2003 edition of the MUTCD was revised in 2004.

**TABLE 1 Current and Previous Editions of National Manuals.**

Document	Current edition	Previous edition	Comment
<i>AASHTO Guide for Design of Pavement Structures</i>	1993 A supplement to this guide was published in 1998.	1986	No set schedule
<i>AASHTO Highway Drainage Guidelines</i>	2004	1999	Just updated – new editions every few years
<i>ITE Traffic Control Devices Handbook</i>	2001	1983	No set schedule - 18 years between current and previous editions
<i>MUTCD</i>	2003 Revision No. 1 was issued in 2004.	2000	New editions every few years, with revisions in-between

## State and Local Design Guidance

Document: *Guidelines for Bicycle and Pedestrian Facilities in Texas*

Robert J. Benz, Katherine F. Turnbull, Shawn Turner, Danise S. Hauser, Pedro S. Hurtado, and H. Gene Hawkins, Jr. *Guidelines for Bicycle and Pedestrian Facilities in Texas*. Report No. FHWA/TX-97/1449-3F. Texas Department of Transportation, Austin, TX, December 1997.

**Abstract (copied from report)** *This report presents guidelines for planning and designing bicycle and pedestrian facilities in Texas. An overview of the process for planning various types of bicycle and pedestrian projects is provided. The design techniques that can be used to accommodate bicycles on existing and new roadways are summarized. These include the use of wide general-purpose traffic lanes, bicycle lanes, and shoulders. The design features associated with separate bicycle paths, multi-use trails, and pedestrian walkways are also presented. The use of supporting facilities to encourage bicycling and walking are highlighted. Strategies and techniques to encourage implementation of the guidelines are described.*

**Comments** The authors conducted a state-of-the-art literature review. They surveyed individuals and groups involved in planning and design. The results of these activities were used to develop the guidelines presented in this report. The chapters and appendices are as follows:

- Chapter 1 Introduction
- Chapter 2 Planning Bicycle and Pedestrian Facilities
- Chapter 3 Roadway Improvements to Accommodate Bicycling
- Chapter 4 Separate Bicycle Paths and Multi-Use Trails

## Literature Search - State and Local Design Guidance

Chapter 5 Design Elements of Pedestrian Facilities

Chapter 6 Supporting Facilities and Services

Chapter 7 Implementation Strategies

Appendix A Glossary of Bicycle and Pedestrian Terms

Appendix B Example of Postcard Survey of Bicyclists and Pedestrians

Appendix C Department of Public Safety Pedestrian and Bicycle Traffic Laws and Safety Guidelines

The coverage of bicycle-related topics is fairly close to that in the AASHTO *Bike Guide*. As indicated on page 23, the authors' design bicyclist has a width of 2.0 feet {0.6 m} (handlebar width). This compares with 2.5 feet (0.8 m) in the AASHTO *Bike Guide*. The narrower bicycle width does not affect the authors' recommended widths for bicycle lanes, wide curb lanes, paved shoulders, and shared-use paths, all of which are consistent with the values in the AASHTO *Bike Guide*.

Figure 12 (p. 30) illustrates a combined bicycle/parking lane of 12 feet {3.7 m}, without a parking stripe or marked stalls. The text (p. 29) remarks that "A wider lane may be appropriate where the volume of on-street parking or delivery vehicles is high." The AASHTO *Bike Guide* (pp. 17-18) recommends a minimum of 12 feet {3.7 m} for a combined bicycle/parking lane, but does not specify whether a parking stripe or stalls are marked. Where parking is permitted but not marked with a stripe or stalls, the AASHTO *Bike Guide* (pp. 22 and 24) recommends 11 feet {3.3 m} without a curb face, 12 feet {3.7 m} with a curb face, and 13 feet {4.0 m} where there is substantial parking or high parking turnover.

Pages 37-38 of the Texas report address tunnels and underpasses. These are not covered in the AASHTO *Bike Guide*. The Texas report does not mention the safety and operational

## Literature Search - State and Local Design Guidance

concerns associated with shared-use paths that are next to roadways, nor does it address the use of sidewalks for bicycling. For example, nothing is said about the potential for conflicts when streets and driveways cross a shared-use path. Only one paragraph is devoted to intersections of roadways and shared-use paths (p. 58).

**Recommendation** We recommend a section discussing the design of tunnels / underpasses be added to the AASHTO *Bike Guide*.

Document: *City of Davis Comprehensive Bicycle Plan*

*City of Davis Comprehensive Bicycle Plan*. Davis, CA, May 2001. Available online at <http://www.city.davis.ca.us/pw/pdfs/01bikeplan.pdf>

**Summary** This plan sets forth goals and objectives related to the four “E’s” of education, enforcement, engineering, and encouragement. The engineering-related goals (pp. 7-13) include

- Provide bike lanes along all arterial and collector streets. Provide separated bike paths adjacent to arterial and collector streets only where justified, with full consideration of potential safety problems this type of facility can create.
- Ensure that bicycle routing is an integral part of street design so that lanes and pathways form an integrated network.
- Consider bicycle-operating characteristics in the design of bikeways, intersections and traffic control systems.
- Provide adequate bike parking.
- Design bike routes as integral parts of new greenways, open space areas (where appropriate) and “greenstreets” to complete and expand the existing bikeway system.
- Maintain roadways and bicycle related facilities so they provide safe and comfortable conditions for the bike rider.
- Design bicycle facilities to minimize maintenance costs by specifying quality materials and standard products.

Bicycle facilities guidelines are found in Appendix 1, engineering standards and guidelines are in Appendix 2, and bicycle facility classifications are in Appendix 6.

## Literature Search - State and Local Design Guidance

**Comments** Bicyclists are classified as avid cyclists, regular bicycle riders, young regular bicycle riders, and beginning bicycle riders (pp. 15-17).

The city is much more generous than the AASHTO *Bike Guide* with regard to bike lane widths –8 feet {2.4 m} when adjacent to the curb and 15 feet {4.6 m} when parking is allowed (8 feet {2.4 m} parking + 7 feet {2.1 m} for bikes) (p. 22).

The bicycle facility classifications in Appendix 6 are those used by the California Department of Transportation: Class I (bike path), Class II (bike lane), and Class III (bike route). As a matter of policy, bike routes are not used in the city of Davis.

**Recommendation** We do not recommend any specific changes to the AASHTO Bike Guide, based on the *City of Davis Bicycle Comprehensive Plan*.



Document: *Bicycle Parking Facilities Guidelines (City of Portland)*

City of Portland. Bicycle Parking Facilities Guidelines. Available online at <http://www.ci.trans.ci.portland.or.us/bicycles/parkguide.htm>

**Summary** These guidelines cover the following topics:

- Planning to Install Bicycle Parking
- Finding a Good Location
- Rack Selection and Installation
- Locating Short-term Parking
- Locating Long-term Parking
- Spacing and Siting Standards
- Covered Bicycle Parking
- Bicycle Parking Signs
- Minimum Required Bicycle Parking Spaces
- Examples of Poor Bicycle Parking Racks

**Comments** Portland's guidelines provide more specific guidance on bicycle parking than the AASHTO Bicycle Guide (pp. 67-68). For example, Portland's guidelines state that short-term bicycle parking should be within 50 feet {15.2 m} of a main entrance (to a building) and if more than 10 short-term spaces are provided, at least 50% must be covered. The guidelines also call for bicycle parking spaces to be 2 feet {0.6 m} by 6 feet {1.8 m}, and for providing an aisle at least 5 feet {1.5 m} wide to allow room for maneuvering.

**Recommendation** Based on Portland's guidelines, we recommend a more thorough discussion of bicycle parking in the AASHTO *Bike Guide*.

## Literature Search - State and Local Design Guidance

Document: *Highway Design Manual (California)*

*Highway Design Manual*. California Department of Transportation, Sacramento, CA, February 2001. Chapter 1000, "Bicycle Planning and Design." Available online at <http://www.dot.ca.gov/hq/oppd/hdm/pdf/chp1000.pdf>

**Summary** Chapter 1000 of California's *Highway Design Manual* pertains to bicycle facilities. It includes these topics:

- 1001 General Information
- 1002 General Planning Criteria
- 1003 Design Criteria
- 1004 Uniform Signs, Markings and Traffic Control Devices

**Comments** The guidance in this chapter varies somewhat from that in the AASHTO *Bike Guide*. Bikeways (facilities that provide primarily for bicycle travel) are divided into Class I (bike path), Class II (bike lane), and Class III (bike route) (page 1000-1) These correspond to shared use paths, bike lanes, and shared roadways, respectively, in the AASHTO *Bike Guide*.

Two-way bike paths shall have a minimum width of 8 feet {2.4 m} (page 1000-4), compared to 10 feet {3.0 m} (under most conditions) in the AASHTO *Bike Guide* (pp. 35-36). The minimum design speed shall be 25 mi/h {40 km/h} (page 1000-7), higher than the 20 mi/h {32 km/h} in the AASHTO *Bike Guide* (pp. 36-37). The prescribed bike lane widths (p. 1000-16) are consistent with those in the AASHTO *Bike Guide* (pp. 22-25).

## Literature Search - State and Local Design Guidance

This chapter calls for combined bicycle/parking lanes to be a minimum of 11 to 13 feet {3.3 to 3.9 m} wide, depending on the type of curb and parking (p. 1000-16). In San Francisco, it was found that the 85<sup>th</sup> percentile of car doors observed opened to 9.5 feet {2.9 m} from the curb (Alta Planning + Design, 2004), so a 13-foot {4.0 m} width would give bicyclists 3.5 feet {1.1 m} of space beyond the car doors. The AASHTO *Bike Guide* (pp. 17-18) recommends a minimum of 12 feet {3.7 m} for a combined bicycle/parking lane, but does not specify whether a parking stripe or stalls are marked. Where parking is permitted but not marked with a stripe or stalls, the AASHTO *Bike Guide* (pp. 22 and 24) recommends 11 feet {3.3 m} without a curb face, 12 feet {3.7 m} with a curb face, and 13 feet {4.0 m} where there is substantial parking or high parking turnover. Unlike the AASHTO *Bike Guide*, this chapter does not cover topics such as separation between shared use paths and parallel roadways or safety considerations for shared use paths.

**Recommendation** We do not recommend any specific changes to the AASHTO *Bike Guide* based on California's *Highway Design Manual*.

## Literature Search - State and Local Design Guidance

Document: *Florida Bicycle Facilities Planning and Design Handbook*

*Florida Bicycle Facilities Planning and Design Handbook*. Florida Department of Transportation, Tallahassee, FL, April 2000. Available online at [http://www.dot.state.fl.us/Safety/ped\\_bike/ped\\_bike\\_standards.htm](http://www.dot.state.fl.us/Safety/ped_bike/ped_bike_standards.htm)

**Summary (mostly copied from handbook)**      *The purpose of this handbook is to provide guidelines and criteria for planning, design, construction, operation and maintenance of safe on-road bicycle facilities and shared use paths. This handbook is intended to serve as an aid to engineers, designers, planners, architects, landscape architects, citizens and others interested in improving Florida's bicycling environment.*

*Information found in this handbook can be useful for private, local, state or federal projects. This handbook is intended to be used for the following:*

- *Training*
- *Reference*
- *Local roadway improvements*
- *State projects*
- *Local/state paths development*

*Section 1, "Introduction," states the purpose of the handbook, gives background information, provides a list of definitions, and summarizes relevant Federal and Florida guidance. The remaining sections address:*

## Literature Search - State and Local Design Guidance

### *SECTION 2 - Planning...*

*provides an overview of planning considerations for bicycles, a discussion of the types of facility improvements, performance measures to the year 2005, and a description of factors to consider when locating a facility.*

### *SECTION 3 - Safety...*

*describes the customer's needs, behavior and problems. It provides background on crash causation, human performance, the design bicyclist and the design bicycle.*

### *SECTION 4 - On-Road Design...*

*provides guidelines to follow when constructing or improving highways and streets.*

### *SECTION 5 - Shared use Paths...*

*incorporates the needs of bicyclists to the maximum extent practicable.*

### *SECTION 6 - Supplemental Topics...*

*provides information on parking, transit links, maintenance, traffic operations, and law.*

### *SECTION 7 - Appendix...*

*provides supplemental data for the handbook.*

**Comments** This handbook covers a comprehensive range of design topics. It goes into considerably more detail than the *AASHTO Bike Guide*. Dozens of photographs and drawings clarify the design guidelines. In addition, some parts of the manual, such as Section 5.1 and pages 5-31 through 5-34, appear to be written and illustrated with the intent of creating a vision for bicycling.

This handbook divides bicyclists into six categories according to their age and experience: young children, youth, young adult, novice adult, senior adult, and proficient adult.

By comparison, the AASHTO *Bike Guide* divides bicyclists into three user types: A (Advanced), B (Basic), and C (Children).

The bicycle and bicyclist dimensions given in Section 4.2 of the handbook are consistent with those in the AASHTO *Bike Guide* (p. 5). Several other conveyances, including adult tricycles, tandems, and tandems with trailers, are mentioned.

The widths of bicycle lanes and wide curb lanes are consistent with the AASHTO *Bike Guide*. Page 4-9 of the handbook notes that “Bike lanes are to be used on future urban roadway sections, whenever right of way and existing curb/drainage sections permit.” Page 4-14 notes that “Wide curb lanes no longer meet FDOT requirements and are not used on new construction.” The handbook (pp. 4-10 and 4-11) also calls for combined bicycle/parking lanes to be a minimum of 13 feet {4.0 m} wide – illustration “b” on page 4-11 depicts a marked bike lane. In San Francisco, it was found that the 85<sup>th</sup> percentile of car doors observed opened to 9.5 feet {2.9 m} from the curb (Alta Planning + Design, 2004), so the 13-foot {4.0 m} width would give bicyclists 3.5 feet {1.1 m} of space beyond the car doors. The AASHTO *Bike Guide* (pp. 17-18) recommends a minimum of 12 feet {3.7 m} for a combined bicycle/parking lane, but does not specify whether a parking stripe or stalls are marked. Where parking is permitted but not marked with a stripe or stalls, the AASHTO *Bike Guide* (pp. 22 and 24) recommends 11 feet {3.4 m} without a curb face, 12 feet {3.7 m} with a curb face, and 13 feet {4.0 m} where there is substantial parking or high parking turnover.

Florida DOT standards call for 5-foot {1.5 m} paved shoulders (p. 4-12 of handbook) (compared to 4 feet {1.2 m} in the AASHTO *Bike Guide*, p. 16).

The handbook (Section 5.3) closely parallels the AASHTO *Bike Guide* (pp. 33-35 and 58) in its discussion of shared use paths adjacent to roadways and sidewalks used as paths. The

same holds for mixing bicyclists and other users (Section 5.4 of the handbook and pp. 58-59 of the *AASHTO Bike Guide*). Florida DOT standards require a 12-foot {3.7 m} minimum width for a two-direction shared use path (p. 5-8 of handbook) (compared to 10 feet {3.0 m} in the *AASHTO Bike Guide*, pp. 35-36). Shared use path design elements such as horizontal clearance, vertical clearance, design speed, horizontal alignment, grade, and stopping sight distance are consistent with the *AASHTO Bike Guide*.

**Recommendation** Based on Florida's handbook example, we recommend that the *AASHTO Bike Guide* include more photographs and drawings with dimensions showing examples of good design. The information in Florida's handbook suggests that it may be appropriate for the *AASHTO Bike Guide* to more thoroughly discuss combined bicycle/parking lane dimensions.



## Literature Search - State and Local Design Guidance

Document: *Idaho Bicycle and Pedestrian Transportation Plan*

*Idaho Bicycle and Pedestrian Transportation Plan*. Idaho Transportation Department, Boise, ID, January 1995. Available online at <http://www.itd.idaho.gov/planning/reports/bikepedplan/IDT.pdf>

**Summary** This plan consists of three chapters and four appendices:

Chapter I Vision and Goals

Chapter II Action Strategies

Chapter III Comprehensive Approach to Bicycle and Pedestrian Transportation Planning

Appendix A Idaho Transportation Department Policies

Appendix B Design Standards for Bicycles

Appendix C Idaho Statutes Pertaining to Pedestrians and Bicycles

Appendix D References

**Comments** As this is a “plan” rather than a “handbook” or “guidelines,” the design guidelines are much more basic than that of other states’, such as Florida, Texas, and Wisconsin. The recommended widths of wide curb lanes (referred to in the plan as “shared lanes,” p. 27), bicycle lanes (p. 28), and shared use paths (“separated multiple-use paths,” pp. 29-30) are consistent with those in the AASHTO *Bike Guide* (pp. 17, 22-23, and 35-36). The plan (pp. 27-28) recommends paved shoulder (“shoulder bikeway”) widths of 6 feet {1.8 m}, compared to 4 feet {1.2 m} in the AASHTO *Bike Guide* (pp. 16-17). These are the only design guidelines given.

## Literature Search - State and Local Design Guidance

The plan advocates the concept of a design bicyclist whereby bicyclists are classified as Group A (Advanced), Group B (Basic), and Group C (Children). According to page 24, “Generally, Group A bicyclists will be best served by designing all roadways to accommodate shared use by bicycles and motor vehicles. Group B and Group C bicyclists will be best served by a network of neighborhood streets and separated, multi-use pathways.” This A-B-C classification scheme is referenced in the AASHTO *Bike Guide* (p. 6): A (Advanced), B (Basic), C (Children).

The plan recognizes the potential for conflicts when streets and driveways cross separated pathways (p. 18) (Figure 1 below).

Number of Crossings per Mile	Design Consideration
0	Ideal for safe pathway
1 - 4	Use special care to treat the conflicts
5 - 8	Proceed with extreme caution. Consider substituting with on-street bicycle lanes.
> 8	DANGEROUS CONDITION. Substitute with on-street bicycle lanes or other treatment.

**Figure 1. Design considerations for separated, multi-use pathways.**

**Recommendation** We do not recommend any specific changes to the AASHTO *Bike Guide* based on the *Idaho Bicycle and Pedestrian Transportation Plan*.

## Literature Search - State and Local Design Guidance

Document: *Local Bicycle Facility Design Guidance for the Metropolitan Kansas City Region*

Kansas City Metropolitan Chapter of the American Public Works Association. Section 5302  
Local Bicycle Facility Design Guidance for the Metropolitan Kansas City Region, December  
2002.

**Summary (excerpted from Foreword)** This section is intended to provide supplemental guidance to local and state governments in the planning, designing and construction of bicycle facilities in the metropolitan Kansas City area.

This section describes a wide variety of bicycle facility accommodations and in each case provides appropriate guidance for use.

**Comments** The design guidance mostly follows that in the AASHTO *Bike Guide*. Bicycle detection is described in more detail in the Kansas City document than in the AASHTO *Bike Guide*. Loops, video, and microwave sensors are all mentioned. The Kansas City document (pp. 5302-27 to 5302-31) gives examples of innovative treatments, such as shared bicycle/bus lanes, bicycle arrows in San Francisco (Alta Planning + Design, 2004), and painted bicycle lanes and advance bicycle boxes in Portland. Modern roundabouts are described favorably in the Kansas City document (p. 5302-32): “The modern roundabout offers safety benefits for motorists, bicyclists, and pedestrians over conventional four way intersections.” No guidance is provided on how to accommodate bicyclists at roundabouts. Bicycle parking is covered in more detail (pp. 5302-37 to 5302-39) than in the AASHTO *Bike Guide*.

**Recommendations** Based on the Kansas City document, we do not recommend any specific changes to the AASHTO *Bike Guide*.

## Literature Search - State and Local Design Guidance

Document: *Vermont Pedestrian and Bicycle Facility Planning and Design Manual*

National Center for Bicycling & Walking. *Vermont Pedestrian and Bicycle Facility Planning and Design Manual*. Available online at <http://www.aot.state.vt.us/progdev/Documents/LTF/FinalPedestrianAndBicycleFacility/PedestrianandBicycleFacilityDesignManual.pdf>

**Summary (copied in part from manual)** This manual serves to

- Guide Vermont state, regional and local agencies in planning and developing pedestrian and bicycle networks and projects
- Inform citizens and others interested in pedestrian and bicycle transportation
- Implement the 1998 VTrans Bicycle and Pedestrian Plan
- Provide approaches and guidelines for planning, designing and maintaining pedestrian and bicycle facilities in Vermont

This manual contains ten chapters and three appendices:

Chapter 1	Introduction
Chapter 2	Planning for Pedestrians and Bicyclists
Chapter 3	Pedestrian Facilities
Chapter 4	On-Road Bicycle Facilities
Chapter 5	Shared Use Paths
Chapter 6	Rail-Trails and Rails-With-Trails
Chapter 7	Traffic Calming
Chapter 8	Signs, Pavement Markings and Signals
Chapter 9	Landscaping and Amenities

## Literature Search - State and Local Design Guidance

Chapter 10 Maintenance

Appendix A Glossary

Appendix B AASHTO Interstate Bicycle Route Numbering Policy

Appendix C Stopping Sight Distance Charts, AASHTO Guide for the Development of  
Bicycle Facilities

**Comments** Each of Chapters 3 – 6 presents general design considerations, followed by recommended designs for a variety of anticipated users and conditions. The beginning of the manual contains Key Concepts and Design Summaries for each chapter. For example, the design summary for on-road bicycle facilities, which are covered in detail in Chapter 4, appears on pages xii – xiii. The reader can readily identify the minimum and preferred widths of bicycle lanes depending on whether the street is curbed or not, and whether there is parking or not. The reader is also referred to Section 4.3.2 for more detailed information. Figures 4-4 through 4-7 and Tables 4-5 through 4-8 show different conditions (bicycle lane – curbed street – no parking, etc.) and the minimum and preferred widths of bicycle lanes. This format renders the Vermont manual more user-friendly than the AASHTO *Bike Guide*. For this example, the information about bicycle lane widths is spread across several paragraphs of text (pp. 22-23) and Figure 6 in the AASHTO *Bike Guide*.

Figure 3-2 of the Vermont manual illustrates the spatial dimensions of a person in a wheelchair, a person using a walker and being assisted by another person, and a person with a visual impairment using a cane. Figure 4-1 illustrates the lengths of not only an adult bicycle, but also a child's bicycle, an adult tandem bicycle, an adult single recumbent bicycle, a child

trailer, and a trailer bike. In contrast, the AASHTO *Bike Guide* (p. 5) presents dimensions only for an adult bicyclist.

Table 2 below compares the user type lengths given in the Vermont manual to those observed in the FHWA study, *Characteristics of Emerging Road and Trail Users and Their Safety*.

**TABLE 2 Lengths for User Types in the Vermont Manual and in the FHWA Study.**

User Type	Lengths from...	
	Vermont Manual	<i>Characteristics of Emerging Road and Trail Users and Their Safety</i>
Adult bicycle	68 inches {172.7 cm} (average)	66 inches {167.6 cm} (mean)
Recumbent bicycle	96 inches {234.8 cm} (longest)	82 inches {208.3 cm} (85 <sup>th</sup> percentile)
Bicycle with trailer	Up to 42 inches {106.7 cm} additional 68 inches + 42 inches {172.7 cm + 106.7 cm} = 110 inches {279.4 cm}	114 inches {189.6 cm} (mean)

**Recommendations** Based on Vermont’s manual, we recommend that the AASHTO *Bike Guide* present guidelines in a summary format (such as that on pages xii – xix) so that readers can clearly see the values for each facility type and situation. We also recommend that the AASHTO *Bike Guide* present design guidelines for rail-trails and rails-with-trails.

## Literature Search - State and Local Design Guidance

Document: *Design Manual, Chapter 1020, "Bicycle Facilities" (Washington State Department of Transportation)*

*Design Manual*. Report No. M 22-01. Washington State Department of Transportation, Olympia, WA, May 2001. Chapter 1020, "Bicycle Facilities" Available online at <http://www.wsdot.wa.gov/fasc/engineeringpublications/desEnglish/1020-E.pdf>

**Summary** Chapter 1020 of Washington State's *Design Manual* pertains to bicycle facilities.

It includes these sections:

1020.01	General
1020.02	References
1020.03	Definitions
1020.04	Planning
1020.05	Design
1020.06	Documentation

**Comments** The guidance in this chapter is consistent with that in the AASHTO *Bike Guide*. Additional pavement width of up to 4 feet {1.2 m} is recommended on the inside of horizontal curves to compensate for bicyclist lean (p. 1020-13). This chapter calls for combined bicycle/parking lanes (without parking lines or stalls) to be a minimum of 12 feet {3.7} wide (pp. 1020-16 and 1020-20). In San Francisco, it was found that the 85<sup>th</sup> percentile of car doors observed opened to 9.5 feet {2.9 m} from the curb (Alta Planning + Design, 2004), so the 12-foot {3.7 m} width would give only bicyclists 2.5 feet {0.8 m} of space beyond the car doors.



## Literature Search - State and Local Design Guidance

The AASHTO *Bike Guide* (pp. 17-18) recommends a minimum of 12 feet {3.7 m} for a combined bicycle/parking lane, but does not specify whether a parking stripe or stalls are marked. Where parking is permitted but not marked with a stripe or stalls, the AASHTO *Bike Guide* (pp. 22 and 24) recommends 11 feet {2.4 m} without a curb face, 12 feet {3.7 m} with a curb face, and 13 feet {4.0 m} where there is substantial parking or high parking turnover.

Unlike the AASHTO *Bike Guide*, this chapter does not cover topics such as separation between shared use paths and parallel roadways or safety considerations for shared use paths.

Chapter 915.08 covers bicycles at roundabouts and is consistent with *Roundabouts: An Informational Guide* (Robinson *et al.*, 2000).

**Recommendation** We do not recommend any specific changes to the AASHTO *Bike Guide* based on the Washington *Design Manual*.

## Literature Search - State and Local Design Guidance

Document: *Wisconsin Bicycle Facility Design Handbook*

*Wisconsin Bicycle Facility Design Handbook*. Wisconsin Department of Transportation, Madison, WI, January 2004. Available online at <http://www.dot.state.wi.us/projects/state/docs/bike-facility.pdf>

**Summary** This handbook consists of four chapters and five appendices:

- Chapter 1 Introduction
- Chapter 2 Basic Roadway Improvements
- Chapter 3 Bicycle Lanes
- Chapter 4 Shared-use Paths
- Appendix A Maintenance & Operations
- Appendix B Traffic Conditions & Bridges
- Appendix C Wisconsin Statutes
- Appendix D Bibliography
- Appendix E Index

**Comments** This handbook covers a comprehensive range of design topics and goes into considerably more detail than the AASHTO *Bike Guide*. For example, pages 2-27 to 2-30 are devoted to a discussion and illustrations of different loop detectors. Dozens of photographs labeled “yes,” “OK,” or “no” illustrate good, okay, and bad design. The design guidelines are further clarified by numerous drawings. According to the Acknowledgments, design manuals

from other states, the AASHTO *Bike Guide*, and the MUTCD were all consulted in the preparation of this handbook.

The bicycle and bicyclist dimensions given on page 1-3 of the handbook are consistent with those in the AASHTO *Bike Guide* (p. 5). Dimensions for tricycles and bicycles with trailers are also mentioned (p. 1-2).

The widths of bicycle lanes and wide curb lanes are consistent with the AASHTO *Bike Guide*.

Page 2-13 states that, “It is Wisconsin DOT policy to give strong consideration to bicycle lanes and wide outside travel lanes on all urban cross-section projects.” By comparison, Florida DOT no longer uses wide curb lanes in new construction.

The handbook also calls for the total width of a bicycle lane and an adjacent parking lane to be a minimum of 13 feet {4.0 m} (pp. 3-10 to 3-11). In San Francisco, it was found that the 85<sup>th</sup> percentile of car doors observed opened to 9.5 feet {2.9 m} from the curb (Alta Planning + Design, 2004), so the 13-foot width would give bicyclists 3.5 feet {1.1 m} of space beyond the car doors. Page 3-11 of the handbook states that, “Combining bicycle lanes and parking lanes without painting parking “T”s or striping between the two is found in some communities. However, the undesignated space may look like a motor vehicle lane. As a result, it may be preferable to identify the parking lane.”

The AASHTO *Bike Guide* (pp. 17-18) recommends a minimum of 12 feet {3.7 m} for a combined bicycle/parking lane, but does not specify whether a parking stripe or stalls are marked. Where parking is permitted but not marked with a stripe or stalls, the AASHTO *Bike Guide* (pp. 22 and 24) recommends 11 feet {3.4 m} without a curb face, 12 feet {3.7 m} with a curb face, and 13 feet {4.0 m} where there is substantial parking or high parking turnover.

The handbook (Section 4.3) does not go into as much detail as the AASHTO *Bike Guide* (pp. 33-35 and 58) in its discussion of shared use paths adjacent to roadways and sidewalks used as paths and does not have a separate section on mixing bicyclists and other users (Pp. 58-59 of the AASHTO *Bike Guide*). Shared use path design elements such as width, horizontal clearance, vertical clearance, design speed, horizontal alignment, grade, and stopping sight distance are consistent with the AASHTO *Bike Guide*. The handbook (Section 4.15) goes into considerably more detail than the AASHTO *Bike Guide* (pp. 46-54) in its discussion of shared use path – roadway intersections.

**Recommendation** Based on the *Wisconsin Bicycle Facility Design Handbook*, we recommend that the AASHTO *Bike Guide* include more photographs showing examples of good design. The information in Wisconsin’s handbook also suggests that it may be appropriate for the AASHTO *Bike Guide* to more thoroughly discuss combined bicycle/parking lane dimensions. Additionally, the researchers recommend an expanded discussion of the application of wide curb lanes.

## **National Guidance**

Document: *An Informational Guide for Roadway Lighting*

AASHTO. *An Informational Guide for Roadway Lighting*. Prepared by the Joint Task Force for Highway Lighting of the AASHTO Highway Subcommittees on Design and Traffic Engineering. American Association of State Highway and Transportation Officials, Washington, DC, 1984.

**Summary** This Guide contains information for the lighting of freeways, streets, tunnels and underpasses, rest areas, and roadway signs.

**Comments** The Guide provides design values for both illuminance (defined as “the density of the luminous flux incident on a surface”) and luminance (defined as “the luminous intensity of any surface in a given direction per unit of project area of the surface as viewed from that direction”). Table 2 (page 17) gives luminance values and Table 3 (page 18) gives horizontal illuminance values. The values for separate bicycle facilities are found at the bottom of Table 3 (the Guide defines a bicycle lane as “any facility that explicitly provides for bicycle travel” and does not specify on-road or off-road). For bicycle facilities that are adjacent to a roadway, the luminance and illuminance values for that roadway classification should be used, as shown in Tables 2 and 3.

**Recommendation** We recommend that the AASHTO *Bike Guide* include more detailed information about lighting.

## Literature Search - National Guidance

Document: *Bicycle Parking Guidelines*

APBP. Bicycle Parking Guidelines. Association of Pedestrian and Bicycle Professionals. Spring 2002. Available online at [www.apbp.org/pdfs/bikepark.pdf](http://www.apbp.org/pdfs/bikepark.pdf).

**Summary** This document discusses the selection and placement of appropriate bicycle racks for short-term bicycle parking. It covers the following components:

- The rack element – the part of the bike rack that supports one bicycle
- The rack
- The rack area – a bicycle parking lot
- The rack area site – the location of the rack area in relationship to a building entrance

**Comments** The APBP is also developing recommendations for long-term bicycle storage and indoor bicycle parking, and for determining the appropriate number of bicycle parking spaces.

**Recommendation** Based on these guidelines, we recommend that the AASHTO *Bike Guide* include a more thorough discussion, along with illustrations, of bicycle parking.

Document: *Collection of Cycle Concepts (Denmark)*

Danish Road Directorate. *Collection of Cycle Concepts*. 2000. Available online at <http://www.vejdirektoratet.dk/pdf/cykelrapport/999Complete.pdf>

**Summary (copied from book)** *This book is primarily intended for traffic planners, but may be read with advantage by anyone who is interested in cycling or other kinds of traffic, no matter whether they are planners, engineers, road administrators, politicians or NGOs.*

*Bicycle traffic in the year 2000 gives a basic impression of what bicycle traffic is. The chapter is supported by statistical data.*

*Bicycle traffic is more than cycle tracks is a process handbook for promoting more and safer bicycle traffic. The chapter presents an overview of possibilities for new projects and of the work processes involved.*

*Communication and campaigns describes effective ways of designing campaigns for both more and safer bicycle traffic.*

*Urban planning describes links between land use and the volume of bicycle traffic. The chapter presents preconditions of “the cycling town.”*

*Planning of traffic areas deals with the planning of cycle networks and the general principles for choosing layout, cross section, speed limits, junction design and pavement.*

*Ways of financing plans and projects are also presented.*

*Design of traffic areas illustrates a large number of designs and describes their advantages and disadvantages.*

## Literature Search - National Guidance

Direction signing and cycle maps *makes it easier to find the right roads, paths and destinations. The chapter describes the Danish way of direction signing for cyclists and walkers and drawing up cycle maps.*

Bicycle parking *treats the location, capacity and standards for bicycle parking.*

*Financing and protection against theft are also issues.*

Road maintenance of cyclists' traffic areas *demonstrates the links between maintenance quality and the promotion of safe bicycle traffic. Ways of raising maintenance quality are described.*

Roadworks *illustrates the possibilities of ensuring good conditions for cyclists at roadworks.*

Collection of examples *describes 8 demonstration projects that have received support from the Ministry of Transport's Traffic Pool. Many good ideas are shown.*

From past to present *recounts 100 years of Danish history about roads, paths and bicycle traffic and puts forward some predictions on future traffic conditions.*

**Comments** This book presents bicycle facilities planning and design from a Danish perspective. Pages 63-100 cover "Design of Traffic Areas": cycle lanes, paved shoulders, cycle paths and tracks, junctions, and roundabouts. "Bicycle Parking" is covered in detail on pages 107-115, followed by "Road Maintenance" on pages 116-124.

**Recommendations** Based on the *Collection of Cycling Concepts*, we recommend a more thorough discussion of bicycle parking and road maintenance in the AASHTO *Bike Guide*.



Document: *Recommended Lighting for Walkways and Class I Bikeways*

Illuminating Engineering Society of North America. *Recommended Lighting for Walkways and Class I Bikeways*. Report No. IESNA DG-5-94. August 1994.

**Summary (copied from www. [http://www.techstreet.com/cgi-bin/detail?product\\_id=14320](http://www.techstreet.com/cgi-bin/detail?product_id=14320))**

*This Design Guide consolidates references made in previous IESNA publications with certain new information for designing lighting systems for walkways and Class I bikeways. It defines pedestrian walkways by the method of separating the pedestrians from vehicular traffic. These methods are horizontal, vertical, and temporal. As described here a bikeway is any road/path open to bicycle travel -- shared (or not shared) with other transportation modes. There are three classes of bikeways exclusive of pedestrians: Class I "Bike Path" (completely separated from vehicular traffic); Class II "Bike Lane" (part of the roadway or shoulder); and Class III "Shared Roadway" (right-of-way shared with motor vehicles).*

**Comments** According to [www.iesna.org](http://www.iesna.org), the Illuminating Engineering Society of North America (IESNA) “is the recognized technical authority on illumination. For over ninety years its objective has been to communicate information on all aspects of good lighting practice to its members, to the lighting community, and to consumers through a variety of programs, publications, and services.”

**Recommendation** We recommend that the AASHTO *Bike Guide* include a reference to this Design Guide.

Document: *Bike Lane Design Guide*

Nick Jackson and David Gleason. *Bike Lane Design Guide*. June 2002. Available online at [http://www.bicyclinginfo.org/pdf/bike\\_lane.pdf](http://www.bicyclinginfo.org/pdf/bike_lane.pdf)

**Summary (copied from [www.bicyclinginfo.org/de/bikelaneguide.htm](http://www.bicyclinginfo.org/de/bikelaneguide.htm))** *The*

*Pedestrian and Bicycle Information Center has teamed up with the City of Chicago and the Chicagoland Bicycle Federation to publish a 48-page guide to signing, striping and marking bike lanes on city streets. The guide contains 35 full-page technical drawings of street layouts, striping patterns, signs, and street markings that show how the City of Chicago installs bike lanes on streets as narrow as 44 feet {13.4 m} wide with parking on both sides. The guide includes detailed information on how to address intersections, bus stops, and other tricky situations.*

*The Guide also features 6 pages of answers to frequently asked questions about bike lanes, a description of how the design guide was developed, and information about how your city's standards might differ from Chicago. The end result is a report that addresses every reason, fear, excuse, or other barrier to getting bike lanes on your city's streets.*

**Comments** Although developed by the Chicago Department of Transportation, this guide is intended to be applicable in cities, counties, and states nationwide. For the most part, the guidance is consistent with the AASHTO *Bike Guide*. However, the City of Chicago does not stripe bike lanes that are less than 5 ft {1.5 m} wide. It should be noted that this dimension can include the width of the gutter pan; however, the Chicago Guide states a minimum 4 foot width should be clear of all surface regularities. The guide advocates painting a stripe between the bike

lane and the parking lane: "The striping encourages motorists to park closer to the curb and thus provide more space for bicyclists in the bike lane, especially when they need to avoid an opening car door. The striping discourages motorists from thinking that the shared bike/parking lane is in fact a travel lane for motor vehicles, particularly when parking is relatively light and turnover is high." (p. 5) Pages 7-42 consist of drawings showing bike lane striping and dimensions for a variety of roadway widths, parking or no parking, intersection geometries, and signs and markings.

The guide is limited to bike lanes. It does not cover shared use paths.

**Recommendation** Numerous survey respondents felt drawings such as those provided in this document should be included within the next AASHTO Bike Guide. While we do not feel the AASHTO Bike Guide should incorporate the drawings from this document, we do recommend that the AASHTO Bike Guide include scale diagrams showing bike lane striping, signing, and dimensions applicable to various intersections configurations. Additionally, we recommend discussing various traffic operational factors that need to be analyzed (e.g., truck volumes, travel speeds, signalization character, saturation flow rates, and motor vehicle LOS, as well as parking turnover, door zone) when determining the cross section dimensions for general travel lanes, bike lanes, and parking lanes. We recommend sample (clearly labeled as "sample") drawings from the centerline to edge of pavement be provided in the Guide.

Document: *Designing Sidewalks and Trails for Access – Part II of II: Best Practices Design Guide*

Kirschbaum, Julie B., Peter W. Axelson, Patricia E. Longmuir, Kathleen M. Mispagel, Julie A. Stein, and Denise A. Yamada. *Designing Sidewalks and Trails for Access - Part II of II: Best Practices Design Guide*. Report No. FHWA-EP-01-027. Federal Highway Administration, Washington, DC, September 2001. Available online at <http://www.fhwa.dot.gov/environment/sidewalk2/index.htm>

**Summary (excerpted from Introduction and Chapter 14)** This guidebook is the second part of a two-phase project focused on designing sidewalks and trails for access. It was created to provide planners, designers, and transportation engineers with a better understanding of how sidewalks and trails should be developed to promote pedestrian access for all users, including people with disabilities. Part I, *A Review of Existing Guidelines and Practices*, is a compilation of data and designs gathered during a comprehensive literature search and site visits conducted throughout the United States. Many of the recommendations provided in this guidebook are based on research gathered during Phase I.

For this report, the majority of the accessibility recommendations for shared-use paths are based on the 1999 AASHTO Guide for the Development of Bicycle Facilities (AASHTO, 1999). Additional issues, such as protruding objects (that are not addressed in the AASHTO bicycle facility guide) are also included in this report. However, the recommendations for grade in this report are based on the work by the Regulatory Negotiation Committee for Outdoor Developed

Areas because the maximum grades identified for bicyclists in the AASHTO bicycle facility guide do not provide access to many people with mobility impairments.

**COMMENTS**

**Comments** This guidebook acknowledges the potential for conflicts among users of shared use paths and suggests how to reduce conflicts (Section 14.3).

Section 14.5 of this guidebook recommends shorter grades than those in the AASHTO *Bike Guide* (p. 39) (Table 3).

**TABLE 3 Recommended Grades in the AASHTO Bike Guide and Designing Sidewalks and Trails for Access.**

<i>AASHTO</i>	<i>AASHTO</i>	<i>Designing Sidewalks and Trails for Access</i>	<i>Designing Sidewalks and Trails for Access</i>
Grade	Length (maximum)	Grade	Length (maximum)
5-6%	800 ft {240 m}		
7%	400 ft {120 m}		
8%	300 ft {90 m}		
9%	200 ft {60 m}	8.3%	200 ft {61 m}
10%	100 ft {30 m}		
11+%	50 ft {15 m}		
		10%	30 ft {9.14 m}
		12.5%	10 ft {3.05 m}

Chapter 16 addresses trail crossings: trail-trail, bridges, trail-street/roadway, grade-separated crossings, and railroad crossings.

**Recommendation** We recommend that the AASHTO *Bike Guide* include a discussion of the impact of grades on persons with disabilities. Also, we recommend that the AASHTO *Bike Guide* refer interested readers to *Designing Sidewalks and Trails for Access*.

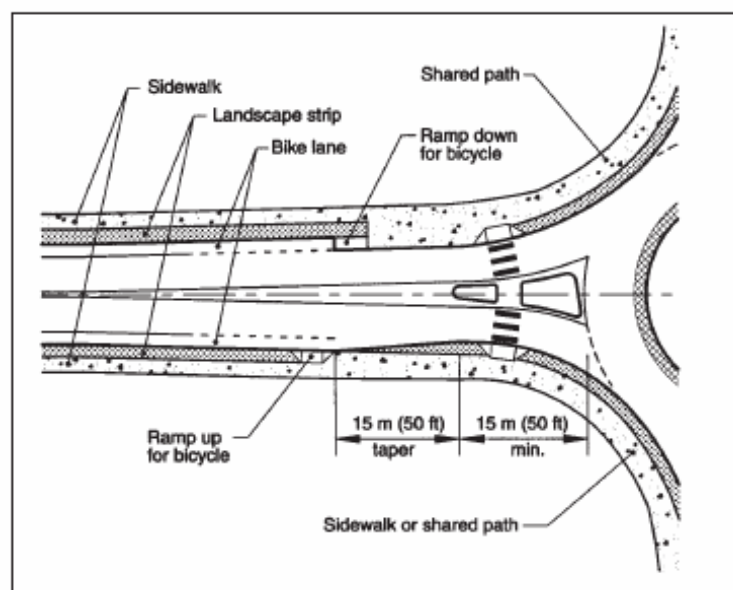
Document: *Roundabouts: An Informational Guide*

Bruce W. Robinson, Lee Rodegerdts, Wade Scarborough, Wayne Kittelson, Rod Troutbeck, Werner Brilon, Lothar Bondzio, Ken Courage, Michael Kyte, John Mason, Aimee Flannery, Edward Myers, Jonathan Bunker, and Georges Jacquemart. *Roundabouts: An Informational Guide*. Federal Highway Administration, McLean, VA, June 2000.

**Abstract (copied from report)** *The guidance supplied in this document is based on established international and U.S. practices and is supplemented by recent research. The guide is comprehensive in recognition of the diverse needs of transportation professionals and the public for introductory material through design detail, as well as the wide range of potential applications of roundabout intersections. The following topics are addressed: definition of a roundabout and what distinguishes roundabouts from traffic circles; public acceptance and legal issues associated with roundabouts; consideration of all user modes, including heavy vehicles, buses, transit, bicycles, and pedestrians; a methodology for identifying appropriate sites for roundabouts and the range of conditions for which roundabouts offer optimal performance; methodologies for estimating roundabout capacity, delays, and queues with reference to the "Highway Capacity Manual"; design principles and guidance on safety and geometric design, with reference to applicable national standards such as the AASHTO "Policy on Geometric Design of Highways and Streets"; guidelines for control features such as signing and pavement markings, with reference to the "Manual on Uniform Traffic Control Devices"; illumination; and landscaping.*

**Comments** Section 5.2.3 discusses bicycle-motor vehicle and bicycle-pedestrian conflicts at roundabouts. Bicyclist crash data from European roundabouts are presented in Section 5.3.4. Design provisions for bicycles are given in Section 6.3.12 and can be summarized as follows (see also Figure 2):

- Terminate bicycle lanes prior to a roundabout, 100 ft {30 m} upstream of the yield line to allow for merging with vehicles.
- Provide a widened sidewalk or a shared bicycle/pedestrian path for bicyclists who prefer not to use the roadway while going around the roundabout. Provide ramps so that bicyclists can get on and off the sidewalk or shared path.



**Figure 2. Possible provisions for bicycles at roundabouts.**

The AASHTO *Bike Guide* (p. 64) recommends discontinuing bike lanes, 35 to 65 feet {10 to 20 m}, upstream of the roundabout. It also suggests shared use of the pedestrian facility as a solution at higher-speed, multi-lane roundabouts.

**Recommendation** We recommend the inclusion of drawings illustrating the roundabout recommendations in the AASHTO *Bike Guide*.



Document: *Highway Capacity Manual*

Transportation Research Board. *Highway Capacity Manual*. Transportation Research Board, Washington, DC, 2000, Chapter 19 (Bicycles).

**Summary (copied from Introduction)** *This chapter addresses the capacity and level-of-service (LOS) analysis of facilities serving bicycles. Specifically, procedures are provided for the following types of facilities:*

- *Exclusive off-street bicycle paths: paths physically separated from highway traffic for the exclusive use of bicycles;*
- *Shared off-street paths: paths physically separated from highway traffic for the use of bicycles, pedestrians, skateboards, roller skaters, in-line skaters, and other nonmotorized traffic;*
- *Bicycle lanes on streets: designated bicycle lanes on urban streets, usually directly adjacent to highway traffic lanes, operating under interrupted flow;*
- *Interrupted-flow bicycle facilities: designated bicycle lanes on streets, usually directly adjacent to highway traffic lanes, operating through fixed interruptions such as traffic signals and stop signs; and*
- *Bicycle lanes on urban streets: designated bicycle lanes on urban streets, incurring the impact of both uninterrupted-flow sections and fixed interruptions.*

**Comments** The procedures for exclusive off-street bicycle paths, shared off-street paths and on-street bicycle lanes (“Uninterrupted-Flow Bicycle Facilities,” pp. 19-1 to 19-5) are those recommended by Allen *et al.* (1998). The LOS for on-street bicycle lanes is dependent on the number of events, which vary according to the bicycle flow rate, mean speed, and standard deviation of the speed.

For interrupted-flow bicycle lanes (pp. 19-5 to 19-8), the LOS depends on control delay at signalized and stop-controlled (on the minor street only, not all-way stop) intersections. As the length of delay increases, the LOS deteriorates from A to F. For bicycle lanes on urban streets (intersections plus segments), the LOS depends on average bicyclist speeds. As speeds decrease, the LOS deteriorates from A to F.

**Recommendation** Based on the *Highway Capacity Manual*, we do not recommend any specific changes to the AASHTO *Bike Guide*.

Document: *Trail Intersection Design Handbook*

UNC-HSRC. *Trail Intersection Design Handbook*. Florida Department of Transportation, 1996.  
Available online at [http://www.dot.state.fl.us/Safety/ped\\_bike/handbooks\\_and\\_research/research/trailint.pdf](http://www.dot.state.fl.us/Safety/ped_bike/handbooks_and_research/research/trailint.pdf)

**Summary (first paragraph copied from [http://www.dot.state.fl.us/Safety/ped\\_bike/ped\\_bike\\_standards.htm](http://www.dot.state.fl.us/Safety/ped_bike/ped_bike_standards.htm))** *This handbook discusses design processes and principles of designing trail/roadway intersections. It includes information on various crossing types, regulating traffic and site design. This handbook also reviews some European trail crossing guidelines. Guidelines from the Netherlands and development of a bicycle crossing time equation are included in the appendices.*

The Introduction (Chapter 1) discusses the need for, and development of, this handbook. Chapter 2, “Background essentials,” contains sections on the design trail user, the design process, and design principles. Design elements are covered in Chapter 3, which contains sections on crossing types (midblock, parallel path, and complex intersection), regulating traffic, sight distance, refuge areas, and additional considerations (access control, pavement markings, crosswalk striping, texture change, lighting, and curb cuts).

**Comments** The information in this handbook is based on

- A literature review of designs and standards in use in the U.S. and abroad
- The author’s principles of bicycle-friendly design
- Observations of 60 trail-roadway and trail-driveway junctions throughout Florida

**Recommendation** We recommend an expanded discussion of trail/roadway intersections in the AASHTO *Bike Guide*.

Document: *Selecting Roadway Design Treatments to Accommodate Bicycles*

W.C. Wilkinson, III, A. Clarke, B. Epperson, and R. Knoblauch. *Selecting Roadway Design Treatments to Accommodate Bicycles*. Report No. FHWA-RD-92-073. Federal Highway Administration, McLean, VA, January 1994. Available online at <http://safety.fhwa.dot.gov/fourthlevel/pdf/Select.pdf> (text) and <http://safety.fhwa.dot.gov/fourthlevel/pdf/Tables.pdf> (tables)

**Abstract (copied from report)** *This manual is designed to assist transportation planners and engineers in selecting roadway design treatments to accommodate bicycles. This is the first attempt to provide comprehensive guidelines for this process. The recommendations are based on assumptions regarding policy goals and the types of bicyclists to be accommodated, the state of the practice, and professional judgment. More research, testing, and evaluation are needed to assess and refine these recommendations. A more detailed final report on this study is available. This manual is not intended to serve as a comprehensive guide to the design of bicycle facilities. The user is referred to the current edition of the American Association of State Highway and Transportation Officials' "Guide to the Development of Bicycle Facilities" for detailed specifications. The manual describes the assumptions, principles, and approaches used to develop the recommendations; provides a model planning process for identifying a network of routes on which designated bicycle facilities should be provided to accommodate bicyclists of moderate ability (casual adult riders and children); and recommends design treatments and specifications for roadways to serve different types of bicyclists under various sets of traffic*

*operational factors. The appendix contains a detailed discussion of the various types of bicycle facilities.*

**Comments** The Appendix to this manual contains six tables that list recommended bicycle facility types (wide curb lane, shoulder, shared lane, and bike lane) for varying average speeds, AADT, and adequate/inadequate sight distance for the following situations:

Table 1 – Group A bicyclists, urban section, no parking

Table 2 – Group A bicyclists, urban section, with parking

Table 3 – Group A bicyclists, rural section

Table 4 – Group BC bicyclists, urban section, no parking

Table 5 – Group BC bicyclists, urban section, with parking

Table 6 – Group BC bicyclists, rural section

**Recommendation** This document is referenced in the current edition of the AASHTO Bike Guide. Based on *Selecting Roadway Design Treatments to Accommodate Bicycles*, we do not recommend any specific changes to the AASHTO Bike Guide. This document represented the consensus of the authors at the time it was produced. With recent developments in measures of bicycle accommodation (BCI and Bicycle LOS), the tabular method is used less now than in earlier years. However, while we do not feel this document should be specifically mentioned in the main text of the AASHTO Bike Guide, we suggest that this document be included merely as an endnote in the AASHTO Bike Guide in the section concerning the selection of bicycle facilities using the functional classification of the roadway.

Document: *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations*

Charles V. Zegeer, J. Richard Stewart, Herman F. Huang, and Peter A. Lagerwey. *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations - Executive Summary and Recommended Guidelines*. Report No. FHWA-RD-01-075. Federal Highway Administration, McLean, VA, April 2001.

**Abstract (copied from Report)** *Pedestrians are legitimate users of the transportation system, and they should, therefore, be able to use this system safely. Pedestrian needs in crossing streets should be identified, and appropriate solutions should be selected to improve pedestrian safety and access. Deciding where to mark crosswalks is only one consideration in meeting that objective. This study involved an analysis of 5 years of pedestrian crashes at 1,000 marked crosswalks and 1,000 matched unmarked comparison sites. All sites in this study had no traffic signal or stop sign on the approaches. Detailed data were collected on traffic volume, pedestrian exposure, number of lanes, median type, speed limit, and other site variables. Poisson and negative binomial regressive models were used.*

*The study results revealed that on two-lane roads, the presence of a marked crosswalk alone at an uncontrolled location was associated with no difference in pedestrian crash rate, compared to an unmarked crosswalk. Further, on multi-lane roads with traffic volumes above about 12,000 vehicles per day, having a marked crosswalk alone (without other substantial improvements) was associated with a higher pedestrian crash rate (after controlling for other site factors) compared to an unmarked crosswalk. Raised medians provided significantly lower*

*pedestrian crash rates on multi-lane roads, compared to roads with no raised median. Older pedestrians had crashes that were high relative to their crossing exposure.*

*More substantial improvements were recommended to provide for safer pedestrian crossings on certain roads, such as adding traffic signals with pedestrian signals when warranted, providing raised medians, speed-reducing measures, and others.*

**Comments** The authors recommended many potential countermeasures to improve pedestrian safety related to crossing streets, instead of merely adding a marked crosswalk. Improvements on multi-lane roads include adding pedestrian signals, installing raised medians or refuge islands, improving nighttime lighting, providing curb extensions, providing tighter turning radii (to shorten crossing distances and lower the speeds of right-turning motorists), reducing the number of lanes, and providing advance stop lines (to improve sight distance between motorists and pedestrians in crosswalks). Improvements on two-lane roads include narrowing travel lanes, removing parking near the intersection, improving lighting, adding signals, and providing traffic calming measures (on residential streets).

**Recommendation** Based on this report, we recommend that the AASHTO *Bike Guide* include a discussion of the use of crosswalks as a possible treatment for the intersection of shared-use paths with roadways. This discussion should include options for when a crosswalk alone is not adequate to provide a safe crossing treatment for shared use path users.



## Synthesis of Practice

Document: *Bicycle Facility Selection: A Comparison of Approaches*

Michael King. *Bicycle Facility Selection: A Comparison of Approaches*. Prepared for the Pedestrian and Bicycle Information Center. Available online at [http://www.bicyclinginfo.org/de/bike\\_selection.htm](http://www.bicyclinginfo.org/de/bike_selection.htm)

**Summary** The author reviewed bicycle facility guidelines from local, state, and national agencies in North America (10), Europe (4), and Australia (2). These are summarized in a series of matrices, one for each guideline, according to motor vehicle speeds and volumes. Facility definitions varied among guidelines, but for purposes of comparison were classified as follows:

Narrow lane	9-12 feet {2.7-3.7 m} wide
Wide lane	13-15 feet {4-4.6 m} wide
Bike lane	4-6 feet {1.2-1.8 m} wide and striped
Separated lane	Anything wider than a 6-foot {1.8 m} on-street bike lane

Examples of each facility type are shown in Figures 8-29 of the report.

The facility guidelines varied considerably among agencies. For example, if a street has a speed of 25 mi/h {40 km/h} and 4,000 ADT, the guidelines call for a narrow lane in Germany, a wide lane in Minnesota, and a bike lane in the City of Cambridge, MA.

Speed-volume matrices were developed for each LOS, A through F, using the Bicycle Compatibility Index. The speed and volume boundaries of each guideline were then compared to the speed-volume matrices to determine the LOS. North American guidelines generally provided for LOS D, while European and Australian guidelines provided for LOS C. With

regard to facility type, narrow and wide lanes usually provided for LOS D, bike lanes provided for LOS C, and separated lanes provided for LOS B.

**Comments** This report is a synthesis of existing guidelines. The 4- to 6-foot {1.2 m to 1.8 m} width used for bike lanes in the author's classification scheme is consistent with the AASHTO *Bike Guide* (pp. 22-23). The recommended 14-foot width for wide curb lanes (p. 17) is in the 13- to 15-foot {4 m to 4.6 m} range for wide lanes in the classification scheme.

**Recommendation** We do not recommend any specific changes to the AASHTO *Bike Guide*, based upon this document. With recent developments in measures of bicycle accommodation (BCI and Bicycle LOS), the other selection methods described in this document are used less frequently than in the past.

## Literature Search - Synthesis of Practice

Document: *Conflicts on Multiple-Use Trails: Synthesis of the Literature and State of the Practice*

Roger L. Moore. *Conflicts on Multiple-Use Trails: Synthesis of the Literature and State of the Practice*. Report No. FHWA-PD-94-031. Federal Highway Administration, Washington, DC, August 1994. Available online at <http://www.fhwa.dot.gov/environment/conflicts/>

**Abstract (copied from report)** *The National Recreational Trails Advisory Committee identified trail-user conflicts on multiple-use trails as a major concern that needs resolution. The Committee asked the Federal Highway Administration to produce a synthesis of the existing research to foster understanding of trail conflict, identify approaches for promoting trail-sharing, and identify gaps in current knowledge. This synthesis is intended to establish a baseline of the current state of knowledge and practice and to serve as a guide for trail managers and researchers. The goal of the report is to promote user safety, protect natural resources, and provide high-quality user experiences. It reviews management options such as trail design, information and education, user involvement, and regulations and enforcement.*

*Trail conflicts can occur among different user groups, among different users within the same user group, and as a result of factors not related to trail user activities at all. Conflict has been found to be related to activity style, focus of trip, expectations, attitudes toward and perceptions of the environment, level of tolerance for others, and different norms held by different users.*

*The report provides 12 principles for minimizing conflicts on multiple-use trails.*

1. *Recognize conflict as goal interference*
2. *Provide adequate trail opportunities*
3. *Minimize number of contacts in problem areas*
4. *Involve users as early as possible*
5. *Understand user needs*
6. *Identify the actual sources of conflict*
7. *Work with affected users*
8. *Promote trail etiquette*
9. *Encourage positive interaction among different users*
10. *Favor “light-handed management”*
11. *Plan and act locally*
12. *Monitor progress*

*Although this report is about conflicts on trails, it is intended to promote cooperation and understanding among trail users and to inspire ideas that will help reduce trail conflict. It is intended to be used by trail managers, State and local trail coordinators, researchers, and trail-user volunteer organizations.*

**Comments** The author presents a variety of strategies – including design, education, regulations, and enforcement – that others have used or suggested as means to avoid or minimize conflicts. The design strategies are general and do not provide any specific guidance.

**Recommendation** We do not recommend any specific changes to the AASHTO *Bike Guide* based on this report.

Document: *Innovative Bicycle Treatments: An Informational Report*

Jumana Nabti, Matthew Ridgway, and the ITE Pedestrian and Bicycle Council. *Innovative Bicycle Treatments: An Informational Report*. Institute of Transportation Engineers, Washington, DC, 2002.

**Summary (excerpted from Executive Summary)** Approximately 50 treatments are summarized in this report. These treatments include on-street innovations such as contra-flow bike lanes, shared bike/bus lanes, bike boulevards, raised bike lanes and colored bike lanes. There is information on trail facilities including one-way trails and median trails. This technical report, which is divided into eight sections, also summarizes treatments for bicycles at intersections, bicycle detection, unique bicycle signs, traffic calming accommodations for bicycles and bicycle parking.

The intent of this report is to identify innovations and share information on their applications, advantages and disadvantages; this report does not necessarily encourage or discourage their use.

**Comments** The main part of this report does not provide design guidance. However, the Appendix includes a 1994 report prepared by W.C. Wilkinson *et al.* for FHWA, *Selecting Roadway Design Treatments to Accommodate Bicycles*.

**Recommendation** Based on this report, we do not recommend any specific changes to the *AASHTO Bike Guide*.

## **Research on Bicycle Facilities and Users**

Document: *Operational Analysis of Uninterrupted Bicycle Facilities*

D. Patrick Allen, Nagui Rouphail, Joseph E. Hummer, and Joseph S. Milazzo II. Operational Analysis of Uninterrupted Bicycle Facilities. *Transportation Research Record 1636*, Transportation Research Board, Washington, DC, 1998, pp. 29-36.

**Abstract (copied from paper)** *The popularity of bicycles in North America is growing. As the popularity of bicycles has increased, so has the physical network of separate bicycle facilities and designated bicycle lanes in many locations. As a consequence of this growth, there is a demand for more information about bicycle operations on these facilities. Unfortunately, the state of knowledge regarding bicycle operations in the United States currently lags far behind that of motor vehicles and pedestrians. The international research that has been conducted to date regarding bicycle operations on uninterrupted facilities is thoroughly reviewed, and recommended procedures for the operational analysis of uninterrupted bicycle facilities are outlined. The recommended procedures are based on the concept of "frequencies of events" involving a bicyclist and other bicyclists or facility users. Events are defined as bicycle maneuvers required by a bicyclist on a facility, including passings (same-direction encounters) and meetings (opposite-direction encounters). The frequency of events for an uninterrupted bicycle facility is related to the service volumes of bicycles using or projected to be using the facility and does not have to be observed directly. The proposed procedures are, therefore, recommended based not only on their theoretical substance but also on their ease of use by practitioners.*

**Comments** The authors categorized uninterrupted bicycle facilities as exclusive paths, shared off-street paths (corresponding to shared use paths in the AASHTO *Bike Guide*), and on-street facilities (corresponding to bike lanes, paved shoulders, and wide curb lanes).

The analysis relies on equations originally proposed by Hein Botma. The level of service (LOS) depends on the number of events experienced by bicyclists. An event occurs when one user passes another user traveling in the same direction, or when one user meets another user traveling in the opposite direction.

The authors present equations for calculating the number of events on one- and two-way shared use paths, and one- and two-way exclusive paths. The equations for shared use paths assume that bicycle and pedestrian speeds are normally distributed with means of 11 mi/h {18 km/h} and 2.8 mi/h {4.5 km/h} respectively.

For example, Table 4 below shows the LOS thresholds (expressed as events per hour) are roughly twice as high for a 10-foot {3.0-m} path, compared to an 8-foot {2.4- m} path. Ten-foot {3.0-m} paths are regarded as operating with three lanes, and 8-foot {2.4- m} paths operate with two lanes.

**TABLE 4 LOS Thresholds for 8-ft {2.4-m} and 10-ft {3.0-m} Paths.**

LOS	Events/hr for 8-ft {2.4 m} paths (2-lane)	Events/hr for 10-ft {3.0-m} paths (3-lane)
A	<40	<90
B	<60	<140
C	<100	<210
D	<150	<300
E	<195	<375
F	≥195	≥375

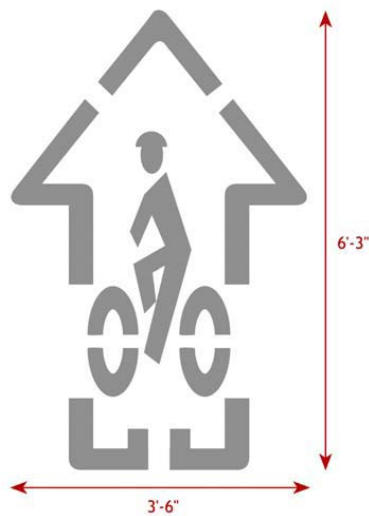


**Recommendation** The results of this study support the recommended 10-ft (instead of 8-ft) width for a shared use path, so we do not recommend any specific changes to the AASHTO *Bike Guide*. However, we recommend that the AASHTO *Bike Guide* include this study as a reference, as it will likely impact the Highway Capacity Manual.

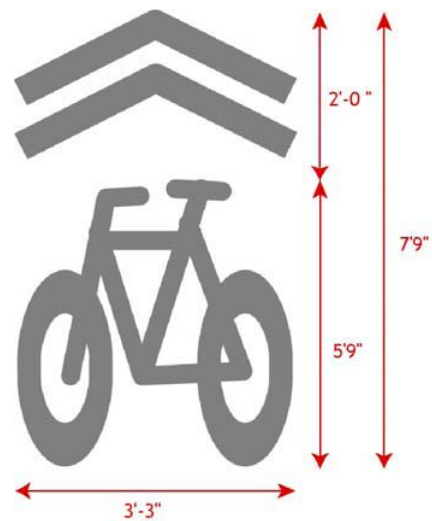
Document: *San Francisco’s Shared Lane Pavement Markings: Improving Bicycle Safety*

Alta Planning + Design. *San Francisco’s Shared Lane Pavement Markings: Improving Bicycle Safety*. Final Report. Submitted to San Francisco Department of Parking and Traffic, February 2004. Available online at [http://bicycle.sfgov.org/site/uploadedfiles/dpt/bike/Bke\\_Plan/Shared%20Lane%20Marking%20Full%20Report-052404.pdf](http://bicycle.sfgov.org/site/uploadedfiles/dpt/bike/Bke_Plan/Shared%20Lane%20Marking%20Full%20Report-052404.pdf)

**Summary** The San Francisco Department of Parking & Traffic (DPT) evaluated two shared-use arrow designs: a “bike-in-house” marking and a bike-and-chevron marking (Figures 3 and 4).



**Figure 3.** “Bike-in-house” marking.



**Figure 4.** Bike-and-chevron marking.

The evaluation took place on six streets, with the bike-in-house markings on one side and the bike-and-chevron marking on the other side. Bicyclists and motorists were videotaped and their positions were recorded.

The goals and findings below are copied from the report.

***Goal 1: Improve the position of both bicyclists and motorists on roadways without bicycle lanes***

- *Overall, the presence of a marking **increased the distance of cyclists to parked cars by 8 inches {20.3 cm}**. The effect of each marking on position was similar.*
- *When passing vehicles were present, the markings caused an **increase of 3 to 4 inches {7.6 to 10.1 cm} in the distance between cyclists and parked cars**. In addition, the markings caused an **increase of over 2 feet {0.6 m} in the distance between cyclists and passing vehicles**. The bike-and-chevron had a greater effect (by 3 inches {7.6 cm}) on the distance between cyclists and passing vehicles.*
- *When no cyclists were present, both of the markings had a significant positive effect of about one foot on the distance between passing vehicles and parked cars.*

***Goal 2: Reduce aggressive motorist behavior***

- *The markings neither significantly reduced nor increased the number of observable hostile behaviors between bicyclists and motorists. This was primarily due to the low number of aggressive behaviors recorded in the "before" videotapes.*

***Goal 3: Encourage correct bicyclist riding behavior***

- *Both the markings significantly reduced the number of sidewalk riders: the bike-and-chevron by 35% and the bike-in house by 25%.*

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- *The bike-and-chevron marking significantly reduced the number of wrong-way riders by 80%. The bike-in-house marking did not have any significant impact on the percentage of wrong-way riders.*

The project team concluded that both types of shared lane markings had a positive impact on motorist and bicyclist behavior, positions, and safety. The bike-and-chevron marking had a stronger impact on motorist positioning and in reducing wrong-way riding, and was preferred by the cyclists who were surveyed. Therefore, the project team recommended that the bike-and-chevron marking be used in San Francisco.

**Comments** The shared-use arrows were placed so that the centerlines were 11 feet {3.4 m} from the curb. This placement accommodates open car doors from cars parked along the curb (the 85<sup>th</sup> percentile of car doors observed opened to 9.5 feet {2.9 m} from the curb) and a 6-inch {20 cm} minimum shy distance between car doors and bicycle handlebars.

From the photographs in the report, it appears that most locations do not have parking stripes or stalls.

**Recommendations** Based on the results of this study, we do not recommend the inclusion of either shared lane marking in the AASHTO *Bike Guide*, unless they are adopted in the MUTCD.

Document: *Sidewalk Bicycling Safety Issues*

Lisa Aultman-Hall and Michael F. Adams, Jr. Sidewalk Bicycling Safety Issues.

*Transportation Research Record 1636*, Transportation Research Board, Washington, DC, 1998, pp. 71-76.

**Abstract (copied from paper)** *Bicycle route and safety data sets for 2,963 commuter cyclists in Ottawa and Toronto, Canada, containing cyclist characteristics, collision and fall history, and regular commute route, are used for this analysis. Previous analyses found sidewalk collisions and fall and injury rates significantly higher on sidewalks than on roads or paths. Of the 52 events reported on sidewalks, none were reported to police and would, therefore, not be found in a police accident database. These events did result in injuries, and in two cases major injuries. This analysis has found that commuter cyclists in Ottawa use sidewalks primarily on major roads (not necessarily high-speed roads) and often to cross bridges or to take shortcuts where no road exists. Toronto commuter cyclists use sidewalks primarily on high-volume multilane roads. Some Toronto cyclists still use sidewalks when bicycle lanes are provided. A slightly higher proportion of women are sidewalk cyclists in Ottawa; however, no age relationship was found. Sidewalk cyclists reported proportionally more near misses with bicycles in the previous month. A relatively large number of sidewalk collisions are with other bicycles. The most significant result of the analysis is that sidewalk cyclists have higher event rates on roads than nonsidewalk cyclists.*

**Comments** The authors remark that “The reasons for the higher rate of collisions, falls, and injury on roads by sidewalk cyclists were not measured in the data set.” (p. 75) They also note that “The nonsidewalk cyclists in Ottawa did have more total travel experience, which may correspond to better cycling skills.” (p. 75) The higher rate of events encountered by sidewalk cyclists may be due to a combination of the potential for conflicts (as described in the AASHTO *Bike Guide*, p. 58) and a lack of experience.

**Recommendation** Based on the results of this study, we recommend that the AASHTO *Bike Guide* strongly discourage the designation of sidewalks as bicycle facilities.

## Literature Search – Research on Bicycle Facilities and Users

Document: *Development of the Bicycle Compatibility Index*

David L. Harkey, Donald W. Reinfurt, and Matthew Knuiman. Development of the Bicycle Compatibility Index. *Transportation Research Record 1636*, Transportation Research Board, Washington, DC, 1998, pp. 13-20.

**Abstract (copied from paper)** *Presently, there is no methodology that is widely accepted by engineers, planners, or bicycle coordinators that will allow them to determine how compatible a roadway is for allowing efficient operation of both bicycles and motor vehicles. Determining how existing traffic operations and geometric conditions affect a bicyclist's decision to use or not use a specific roadway is the first step in determining the bicycle compatibility of the roadway. The Federal Highway Administration sponsored a study in which a methodology for deriving a bicycle compatibility index was developed. This tool can be used by bicycle coordinators, transportation planners, traffic engineers, and others to evaluate the capability of specific roadways to accommodate both motorists and bicyclists. It is intended to provide practitioners with the ability to assess the bicycle level of service present on existing facilities or on proposed facilities and can be used for operational, design, and planning analyses.*

**Comments** A video methodology was used to develop the Bicycle Compatibility Index (BCI). Participants viewed roadway segments on videotape and rated the segments with respect to how comfortable they would be riding a bicycle on those segments. The videotape included video clips from 67 roadway segments in cities across the U.S. The geometric and operational characteristics varied considerably across the segments:

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- Curb lane widths ranged from 9.8 to 15.4 ft {3.0 to 4.7 m}
- 85<sup>th</sup> percentile motor vehicle speeds ranged from 24.8 to 55.3 mi/h {40 to 89 km/h}
- Traffic volumes ranged from 2,000 to 60,000 vehicles per day
- Bicycle lane and paved shoulder widths ranged from 2.9 to 8.0 ft {0.92 to 2.44 m}

As shown in Figure 5, the BCI model incorporates bicycle lane (or paved shoulder) width, curb lane width, and other geometric and operational variables.

BCI = 3.67 - 0.966BL - 0.410BLW - 0.498CLW + 0.002CLV + 0.0004OLV + 0.022SPD + 0.506PKG - 0.264AREA + AF			
where:			
<b>BL</b> = presence of a bicycle lane or paved shoulder $\geq 0.9$ m no = 0 yes = 1	<b>BLW</b> = bicycle lane (or paved shoulder) width m (to the nearest tenth)	<b>CLW</b> = curb lane width m (to the nearest tenth)	<b>CLV</b> = curb lane volume vph in one direction
<b>PKG</b> = presence of a parking lane with more than 30 percent occupancy no = 0 yes = 1	<b>AREA</b> = type of roadside development residential = 1 other type = 0	<b>AF</b> = $f_t + f_p + f_{rt}$	where: <b>f<sub>t</sub></b> = adjustment factor for truck volumes (see below) <b>f<sub>p</sub></b> = adjustment factor for parking turnover (see below) <b>f<sub>rt</sub></b> = adjustment factor for right-turn volumes (see below)
<b>OLV</b> = other lane(s) volume - same direction vph	<b>SPD</b> = 85th percentile speed of traffic km/h		
Adjustment Factors			
Hourly Curb Lane Large Truck Volume <sup>1</sup>	$f_t$	Parking Time Limit (min)	$f_p$
$\geq 120$	0.5	$\leq 15$	0.6
60 - 119	0.4	16 - 30	0.5
30 - 59	0.3	31 - 60	0.4
20 - 29	0.2	61 - 120	0.3
10 - 19	0.1	121 - 240	0.2
< 10	0.0	241 - 480	0.1
		> 480	0.0
Hourly Right-Turn Volume <sup>2</sup>	$f_{rt}$		
$\geq 270$	0.1		
< 270	0.0		

<sup>1</sup> Large trucks are defined as all vehicles with six or more tires.

<sup>2</sup> Includes total number of right turns into driveways or minor intersections along a roadway segment.

**Figure 5. Bicycle Compatibility Index model, variable definitions, and adjustment factors.**

The model shows that, holding other variables constant, the addition of a bike lane or paved shoulder of at least 3.0 ft {0.9 m}, reduces the BCI (*i.e.*, bicyclists will feel more comfortable) by 0.966 plus 0.410 times the width (in meters) of the bike lane or paved shoulder.



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The addition of a paved shoulder of less than 2.9 ft {0.9 m} will reduce the BCI by 0.410 times the width (in meters). This supports the statement in the AASHTO *Bike Guide* (p. 16) that “any additional shoulder width is better than none at all.” This also suggests that 2.9 ft {0.9 m} is a minimum width, below which bicyclists do not perceive the bike lane (or paved shoulder) as being “present.”

A serious disadvantage of the video methodology is that participants are not riding actual roadway segments. Therefore, their ratings reflect perceived comfort and not real-life, experienced comfort. The Bicycle Level of Service by Landis *et al.* (1997 and 2003) addresses this shortcoming.

**Recommendation** Based on the results of this study, we recommend that the AASHTO *Bike Guide* be updated to discuss the BCI and the factors that were found to influence cyclists’ perceptions of how comfortable they felt riding along roadways. The BCI research also suggests that the AASHTO *Bike Guide* should discuss minimum bike lane widths of 3 feet {0.9 m}.

## Literature Search – Research on Bicycle Facilities and Users

Document: *Evaluation of Shared-Use Facilities for Bicycles and Motor Vehicles*

David L. Harkey and J. Richard Stewart. Evaluation of Shared-Use Facilities for Bicycles and Motor Vehicles. *Transportation Research Record 1578*, Transportation Research Board, Washington, DC, pp. 111-118.

**Abstract (copied from paper)** *This study was conducted for the Florida Department of Transportation with an objective of evaluating the safety and utility of shared-use facilities to provide engineers and planners comprehensive results that can be used in planning, designing, and constructing roadways to be shared by motorists and bicyclists. The results were developed from an analysis of observations of bicyclists and motorists interacting on different types of roadways. The evaluation included roadways with wide curb lanes, bicycle lanes, and paved shoulders. Locations from both rural and urban environments were included and varied in terms of motor-vehicle speed, traffic volume, lane width, and number of lanes. The operational measures of effectiveness used in evaluating the different types of facilities included (a) lateral placement of the bicyclist, (b) lateral placement on the motor vehicle, (c) separation distance between the bicycle and motor vehicle, and (d) encroachments by the motorist or bicyclist during the passing maneuver. Results of the analysis showed that the type of facility (wide curb lane versus bicycle lane versus paved shoulder) does have a significant effect on the separation distance between bicyclists and motor vehicles; this distance ranged from 5.9 to 6.4 ft {1.80 to 1.95 m}. The findings also indicated that paved shoulders and bicycle lanes generally result in similar interactions between motorists and bicyclists and that when compared with wide curb lanes they offer some distance advantages to both user groups. The results also indicated that*

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*bicycle lanes as narrow as 3 ft {0.92 m} provide sufficient space for motorists and bicyclists to interact safely. At the same time, a 4-ft {1.22-m} wide bicycle lane tended to optimize operating conditions because there were very few differences in the measures of effectiveness when 4-ft {1.22-m} lanes were compared with wider lanes.*

**Comments** The authors suggested that motorists were willing to accept a slightly smaller separation distance when passing bicyclists when there is a stripe on the roadway designating distinct areas for motorists and bicyclists. Motorists were less likely to encroach into the adjacent lane when passing a bicyclist on roads with paved shoulders or bicycle lanes. Other studies have found that bicyclists are more comfortable riding on roads with bicycle lanes or paved shoulders, due to the presence of the stripe (Harkey *et al.*, 1998; Landis *et al.*, 1997).

**Recommendation** Based on the results of this study, we recommend that the AASHTO *Bike Guide* should discuss minimum bike lane widths of 3 feet {0.9 m} also recommend that the AASHTO *Bike Guide* discuss when bike lanes may be the best treatment to install.

Document: *Evaluation of a Combined Bicycle Lane/Right-Turn Lane in Eugene, Oregon*

William W. Hunter. *Evaluation of a Combined Bicycle Lane/Right-Turn Lane in Eugene, Oregon*. Report No. FHWA-RD-00-151. Federal Highway Administration, McLean, VA, August 2000.

**Abstract (copied from report)** *In many bike-lane retrofit projects, there is not enough space to mark a minimum 0.9 ft {1.2-m} bike lane to the left of the right-turn lane. This report focuses on a combined bicycle lane/right-turn lane used when right-of-way at an intersection is limited. This evaluation took place in Eugene, OR. The narrow right-turn lane described above was evaluated by comparing the behaviors of bicyclists and motor vehicle drivers at 13<sup>th</sup> and Patterson (an intersection that had the shared, narrow right-turn lane described above in place) with behaviors at 13<sup>th</sup> and Willamette (an intersection that had a standard-width (12.1 ft) {3.7-} right-turn lane and accompanying bike lane (pocket) to the left of the right-turn lane). The intersection of 13<sup>th</sup> and Willamette is located about ½ mi {0.8 km} to the west of 13<sup>th</sup> and Patterson. It is important to note that bicyclists approaching on 13<sup>th</sup> at Patterson Street proceed straight ahead to the bike pocket at the intersection proper, in that the right-turn lane is “bulbed out.” Bicyclists approaching on 13<sup>th</sup> at Willamette have to shift to the left to get in the bike pocket adjacent to the right-turn lane at the intersection (i.e., there is no “bulb out”). Bicyclists traveling through each intersection were videotaped. The videotapes were coded to evaluate operational behaviors and conflicts with motorists, other bicyclists, and pedestrians. More than 17 percent of the surveyed bicyclists using the narrow-lane intersection felt that it was safer than the comparison location with a standard-width right-turn lane, and another 55 percent felt that*

*the narrow-lane site was no different safety-wise than the standard-width location. This is probably a function not only of relatively slow motor vehicle traffic speeds on 13<sup>th</sup> Street, but also due to the bike lane proceeding straight to the intersection at the narrow-lane site such that motorists crossing to the right-turn lane tended to have to yield. It was also relatively easy for bicyclists to time their approach to the intersection and ride through on a green indication. It was quite easy for bicyclists to ride up to the narrow-lane intersection and position themselves beside passenger cars or light trucks. Bicyclists at the narrow-lane site were “forced into” the adjacent traffic lane on a few occasions, usually the result of a heavy vehicle taking extra space. Sometimes bicyclists would shift to the right-turn portion of the lane if a heavy vehicle were in the through lane. Right turns on red by motor vehicles were rarely prevented when bicyclists were present at the front of the queue at the narrow-lane site. No conflicts between bicyclists and motor vehicles, other bicyclists, or pedestrians took place at either intersection. It is recommended that the design be implemented at other types of intersection locations (i.e., different motor vehicle approach speeds and approach configurations) and evaluated for effectiveness.*

**Comments** At 13<sup>th</sup> and Patterson, the narrow right-turn lane was 6.88 ft {2.1 m} wide. The 4.9 ft {1.5-m} bike lane was to the left of the narrow right-turn lane, and a 12.1 ft {3.7-m} through lane was to the left of the bike lane. The right-turn lane was not wide enough to accommodate heavy vehicles. Even passenger cars, which could have stayed within the right-turn lane with careful positioning, usually encroached across part or all of the bike lane. About 7 percent of the observed bicyclists were in the through lane, due to vehicles in the right-turn lane encroaching into the bike lane.

**Recommendation** Based on the results of this study, we do not recommend the inclusion of combined bicycle lanes / right-turn lanes in the AASHTO *Bike Guide*.

Document: *Evaluation of Innovative Bike-Box Application in Eugene, Oregon*

William W. Hunter. *Evaluation of Innovative Bike-Box Application in Eugene, Oregon. Transportation Research Record 1705*, Transportation Research Board, Washington, DC, 2000, pp. 99-106.

**Abstract (copied from paper)** *An innovative "bike box"--a right-angle extension to a bike lane (BL) at the head of the intersection--was installed with accompanying traffic signs but no extra traffic signals at a busy downtown intersection featuring two one-way streets in Eugene, Oregon, in summer 1998. The box allows bicyclists traveling to the intersection in a left side BL to get to the head of the traffic queue on a red traffic signal indication and then proceed ahead of motor vehicle traffic toward a right side BL when the traffic signal changes to green. Cyclists traveling through the intersection were videotaped before and after placement of the box. The videotapes were coded to evaluate operational behaviors and conflicts with motorists, other bicyclists, and pedestrians. Twenty-two percent of the bicyclists who approached in the left side BL and then crossed to the BL on the right side of the street (the bicyclists for whom the box was most intended) used the box. Many more bicyclists in this target group could have used the box (i.e., they had a red signal indication and enough time to move into the box). A problem with motor vehicle encroachments into the box likely diminished the frequency of use. The rate of conflicts between bicycles and motor vehicles changed little in the before and after periods. No conflicts took place while the bike box was being used as intended.*

**Comments** The AASHTO *Bike Guide* says that bicycle lanes should generally be placed on the right-hand side of a one-way street and indicates that a left-side bicycle lane be considered only “when a bike lane on the left will substantially decrease the number of conflicts, such as those caused by heavy bus traffic or unusually heavy turning movements to the right, or if there are a significant number of left-turning bicyclists.” (p. 22) The bicycle lane in this paper was placed on the left to match with another one-way couplet and to avoid having a right-side bicycle lane next to intersections with double right-turn lanes.

Although the bike box evaluated in Eugene was designed to allow bicyclists to get from a left-side bicycle lane over to the right-side of the street, it can be designed to facilitate the opposite maneuver. The AASHTO *Bike Guide* has information about striping bicycle lanes at intersections (pp. 25-27), but it does not address how to stripe a bicycle lane that crosses over from one side of the roadway to the other.

**Recommendation** Based on the results of this study, we do not recommend the inclusion of bike boxes in the AASHTO *Bike Guide* at this time. However, pending evaluations showing benefits and if bike boxes are adopted in the MUTCD, bike boxes should be considered for inclusion in a future update of the AASHTO *Bike Guide*.



## Literature Search – Research on Bicycle Facilities and Users

Document: *An Evaluation of Red Shoulders as a Bicycle and Pedestrian Facility*

William W. Hunter. *An Evaluation of Red Shoulders as a Bicycle and Pedestrian Facility*.

Submitted to the Florida Department of Transportation, July 1998. Available online at

[http://www.dot.state.fl.us/Safety/ped\\_bike/handbooks\\_and\\_research/research/redstudy.pdf](http://www.dot.state.fl.us/Safety/ped_bike/handbooks_and_research/research/redstudy.pdf)

**Summary** A 1.1-mile section of a road was widened by adding 3-foot {0.9 m} shoulders on both sides. To address public concerns that the widening would increase motor vehicle speeds, the shoulders were painted red with the intent that the road would not appear wider. The author evaluated the effects of the red shoulders by videotaping bicyclists and motorists at four locations along the road, three with red shoulders (Sites 1-3) and one with no shoulders at all (Site 4). Sites 3 and 4 were non-intersection locations.

Use of the red shoulders - About 80 percent of the bicyclists rode entirely in the shoulder.

Motorists passing bicyclists - An encroachment occurred if a motorist crossed the centerline while passing a bicyclist. At Site 3 (with red shoulders), 38 percent of the encroachments were severe (i.e., more than one-half of the motor vehicle was over the centerline), but at Site 4 (without red shoulders), 93 percent of the encroachments were severe. There were no conflicts between motor vehicles as a result of encroachments at Site 3, but there were eight such conflicts at Site 4. This reflects the greater severity of encroachments at Site 4.

Lateral positioning of bicyclists being passed by motor vehicles - Bicyclists who were being passed by motorists positioned themselves about the same distance from the edge of the pavement on both the sections with and without red shoulders. The lateral separation between bicycles and passing motor vehicles was greater on the section without red shoulders.

Motor vehicle speeds - There was very little difference in the mean and 85th percentile speeds before and after the red shoulders were installed.

A survey of bicyclists riding along the road revealed that after the red shoulders were installed:

- Most perceived no change in the speeds of cars and trucks,
- Most felt that there was more space between bicyclists and passing motorists, and
- Most felt that the red shoulders made them feel safer than “conventional” shoulders

**Comments** This study compared red shoulders with no shoulders. It did not compare red shoulders with “conventional” shoulders, so it is not known whether similar results would have been obtained with “conventional” shoulders. Also, the 3-foot {0.9 m} shoulders are narrower than the 4-foot {1.2 m} shoulders recommended in the AASHTO *Bike Guide* (p. 16), but as the *Bike Guide* notes, “Any additional shoulder width is better than none at all.”

**Recommendation** We do not specifically recommend the inclusion of red shoulders in the AASHTO *Bike Guide*. However, we do recommend that the AASHTO *Bike Guide* include a statement such as this from the AASHTO Green Book (p. 322), “It is desirable that the color and texture of shoulders be different from those of the traveled way. This contrast serves to clearly define the traveled way at all times, particularly at night and during inclement weather, while discouraging the use of shoulders as additional through lanes.”

Document: *Evaluation of Blue Bike-Lane Treatment in Portland, Oregon*

William W. Hunter, David L. Harkey, J. Richard Stewart, and Mia L. Birk. Evaluation of Blue Bike-Lane Treatment in Portland, Oregon. *Transportation Research Record 1705*, Transportation Research Board, Washington, DC, 2000, pp. 107-116.

**Abstract (copied from paper)** *Many European cities use colored markings at bicycle-motor vehicle crossings to reduce conflicts. To determine whether such colored markings help improve safety at American bicycle-motor vehicle crossings, the city of Portland, Oregon, studied the use of blue pavement markings and a novel signage system to delineate selected conflict areas. The University of North Carolina Highway Safety Research Center (HSRC), under contract to the Federal Highway Administration, analyzed the project data. From 1997 to 1999, Portland marked 10 conflict areas with paint, blue thermoplastic, and an accompanying "Yield to Cyclist" sign. All of the sites had a high level of cyclist and motorist interaction, as well as a history of complaints. The crossings were all at locations where the cyclist travels straight and the motorist crosses the bicycle lane in order to exit a roadway (such as an off-ramp situation), enter a right-turn lane, or merge onto a street from a ramp. The study used videotape analysis and found most behavior changes to be positive. Significantly higher numbers of motorists yielded to cyclists and slowed or stopped before entering the blue pavement areas, and more cyclists followed the colored bike-lane path. However, the blue pavement also resulted in fewer cyclists turning their heads to scan for traffic or using hand signals, perhaps signifying an increased comfort level. The overwhelming majority of cyclists and close to a majority of*

*motorists surveyed felt the blue areas enhanced safety. Colored pavement and signage should continue to be used and evaluated in bicycle-motor vehicle conflict areas.*

**Comments** The use of colored pavement markings to delineate bicycle-motor vehicle conflict areas at intersections is not covered in the AASHTO *Bike Guide*.

The AASHTO Green Book recommends contrasting surfaces in some situations (for example, shoulders, p. 322). The MUTCD restricts the use of colored pavement and colored pavement markings (Sections 3E.01 and 3A.04, respectively). Additional research on the use of colored pavement is underway.

**Recommendation** Given the mixed results of this study (increased motorist yielding but fewer cyclists scanning for traffic) and the MUTCD's restrictions on the use of colored pavement, we do not recommend the inclusion of colored pavement markings in the AASHTO *Bike Guide*.

## Literature Search – Research on Bicycle Facilities and Users

Document: *An Evaluation of Bike Lanes Adjacent to Motor Vehicle Parking*

William W. Hunter and J. Richard Stewart. *An Evaluation of Bike Lanes Adjacent to Motor Vehicle Parking*. Submitted to the Florida Department of Transportation, December 1999.

Available online at [http://www.dot.state.fl.us/Safety/ped\\_bike/handbooks\\_and\\_research/research/ftlaud.pdf](http://www.dot.state.fl.us/Safety/ped_bike/handbooks_and_research/research/ftlaud.pdf)

**Summary** The authors compared two roadways that have bike lanes next to motor vehicle parking:

- Ft. Lauderdale, FL – Route A1A has a 4.5-foot {1.4 m} bike lane with a 10.5-foot {3.2 m} traffic lane next to the bike lane
- Hollywood, FL – Hollywood Blvd. has a 5-foot {1.5 ft} bike lane with a 12-foot {3.7 ft} traffic lane next to the bike lane

Route A1A has more than double the traffic volume and 10 times the parking turnover, compared to Hollywood Blvd. About 320 bicyclists were observed on each bike lane.

At both locations, bicyclists tended to ride in the middle of the bike lane. Bicyclists on Hollywood Blvd. rode farther from the outside edge of the bike lane stripe when they were being passed by a motor vehicle, compared to Route A1A. The mean separation from passing vehicles was 5.77 feet {1.8 m} on Route A1A and 7.52 feet {2.3 m} on Hollywood Blvd. This difference is close to the 1.5-foot {0.5 m} difference in travel lane widths.

There were 8 conflicts between bicyclists and motorists, pedestrians, and other bicyclists on Route A1A. Six of these conflicts involved motorists conducting parking maneuvers. There

were 5 conflicts on Hollywood Blvd, four of which involved motorists either crossing the bike lane from a side street or crossing the bike lane to turn onto a side street.

### **Comments**

The study findings indicate that a 5-foot {1.5 m} bike lane (as recommended in the AASHTO *Bike Guide*, p. 22) is appropriate for Hollywood Blvd, as evidenced by the observations of bicyclist riding position, separation from passing vehicles, and conflicts. A narrower bike lane of 4.5 feet {1.4 m} is also appropriate, as evidenced by the observations on Route A1A. Even with the narrower bike lane and narrower traffic lane, most bicyclists rode at least 5 feet {1.5 m} from passing vehicles.

**Recommendation** The study findings support existing guidance on bike lane widths, so we do not recommend any specific changes to the AASHTO *Bike Guide* with respect to bike lane widths.

## Literature Search – Research on Bicycle Facilities and Users

Document: *Study of Bicycle Lanes Versus Wide Curb Lanes*

William W. Hunter, J. Richard Stewart, and Jane C. Stutts. *Study of Bicycle Lanes Versus Wide Curb Lanes. Transportation Research Record 1674.* Transportation Research Board, Washington DC, 1999, pp. 70-77.

**Abstract (copied from paper)** *A comparative analysis of bicycle lanes (BLs) versus wide curb lanes (WCLs) was done. The primary analysis was based on videotapes of almost 4,600 bicyclists from 48 sites in Santa Barbara, California; Gainesville, Florida; and Austin, Texas. The videotapes were coded to evaluate operational characteristics and conflicts with motorists, other bicyclists, or pedestrians. Significant differences in both operational behaviors and conflicts were associated with BLs and WCLs, but they varied depending on the behavior being analyzed. Wrong-way riding and sidewalk riding were much more prevalent at WCL sites compared to BL sites. The aggregated data showed that significantly more motor vehicles passing bicycles on the left encroached into the adjacent traffic lane from WCL situations compared to BL situations. Proportionally more bicyclists obeyed stop signs at BL sites; however, when a stop sign was disobeyed, the proportion of bicyclists with both "somewhat unsafe" and "definitely unsafe" movements was higher at BL sites. The vast majority of observed bicycle-motor vehicle conflicts were minor, and there were no differences in the conflict severity by type of bicycle facility. Bicyclists in WCLs, however, experienced more bike-pedestrian conflicts, whereas bicyclists in BLs experienced more bike-bike conflicts. The overall conclusion is that both BL and WCL facilities can and should be used to improve riding conditions for bicyclists. The identified differences in operations and conflicts appeared to be related to the*

*specific destination patterns of bicyclists riding through the intersection areas studied and not to characteristics of the bicycle facilities.*

**Comments** This paper did not say anything about the appropriateness of the widths of the bicycle lanes and wide curb lanes that were observed in the study.

The authors recommend the use of bicycle lanes (instead of wide curb lanes) at sites where there is adequate width for a 4-foot {1.2 m} bicycle lane, given the stated preferences of bicyclists for bicycle lanes and the increased comfort level on bicycle lanes as found in the development of the Bicycle Compatibility Index. According to the AASHTO *Bike Guide* (page 17), “In situations where more than 15 feet {4.5 m} of pavement width exists, consideration should be given to striping bike lanes or shoulders.”

**Recommendation** Based on the results of this and other studies, we recommend that the AASHTO *Bike Guide* discuss when bike lanes may be the best treatment to install. While there are some who question whether or not the data in this study supports the conclusions presented, the researchers of this NCHRP project believe it would be instructive to those choosing and designing bicycle facilities to be aware of the behavioral observations documented in this report.



Document: *Characteristics of Emerging Road and Trail Users and Their Safety*

Bruce W. Landis, Theodore A. Petritsch, and Herman F. Huang. *Characteristics of Emerging Road and Trail Users and Their Safety*. Report No. FHWA-HRT-04-103. Federal Highway Administration, McLean, VA, July 2004.

**Abstract (copied from report)** *This study was undertaken to clarify the operational characteristics of an increasingly diverse group of trail and other nonmotorized transportation users. Three “Ride for Science” data collection events were conducted to obtain the physical dimensions, turning capabilities, lateral operating space, acceleration, speed, and stopping sight distance of trail users. The results confirmed the great diversity in the operating characteristics of various road and trail user types. Some examples of findings include:*

***Sweep Width***—*The 85<sup>th</sup> percentile inline skater had a 4.9-foot (ft) {1.5-meter (m)} sweep width, wider than the AASHTO recommended width for bike lanes.*

***Design Speed***—*Recumbent bicyclists had the highest observed 85<sup>th</sup> percentile speeds of 18 miles per hour (mi/h) {29 kilometers per hour (km/h)}, less than AASHTO’s minimum design speed.*

***Horizontal Alignment***—*Most users did not reduce their speeds for turning radii greater than 52.5 ft {16 m}.*

***Stopping Sight Distance***—*A recumbent cyclist in the 85<sup>th</sup> percentile requires a stopping sight distance of 107.3 ft {32.7 m} on wet pavement, less than the AASHTO value.*

***Vertical Alignment/Crest Vertical Curves***—*Recumbent bicyclists had a required length of a crest vertical curve of 153 ft {46.7 m}, less than the AASHTO value.*

***Signal Clearance Intervals***—Five-second clearance intervals would provide insufficient time for most users (85<sup>th</sup> percentile users) to clear a five-lane (60-ft {18.3-m} wide) intersection.

***Characteristics of Segway™ Users***—Many characteristics of Segway users were comparable with those of other emerging trail users.

*These findings suggest that design guidelines may need to be revised to incorporate the needs of emerging trail users. The results of this study can be used to help design professionals adequately design roadway and shared use path facilities to meet the operational and safety needs of this growing group of users.*

**Comments** The data reveal important information about the physical dimensions, speeds, etc. for various user types. The appropriate design user for shared use paths may vary with respect to design criteria or a facility design element. Table 5 below (Table 23 from the report) shows design features, AASHTO design values for bicyclists, potential design users, and 85<sup>th</sup> percentile performance values. Thus, some users will be better accommodated on facilities designed according to the AASHTO *Bike Guide*, and other users will not be as well-accommodated.

**TABLE 5 Design Criteria and Potential Design Users.**

DESIGN FEATURE	AASHTO DESIGN VALUE (FOR BICYCLISTS)	POTENTIAL DESIGN USER	PERFORMANCE VALUE (85 <sup>TH</sup> PERCENTILE)
Sweep width	3.9 ft {1.2 m}	Inline skaters	4.9 ft {1.5 m}
Horizontal alignment	88.5 ft {27 m}	Recumbent bicyclists	87.9 ft {26.8 m}
Stopping sight distance (wet pavement)	126.9 ft {38.7 m}	Recumbent bicyclists	107.3 ft {32.7 m}
Vertical alignment—crest	163.4 ft {49.8 m}	Recumbent bicyclists	153.2 ft {46.7 m}
Refuge islands	8.2 ft {2.5 m}	Bicyclists with trailers	9.8 ft {3.0 m}
Signal clearance intervals	7.5 sec for a distance of 80.0 ft {24.4 m}	Kick scooters	10.6 sec for a distance of 80.0 ft {24.4 m}
Minimum green times	12.8 sec for a distance of 80.0 ft {24.4 m}	Hand cyclists	17.9 sec for a distance of 80.0 ft {24.4 m}
Pedestrian clearance intervals	20.0 sec for a distance of 80.0 ft {24.4 m}	Manual wheelchairs	15.4 sec for a distance of 80.0 ft {24.4 m}

1 m = 3.28 ft

**Recommendation** This research reveals that the practice of using the traditional bicycle as the overall design user is probably not appropriate: depending on the design element and user population, either the geometry is insufficient to safely accommodate all the users, or in other cases, design flexibility is being lost due to overly conservative design parameters. This research indicates that the design user will vary with the design feature; while additional research can provide more guidance as to which should be the design user(s) for the various design elements, this study provides crucial information to begin updating national design guidelines such as *AASHTO*.

If it is determined that the *AASHTO Bike Guide* should incorporate additional modes besides bicycles, perhaps the performance values shown in the table above can serve as initial

guidance for design values. The results of this study suggest that the equation for minimum green time be revised (p. 65).

The data collected during this project suggest that several actions should be considered:

- The results of this study should be disseminated to design professionals and shared use path operators for their review and comments.
- A one-day presentation should be made to, and discussed with, an expert panel of facility design engineers and trail operators.
- A new NHI course should be developed (or the existing courses should be significantly modified).
- An interim FHWA design guide for shared use paths should be developed.
- The AASHTO *Guide for the Development of Bicycle Facilities* should be updated to reflect this research's findings on bicycles.
- An AASHTO document on shared use path design guidelines should be developed.

Document: *Real-Time Human Perceptions: Toward a Bicycle Level of Service*

Bruce W. Landis, Venkat R. Vattikuti, and Michael T. Brannick. Real-time Human Perceptions: Toward a Bicycle Level of Service. *Transportation Research Record 1578*. Transportation Research Board, Washington, DC, 1997, pp. 119-126.

**Abstract (copied from paper)** *The primary focus of this study by Sprinkle Consulting Engineers, Inc., is to develop a bicycle-quality, or level-of-service, model for applications in U.S. metropolitan areas. Although there are several model forms being used throughout the United States that attempt to quantify road suitability or the quality of service afforded bicyclists traveling the street and roadway networks of urbanized areas, to date there have been no statistically calibrated models published. The statistically calibrated level-of-service model described here is based on real-time perceptions from bicyclists traveling in actual urban traffic and roadway conditions. The study's participants represented a cross section of age, gender, experience level, and geographic origin of the population of cyclists that use the metropolitan road networks in the United States. The test course is representative of the collector and arterial street systems of North American urban areas. Although further hypothesis testing is being conducted and additional studies are planned to test the need for disaggregate models for central business district streets with high turnover parking, truck routes, and two-lane high-speed rural highways, the general bicycle level-of-service model reported here is highly reliable, has a high correlation coefficient ( $R\text{-squared} = 0.73$ ), and is transferable to the vast majority of United States metropolitan areas. The study reveals that pavement surface conditions and striping of bicycle lanes are important factors in the quality of service.*

**Comments** The study course was approximately 17 miles {27.3 kilometers} in length and consisted of 30 roadway segments with near-equal lengths. The width of outside lanes ranged from 10 ft to 16 ft {3.0 m to 4.6 m}. Striped bike lanes and paved shoulders ranged from nonexistent to 6 ft {1.8m} wide.

The presence of a stripe separating the motor vehicle and bicycle areas of an outside travel lane resulted in the perception of a safer condition than an outside travel lane of the same width but without delineated motor vehicle and bicycle areas. The authors provide an example in Table 2 of the paper (shown as Table 6 below). Using a set of baseline inputs, the calculated segment LOS for an outside lane width of 15 feet {4.6 m} is 3.7. If the same outside lane is partitioned into a 12-foot {3.7 m} motor vehicle lane and a 3-foot {0.9 m} bicycle lane, the LOS improves to 3.2.

**TABLE 6 Calculated Segment LOS Values for Different Baseline Inputs.**

OUTSIDE LANE WIDTH	MOTOR VEHICLE LANE WIDTH	BICYCLE LANE WIDTH	CALCULATED LOS SCORE
15 feet {4.6 m}	Unstriped	Unstriped	3.7
15 feet {4.6 m}	12 feet {3.7 m}	3 feet {0.9 m}	3.2
16 feet {4.9 m}	Unstriped	Unstriped	3.6
16 feet {4.9 m}	12 feet {3.7 m}	4 feet {1.2 m}	2.9
17 feet {5.2 m}	Unstriped	Unstriped	3.4
17 feet {5.2 m}	12 feet {3.7 m}	5 feet {1.5 m}	2.5

Although the AASHTO *Bike Guide* (p. 23) recommends 5-foot {1.5 m} bike lanes, 3-foot {0.9 m} and 4-foot {1.2 m} bike lanes result in perceptions of a safer condition and are therefore better than nothing when it comes to improving the quality of service. Bicyclists’ perceived safety and comfort while riding along roadway segments depends in part on the separation from

parallel motor vehicle traffic afforded by wider outside lanes, and the presence of a bike lane or paved shoulder stripe accentuates that feeling of separation.

The Florida Department of Transportation adopted the Bicycle LOS model in the year 2000 as its standard. This model has also been adopted by many other agencies and jurisdictions throughout the U.S.

**Recommendation** Based on the results of this study, we recommend that the AASHTO *Bike Guide* be updated to discuss the Bicycle LOS model and the factors that were found to influence cyclists' perceptions of how safe and comfortable they felt riding along roadways. The Bicycle LOS research also suggests that the AASHTO *Bike Guide* should discuss minimum bike lane widths of 3 feet {0.9 m}.

Document: *Intersection Level of Service for the Bicycle Through Movement*

Bruce W. Landis, Venkat R. Vattikuti, Russell M. Ottenberg, Theodore A. Petritsch, Martin Guttenplan, and Linda B. Crider. *Intersection Level of Service for the Bicycle Through Movement*. *Transportation Research Record 1828*. Transportation Research Board, Washington, DC, 2003, pp. 101-106.

**Abstract (copied from paper)** *The Florida Department of Transportation (DOT) has initiated multimodal level-of-service (LOS) methodologies, including that for the bicycle travel mode. It has already adopted a bicycle LOS methodology for the roadway segment portion of the transportation network, the Bicycle Level of Service Model. Florida DOT's ultimate goal is to develop corridor- and facilities-level LOS methodologies. Toward that goal, Florida DOT sponsored research to develop the first part of an intersection bicycle LOS methodology, the Intersection LOS for the bicycle through movement. This Intersection LOS for the bicycle through movement would provide a measure of the level of safety and comfort experienced by bicyclists riding through an intersection. The Intersection LOS model for the bicycle through movement is based on Pearson correlation analyses and stepwise regression modeling of approximately 1,000 combined real-time perceptions from bicyclists traveling a course through a typical U.S. metropolitan area's signalized intersections. The study's participants represented a cross section of age, gender, and geographic origin of the population of cyclists. Although further hypothesis testing is being conducted, the resulting general model for the Intersection LOS for the bicycle through movement is highly reliable, has a high correlation coefficient ( $R$ -squared = 0.83) with the average observations, and is transferable to the vast majority of U.S.*



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*metropolitan areas. The study reveals that roadway traffic volume, total width of the outside through lane, and the intersection (cross street) crossing distance are primary factors in the Intersection LOS for the bicycle through movement.*

**Comments** The study course was approximately 17 miles {27.3 kilometers} in length and included 21 intersections, 19 of which were signalized. The widths of outside lanes ranged from 9 to 16 feet {2.7 to 4.9 m}. Striped bike lanes and paved shoulders ranged from nonexistent to 4 feet {1.2 m} wide. The total width of the outside lane and striped bike lane or paved shoulder (if present) is one of the terms in the intersection LOS model. Although the presence of a marked bike lane on the intersection approach was found to have a beneficial effect on the intersection LOS, the presence of striping did not have the same dramatic benefit on intersection LOS that it had on segment LOS. Bicyclists' perceived safety and comfort while riding through intersections comes from the separation from parallel motor vehicle traffic afforded by wider outside lanes. The presence of a bike lane or paved shoulder stripe is not as important as it is in the case of bicyclists riding along roadway segments.

**Recommendation** Based on the results of this study, we recommend that the AASHTO *Bike Guide* be updated to discuss the intersection model and the factors that were found to influence cyclists' perceptions of how safe and comfortable they felt riding through intersections. This will provide tangible guidance for designing intersections to better accommodate bicyclists.

Document: *Bicyclist Performance on a Multiuse Trail*

Wayne Pein. Bicyclist Performance on a Multiuse Trail. *Transportation Research Record 1578*, Transportation Research Board, Washington, DC, 1997, pp. 127-131.

**Abstract (copied from paper)** *Bicyclist crossing time from a full stop was measured using video recording equipment at 16 diverse trail-roadway intersections (two to six lanes, stop or signal controlled, divided or undivided) of the Pinellas Trail in Pinellas County, Florida. A total of 442 bicyclists (single individuals or randomly selected individuals from a group) were timed. The cruising speed of 65 bicyclists was also determined. A linear regression model was fit to the time and crossing-distance data. A linear regression was also fit to eight 85<sup>th</sup> percentile crossing-time points that were calculated from grouped raw data. Using kinematic physics, in which bicycle acceleration and intersection crossing velocity are variables, a theoretical equation was derived to predict bicyclist crossing time for any distance. This derived equation is a linear function of distance, so the regression coefficients could then be used to estimate bicyclist crossing velocity and acceleration on the Pinellas Trail. These estimated values for bicyclist acceleration and intersection crossing velocity compare favorably with the scant available data from foreign and domestic sources. Thus, the crossing-time prediction equation can be a useful tool when designing intersections for bicyclists, with application in signal timing and crossing-sight distance calculations.*

**Comments** The mean acceleration was estimated to be 3.5 ft/sec<sup>2</sup> {1.1 m/sec<sup>2</sup>}, and the crossing speed, 7.9 mi/h {12.7 km/h}. The estimated 85<sup>th</sup> percentile values (i.e., 85 percent were

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at or above those values) were 2.4 ft/sec<sup>2</sup> {0.7 m/sec<sup>2</sup>} and 6.7 mi/h {10.8 km/h}, respectively. The AASHTO *Bike Guide* (p. 98) provides for an acceleration of 1.5 to 3.0 ft/sec<sup>2</sup> {0.4 to 0.9 m/sec<sup>2</sup>} and notes that 98 percent of Group C cyclists can clear signals timed for 6 mi/h {9.6 km/h}. Thus, the research results support the acceleration and speed values in the AASHTO *Bike Guide*.

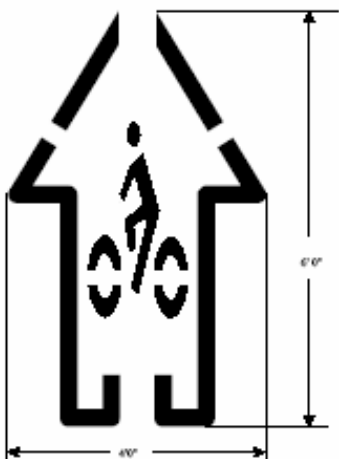
**Recommendation** Based on the results of this study, we do not recommend any specific changes to the AASHTO *Bike Guide*.

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Document: *Evaluation of the Shared-Use Arrow*

Wayne E. Pein, William W. Hunter, and J. Richard Stewart. *Evaluation of the Shared-Use Arrow*. Submitted to the Florida Department of Transportation, December 1999. Available online at [http://www.dot.state.fl.us/Safety/ped\\_bike/handbooks\\_and\\_research/research/finalwwh.pdf](http://www.dot.state.fl.us/Safety/ped_bike/handbooks_and_research/research/finalwwh.pdf)

**Summary** The shared-use arrow is intended to encourage bicyclists to ride in the direction of (*i.e.*, on the correct side of the street), and through, the arrow (Figure 6). It does not delineate separate areas of the roadway for motor vehicles and bicycles. This device was evaluated at four locations in Gainesville, FL.



**Figure 6. Shared-use arrow in Gainesville, FL.**

## Literature Search – Research on Bicycle Facilities and Users

The findings are as follows:

Bicyclist position and direction – A higher percentage (45 percent) of bicyclists rode in the street, with traffic after the arrows were installed than before (39 percent).

Bicycle to curb distance – The arrows resulted in a greater mean bicycle to curb distance (1.58 feet {0.5 m} before the arrows were installed and 1.83 feet {0.5 m} after).

Bicycle to motor vehicle – There was no statistically significant difference in the lateral separation between bicycles and motor vehicles, before and after the arrows were installed.

Motor vehicle to curb distance – There was no statistically significant difference in the motor vehicle to curb distance, before and after the arrows were installed.

**Comments** The arrows were installed in a 15-foot {4.6 m} wide curb lane. The arrows are 4.0 feet {1.2 m} across at the widest point and the centerlines of the arrows were 3.5 feet {1.1 m} from the curb. They were placed 80 feet {24.4 m} in advance of an intersection, 20 feet {6.1 m} after an intersection, and roughly every 200 feet {61 m} between intersections. In the absence of a striped bike lane, the arrows can provide guidance to bicyclists on where to ride. However, it is not known how the effectiveness of the arrows compares to that of striped bike lanes, with respect to the four MOE's listed above.

**Recommendation** Based on the results of this study, we do not recommend the inclusion of shared-use arrows in the AASHTO *Bike Guide*, unless they are adopted in the MUTCD.

## Literature Search – Research on Bicycle Facilities and Users

Document: *Evaluation of Bicycle and Pedestrian Facilities: User Satisfaction and Perceptions on Three Shared Use Trails in Texas.*

C. Scott Shafer, Bongkoo Lee, Shawn Turner, and Matt Hughart. *Evaluation of Bicycle and Pedestrian Facilities: User Satisfaction and Perceptions on Three Shared Use Trails in Texas.* Report No. SWUTC/99/472840-00021-1, Texas A&M University, College Station, TX, May 1999.

**Abstract (copied from report)** *This report describes research conducted to evaluate bicycle and pedestrian facilities (i.e., shared use trails) with user satisfaction and perception surveys. Public and community input on transportation projects is often mentioned as a necessary step in the planning process but seldom performed. The opinions and perceptions of facility users are immensely valuable in improving conditions at current trails as well as in the development and design of new trails. In this study, the research team developed on-site and mail-back survey instruments that were distributed on three shared use trails in Texas: the Brays and Buffalo Bayou Trails in Houston, and the Shoal Creek Trail in Austin. The responses to the surveys were analyzed to determine consistent themes and trends in user satisfaction and perceptions. The study found that several trail attributes contribute significantly to user satisfaction and higher levels of trail use. Adequate separation from motor vehicles was noted as a positive attribute that should be provided whenever possible on shared use trails. Trail surface quality and width was also noted as an important attribute, particularly in cases where numerous user types (e.g., bicyclists, joggers, walkers) were using the same trail. The study also revealed that many of the trail users felt that the shared use trails significantly contributed to*

## Literature Search – Research on Bicycle Facilities and Users

*harmonizing transportation and community goals. The survey responses indicated that the trails were used for a variety of purposes, including transportation, recreation, social interaction, and enjoyment of the natural environment. The researchers concluded that user surveys (such as those conducted in this study) are a valuable addition to other traditional transportation planning tools, and as such, can provide more and better insight into roadway and trail user behavior and motivation.*

**Comments** About 18 percent of the respondents on the Brays Bayou Trail commented that it was not wide enough. This compared with less than 4 percent on the Buffalo Bayou Trail and less than 1 percent on the Shoal Creek Trail.

Respondents were asked to indicate the relative importance of 12 trail attributes to their use of any trail. The top six most important were litter on trail, trail's separation from traffic, trail surface maintenance, trail surface type, width of trail, and water fountains. Most of these are addressed in the AASHTO *Bike Guide*: litter (p. 73, "Operation and Maintenance"), separation (p. 33), maintenance (p. 73), surface type (p. 54, "Pavement Structure"), and width (pp. 35-36).

**Recommendation** We do not recommend any specific changes to the AASHTO *Bike Guide* based on the results of this study.

Document: *Bicycle and Pedestrian Detection: Final Report*

SRF Consulting Group, Inc. *Bicycle and Pedestrian Detection: Final Report*. Prepared for Federal Highway Administration, February 2003. Available online at

<http://projects.dot.state.mn.us/nit/BicyclePedFinalReport/bikePedDetFinalReport.pdf>

**Summary** This report presents the results of a field test of six commercially-available bicycle and pedestrian detectors (Table 7).

**TABLE 7 Detectors and Technologies Tested.**

DETECTOR	TECHNOLOGY
ASIM DT 272	Passive infrared / ultrasonic
Diamond Traffic Counter	Infrared
MS Sedco SmartWalk	Microwave
Autoscope Solo	Video
3M Microloop	Magnetic
Inductive Loop	Magnetic

The field test was conducted on the Cedar Lake Trail in Minnesota. This trail has a pedestrian lane and two bicycle lanes. At the test location, the pedestrian lane is physically separated from the bicycle lanes. The following activities were performed to measure the level of detection:

- A ferrous-metal (chrome alloy) bicycle was ridden through the detection zone a total of 100 times
- A non-ferrous (aluminum) bicycle was ridden through the detection zone a total of 100 times



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- One researcher walked through the detection zone a total of 100 times.

All six detectors had an accuracy of 96 percent or higher in detecting the ferrous-metal bicycle. The 3M Microloop and Diamond Traffic Counter were not included in the non-ferrous bicycle detection tests; the remaining four detectors had an accuracy of 98 percent or higher. For pedestrian detection, the 3M Microloop and Inductive Loop were not included; the other four detectors had an accuracy of 93 percent or higher.

**Recommendation** We recommend the inclusion of additional detection technologies (besides loop detectors) in the AASHTO *Bike Guide*.

### **Additional References Identified by Survey Respondents**

Concurrently with this literature search, some respondents to the nationwide survey identified additional references. These are listed below, along with the researchers' recommendations whether they should be added to this literature review.

Bicycle Boulevards in Berkeley. Available online at <http://www.ci.berkeley.ca.us/transportation/Bicycling/BB/BicycleBoulevard.html>.

We did not add the information on this website to the literature review, as the design guidelines are limited to specific applications in Berkeley, CA. Also, no operational or safety studies of these applications are given.

City of Portland. Bicycle Parking Facilities Guidelines. Available online at <http://www.trans.ci.portland.or.us/bicycles/parkguide.htm>

We have added these guidelines to the literature review, under “State and Local Design Guidance.”

Danish Road Directorate. *Collection of Cycle Concepts*. Available online at <http://www.vejdirektoratet.dk/pdf/cykelrapport/999Complete.pdf>

We have added this book to the literature review, under “National Guidance.”

## Literature Search – Additional References Identified by Survey Respondents

Illuminating Engineering Society of North America. *Recommended Lighting for Walkways and Class 1 Bikeways*.

We have added this design guide to the literature review, under “National Guidance.”

Interface for Cycling Expertise. <http://www.i-ce.nl/>

From the mission statement:

I-ce is an expertise centre with the aim to support capacity building for planning and design of cycling facilities in an urban policy context. I-ce delivers expertise to governments, expert organizations and lobby groups. I-ce facilitates the exchange of experiences and expertise and makes these applicable in a wide different context.

We did not add the information from this website to the literature review, as it is neither an evaluation nor design guidance.

Graham Rayman. ‘Dooring’ top culprit in cycling crashes. *Newsday*. November 19, 2004.

Available online at <http://www.transalt.org/press/media/2004/041119newsday.html>

We did not add this newspaper article to the literature review. This article is not a safety study or design guidance. The author interviewed two cyclists who had been doored and noted that “Transportation advocates estimated yesterday that accidents involving abruptly opened vehicle doors, known as “dooring,” are the No. 1 cause of bicycle crashes in the city. It happens about 900 times a year across the city, causing injuries across the spectrum, according to Transportation Alternatives.” Transportation

## Literature Search – Additional References Identified by Survey Respondents

Alternatives ([www.transalt.org](http://www.transalt.org)) is a 5000-member NYC-area non-profit citizens group working for better bicycling, walking and public transit, and fewer cars.

John Schubert. Pretending to accommodate bicyclists is no solution: Don't sweep known safety hazards under the rug. Available online at <http://www.labreform.org/pretending.html>

This article is a position paper rather than original research, so we did not add it to the literature review.

*Sign up for the bike.* 3<sup>rd</sup> edition. November 1996

This manual was published in the Netherlands. We recommend that it be considered for possible inclusion in the literature review, under “National Guidance.” The 1993 edition of this manual is referenced in the current AASHTO *Bike Guide*.

United States Green Building Council. LEED Green Building Rating System. Summary available online at [http://www.usgbc.org/LEED/LEED\\_Main.asp](http://www.usgbc.org/LEED/LEED_Main.asp).

We did not add LEED to the literature review, as it pertains to buildings, not bicycle facilities.

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System<sup>®</sup> is a voluntary, consensus-based national standard for developing high-performance, sustainable buildings. Members of the U.S. Green Building Council representing all segments of the building industry developed LEED and continue to

## Literature Search – Additional References Identified by Survey Respondents

contribute to its evolution. LEED standards are currently available or under development for:

- New commercial construction and major renovation projects (LEED-NC)
- Existing building operations (LEED-EB)
- Commercial interiors projects (LEED-CI)
- Core and shell projects (LEED-CS)
- Homes (LEED-H)
- Neighborhood Development (LEED-ND)

### *Vermont Pedestrian and Bicycle Facility Planning and Design Manual*

Available online at

<http://www.aot.state.vt.us/progdev/Documents/LTF/FinalPedestrianAndBicycleFacility/PedestrianAndBicycleFacilityDesignManual.pdf>

We have added this manual to the literature review, under “State and Local Design Guidance.”

W.C. Wilkinson, III, A. Clarke, B. Epperson, and R. Knoblauch. *Selecting Roadway Design*

*Treatments to Accommodate Bicycles*. Available online at

<http://safety.fhwa.dot.gov/fourthlevel/pdf/Select.pdf> (text) and

<http://safety.fhwa.dot.gov/fourthlevel/pdf/Tables.pdf> (tables)

Although this manual is already referenced in the current AASHTO *Bike Guide*, we have added it to the literature review, under “National Guidance.”

## CHAPTER 4: SURVEY RESULTS

The following pages are a reduction of responses to the nationwide internet survey. There were 468 respondents to the survey. They made a total of 3620 specific comments on the *AASHTO Guide for the Development of Bicycle Facilities* and its contents. A printout of the actual web-based survey questionnaire is at the beginning of Appendix “A.”

There was a wide range of comments made concerning the *AASHTO Bike Guide*. Many of the comments made were with respect to specific details of information contained in the Guide. For instance, many of the comments reflected opinions concerning specific dimensions given in the Guide. Other comments addressed the format of the Guide. Examples of these include using a bulleted text format versus a narrative format and numbering the sections. The researchers believe the comments contained in the survey database and the information gained in subsequent discussions with respondents will provide valuable information in drafting the actual text of the next *AASHTO Bike Guide*.

For each question on the web based survey, each respondent’s answer (or rather, suggestion) was evaluated in the context of other respondents’ answers to the same question. Additionally, the researchers looked at the background of each respondent (occupation, job title, how often and for what he/she uses the *AASHTO Bike Guide*) to determine additional perspective on the context (e.g., experience in the planning, design or operation of bicycle facilities) of the respondent’s recommendations.

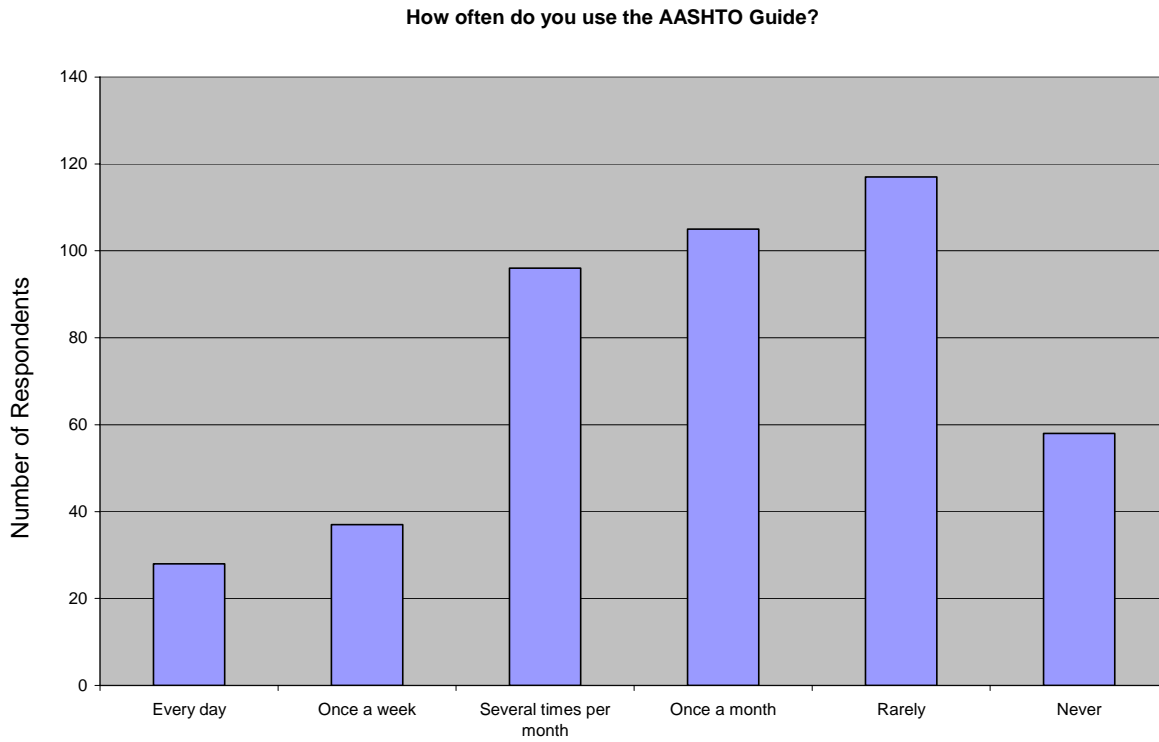
The pages that follow are essentially the working notes of the project team as they relate to the existing *AASHTO Bike Guide*. In general, they represent the reduced notes of actual topic areas respondents said the Guide should cover. They are primarily restricted to topics which need

## Chapter 4: Survey Results

to be included in next AASHTO *Bike Guide*, but in some cases may contain specific content comments.

The final questions on the survey relate to those specific items identified by the researchers, either from comments of the panel or from their experience teaching the NHI Bicycle Facilities Design Course. These are contained in the Appendix.

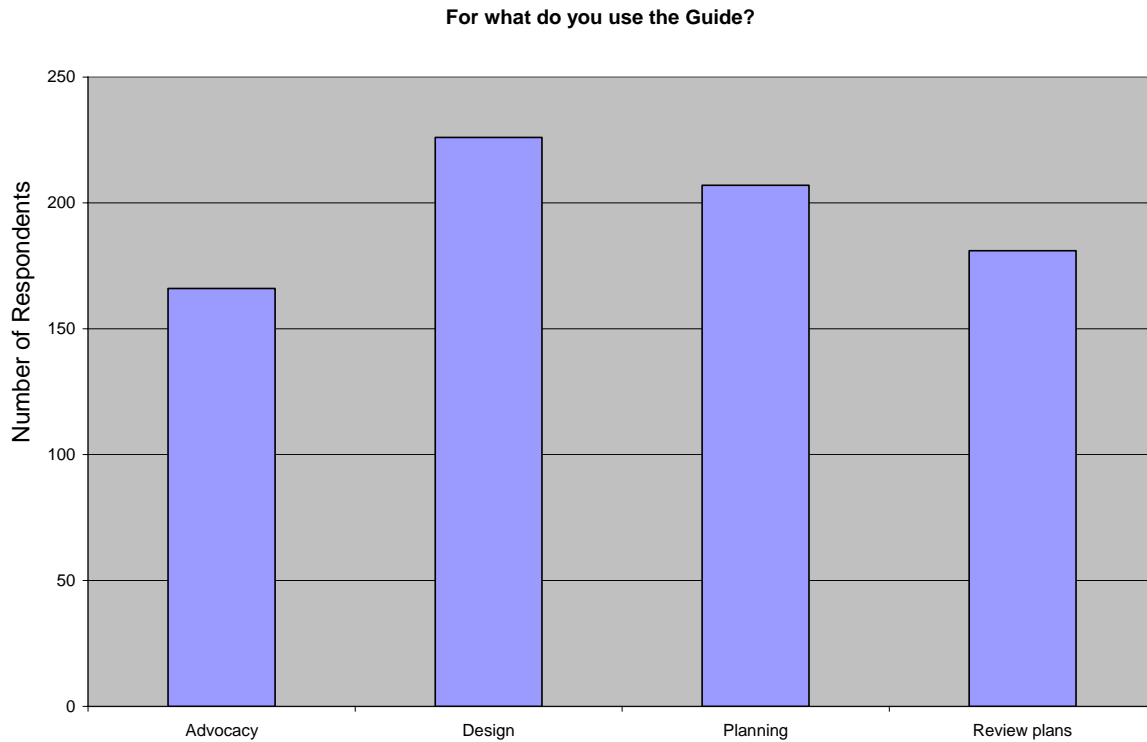
**How often do you use the AASHTO Guide?**



**Figure 7. How often do you use the AASHTO Guide?**



**For what do you use the Guide?**



**Figure 8. For what do you use the Guide?**

**Additional Responses**

Advise CA Bike Advisory Committee

Design check

Education (4)

Expert Witness

General information (6)

I helped write KY's Highway Design Manual chapter on Bikes.

I seek all sources of information regarding statistics of bicycle use to promote the further use of bicycling and to convince government leaders to improve bicycle facilities.

Inform consultants

Interpreting engineer-speak

Legal

Maintenance

Policy Development

Preparation of TEP applications

## Chapter 4: Survey Results

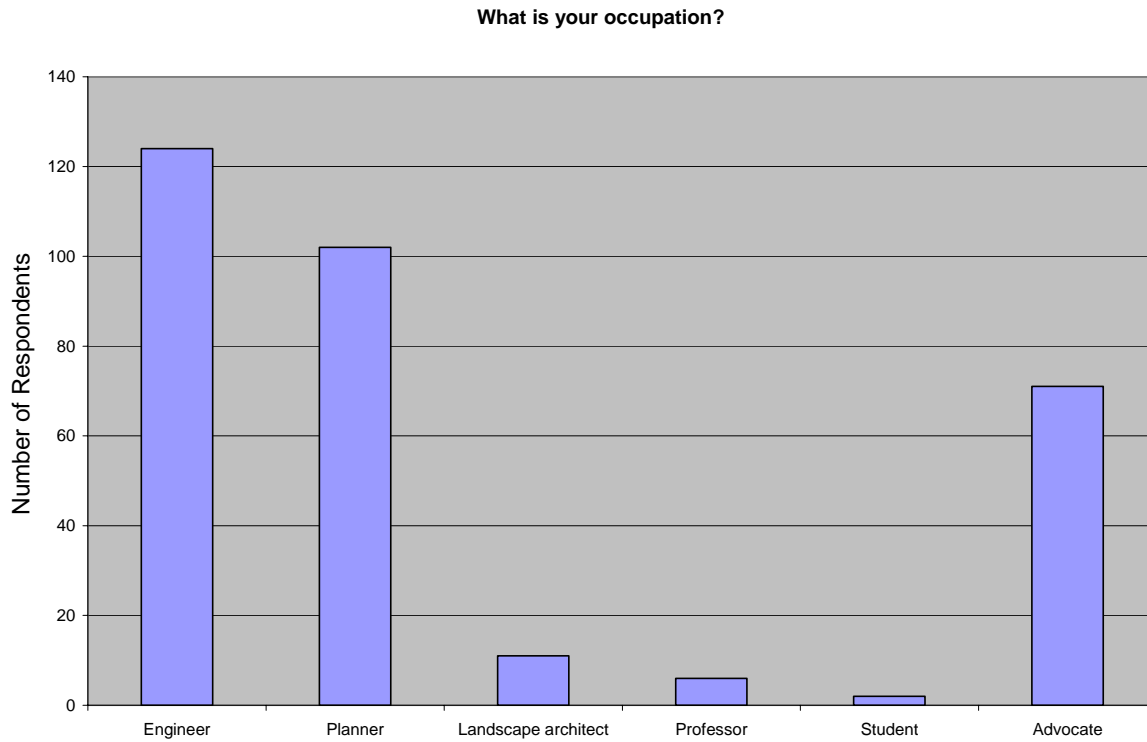
Railroad grade crossing safety	Reference (3)
Respond to citizen inquiries (4)	Review standards/requirements
Safety Studies	Teaching / Training (5)
Technical questions	Traffic Designer in the 1960's and 1970's
Traffic Policy	

### **Have you ever attended the National Highway Institute (NHI) Bicycle Facilities Design course?**

Yes 62

No 376

**What is your occupation?**



**Figure 9. What is your occupation?**

**Additional Responses**

Alternate Modes Coordinator

AmeriCorps Member

Attorney (5)

Bicycle / Pedestrian Coordinator (6)

Bicycle Retailer

Bicycle tour leader (2)

Bicyclist (2)

Catholic Priest

Chemist

Clerk

Communications network planner

Computer Pmgr/Analyst (2)

Computer Scientist

Computer Software Instructor

Consultant (3)

Contractor

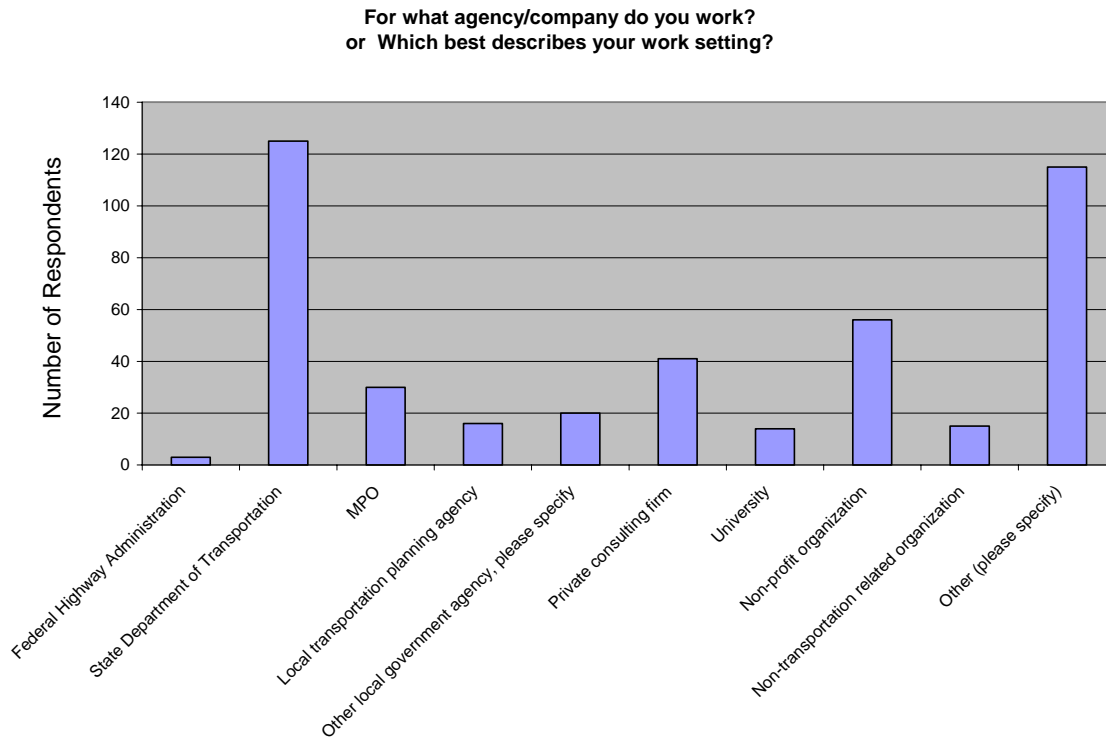
County Park Dept. staff

Cyclist Educator (3)

## Chapter 4: Survey Results

Designer (2)	Director of parks and recreation (4)
Economic development	Economist
Engineer & PT professor	Engineer and Planner (2)
Engineering Technician (2)	Enhancement coordinator
Grant administrator (2)	Information Technology Architect
Insurance underwriter	Judge
Law Enforcement	Maytag employee----who loves to ride bike
MD	Mechanic
Military	Musician
Network software engineer	Non profit trail organization administrator
Non-engineer in engineering	Orthodontist
Photographer	Physician
Planner & Advocate (2)	Project Manager
Psychologist	Public Relations
Retail Worker (2)	Retired (8)
School Bus Driver	Software Engineer
State Government Non-motorized policy combines planning and engineering	
Stay-at-home mother	System administrator
Teacher	Technician
Traffic Designer in the 1960's and 1970's	Traffic Engineer
Traffic safety analyst (ped & bike)	Trail planner in my community
Transit Design	

**For what agency/company do you work? or Which best describes your work setting?**



**Figure 10. Which best describes your work setting?**

**Additional Responses**

- Aerospace
- Albion Downtown Development Authority
- As NGO representative individually and as a member of local government boards
- Advisory Committee Member (6)
- Advocacy Group (3)
- Advocate (2)
- Bicycle retail store (2)
- Bicycle tour company
- Bicycle touring club
- Bike advocacy
- Church
- City government (13)
- Columbus Transportation Division
- Computer consulting
- Conservancy District
- Consumer
- Convenience store

## Chapter 4: Survey Results

County government (10)	Design and manufacture
DOD (2)	Elected official
ERC, Inc ,NASA contractor	Federal Railroad Administration
General contractor	General Dynamics
Grocery Industry	Hamilton & Terrile, LLP
Health Care	Home
Hospital	Insurance Company
ISP	Law Office
LAB Certified Instructor	Menswear retailer
Municipal Government (3)	NASA
National Park Service	Park district
Private enterprise	Private mechanical engineering
Private transportation related	Public Works
Regional Planning Agency	Retired (8)
Satellite Systems Engineer/League Cycling Instructor/Traffic Engineering Knowledgeable	
School District (3)	Self employed (5)
Small business owner, bicycle activist.	Software - governmental
State and local (DC)	State Department of Planning
State Dept of Fish and Game	State Dept of Parks and Land
State Dept of Natural Resources (2)	State Dept of Environmental Protection
Tiki's Grill and Bar	Traffic Safety Department
Transportation Writer	US Environmental Protection Agency
USAF	Zurich American Insurance Company

**What is your position title?**

2nd VP-trail co-coordinator	Admin. Asst. III
Administrative Law Judge	Administrative Manager (2)
Advocacy Coordinator	Advocacy Director
Air Resources Engineer	Alternate Modes Coordinator
Architect, Associate	Area Engineer
Assistant Director	Assistant Director of Transportation
Assistant Engineer	Assistant Manager
Assistant Planner	Asst. State Ped & Bicycle Coordinator
Assoc Director	Associate (2)
Associate Architect	Associate Planner (3)
Associate Professor (2)	Associate Transportation Analyst
Asst. City Engineer	Asst. Dir./Project Manager
Asst. Director of Public Works	Asst. Manager
Attorney (2)	BFAC representative
Bicycle and Pedestrian Planning Specialist	Bicycle Pedestrian Transportation Engineer
Bicycle Program Manager (2)	Bicycle Program Manager
Bicycle Transportation Engineer	Bicycle, Pedestrian & Greenways Coordinator
Bicycle/Pedestrian Planner	
Bicycle/Pedestrian Program Manager	Bicycle/Pedestrian Transportation Planner
Bicycle/Pedestrian Transportation Program Manager	
Bicycle/Pedestrian/ADA Coordinator	Bicycle-Pedestrian Coordinator (23)

## Chapter 4: Survey Results

Bikeway Coordinator	Bikeways Project Manager
Bikeways Traffic Engineer	Board Member (2)
Board of Directors	Bus Driver
Cartographer	Chair (10)
Chemist	Chief Transp Planning Engineer
Chief Engineer	Chief of Highway Quality Assurance Division
Chief Road Design Engineer	
Chief Strategy Officer	Chief Transportation Planner
Chief, Bicycle Facilities Unit	Circuit Court Judge
City Engineer / Director of Public Works	
City of Austin Bicycle and Pedestrian Program Coordinator	
Civil Engineer (3)	
Civil Engineer Specialist	Civil Engineering Manager
Clerk	Clinical Psychologist
Clinical Social worker supervisor	Commercial Underwriting Manager
Commission Member	Community Cycling Project Director
Community Development Director	Computer Scientist
Computer Specialist	Consultant (2)
Coordinator Information Management Systems	
CTEP Project Engineer (2)	CTO
Cyclist	Deputy Chief Engineer
Deputy Director, Long Range Planning	Deputy Town Clerk
Design Division - Enhancement Engineer	Design Engineer



## Chapter 4: Survey Results

Design Resource Engineer (CE V)	Designer
Director (3)	Director Engineering Services
Director of Bicycle and Pedestrian Access	Director of Burn Services
Director of Parks & Recreation (2)	Director of Planning
Director of Transportation and Data Services	
Director, Tech Support	District 1 Local Systems Engineer
District Enhancement Coordinator (also Bike/Ped. Coordinator)	
District Planner (2)	District Roadway Design Engineer
District Safety Engineer	District Traffic Engineer
Division Chief, Highway Design	Education Director
Embedded Software Engineer	Engineer (3)
Engineer 5 Dual Career Ladder (DCL)	Engineer of Roadway Design
Engineer Technician II	Engineering Manager
Engineering Technician	Enhancement Engineer
Engineering Tech II	Enterprise Systems Architect
Environmental Programs Coordinator	Environmental Specialist
Envr. Coord./ROW/Homeland Security	Executive Director (16)
Field Representative (2)	Field Representative
Founding Member	General Manager
Geometrics Engineer	Government Relations Director
Government to Government Section Supervisor	
Grants Coordinator	Highway Design Engineer
Insurance broker	Industrial Designer

## Chapter 4: Survey Results

Instructor	King
Landscape Architect (5)	Library Asst.
Local Agency Project Manager	Local Project Liaison
LPA Coordinator	Manager
Manager - Traffic Engineering	Manager - Transportation Planning
Manager of Planning & Development	
Manager of the River Corridor Improvement Subdistrict	
Manager Transportation Enhancement and Scenic Roads	
Manager, Grants and Community Recreation	
Managing Attorney	Managing Director
Managing Engineer	Mechanical Engineer
Membership development	MPO Director
Municipal Engineer Senior	n/a (5)
Network Engineer	Newspaper Reporter
Non-Motorized Transportation Coordinator (2)	
Off-Systems Engineer	Operations Coordinator
Orthodontist	Outdoor Recreation Planner
Owner (4)	P.E.1
Park Project Coordinator	Parks & Recreation Acting Director
Part-time Faculty	Partner
Pastor	Pastoral Representative
Pathways Project Manager	Pedestrian & Bicycle Program Manager
Pedestrian and Bicycle Engineer	Photographer

## Chapter 4: Survey Results

Physical Planner	Planner (6)
Planner/Analyst	Planning Coordinator
Planning Director	Planning Manager
President (9)	Principal (3)
Principal Engineer (2)	Principal Planner (2)
Product Planning Engineer	Professor (3)
Program Manager	Project Engineer (5)
Project Manager (8)	Bike Ped Coordinator
Project Planner (2)	Public Information Officer
Public Works Engineering Specialist	Public Works Planner
Purchaser	Recreation Planner
Regional Landscape Architect	Regional Traffic Design Manager
Research Associate	Resident Engineer (2)
Retired (2)	Roadway Design Division Engineer
Roadway Design Engineer	Rural/Enhancement Development Engr.
Safety Officer	Safety Technician
Sales Advisor	Scientific Research Assistant
Scientific/Technical (4)	Senior Civil Engineer
Senior Civil Engineers Supervisor	Senior Engineer (3)
Senior Environmental Planner	Senior Highway Designer
Senior Highway Design Technician	Senior Industry Economist
Senior Planner (6)	Senior Project Engineer
Senior Project Manager (3)	Senior Structural Engineer

## Chapter 4: Survey Results

Senior Transportation Engineer	Senior Transportation Planner (7)
Site-based Pediatric Services Engineer	Software Engineer
Software Engineer	Special Projects Engineer/Area Design Facilitator
Sr Applications Development Specialist	
Sr Software Engineer	Sr. Engineering Associate
Sr. Mech. Design Engr	Sr. Project Manager
Staff Design Engineer	Staff Engineer
Standards Engineer	State Bicycle and Pedestrian Coordinator (5)
State Program Administrator	State Traffic Engineer
Systems Planning Branch Manager	Teacher (2)
Team Leader, Statewide Studies Team	Technical Sergeant
Technical Support Engineer	Tour Leader
Traffic Control Specialist	Traffic Engineer III
Traffic Engineer/Bicycle Coordinator	Traffic Engineering Administrator
Traffic Operations Engineer	Traffic Policy Engineer
Traffic Safety Program Manager	Traffic Studies Engineer
Trail Maintenance Manager	Trail Program Specialist
Trails Coordinator (3)	Transit Program Manager
Transportation Alternatives Planner	Transportation Engineer Branch Manager
Transportation Planner (14)	Transportation Planning Coordinator
Transportation Planning Coordinator	Transportation Program Manager
Transportation Project Manager	University Police Officer
Vice president (3)	Vice-Chair

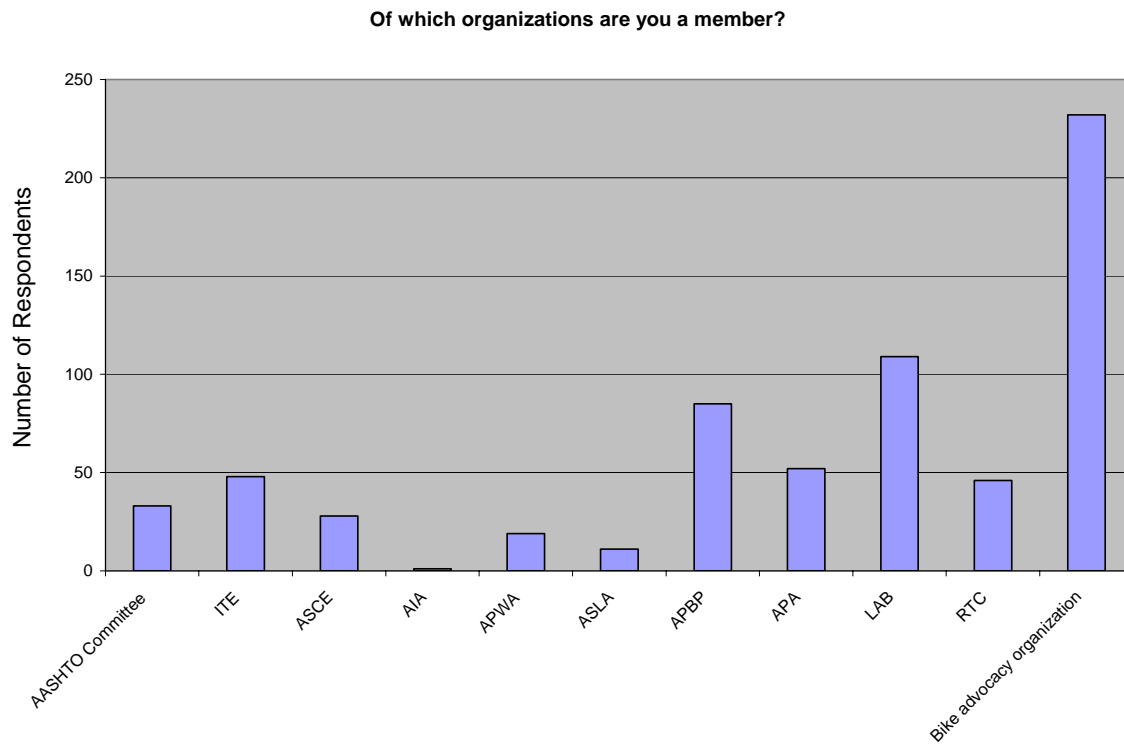
Visiting Scientist

Volunteer

Was Traffic Design and Standards Engineer

Writer

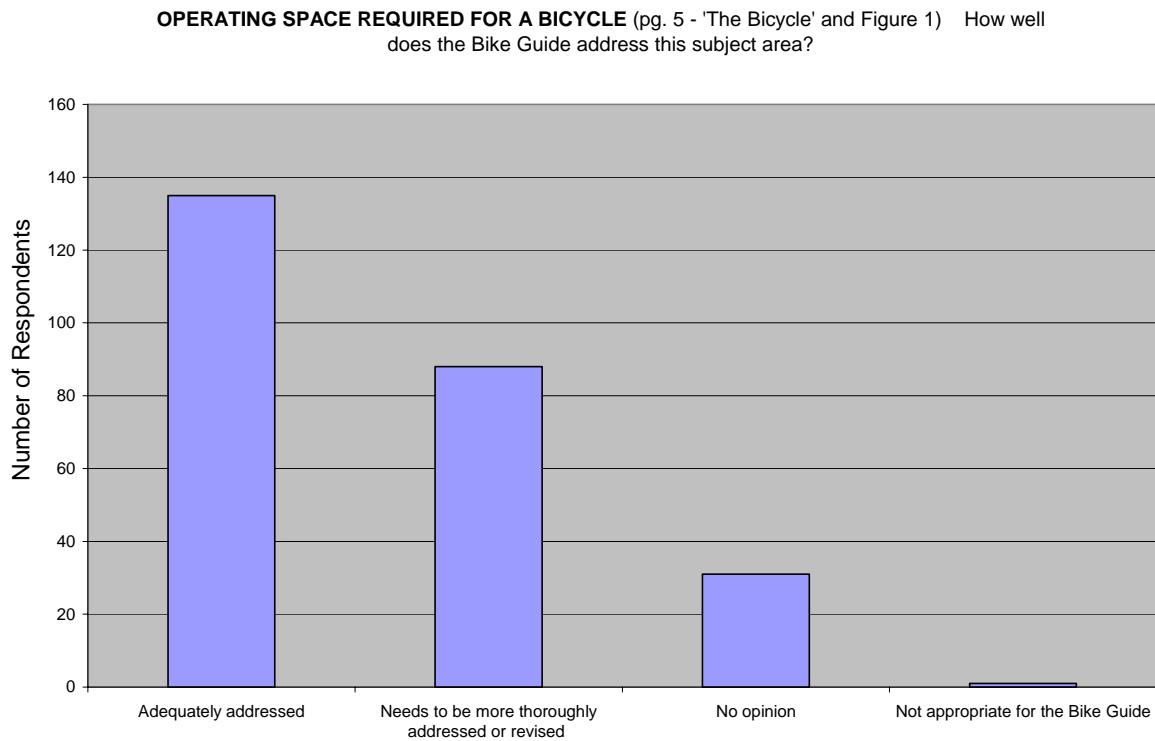
**Of which organizations are you a member?**



**Figure 11. Of which organizations are you a member?**

## OPERATING SPACE REQUIRED FOR A BICYCLE

(pg. 5 - 'The Bicycle' and Figure 1) How well does the Bike Guide address this subject area?



**Figure 12. Operating Space Required for a Bicycle – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

**Needs to be more thoroughly addressed or revised -**

Greater discussion of side clearance or shy distance

Discussion of various user types

Discussion of two way operations

Discuss how widths are linked to design standards

## Chapter 4: Survey Results

areas with numerous driveways

how traffic volume and speed can increase the needed width

how pavement condition can increase needed width

Discuss how user type impacts needed width

Description of bicycles should be separated from discussion of bicycle users

Update the dimensions using data from the most current research

## THE BICYCLE USER

(pg. 5) How well does the Bike Guide address this subject area?

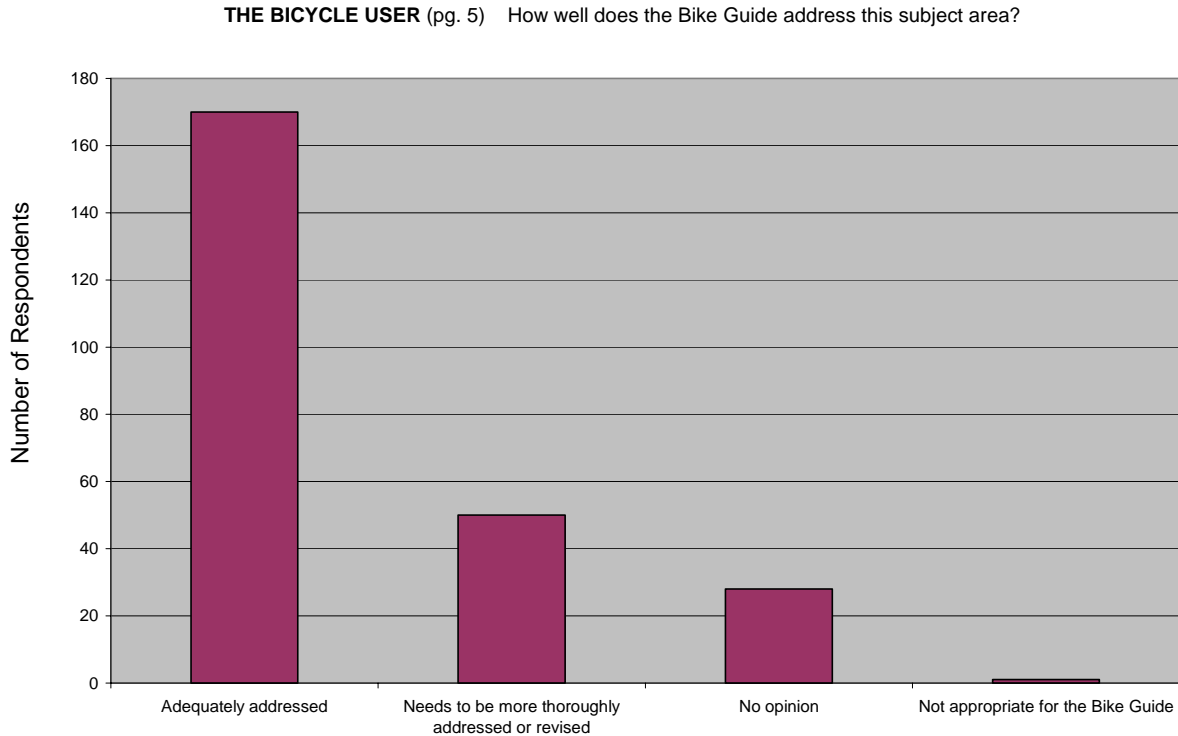


Figure 13. The Bicycle User – How well does the Bike Guide address this subject area?

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

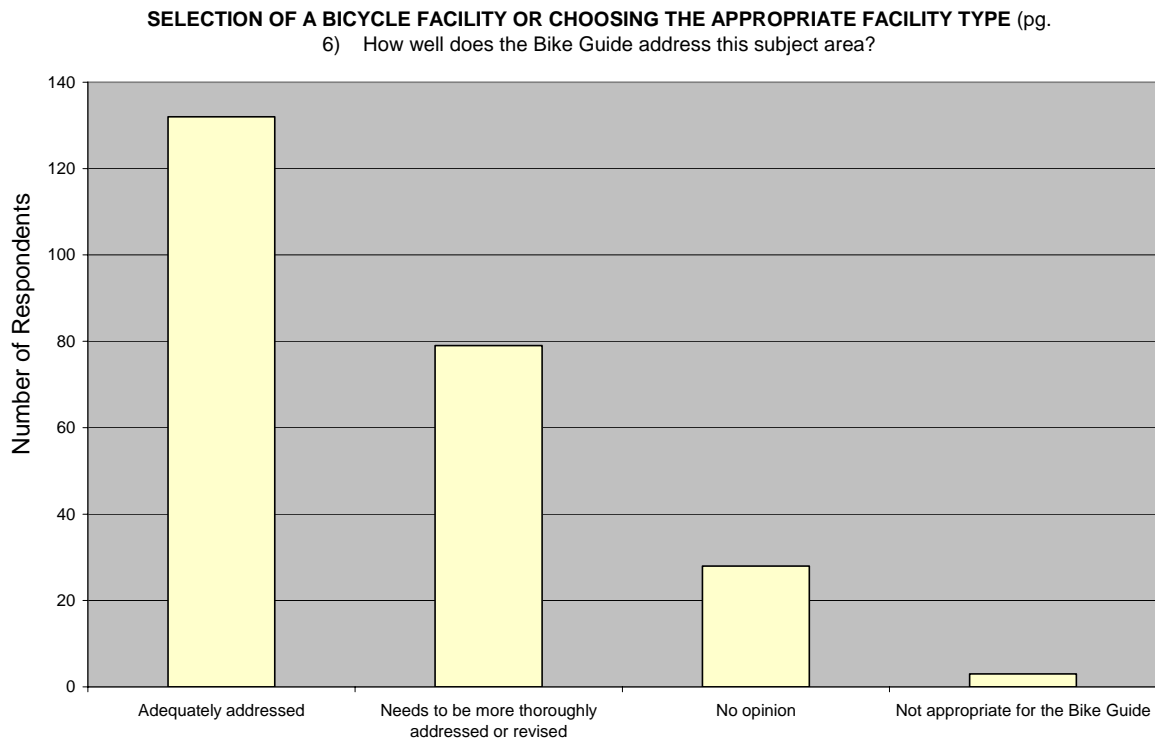
**Needs to be more thoroughly addressed or revised -**

There is considerable concern that the A/B/C classification of cyclists is not sufficient to describe all cyclists. A more detailed discussion of the various bicycle users and their levels of experience, ability, and knowledge is suggested.



## SELECTION OF A BICYCLE FACILITY OR CHOOSING THE APPROPRIATE FACILITY TYPE

(pg. 6) How well does the Bike Guide address this subject area?



**Figure 14. Selection of a Bicycle Facility or Choosing the Appropriate Facility Type – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Not necessary

An advocacy document

Unknown

**Needs to be more thoroughly addressed or revised -**

There were a significant number of comments suggesting that no choice is necessary as all roadways are bicycle facilities and bike lanes detract from the safety of the shared travel lanes. Several comments were made recommending a matrix or table to determine under what roadway conditions a particular facility would be appropriate (such as that FHWA's Design Treatments for Bicycle Facilities)

The mix of facility users (skaters, pedestrians, equestrians) was recommended as a criterion for selecting a facility

Discuss choosing a facility is by functional class of the roadway

Discuss which facilities accommodate cyclists in given roadway environments

Recognize that all roadways are bicycle facilities

Reference FHWA's Guidance that bicycle facilities should be included on all roadways where bicyclists are not prohibited

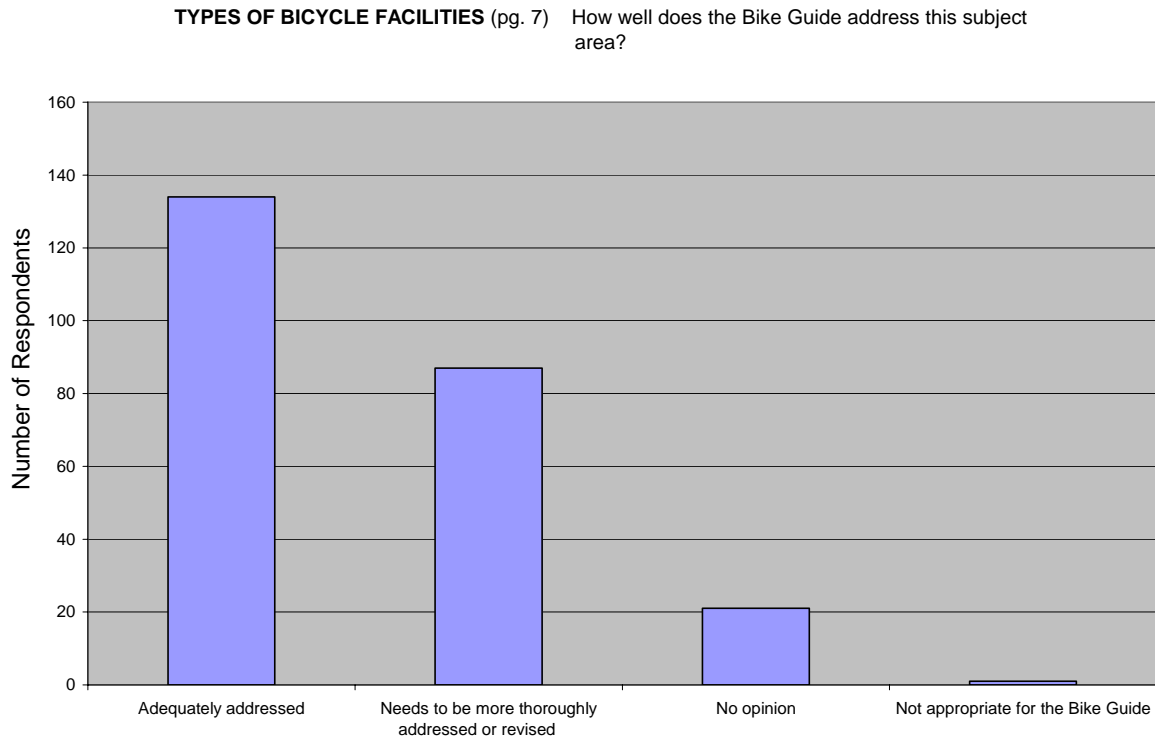
Provide a greater emphasis on continuity

Combine with selection of a bicycle facility

Provide discussion that choosing the appropriate facility type also depends on existing terrain, right-of-way, local municipal ordinances, etc.

## TYPES OF BICYCLE FACILITIES

(pg. 7) How well does the Bike Guide address this subject area?



**Figure 15. Types of Bicycle Facilities – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

**Needs to be more thoroughly addressed or revised -**

There were a significant number of comments suggesting that the best and safest bicycle facility is the shared roadway, some included the wide curb lane in this category. These respondents felt that no other facility needs to be included in the Guide. Some felt that this guide should stress that the best system is a shared lane system with well educated bicyclists.

## Chapter 4: Survey Results

Others suggested that any residential roads should be eligible to be signed as bicycle facilities as these roadways are where most children ride.

Remove the statement that some roadways may be unsuitable for bicycle travel

Point out in the introduction that all roadways, except those where bicyclists are prohibited, are bicycle facilities and should therefore be made as bicycle friendly as possible

Recognize that many roadways and rural highways, even with narrow lanes and no shoulders, can be entirely suitable for bicycle travel when there is low ADT

Include example pictures of each type of facility

There are states in which riding on a paved shoulder is prohibited by law (Missouri for instance)

Discuss the shared lane using the shared lane arrow

Others request shoulders be included as separate type of bicycle facility

Discuss the impact of rumble strips on the usability of paved shoulders

Include wide curb lanes as a separate facility type

Clarification should be made that designated bikeways may pertain to a master plan or map only

– that they do not necessarily require signing in the roadway environment

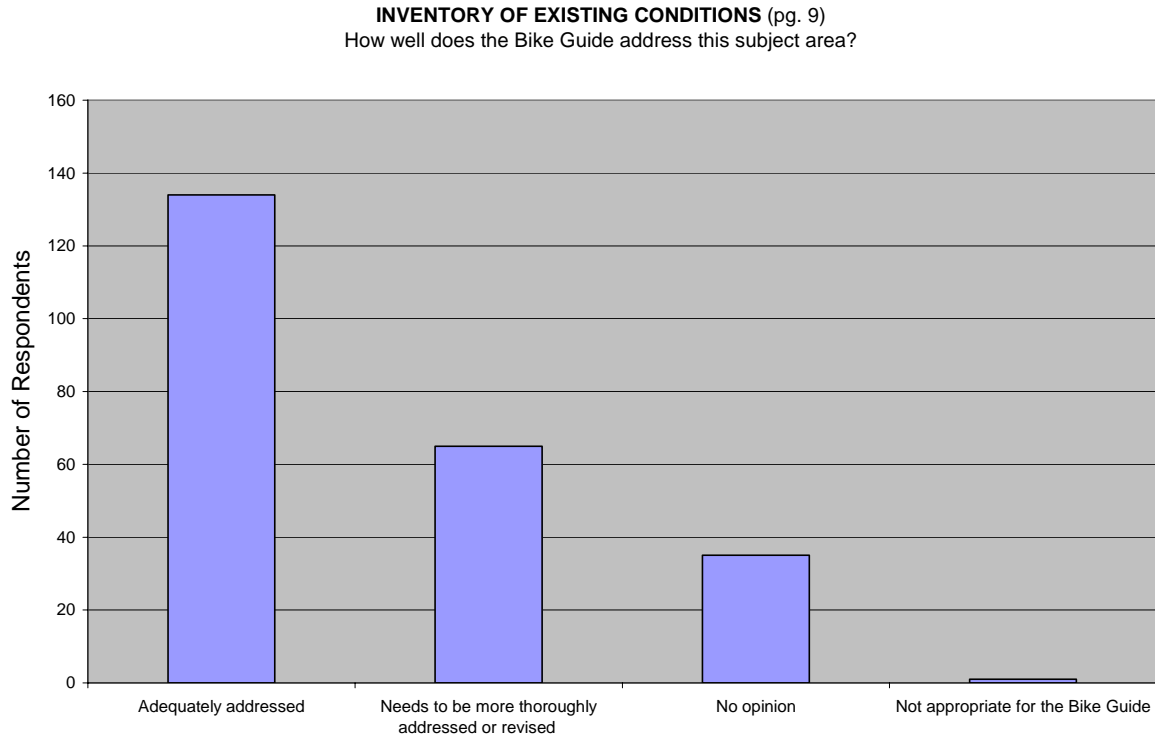
Discuss bicycle boulevards

Refer to the cautions concerning shared use paths adjacent to roadways

Discuss multimodal facilities

## INVENTORY OF EXISTING CONDITIONS

(pg. 9) How well does the Bike Guide address this subject area?



**Figure 16. Inventory of Existing Conditions – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

**Needs to be more thoroughly addressed or revised -**

Discuss how an inventory would be used as part of an overall planning process

Discuss the use of GIS to inventory

Discuss the need to update existing GIS systems and models to consider bicycle facilities

Discuss not only existing conditions but latent demand as well

## Chapter 4: Survey Results

Integrate this section with facilities types and plans for improvements

Include a discussion of BCI and/or BLOS

Discuss the need for an entire network

Discuss the drawbacks of bicycle volume counts

Should include a survey of bicycle crash reports to identify areas where actual hazards exist

Provide a list of what items should be inventoried

Discuss travel demand studies and mode shift potential

Discuss the need for bicycle access and circulation in development planning

Include tools for a bikeability audit

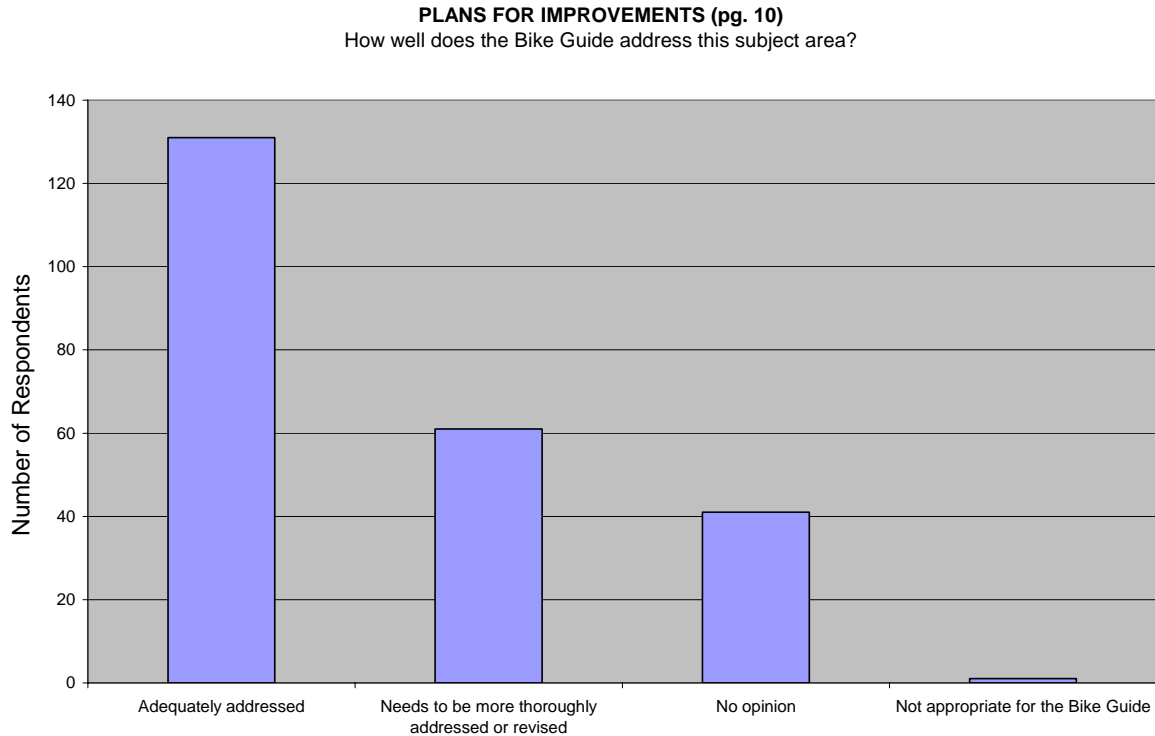
Include a recommendation to survey actual bicyclists in the area

Discuss the importance of adjacent land use

Discuss identification of origins and destinations

## PLANS FOR IMPROVEMENTS

(pg. 10) How well does the Bike Guide address this subject area?



**Figure 17. Plans for Improvements – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

**Needs to be more thoroughly addressed or revised -**

Integrate with facility type and existing conditions

Include discussion of a route network

Provide example plan for improvement (website or appendix)

Discuss methods for prioritization

## Chapter 4: Survey Results

Discuss the merits of integrating pedestrian with bicycle planning

Provide recommendations for conducting preliminary feasibility analysis of top ranked proposals to ensure they can be constructed.

Discuss the consideration of environmental and community factors

Discuss bicycle improvements (paved shoulders) as part of routine accommodation

Discuss funding options

Discuss the need for bicycle friendly policies

Discuss the potential for restriping existing roadways to include bike lanes

Include a formula for predicting usage

Discuss a bicycle facility / route hierarchy

Discuss multimodal planning

Discuss specific project planning in addition to network planning

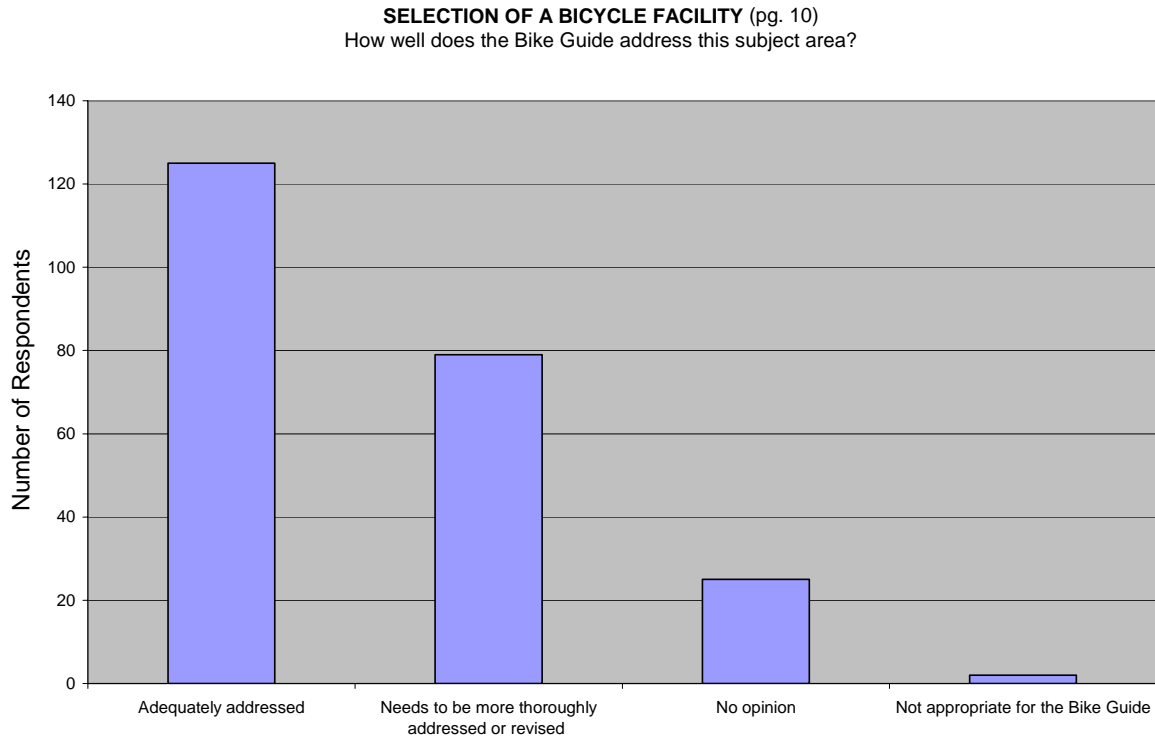
Discuss access management

Discuss mainstreaming bicycle planning into regular planning efforts



## SELECTION OF A BICYCLE FACILITY

(pg. 10) How well does the Bike Guide address this subject area?



**Figure 18. Selection of a Bicycle Facility – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

Bicycle Transportation, by John Forester, MIT Press, 1994.

**Needs to be more thoroughly addressed or revised -**

Again, some respondents suggested that this section was not needed as people are either competent to ride with traffic or not.

## Chapter 4: Survey Results

Numerous respondents suggested that back in angle parking be recognized as preferable to traditional angle parking

Discuss the “why” of selecting a particular bicycle facility

Include traffic calming as a consideration

Include accessibility of destinations and amenities as considerations

Include community priorities as a consideration

Include connectivity, including access to transit, as a consideration

Include roadway lighting as a consideration

Include BLOS / BCI as a consideration

Include risk of derailment of adjacent rail lines

Include steep grades as a consideration

One respondent stated, “I think this section is a somewhat rudderless long list of things to muse about.”

Classify the factors with respect to their relevance for particular situations

Include a flow chart to illustrate how to apply these factors

Include in the section on SELECTION OF A BICYCLE FACILITY or CHOOSING THE APPROPRIATE FACILITY TYPE

This section should precede PLANS FOR IMPROVEMENTS and somehow be merged with INVENTORY OF EXISTING CONDITIONS

Include tables from FHWA's *Design Treatments for Bicycle Facilities*

Another respondent counters with “This document just doesn't have the research or operational justification to be cited as an authoritative reference by AASHTO.”

Mention effects of wind blast due to trucks and buses

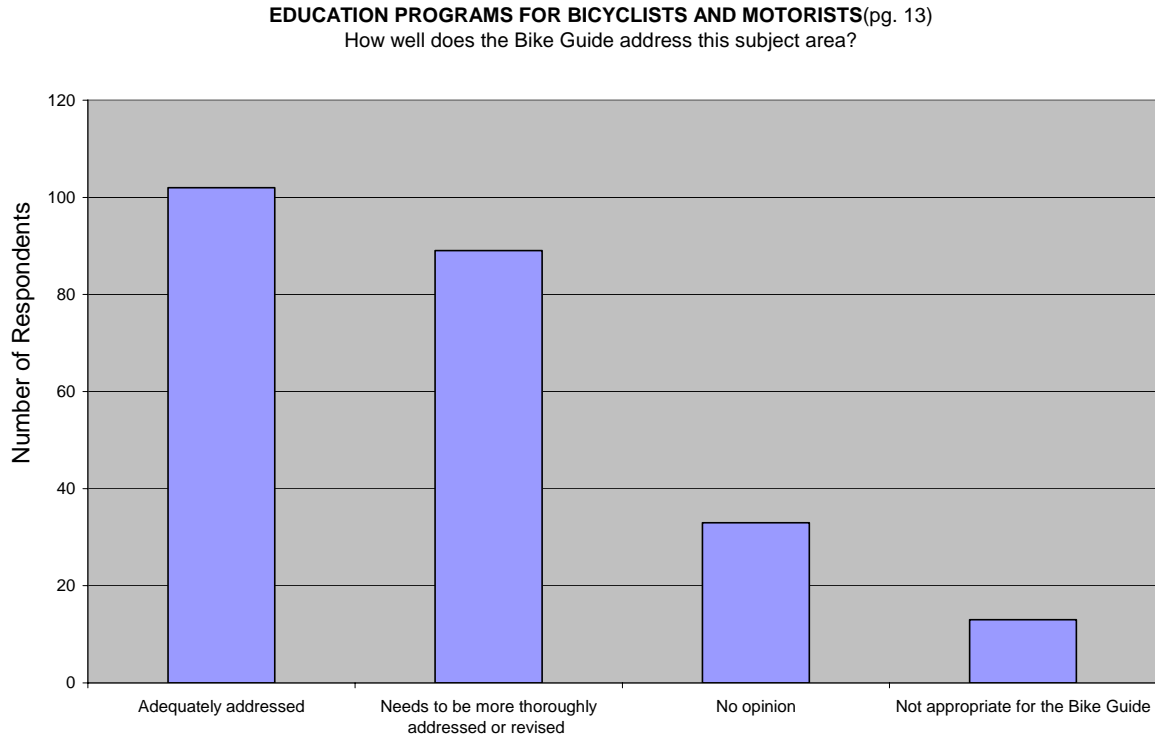
## Chapter 4: Survey Results

Mention extremely low friction coefficient of metal bridge decking when wet

Discuss the potential for using multiple facility types to serve multiple user types

## EDUCATION PROGRAMS FOR BICYCLISTS AND MOTORISTS

(pg. 13) How well does the Bike Guide address this subject area?



**Figure 19. Education Programs for Bicyclists and Motorists – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Not a design guide issue (4)

Effective Cycling

NHTSA

Bicycle Plans

Specific Safety Curriculum

Drivers Education

## Chapter 4: Survey Results

### Safety Education in Schools

#### Education Programs for Bicyclists and Motorists

#### Unknown (3)

### **Needs to be more thoroughly addressed or revised -**

Identify funding sources

Include the rules of the road for bicyclists

Include the importance of using lights and a rear reflector at night

Incorporate LAB Road 1 information

Discuss the proper use of mirrors

Create a separate chapter for education

Remove this section except to reference a more comprehensive work

Discuss the coordination of educational efforts

Discuss developmental factors that impact children's abilities

Add details on crash causes

Place motorist education first to emphasize its importance

Discuss the need to educate law enforcement

Discuss the need to educate engineers

Discuss the need to educate children's parents

Bicycles are not vehicles in all states

Add a section on Safe Routes to School

Discuss different types of educational programs

**Please indicate any other topics related to Bicycle Facilities Planning that should be addressed in the next Bike Guide update**

Discuss strategic bicycle network planning including land development regulations and integration with other plans

Discuss the impact of local laws on the selection of and design of bicycle facilities

Include a definition for sidepaths and sidewalks

Promote mainstreaming of shared use facilities

Provide a checklist of bicycle consideration to be included on non-bicycle specific transportation projects

Discuss the liability of providing bicycle facilities

Discuss facility costs

Discuss how the requirements of the ADA impact the planning and design of bicycle facilities

Provide links to good bike plans

Discuss the safety and economic benefits of bicycle facilities

Discuss traffic calming and streetscaping

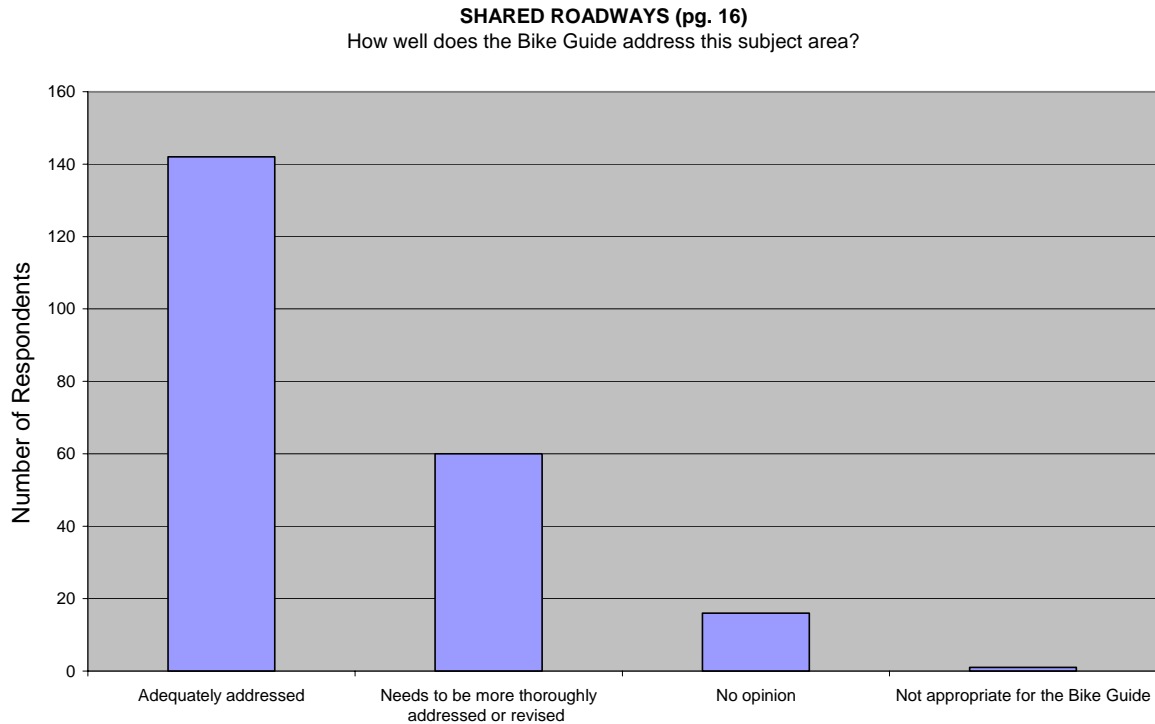
Discussion of bicycle crash types and causes

Consider the needs of all non-motorized modes in the planning section

Discuss including shared use path facilities as part of a functional classification for roadways system

## SHARED ROADWAYS

(pg. 16) How well does the Bike Guide address this subject area?



**Figure 20. Shared Roadways – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

**Needs to be more thoroughly addressed or revised -**

Discuss the use of the shared lane arrow

Discuss maintenance issues being less of a concern in shared lanes

Discuss the potential of reducing general travel lane widths to provide space for bike lanes

Discuss the impact of speed on the appropriateness of shared roadways

## Chapter 4: Survey Results

Discuss the impact of speed on the appropriateness of shared roadways

Discuss the impact of volume on the appropriateness of shared roadways

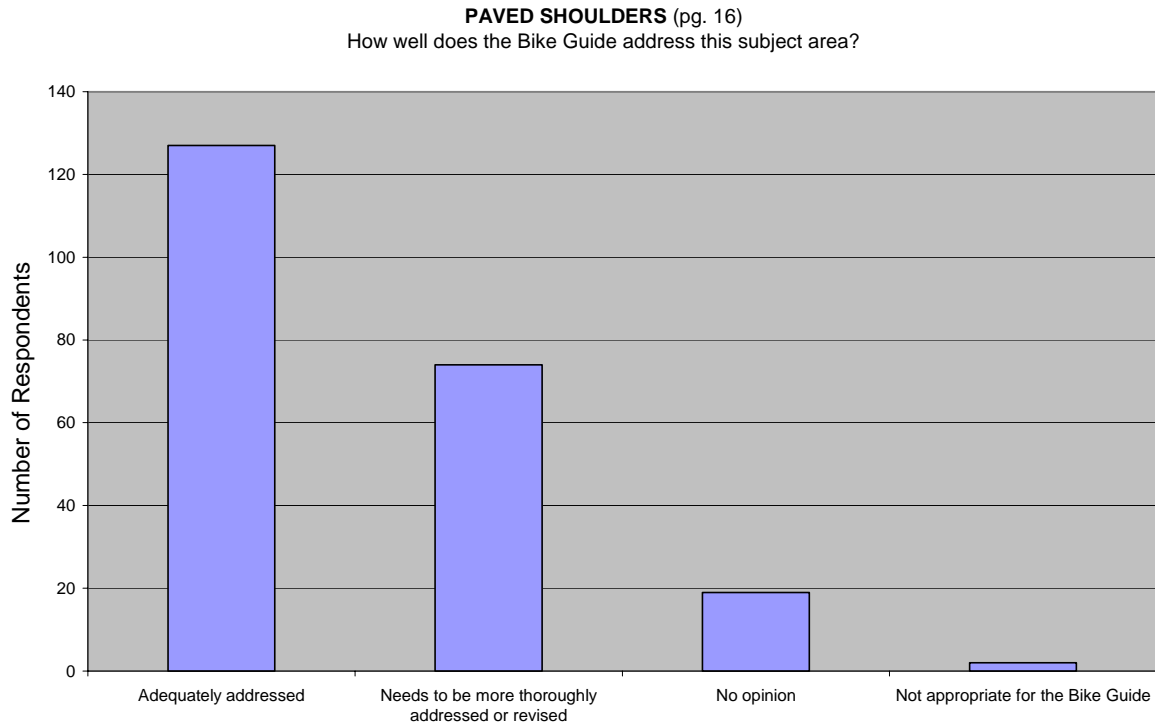
Discuss the impact of on-street parking on shared roadway facilities

Discuss maximum cross slope



## PAVED SHOULDERS

(pg. 16) How well does the Bike Guide address this subject area?



**Figure 21. Paved Shoulders – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

N/A

**Needs to be more thoroughly addressed or revised -**

Discuss the impact of rumble strips on the effective width of paved shoulders

Delete the statement that any shoulder width is better than none at all

Discuss the impacts of maintenance on the usefulness of paved shoulders

## Chapter 4: Survey Results

Discuss that riding a bicycle on a paved shoulder is illegal in some states

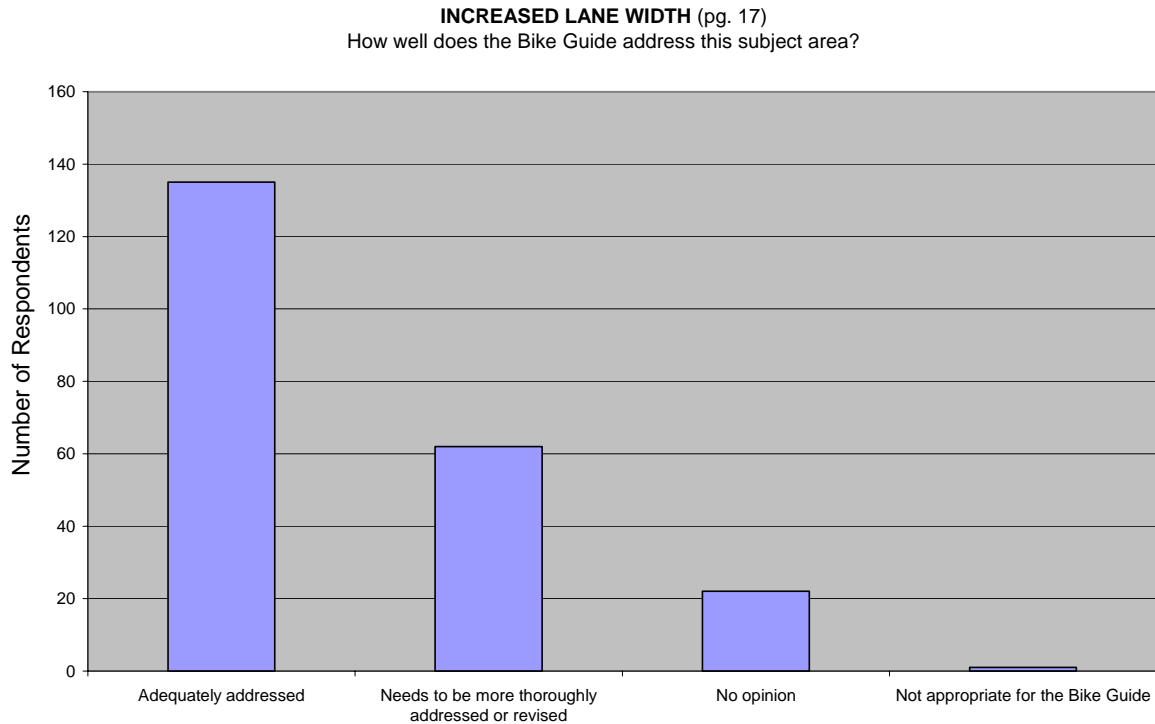
Clarify that paved shoulders are not bike lanes in that shoulders are placed to the right of right turn lanes. This means the cyclists must leave the shoulder to be in the proper position to travel straight through an intersection with a right turn lane.

Discuss desirable shoulder width as a function of volume, speed, truck volumes

Discuss the use of paved shoulders on curb and gutter sections

## INCREASED LANE WIDTH

(pg. 17) How well does the Bike Guide address this subject area?



**Figure 22. Increased Lane Width – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

**Needs to be more thoroughly addressed or revised -**

Discuss the importance of width of various types of roadways

Discuss the potential need to prohibit parking from roadways with wide lanes

Discuss the appropriate lane width for various combinations of roadway speeds, volumes, truck percentages

## Chapter 4: Survey Results

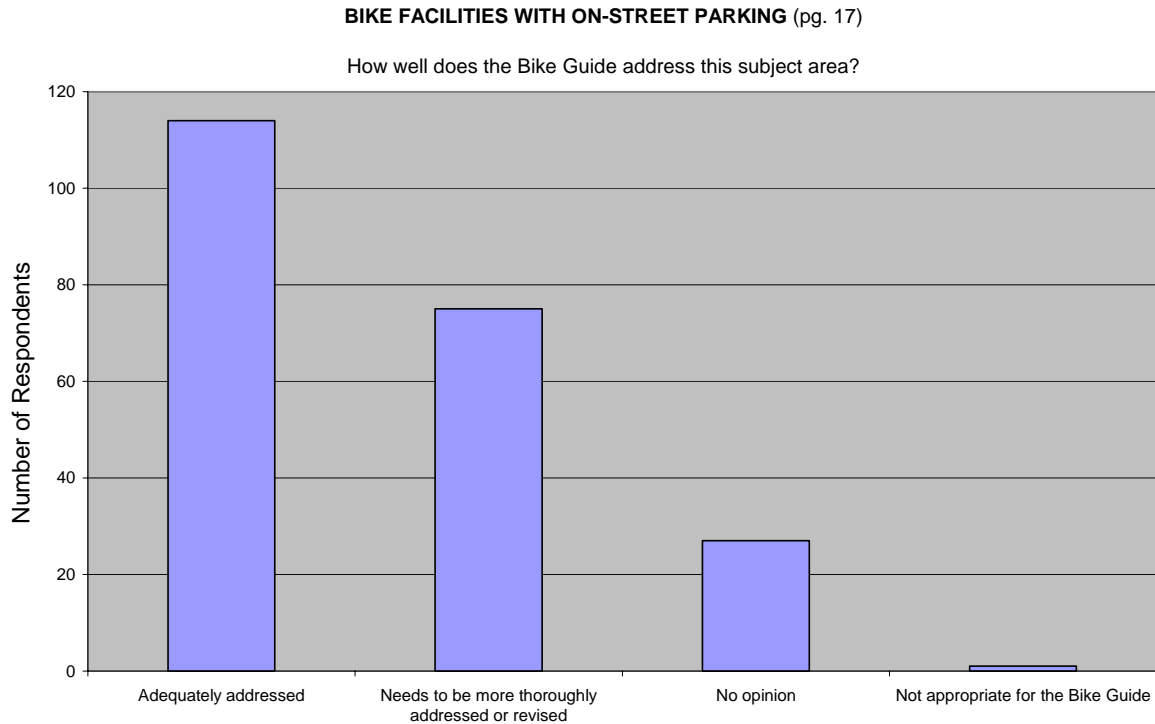
Discuss the impact of wide curb lanes on motor vehicle speeds

Expand the discussion on the potential for restriping roadways for bike lanes instead of using wide outside lanes

Discuss how minimum safe passing distance between motorists and bicyclists, bicyclists operating width requirements and motor vehicle width requirements add up to require a minimum wide curb lane width

## BIKE FACILITIES WITH ON-STREET PARKING

(pg. 17) How well does the Bike Guide address this subject area?



**Figure 23. Bike Facilities with On-street Parking – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

**Needs to be more thoroughly addressed or revised -**

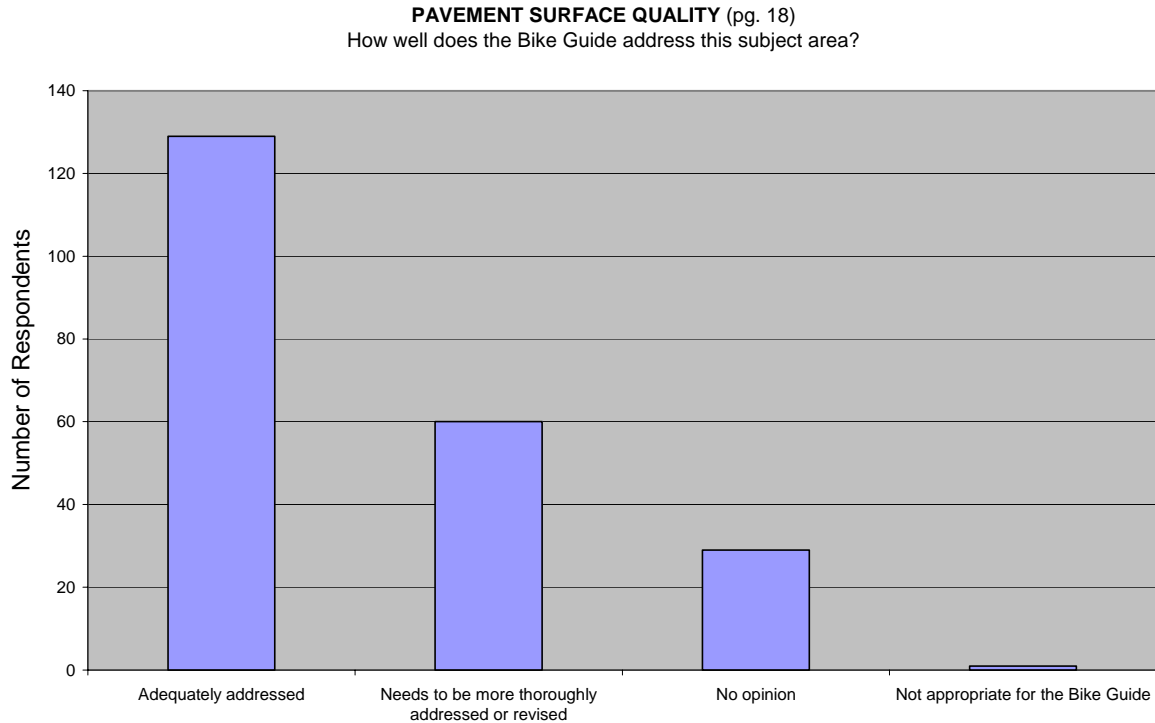
Most of the respondents comments were concerned with the issue of the door zone and dooring crashes. Many opinions and mathematical constructs were suggested for dealing with this issue

Discuss back-in angle parking

Discuss time-of-day on-street parking

## PAVEMENT SURFACE QUALITY

(pg. 18) How well does the Bike Guide address this subject area?



**Figure 24. Pavement Surface Quality – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

**Needs to be more thoroughly addressed or revised -**

Quantify acceptable joint widths, drop offs, etc.

Discuss unacceptable surface treatments (chip-seal)

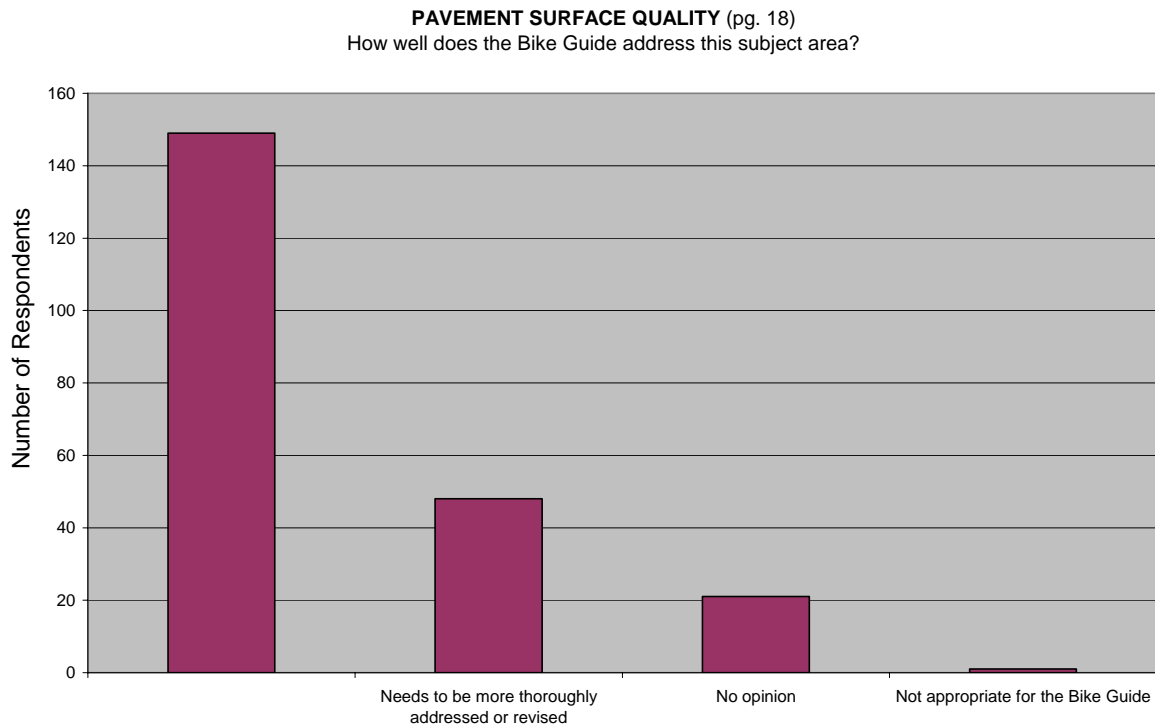
Discuss the potential problems with some traffic calming surfaces

Discuss longitudinal versus transverse cracks

Discuss problems with thermoplastic markings

### **DRAINAGE INLET GRATES**

(pg. 18) How well does the Bike Guide address this subject area?



**Figure 25. Drainage Inlet Grates – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Unknown

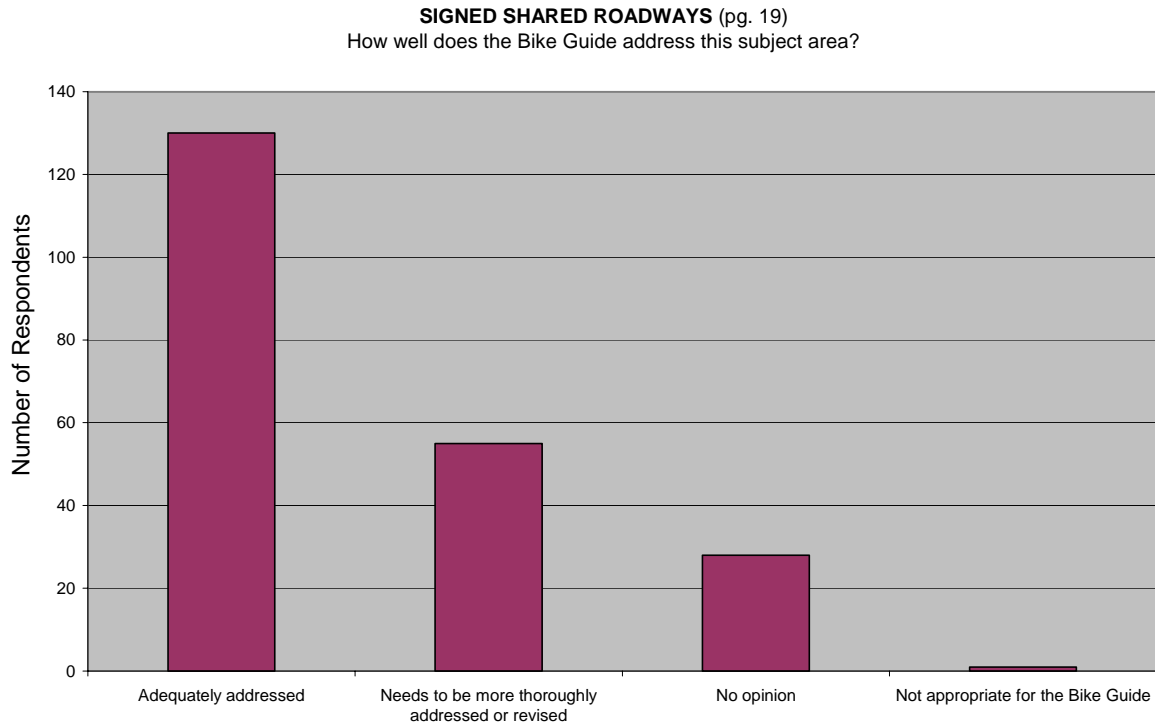
**Needs to be more thoroughly addressed or revised -**

Discuss curb inlet designs

Discuss the drop-in type crash

## SIGNED SHARED ROADWAYS

(pg. 19) How well does the Bike Guide address this subject area?



**Figure 26. Signed Shared Roadways – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

MUTCD

**Needs to be more thoroughly addressed or revised -**

Rename this section Designated Bicycle Routes

Expand the discussion of distance, direction, and destination signing

Add a section on the Share the Road sign

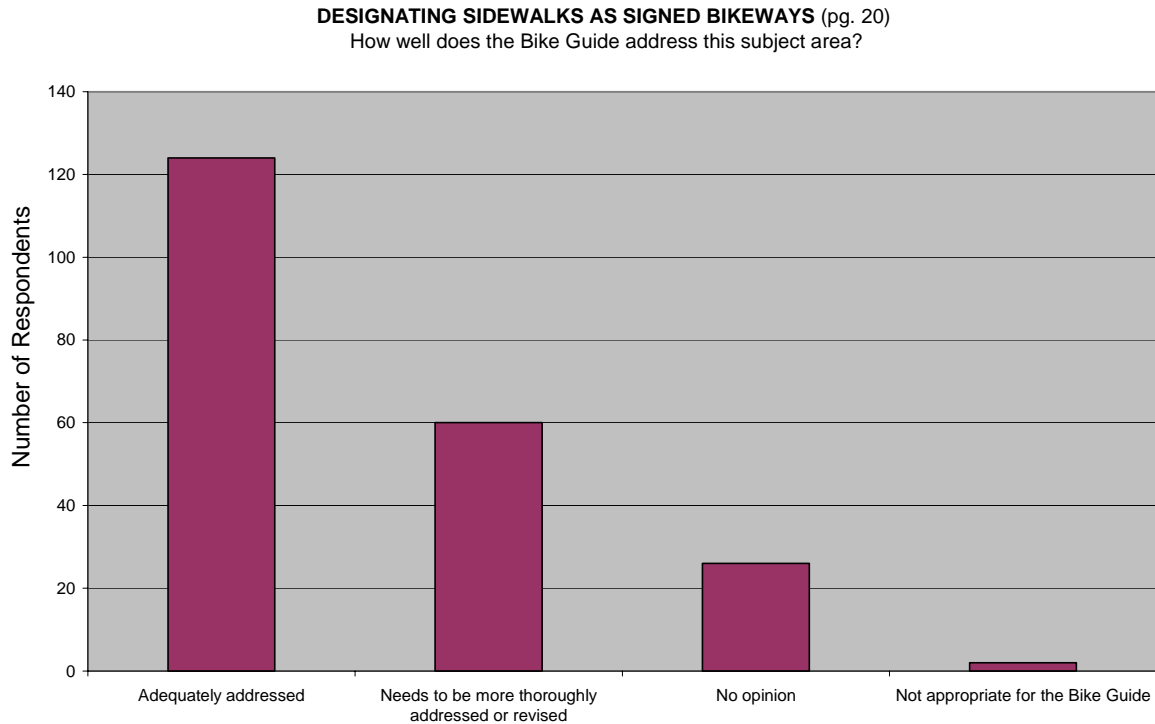


## Chapter 4: Survey Results

Make this section an introduction and move the Bike Rout info to the SIGNING OF SHARED ROADWAYS SECTION

## DESIGNATING SIDEWALKS AS SIGNED BIKEWAYS

(pg. 20) How well does the Bike Guide address this subject area?



**Figure 27. Designating Sidewalks as Signed Bikeways – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

MUTCD

I don't agree with the use of sidewalks for bikes

**Needs to be more thoroughly addressed or revised -**

Most of the comments in this section suggested increasing the emphasis on discouraging sidewalk bicycle facilities

## Chapter 4: Survey Results

Provide crash statistics

Change this heading to SIDEWALKS SHOULD NOT BE DESIGNATED AS BIKEWAYS

Discuss access management

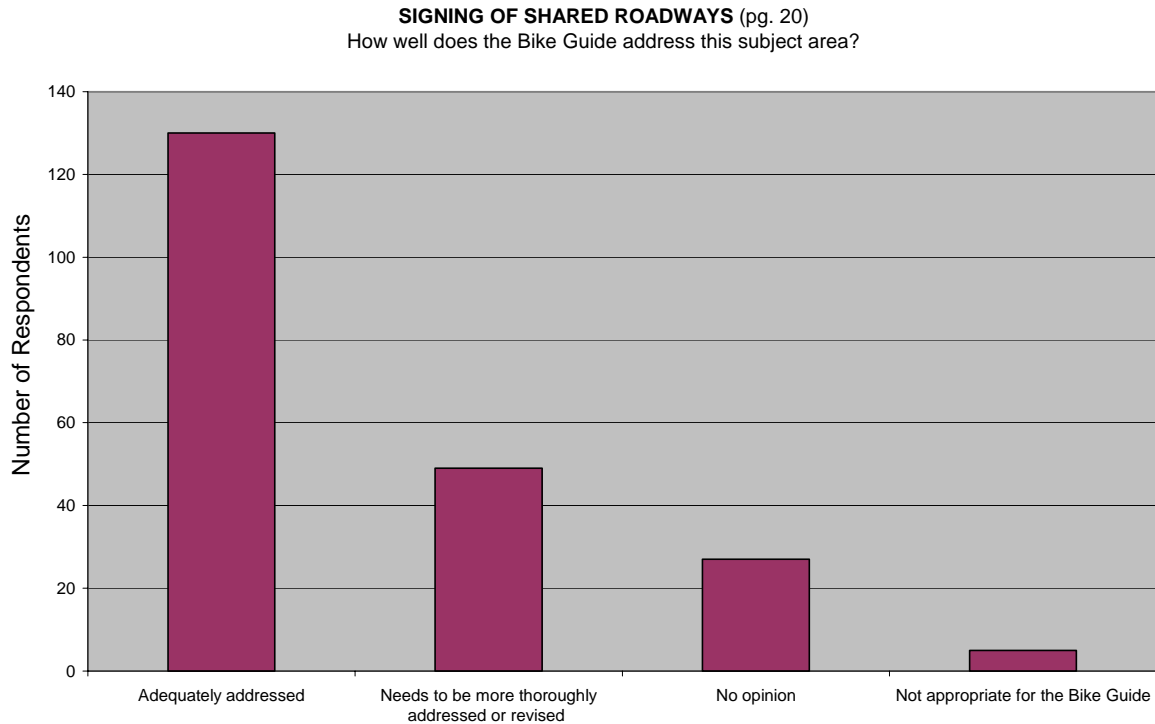
Discuss why sidewalks are not bicycle facilities (design criteria)

Discuss who might be comfortable using sidewalks as bicycle facilities

Discuss the legal issues with bicyclist use of crosswalks, with some states' laws interpreted to mean that bicycle riding in crosswalks is illegal or negligent

## SIGNING OF SHARED ROADWAYS

(pg. 20) How well does the Bike Guide address this subject area?



**Figure 28. Signing of Shared Roadways – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

MUTCD (5)

**Needs to be more thoroughly addressed or revised -**

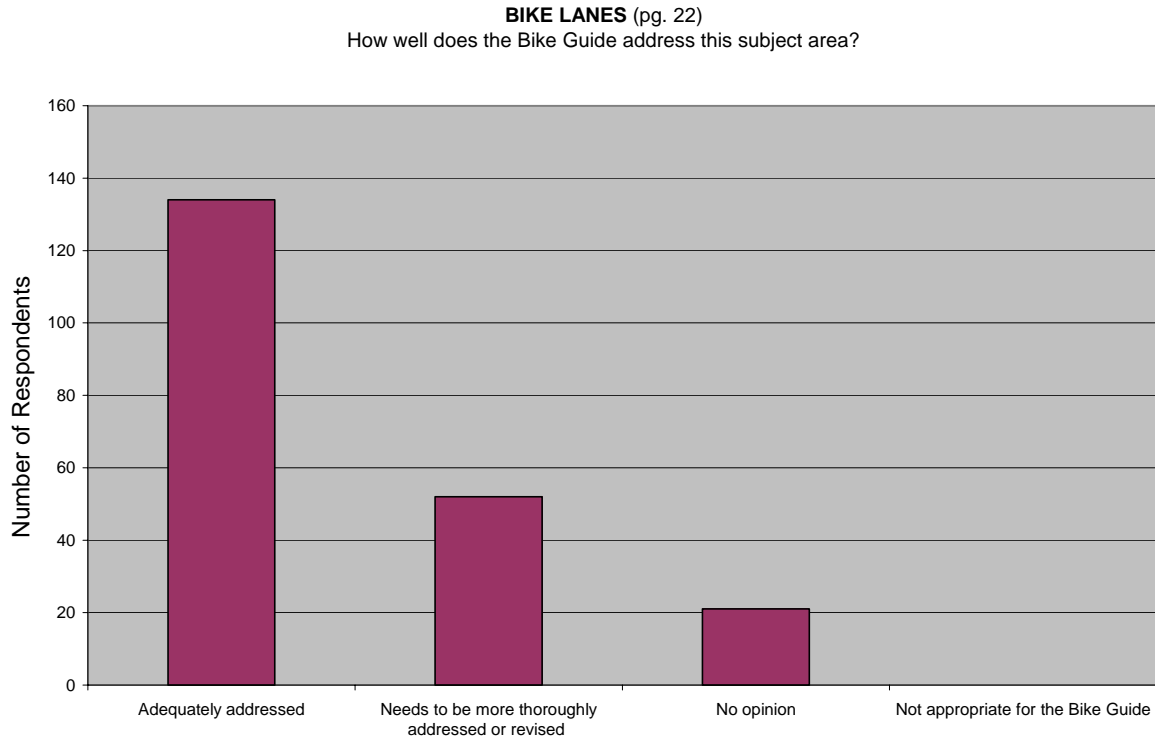
Expand the discussion of distance, direction, and destination signing

Include a discussion of the M1-8 and M1-9.

Bicycle routes should be covered in a different section; they are not technically a facility type

## BIKE LANES

(pg. 22) How well does the Bike Guide address this subject area?



**Figure 29. Bike Lanes – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

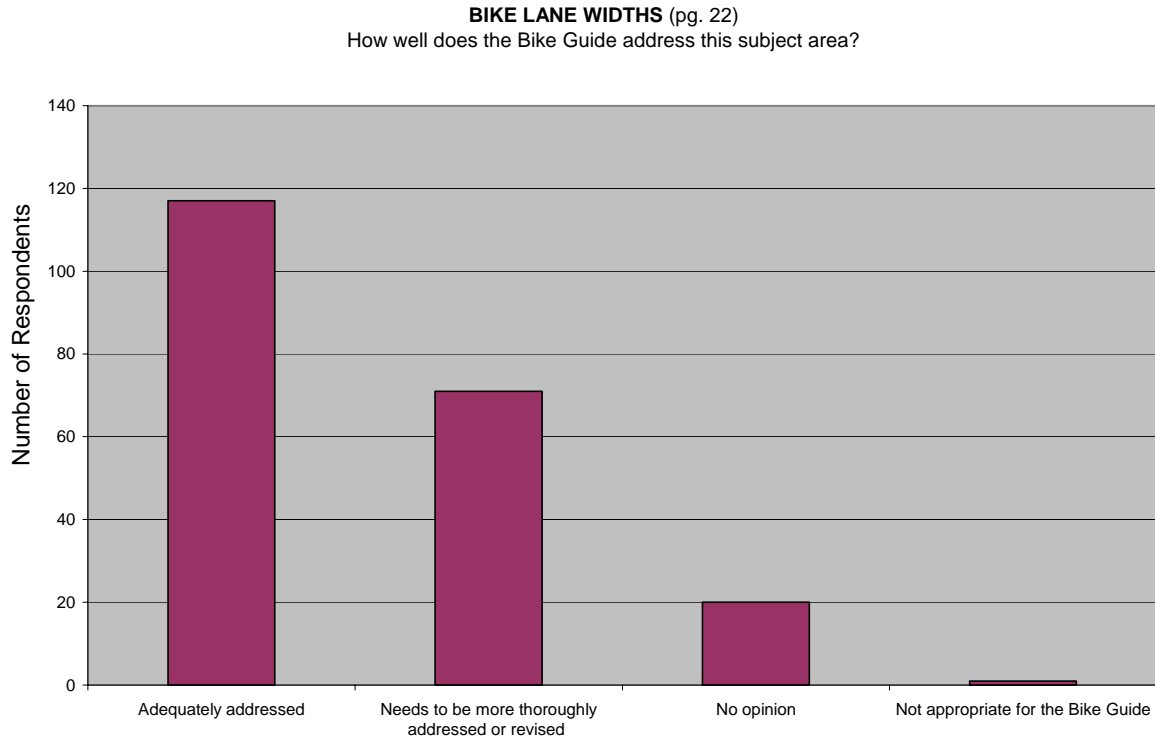
**Needs to be more thoroughly addressed or revised -**

A large number of respondents stated that bike lanes decreased the safety of the roadway for bicyclists and led to improper cycling behavior.

Discuss how the mandatory sidepath law affects the desirability of providing bike lanes.

## BIKE LANE WIDTHS

(pg. 22) How well does the Bike Guide address this subject area?



**Figure 30. Bike Lane Widths – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Nowhere

**Needs to be more thoroughly addressed or revised -**

Many of the respondents' comments were concerned with the door zone next to on-street parking

Discuss the use of contrasting pavement in bike lanes

Discuss the impact of traffic volumes, speeds, and percent trucks on the desirable bike lane width

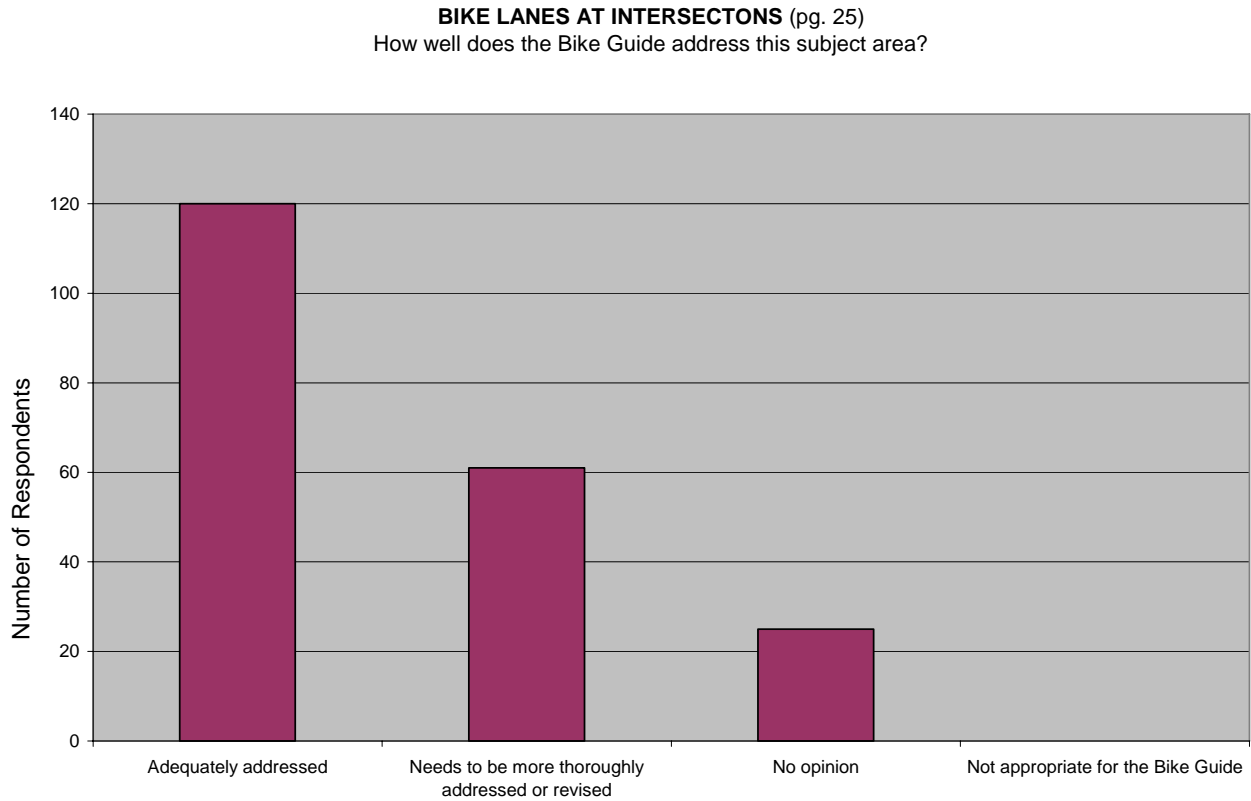
Discuss clearance to roadside hazards

## Chapter 4: Survey Results

Discuss the width requirements of non traditional users – in-line skaters, tricyclists

## BIKE LANES AT INTERSECTIONS

(pg. 25) How well does the Bike Guide address this subject area?



**Figure 31. Bike Lanes at Intersections – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

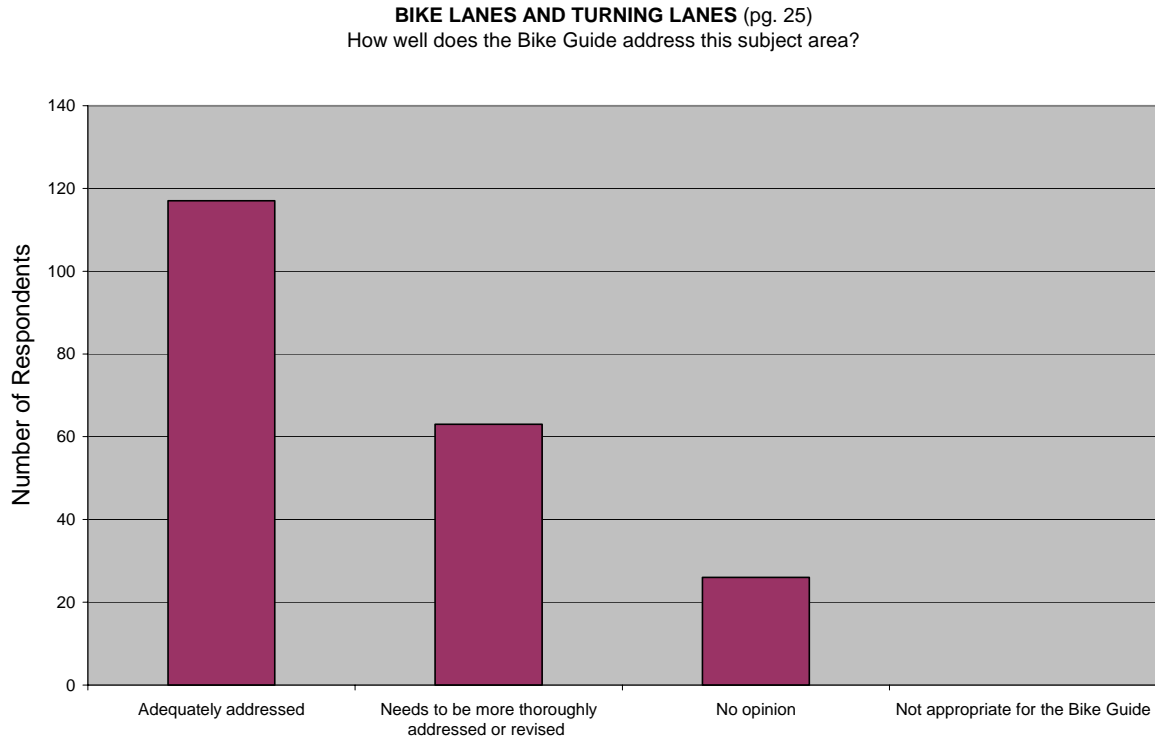
Introduce and define bike boxes and bike slots

Discuss how bicyclists are supposed to navigate through intersections with respect to their movements – right turns, left turns, through movements



## BIKE LANES AND TURNING LANES

(pg. 25) How well does the Bike Guide address this subject area?



**Figure 32. Bike Lanes and Turning Lanes – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

MUTCD

**Needs to be more thoroughly addressed or revised -**

The discussion of whether or not bike lanes promote safety or good riding behavior was continued in the comments in this section

Discuss what to do if there is not room for a bike lane within the intersection (due to the additional of turn lanes)

## Chapter 4: Survey Results

Discuss blue bike lanes

Discuss the use of right turn motorist / through bike lanes

Discuss bike boxes

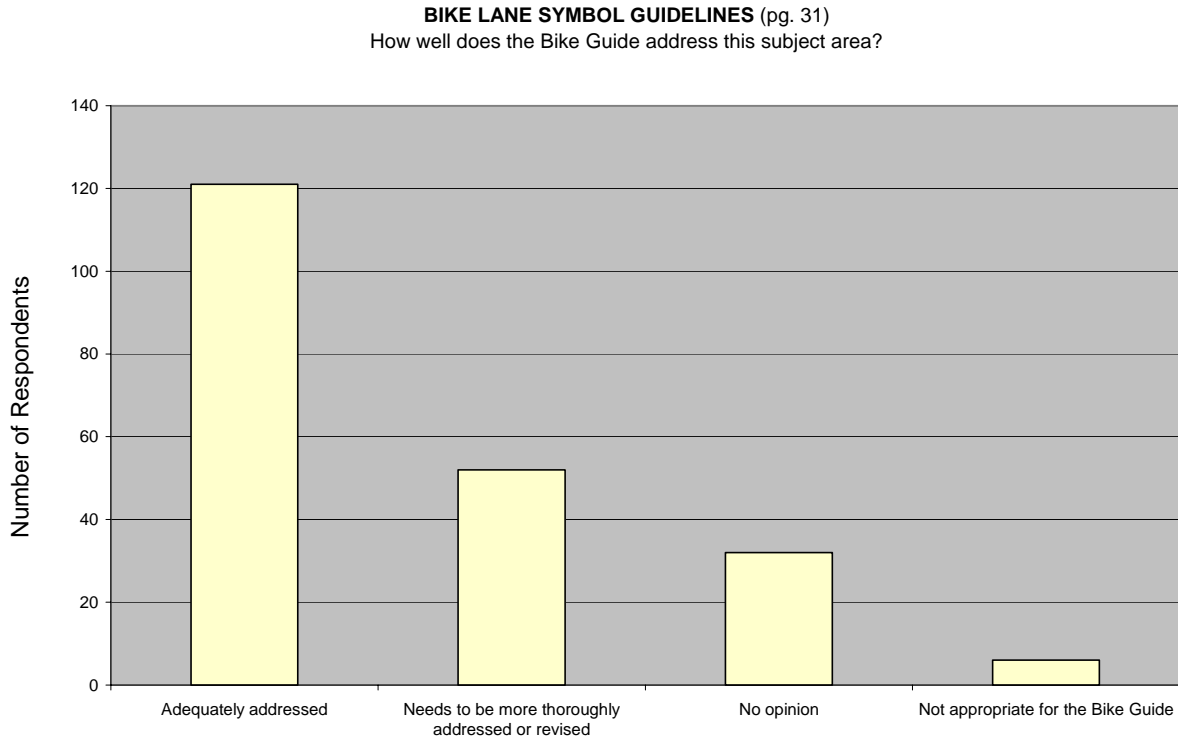
Discuss bus pull out areas

Discuss trap lanes and tee intersections with right turn lanes

Discuss bike lane treatments at channelization islands

## BIKE LANE SYMBOL GUIDELINES

(pg. 31) How well does the Bike Guide address this subject area?



**Figure 33. Bike Lane Symbol Guidelines – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

MUTCD (6)

**Needs to be more thoroughly addressed or revised -**

Discuss the pros and cons of the various bike lane pavement markings (text, riderless bike, bike w/ rider w/ or w/o helmet)

Discuss the use of paint versus thermoplastic

Discuss colored bike lanes

## Chapter 4: Survey Results

Discuss when designating a bike lane is desirable

Specify the frequency for markings in urban, suburban and rural areas

**Please indicate any other topics related to Bike Lane Design that should be addressed in the next Bike Guide update.**

Discuss the use of supplemental graphics in the bike lane to warn motorists to watch for cyclists

Discuss signal detection of bicyclists in bike lanes or elsewhere on the street

Discuss bike lane markings at roundabouts

Discuss signage of bike lanes

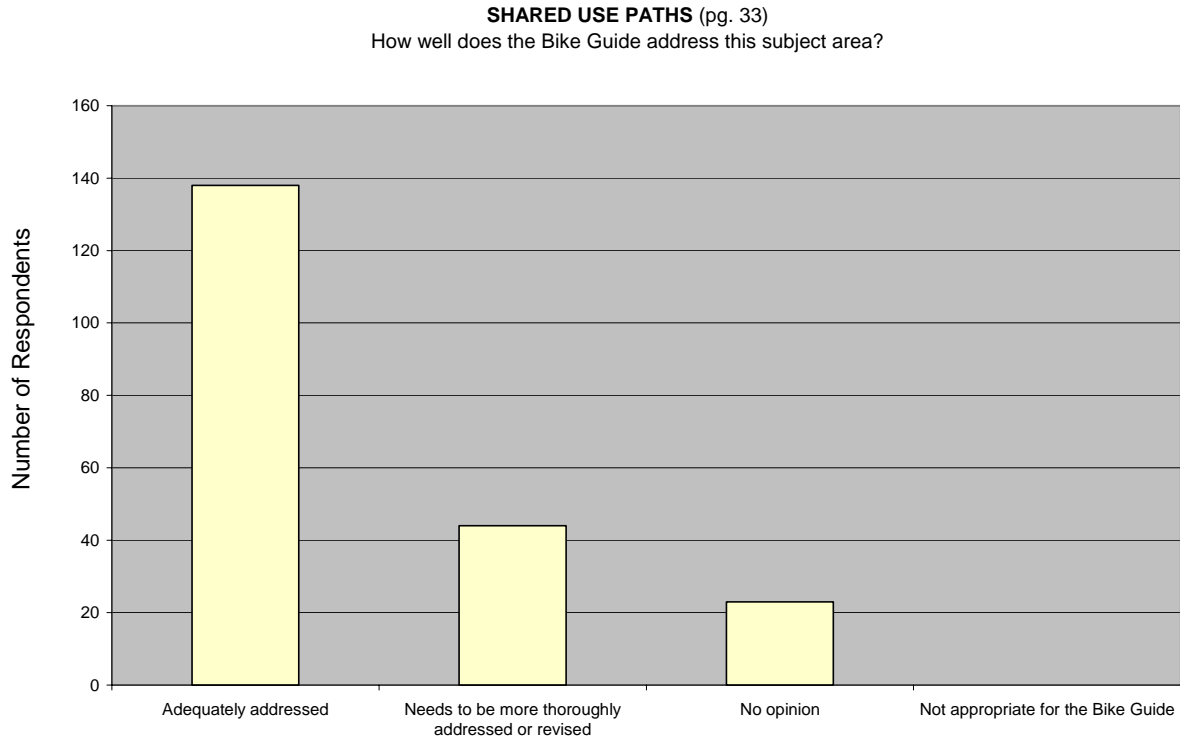
Discuss the maintenance of on-street facilities

Discuss contraflow bike lanes

Discuss the use of bike lanes in a rural environment

## SHARED USE PATHS

(pg. 33) How well does the Bike Guide address this subject area?



**Figure 34. Shared Use Paths – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Discuss the difference between paths, trails and greenways

Discuss surface treatments

Discuss the lack of orderly, predictable behavior on shared use paths

Expand discussion on striping and signing

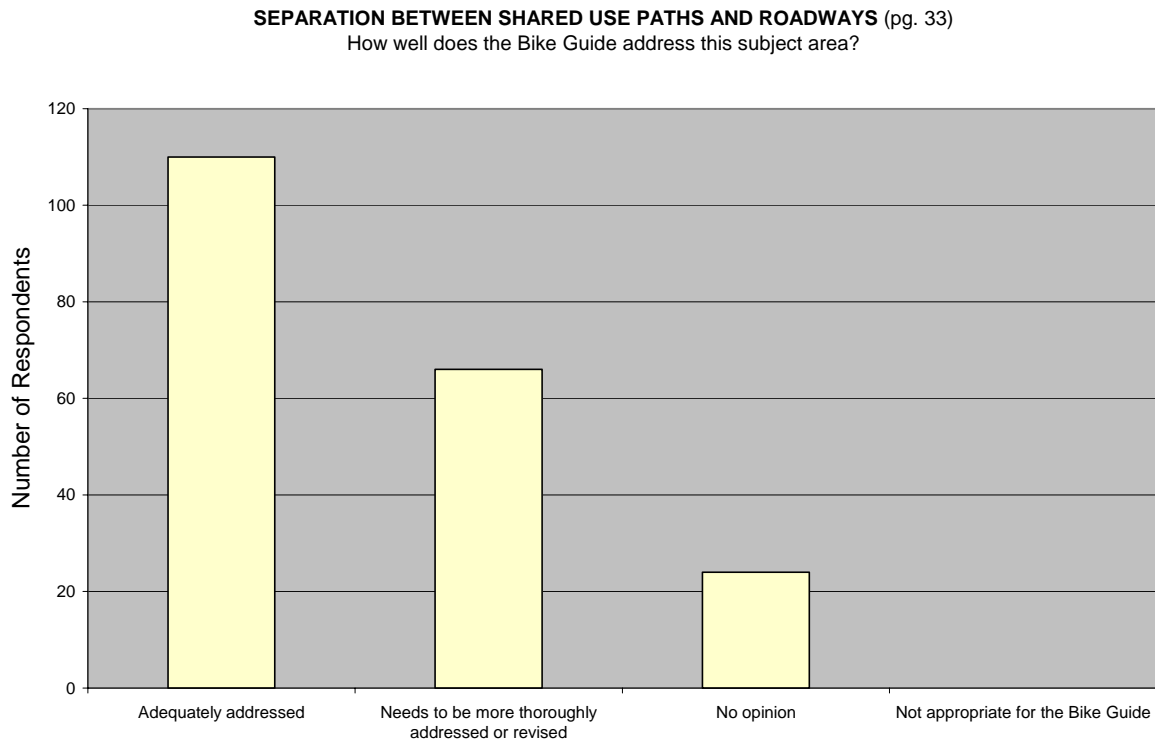
Discuss the design users of shared use paths and how design is impacted by the design users

## Chapter 4: Survey Results

Create a separate document for the design of shared use paths

## SEPARATION BETWEEN SHARED USE PATHS AND ROADWAYS

(pg. 33) How well does the Bike Guide address this subject area?



**Figure 35. Separation between Shared Use Paths and Roadways – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Provide specific guidance on when paths adjacent to the roadway may be acceptable

Provide separation specifications

Provide examples of acceptable barrier types



## Chapter 4: Survey Results

Discuss the disadvantages of sidepaths over roadways in northern climates where the snow removal and storage are concerns

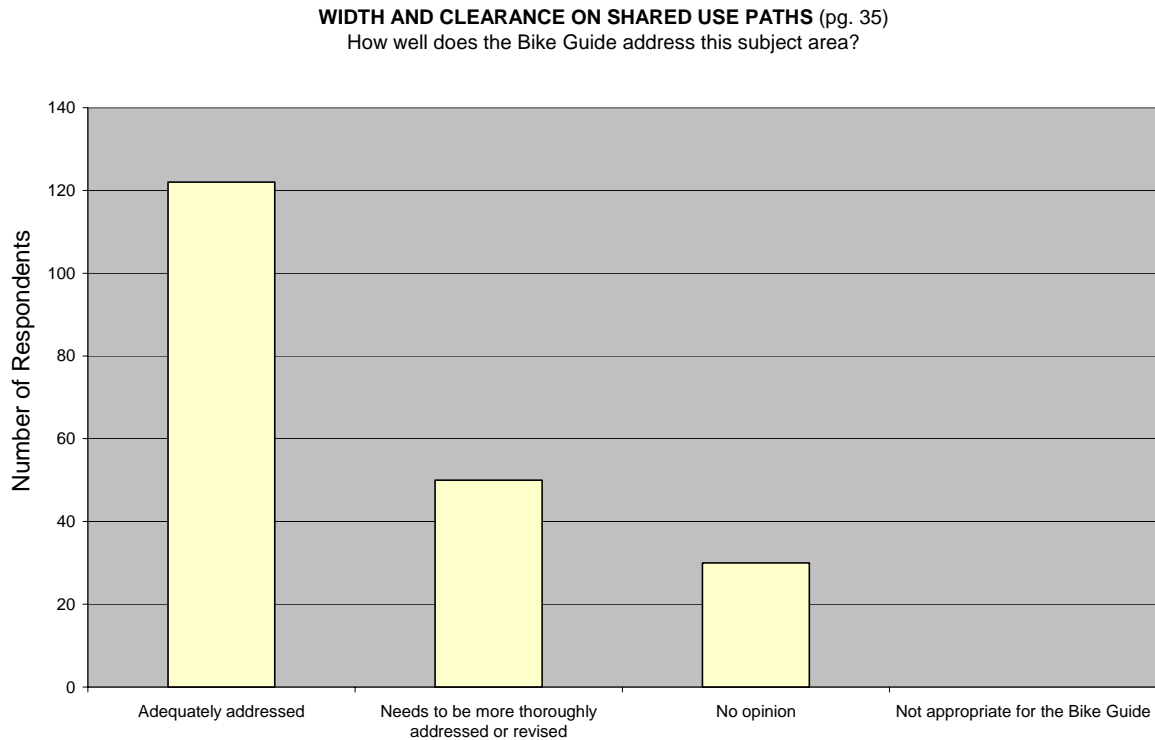
Discuss the types of users who prefer sidepath facilities and their characteristics

Discuss maintenance concerns

Clarify the appropriate barrier height

## WIDTH AND CLEARANCE ON SHARED USE PATHS

(pg. 35) How well does the Bike Guide address this subject area?



**Figure 36. Width and Clearance of Shared Use Paths – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Revise base upon design users other than bicyclists

Expand the discussion of when 8' {2.4 m}, 10' {3.0 m}, 12' {3.7 m}, or greater path widths are needed

Discuss the use of capacity / volume in setting shared use path widths

## Chapter 4: Survey Results

Discuss landscaping requirements

Discuss the need to consider environmentally sensitive areas when setting path width

Discuss the required r-o-w widths to accommodate shared use paths

Discuss under what conditions a one-way path would be appropriate

Discuss the user of guardrail

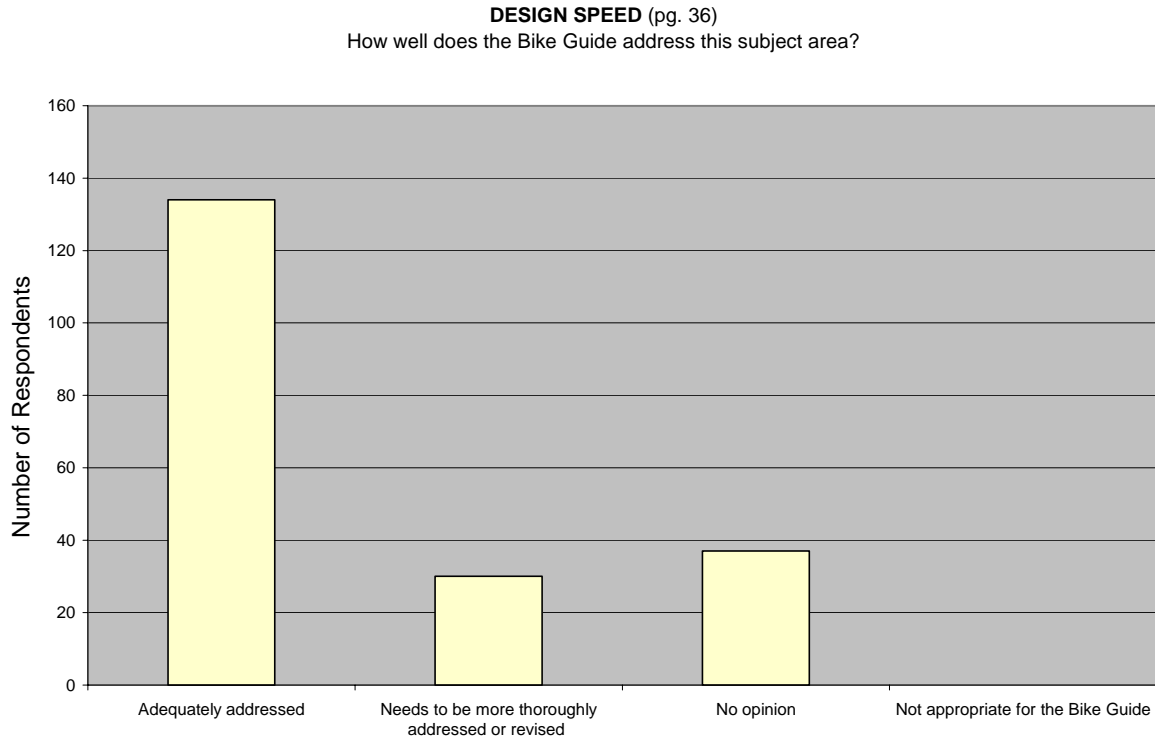
Discuss when a barrier is needed to protect from dropoffs

Discuss clearance to parallel rail lines

Discuss clearance to adjacent equestrian paths

## DESIGN SPEED

(pg. 36) How well does the Bike Guide address this subject area?



**Figure 37. Design Speed – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

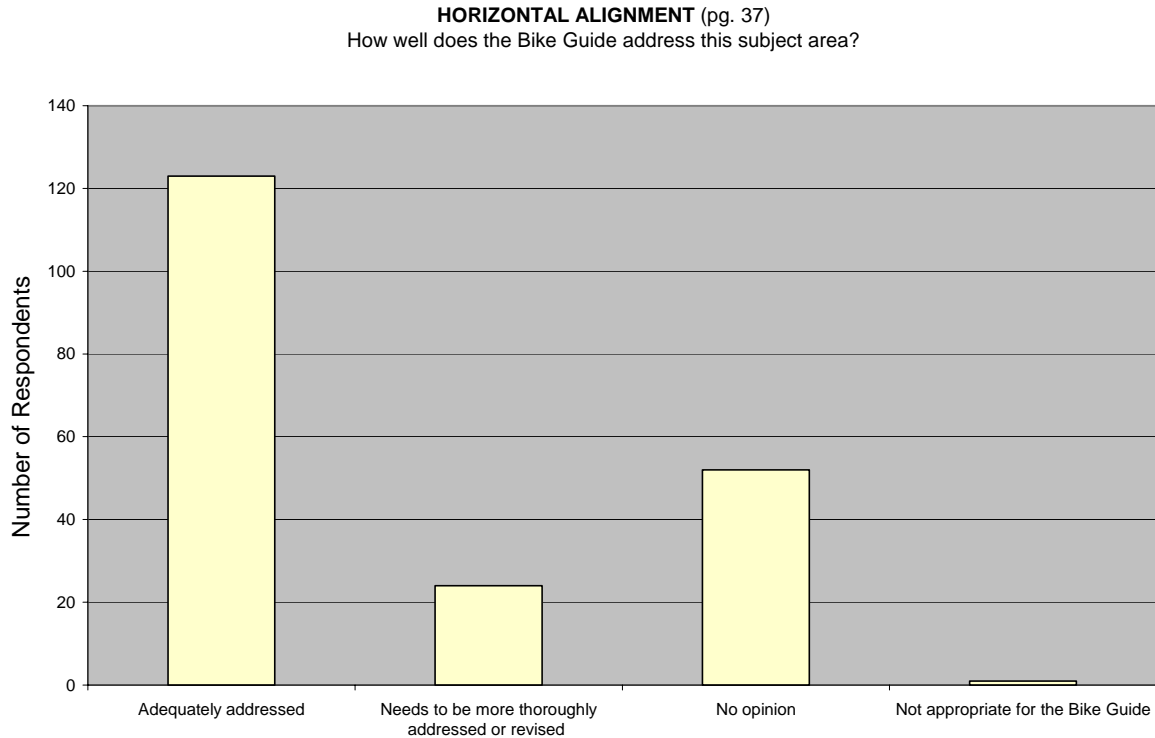
Expand the discussion of design speeds on various grades

Discuss the design speed as a function of design user

Discuss the design user as a function of location (of functional classification)

## HORIZONTAL ALIGNMENT

(pg. 37) How well does the Bike Guide address this subject area?



**Figure 38. Horizontal Alignment – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Covered by ADA requirements

**Needs to be more thoroughly addressed or revised -**

Discuss increasing the width of shared use paths on curves

Discuss the use of switchbacks in steep terrain

Discuss the maximum horizontal deflection not requiring a curve

Discuss techniques to get users to slow down on the approach to intersections

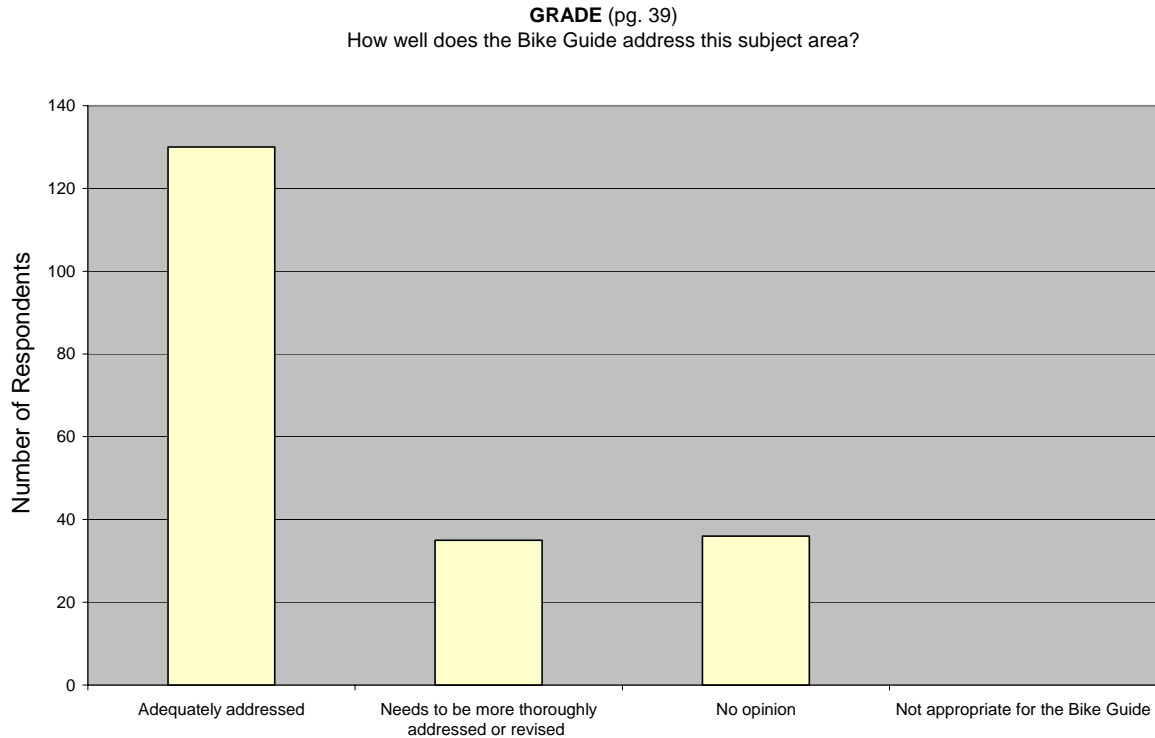
## Chapter 4: Survey Results

Discuss mitigation measures for when minimum radii cannot be met

Include superelevation transition information

## GRADE

(pg. 39) How well does the Bike Guide address this subject area?



**Figure 39. Grade – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Discuss the implications of the ADA

Discuss the maximum change in grade without a vertical curve

Discuss how a maximum change in grade would be applied to overpass/underpass approaches

Discuss climbing turns

Discuss the use of stairs as alternative accesses to overpasses/underpasses

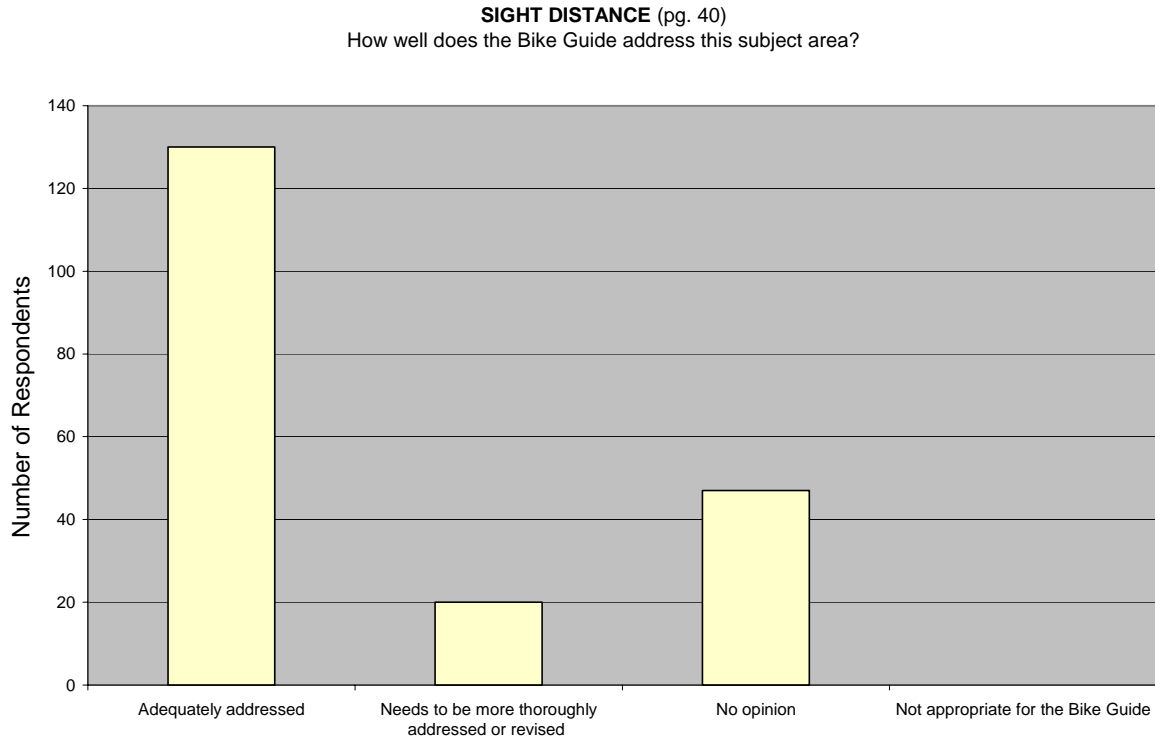
## Chapter 4: Survey Results

Discuss increasing widths on trails with significant grades



## SIGHT DISTANCE

(pg. 40) How well does the Bike Guide address this subject area?



**Figure 40. Sight Distance – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Discuss landscaping requirements

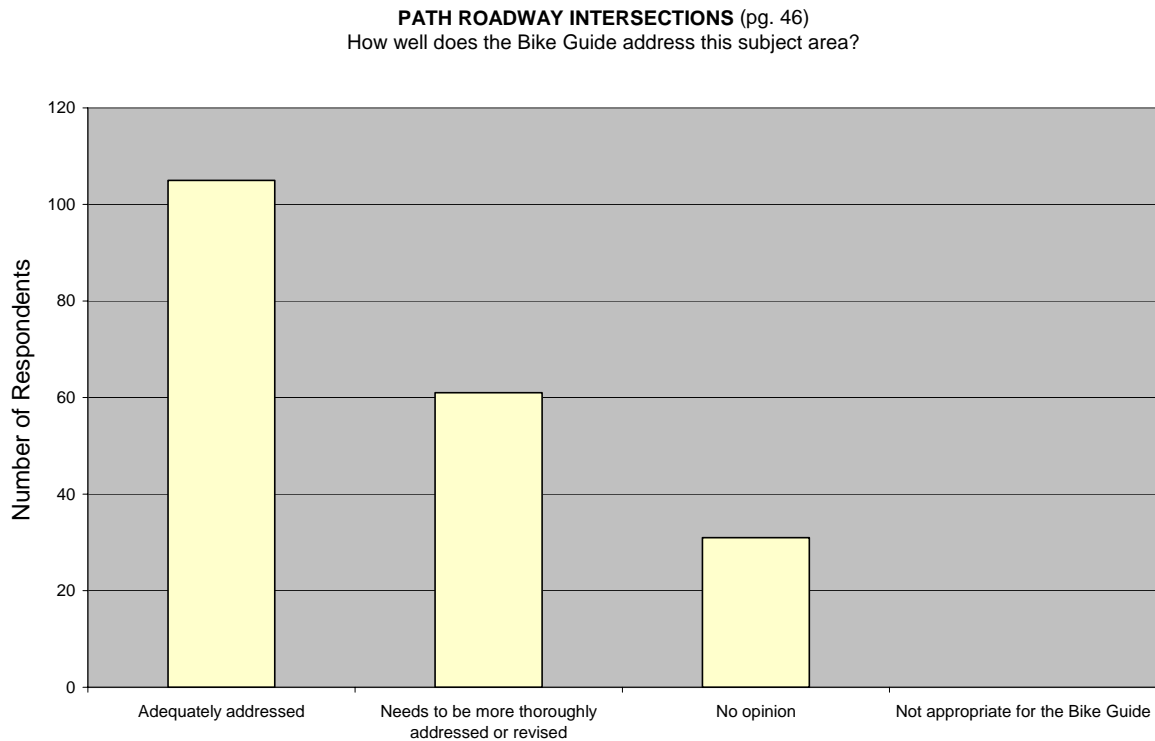
Discuss the use of striping and signing to warn of nonconforming conditions

Discuss sight distance requirements for passing

Discuss the sight distance requirements of users other than traditional bicyclist

## PATH ROADWAY INTERSECTIONS

(pg. 46) How well does the Bike Guide address this subject area?



**Figure 41. Path Roadway Intersections – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Discuss the need for detectable warnings

Discuss how to set priority at a shared use path / roadway intersection

Discuss sight triangles

Discuss sign locations

Discuss striping requirements/options

## Chapter 4: Survey Results

Discuss how the principles of the MUTCD apply to path / roadway intersections

Discuss options to bollards for motor vehicle access control

Discuss the use of Danish offsets at intersections

Discuss how various design users impact the requirements for refuge islands and bollard spacing

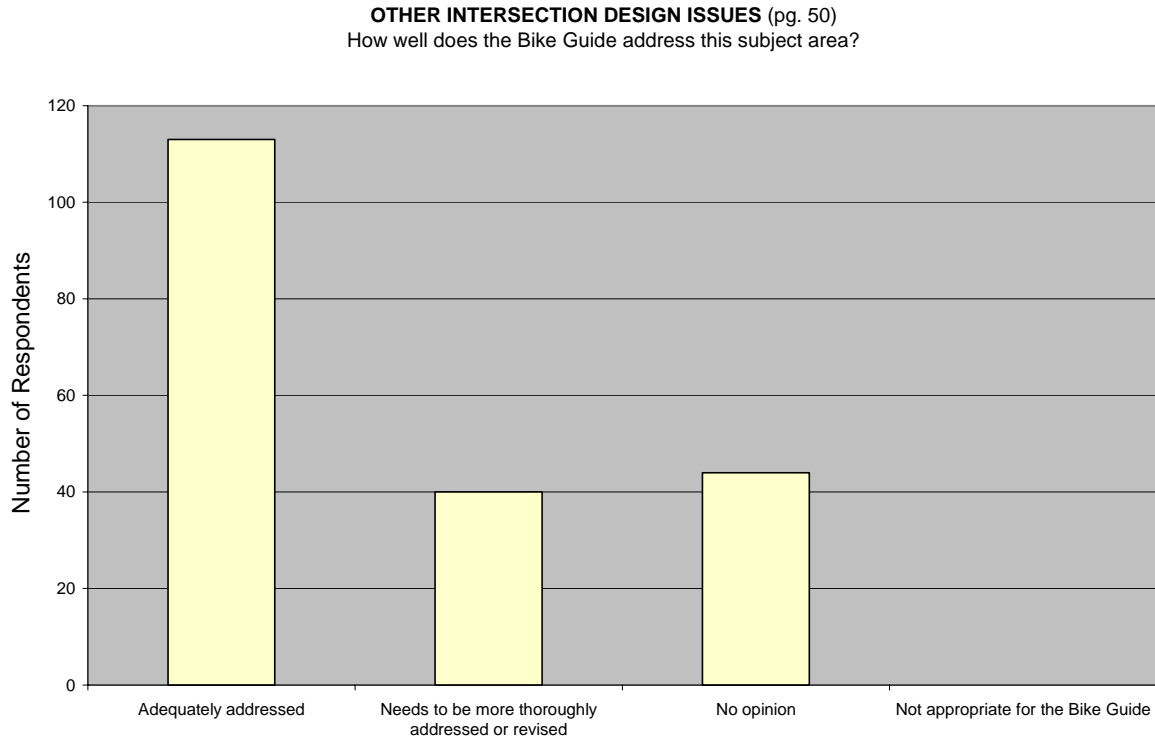
Discuss advance warning technologies for motorists

Discuss the legal ramifications of providing (or not) crosswalk stripes

Provide guidance on the appropriate separation between shared use path and adjacent roadway intersections

## OTHER INTERSECTION DESIGN ISSUES

(pg. 50) How well does the Bike Guide address this subject area?



**Figure 42. Other Intersection Design Issues – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Discuss the placement of push buttons at signalized crossings

Discuss the detection of bicycles and other users at signalized crossings

Discuss roundabouts and SPUIs

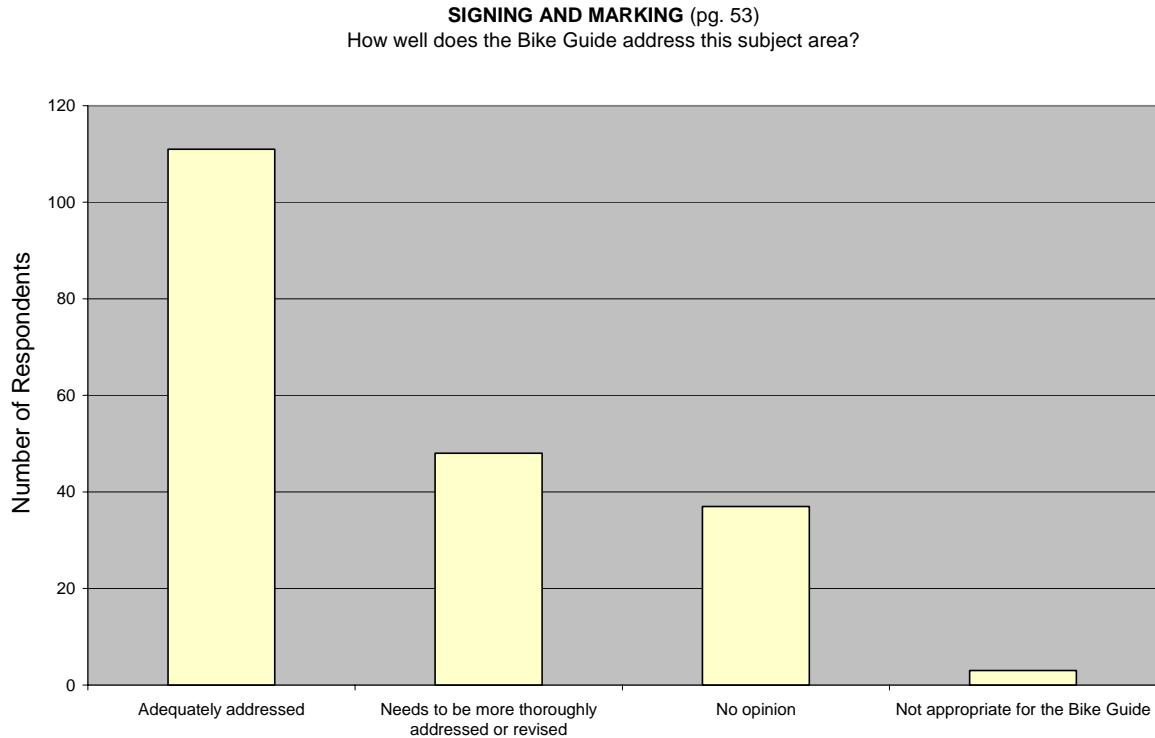
Discuss path / path intersections

## Chapter 4: Survey Results

Provide an expanded discussion of how to terminate a shared use path at a roadway or intersection

## SIGNING AND MARKING

(pg. 53) How well does the Bike Guide address this subject area?



**Figure 43. Signing and Marking – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

MUTCD (3)

**Needs to be more thoroughly addressed or revised -**

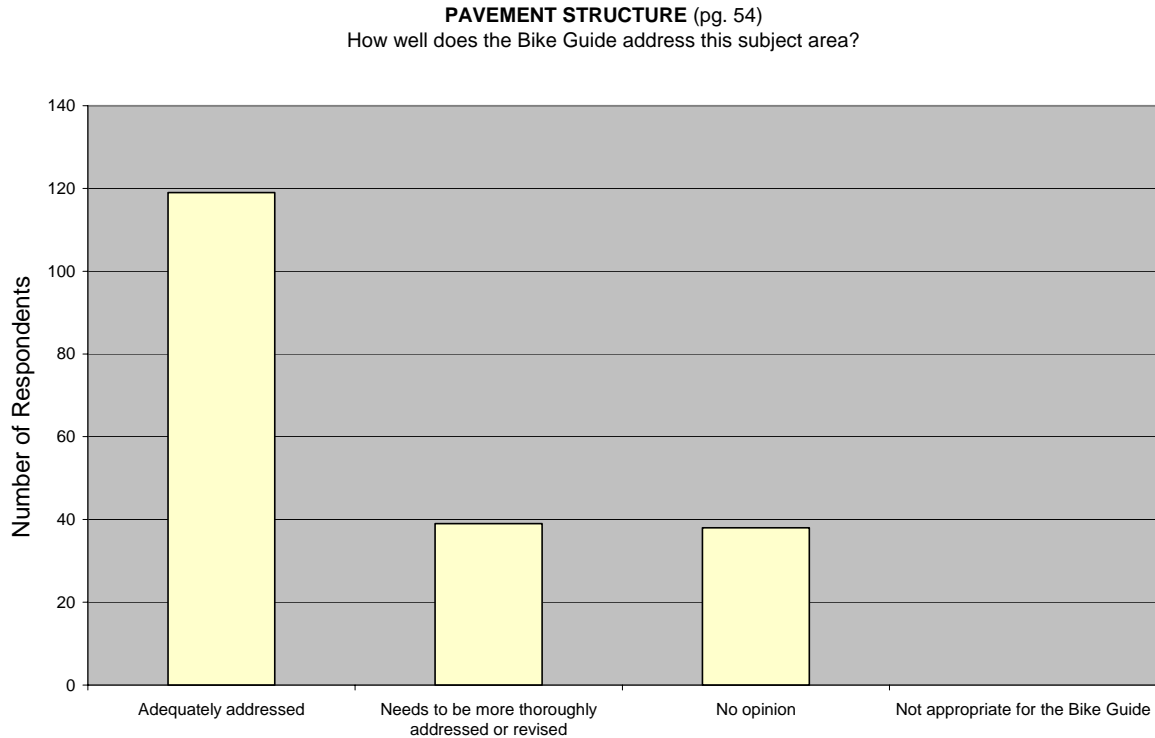
Provide greater guidance on when to stripe crosswalks

Discuss different materials for striping paths

Emphasize compliance with the MUTCD

## PAVEMENT STRUCTURE

(pg. 54) How well does the Bike Guide address this subject area?



**Figure 44. Pavement Structure – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Provide greater guidance on bases and sub-structures

Discuss the pros and cons of different surface treatments (asphaltic concrete, PC concrete, stone dust surfaces, limestone)

Discuss the impact of climate on pavement surface selection

Discuss the use of permeable surfaces

## Chapter 4: Survey Results

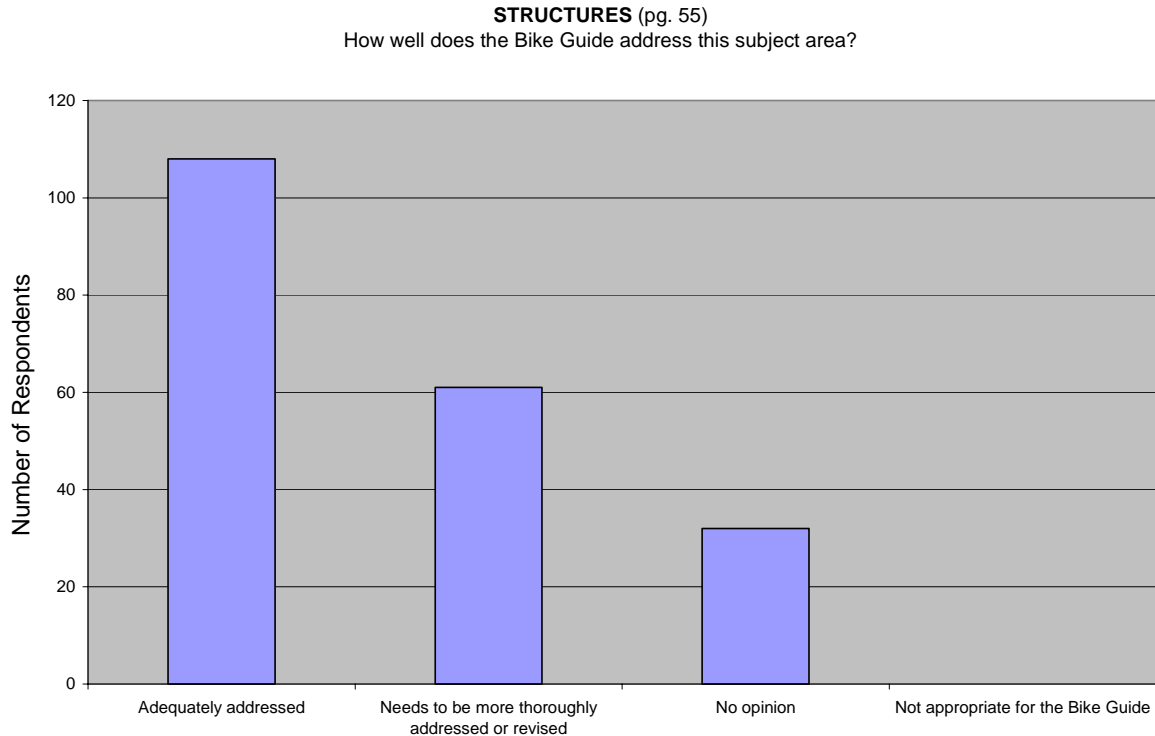
Discuss the use of root barriers

Discuss how to minimize freeze thaw problems at culverts



## STRUCTURES

(pg. 55) How well does the Bike Guide address this subject area?



**Figure 45. Structures – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Specify a consistent railing height with AASHTO's Structures Manual

Discuss the use of open vs balustrade railings versus standard pedestrian railings

Reference the AASHTO Structures Manual

Discuss end treatments for railings

Discuss the use of fencing (caging) on overpasses over roadways

## Chapter 4: Survey Results

Provide guidelines for when grade separation should be provided at intersections

Discuss maximum length w/ respect to lighting requirements

Discuss the use of culverts as tunnels

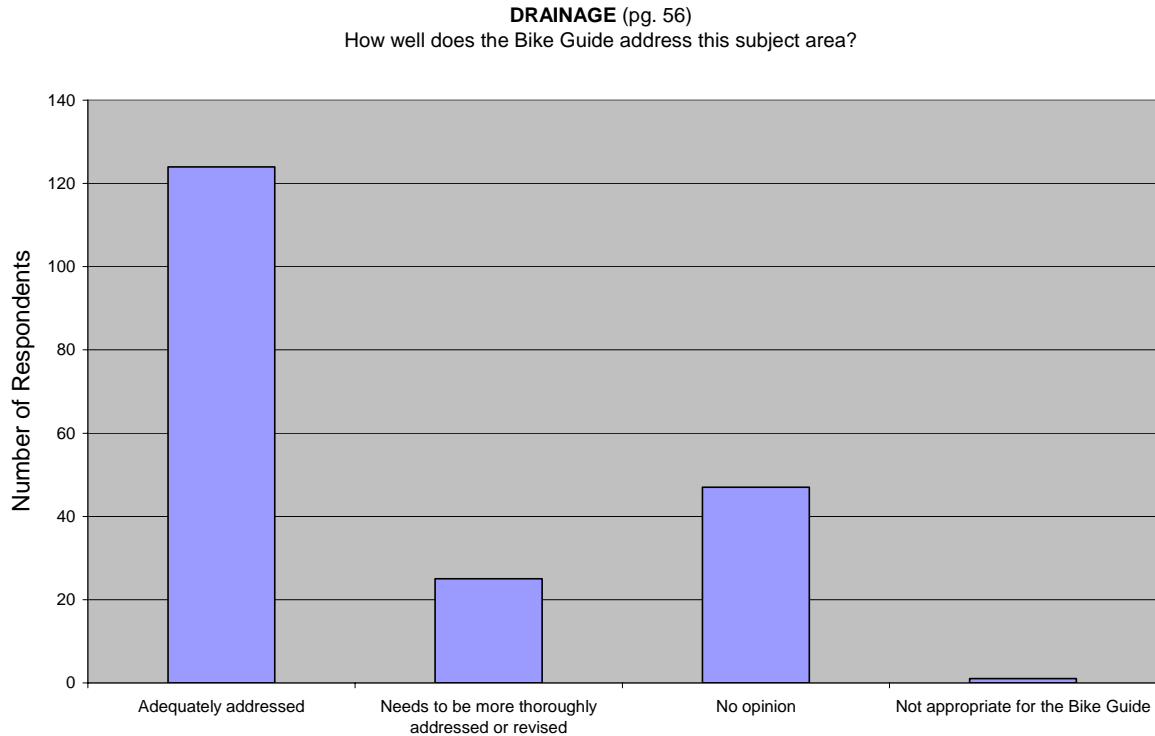
Discuss design loading of structures

Discuss the disadvantages of using longitudinal planking on structures

Discuss retrofitting cantilever paths onto existing bridges

## DRAINAGE

(pg. 56) How well does the Bike Guide address this subject area?



**Figure 46. Drainage – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

AASHTO Pavement Design Guidelines

**Needs to be more thoroughly addressed or revised -**

Discuss the impact of ADA’s minimum 2% cross slope on design

Discuss the use of crowned facilities instead of the 2% cross slope

Discuss what must be done with the captured water

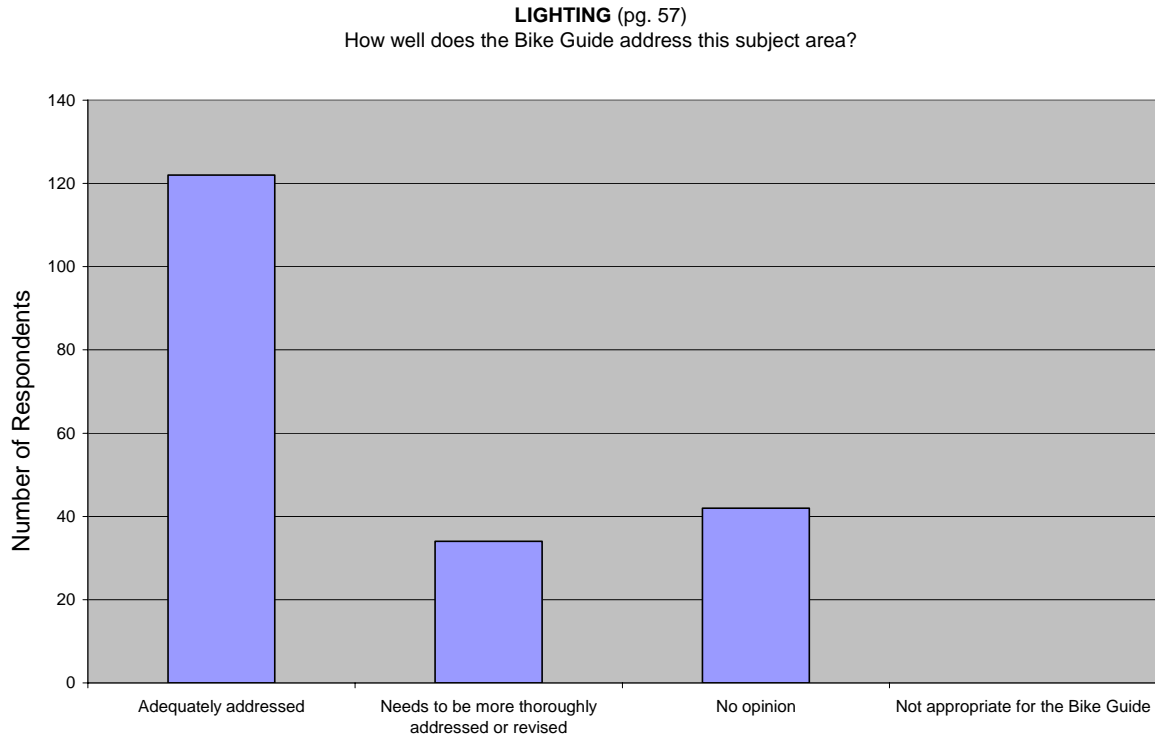
Discuss maintenance requirements for drainage facilities

## Chapter 4: Survey Results

Include a reference to AASHTO Model Drainage Manual

## LIGHTING

(pg. 57) How well does the Bike Guide address this subject area?



**Figure 47. Lighting – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised -**

Provide specs for facility lighting

Discuss the use of directional lighting to reduce light pollution

Discuss the placement of lights adjacent to the trail or within structures

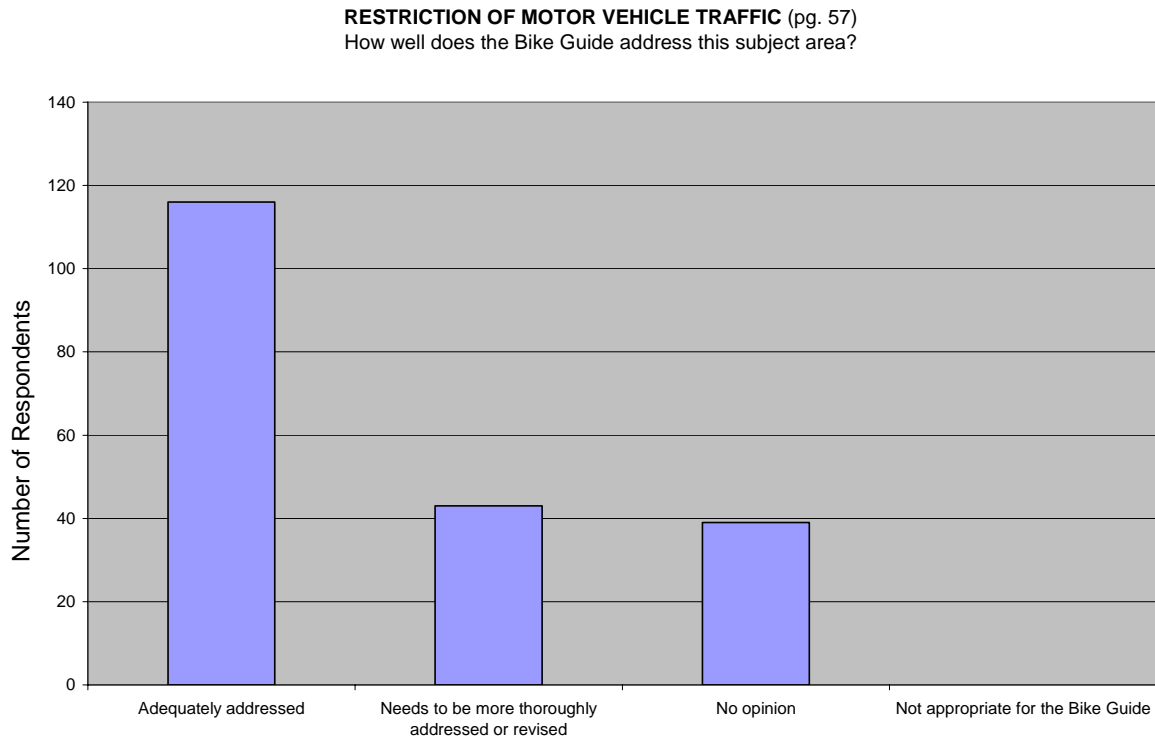
## Chapter 4: Survey Results

Discuss the daytime lighting of underpasses

Discuss the use of variable intensity lighting that adjust in response to ambient lighting conditions

## RESTRICTION OF MOTOR VEHICLE TRAFFIC

(pg. 57) How well does the Bike Guide address this subject area?



**Figure 48. Restriction of motor vehicle traffic – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised –**

Many of the respondents suggested restricting / discouraging the use of bollards

Provide descriptions of treatments other than bollards

Discuss how the design user can impact bollard spacing

Discuss how bollards impact emergency / maintenance service vehicles

## Chapter 4: Survey Results

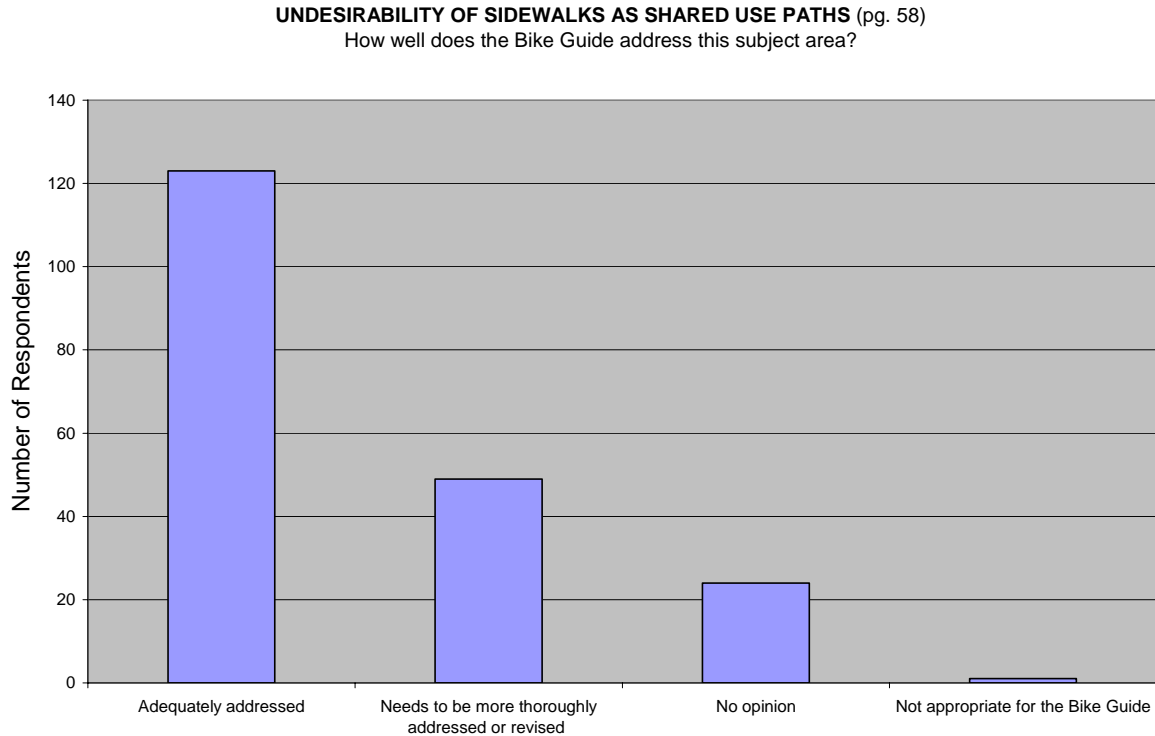
Discuss why an odd number of posts is recommended

Discuss whether a barrier is needed in the first place, and provide recommendations on the tradeoffs of installing bollards or other barriers



## UNDESIRABILITY OF SIDEWALKS AS SHARED USE PATHS

(pg. 58) How well does the Bike Guide address this subject area?



**Figure 49. Undesirability of Sidewalks as Shared Use Paths – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised –**

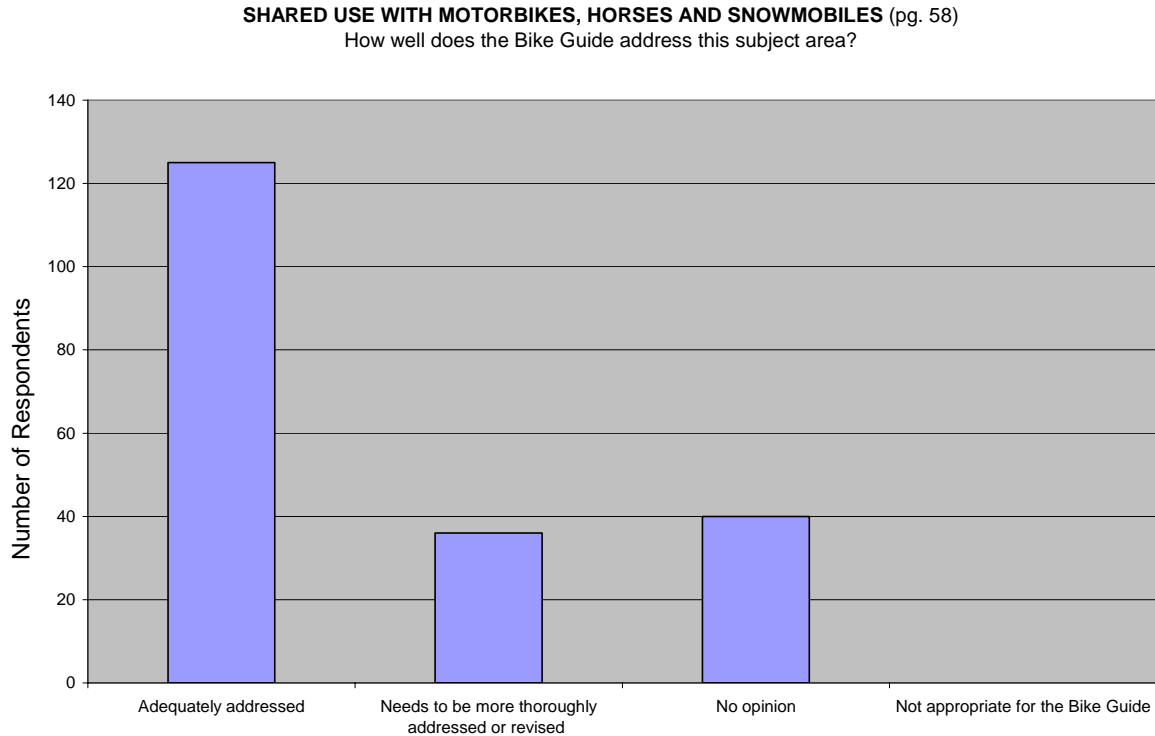
Combine with sidepath information

Discuss crash data / research

Discuss who these facilities are usually provided for and how those users could be better provided for

## SHARED USE WITH MOTORBIKES, HORSES AND SNOWMOBILES

(pg. 58) How well does the Bike Guide address this subject area?



**Figure 50. Shared Use with Motorbikes, Horses, and Snowmobiles – How well does the Bike Guide address this subject area?**

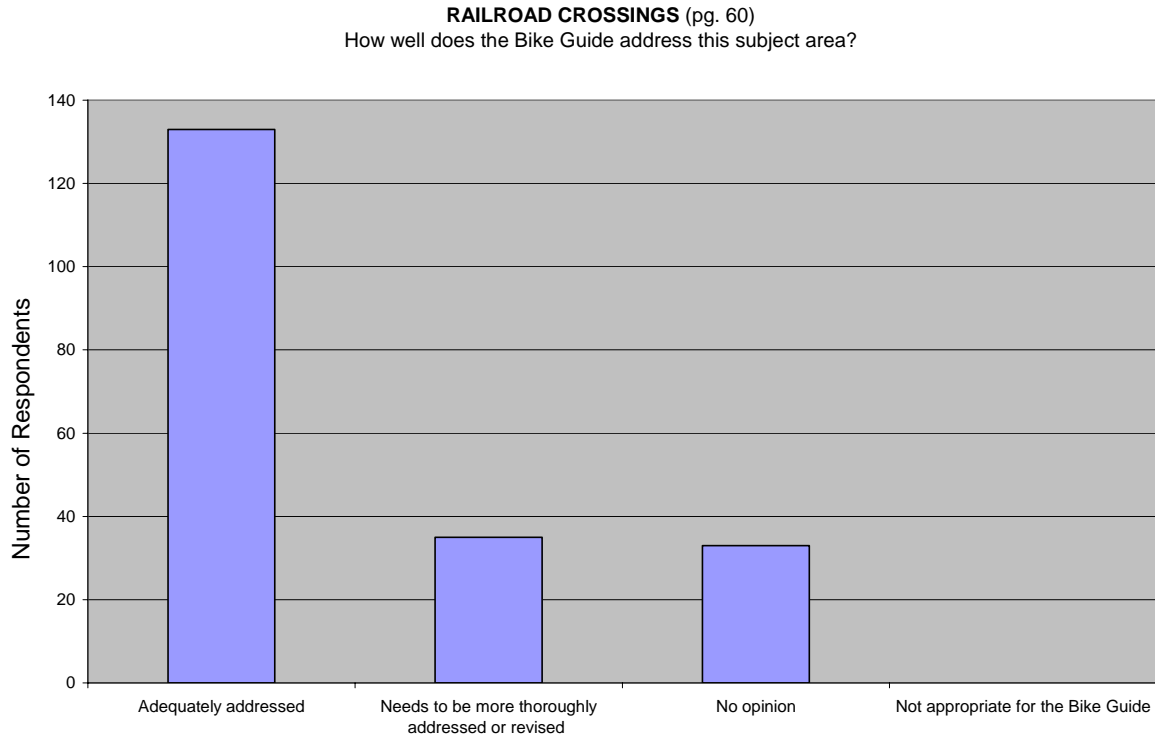
**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised –**

Discuss the impact of the ever increasing variety of users on shared use paths

## RAILROAD CROSSINGS

(pg. 60) How well does the Bike Guide address this subject area?



**Figure 51. Railroad Crossings – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised –**

Discuss recommended signage and striping

Discuss the role of the local RR coordinators in the accommodation of cyclists at RR crossings

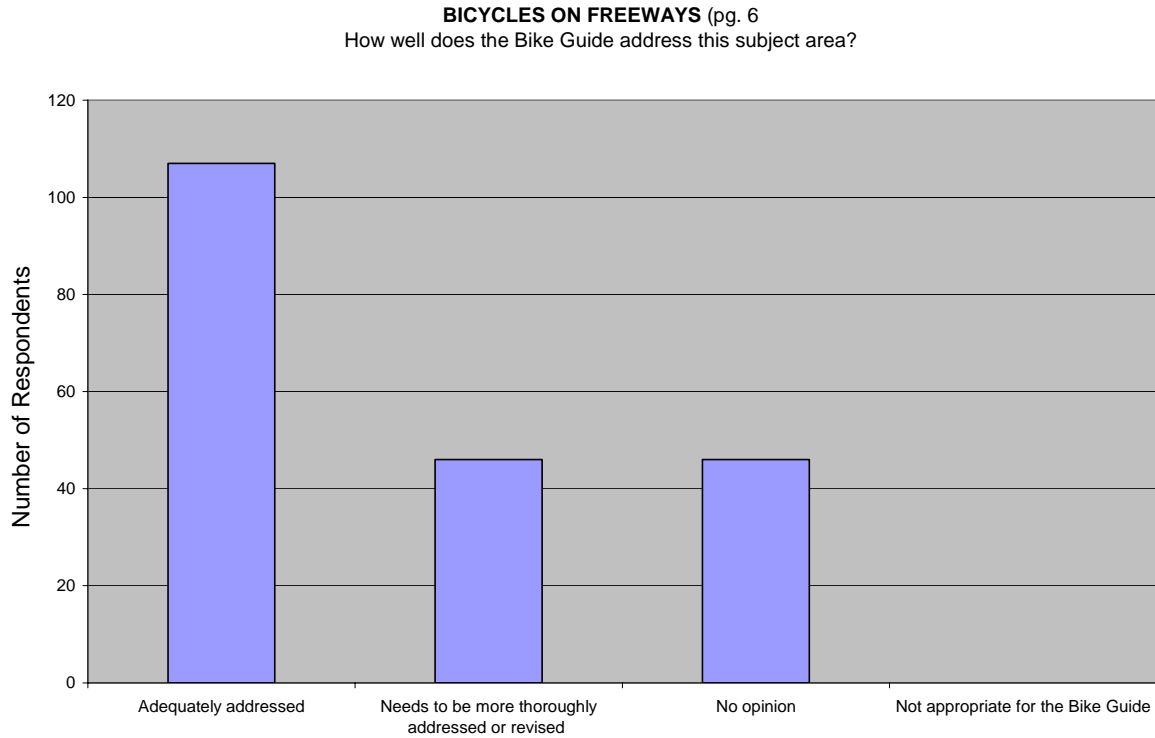
Discuss the use of flange fillers

Recognize that the RR must approve any crossing treatment

Discuss the use of barrier arms

## BICYCLES ON FREEWAYS

(pg. 60) How well does the Bike Guide address this subject area?



**Figure 52. Bicycles on Freeways – How well does the Bike Guide address this subject area?**

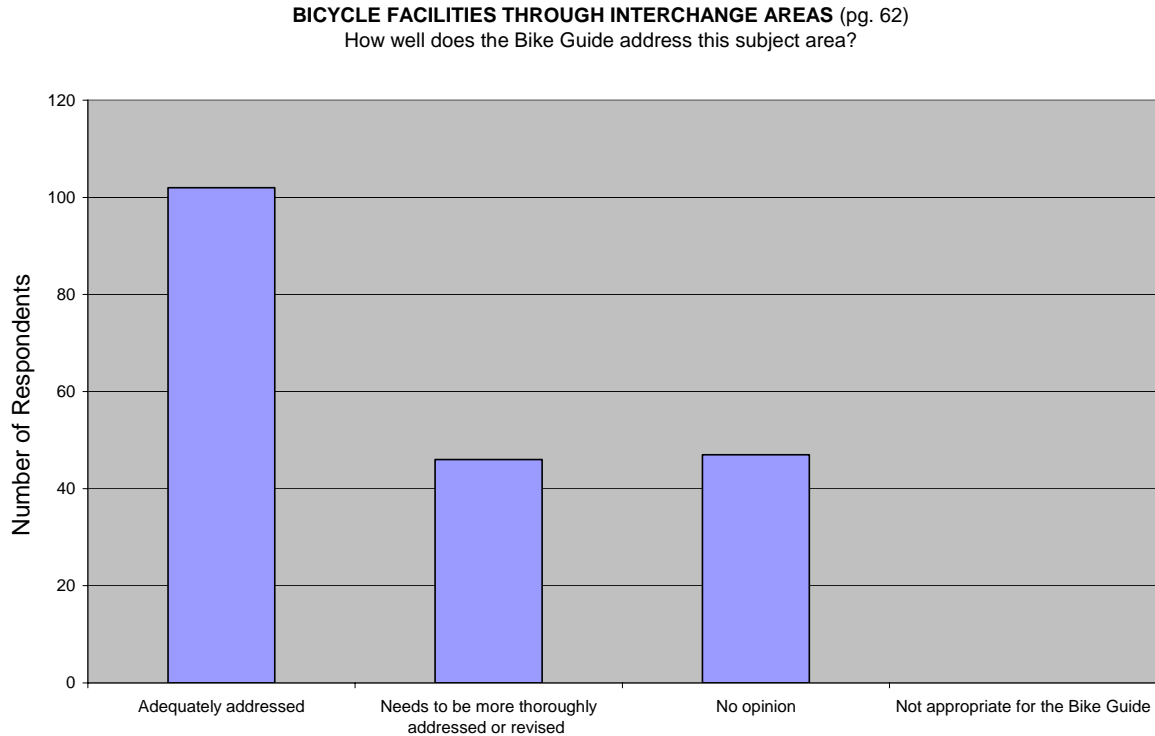
**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised –**

Many respondents were enthusiastic in their support of allowing bicyclists on freeway shoulders, some however were adamantly against it

## BICYCLE FACILITIES THROUGH INTERCHANGE AREAS

(pg. 62) How well does the Bike Guide address this subject area?



**Figure 53. Bicycle Facilities through Interchange Areas – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised –**

Discuss SPUIs

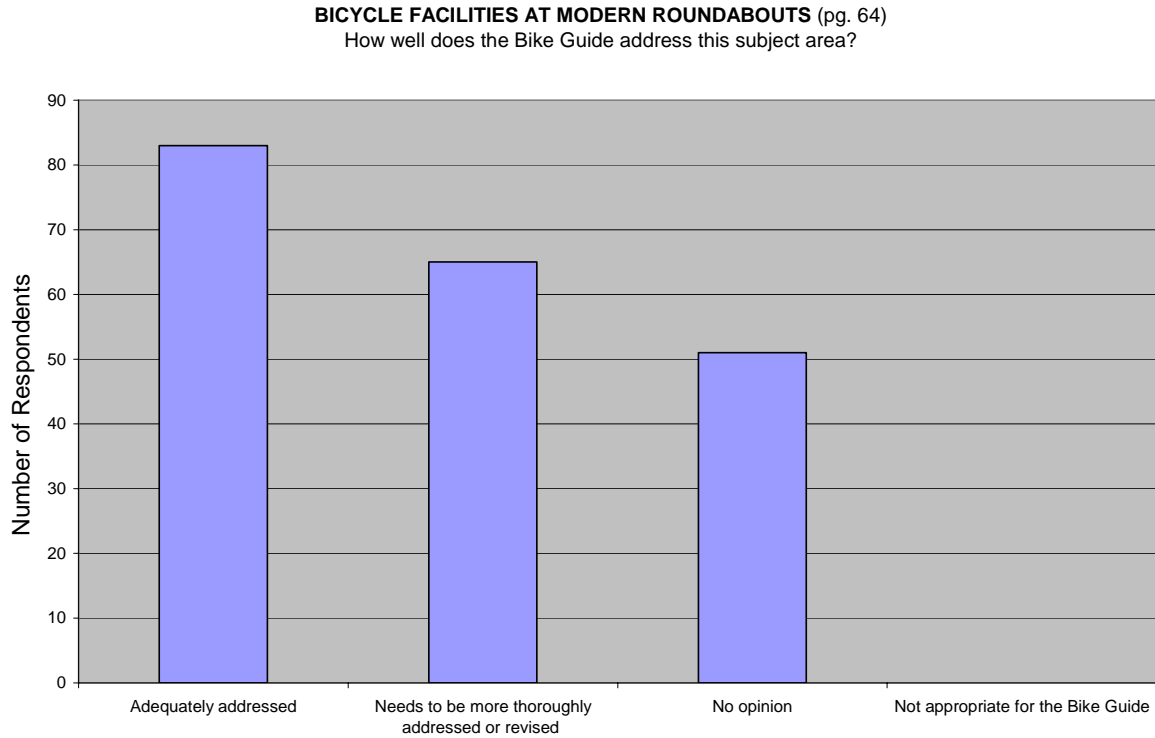
Discuss cloverleaf interchanges

Discuss the treatment of shared use paths through interchanges

Discuss multi-lane ramp scenarios

## BICYCLE FACILITIES AT MODERN ROUNDABOUTS

(pg. 64) How well does the Bike Guide address this subject area?



**Figure 54. Bicycle Facilities at Modern Roundabouts – How well does the Bike Guide address this subject area?**

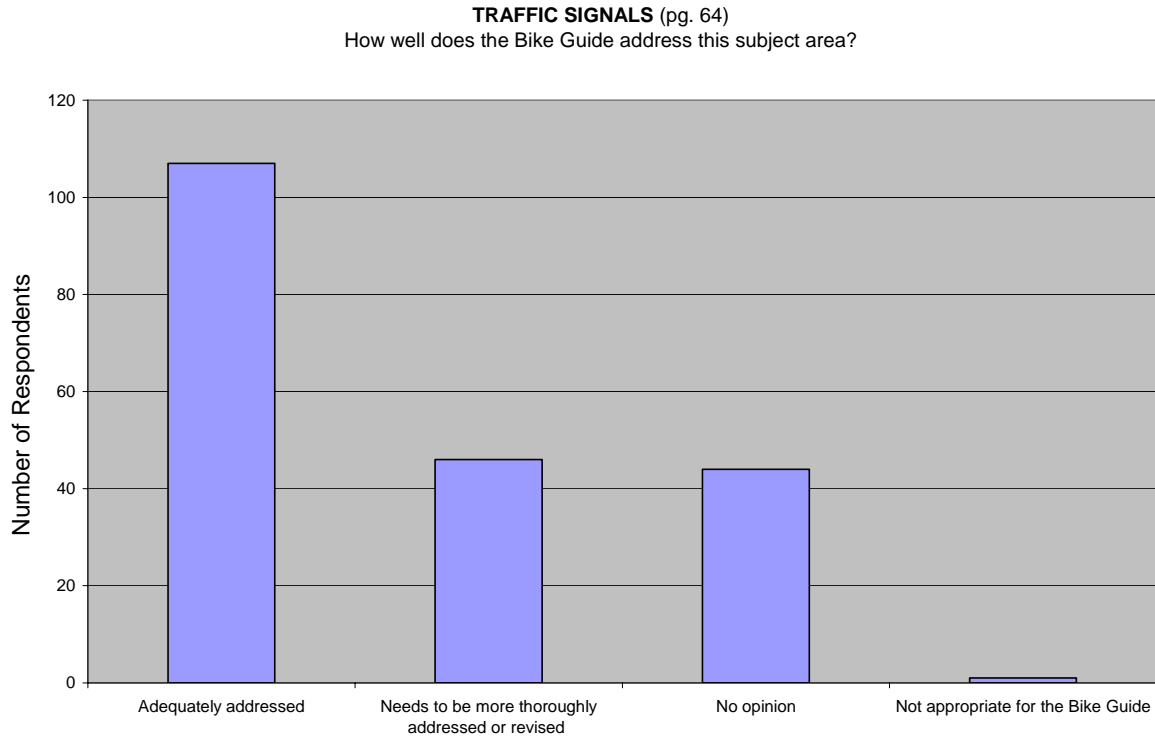
**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised –**

Describe approach treatments

## TRAFFIC SIGNALS

(pg. 64) How well does the Bike Guide address this subject area?



**Figure 55. Traffic Signals – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

MUTCD

**Needs to be more thoroughly addressed or revised –**

Discuss detection and technologies

Discuss the impact of clearance intervals and minimum green times on various user types

Move to intersection design section

Discuss bike boxes and advance stop bars for bicycles

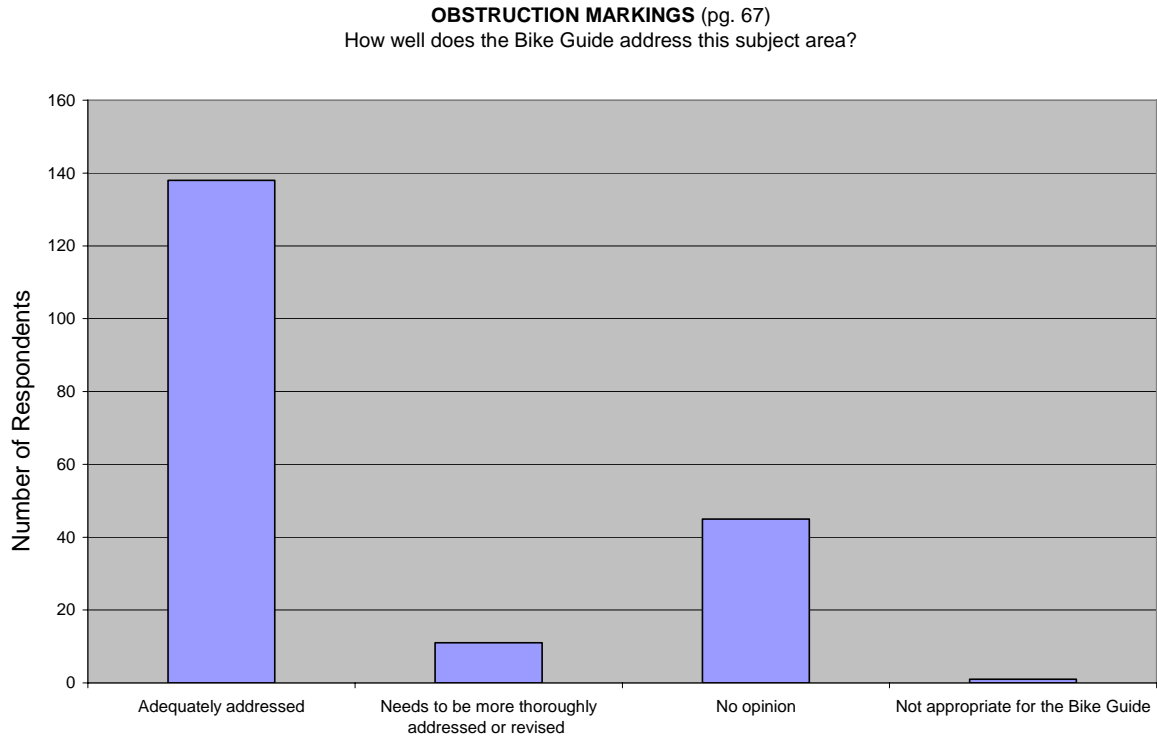
## Chapter 4: Survey Results

Discuss bicycle specific signal heads



## OBSTRUCTION MARKINGS

(pg. 67) How well does the Bike Guide address this subject area?



**Figure 56. Obstruction Markings – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

MUTCD (2)

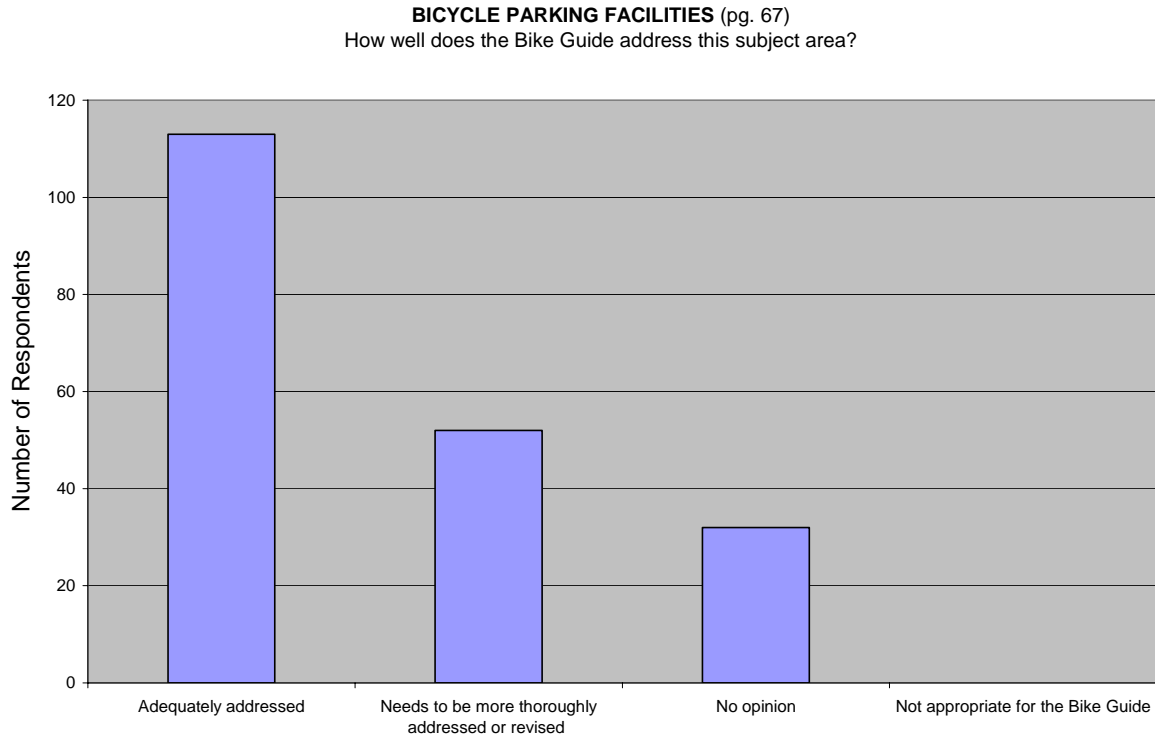
**Needs to be more thoroughly addressed or revised –**

Discuss vertical obstructions

Discuss appropriate taper lengths

## BICYCLE PARKING FACILITIES

(pg. 67) How well does the Bike Guide address this subject area?



**Figure 57. Bicycle Parking Facilities – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

**Needs to be more thoroughly addressed or revised –**

Discuss existing municipal programs to improve bicycle parking

Incorporate APBP guidance

Discuss bike stations

Discuss city ordinances

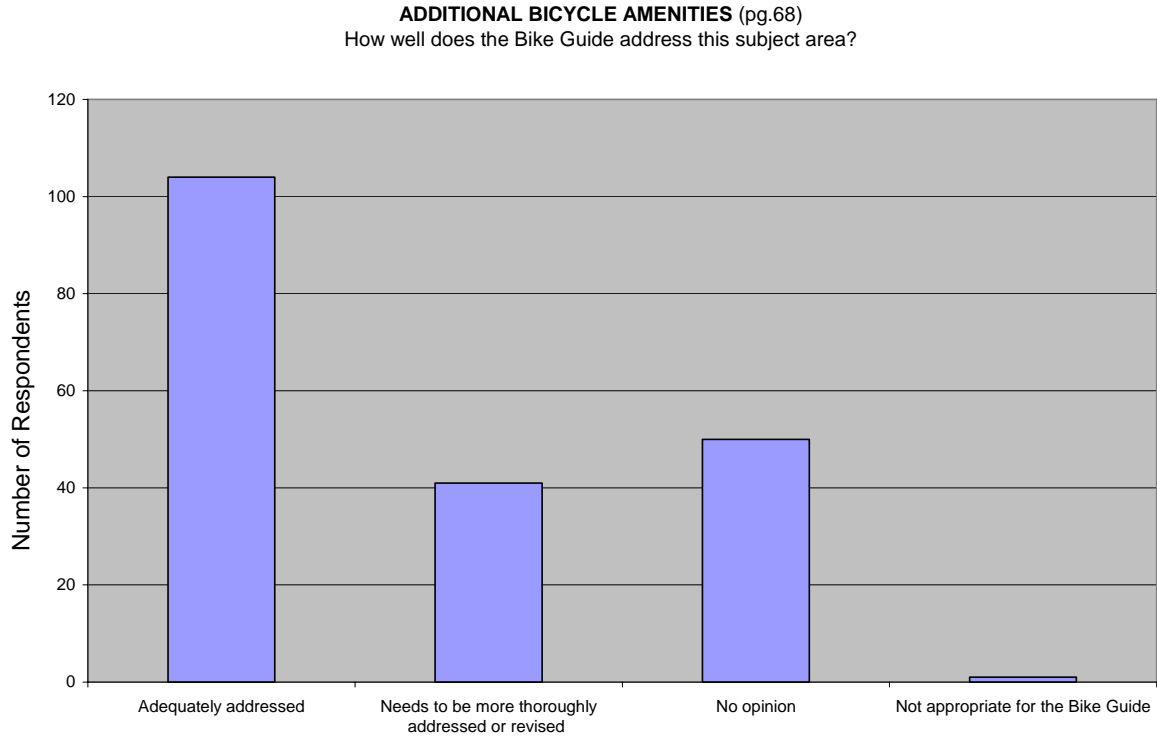
Discuss how to protect bicycles from the weather

## Chapter 4: Survey Results

Discuss parking space rates

### ADDITIONAL BICYCLE AMENITIES

(pg.68) How well does the Bike Guide address this subject area?



**Figure 58. Additional Bicycle Amenities – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Bicycle Plans

**Needs to be more thoroughly addressed or revised –**

Discuss bike racks on buses

Discuss access to light rail

Discuss interfacing bikes with transit

Create a transit chapter

## Chapter 4: Survey Results

Discuss bike trip destinations

Discuss workplace shower and locker facilities

Discuss water fountains

Discuss the use of locator maps and rest stops (for trails)

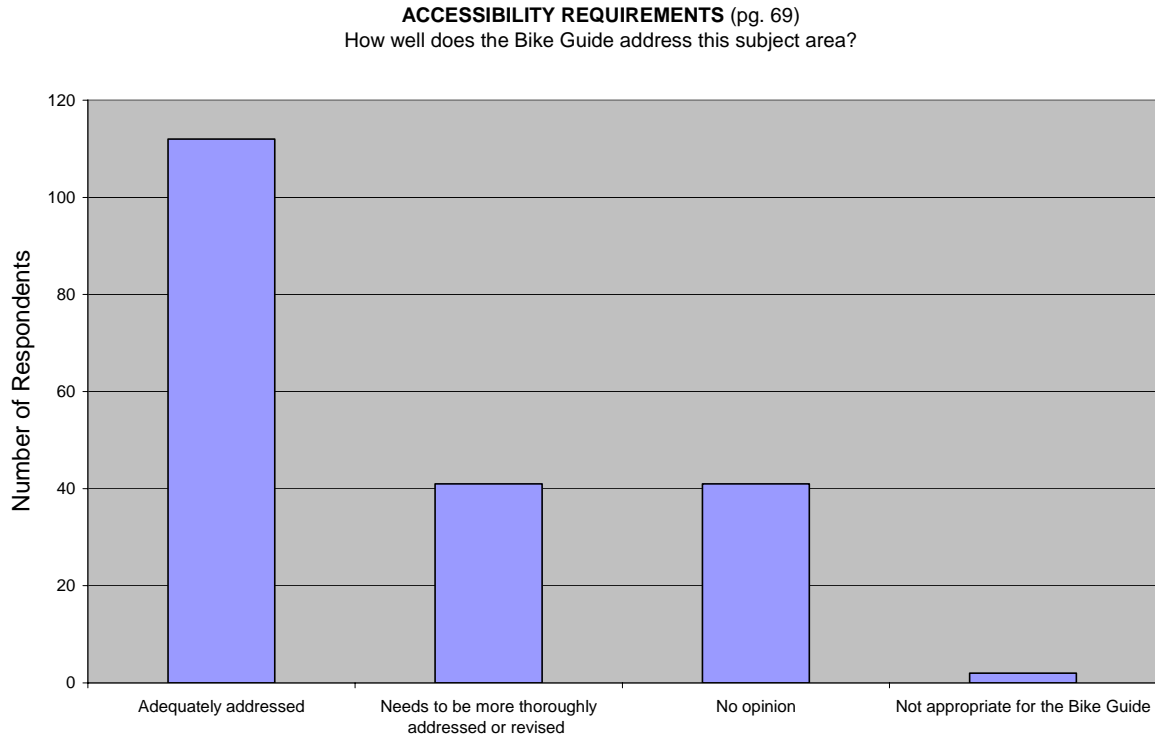
Discuss bicycle maps

Discuss emergency phones

Discuss trailheads

## ACCESSIBILITY REQUIREMENTS

(pg. 69) How well does the Bike Guide address this subject area?



**Figure 59. Accessibility Requirements – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

Access Guide

Pedestrian Guide

**Needs to be more thoroughly addressed or revised –**

Discuss truncated domes

Discuss ADAAG requirements

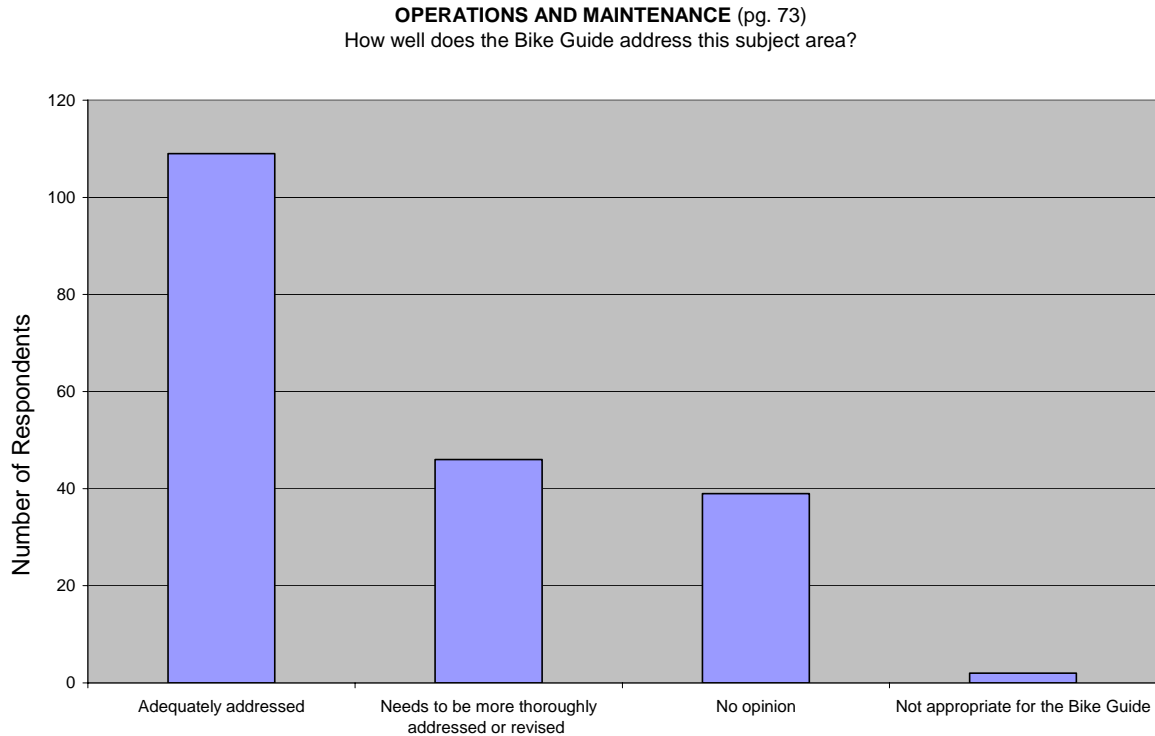
Reference FHWA publication no. FHW-EP-01-027, title 'Best Practices Design Guide, Part II, Designing Sidewalks for Access,' 2001

## Chapter 4: Survey Results

Incorporate into shared use paths section

## OPERATIONS AND MAINTENANCE

(pg. 73) How well does the Bike Guide address this subject area?



**Figure 60. Operations and Maintenance – How well does the Bike Guide address this subject area?**

**Not appropriate for the Bike Guide, please identify what document should address this subject?**

ADAAG

Not Necessary

**Needs to be more thoroughly addressed or revised –**

Many respondents felt maintenance needed to be more emphatically addressed

Discuss sand buildup and path / unpaved roadway crossings

Discuss sweeping shared use paths



## Chapter 4: Survey Results

Discuss sweeping of bike lanes and shoulders

Discuss reasonable expectations for pavement life before requiring resurfacing

Discuss access requirements of maintenance vehicles

Discuss the liability issues associated with maintenance

Discuss MOT

Discuss maintenance costs

Discuss the use of volunteers / adopt-a-trail groups

Discuss snow removal and ice control

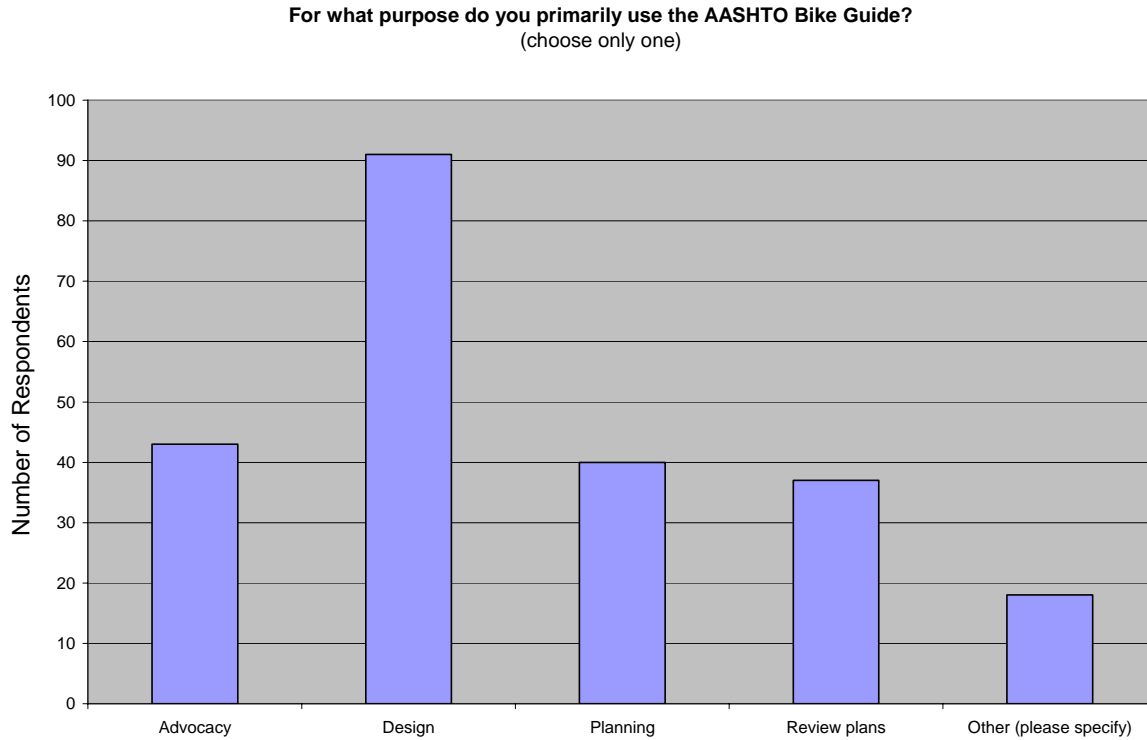
Discuss removal of thermoplastic prior to remarking bicycle facilities

Discuss the prioritization of bikeways for winter maintenance

Discuss the maintenance of cross drains

**For what purpose do you primarily use the AASHTO Bike Guide?**

(choose only one)



**Figure 61. For what purpose do you primarily use the AASHTO Bike Guide?**

**Other (Please Specify)**

Education

Technical questions

Review standards

Address policy needs on structures, respond to questions re: design and planning, and all the above.

Never used

Referring to others

Response to survey only.

## Chapter 4: Survey Results

Safety analysis

I would like to help Bike Athens.

Traffic Policy

Deter bad facilities

Training through workshops

Teaching

Forensics

## CHAPTER 5: PROPOSED ARRANGEMENT OF THE BIKE GUIDE

The proposed scope and outline for the next update of the *Bike Guide* is presented in Chapter 6 of this report. The overall arrangement of the *Bike Guide* was created based upon discussions with individuals who participated in the survey, or who contacted us directly to provide input. As stated previously, for each question on the web based survey, each respondent's answer (or rather, suggestion) was evaluated in the context of other respondents' answers to the same question. Additionally, the researchers looked at the background of each respondent (occupation, job title, how often and for what he/she uses the AASHTO *Bike Guide*) to determine additional perspective on the context (e.g., experience in the planning, design or operation of bicycle facilities) of the respondent's recommendations.

Many items are proposed to be added to the material in the existing *Bike Guide*. A description of some of the most significant proposed changes and the recommended subject format for the guide are discussed below:

**Introduction.** A section has been added within the Introduction that describes how the *Bike Guide* is related to other documents and how users should utilize the documents in concert to plan, design, and maintain bike facilities. As can be seen in the outline, it includes descriptions of the different types of design documents and a discussion of design guidance.

**Planning.** The Planning Chapter of the *Bike Guide* should be expanded. Recommended additional sections include information mainstreaming bicycle planning. Discussions of planning tools such as BCI/BLOS and the Highway Capacity Manual are included in the outline. The

section on selection of a facility type has been expanded to discuss four methods for selecting roadway treatments.

**Bicycle Operations and Safety.** A chapter on Bicycle Operation and Safety is recommended. Several respondents noted that there is more to designing facilities than simply stating where a stripe must be placed or how to sign a particular roadway section. They felt that just as traffic engineers must understand the rules of the road to design appropriate facilities for motorists, designers must understand how bicycles are intended to operate on the roadway to properly design bicycle facilities. To reinforce the information contained in the operations section of this chapter, a discussion of bicycle crashes has been added. Charts representing the percentages of crash types should be included in this section. This section should also explain that crash risks do not necessarily conform to many commonly held safety perceptions. Information concerning motorists' and bicyclists' education has been relocated to this chapter and expanded to include the education of law enforcement personnel and engineers.

**On-Street Design.** The discussions of on-street design and shared use path design have been separated into two different chapters.

Within the On-Street Design chapter, there are several significant recommended changes. Many respondents felt the classification of cyclists in the A/B/C categories was of limited usefulness in design. A more complete discussion of user attributes is included. The philosophy of treating bicyclists as vehicles is discussed and reinforced in the section on bike lanes.

Numerous respondents requested the section on interchange design be expanded to include information on single-point urban interchanges (SPUIs) and cloverleaf interchanges.

Several respondents suggested the design chapters should be arranged in a manner similar to that of the AASHTO *Green Book*. We attempted to do this as much as was practical.

**Shared-Use Paths.** Many respondents suggested the shared use path information be updated to reflect the fact that many different users will be using these facilities. This has been done within the outline. We recommend the information from FHWA's *Characteristics of Emerging Road and Trail Users and Their Safety* be incorporated into this design guidance.

Numerous requests were made for additional guidance for designing intersections shared use paths with roadways. Therefore, we have recommended providing additional information on assigning priority at these intersections, how to calculate required sight triangles and signing and striping. A discussion of the use of the use of crosswalks has also been included within the outline.

**Maintenance.** Many respondents felt that maintenance was important enough to merit its own chapter. Consequently, in addition to brief discussions within the other chapters as shown, we recommend a separate chapter be provided. In addition to the information provided in the exiting *Bike Guide*, discussions of snow management and the clearing of vegetation should be included in this chapter. The liability associated with poor maintenance should also be addressed in this chapter.

**Maintenance of Traffic (MOT) Through Work Zones.** Several respondents suggested a chapter be added to discuss traffic control through work zones. The need for MOT and the liability associated with not providing good MOT should be discussed in this chapter.

**Linking Bicycling with Transit.** The current *Bike Guide* discusses this as a subset of bicycle amenities. Respondents felt this subject should be addressed as its own chapter.

**Additional Bicycle Facilities / Amenities.** This section has been separated out as a new chapter and is proposed to include information on showers in employment centers, bicycle maps, loaner bike programs and maintenance request cards.

## **CHAPTER 6: PROPOSED OUTLINE FOR THE NEXT UPDATE TO THE AASHTO GUIDE FOR THE DEVELOPMENT OF BICYCLE FACILITIES**

Based upon the extensive literature search, the detailed analysis of the web-based survey responses and the combined experience of the research team, the following outline is proposed for the next update to the AASHTO *Guide for the Development of Bicycle Facilities*:

*Note: Some items have the notations “(reference some other document)”. This means that while a discussion of these subjects should be included within the updated AASHTO Bike Guide, the other document should be referenced as the authoritative source for standards or recommendations.*

Underlined text denotes items not currently in the AASHTO Guide.

### 1) Introduction

#### a) Purpose

#### b) Scope

##### i) Definitions of Manual, Guide and Handbook

##### ii) Definition of Standards, Guidelines, Criteria, and Options

##### iii) Relationship to other documents

(1) A Policy on Geometric Design of Highways and Streets (the AASHTO Green Book)<sup>1</sup>

(2) Manual on Uniform Traffic Control Devices (MUTCD)<sup>2</sup>

(3) The Highway Capacity Manual<sup>3</sup>

- (4) ADAAG<sup>4</sup>
- (5) AASHTO Pedestrian Guide<sup>5</sup>
- iv) Document overview
- c) Definitions
  - i) Arterial
  - ii) Bicycle
  - iii) Bicycle facilities
  - iv) Bicycle lane or bike lane
  - v) Bicycle path or bike path
  - vi) Bikeway
  - vii) Designated Bicycle Route
  - viii) Highway
  - ix) Rail-trail
  - x) Right-of-Way
  - xi) Right of Way Manual
  - xii) Rumble Strips
  - xiii) Shared roadway
  - xiv) Shared use path
  - xv) Shoulder
  - xvi) Sidepath
  - xvii) Sidewalk
  - xviii) Signed shared roadway
  - xix) Traveled way



xx) Unpaved path

2) Planning

a) Background

i) Why providing for bicycling is important

ii) How providing for bicycles can improve the overall transportation system

iii) How planning for bicycles affects bicycle operation and safety (see section on “Bicycle Operation and Safety” for more information)

b) Types of Bicycling

i) Utilitarian

ii) Commuting

iii) Recreational

c) Planning processes

i) Stand alone bicycle plans

ii) Incorporating bicycle planning into the overall planning process

(1) Importance of planning bicycling networks

(2) Long range transportation planning

(3) Capital improvement plan development

(4) Land (re)development codes

(5) Access permitting requirements

d) Plans for Improvement

i) Planning tools

(1) Measures of accommodation

(a) BCI<sup>6</sup>

- (b) BLOS<sup>7, 8</sup>
    - (c) HCM<sup>9</sup>
  - (2) Measuring travel demand
    - (a) Revealed demand
    - (b) Stated demand
    - (c) Theoretical demand
- ii) Inventory of Existing Conditions
  - (1) Geometric conditions
  - (2) Barriers to bicycling
  - (3) High crash locations
  - (4) Land use data
- iii) Selection of a Bicycle Facility
  - (1) By functional class of roadway
  - (2) By major origins and designations
  - (3) By level of accommodation
  - (4) By routine accommodation
- e) Potential for travel lane reductions
  - i) Will probably require motor vehicle LOS analysis
  - f) Importance of planning for maintenance activities
  - g) Impact of providing bicycle facilities on the liability of transportation agencies
- 3) Bicycle Operation and Safety
  - a) Safe operation of a bicycle
    - i) Traffic laws as they relate to the operation of cyclists

- (1) Bicyclists are to behave as the operators of vehicles
    - (a) Bicycles are not vehicles in all states
  - (2) Driving on the right side of the roadway
  - (3) Passing vehicles in opposite direction
  - (4) Overtaking and passing a vehicle
  - (5) When overtaking on the right is permitted
  - (6) Limitations on overtaking, passing, changing lanes and changing course
  - (7) Vehicles approaching or entering an intersection
  - (8) Required position and method of turning at intersections
    - (a) Proper approach behavior for bicyclists making a left turn, right turn or making a through movement
  - (9) Allowable methods for making a left turn
  - (10) Lighting requirements<sup>10, 11</sup>
  - (11) Legality of riding on paved shoulders
  - (12) Legality of riding on the sidewalk or in crosswalks
- b) Causes of bicycle crashes
- i) Falls
  - ii) Dogs
  - iii) Types and frequencies of crashes with motor vehicles<sup>12</sup> - text and charts
  - iv) Commonly held perceptions do not often conform to actual crash exposure or risk
  - v) Discussion of the door zone adjacent to on-street parking
- c) How proper operation of a bicycle (w/ respect to traffic laws) can prevent bicycle / motor vehicle crashes

- d) Traffic safety education programs
  - i) Bicyclists
    - (1) Young cyclists
    - (2) Parents
    - (3) Adult cyclists
  - ii) Motorists
  - iii) Law enforcement
  - iv) Engineers
- 4) Design of On-street Facilities
  - a) Elements of Design
    - i) Design philosophy
      - (1) Treat bicyclists as the operators of vehicles
      - (2) Provide for the mobility of all users
    - ii) Design vehicle
      - (1) Bicycles
        - (a) Dimensions
        - (b) Space requirements
        - (c) Surface requirements
        - (d) Design speed
        - (e) Turning paths
          - (i) How bicycles steer
          - (ii) Radius requirements
        - (f) Acceleration

(g) Deceleration

iii) Bicyclist Performance

(1) Variations by age

(2) Variations by experience

(3) Variations by training

(4) Variations by physical abilities

iv) Elements of Design

(1) Geometric criteria for roadway design will usually accommodate the on-street cyclist

(2) Sight Distance

(a) Definition

(b) Stopping Sight Distance

(i) Brake Reaction Time

(ii) Braking Distance

(iii) Design Values

(iv) Effects of Grade on Stopping

(v) Considerations for non-bicyclists (see shared use-path section)

(c) Passing Sight Distance

(d) Criteria for Measuring Sight Distance

(i) Eye height

(ii) Object height

(3) Horizontal alignment

(a) Theoretical considerations

- (i) Friction factors
- (ii) Influence of superelevation
- (b) Design Considerations
  - (i) Maximum Superelevation Rates
  - (ii) Side friction factor (factor of lateral acceleration)
  - (iii) Minimum Radii
- (4) Vertical alignment
  - (a) Theoretical considerations
    - (i) Changes from Green Book values for eye height and object height
    - (ii) Modified simplified equations
  - (b) Design considerations
  - (c) Minimum length of a sag curve
  - (d) Minimum length of a crest curve
- (5) Grades
  - (a) Effect of grade on design speed
  - (b) Maximum desirable grades
- (6) Cross Slope
  - (a) Maximum cross slope
- b) Shared lanes
  - i) Bicyclists can operate safely in shared lanes
  - ii) Factors that influence the perceptions of safety and comfort (refer to discussion of BCI and BLOS)<sup>13, 14, 15</sup>
- (1) Roadway width

- (2) Volume of traffic
- (3) Speed of motor vehicle traffic
- (4) Traffic mix
- iii) Impact of parking on effective space and safety
- iv) Use of the Share the Road sign (reference MUTCD)<sup>16</sup>
- v) Use of the Shared Lane Marking (If approved by MUTCD before printing of this document – reference MUTCD)<sup>17, 18, 19</sup>
- c) Wide curb lanes
  - i) Purpose of wide curb lanes
  - ii) Recommended minimum widths of wide curb lanes<sup>20,21</sup>
  - iii) Use of the Share the Road Sign (reference MUTCD)<sup>22</sup>
  - iv) Use of the Shared Lane Marking (If approved by MUTCD before printing of this document – reference MUTCD)<sup>23</sup>
- d) Paved shoulders
  - i) In some states riding a bicycle on paved shoulders is against the law
  - ii) In other states cyclists may be required to ride on paved shoulders (sidepath / bike path) resulting in increased potential for unsafe riding practices
  - iii) Primarily used in rural areas
  - iv) Do not provide accommodation at intersections (they are typically placed to the right of right-turn lanes)
  - v) Minimum widths
  - vi) Rumble strip considerations (reference FHWA Policy)<sup>24</sup>
- e) Bike Lanes

i) General considerations

- (1) Bike lanes are used to provide a preferential space for through bicyclists on the roadway, not to restrict bicyclists to the right side of the roadway.
- (2) In states with laws mandating that cyclists ride on any available bike path, the inclusion of bike lanes may result in increased potential for unsafe riding
- (3) Bike lanes must be designed to encourage bicyclists to operate in a manner that is consistent with the legal and safe operation of their bicycles as vehicles
- (4) Poor maintenance of bicycle lanes can lead to their being unused by bicyclists and the bicyclists' subsequent harassment by motorists
- (5) Discontinuance of bike lanes on roadway sections with significant down grades
- (6) On-one way streets
- (7) Contra-flow bike lanes

ii) Bicycle lane widths

- (1) Minimum bike lane widths<sup>25</sup>
- (2) Impact of motor vehicle traffic speeds, volumes and type impact the minimum bike lane widths
- (3) Minimum widths of bike lanes adjacent to on street parking

iii) Striping, marking and signing of bike lanes (reference MUTCD)<sup>26</sup>

iv) Use of contrasting pavement for bike lanes

- (1) AASHTO provides for the use of contrasting pavements for shoulders and auxiliary lanes<sup>27</sup>
- (2) Colored pavements not currently allowed by MUTCD<sup>28</sup>

v) Placement of bike lanes at intersections



- (1) The bicycle lane is usually a through lane for bicycles and is therefore designed as such
    - (a) Exceptions for T-intersections
  - (2) Discuss the operation of a bicycle on the approach to an intersection and who must yield to whom under certain conditions
    - (a) Motorists crossing a continuous through bike lane are required to yield to bicyclists
    - (b) Bicyclists leaving the bike lane to turn left must yield to motorists in the adjacent lanes before merging
    - (c) At a drop lane (or T-intersection where a through lane changes to a right turn lane), bicyclists must yield prior to moving to left of the right turn lane
    - (d) Provide space for bike lanes to the left of right turn channelization islands
- vi) Treatment of bicycle lanes at interchanges
- (1) Striping options through a diamond interchange
    - (a) Continuous bike lane, motorists yield/merge
    - (b) 90° crossing, bicyclists yield to ramp traffic
  - (2) Concerns at cloverleaf interchanges
  - (3) Concerns at interchanges with multi-lane ramps
  - (4) Treatments at single point urban interchanges
  - (5) Consider providing access to a sidepath treatment through the interchange
- f) Intersection considerations
- i) Detection of bicycles at intersections
    - (1) Inductive loops

- (a) Traffic signal loops' detection of bicyclists
- (b) Marking (and signage) for bicyclists
- (c) Placement in bike lanes
  - (i) Not frequently needed on arterials
  - (ii) May be needed on semi- or fully-actuated approaches
- (2) Alternative detection technologies<sup>29</sup>
  - (a) Video
  - (b) Microwave
  - (c) Infrared
- ii) Minimum green time
  - (1) Discuss other users (refer to Shared Use Path section)<sup>30</sup>
- iii) Minimum clearance intervals
  - (1) Discuss other users (refer to Shared Use Path section)<sup>31</sup>
- iv) Roundabouts<sup>32</sup>
  - (1) Bike lanes should be terminated on the approach to the roundabout
    - (a) Bicyclist option to claim the lane and ride through the roundabout
    - (b) Bicyclist option to access sidewalk and proceed through roundabout as a pedestrian
- v) Bicycles on freeways
  - (1) No Federal prohibition
  - (2) May be illegal in some states
  - (3) Typically on rural freeway sections
- g) Bike Routes

- i) Not actually a facility type
- ii) Serve to provide cyclists guidance to destinations
- iii) Can include a variety of different roadways and facilities including shared use paths
- iv) Criteria to consider when signing a route
- v) Usually signed with the D11-1 sign and supplemental plates
- vi) Just as with designated US, State, or County routes additional signage is needed at important intersections (Destination, Direction, Distance, Confirmation}
- vii) Sign options
  - (1) M1-8
  - (2) M1-9 (refer to AASHTO requirements)
- h) Bicycle Boulevards
  - i) Enhanced signing
  - ii) Enhanced traffic control
  - iii) Enhanced connections
  - iv) Bicycle priority
- i) Other roadway considerations
  - i) Bridges and Tunnels
    - (1) Continue existing facility
    - (2) Provide space beyond minimums if possible
    - (3) Bridge railing heights
  - ii) Railroad crossings
    - (1) Potential hazards to cyclists
      - (a) Slippery

- (b) Forced front wheel turn
  - (c) Loss of steering control
- (2) Coordination with railroad
- iii) Rumble strips
  - (1) Potential hazards to cyclists
  - (2) Mitigative measures: periodic gaps, profile marking, etc.
  - (3) FHWA Guidance<sup>33</sup>
- iv) Drainage grates
  - (1) Potential hazards to cyclists
  - (2) Description of bicycle friendly grates
  - (3) Obstruction markings
- v) Continuous right turn lanes
  - (1) Potential hazards to cyclists
  - (2) Potential operational and safety problems for motorists
  - (3) Potential solutions
    - (a) Access management
    - (b) Breaking up turn lanes with striping/curbing
- vi) Climbs and descents
- vii) Discontinuity in a bike lane or paved shoulder facility
  - (1) Tunnels
  - (2) Bridges
  - (3) Potential traffic control solution (real time share the road)
- j) Maintenance

- i) Pavement surface
  - ii) Sweeping
  - iii) Minimizing thermoplastic buildup
  - iv) Proper drainage
  - v) Snow management
- 5) Design of Shared-Use Paths
- a) Design philosophy
    - i) Shared-use paths should be designed as destinations
      - (1) Importance of aesthetics
      - (2) Connections to other paths
      - (3) Connections to parks, schools, other destinations
      - (4) Users should feel safe and secure
      - (5) Shared-use paths should be designed with the same care as roadways
    - ii) Provide for the mobility of all users
  - b) Shared use paths adjacent to the roadway
    - (1) Operational and safety concerns of shared use paths adjacent to the roadway
    - (2) Sidewalks are not bicycle facilities
    - (3) Provision of fences between limited access roadways and shared use paths within the right-of-way.
  - c) Elements of Design for various users
    - i) Design Users
      - (1) Dimensions
      - (2) Space requirements

- (3) Surface requirements
- (4) Design speed
- (5) Turning paths
  - (a) How bicycles steer
  - (b) Radius requirements
- (6) Acceleration
- (7) Deceleration
- ii) Mixing users
  - (1) A greater variety of users types and user abilities will be using shared use paths
  - (2) Speed differentials
  - (3) Space requirements
  - (4) Behavioral concerns (horses)
  - (5) Potential solutions
    - (a) Providing separate facilities
    - (b) Signing / striping
  - (6) Possible use by motorized users
    - (a) Motorbikes
    - (b) ATVs
    - (c) Snowmobiles
  - (7) Possible use by skiers
- iii) Elements of Design for various users<sup>34</sup>
  - (1) Geometric criteria for shared use paths will depend upon the design user chosen for the specific aspect of the shared use path design

- (2) Design Speed
  - (a) Paved trails
  - (b) Unpaved trails
- (3) Sight Distances
  - (a) Definition for key user types
  - (b) Stopping Sight Distance
    - (i) Brake Reaction Time
    - (ii) Braking Distance
    - (iii) Design Values
    - (iv) Effects of Grade on Stopping
  - (c) Passing Sight Distance
  - (d) Criteria for Measuring Sight Distance
- (4) Horizontal alignment
  - (a) Theoretical considerations
    - (i) Friction factors
    - (ii) Influence of superelevation
  - (b) Design Considerations – for key user types
    - (i) Maximum Superelevation Rates
      - 1. ADAAG maximums<sup>35</sup>
    - (ii) Side friction factor (factor of lateral acceleration)
    - (iii) Minimum Radii
    - (iv) Sharpest change in alignment without a horizontal curve
- (5) Vertical alignment

## Chapter 6: Proposed Outline for the Next Update to the AASHTO *Bike Guide*

- (a) Theoretical considerations
  - (i) Changes from Green Book values for eye height and object height
  - (ii) Modified simplified equations
- (b) Design considerations
- (c) Minimum length of a sag curve
- (d) Minimum length of a crest curve
- (e) Maximum algebraic change in grade without a curve
- (6) Grades
  - (a) ADAAG maximum grades<sup>36</sup>
  - (b) Ramp design criteria
  - (c) Effect of grade on design speed
  - (d) Maximum desirable grades
  - (e) Use of staircases
- iv) Cross section elements
  - (1) Pavement structure and type
    - (a) Asphaltic concrete
    - (b) PC concrete
    - (c) Resin concrete
    - (d) Stone dust
    - (e) Crushed stone
    - (f) Limerock
  - (2) Cross Slope
    - (a) Drainage requirements



- (b) ADAAG requirements<sup>37</sup>
- (3) Width
- (4) Shoulders
  - (a) Minimum widths
  - (b) Should be maintained across / through structures
- (5) Unpaved crossing turnouts
- (6) Horizontal clearance to obstructions
- (7) Drainage channels
  - (a) Intercepting runoff before it crosses the trail
- (8) Side Slopes
  - (a) Maximum allowable side slopes
  - (b) Protection from pathside hazards
    - (i) Railings
    - (ii) Barriers
- (9) Tunnels and Bridges
  - (a) Vertical clearance
  - (b) Width
- (10) Lighting Criteria
- v) Striping and Signing (refer to the MUTCD)<sup>38</sup>
  - (1) All signing and striping must conform to the MUTCD
  - (2) Centerline striping
    - (a) Dashed lines can help separate directions of users
    - (b) Solid lines can be used on the approach to hazards

- (i) Substandard curves
  - (ii) Intersections
  - (iii) Substandard overhead clearances
  - (iv) Structure approaches
- (3) Edge lines
- (a) Not usually recommended as they reduce the effective path width
  - (b) Can be used on paths with high expected use after dark
  - (c) Can be used on the approach to pathside hazards
    - (i) Railings
    - (ii) Narrow structures
- (4) Provide wayfinding signage
- (5) Provide user information signs (analogous to motorist information signage on interstates)
- (6) Proposed mode permission and prohibition signs for paths (to be included if adopted into the MUTCD)
- vi) Intersections with Roadways
- (1) Should be designed as the intersection of two roadways
    - (a) Assigning right of way
      - (i) Improper assignment of priority at intersections can cause unpredictable behavior on the part of roadway and path users
      - (ii) Priority should be set based upon three criteria (reference MUTCD)<sup>39</sup>
        1. Speed of users
        2. Volume of facility

3. Importance of facility

(iii) The least restrictive form of traffic control should be used

(iv) Sight triangles required for uncontrolled, yield controlled and stop controlled intersections

1. Description of each condition

2. Sight triangle requirements

(b) Pathway approach signage and striping

(i) Signing as per the MUTCD<sup>40</sup>

(ii) Solid centerline stripe may be placed for a distance of the stopping sight distance in advance of the intersection

(c) Roadway approach striping and signing as per the MUTCD<sup>41</sup>

(2) Additional crossing treatments

(a) Crosswalks

(i) Crosswalks alone can decrease the safety of uncontrolled multi-lane roadway crossings with volumes exceeding 12,000 vehicles per day.<sup>42</sup>

(ii) Legality of riding in crosswalks (covered in detail in “Bicycle Operation and Safety”)

(iii) Additional treatments should be considered

1. Advance signage

2. User activated real time warnings

a. Flashing beacons

b. In pavement flashers

(b) Raised median island / refuges

- (i) Minimum width for various users
- (ii) Use of Danish offsets
- (c) Signalization (refer to warrants in the MUTCD)<sup>43</sup>
  - (i) Bicycles may be considered pedestrians or vehicles
  - (ii) Detection of bicycles at intersections (see On Road design discussion)
  - (iii) Minimum green time for various users<sup>44</sup>
  - (iv) Minimum clearance intervals for various users<sup>45</sup>
- (3) Restriction of motor vehicle traffic
  - (a) Are restrictions needed?
  - (b) Tradeoffs of restricting motor vehicle traffic
  - (c) Landscaping
  - (d) Constrained Radii
  - (e) Medians
  - (f) Bollards
- (4) Shared use paths adjacent to the roadways
  - (a) Intersections at signalized crossings
  - (b) Intersections at unsignalized crossings
- (5) Grade Separation
  - (a) High roadway volumes
  - (b) High shared use path volumes
  - (c) Potential for non-use
    - (i) Indirect routes
    - (ii) Time delay if used

vii) Structures

(1) Approach requirements w/ respect to ADAAG<sup>46</sup>

(2) Bridges

(a) Railing requirements

(b) Fencing / caging

(c) Retrofitting structures

(3) Tunnels

(a) Perceived security

(i) Width

(ii) Exit visibility from entrance

(b) Lighting

(4) Maintenance

(a) Sweeping

(b) Drainage

(c) Lighting

viii) Trailheads

(1) Design to provide priority to the shared use path users

(2) Provide amenities

(a) Bicycle Parking

(b) Motor Vehicle Parking

(c) Restrooms

(d) Water fountains

(e) Picnic areas

- (f) Trash bins
- (g) Location / system maps
- ix) Additional shared use path amenities
  - (1) Periodic rest areas
    - (a) Benches
    - (b) Water fountains
    - (c) Interpretive areas
- 6) Maintenance
  - a) Quality surface for cyclists to ride upon
  - b) Sweeping of roadways and shoulders
  - c) Drainage facilities
  - d) Clearing vegetation
  - e) Snow management
  - f) Lighting
  - g) Liability
- 7) Maintenance of Traffic through Work Zones
- 8) Bicycle Parking<sup>47</sup>
  - a) Short term parking
    - i) Location
    - ii) Design criteria
  - b) Long term parking
    - i) Location
    - ii) Design Criteria

9) Linking Bicycling with Transit

a) Buses

i) Parking / lockers at bus stops and transfer stations

ii) Bike racks on buses

b) Light rail facilities

i) Parking at light rail stations / stops

ii) Carry on access to light rail facilities

10) Additional Bicycle Facilities / Amenities

a) Showers in employment centers

b) Bicycle system maps

c) Loaner bike programs

d) Roadway maintenance request card

ENDNOTES

- <sup>1</sup> AASHTO, *A Policy on Geometric Design of Highways and Streets*, 5<sup>th</sup> Edition (AASHTO Green Book). American Association of State Highway and Transportation Officials, Washington, DC, 2004.
- <sup>2</sup> *Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD)*, 2003 Edition. Federal Highway Administration, Washington, DC, 2003.
- <sup>3</sup> *Highway Capacity Manual*. Transportation Research Board, Washington, DC, 2000.
- <sup>4</sup> U.S. Access Board. *Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)*. Available online at <http://www.access-board.gov/adaag/html/adaag.htm>
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## **CHAPTER 7: AREAS IDENTIFIED FOR FUTURE RESEARCH**

The literature search and survey responses indicated that there are several areas impacting the planning and design of bicycle facilities that are in need of additional research. Nine of these subject areas are discussed below:

1. The safety and operational impacts of properly designed bike lanes. Many respondents commented that there is no proof that bike lanes reduce crashes and suggested that the opposite is in fact the case. Some of the arguments are summarized below:
  - a. Bike lanes are essentially used to contain bicyclists on the right most portion of the roadway. This position is often times not the correct location for bicyclists to ride. Such things as debris and pavement conditions can make it appropriate for cyclists to ride farther left than the bike lane.
  - b. Bicyclists who are turning will be in an improper location to make legal turn. For instance, left turning cyclists will attempt to turn left from the bike lane.
  - c. Motorist will not make right turns from the proper location (as right as practicable). They will turn across bike lanes, possibly cutting off cyclists, instead of merging to the right, yielding to cyclists in the bike lane, before turning.
  - d. Bike lanes result in less predictable and illegal turning movements by bicyclists.
  - e. Bike lanes place the bicyclist outside the normal viewing area of motorists (this may depend on the width the bike lane).

The above effects of bike lanes result in a less safe roadway system and more bicycle crashes.

We recommend a research project be developed to determine if bicycle lanes do improve the safety of the roadway. A primary measure of effectiveness (MOE) would be a reduction in

crash rates for bicyclists; consequently, good data concerning the frequency and types of crashes as well as the volumes of cyclists would be required. This would imply a before and after study of roadways being rebuilt / restriped as bike lanes. It should be noted that in some previous studies of the safety and operational impacts of bike lanes, more than one variable was changed between the before and after periods, confounding the results. Therefore, it is important to ensure that the installation of the bike lane is the only change between the before and after periods. Additional MOEs would address the above specified operational concerns and additional factors such as maximum safe widths for bike lanes, impacts of driveways on bike lane safety, and safety at auxiliary lanes.

2. The appropriate design user for specific design criteria for shared use paths. FHWA's *Characteristics of Emerging Road and Trail Users and Their Safety* documents the range of spatial requirements and operating characteristics of various user types of shared use paths. In its conclusions the report notes that the bicycle is not the critical user for any of the design criteria evaluated. However, the study does not identify what user should be the design user for the various design criteria. The authors of the report observed that determining the appropriate design user would likely be a function of the relative usage rates of particular users on path facilities. Determining user type splits was beyond the scope of that project. The authors of *Characteristics of Emerging Road and Trail Users and Their Safety* recommend a study be performed to determine the relative usage rates of various user types and that an expert panel be brought together to determine the appropriate design vehicle for the design criteria used to design shared use paths. It is recommended that this effort be pursued.

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3. The proper position / separation of shared use path users. There were several respondents who requested guidance on the separation of bicyclists and pedestrians on shared use paths.

Questions included the following:

- a. Should they be totally segregated with cyclists on one side of the path and pedestrians on the other?
- b. Should the bicyclists use the middle of the path while pedestrians use the outside? If so, should pedestrians walk on the left or right?

These questions also relate to several comments from those who feel that shared use paths are inherently unsafe because users do not behave in a predictable manner.

We recommend a research project be developed to determine whether measures to separate shared use path users are effective in changing path user behavior.

4. The proper (more thorough) criteria for providing protection of dropoffs. This includes addressing the following questions:

- a. What is the definition for a dropoff? Does the allowable maximum slope vary with the maximum change in grade?
- b. What is the appropriate treatment for protecting the dropoff?
- c. Should protection treatments be flared on their approaches?

5. Cyclists' behaviors on the approach to yield control intersections. Yield control intersections are purported to be more desirable for cyclists than stop controlled intersections. However, the sight triangles required for a yield control intersection require much more sight distance than can frequently be achieved for shared use path / roadway intersections. The AASHTO Green Book assumes the traffic that is to yield slows to 60% of its midblock travel speed.

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Evaluation of the accuracy of this assumption for shared use path users may provide for more appropriate design sight triangle criteria for shared use path / roadway intersections.

6. Quantification of the cautions against sidepaths. Respondents to the survey commented that they would like additional guidance on the warnings provided against sidepaths:
  - a. How many conflicts are allowable before a sidepath becomes inadvisable?
  - b. What is the best separation distance between the roadway and a sidepath?
  - c. Does the provision of a sidepath affect motorists' attitudes or behavior toward cyclists on the road?
  - d. Are there traffic control devices or design treatments which can mitigate these safety concerns?
7. The impact of grade on design speed. Currently the guide provides minimal guidance on the impact of grade on design speed (use 30 mph on significant grades). A respondent suggested this be researched to develop an equation or table providing design speed as a function of grade.
8. Several respondents requested some sort of information on what user volumes or mode shifts could be expected as a result of the development of a facility or network for bicyclist.
9. Numerous respondents suggested including guidance on innovative traffic control devices / treatments in the *AASHTO Guide*. However, as yet conclusive documentation of the operational and safety effects of these treatments is not available or they have not yet been adopted into the MUTCD. These treatments include the following:
  - a. Midblock colored bike lanes
  - b. Conflict zone colored bike lanes
  - c. Advanced stop bars for bicyclists

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- d. Shared lane marking (this treatment may be included in the draft 2008 MUTCD and is included within the proposed outline)
- e. Bike boxes
- f. Bicycle specific signal heads